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Ecodistricts - principles of planning and designing based on case studies

Dissertation Thesis

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The thesis titled "Ecodistricts – principles of planning and designing based on case studies" has been submitted for the degree of Doctor of Philosophy.

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Abstract

Ecodistricts – principles of planning and designing based on case studies

This thesis focuses on the ecodistrict as a concept of sustainable development, its particular role on finding balanced elements that enable high quality of life for residents and simultaneously support actions towards global climate neutral goals. In this thesis, ecodistrict sites have been examined and elaborated through detailed analysis of the selected case studies. Ecodistricts are city components that encourage practical solutions that cities, due to their complex and rather complicated structure, cannot achieve. There has been an enormous technological development in recent decades which has created a huge potential for cities. Certainly, many cities have taken advantage of, however there are still limitations to the extent that technological innovations have been applied.

This research work draws upon specific features of the ecodistrict structure that contribute to green solutions. Aspects that have been taken into consideration and thoroughly analyzed in this study are: general data, urban planning approach, architectural approach, energy, mobility, public spaces and landscape. Every single one of these components has been examined for each case study, and later on synthesized for all three case studies. The selected ecodistrict sites represent cases that are globally acclaimed models that successfully integrated architectural innovation, high values in sustainability approach, carbon neutral transportation and energy efficiency and renewable energy solutions, highly focused on livability, air quality and green spaces, among many others.

This thesis discusses and explores three overarching and interconnected research questions. Drawing from the case studies evaluation, which key urban and architectural categories and indicators can be taken into consideration for preparing principles of planning and designing ecodistricts? How should ecodistricts be designed? Based on the lessons learned, which principles serve as a baseline for ecodistricts planning and designing?

The thesis addressed the first question by listing and elaborating several urban and architectural categories and their sets of indicators, whereas the last two questions through thorough analysis of principles of planning and designing of ecodistricts.

The research work analyzed the design concepts of ecodistricts for the selected case studies and explored a certain number of categories and their relevant sets of indicators that would be used as part of a sustainable design approach. The thesis outcome is interlinked to the goals of the research. The first goal was achieved through increasing the general understanding of the potentials of the ecodistricts. Identification of the key urban and architectural categories and indicators was part of the second goal. Third goal was attained by exploring and elaborating on how ecodistricts should be designed and proposing principles of planning and designing of ecodistricts.

The main outcomes that have been presented in this thesis are the detailed results from the analysis of each category and its respective indicators. This should provide solid and reliable data to experts, architects and design community when planning and developing ecodistricts. The outcome explores in great detail the potential of categories and indicators combined with new tools and technologies in realizing the ecodistricts and cities of the future, a built environment completely in line with carbon free goals and ecofriendly pathways.

The results of the technical conclusions include many advantages and disadvantages detailed in principles of planning and designing of ecodistricts. Those included suggestions about the general data, on site conditions, area, population; about urban planning, on position, blocks, density, height, mix-use; about architectural, on building design and building owners; about energy, on low-energy and passive house buildings, bio based and wind power; about mobility, on public transportation, roads, garages, bikes and pedestrians; about public spaces, on public squares and other functions; about landscape, on green spaces, green roofs, rainwater, and green gardening. Each one of the indicators and categories has been valued for the relevant prominence and has been elaborated based on the data analysis from the case studies.

Finally, through this detailed exploration of how ecodistricts are planned, designed and implemented, the thesis outcome fulfills the overarching goal to offer new knowledge on the topic, with the hopes and motivation that this knowledge will be practically utilized when developing future ecodistricts.

Keywords: ecodistricts; econeighborhoods; ecocities; design principles; categories and indicators; sustainable architecture; Sustainable Development Goals (SDGs), climate change; adaptation;

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1. Chapter 1 - Introduction

1.1. Problem Identification

Many human activities have negative impacts on the environment. According to the recent studies, the impacts have reached the highest levels ever. The building sector, which is responsible for around one third of the total final energy use and about the same of greenhouse gas emissions, is one of the main drivers of the impacts.

Projected increase of the energy demand and CO₂ emissions will almost double by 2050 (IPCC, 2014c). Cities and urban areas are highly energy intensive (see sub-section 2.4.1 in Chapter 2), approximately two thirds of the total energy consumed in the world will be used by cities and urban areas (GEA, 2012) and (Bottero et al., 2019).

As such, the building sector has a huge role and a real potential to lead the way on climate change mitigation and offer an enormous contribution to the worldwide efforts of achieving the climate neutral goal.

How could this be achieved? By developing and utilizing advanced smart and sustainable strategies that enhance application of energy efficiency measures on existing and new buildings. By using renewable energy sources, selection of smart solutions and similar approaches, buildings, ecodistricts and cities have shown that sustainable and ecofriendly solutions do exist, are possible to be implemented and most importantly, are economically viable. While there are a lot of initiatives and many implemented projects that concern sustainable buildings and ecodistricts, it is apparent that a lot more needs to be done in order to reach the ambitious goals of sustainable and climate friendly living, and net zero carbon economy.

What is an ecodistrict?

There are broad varieties of definitions and characterizations in the literature as well as the planning documentations from various cities, however in this study the concept of ecodistrict is defined and understood as a city component that applies green strategies and urban/architectural solutions of sustainable buildings and infrastructure, by engaging cutting edge ecofriendly techniques, tools and technologies. An ecodistrict collects

rainwater and incorporates water saving measures and devices, produces its own energy from the onsite renewables and saves energy by applying energy efficiency measures. Focuses primarily on urban solutions that prioritize pedestrians, bikers as well as makes the most of using public transportation. An ecodistrict is people-centered, it puts human wellbeing at the heart, addresses citizens' needs and generates positive impact on the planet.

In addition to increasing quality of life, social inclusivity, equity, access to green spaces, the main goal is to tackle climate change by fostering solutions that reduce man-made emissions and impacts on the environment and overall carbon footprint. Among site options, it includes existing brownfields or new greenfields, which, in both cases, the whole process of planning and designing of buildings and infrastructure is done based on the ecofriendly solutions and sustainable technologies.

Ecodistricts play an immense role in expanding climate action in a city they belong to, as well as encourage other cities and regions worldwide to address the same issues and take similar approaches. As a result, it is obvious the influential impact that the existing ecodistricts have in many cities around the globe, among others, by learning from testing new technologies and applying advanced architectural and urban planning approaches as well as strengthening practical responses and sustainable pathways.

Planning and designing ecodistricts must be a collaborative effort of many fields of expertise that introduce and embrace state of the art green technologies. The process must include strategies that call for innovative urban planning and architectural solutions. But most importantly, it should include approaches that have been tested and used in the existing cases, therefore the need for further research on how these innovative approaches and technologies have been implemented and how they should be applied to future ecodistrict sites.

This research attempts to contribute to this topic by exploring and analyzing several existing ecodistrict case studies. Comparing and evaluating a wide range of alternative ideas and solutions from these developed projects, with the aim to generate a number of categories and their sets of indicators that would be the basis for identifying the lessons learned and composing a 'best case scenario' of principles of planning and designing that are part of the outcomes of this study.

1.2. Research Questions

This thesis settles on the approach that there are variable and multiple perspectives of the interpretation of how the ecodistricts should be implemented, and besides many relating factors and components, it argues that principles for planning and designing ecodistricts are connected and interlinked around the sustainability realm.

When referring to further research on sustainable urban neighborhoods (Luederitz et al., 2013) highlight the need for examination whether additional components and principles are necessary to fully advance the ecodistricts and econeighborhoods towards sustainability. Further, the same study considers the set of selected principles as 'working list' that requires further improvement, and 'needs to be critically examined in terms of its applicability and if additional principles are required or existing ones need to be adjusted', and claim that principles should serve as a 'compass in different circumstances' and 'reflect sustainability issues appearing in advance of or after a project'. Therefore, research community and urban practitioners need to learn, understand and give consideration to the particularities of circumstances that form the setting for a locale, in terms of which of those can be fully understood, then they need to contextualize and scrutinize the principles according to the settings.

Through this research it is aimed to investigate and provide answers to the following overarching research questions:

- a. Drawing from the case studies evaluation, which key urban and architectural categories and indicators can be taken into consideration for preparing principles of planning and designing ecodistricts?
- b. How should ecodistricts be designed? Based on the lessons learned, which principles serve as a baseline for ecodistricts planning and designing?

Chapter four addresses and answers the first question, by listing and elaborating several urban and architectural categories and their sets of indicators.

Based on the lessons learned, Chapter five answers the second question and provides a thorough analysis of principles of planning and designing of ecodistricts.

Development of a sufficient principle set, as scholars (Lang et al., 2007) and (Luederitz et al., 2013) also argue, should consider use of a transdisciplinary examination and facilitate exchange between various disciplines and sectors, however the principle set should keep away from having excessive number of redundancies. The same

authors also claim that for the principles to be continuously supplemented, upgraded and improved, studies emphasize the need for the recently evolved principles to be practically used and applied as well as contextualized in disparate settings.

To gain valuable knowledge, the existing implemented ecodistricts which sustainability principles have been applied to should be elaborated and their influence and effects be adequately assessed, this process is necessary to generate a modified set of principles that are higher quality and better assist in the process of planning and designing new ecodistrict sites.

1.3. Motivation and Research Goals

Eco-friendly solutions, ecodistricts and sustainable buildings have been part of the author's research interest for quite a while. First, the introduction to the LEED (Leadership in Energy and Environment Design) in 2005 and then to many other projects, such as AIA COTE (American Institute of Architects Committee on the Environment) Top 10 awards, as well as Passive House buildings, have motivated the author to try some of these techniques when building his own house. Good energy efficiency envelope, solar panel installations with hot water accumulation, were some of the basic measures that were implemented in the house, it showed that sustainable solutions are not only good for healthy living and environment, but also economically viable and have a really good return on investment. As such, the idea of further exploring and studying this topic became even more prominent. In 2015, the Faculty of Architecture of the Prague Technical University had a PhD topic on ecodistricts and sustainable architecture, and the author was admitted as a PhD student of the Department of Architectural Design II.

Further, as a Director of Operations of the IPCC Working Group II (WGII) Technical Support Unit, which supported and contributed (IPCC, 2019c, and IPCC, 2022c) in preparation of the three IPCC Special Reports (Global Warming of 1.5°C - SR1.5, The Ocean and Cryosphere in a Changing Climate - SROCC, and Climate Change and Land - SRCCL) as well as the main report WGII Contribution to the IPCC Sixth Assessment Report (WGII AR6) Climate Change 2022: Impacts, Adaptation and Vulnerability, the author had an exclusive opportunity to collaborate with the world class scientists and experts and was exposed to rich and valuable research data on impacts, adaptation

and vulnerability, and climate change in general. As such has used the opportunity to integrate any critical insights from the latest IPCC reports and assessment as well as this experience, into the outcomes of this thesis.

Based on results of the thorough review of relevant body of literature and the highlighted issues above, the first goal of this research is to contribute to increasing the general understanding of the potential that ecodistricts have in fostering sustainable solutions in new projects.

This research is set to analyze the design concepts of ecodistricts for the selected case studies and explore if a certain number of categories and their relevant sets of indicators can be used as part of a sustainable design approach.

Therefore, drawing from the case studies evaluation, the second goal is to identify the key urban and architectural categories and their sets of indicators that are taken into consideration for preparing principles of planning and designing ecodistricts.

While the third goal is to explore and elaborate how ecodistricts should be designed, and based on the lessons learned to propose the main principles of planning and designing of ecodistricts.

Through exploring how ecodistricts are planned, designed and implemented the overarching goal of this thesis is to provide new knowledge on the topic, with the motivation that this knowledge will be used in practice when developing future ecodistricts.

1.4. Methodology

When starting a project with certain statements on how and what one will learn during an inquiry, according to (Creswell, 2003), researchers are setting a 'knowledge claim', which by some (Lincoln, Lynham and Guba, 2011; Mertens, 2010; Creswell, 2003), are called paradigms or broadly conceived as research methodologies (Neuman, 2009; Creswell, 2003).

The three elements of inquiry that mix to create different approaches to research are, "knowledge claims, strategies, and methods". Steps included when designing a research are, evaluating the 'knowledge claims'

brought to the research, then taking into consideration the 'strategy of inquiry' that will be used in the research, as well as selecting particular methods for the research that will be done. (Creswell, 2003)

There are different views on classifying the case study research as a methodology. (Creswell, 2007) considers it as a 'type of design in qualitative research, or an object of study', whereas (Stake, 2006) does not agree that case study research is a methodology, but views it as a 'choice of what is to be studied', however (Denzin and Lincoln, 2011; Merriam, 1998; Yin, 2003) present it as a strategy of inquiry, a methodology, or a comprehensive research strategy.

Based on the three composite elements of inquiry, one of the research approaches can be selected, these approaches are quantitative, qualitative, or mixed methods. (Creswell, 2003)

Many scholars (Flyvbjerg, 2011; Merriam, 2009; Stake, 2006; Yin, 2014; Harrison et al., 2017) support using multiple methods to collect data in case study research. It is agreed that when combined, those methods provide a more across-the-board view of the researched topic.

When considering the use of the case study as a method for this research, the definition stated by (Yin, 2003) a case study method can be "an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident", entirely fits the goal of this research and paves the way to properly addresses the questions set forward.

This case study research employs a mixed methods approach. The researcher is using a mixed methods approach, when he or she bases 'knowledge claims on pragmatic grounds', the data collection includes assembling both numeric (quantitative) as well as text information (qualitative), which are both represented in the final database (Creswell, 2003).

1.4.1. Research Design

In a study, the research design is employed to depict and rationalize the strategy that a researcher uses as a way to incorporate the diverse parts of the research in a consistent manner (De Vaus, 2001; Trifonova and Pardi, 2017).

In addition to selection of the case study and mixed method, the use of the sequential procedures enables the employment of quantitative and qualitative methods in a sequential way. Therefore, Mixed-Methods Sequential Explanatory Design has been adopted for this research.

It basically consists of two distinct phases: quantitative data collection and analysis followed up with qualitative data collection and analysis.

When utilizing the sequential explanatory design, the researcher gathers data in two sequential phases over the period of time, initially the quantitative data are collected and analyzed whereas the second phase addresses collection of qualitative data which are related to the outcomes from the quantitative data (Ivankova et al., 2006).

The research work of this study begins with a quantitative method by collecting data from the literature review and desk research, which include, among others, books, reports, journal articles, papers and similar, and then followed by a qualitative method that involves collecting and analyzing data from the onsite physical observations as well as structured questionnaires with general open questions at the end, that assist on explaining the previously gathered quantitative results.

In their paper that gathered and listed the principles assessed from the reviewed literature, (Luederitz et al., 2013) treated the principles as 'starting points for an integrated set of principles for the development of sustainable urban neighborhoods', they claim that sustainability aspects were not sufficiently covered by the assessed literature, and suggest the need for further research on the elaboration of a comprehensive principle set.

Building on a broad body of available literature on the subject, data collection and the subsequent steps toward data analysis as well as case study selection criteria and inclusion of final cases, was not a straightforward process and needed some rigorous structuring.

It has been highlighted that although there are clear indications that sustainable urban neighborhoods principles that have emerged so far are linked to the sustainability realm, there are various views and interpretation of how the sustainable neighborhood should be realized (Gibson, 2006; Luederitz et al., 2013), regardless of contradictions over the concepts of 'sustainability' and 'sustainable development', 'there is now an emerging consensus on the fundamentals of what is needed for progress in the desired direction'.

Concerning the process of identifying the categories and indicators in the literature, (Boyatzis, 1998) and (Jabareen, 2008)'s approach in regards to the 'recognition of patterns in seemingly random information' was practical and motivational. As they claim, this move searches 'for similarities or patterns within the sample and codes the results according to categories of meaning'.

1.4.2. Data collection

In a case study research, the data collection draws on multiple bases of evidence, to include documents, reports, observations, archival records, interviews, physical artifacts and audio-visual materials (Creswell, 2007; Yin, 2009). As noted above, in this research mixed methods approach has been employed, as such collection of quantitative data was followed up by qualitative data.

1.4.3. Quantitative data collection

Desk research/literature review included data collection from different sources such as scientific journals, research articles, books, official reports, technical reports, cities' policies and guidelines, and other available online resources. In some instances, to be able to dive in further in a particular subject with a purpose of gaining additional insights, snowballing technique was found as useful and has been applied. Particular focus was given to literature materials that highlighted and explained characteristics, as well as the actions, methods and strategies undertaken and implemented by the existing ecodistrict case studies.

The desk/secondary research continued with utilizing data from various sources that concern ecodistricts. The use of data from the desk research is critical in introducing and presenting a wider picture for the case studies that are selected in this study, it offers a wide range of valuable information on different levels, such as urban planning maps, city development plans, sustainable approaches, location in the urban context, infrastructure planning, green and open spaces, building design and construction, as well as other social data on demographics and education, community engagement, just to name but a few.

1.4.4. Qualitative data collection

To complement the data collected from the literature review and desk research it was decided to include the personal onsite observation and a questionnaire. As part of collection of qualitative data, both onsite physical survey, and structured questionnaires with general open questions at the end, were employed to support and contextualize the desk research/literature review results, and give a well-rounded perspective of the various strands and features of ecodistrict functional characteristics. Both techniques searching for qualitative data were purposely arranged to follow up the quantitative data process.

1.4.4.1. Personal onsite physical observations

The researcher pays attention to the comments and feedback provided by the respondents about a particular location, however it is normally much better if the former can experience it in person (Stake, 1995). Physical observational surveys can yield precious means of documenting features of the social context as well as physical environment, they can also be used to create intricate factual records of particular events and settings (Denscombe, 2007).

Observational surveys are commonly conducted in person by the researcher. Although they do not need to use sophisticated equipment, preparations before the first site visit, in addition to information through desk research are necessary and beneficial. This included familiarization of the author with the sites through online maps and learning about key functions and features of ecodistricts beforehand. This preparatory step was very helpful and made the site visit much more productive and the process more efficient.

Onsite visits to the locations were organized with the intention to experience the ecodistrict sites in person. The survey of the urban areas, streets, connectivity to public transportation, biking lanes, pedestrian sidewalks, green spaces, the relation between the public and private open spaces, residential complexes and buildings, enabled collecting and documenting valuable data as well as taking many onsite pictures. Detailed field notes were prepared as soon as each instance of observation site visit was done. The data collected through the observation has been clustered into themes-based groups, outcomes and findings results from the site analysis were transferred and elaborated in detail at the dedicated sections for each case study (see three sub-sections A.1.9, A.2.9 and A.3.9) in Chapter 3.

1.4.4.2. Onsite structured questionnaires with general open questions at the end

Onsite structured questionnaires with general open questions at the end with a number of occupants were carried out as part of collection of qualitative data and enriching information on many aspects (i.e. urban planning, architecture, energy, mobility, public spaces and community facilities, livability, green spaces, socioeconomic, and many others), and in support of the data outcome from desk research. The onsite questionnaires have been critical in reaching a deeper understanding of resident satisfaction in the case studies as well as in complimenting the other desk research data. Detailed description and elaboration of the process of conducting the questionnaire and all phases that this process involved, have been presented in Appendix 1. (see section 7.1, 'Onsite structured questionnaires with general open questions at the end'), which includes sub-sections: Questionnaire development and administration, The role of general open questions at the end, Survey questions randomization, Piloting and Pre-testing the questionnaire, Sampling technique - simple random sampling, Self-administration of questionnaire and face-to-face interaction with participants, Data collection, extraction and sorting, Data analysis, Ecodistrict occupant feedback questionnaire form, and Limitations. Also, extensive elaboration of the majority of the textual part of the open ended responses have been captured in three sub-sections (A.1.9, A.2.9 and A.3.9) in Chapter 3.

1.4.5. Keyword search

During the desk research/literature review search and collection of study material phase, search was limited to two variations of the word ecodistrict, so keywords 'eco-district' and 'ecodistrict'. However, as the search process emerged, it was realized that due to a broad range of concepts other terms will have to be introduced. As explained in Chapter 1, a variety of terms have been used in literature for almost similar city 'districts', therefore the search expanded to include keywords such as: 'eco-neighborhood', 'eoneighborhood' (not distinguishing here the British and US versions), 'eco-community', 'ecovillage', 'sustainable community', 'sustainable urban district', and 'ecoquartier'. At the later stage, data analysis and the clean up process dealt with any discrepancies and misalignments of the terminology found in literature.

1.4.6. Initial identification of the main thematic clusters ('categories')

As a next step of the initial phase of desk research/literature review data collection and analysis was carried out with the aim to identify main thematic clusters that are relevant for ecodistricts and most frequently used in literature. This initial phase identified seven of these thematic clusters, which in this thesis are referred to as 'categories', those are: general data, urban planning, architecture, energy, mobility, public spaces/community facilities, and landscape/green spaces. Thematic clusters composition was fully derived from the outcomes of and as a result of literature review. Similar approaches on defining characteristics were taken by other studies as well (Zhang et al., 2021; Luederitz et al., 2013; Organ, 2015). An additional and critical step in this process of identification and selection of categories, was the comparison of the characteristics of the categories against Sustainable Development Goals (SDGs) and ensuring that each category has some linkages with, and is interrelated to one or multiple goals and targets from the 17 SDGs and the respective 169 targets. This step confirmed that the SDGs framework provides the conceptual coverage for all categories, and lays down a basis for their expected actions as part of their functions within an ecodistrict in achieving the SDGs.

1.4.7. List of potential case studies

Based on the outcome of literature review analysis, and screening of the ecodistricts available from the gathered literature, several potential case studies were identified for further elaboration and analysis towards case selection. Identification of the potential case studies was based on their data availability in relation to the seven categories identified above. List of potential case studies has been included in a table (Table 2) in an excel spreadsheet, which was later populated with data from each case study and used for the next phase in case study selection. The table is structured so each of the potential case studies is listed in a separate column.

1.4.8. Definition of case study selection criteria, and composition of the list of indicators

In the process of preparation of case study selection criteria, the input from the recently identified categories (thematic clusters) was fundamental. Further detailed desk research enabled composition of selection criteria items that were extracted from each thematic cluster based on the available data. At this stage these items are called 'indexes' however in this thesis, after refinement, they are referred to as 'indicators'. Each identified index/indicator

carries relevant information on specific characteristics of an ecodistrict and other similar concepts of sustainable urban district. The extracted data was then entered in the excel spreadsheet table (Table 2). Three additional columns were inserted, first one indicating 'category' (thematic cluster), second column 'index' (indicator), and third column 'requirement' indicating the specific selection criteria requirements for each index. This led to the composition of the final set of case study selection criteria. The set of selection criteria included 19 mandatory requirements (see Table 1, and highlighted rows in Table 2) that were disqualifying for all of the case studies that did not meet them. Although some of the mandatory requirements are obviously more prominent than others, they have been listed in the table based on the thematic cluster they belong to and not necessarily the weight they represent. It needs to be mentioned that some non-mandatory indexes have been included in the table and their data has been entered. However the purpose of this specific data is to gather general information on the potential cases, rather than providing any additional weighting factors, thus listed as 'Not specified' under the requirements column.

Therefore, starting at the top of the table, the 'Year implemented' of the case study, for data to have some valuable relevance, the case study had to be in operation for some time, hence the requirement for five years in operation. Next one, the size of the ecodistrict, to prevent having case studies with extremely different area and the number of inhabitants, and as a result, different functions and infrastructure supporting those functions, the requirement was that a case study should have an area in a range between 40-120 ha, population between 5,000-10,000 residents, housed in a range of 2,000-4,000 housing units. Additional criteria include: Position in relation to the city, Mixed-use, Blocks of residential complexes, Public squares, School, Daycare/ Kindergarten, Youth and community center, Green spaces, and others as listed in Table 1.

Table 1. Case study selection criteria - mandatory requirements (prepared and compiled by Bardhyl Rama)

Index	Mandatory Requirements (for the case study to be selected)
Year implemented	at least 5 years in operation
Area	between 40-120 ha
Housing units	2,000 - 4,000 units
Population	5,000 - 10,000 residents
Position in relation to the city	max 10 km from city center
Urban planning competition criteria	Set by the city
Blocks of residential complexes	Yes
Mixed-use included	Yes
Property developers buildings	Yes
Use of multiple architectural firms to foster diversity of architectural expression	Yes
Includes Low-energy buildings	Yes
Includes Passivehouse standard (15 kWh / m ² a) buildings	Yes
Operational and reliable public transportation	Yes
Bike and pedestrian friendly	Yes
Public squares	Yes
School	Yes
Daycare/ Kindergarten	Yes
Youth and community center	Yes
Green spaces	Yes

1.4.9. Case study selection

Researchers agree that the use of methods depends on the purpose and design of the research, which could be a single or multiple case study research design. (Flyvbjerg, 2011; Merriam, 2009; Stake, 2006; Yin, 2014; Harrison et al., 2017)

With regards to case study as a research strategy, (Robson, 2002) and (Pathiraja, 2007) argue that the focus is on a case, which includes the study of, among others, a setting as well as taking its context into account. Further, case studies can be especially helpful for studying, inter alia, a process in a thorough and holistic manner that provides a meaningful understanding (Merriam, 1998; Pathiraja, 2007).

Further detailed review of all eight potential case studies was carried out. The excel spreadsheet table respective columns were completed with relevant data extracted from literature for each one of eight potential case studies. As

the last step, the entered data for each case were compared against the mandatory requirements. A color-coded technique was used, 'green' in the instance when the requirement was met or exceeded, and 'red' when it was not. This final step completed the case study selection analysis and enabled a visual presentation in the excel table (Table 2). Given the detailed and simple representation of the voluminous data, it was a relatively easy task to determine the cases that passed the selection criteria. Three case studies turned out to have been indicated as green on all of the mandatory requirements. Those three cases were selected to be part of the research work and further elaboration in this thesis.

Table 2. Case study selection criteria, with data from all potential case studies (prepared and compiled by Bardhyl Rama)

Category (thematic cluster)	Index (Indicator)	Requirement	Hunziker Areal, Zürich	Bahnstadt, Heidelberg	Tivoli GreenCity, Brussels	Hafen City, Hamburg	Bo01, Malmö	Kronsberg, Hanover	Eva Lanxmeer, Culemborg, NE	Vauban, Freiburg
General data	Year implemented	at least 5 years in operation	2014 No	2008 - 2022 Yes	2016 No	2012 Yes	2001 Yes	1992 - 2013 Yes	1994 - 2009 Yes	1993 - 2006 Yes
	Site condition	Not specified	Brownfield (old factory site)	Brownfield (Railway freight and station area)	Brownfield (former urban wasteland)	Brownfield (Industrial Harbour)	Brownfield (Industrial Harbour)	Greenfield	Greenfield	Brownfield (former military base)
	Area	between 40-120 ha	5.5 ha	60 ha	4.5 ha	157 ha	25 ha	70 ha	30 ha	41 ha
	Housing units (at least 2,000 units)	2,000 - 4,000	406	3,700	397	7,500	1,400	3,200	240	2,530
	Population	5,000 - 10,000	1,400	6,800	1,500	15,000	2,500	7,150	1,000	5,500
Urban planning	Position in relation to the city	max 10 km from city center	5.5km	4 km	3 km	2.5	2.5	9 km	1.5 km	4 km
	Urban planning competition criteria	Set by the city	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Blocks of residential complexes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Building height limit	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Mixed use included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Architecture	Individual owner buildings, including terraced buildings	Not specified	No	Yes	N/A	No	Yes	Yes	Yes	Yes
	Group owners buildings	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Property developers buildings	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Use of multiple architectural firms to foster diversity of architectural expression	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Energy	Includes Low-energy buildings	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Includes Passive house standard (15 kWh / m ² a) buildings	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
	Energy plus housing	Yes	No	Yes	Yes	No	No	Yes	No	Yes
	Combined Heat and Power (CHP)	Not specified	Yes	Yes	N/A	Yes	No	Yes	N/A	Yes
	Wind Power	Not specified	No	Yes	N/A	No	Yes	Yes	No	Yes
Mobility	Public transportation	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Bike and pedestrian friendly	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Quiet residential streets	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Parking garages	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Public spaces and community facilities	Public squares	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	School	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes
	Daycare/ Kindergarten	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Youth and community center	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Landscape/ Green spaces	Rainwater addressed	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Green roofs	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
	Green spaces	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Other functions in green spaces (playgrounds etc)	Not specified	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Green gardening	Not specified	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1.4.10. Data analysis and clean up

Case studies are drawn from a number of cities within different locations in Central Europe, and represent cases that are world-wide well-known models for their, among others, architectural innovation, high values in sustainability approach, sustainable land use, eco-friendly transportation, energy efficiency and renewable energy solutions, high focus on livability, indoor air quality and green spaces. The outcome of this comparative case studies research involves analysis of each case and then synthesis of a number of elements across the cases. Therefore, on the technical level the selected case studies had to contain enough information on a number of categories and indicators in order to generate solid data that would be included in the design principles.

Collected data was put together in various formats. Textual and descriptive material was screened, collected, separated and integrated in the word document. All photographic (pictures, schematics, maps and other) were included in respective sections in the word document. Specific data related to categories and indicators was collected and entered in excel tables. The material was screened, cleaned up and checked as necessary. Any missing data was searched for and the tables were populated. The collected data from the onsite physical survey and structured questionnaires with general open questions at the end, was similarly structured, analyzed and integrated with the rest of the data. The sheer number of pictures that were taken by the author during the multiple site visits needed proper labeling, screening and grouping relative to each case study as well as themes within each case. Nevertheless, only the pictures that were relevant to the study and were referenced in the textual part have been included in the word document. The additional questionnaire data analysis has been elaborated in the Annex. (sub-section 7.1.8).

The collected data has gone through mixing and synthesizing, or as referred to as, process of integration. Integration is the stage or stages in the research process where the mixing of the quantitative and qualitative methods occurs (Creswell, 2003). The integration process synthesized and elaborated collected data from different sites in two chapters. Chapter four listed and described several urban and architectural categories and indicators, while chapter five provided a comprehensive study on the lessons learned as well as identified the main design principles.

1.4.11. Exclusions from case studies

A rigorous selection criteria requirements set was established at the initial phase of the research. The set of case study selection criteria included 19 mandatory requirements that were disqualifying for the case studies that did not meet them (see sub-section 1.4.6). Five case studies did not meet the selection criteria requirements therefore were excluded from the case studies list.

1.4.12. Research Limitations

First, given the specific focus and the limited scope, the outcomes and findings of this study should rather be seen as a contribution to a broader discussion about the principles of planning and designing ecodistricts, instead of conclusive overview of the complex and interrelated factors that build on the process and the structure of sustainable approaches in cities.

Second, the list of categories and indicators is not exhaustive and by no means captures the whole interconnectedness and underlying complexity, characteristics and features of ecodistricts.

Third, the three case studies analyzed in this research undertaking were selected based on rigorous selection criteria requirements set at the initial phase of the research, however it must be pointed out that they are located in relatively proximate regions in Europe. Therefore, the outcomes and suggestions based on the three elaborated cases will most likely not have captured any or all context specific features that might be distinctive to any other particular region or even climatic conditions. Also, further aspects, such as top-down versus bottom-up approach, or cases which aimed at high energy efficiency thus focus more on environmental and economic pillars than in social pillar, or on the site conditions, in this case, brownfields and greenfields, which do not necessarily represent any particular proportion of the actual implemented ecodistrict sites. Similar issues have been identified in the existing literature, therefore rightfully highlighted by many scholars as well. In particular, (Bottero et al., 2019) stating that 'the analysis of the literature showed a predominance of examples from Northern or Western Europe', further (Hammer, et al., 2011) arguing that the most prominent currently under development or completed econeighborhood sites are located in Western and Northern Europe, as well as (Kyvelou, Sinou and Baer, 2011) who calls the concept of sustainable neighborhood as a Northern European model.

Finally, (Bell et al., 2014) state that in small projects with insufficient data, it is unlikely to generalize, however it may be completely possible to use reliability, also (Bassegy, 1981) argues that 'reliability of a case study is more important than its generalizability'. Further, as noted by (Denscombe, 2007) 'the extent to which findings from the case study can be generalized to other examples in the class depends on how far the case study example is similar to others of its type'. Therefore, outcomes and findings from this study should be considered from the reliability standpoint rather than attempting to generalize for other future cases.

2. Chapter 2 - Theoretical background

Global efforts are directed towards a net zero economy and achieving the Sustainable Development Goals (SDGs). As such, countries, regions, cities, local governments, communities and many others, are on the race to achieve those goals. Ecodistricts, econeighborhoods, sustainable communities, ecocities, as well as any other forms of sustainable urban settlements are seen as practical tools and enablers for cities to implement many of those goals. Therefore, based on the research objectives and the stretch of categories and potential indicators that this thesis is set to address in this research undertaking, a careful application of proper lens was necessary.

2.1. Sustainable Development (SD) theory and the SDGs framework as the theoretical background

Since this thesis addresses the ecodistricts principles of planning and designing, as such requiring a holistic approach and capturing a range of fields and subjects, it is reasonable and rational to be grounded in the Sustainable Development theory. However, due to the complexity, the broad range and coverage of disciplines that ecodistricts have to touch upon, as well as the interconnectedness of the process of planning and designing of ecodistricts, additional lenses were deemed necessary.

Sustainable development theory is known for its global, very holistic and wide coverage nature, however it has been apparent that single theory would probably neither be enough nor be able to properly cover the whole complexity and the range of fields, subjects, sectors and topics, that are usually integrated in the ecodistricts planning and designing process. In the quest to find additional broader and more appropriate lenses to highlight all the features belonging to the ecodistrict planning and designing process, the author has sought further into the theoretical world for other appropriate theories that would complement and assist sustainable development theory in bringing forward all these perspectives.

There are many theories that are appropriate and would probably fit in this prospect, especially two additional ones are really important and possess the needed features to assist in addressing the above mentioned complexity of the process, Ecological Modernization and New Urbanism which are known for their widespread influence globally

and for their obvious practical applications of the research as well as pragmatic and real world usage in many aspects, and also in urban settlements implementation.

The Sustainable Development theory tackles the long-term approach of the relationship and interconnectedness between three sustainable development pillars, economic, social and environmental and aims that while the economy is expected to grow, the social equity and environmental protection are equally valued and addressed. The SDGs framework, as noted above, is based on sustainable development theory, but the goals and targets integrated in this framework are action-based, pathway oriented and within a given timeframe, as such, are to be achieved by 2030.

Scholars provide relevant views on the SDGs framework. While (Chapman et al., 2020)'s study proposes that the SDGs and respective targets form an effective framework for determining real-world research impact', (Bengtsson et al., 2018) views the SDGs as a 'comprehensive global policy framework for addressing the most pressing social and environmental challenges currently facing humanity'. In a similar way, the SDGs is viewed by (Fox and Macleod, 2023) as a practical framework for engaging local communities concerning sustainability topics and also a precious instrument for indicating the city's global ambitions, they further state that 'many of the city's leaders wanted to use the SDGs framework to deliver their ambitions'. Highlighting the linear causality effect, (Nilsson et al., 2016) claim that causal chains across the SDG framework is possible. In terms of sustainability reporting and accounting of organizations, the SDGs as a worldwide sustainability framework can be integrated in a relevant way (Elalfy et al., 2021).

Surfaced a few decades ago, the Sustainable Development theory, as claimed by (Shi et al., 2019) is the center of attention on the 'coordinated development of economy, society, and environment', and as authors further claim, it has 'entered the high-level political agenda'. However, 'we must improve the integration of sustainable development theory with the practice of characterization and measurement, and recognize that the process is as important as the product' (Parris and Kates, 2003). The triple bottom line of Sustainable Development as a theoretical approach is widely accepted by practitioners (Alvarado-Herrera et al., 2017). (Shi et al., 2019) argue that the sustainable development theory has encountered various stages of development since it was put forward,

therefore (Pohoată, et al., 2020) call for reconstruction of the theory of sustainable development 'through the reconciliation with the laws of healthy growth'.

Based on the research goals, the above elaboration, and assisted by the core definition of both concepts, the theoretical background expands on and develops in several thematic clusters that serve as multiple lenses through which the thesis views this research work. (Gunnarsdóttir, et al., 2020) suggest that thematic frameworks group indicators into different issues or themes of sustainability.

The clusters cover and group relevant themes that are necessary to be integrated in order to tackle the complexity of work of addressing the ecodistrict planning and designing, and the proposal of potential principles. Due to the overlapping nature and interlinkages of the themes addressed, they might fit into one or more clusters.

Nevertheless the approach is that they would be clustered based on their foremost appropriateness in relation to the thesis research goals, how best they fit into, as well as the level that they serve and support the process of analysis and elaboration of the following seven categories (and their respective indicators): general data, urban planning approach, architectural approach, energy, mobility, public spaces and landscape. The broad scope of thematic clusters permits filtering and sifting through the collected information. It is valuable to reiterate that all the SDGs concepts for the thematic clusters derive from (UN General Assembly, 2015).

Even though it has appeared in literature for quite a long time, currently there is no single, universally agreed upon definition of sustainable development, nonetheless most definitions underscore the importance of integrating social, economic, environmental, and institutional dimensions (Boyoko et al., 2006; Sharifi and Murayama, 2013; Valentin and Spangenberg, 2000; Sharifi, 2016)

One of the major definitions in the history of sustainable development which is probably most widely used is the Brundtland definition of sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015 (UN General Assembly, 2015). Considered an urgent call for action, in its core it includes 17 Sustainable Development Goals (SDGs) with 169 associated targets. It was the first time that the world leaders pledged common action across such a broad and universal policy agenda. This agenda states that the world is heading on the path towards

sustainable development and that the implementation is for the benefit of both, current and future generations. SDGs and targets are universally applicable, they consider different national realities, capacities and levels of development (UN General Assembly, 2015).

2.1.1. Theoretical background for this thesis

The author has adopted the Sustainable Development theory and utilized the SDGs framework to establish the theoretical background for this research. This is routed in a few points that derived from the literature review. First, cities around the globe actually measure their sustainability actions and their progress against the SDGs approved by the United Nations. Second, the SDGs are borne from and grounded in the Sustainable Development theory. Last, and most importantly, the SDGs framework actually covers and provides solid grounds for all the categories of the ecodistricts that have been aimed by this thesis.

While every single one of the SDGs and targets has its own importance and is interlinked with all sectors, including the built environment, a few of them stand out in their messages and objectives that are directly connected to way buildings and cities are planned and designed and the impact of the latter in realizing those objectives. Therefore, the follow on sub-sections provide an overview of these particular goals and targets that are linked to the way sustainable cities, urban spaces, districts, neighborhoods, communities, building complexes and buildings are planned, and their direct implications on the achievement of these goals.

2.2. The thematic cluster grounded in SDG Framework concepts - theoretical background related to urban planning approach in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 11. Make cities and human settlements resilient and sustainable, access to adequate and affordable housing (Goal 11.1), access to and expansion of sustainable public transportation (Goal 11.2), inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management (Goal 11.3), reduce the environmental impact of cities and improve air quality (Goal 11.6), access to inclusive and accessible green and public spaces (Goal 11.7), support economic, social and environmental links between urban and rural areas (Goal 11.a), further asks for more cities to adopt and implement policies towards inclusion, resource efficiency, mitigation and adaptation to climate change (Goal 11.b).

2.2.1. Integrated and sustainable human settlement planning - Urban planning and design

Goal 11.3 calls for integrated and sustainable human settlement planning and management, which aims at fostering Urban planning and design. Urbanization is defined as a 'multi-dimensional process that involves at least three simultaneous changes', these are land-use change, demographic change and infrastructure change. Urban systems, on the other hand, refer to two interconnected systems, the 'comprehensive collections of city elements with multiple dimensions and characteristics', and 'the global system of cities and towns' (IPCC, 2022b).

Urban developments are formed by 'economic forces, the evolution of policies, and a range of invisible forces such as land-use regulations, codes for floor space ratios and economic power structures' and seldom a result of design considerations (Lehmann, 2016). Through potentials for improvements in urban form and building design, cities can achieve sustainable solutions that would result in enabling and encouraging more sustainable lifestyles and any other social forms (Weisz and Steinberger, 2010; Grimm et al., 2008; Williams et al., 2010; WBGU, 2011; Luederitz et al., 2013).

(Bottero et al., 2019) claim that 'urban design considers the physical characteristics of the neighborhood', while the development of the territory and urban planning makes sustainable city one of the key challenges (Long et al., 2012). Even though the effects of the building sector are well known and documented, the same can be tackled in a more comprehensive manner if sustainability measures are applied and implemented on a larger scale, such as urban planning (Castanheira and Bragança, 2014). (Grove and Freytag, 2019) question the level to which the three pillars of sustainability are underscored by urban development projects. (Ingersoll, 2012) state that the

ecology has been included in theories of architectural and urban design in the last quarter of the last century as a response to negative environmental impact of architecture and urbanism.

The increasing awareness and concern about the environment as well as the rapid urbanization and high growth trends in the world's urban population, have pushed a lot of designers, academics and policymakers towards prioritizing sustainable urban living (Rapoport and Vernay, 2014). Through improvements in energy, buildings, technology, water and waste systems, as well as other social impacts, urban areas can have a leading role in the greening of the global economy (Hofmeister et al., 2014). However, when taking into consideration planning processes, construction, and usage, the urban areas are yet mostly considered unsustainable (Alberti et al., 2007; WBGU, 2011; Williams et al., 2010; Wu, 2009; Luederitz et al., 2013)

An important approach in a sustainable built environment is the scaling up, which would be achieved by not focusing just on buildings, but expanding our perspective on a larger scale, such as building complexes, districts, and cities. Therefore, go beyond the building envelope, and understand green performance on a neighborhood and city scale as well as find out how one evaluates the design approaches and outcome decisions from a super-connected environment viewpoint (WGB, 2018). Scale is one of the most important aspects of the sustainable architecture (Rama, 2017), claiming it all started with individual ideas and initiatives, however the change is shifting from 'the individual and small scale projects to the more complex scale, to include multifamily buildings, residential complexes, urban blocks and even the entire new city, that are planned and realized on the basis of sustainable principles'.

2.2.2. Cities and human settlements

Goal 11 promotes action to make cities and human settlements inclusive, safe, resilient and sustainable, that way encourages cities to take action towards a sustainable future. Cities around the globe are facing many challenges, including depletion of resources, increase of transportation needs, waste management, air and water pollution, loss of biodiversity, and other social and urban issues, such as increase of population, as well as social inequality and justice, urban planning and land use issues. Cities use approximately 70% of energy and generate about the same percentage of greenhouse gas emissions.

'Cities are open systems, continually exchanging resources, products and services, waste, people, ideas and finances with the hinterlands and broader world. Cities are complex, self-organising, adaptive and constantly evolving. Cities are embedded in broader ecological, economic, technical, institutional, legal and governance structures that enable or constrain their systemic function, which cannot be separated from wider power relations.' (IPCC, 2022b) The population in cities and urban areas is expected to increase further. It is predicted that by 2030 more than 60% of the world's population will be living in cities (UNDESA, 2018) and (Bottero et al., 2019).

A significant condition to ensuring livability of the planet for coming generations is the transition towards sustainable cities (Hofmeister et al., 2014). Transition can be in individuals, cities, regions and more, it is defined as the process of changing from one state or condition to another in a given period of time (IPCC, 2019b). This step is considered critical in shifting the current trends towards a sustainable and carbon free planet.

(Holling, 2000) and (Bakshi et al., 2014) claim that human activities have significant impacts on the environment. (IPCC, 2021) states that 'it is unequivocal that human influence has warmed the atmosphere, ocean and land' and 'cities intensify human-induced warming locally', therefore preventing human-induced global warming requires limiting CO₂ emissions to at least net zero. To address this issue cities should act in different levels and multiple directions. It has already been proven that right policies and good planning can reduce greenhouse gas emissions and promote better sustainable development (Bulkeley and Betsill, 2003; Collier and Lofstedt, 1997; Fitzgerald, 2010; Rosenzweig et al., 2011; Portney, 2013). On the other hand, according to many researchers, urban sprawl and single function zones contribute to increasing negative impacts. That being said, there are different perspectives and approaches on tackling climate change and the measures that need to be taken.

Cities' structures are complex, they consist of physical components that include buildings, roads and other infrastructure elements, and social components that include inhabitants and other social and cultural elements. As such, (Batty, 2008) suggests that cities are complex systems that mostly emerge from the bottom up. Similarly, (Stoltz, Arrias, and Lundqvist, 2015) suggest that many times cities are regarded as 'sociotechnical systems', and their interconnected complex systems of infrastructure networks, lines, power and water grids are essential components of the modern city system.

Ecocities and other similar concepts have, in the last two decades, gained global popularity. Whether in scientific literature or in the policies at different levels of cities' governance. They are seen as promoters of sustainable development in all aspects. Overall, ecocities are characterized by different features, they can be large or small towns, be considered as new developments or as part of the upgrades on an existing settlement. They could be established as bottom-up or top-down approaches.

(Joss, 2010), emphasizes the significant socio-technological innovation and policy coordination as integral part of a definition of an ecocity. He further characterizes ecocities as knowledge creation and transfer laboratories that 'develop, test and replicate' new technologies.

In conclusion, often there are questions whether an ecocity is categorized as such, due to the fact that it has been designed or because it is being governed following the sustainable development practices. As it seems, both phases play a critical role, and neither of them can be ignored or regarded as less important.

Although the smart city concept has been introduced and been around for more than two decades already, it was only about ten years ago when the scientific publications on this topic started to appear more often, according to (Dameri and Cocchia, 2013) and (Jucevicius et al., 2014) this was as a result of the launch of smart city projects supported by the European Union.

Many smart city definitions mainly focus on information and communications technology on the one hand, and smart people on the other. As such, some of them highlight the use of technologies to make 'innovative transport systems, infrastructures, logistics, and green and efficient energy systems' (Ahvenniemi et al., 2017).

Smart city approach couples with the concepts of sustainability, livability, workability and quality of life, with smart technological and information components in a very sophisticated and practical way. With utilization of information and communications technologies, smart city projects aim to monitor, run and operationalize city infrastructure and at the same time provide better services to the community. Although cities' sustainability has been discussed for many years, the introduction of the smart city concept has sparked the curiosity and interest in reaching sustainability targets using smart technologies and approaches.

Smart city framework is viewed from different aspects and claimed to have particular focus and to cover a number of elements. (Ahvenniemi et al., 2017) states that smart city framework has a clear focus on social aspects and much less on the environmental aspects. While in terms of coverage, smart city integrative framework covers 'management and organization, technology, policy context, communities, governance, economy, built infrastructure, and natural environment' (Chourabi et al., 2012) and (Maccani et al., 2013). (European Parliament, 2014) identifies information and communications technology-based smart economy, smart mobility, smart environment, smart people and smart living, as the main components of a smart city. With the help of information and communications technology a smart city collects data about itself, then it communicates and analyzes the data to understand the present and predict the forthcoming occurrences (Russo et al., 2014).

Smart neighborhoods operate on a smaller scale compared to the smart cities. They share the same holistic approach and demonstrate comprehensive concepts of the smart cities, therefore they are anticipated to scale up to cities level. (European Parliament, 2014) identifies them as entities depicted as information and communications technology-enabled econeighborhoods and carbon neutral units that have the whole infrastructure of smart economy, smart mobility, smart environment, smart people and smart living.

2.2.3. Econeighborhoods and eco/sustainable communities

In a historical correlation, it is argued that the latest initiatives on sustainable neighborhood can be linked back to the urban planning and design work from the early phase of last century. (Farr, 2008) refers to the Ebenezer Howard's Garden City Movement that strived to "develop livable and environmentally friendly neighborhoods". However, other scholars are of the opinion that sustainability as well as econeighborhood development are relatively new concepts which emerged towards the second half of the last century, compared to the neighborhood planning, as a discipline within the city and regional planning which has been applied since the early stage of last century (Sharifi, 2016).

There is a variety of terms and notions that concern the eco initiatives, and as such it is quite difficult to have a straight general definition or characterization, therefore depending on where the initiative is, how it is assessed and by whom, one can encounter various definitions for ecocities, ecodistricts, ecoquartiers, ecovillages, ecocommunities and econeighborhoods. Some terms are often used interchangeably thus creating a void in

labelling. Terms like eco-city, econeighborhood, eco-district and similar, frequently create overlapping and misunderstanding (Bottero et al., 2019; Eales et al., 2021), and sometimes related to certain contexts.

It is generally agreed that there is no clear definition of the neighborhood as a term. It is ambiguous and as such there is neither consensus on how it is spatially identified (Jenks and Dempsey, 2007) nor on its definition, although it is frequently used in literature and in everyday life (Kearns and Parkinson, 2001; Jenks and Dempsey, 2007). Therefore, depending on the location and the perspective that is being viewed from, it allows for slightly different interpretations.

With regards to the zoning and urban planning, neighborhoods are considered 'the building blocks of cities', that carry 'their own architectural, cultural and economic system' (Orova and Reith, 2013). They represent a 'good practice of architecture and urban sustainability' (Higuera Garcia and Omar, 2016).

In a way, neighborhood can work as a single standalone unit, sort of a 'mini city', however it is argued that it might be too much of a narrow concept to consider the neighborhood just as sub-division of the wider urban area (Bottero et al., 2019), as neighborhoods have much bigger role in the whole complex systems of the city, and (To, 2018) who claims that the neighborhood level enables connecting 'downwards to the communities as well as upwards to the city'. As for the populations size, (Choguill, 2008) and (Bottero et al., 2019) state that is no set recommendation or requirements in the definition of the neighborhood concerning the number of inhabitants.

(Briggs, 1997; Galster, 2001; Jenks and Dempsey, 2007) define neighborhood as a district and a community, the former as a physical construct, which would be used to describe the zone that the inhabitants are living and doing their daily activities, while the latter as a social construct, to describe the inhabitants of the zone. This is a noteworthy approach, as the definition expands from a physical/zonal and urban planning perspective to the social/community structure one.

Many studies are in line with the statements that refer to two points concerning the sustainability principles at the neighborhood level. The first one, which regards the fact that recently there is a growing focus in practicing sustainability goals through planning at the neighborhood level (Luederitz et al., 2013; Sharifi, 2016), and the second, which claims that the neighborhood is the adequate level for accomplishment of sustainability principles in urban development (Bottero et al., 2019).

Sustainable communities are known for their high motivation to preserve the environment, nature, and for adjusting their way of living to be in line with protection of the earth's ecosystems. They bond together towards social networks that promote and apply planet friendly lifestyles. These communities encourage members to be responsible on how they organize life within the community, and take action according to their common vision. Always with the goal of using resources in such a way that would be sustainable for current and future generations. Recent efforts lead towards achieving sustainability goals through planning at the community and neighborhood level. (Luederitz et al., 2013; Sharifi, 2016) argue that sustainability principles are widely used to guide neighborhood planning and development.

This highlights the important interrelations between planning of the whole city as a bigger scale and its districts and smaller components which need to be adequately addressed. This is important, since the whole system of measures and actions will only function if all levels are synchronized and well planned. Therefore, sustainability principles applied at the city scale should derive from and connect with the sustainability principles at the neighborhood/community level.

2.2.4. Ecodistricts as inclusive, resilient and sustainable human settlements

As an integral part of the city, an ecodistrict plays a crucial role in sustainable urban planning. An ecodistrict is defined as a development that is able to tackle climate change thru mitigation and adaptation, by applying sustainable planning strategies and by utilizing the most up to date products and technologies in green building, renewable energy (Fitzgerald and Lenhart, 2015) and other sustainable measures. As such, creating city units that are environmentally friendly and resilient, as well as socially inclusive. Or, as areas in cities that significantly reduce anthropogenic impacts while increasing quality of life (Bice et al. 2011; Fitzgerald and Lenhart, 2015).

From the urban design and technical standpoint, an ecodistrict concept is labeled as a diverse mix, with an increase of streets reserved for pedestrians and bikers (Bottero et al., 2019) with streetcar and light rail transportation system (Toros, 2011), which produces all its energy using onsite renewables, has a system of rainwater collection and waste recycling. It does not consider buildings as individual elements that work as standalone units, but as interconnected and well-coordinated structures capable of generating and sharing energy, water and other resources (Brickman, 2009; Toros, 2011).

The implementation of sustainable development at the city or regional level is closely related to the sustainable development in districts (Hamedani and Huber, 2012). By focusing on community collaboration and communication, as well as management an ecodistricts helps cities become more successful (Bibri, 2020). As such, an ecodistrict as a smaller scale urban unit, can aim for higher standards for implementation of sustainable development in a city.

In Europe, there are a number of cities that have successfully implemented ecodistricts, have launched projects and taken actions that showcase practical solutions and provide invaluable knowledge on multi levels of city sustainability planning.

To summarize, in this sub-section it was given a general overview of the eco initiatives, and it was concluded that there is hardly any broad definition that would fully distinguish between the concepts of ecodistricts, econeighborhoods, ecocommunities, ecovillages, and other similar ones. As most of them, depending on the circumstances, would overlap on each-others definition. Based on the reviewed literature, it is clear that it is almost impossible to put hard boundaries between the ecodistricts and econeighborhoods concepts. Thus, as widely suggested in the existing literature, the terms can be used interchangeably.

2.3. The thematic cluster grounded in SDG Framework concepts - theoretical background related to architectural approach in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

Goal 11. Make human settlements resilient and sustainable, access to adequate and affordable housing (Goal 11.1), special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons (Goal 11.2), capacity for participatory, integrated and sustainable human settlement planning and management, (Goal 11.3), reduce the environmental impact of cities and improve air quality (Goal 11.6), further asks for more cities to adopt and implement policies towards resource efficiency, mitigation and adaptation

to climate change (Goal 11.b). Achieve the sustainable management and efficient use of natural resources (Goal 12.1). Ensure healthy lives and promote well-being for all at all ages (Goal 3). Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters (Goal 13.1).

2.3.1. Architecture that fosters climate resilient and sustainable buildings

Given the provisions stipulated in many of the SDGs, architecture can lead the role to foster resilient and sustainable buildings, account for affordable housing, strengthen capacity for participatory planning, efficient use of materials, and many other actions. As stated above about the term sustainable development, in a similar way the sustainable architecture term is not universally defined either. Nevertheless, a number of different perspectives on definitions of sustainable architecture can be found in literature. Some argue that sustainable architecture is much more focused on technical aspects rather than a holistic approach that would include social, cultural, aesthetic and many others. While focusing on the environment by addressing the ways how to reduce the negative impact of the built environment is seen as a positive approach, inclusion of other aspects is strongly suggested and argued for.

Architectural sustainability challenges a variety of theoretical questions about how nature is conceived, how various competing ecological and environmental concerns are prioritized and dealt with (Vandevyvere and Heynen, 2014). Sustainable architecture is defined rather as an approach and practice and not a prescription (Guy and Farmer, 2001). (Cook and Golton, 1994) go even further to categorize it as 'essentially contestable', further (Donovan, 2020) argues that there are multiple approaches and definitions, and there is not one agreeable definition. But, as stated above some scholars are of the opinion that it is mainly influenced by energy efficiency measures while it strives to constantly improve the economic performance of buildings (Moore and Karvonen, 2008).

Sustainable architecture as well as many other similar terms (eco, green, etc), have been part of the urban literature for quite a while. The terms get used interchangeably to basically refer to the same matter. Sustainable architecture is seen as a strategy that strives to increase the quality of the built environment and the occupant wellbeing, while at the same time eliminate, or at least mitigate environmental impacts.

While the term is heavily used, it is difficult to come up with a definition. In general, the built environment and cities are major contributors to energy consumption and greenhouse gas emissions, as well as generating waste

and other negative impacts. The sustainable architecture is not only seen as problem solving tool and strategic approach to address those issues, but also as a means to increase the quality of life and wellbeing.

2.3.2. Resource efficient aligned, sustainability- and resiliency-oriented building design

Building design is quite an extensive topic, and it covers a wide range of structures as well as technical specifications. However, when discussing building design in the context of ecodistricts and sustainable buildings, it is not the intention to go into the technicality of the actual building design specification of the conventional design. By default, the focus goes to all the features and characteristics of building design that concerns the composition and creation of sustainable, human- and environmental-friendly structures. Structures that enhance wellbeing and quality of life, and at the same time consume very low energy and generate nearly zero GHG emissions. As part of the building design, building performance simulation offers designers and building owners an early stage scenario and model where projections can be generated. Thus enabling initial assessments as well as pre construction calculations of energy consumption and other important features.

According to (IPCC, 2014c), other aspects could offer solutions in providing high levels of energy services with much lower energy inputs, aspects such as inclusion of traditional lifestyles into architectural design and building practices. In addition, (IPCC, 2022a) states that to build resilience and enhance human well-being it is critical to consider 'climate change impacts and risks in the design and planning of urban and rural settlements and infrastructure'.

As building design is expected to include various solutions, the process should also account for the sustainability concepts and definition of key goals and targets (Andrade et al., 2019). This is particularly important, as usually integration of key goals and targets in the design phase helps in guiding the development process and envisioning the end phase, as well as what the building will achieve.

Building design needs to take into consideration the participation of building inhabitants, otherwise it is not fully comprehensive and cannot be sustainable in the long-term (Khatibi, 2019).

In this context, attention should be paid to technical sustainability design elements that are normally influenced by, or are, in many cases, dependent upon certain aspects, including, in particular, human behaviors in achieving their goals (Holden et al., 2015). That emphasizes the importance of integration of the occupant behavior in the

design process of sustainable buildings. Further, the role of occupant behavior expands even more when considering design ideas and solutions at the ecodistrict scale, as a much more complex process.

As noted, sustainable building design practices should promote all technical features that concern, among others, energy efficiency and renewable energy, use of local materials, integration of circular approaches, and recycling techniques. Also, social features, such as enhancing human health and wellbeing and increasing quality of life.

2.3.3. Sustainable built environment that is focused on multiple climate actions

A built environment that is focused on resource efficiency, strengthening resilience and adaptive capacity to climate-related hazards, improving air quality, taking action to combat climate change and its impacts. The built environment consists of the human-made structures and settings that offer spaces which people use for living and other daily activities (Roof and Oleru, 2008). It includes all kinds of buildings and infrastructure and all the areas surrounding them. Areas that serve for different activities that people constantly engage in.

Housing, as a big part of the built environment, is considered to have a significant role, especially in the impacts on the environment. It is suggested that sustainable housing should mainly focus on the innovative design that considers, among others, site location, land use, biodiversity, building materials and construction methods, simple and easy maintenance, and good traffic connections with other surrounding areas.

Housing settlements should be part of the 'mixed use developments', avoiding urban sprawl, also preferences for 'brownfield rather than greenfield sites' are suggested by many authors (Wheeler, 2004; Winston, 2012), similarly (Bottero et al., 2019) claims that 'the majority of existing ecodistricts are developed in brownfield areas or underdeveloped parts of the city'.

However, without doubting the fact that buildings are one of the most important components of the built environment, (Castanheira and Bragança, 2014) argue that a built environment is much more than the 'agglomeration of buildings'. They also concluded that the impacts of transportation, energy production, waste management, among others, go way beyond the realm of buildings' scope. Further, from another interesting perspective, (Moore and Karvonen, 2008) claim that the built environment embodies human intentions and understandings of the world.

2.3.4. Sustainable buildings that integrate healthy lives and promote wellbeing

When discussing the process of designing and developing ecodistricts and their urban characteristics, it is imperative to highlight the role of the whole infrastructure that is an integral part. Within this infrastructure, as it can be expected, buildings are fundamental components. As such, attention and focus are rightfully placed on how to create high quality buildings that consume low energy, have small carbon footprint, and enhance livability, quality of life and wellbeing of their inhabitants.

It is argued that focusing on just a single building's sustainability is not sufficient to achieve the general sustainability goals (Wu et al., 2018). (Castanheira and Bragança, 2014) emphasizes the importance of interaction between the buildings and their surroundings, while (Gehl, 2011; Holden et al., 2015) highlight the features of social life that happen in the spaces between buildings.

Circularity is another aspect that has recently been introduced in sustainable buildings discussion. It can be achieved through multi functional modular energy positive buildings which are made of nontoxic sustainable materials, and through increase of recycling, reusing and reproducing building materials, as well as by integrating circularity into urban developments. (Andrade et al., 2019)

Green/sustainable buildings approach has been used for decades. It is highly on the rise and the prominence will continue to expand. Green buildings are viewed as an approach to the recent demands rather than an attractive trend. Green buildings incorporate many features. They provide good comfort due to the fact that they are highly energy efficient and are free of drafts. Further, passive house design integrates highly efficient heat recovery ventilation that constantly brings fresh air indoors. Green buildings, especially passive houses require minimum energy for heating, thus making them very environmentally friendly as well as very cost efficient year round. When properly planned and designed at an early stage, green buildings construction costs should be almost similar to conventional construction. Green buildings can also be aesthetically pleasing as, if properly installed, there are no restrictions on the usage of facade elements. Some other general approaches could also include: Site location - by orienting the building to increase solar gains in winter but plan shading to avoid overheating during summer; Reusing and recycling building materials. Selecting non-toxic materials that are locally manufactured to minimize transportation and other negative impacts on the environment.

2.4. The thematic cluster grounded in SDG Framework concepts - theoretical background related to energy in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

Goal 7 asks to ensure access to affordable, reliable, sustainable and modern energy, to ensure universal access to affordable, reliable and modern energy services (Goal 7.1), substantial increase of the share of renewable energy in the global energy mix (Goal 7.2) double the global rate of improvement in energy efficiency (Goal 7.3), mitigation and adaptation to climate change, resilience to disasters (Goal 11.b), ensure sustainable consumption and production patterns (Goal 12.1), achieve the sustainable management and efficient use of natural resources (Goal 12.2), access to relevant information and awareness for sustainable development and lifestyles (Goal 12.8)

2.4.1. Energy that is affordable, reliable, sustainable and modern

According to (IEA, 2021) nearly 75% of global energy consumption and 70% of global CO₂ emissions is attributed to cities, but at the same time 'cities are also a global economic engine, responsible for 80% of global GDP', which 'represent a key opportunity to accelerate progress toward ambitious climate goals'. Therefore, it is suggested that emissions from urban buildings, materials, transport and others can be reduced significantly by 2050 if action is taken in cities.

Global energy-related carbon dioxide emissions have seen a steady increase from little over 20 Gt CO₂ in 1990 to historic high of 33.1 Gt CO₂ in 2018. With over 30% of all energy-related carbon dioxide emissions, coal-fired power generation is still the single largest emitter. The IEA assessment of the impact of fossil fuel use on global temperature increases stipulated that CO₂ emitted from coal combustion was responsible for over 30% of the

increase in global average annual surface temperatures above pre-industrial levels was, therefore categorizing coal as the single largest source of global temperature increase (IEA, 2019).

Final energy consumption (FEC) and primary energy consumption (PEC) have decreased by an average of 0.5% and 0.8%, respectively, annually since 2005. The EU is unlikely to meet its 2030 energy efficiency target of a reduction of 32.5% for both FEC and PEC at this trend. However, the European Commission has initiated changes to the Energy Efficiency Directive with more ambitious targets, thus getting closer to the overall goal of carbon neutrality by 2050.

Final energy consumption in the buildings sector is dominated by three major contributors, residential (21.2%) other industry (31.1%) and transport (25.8%) while non-residential, buildings construction industry, other construction industry, and others share the rest.

The (EEA, 2022a) indicates the trends in greenhouse gas emissions from energy use in buildings in the EU. Between 2005-2020 the annual average greenhouse gas emissions from electricity and heat used in buildings were 654,63 Mt CO₂e while emissions from fossil fuel used in buildings were 502,63 Mt CO₂e. Which includes emissions from direct use of fossil fuels in buildings, such as oil and gas for heating boilers as well as from the electricity and heat production consumed in buildings, such as use of electricity for lighting, water heaters, electrical appliances, and other.

One of many factors that have a significant impact on building energy consumption is the Urban heat island (UHI) effect. The impact is usually manifested in two ways, by decreasing space heating demand and increasing space cooling demand.

There have been many studies on the UHI effect, and one of the challenges noted by many is the difficulty of quantifying UHI-induced temperature variation and assessment of building energy consumption in relation to that. In their study, (Xiaoma et al., 2019) claim that a median energy consumption as a result of UHI is noticed, indicating an increase of 19.0% in cooling and a decrease of 18.7% in heating. Their study also shows strong intercity variations ranging from 10% to 120% increase of cooling energy consumption and from 3% to 45% a decrease of heating energy consumption. It also shows the intra-city disparities leaning towards stronger impacts in urban centers versus in urban periphery.

The UHI effect has its share in terms of greenhouse gas emissions as well. A 7% increase of the CO₂ equivalent annual emissions is reported by (Magli et al., 2015) as a result of building energy consumption impacted by the UHI effect.

Changes in the average UHI intensity are also documented in a large-scale assessment with real building energy use data that was done by (Su et al., 2021). It validates theoretical affirmation on the impact of the UHI on building energy and is in line with previous studies in major global cities. It stipulates that an increase in monthly cooling energy consumption between 0.17 kWh/m²–1.84 kWh/m² correlates to a variation of 0.5 K, however it also notes that a slight reduction in heating energy requirements is expected as a result of the UHI-related increase in temperature during the cold season. Further, (Magli et al., 2015) converted heating and cooling energy needs into primary energy, and stipulate that the annual balance is positive. The literature refers to the inherent definition of the UHI when elaborating the potential basis for the UHI's negative impact on cooling energy requirements and positive impact on heating energy requirements (Oke, 1982) in (Su et al., 2021).

It is well known that the UHI effect impacts performance of buildings during the hot summer season. This is backed up by many researchers conducted in different global regions. (Calice et al., 2017) highlight the poor performance of near-zero energy performance buildings in relation to the UHI effect. Further, the authors alert of the adverse snowball effect, as the higher the consumption is, the more the heat is released to the environment.

Although the increase in the use of more efficient and renewable energy technology in buildings along with the growing scope and stringency of building energy codes and regulations are helping decarbonization, the buildings sector requires further rapid improvements to get on track with the 2050 goals. About 30% of global final energy consumption and 27% of total energy sector emissions in 2021 are attributed to operation of buildings, which include direct emissions in buildings (8%) and indirect emissions from the production of electricity and heat used in buildings (19%). (IEA, 2022) However, according to the recent greenhouse gas (GHG) emission projections (EEA, 2022), considerable emission reductions are expected by 2030, especially for the buildings sector. Many studies identified energy aspects as a priority in developing an ecodistrict (Bottero et al., 2019).

2.4.2. Human behavioral and lifestyle as driver for sustainable development action and energy saving

In the recent literature, it is quite often noted that lifestyle, culture and behavior have a significant influence when it comes to energy consumption in buildings (IPCC, 2014c). Many studies have shown that energy performance is influenced by human behavior (Fabi et al., 2017). Occupant behavior has a significant role on energy consumption and subsequently on emissions reduction, therefore it is imperative that when planning energy efficiency measures, human behavior and lifestyle are given proper attention so the planned energy efficiency measures can be fully implemented in practice, as usually there is quite a significant difference between the planned energy consumption reduction and the actual onsite reduction. This discrepancy is quite often attributed to occupant behavior and lifestyle. It is noted that for provision of similar energy service levels in buildings, there is a difference of three to five times more in energy use (IPCC, 2014c).

(Gill et al., 2010) further illustrate this discrepancy, by showing a case of carbon emissions reduction based on sustainable design principles and renewable technologies in several housing sites. While based on calculations, these were beyond regulatory requirements and thus seen as high-performance buildings, their actual energy performance is hardly validated from design engineer or the occupants' perspective. The post-occupancy survey indicated that energy-efficiency behaviors account for, among others, 51% variance in heat consumption between similar dwellings (Gill et al., 2010). It is interesting to note that low-energy buildings tenants, despite expected to take more responsibility, often identify other actors as responsible for energy efficiency (Palm, 2011) and (Khatibi, 2019).

Energy use in buildings is connected to the occupants' behavior due to their presence and daily activities in buildings and the control actions on the indoor environment (Hoes, 2009), while for the tenants, 'residing in a purpose-built sustainable house makes performing sustainable actions easier' (Buys et al., 2005) and (Miller and Bentley, 2012).

In another case, even though tenants have clearly expressed their sustainability awareness and interest in energy use reduction, it is documented that they had not acted in an environmentally sustainable manner thus had not achieved the intended goals (Khatibi, 2019). However, in contrast, (Zou and Yang, 2014), in their study, indicated that many households had exhibited a high level of awareness and implemented some sustainable measures. Further, they identified construction costs and government incentives as two major factors in achieving energy-efficiency in residential buildings.

People are more cognizant of the massive human impacts on the environment and the need for a fundamental lifestyle change (Holling, 2000; Bakshi et al., 2014), the exposure of the human footprint on ecology is helping put the industrialized lifestyles in clear plain view (Toros, 2011). Therefore, improvement efforts should be undertaken, as behavioral change towards sustainable lifestyle is possible (Fabi et al., 2017). Therefore, the discussion leads to the importance of reconfiguring cities and districts that enable and manifest those lifestyles.

(Miller and Bentley, 2012) identified personal experiences and a strong sense of moral responsibility towards the environment, as two critical personal motivations for leading and contributing to a sustainable lifestyle. It is claimed that by living in an eco-community, a non-sustainable oriented individual changes behaviors to conform to the norms and the lifestyle of the community (Miller and Buys, 2008; Pretty, 2003; Miller and Bentley, 2012).

As a conclusion, there is ample evidence that occupant's behavior and lifestyle play a crucial role in achieving the energy efficiency goals. Often making the whole project achievements questionable and showing poor performance despite the fulfillment of all of the technical requirements. Therefore, including them as part of the project at the very beginning and taking measures to avoid any issues along the way, leads towards the assurance of the overall project success.

2.5. The thematic cluster grounded in SDG Framework concepts - theoretical background related to mobility in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 11.2 Provide access to safe, affordable, accessible and sustainable transport systems for all

Goal 9. Build resilient infrastructure

Goal 13. Take urgent action to combat climate change and its impacts

Goal 11.2 addresses mobility, it asks for access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons; develop quality, reliable, sustainable and resilient infrastructure (Goal 9.1), strengthen resilience and adaptive capacity to climate-related hazards and natural disasters (Goal 13.1). 1.1.1.

2.5.1. Mobility that expands public transport, and relies on affordable, reliable, and sustainable transport systems for all

Given the role of transportation and its linkages with other sectors, scholars warn that the SDG indicators related to transport single handedly are not sufficient to achieve sustainable cities and communities (Tan, 2018), in the same line (Vandycke and Viegas, 2022) state that although 'transport is recognized as an enabler for several SDGs', it unfortunately has not been listed as an individual goal among the 17 SDGs. Thus, as the same authors further claim, it 'became essential to define and align transport-specific policy goals with the officially designated SDGs to translate these international commitments into specific policy and investment action in transport'.

Many scholars bring their perspectives concerning the general concept of sustainable urban mobility and point out distinctive features. Targets reduction of, a various set of environmental impacts triggered by transportation sector (SMA, 2017), and greenhouse gas emissions, air pollution, and noise (Oliva et al., 2019). The overall approach and the broad concept of sustainable urban mobility is subjective (Ali, 2021) and it would account for a stretch of parameters which are inherent on custom and specific circumstances. (Escobar et al., 2021) states that its solutions would need to be in accordance with and relating to the particular city contexts, as well as heterogeneous approaches that enable engagement and participation of residents, which in turn facilitates and promotes innovative ideas and solutions.

Of the whole urban movement, public transport daily trips account for around 16% globally, more than doubled by walking and cycling which are about 37%, however yet private motorized vehicles are the highest, at about 47%. It is estimated that by 2050, the number of daily public transport trips will increase by 50%. (Turner and Ciambra, 2019)

(UITP, 2015), suggests that the percentage of the urban space serving the transport function decreases when public transport is more widely used. The study goes on to state that the increase in use of public transport would potentially provide other values, such as enabling urbanized areas to offer other functions, thus increasing quality of life, livability, as well as productivity within the urban context.

Planning, development, swift increase in application and scale, of ecofriendly and decarbonized urban mobility solutions has become an urgency. Especially now that it has unequivocally been agreed that anthropogenic greenhouse gas emissions are causing rapid changes in climate including, increase in intensity and frequency of extreme weather events and many other impacts. Impacts that many European cities have been experiencing every year, especially in the recent decade. Despite potential limitations (Gota et al., 2019) argue that deep decarbonisation of the transport sector is possible. (Tsavachidis and Petit, 2022) suggest that urban mobility solutions will have to tackle many of those challenges that residents and cities as the whole are facing, further, highlighting the interlinkages between urban and mobility planning, and the imperative of 'actively engaging with citizens at all stages of transformation processes, from design to implementation'.

Technological advancement has enabled new and innovative means of transportation. New mobility approaches that lead towards enhancement and integration of intermodal urban transport systems. Also, traditional transportation means have been challenged by penetration and application of innovative approaches of smart mobility, including car and bike sharing and many other variation (Vargas-Maldonado et al., 2022). While (Gallo and Marinelli, 2020) believe that the development of shared mobility is the future, (Holotová et al., 2023) highlight the increase in popularity of app-based as well as shared ride services, arguing that those services bring a 'level of convenience unseen before in the urban mobility systems all over the world'. Although (Fransen et al., 2023) claim that diffusion of sustainable mobility policies and strategies that aim towards healthier, more inclusive and livable cities, has gained track recently, (Cruz et al., 2023) caution that current urban policies do not adequately address impacts of emerging mobility solutions. Whilst, (Gallo and Marinelli, 2020) think that sustainable mobility policies' main focus is on environmental protection.

In addition to conferring many other health and wellbeing benefits, non-motorized transportation means, are also seen as eco-friendly mobility approaches that avoid greenhouse gas emissions and help cities and urban areas in their path to achieving climate action goals. Particularly in cases for 'urbanized spaces with their growing problems in meeting emissions limits' (Schreck, 2017). (Rui and Othengrafen, 2023) bring an interesting aspect of urban streets and their transition into places for, among other, community and cultural activities, claiming that streets serve both purposes, transportation and social.

A useful way to optimize urban mobility is dedicating the use of urban area for road users other than motorized vehicles. This leads towards reduction of negative impacts in transportation, as well as helps in transitioning of sustainable urban mobility (Fransen et al., 2023) and (Ricci et al., 2017) and improve urban livability, safety and health (Rye and Hrelja, 2020). Mobility signifies an essential aspect in all actions of ecodistricts, it enables reduction of negative effects of private cars use and it proposes streets as a sharing place for pedestrians and bikers (Bottero et al., 2019).

The high proliferation of electric vehicles will eventually decrease fossil fuel use and reduce carbon emissions, however it will inevitably increase the electricity demand. Therefore, (Payakkamas et al., 2023; Zhang and Fujimori, 2020) caution that greenhouse gas emissions in the energy production will increase if the electricity continues to be produced using fossil fuels. To avoid pollution shifting (Sovacool et al., 2018), and for the whole transitioning from fossil fuels burning cars to electric ones to make sense, we need to ensure that energy production and distribution is decarbonized, or at least operates in low-carbon (Kotilainen et al., 2019).

Ecodistricts by default discourage car use, while focusing on more community space, better air quality, lower noise level and less disturbance for residents. The quality of a street, as (ESMAP, 2014) emphasizes, is enriched by sidewalks, traffic calming measures, adequate lighting, as well as different outside activities. Car-reduced concept is widely accepted and embraced by an increasing number of people (Kunze and Philipp, 2016).

Studies show that when it comes to trip satisfaction, pedestrians and bikers are very clear in their feedback. A study by (Fordham et al., 2018) indicates that pedestrians and bikers report that their life satisfaction is affected by their commute. Further, (ESMAP, 2014) notes that good urban forms contain 'safe, connected, and continuous pedestrian network'. Therefore ensuring adequate spaces and infrastructure not only has direct impact on residents' mobility, but it also indirectly improves wellbeing and quality of life, features that many cities and urban areas lack and desperately need.

2.6. The thematic cluster grounded in SDG Framework concepts - theoretical background related to public and community spaces in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 11.7 provide universal access to safe, inclusive and accessible public spaces

Goal 4. ensure inclusive and equitable quality education and promote learning opportunities for all

Goal 9. build resilient infrastructure

Goal 11.1 ensure access for all to adequate, safe and affordable basic services; enhance inclusive capacity for participatory, integrated and sustainable human settlement planning and management (Goal 11.3); ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including appreciation of cultural diversity and of culture's contribution to sustainable development (Goal 4.7), enhance scientific research (Goal 9.5), access to relevant information and awareness for sustainable development and lifestyles (Goal 12.8), ensure responsive, inclusive, participatory and representative decision-making at all levels (Goal 16.7)

2.6.1. Public spaces - including community activities and services

Public space has been studied and explored in many ways by researchers, urban planners, landscape architects, geographers, engineers and many others. Studies emphasize the role of public space in urban life, quality of urban environment and construction of cultural identity (Costa et al., 2020), also categorizing it as is a resource that critically affects community values and positively impacts the quality of urban life (UN-Habitat, 2015). Public space provides flexibility, as such accommodating various scheduled or spontaneous activities and possesses ability to change over time to inspire new uses and vitalizing the site (Ryan, 2006). Urban public spaces achieve significant societal functions as well as form many features of cities and urban areas (Costa et al., 2020). They facilitate social interactions of people (Rezazadeh and Yazarloo, 2017), add local cultural ornaments (Muhamad and Faradisa, 2021), have the duty of accommodating all public interests (Egam et al., 2023), can establish particular forms of place identity (Choi et al., 2023), and represent a major source for social cohesion and economic development in an urban settings (UN-Habitat, 2015).

(To and Nakaseko, 2017) suggest that public space at the ecodistrict scale is intimate to the local community, which facilitates their daily social life, exchanges, and joint activities. In terms of types of activities which communities do in public spaces, (Gehl, 2011) claims that there are main types of activities and subtype ones which he refers to 'necessary, optional, and social activities'. Interactions between residents in public spaces leads to social activities through the practice of necessary and optional activities (Shtaya and Ghodieh, 2019).

Study of concepts about public spaces was focused on the spatial level (Purnomo et al., 2014). As such, (Costa et al., 2020) argue that spaces vary in terms of physical shape, character, dedicated purpose or way of use. Further, (Pratama et al., 2020) state that 'public spaces have good visual and physical access and are placed in strategic locations'. However, (Egam et al., 2023) claim that public spaces do not have any individualities or distinctive attributes. As such, the spatial and physical characters of public spaces are various and depend on many factors related to specific site as well as the context where the ecodistrict is developed.

As a conclusion of this subsection, the literature suggests that just because public space exists in a location it does not mean that the local community uses it. But, rather it suggests that public space has to be flexible and dynamic, it should respond to the community needs, be able to assemble different crowds and offer different services and gatherings for the local people to benefit from it.

2.6.2. Public spaces and their influence on livability

Public spaces at the district level have a significant role and could become a dynamic drive to enrich the livability of the neighborhood, as such they should be planned, developed and designed in an attractive and inclusive way for whole range of users (To, 2018). They represent a vital resource for livability in urban settings (UN-Habitat, 2015). The city's livability is enhanced through carefully planning and designing public places and other various basic elements and functions that are closely related to public spaces in the city.

Livability, as an assessment instrument, is used to evaluate the scale to which cities or settlements around the globe offer the level of living conditions. This evaluation, depending on the overall score of a city, may depict a range of assessment levels. It usually includes rating a number of qualitative and quantitative indicators across certain categories that are considered important. There are different tools that might have various approaches and categories, some might include education, infrastructure, safety, healthcare system, culture, environment protection, and similar.

Other features of livable neighborhoods can also include a social fabric, cultural richness, sense of place, as well as local identity (Benachio et al., 2018). Also, (To and Nakaseko, 2017) argue that initiatives for place-making that include diverse and multi-sectoral stakeholders undoubtedly improve the urban livability.

Overall, livability is interpreted as 'objective conditions' that satisfy social, economic, physical, and environmental needs, which in turn render long-term community comfort and wellbeing. (Ghasemi et al., 2018; Martino et al., 2021). While, well-being is defined by (IPCC, 2022b) as 'a state of existence that fulfills various human needs, including material living conditions and quality of life, as well as the ability to pursue one's goals, to thrive and to feel satisfied with one's life'.

At the community level, livability is viewed as an approach that has affordable and proper accommodation, supportive community characteristics and services, and suitable mobility alternatives, which jointly 'facilitate personal independence and the engagement of residents in civic and social life' (Kihl et al., 2005). In the same line, (Rama and Andoni, 2017) conclude that 'provision of quality housing with reasonable prices' for 'lower-income groups will have a big influence on their quality of life and wellbeing'.

It can be noted that livability might be viewed at different levels, such as environmental level or even personal level. Sometimes also in cross-cutting ways, where environmental and individual features overlay and depict same or similar values and outcomes.

In some cases, practical functions and amenities are regarded as an increase in quality of life. For example, reliable public transportation, infrastructure network that promotes biking and walking, health facilities in vicinity, high level of safety, shopping and recreation, and a variety of social and cultural activities.

2.6.3. Social and cultural dimensions - including appreciation of cultural diversity

Social dimension is one of the main pillars of sustainable development. As such it is of the particular importance that this dimension is integrated in all activities related to urban sustainable development as well. In general, it is agreed that there is no single definition of social sustainability and its concept, however many authors define it in a number of ways. (Balaman, 2019) defines social sustainability as 'specifying and managing impacts of systems, processes, and activities on people and social life'. While (Dempsey et al., 2011) argues that the social

sustainability concept is dynamic, and that it is in constant change. Since it is unclear how social sustainability concept relates to the other dimensions of sustainable development (Boström, 2012) and (McGuinn et al., 2020), it is called for a balance among the pillars of sustainability, so the 'social sustainability does not come at the expense of economic or ecological sustainability' (Dempsey et al., 2011).

But, at the same time (Woodcraft et al., 2011) argue that social sustainability in communities should be treated at the same significance as economic and environmental sustainability, in order to have an enduring accomplishment.

Social interaction, participation in community groups and networks, community stability, sense of place, as well as safety and security are considered quantifiable features of social life which can serve as indicators of community sustainability (Bramley et al., 2006) and (Hamiduddin, 2015). In the same spirit, (Seidman, 2013) and (Hagen et al. 2017) state that 'social cohesion within a community improves its adaptive capacities' to react against different threats, such as crime, environmental disasters and other.

During the planning phase of ecodistricts and econeighborhoods a strong engagement of civic organizations has demonstrated to be critical in creating the social bond among the communities concerned, but also in generating a variety of ideas and proposals. (Talmage et al., 2018) claims that concepts of social well-being, community satisfaction, social engagement, community involvement and quality of life, are critical factors that contribute to the development of social sustainability.

Many times, rushing to deliver large scale housing creates a gap in properly addressing social needs of new communities. This is due to the fact that, although planning is done by city government and public agencies, investment is provided by private developers (Woodcraft et al., 2011).

Therefore, similar to economic and environmental sustainability, the successful cases of social sustainability should be part of and reflected in guidelines and regulations of all disciplines and fields that contribute in planning and development of ecodistricts.

Many scholars challenge the three-pillar sustainability development framework. A lot of them offer approaches that call for inclusion of other aspects in the main pillars of sustainable development.

An increased interest is to consider cultural sustainability as a pillar of sustainable development (Sabatini, 2019) and (Astara, 2014), however (Soini and Birkland, 2014) claim that until lately, consideration of culture 'within the framework of sustainable development has remained vague'.

Social life and cultural activities indicate the way people experience development and how this reflects in their quality of life, among many other aspects (Dixon and Woodcraft, 2013). In the same line, (Hawkes, 2001) states that cultural action is crucial for the realization of successful sustainability and achievement of wellbeing. Both emphasize the importance of culture and its influence in enhancing inhabitant's quality of life and wellbeing. Whether considered as the fourth pillar of sustainability or not, there is no doubt that cultural sustainability plays a crucial role in achievement of sustainable development goals, as such it already is part of the sustainable development framework as well as of the interactions with the social, economic and environmental dimensions.

Research provides abundant evidence of participatory design as well as collaborative design, addressing their particular role and importance during the process of planning and designing ecodistricts. The participatory process is characterized in three ways. One-way communication where the project stakeholders are solely given information about the project. Two-way communication, where stakeholders are solicited their views, however not necessarily these views will be used in the decision-making, and promote knowledge sharing among stakeholders with the aim to reach a consensus on anticipated results. (Oliver, 2018)

The participatory process has a full importance only when the community is enabled to express its views on particular issues and has a direct and meaningful say on the decision-making, thus indirectly influencing the final outcomes. It is worth noting that while both, participatory design as well as collaborative design, are highly valued for their role in the process, given the scope of this thesis and the focus on the technical part of the ecodistrict, neither of them will be further elaborated in this research.

2.7. The thematic cluster grounded in SDG Framework concepts - theoretical background related to landscape and green spaces in ecodistricts

Themes grounded in and borrowed from the following SDG concepts:

Goal 11.7 provide universal access to safe, inclusive and accessible green spaces

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 6. Ensure availability and sustainable management of water and sanitation

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, halt biodiversity loss

Goal 11.7 stipulates provision of universal access to safe, inclusive and accessible, green spaces, in particular for women and children, older persons and persons with disabilities; Protect and restore water-related ecosystems (Goal 6.6), support and strengthen the participation of local communities in improving water and sanitation management (Goal 6.b); develop quality, reliable, sustainable and resilient infrastructure to human well-being (Goal 9.1); ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services (Goal 15.1), reduce the degradation of natural habitats, halt the loss of biodiversity (Goal 15.5).

2.7.1. Open and green spaces that are safe, inclusive and accessible

It is almost impossible to imagine attributing the term 'sustainable' or 'green' to a city district or another smaller scale city component without carefully considering and evaluating the open and green spaces that belong to that component. Not because of the association of the term 'green', but because of the role of those spaces in multiple aspects. Such as, the quality of life, quality of air, reduction of heat islands effect, increase of biodiversity and many other values that green spaces offer. The land area is scarce and the tendency is always to increase the built up surface versus the open spaces, however all cities that want to genuinely achieve sustainable districts, typically allocate abundant amount of green spaces.

The advantage is that green spaces are not only on the dedicated green zones, but they occupy all the areas between the buildings as well. Those often serve as green corridors that connect adjacent larger spaces within borders of an ecodistrict, and sometimes even connecting the ecodistrict to a larger green park or green fields.

Open spaces can have an impact on social qualities of a district, as they represent a valuable place where people spend time with each other as well as the natural environment near their living places (Kilnarová and Wittmann, 2017). In some cases, according to (Trojanowska, 2019) buildings are constructed in the city quarter only after a public park is situated and set up, and whenever applicable, have at least one window with a view of greenery for

each apartment. This highlights the importance of the link between the indoor and outdoor environment and the role of the greenery in the quality offered by the built environment and the overall quality of life in the ecodistrict.

2.7.2. Reliable, sustainable and resilient green infrastructure

According to (IPCC, 2022b) green infrastructure is 'strategically planned interconnected set of natural and constructed ecological systems, green spaces and other landscape features that can provide functions and services including air and water purification, temperature management, floodwater management and coastal defense often with co-benefits for human and ecological well-being'.

Although adopted by the various planning and designing disciplines at different levels, there is not a universally agreed upon definition of green infrastructure. It, for example, could be viewed as an instrument to foster sustainability in cities and its components in a cost effective manner. Providing numerous services, such as rain water collection and management, bringing greenery into urban areas, cooling temperature, increasing air quality, as well helping in diversifying and enriching local habitats and ecosystems. It directly influences inhabitants' health and wellbeing, and enables further social interactions.

Given the multitude benefits of green infrastructure, two scale-based concepts have been suggested, one being the urban and the other, landscape scale. Green infrastructure concerns linking and bolstering ecosystems and their services, such as landscape permeability improvement. By applying ecosystem-based approaches in taking flood protection measures, green infrastructure helps in reducing natural disaster risks. It also contributes to sustainable provision of ecosystem benefits and services and at the same time strengthening ecosystems resilience. (EEA, 2011). Also, as stated by (IPCC, 2019a) 'Ecosystem-based and hybrid approaches' that mix 'ecosystems and built infrastructure' are gaining popularity globally. Further, the recent (IPCC, 2022a) report claimed that application of the ecosystem-based adaptation in urban areas has increased.

Urban adaptation options can be increased through the green space, ecosystem goods and services, and the built environment nexus (Puppim de Oliveira et al., 2013). One of the options is the cooling effect that urban greening can provide, for example by using trees and other vegetation (IPCC, 2022a).

Green infrastructure ecosystem services and the other practical benefits can serve cities in their planning and coordinating of climate change adaptation, building resilience and disaster response measures. Further, incorporating green infrastructure in urban planning, elements such as trees, vegetation, green parks and corridors, woodlands, green facades and rooftops, water retention and collection can enhance city biodiversity and highly increase quality of life.

Even though there is no universally agreed definition, sources in literature provide a few concepts. (European Commission, 2013) defines green infrastructure as 'strategically planned network of high quality natural and semi-natural areas with other environmental features', with the aim to protect biodiversity and offer various ecosystem services. In the same way, (British Design Council, 2011) calls it a 'network of natural places and systems in, around and beyond urban areas'. Also, as an 'network of natural areas and open spaces that conserves natural ecosystem values' which benefits humans and wildlife (Benedict et al., 2012). (EPA, 2008) further defines it as a wet weather management approach that incorporates greenery and soils to enhance the natural hydrological infiltration and reuse.

In conclusion, the green infrastructure concept helps further understand benefits that ecosystems can offer and how to best make use of and manage those benefits. There is no shortage of advantages if green infrastructure is incorporated in the city planning. However, it is critical to strive for finding a balanced integration of green urban infrastructure elements that contribute not only to human benefits from the ecosystem, but also the one that results in an unharmed ecosystem by human activities.

2.8. Knowledge gaps

In general, knowledge gap is considered a particular area in a field or a subject, that has an unanswered question or unresolved problem, or is regarded as under-explored. Frequent types of knowledge gaps may include typical literature gap and the methodological gap, both encountered in this study. Further examining trait is their connection to the theoretical background. When analyzing the existing ecodistrict/econehborhood case studies the literature suggests that is better to focus on the role they play within the urban areas, and which characteristics

were considered more relevant when they were planned and implemented, rather than attempting to coin a definition or concept.

While there are a lot of papers and research studies that focus on social and governance aspect and mainly view ecodistricts from the social science perspective, there is a much smaller number that addresses technical aspects. That is not to say that the literature does not cover this aspect, but it simply is less present. Even those that exist in the technical arena are mainly focused only on several dimensions.

Some of the suggestions for future research from existing literature lead toward similar topic. (Luederitz et al., 2013) underline the need for examination whether additional components and principles are necessary to fully advance the ecodistricts and econeighborhoods towards sustainability. They further deliberate that the set of selected principles is as 'working list' that requires further improvement. Also, (Lang et al., 2007; Luederitz et al., 2013) suggest to consider use of a transdisciplinary examination and facilitate exchange between various disciplines and sectors when developing a principle set.

Even though there is an evolving body of literature on ecodistricts, efforts focused in understanding the design principles of ecodistricts specifically from architectural and urban planning perspective are hard to be located. Thus, further comprehensive research and comparative studies that assess the design principles in ecodistrict planning, designing and developing, are necessary. In addition, analysis of their effectiveness in achieving sustainable development goals and addressing climate change concerns.

Some studies have explored individual aspects of ecodistrict design, such as energy efficiency, mobility, green areas, environmental and social aspects. Nevertheless there is a need for a comprehensive framework that integrates multiple design elements and enhances understanding of the contextual factors or 'categories', such as: general data, urban planning, architecture, energy, mobility, public spaces/community facilities, and landscape/green spaces. Factors that influence the implementation of these design principles, how to integrate them into the broader urban fabric, and explore the urban spatial organization. Therefore, providing guidance, a range of ideas, and design principles from the real case studies that can be utilized by urban planners and designers, architects, urban practitioners, policymakers and other professionals, when developing and implementing optimize outcomes in future ecodistricts developments.

As such, first, there is a significant gap regarding the state of knowledge on which planning and design principles are relevant and their application to various sustainable urban developments, primarily ecodistricts, from the architectural and urban context and point of view. Also, how the ecodistricts should be designed, the design considerations that are required for their integration into the surrounding urban context, and their interaction with adjacent neighborhoods and urban systems. Bridging this knowledge gap is crucial to achieving overall sustainability and livability of ecodistricts.

Second, although there are many papers and studies that use SD theory and the SDGs framework as theoretical background, the literature review has not discovered any that relate the Sustainable Development Goals and targets with a comprehensive list categories and indicators that would aim at proposing a list of planning and design principles for ecodistricts.

Finally, the methodology gap, which examines the matters related to the research methodologies used in the previous studies, and benefits to use a variety of research methods. Though there are many research studies that analyze ecodistricts using qualitative or quantitative methods, none has been encountered that uses mixed methods to elaborate planning and design principles. The same can be said with regards to the data collection, there has not been identified any study that employs three techniques, mainly desk research/literature review, personal observations and survey of residents in the quest for ecodistrict planning and design principles.

3. Chapter 3 - Case studies: Analysis of selected ecodistrict sites

The three cases have been included and analyzed as part of the “Case studies” in this chapter. The outcomes and results of potential categories and indicators have been discussed in chapter 4, while the elaboration of lessons learned and the design principles for ecodistricts is performed in chapter 5.

The two-phase process provided the basis for pinpointing the study focus areas that would generate credible information on identifying the main categories and their indicators, that would potentially be used further as part of the design principles, the categories and their indicators, are listed here: General data (site condition, area, population, density); Urban planning approach (position in relation to the city, urban planning competition criteria, urban density, blocks of residential complexes, height limit for the house rows, street spaces an edge-to-edge, non-public green areas, mix use); Architectural approach (building design, individual owner buildings, group owners buildings, property developers buildings, cooperative-oriented property developers); Energy (low-energy buildings, passive house standard (15 kWh / m²a) buildings, plus-energy housing, combined heat and power (CHP), wind power); Mobility (public transportation, car-reduced concept, bike and pedestrian friendly, main access and inside roads, quiet residential streets, parking garages); Public spaces (public squares, school, kindergarten, youth and community center); Landscape (rainwater, green roofs, green spaces, other functions in green spaces, green gardening).

3.1. Case Study 1: Vauban - Freiburg

3.1.1. History

A brownfield development site on a former military base, Vauban is an ecodistrict, a world class sustainable living ecodistrict example. Located on the south side of the city of Freiburg, Vauban is only four kilometers, or approximately 20 minutes by public transportation from the city center. It is very well positioned in relation to the city and other surrounding districts. On the north side, Vauban (Figure 3.1.1) is bordered with parts of the city, on the east and west sides it touches on two neighboring districts, while on the south part it borders a relatively wide belt of open green area that leads to the nature reserve on Dorfbach and further with the wide-open greenery.

The city's urban planning ideas competition clearly indicated that the goal was to create a district where the sustainability and green approach were the way of living. Planning provisions include mix of work and living, priority for pedestrians, cyclists and public transport, ecosystem preservation, integration of the residential units with the open spaces, locally generated heat supply and low-energy residential buildings.

Looking from the perspective of eco initiatives, this was the beginning of the establishing of the Vauban ecodistrict. Though under the pressure from the organized citizens and communities, the role of the city in establishing the basis for the ecodistrict was critical. It is evident that the criteria on the urban planning competition were set by the city.



Figure 3.1.1 Vauban district (source: (City of Freiburg, 2008))

At its core development plan, the ecodistrict has put the resident's wellbeing, while at the same time protecting the environment. A family friendly neighborhood, Vauban leads the way in residents' engagement which makes an environmentally conscious living (Hofmeister et al., 2014). The ecodistrict is known for its cohesive local community with a strong local identity (Medved, 2017).

Communities were involved via workshops and other means in the planning of the green areas. Those green spaces provide fresh air to the living areas, but also serve as places where the inhabitants and children spend their leisure time and play different activities. In addition, their function is to also 'ventilate' the entire neighborhood by connecting to the wider green belt.

Its connection to the open spaces and green areas is part of careful planning, this not only visible from inside the district, but could also be observed from the nearby hills (Figure 3.1.2).



Figure 3.1.2 The view from the nearby hills (top) (source: Bardhyl Rama), and the aerial photo of Vauban district (bottom) (source: City of Freiburg, 2008).

3.1.2. Urban planning

The ecodistrict is planned based on block structure urban planning concept. The main axis is Vauban-Allee. There is an interconnection of the individual road sections with the residential streets arranged on them. A maximum of 13 m height is limited for the house rows, and for the street spaces an edge-to-edge distance of 20 m. The non-public green areas between the individual buildings span at about 20 m. In terms of the designated areas within the development plan, as expected the main part, approximately half of the area (20 hectares) is designated for residential use, while a portion (4.5 ha) is left for mixed and commercial functions and public green spaces (6 ha). On average, the floor space index is around 1.4 floors.

Experiencing the ecodistrict from the resident's perspective, gives you another insight, only then you realize that the whole district is designed around pedestrians. Starting with the walking pathways, bike lanes, easily and very convenient road crossings, then connections passageways to the green and open spaces as well as playgrounds, reflect a carefully planned and designed urban planning idea. This was possible by integrating the community at a very early stage, in fact in Vauban's case, the community is the driving force behind the idea. It should serve as a lesson learned for other ecodistricts that are in the planning and development phase.

3.1.3. Architecture

The architectural design rules and guidelines, that included specifications like exterior appearance concerning materials, colors, roof pitches, in the development plan were purposely left unspecified, this was done with the aim to allow more flexibility in solutions as well as varieties in designing the buildings of the ecodistrict. Thanks to this approach, a district with an increased lively character and diverse architectural appearance has materialized. As a contributor to this approach is the use of different individual plot sizes and shapes. The plot sizes varied from the smallest (162 m²) dedicated to individual builders, to larger ones (up to 5,400 m²) allocated to commercial investors.

The urban identification of the new district is linked to the variety of mix users in relation to the set urban density. The outcome of this variety of mix users in residential as well as commercial and public use, is an ecodistrict with a successfully implemented a wide range of architectural qualities, not only with attractive and good-looking buildings, but with a pleasing appearance of the squares and spaces between the buildings in the entire district area, Figure 3.1.3.



Figure 3.1.3 The use of different types of architectural approaches in buildings (source: Bardhyl Rama)

3.1.3.1. Typology of multifamily residential buildings

Allocating the building plots mainly to private owners has helped in achieving the goals of developing distinctive building designs and avoiding constructing monostructural and look-alike residential compounds. Private owners' projects are, individual owner buildings constructed on six- and nine-meters wide parcels, and group owners who cooperated in the development of the building from initial phase, these include four-story multi-family houses, that have two two-story housing units built on top of each other (maisonette). It is common that the upper unit is accessed via outside balcony Figure 3.1.4.



Figure 3.1.4 Group owner's four-story multi-family houses (left), access to upper unit via outside balcony (right) (source: Bardhyl Rama).

High-quality multi-story buildings are widely present. Apartment buildings, condominiums, and buildings with a mix of both condos and rented apartments are among the buildings constructed by property developers. When analyzing their outside appearance, it is noticeable that these types of buildings are characterized by a variety of shapes, colors and materials, presenting pleasing views, grand and impressive appearances, and an imposing architectural and urban design harmony in different parts of the district. Figure 3.1.5.

Another successful aspect in planning the district's buildings is their orientation, while some might be oriented differently, the majority of buildings are facing east and west, by that making good use of the sunlight throughout the day.



Figure 3.1.5 Property developers apartment buildings (source: Bardhyl Rama).

3.1.4. Energy

3.1.4.1. Energy Efficiency, Solar Installation and Wind Energy

The ecodistrict development plan incorporated all the sustainable and ecological features that were initiated and agreed upon during the collaborative process. The mandatory requirement was for construction of low-energy buildings (not more than 65 kWh / m²) in accordance with the city's standards. In addition, several buildings were constructed following the passive house standard (15 kWh / m²a). Further, a solar housing estate is among plus-energy houses, constructed on a voluntary basis, these buildings produce more energy than they consume in a one year timeframe, thus considered plus-energy houses.

The use of highly energy-efficient buildings and solar energy is a standard for many buildings of the ecodistrict. This includes the passive house and plus-energy building design (Hofmeister et al., 2014) and innovative green technologies and much more (Medved, 2017).

Passive house "Working and Living" represents the first passive apartment block in Germany. With this sustainable residential complex, it was aimed to have living and working combined under one roof. As a result of this residents lead initiative, a total of over 30 passive houses have been built.

Similarly, by combining accommodation, offices and shops in one location, the Sun Ship is a very good case of the multifunctional use concept. "Sun Ship" is the first plus-energy commercial building in the world. In addition, "Solar Settlement", a terraced house complex is the very first plus-energy housing community. (Figure 3.1.6)



Figure 3.1.6 Plus-energy residential complex (left and middle) (source: (City of Freiburg, 2008)); Solar thermal (top right) and Solar Photovoltaic (PV) (bottom right) (source: Bardhyl Rama).

Figure 3.1.7 depicts the sustainable residential complexes within the ecodistrict, the color-coded view is based on their energy efficiency standard approach, which includes passive houses, zero energy houses and plus-energy houses.

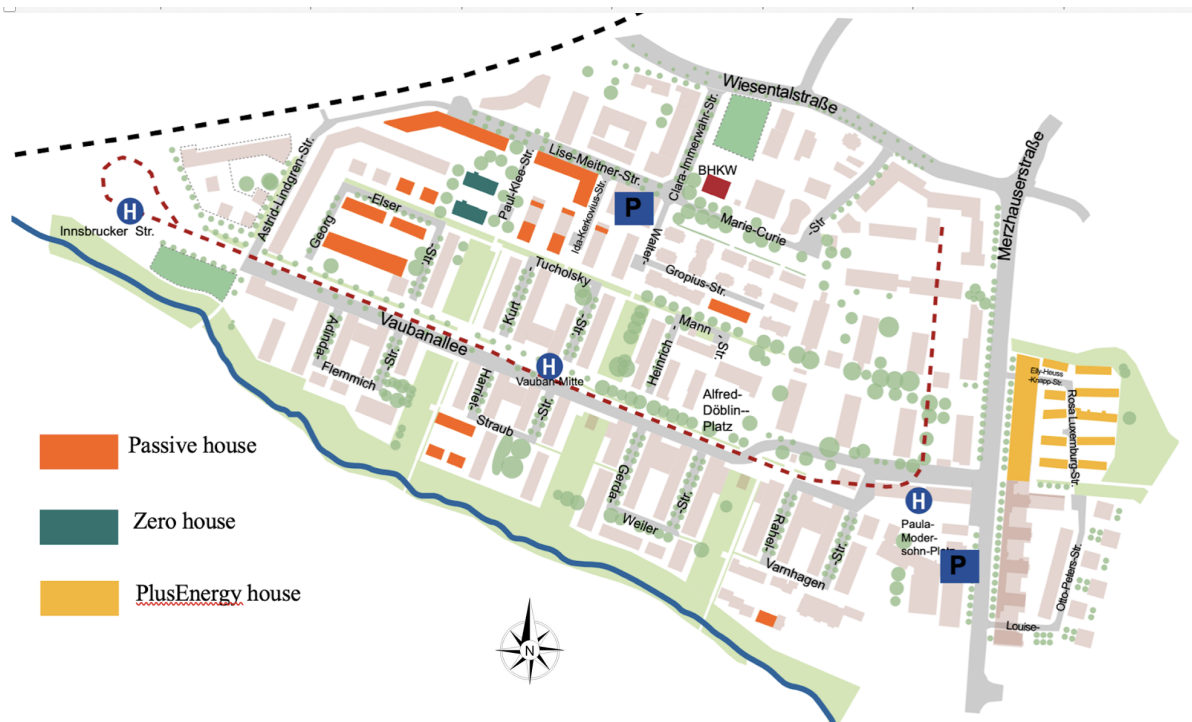


Figure 3.1.7 Sustainable residential complexes based on their energy efficiency standard approach. (source: (City of Freiburg, 2008))

This energy efficiency approach in all the ecodistrict's buildings, no matter size, height or function of the latter, has resulted in a minimum energy consumption and allowed for the renewable and eco-friendly sources to provide the clean energy to fulfill the community's needs.

Wind Energy

Six wind turbines built in a nearby mountain supply city and the Vauban district with renewable electricity.

Altogether in one year they produced over twelve thousand megawatt hours of energy or equivalent to supplying electricity to 5,400 households.

3.1.4.2. Combined Heat and Power (CHP) Plant

The biomass Combined Heat and Power (CHP) Plant (Figure 3.1.8) supplies the district with electricity and heating, it uses renewable fuels (natural gas and wood-chip) and incorporates heat pumps and a heat storage system. This covers the entire district (of around 700 households) but does not include the buildings that generate their own power.

The cogeneration power plant is one of Vauban series of applied technologies at the district scale, it uses wood chips and materials generated locally in the nearby forestry (Toros, 2011).



Figure 3.1.8 The ecodistrict biomass Combined Heat and Power (CHP) Plant (source: Bardhyl Rama)

Using CHP power and heat source has increased the sustainability level, as it completely avoids the ecodistrict's reliance on fossil fuel, thus contributing to reduction of the carbon emissions.

3.1.5. Mobility

One of the main components of an ecodistrict is for sure the mobility, and Vauban is no exception. Sustainable mobility was part of the urban planning competition requirement, it called for sustainable alternatives such as giving priority to pedestrians, cyclists and public transport, while minimizing vehicular use.

As a result of careful planning and development of the traffic network of public transportation (bus services and tram line), incorporation for the car-reduced concept as well as bike and pedestrian friendly streets, Vauban can be considered as one of the best leading examples of a sustainable transportation (Figure 3.1.9).

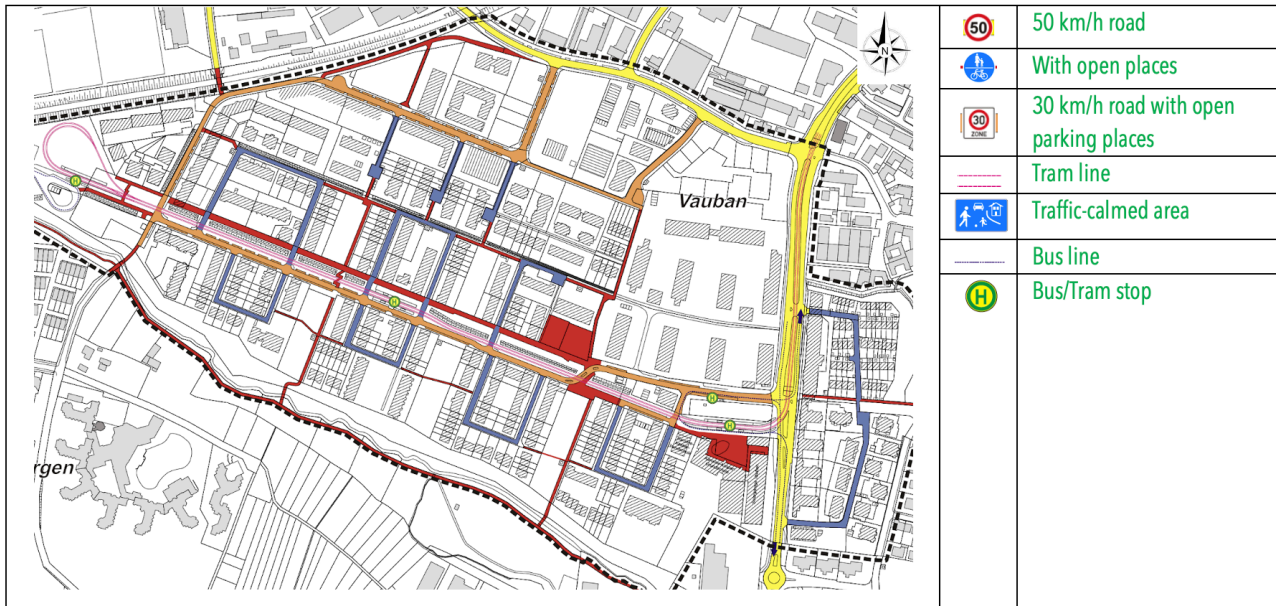


Figure 3.1.9 Schematic view of the traffic concept (source: (City of Freiburg, 2008))

3.1.5.1. Public Transportation

The public transportation plays a critical role in connecting the ecodistrict with the city. This is enabled thanks to the local bus services as well as the tram line (Figure 3.1.10) that are operational and very reliable. Positioned very close to the city, it takes less than 20 minutes for the Vauban residents to reach the city center by tram. The district commuters can access the tram and bus lines via three stops, at the beginning of the district, in the middle and at the end. Very convenient for all inhabitants to catch the public transportation within short walking distances.



Figure 3.1.10 View of the tram and bus line and the stops at different points (source: Bardhyl Rama)

3.1.5.2. Private cars

Vauban ecodistrict is well known for its innovative “car-free” zoning concept (Medved, 2017).

The district has followed a car-reduced approach. The district’s main access road, Vauban-Allee and other roads inside the district are at the reduced speed limit of 30 km/h, whereas on the other quiet residential streets the traffic is at walking speed. While there are parking spaces available along the 30km/h speed limit road, in the traffic-reduced residential roads, unless for loading and unloading, there are not parking spots available.

Guests, and inhabitants who own a vehicle, however live on car-free residential streets, can park their vehicles in one of the two district parking garages that have been constructed within the area of the district (Figure 3.1.11). (Hofmeister et al., 2014) states that numerous families do not own a car, while those who have, can park them in parking garages. Vauban has around 0.6 parking spaces per housing unit.



Figure 3.1.11 District parking garage (source: Bardhyl Rama)

Thanks to very good public transportation service, the concept of the car-reduced district (Figure 3.1.12) could be implemented.

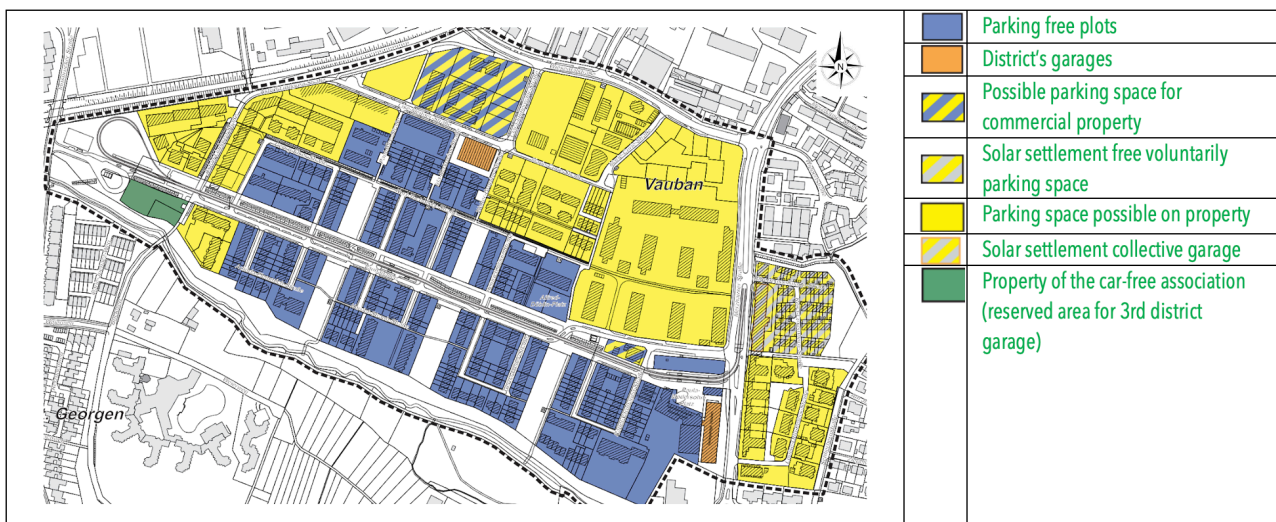


Figure 3.1.12 Schematic view of the parking concept (source: (City of Freiburg, 2008))

The whole idea of car-reduced traffic has yielded immense results in terms of space usage, residents, their families and children can easily walk along the roads throughout the district, as it can be seen on site, in some parts of the districts the speed on the roads is so low that the roads are being used by the children for their daily leisure activities.

3.1.5.3. Biking and Walking

In Vauban, many people use bikes to get around (Hofmeister et al., 2014). The city's strategy of traffic avoidance is visible in Vauban through encouragement of the use of environmentally-friendly transport systems: walking, cycling and local public transport. Majority of the ecodistrict areas are designated as pedestrian and biking friendly zones (Figure 3.1.13).



Figure 3.1.13 Majority of the ecodistrict areas are designated as pedestrian and biking friendly zones (source: Bardhyl Rama)

Bicycle parking places, traffic signs and other measures give importance and highlight this approach. Bikers and pedestrians value and make use of the broad traffic calming actions in residential roads and areas.

3.1.6. Public spaces

Vauban has two main squares, one is the "Alfred-Döblin-Platz" (Figure 3.1.14 left), which is regarded as the district's central market and community gathering area, and the other the "Paula-Modersohn-Platz" (Figure 3.1.14 right) which is located at the entry of, and is considered the public transportation hub of the district. Alfred-Döblin-Platz is as a result of the efforts of occupants in requesting changes to the initial plans, therefore the square has now become a lively community area. In this square is located the Community Center or as known as "House No. 037", which hosts many local organizations and is the social and cultural place of the district.



Figure 3.1.14 Public spaces - "Alfred-Doblin-Platz" square and "House No. 037" Community Center (left), and "Paula-Modersohn-Platz" square (right) (source: Bardhyl Rama)

When visiting the square and the community center, you can experience first-hand all the liveliness of the area, the building full of young people taking all kinds of courses, while the square is full of families mingling with their friends and relatives while children play uninterrupted. The additional value to the square is the restaurant where having a drink or a meal while enjoying the atmosphere is an experience not to be missed.

Concurrent to the construction of housing buildings and other district facilities, the development of public infrastructure flourished as well. Among others, a school, several kindergartens, a youth and community center, a market place and similar (Hofmeister et al., 2014).

3.1.7. Social and cultural interaction

Social concept recognising community needs and social engagement was part of the Vauban ecodistrict development process, it added value to design, transportation, and ecological concepts to fully complement the whole process.

Social sustainability as well as its attention to the community matters is seen as one of the main factors of ecodistrict developments (Woodcraft et al., 2011).

The use of a collaborative group-build approach to housing development and participation of local community to the shaping of the Vauban masterplan are two points that indicate the influence of communities on the ecodistrict planning (Hamiduddin and Daseking, 2014). Eco-friendly oriented and well educated, middle class people who

introduced a new way of living and gave Vauban its specific features, were essential for the success of the ecodistrict (Sperling, 2002).

A number of factors might have affected the population structure and social relations within the Vauban ecodistrict. (Hamiduddin, 2015) identifies two of them. First one, the 'self-build housing model', allowing younger families access to private finance and enabling 'wider community bonding'. While the second one, the residential design and a traffic-free streets concept that prioritizes social functions over vehicles, as well as converting car parking areas to green and recreational spaces.

Several committees were founded to carry out social work within the district, the social work includes children, youth, families target groups, grassroots engagements, and conflict management.

As for the cultural dimension, Vauban is very rich in many activities. The community center is always busy with all kinds of events, similarly the market area with outdoor activities.

The 'Baugruppen-coordination group' was formed to 'exchange knowledge, information, and social and community networks', with time it became the basis of the participation process (Ramos and Barca, 2010).

In a study, (Hagen et al. 2017) evaluated occupant's satisfaction in Vauban. They list 'quality of schools, safety, local governance, social contacts, environmental quality, and housing conditions' as dominant factors in ecodistrict satisfaction. 'Satisfaction with living in a place' is used to explain the high percentage of occupants who had lived in the ecodistrict for more than a decade. Authors go one step further, by stating that the level of occupants' satisfaction with living in Vauban is a result of 'environmentally friendly designs, maintaining social capital, and community engagement and participation'.

It can be concluded that social and cultural interaction in Vauban was part of the whole ecodistrict establishment process. This community interaction played a vital role in how the ecodistrict was shaped and still provides a valuable contribution on how it is run.

3.1.8. Landscape

3.1.8.1. Green spaces and playgrounds

Vauban's green spaces are a vital part of the ecodistrict, their role in increasing the quality of living is unquestionable. They serve as attractive places for inhabitants to spend quality time in nature. This is important in particular for the elderly people as well as children (Figure 3.1.15).

The preservation of the existing ecosystems, including old trees (Hofmeister et al., 2014) and vegetation was one of the goals and was part of the original urban planning competition.

The green concept for the district has helped provide fresh air deep into the neighborhood, the main open green spaces or known as green corridors are also supplemented by other smaller scale usable green spaces which then continue to much wider greenery area on the south.

(Hofmeister et al., 2014) emphasizes the good role that the green areas between the building blocks play in providing qualitative local climate.



Figure 3.1.15 Open green spaces (source: Bardhyl Rama)

There are numerous children's playground places (Figure 3.1.16) in the district area. Positioning them in strategic points allows for quick and easy access and makes it very convenient for kids to spend time playing and families enjoy the open air at their leisure time.



Figure 3.1.16 Open playgrounds (source: Bardhyl Rama)

3.1.8.2. Green gardening

While the traditional gardening is still in use in many places, new urban gardening has become a favourite way of green gardening for citizens and it is on the rise everywhere in the world.

Occupants get their own little gardening area that they may plan and utilize to suit their needs, they can enjoy being in nature and growing their own vegetables in the vicinity of their living place .

The ecodistrict has proudly included green gardening and successfully implemented this on site, where residents can be seen passionately working on their small gardens (Figure 3.1.17).



Figure 3.1.17 Green gardening space (source: Bardhyl Rama)

3.1.8.3. Rainwater

The eco-friendly approach to the rainwater in the ecodistrict buildings and the whole site yields a lot of benefits to the vegetation and nature. Since the district does not contain any rainwater collecting system, the rainwater is discharged into the open. The two main drainage ditches naturally drain the rainwater into the ground, thus the majority of the rainwater remains on site, reducing the heavy rain discharge on the water collecting infrastructure and refilling the groundwater table.

In many cases residents collect the rainwater in individual tanks and then use it for gardening or even for other household services.



Figure 3.1.18 Rainwater collection, infiltration area (left) (source: (City of Freiburg, 2008)); view of functioning open water collection/drainage ditch (source: Bardhyl Rama)

Table 3. Vauban ecodistrict compiled data (source: compiled by Bardhyl Rama, info from the literature research)

General data	
Site condition	Brownfield
Area	41 hectares
Population	Approx. 5,500 residents in 2,531 households
Urban planning approach	
Position in relation to the city	4 kilometers from the city center - 20 minutes by tram
Urban planning competition criteria	Set by the city
Density	Approximately 134.9 residents/hectare; 2.2 residents/apartment; 61 apartments/hectare
Floor space index	Around 1.4
Blocks of residential complexes	'Classic' closed blocks not used, dominates the linear arrangement blocks, few other forms are present, such as point blocks and one 'semi-open' block which is designed in a free (irregular) building shapes.
Building height limit	Approx. 13 m
Street spaces an edge-to-edge	20 m - distance
Non-public green areas	20 m - between the individual buildings
Mix use	Yes. Sun Ship a case of the multifunctional use concept.
Architectural approach	
Building design	Flexibility in solutions and varieties (lively character and diverse architectural appearance)
Individual owner buildings	Yes. constructed on 6 m and 9 m wide parcels
Group owners buildings	Four-story multifamily houses (two two-story housing units -maisonette)
Property developers buildings	Apartment buildings, mix of both condos and rented apartments
Cooperative-oriented property developers	SUSI
Energy	
Low-energy buildings	Mandatory requirement - construction of low-energy buildings (not more than 65 kWh / m ²) in accordance with the city's standards
Passive house standard (15 kWh / m ² a) buildings	Over 30 passive houses
Energy plus housing	Solar Settlement a terraced house complex is the very first PlusEnergy housing community
Combined Heat and Power (CHP)	The biomass (natural gas and wood-chip) CHP plant supplies the district with electricity and heating, incorporates heat pumps and a heat storage system.
Wind Power	The six wind turbines built in 2003 on Mount Rosskopt produced 12.9 million kWh in 2007, i.e. 1.29% of the city's energy needs.

Mobility	
Public transportation	Yes. Tram and bus stops within 500 meters
Car-reduced concept	The district has followed a car-reduced approach.
Bike and pedestrian friendly	Many streets and the majority of areas are designated as pedestrian and biking friendly zones. Bicycle parking places.
Main access and inside roads	Main access and inside roads speed limit is 30 km/h, parking spaces along the road
Quiet residential streets	Residential streets the traffic at walking speed, no parking spaces, only loading/ unloading
Parking garages	Two
Public spaces	
Public squares	Two main squares (House No. 037 and Alfred-Doblin-Platz)
School	One school
Daycare/Kindergarten	Several day care centers
Youth and community center	One. Existing building was converted into a community center.
Landscape	
Rainwater	Discharged into the open and naturally drains into the ground
Green roofs	Several buildings - retained green roof rainwater is collected and stored
Green spaces	Main open green spaces (green corridors), supplemented by smaller scale green spaces
Other functions in green spaces	Playgrounds, public green spaces, open space kindergarten
Green gardening	Designated location

3.1.9. Personal onsite observations and structured questionnaires with general open questions at the end

Description from the literature has its own benefits and gives a realistic perspective, however in many cases there are many details that can only be experienced by being present physically in a location and by observing all aspects and interactions that happen. In an ecodistrict, buildings are an essential component, nevertheless infrastructure, green spaces, the areas between the buildings and many others, are as much important. Therefore, being able to observe and take observational notes of how the ecodistrict life takes place, is a perspective that is not present when reviewing the literature.

Given the above, the author has dedicated some time for the personal onsite observation of Vauban ecodistrict. By doing so the author was able to experience the ecodistrict from the resident's point of view and gain hands-on insights by walking around and personally observing the site from different possible angles and standpoints. Additional data has been gathered by interacting with the residents during the site visit. As expected, structured questionnaires yielded interesting results. Outcomes from the personal onsite observation as well as from the structured questionnaires with general open questions at the end have been presented in this sub-section.

Urban planning

The Vauban site is only four kilometers away from the city center. Well positioned in relation to the city and other surrounding districts, Vauban is bordered with parts of the city on the north side, two neighboring districts on the east and west sides, while on the south side it touches a wide open green area towards the nature reserve on Dorfbach.

Vauban can best be reached via tram line, while the bike and car options are available too. As described earlier, the urban planning aspects are carefully applied, so the ecodistrict offers residents and visitors higher quality and a unique experience. The main residential complexes and higher apartment buildings are all located along or very close to the tram line, number of stories declines as the distance from the tram line gets longer, however there are some blocks that are low height but still not far from the tram line. The ecodistrict has different zones, those include residential, mixed and commercial functions, and public green spaces.

Once you start walking on the site, you end up experiencing the ecodistrict from the resident's perspective.

Pathways, bike lanes, road crossings, playgrounds, the green and open spaces as well, confirm the suggestion that the ecodistrict is designed around pedestrians.

One interesting element that might not be very noticeable by just looking at the urban plan, is the way the green corridors have been planned and implemented. It is really a great experience to 'encounter' these calming belts as you walk down or up the district. I think this is a unique feature that only Vauban has among the case studies and it might be worth considering for future planning of the ecodistricts.

The way Vauban's urban blocks are designed and implemented feels unique too. Majority of them are quite open, however even those that are a bit more closed, they all still kind of vanish in the green spaces, and when walking you do not get the feeling that you are leaving one block and entering the other.

The structured questionnaires with residents are fairly in line with the outcomes of the literature review. 83% responded 'Very satisfied', while 12% 'Satisfied', to the question 'How satisfied are you with the urban approach?', 5% did not provide any response. About 39% provided additional feedback during the general open questions at the end. Worth mentioning are, 'This is the best way the former military base location would be used' and 'Glad that the city of Freiburg has taken this very seriously and we all are satisfied with the end results'. Another one focused on green spaces stating 'Green areas are the best thing that Vauban has, you can access them very easily, in fact once you open the door and take the first step, you already are surrounded by greenery'.

Architecture

Vauban's architecture and its buildings are very diverse and colorful. That's not only noticed when walking by, but also is proudly stated by the interviewed residents. In the question 'How satisfied are you with the 'Buildings' design and appearance?', about 89% responded 'Very satisfied', while 6% responded 'Neither satisfied nor dissatisfied', and 5% did not provide any response. About 78% were 'Very satisfied' while 11% 'Satisfied' and 11% did not respond on the question 'Overall, how satisfied are you with the architectural approach?'. Additional feedback was provided by 28%, mostly emphasizing the fact that the community had a huge influence in the design of buildings, so statements like 'We as a community are proud of the result, we put a lot of effort into this and I think everyone likes it', the other one stating 'Getting community involved from the beginning guarantees good outcome, at least that's the case with Vauban'. But, also statements such as 'I really think in the case of Vauban, the city has managed to avoid having another conventional district, and instead provided a world class pioneering sample for all future similar projects'.

Energy

Vauban has a mixture of buildings that have different levels of energy efficiency. While most of them are low-energy buildings as per planning requirement, several passive house standard buildings, some are energy neutral and some other are even energy positive. Vauban's energy comes from the Combined Heat and Power (CHP) biomass Plant as well as from wind turbines, which when combined with high efficiency buildings, makes the energy one hundred percent renewable.

'Here in Vauban we have buildings with different levels of energy consumption' stated one resident, who happens to be an architect and who was involved since the beginning. 'We have around 30 passive house buildings which are known for their low energy consumption, we also have the "Sun Ship" and the "Solar Settlement" complex that are plus-energy buildings'. When talking about the community engagement, he states 'It took some time to convince all the families investing in our passive house, but once they realized the benefits, they all went for it, and we are glad we did, as the investment has already paid off'. In addition he showed the author the solar panels installed on the roof top, and claimed that the power produced during the sunny days that is fed into the grid makes those buildings energy positive.

Other residents share similar opinions, all interviewees responded 'Very satisfied' with Vauban's energy efficiency and low energy consumption buildings as well as the renewable energy sources.

Mobility

It is obvious that the Vauban's mobility planning aimed for sustainable mobility. Prioritizing pedestrians, cyclists and public transportation and discouraging use of cars is key to this sustainable approach. The ecodistrict is connected to the city by different means, but public transportation is the main one for many Vauban residents. As stated by an interviewee, 'Both tram and bus line services are very reliable and convenient. It takes me less than twenty minutes to go to city center or to return from there'. The other one emphasized the fact that the tram line connects with the main train station, thus connecting to other regional destinations in a very quick manner.

Overall, 78% responded 'Very satisfied', 17% 'Satisfied', 5% did not respond to the question on 'How satisfied are you with the Public transportation?'. Similarly, the car-reduced approach is something that residents highly value. The architect that was interviewed stated that 'The reduced speed limit for the main roads as well as the walking speed and no parking rule for lower level streets gives us families, especially children, the flexibility to enjoy the outdoors at any given time without the risk of being run over by a car'. When asked 'How satisfied are you with the 'Car-reduced concept and quiet residential roads?' 100% responded very satisfied.

Public spaces

'The house number 037 and the "Alfred-Doblin-Platz" in front of it, are our community areas. They serve us as a multipurpose area where we hold our social, cultural and many other activities' says one of the interviewees.

'Whether seasonal festivals, local market, and any outdoor gatherings or a variety of indoor activities, they all

happen here'. 'Since the beginning we knew we wanted house 037 and the area in front of it to be our community place. We achieved this and now this place flourishes with activities' says the other one. In general all interviewees expressed their satisfaction with public spaces. When asked 'How satisfied are you with the 'Public squares and other public amenities?'' 83% responded 'Very satisfied' others provided no response. The onsite observation for public spaces might not be as powerful as it could be, as visiting the squares on a 'random' day might give the impression that the outdoors place is under utilized, however based on the feedback from the residents, that is not the case. For the indoors spaces however, there are always some kind of activities going on, whether youth and children programs or resident's events upstairs, as well cafe-restaurant in the ground floor, the place looks quite busy.

Landscape

Vauban's landscape infrastructure and elements are highly appreciated and very well used by the residents and visitors. As mentioned earlier, some features are only valued once you actually experience them first hand. In the author's case, the district's green concept with the green belts placed at certain intervals in the sectional lines of the district enables a 'refreshing' mode in an emotional way as well as physically providing cooler air. Interconnected smaller green areas and pockets create an unquestionable green web in the entire ecodistrict, which when translated into the personal experience when walking around, it means high quality ambient air as well as healthy surroundings.

Residents express their satisfaction with the ecodistrict's landscape. 95% responded 'Very satisfied' and 5% 'Satisfied' in the question 'How satisfied are you with the 'Green spaces and other functions in green spaces?'. Further feedback was provided by 23%, which stated 'Green spaces are everywhere in the district', another one expressed the valuable playground areas stating 'The playgrounds are fantastic, they are not only good for children to play in daily basis, but also for parents to get involved too', however one noted a need for some refreshing, 'There are plenty of playground equipment and regularly maintained, but I would prefer to see some newer equipment in the one near my neighborhood'. Another one reminded how determined the community was in requesting that old trees and vegetation to be saved, 'We asked and the city officials listened to us, but if we needed to push more we would have done. Those trees are invaluable'.

One interesting area in Vauban's landscape is the urban gardening location which is open to all residents and it's a pleasure to see the vegetables being grown and the cooperation of residents in taking care of them.

Although interviews with any city officials or professionals are not part of the scope of this research, a very few of them have been selected to add their perspective and to provide further insights on the achieved success of the ecodistricts. In an interview with (ICLEurope, 2020), Martin Horn, the Mayor of Freiburg states that to deal with major challenges of our time including climate change, migration, education, mobility and similar, it is imperative that the change is done at the local level. The city of Freiburg, he claims, is well known as a green city, as such we continue to implement sustainability projects and to change our social behavior. Nils Sondernamm, the chief of the project of the Energy Agency in Freiburg states in an interview with (AfpaWebTv, 2014) that Freiburg has set a low-energy standard with its flagship district of Vauban, which means that only low energy consumption new buildings were allowed. He continues that, to build a sustainable city district it is much more than just thick insulation on your building envelope, solar energy and rainwater uses. An ecodistrict also includes the social component, a good transport concept, shops nearby, schools, kindergartens, care for the elderly. All of this is part of a comprehensive sustainable district.

3.2. Case Study 2: Kronsberg - Hanover

3.2.1. History

Sited in the southeast of Hanover city, and just nine kilometers from the city center, Kronsberg is a well-placed residential ecodistrict with a high potential. Its position on the hillside allows for a relaxing view of the beautiful surrounding landscape as well as Hanover city. During the sixties of last century, this greenfield and farm area was envisioned as the city's largest development site. The original plans for a large number of apartments were later reduced, allowing for a forestation of a big part of it.

The early stages of the city planning (Figure 3.2.1), identified Kronsberg as the last remaining part in Hannover area that is "suitable for a large-scale building project" (Schottkowski-Bähre, 2000).

The decision for Hanover, Germany to host the World Exhibition, EXPO 2000 sparked huge pushback from people in the city of Hanover, as they were concerned that, with so many temporary employees in the area, the rent prices would go up during the exhibition. However, to alleviate this issue the city had promised to build about 3,000 apartments in Kronsberg ecodistrict before the exhibition.

This decision resulted in transforming a greenfield and farmland into a showcase of exemplary sustainable and lively residential ecodistrict with many commercial shops, public areas, job places, green and playground areas so close to the green fields, yet very well connected to the city by public transportation.

By 2013 Kronsberg had already been hosting over 7,000 residents spread in more than 3,200 apartments (Rumming et al., 2013).



Figure 3.2.1 View of Kronsberg development concept (source: (Schotkowski-Bähre, 2000))

3.2.2. Urban planning

The urban plan for Kronsberg is in line with the regional planning principle which stipulates for the housing developments to expand along local public transport lines and be focused at urban densities in the catchment areas around stops (Fraker, 2014).

Analyzing the wider site, it is obvious that the part of the land on the east of Bremerode dedicated as Kronsberg ecodistrict development site (Figure 3.2.2) is very convenient in many urban planning aspects. First of all, the district stretches along the tram line which is several minutes walking distance from any of the residential units, another aspect, which further contributes to walkability and livability, is the fact that the district is on the edge of the farmland and wide-open landscape.

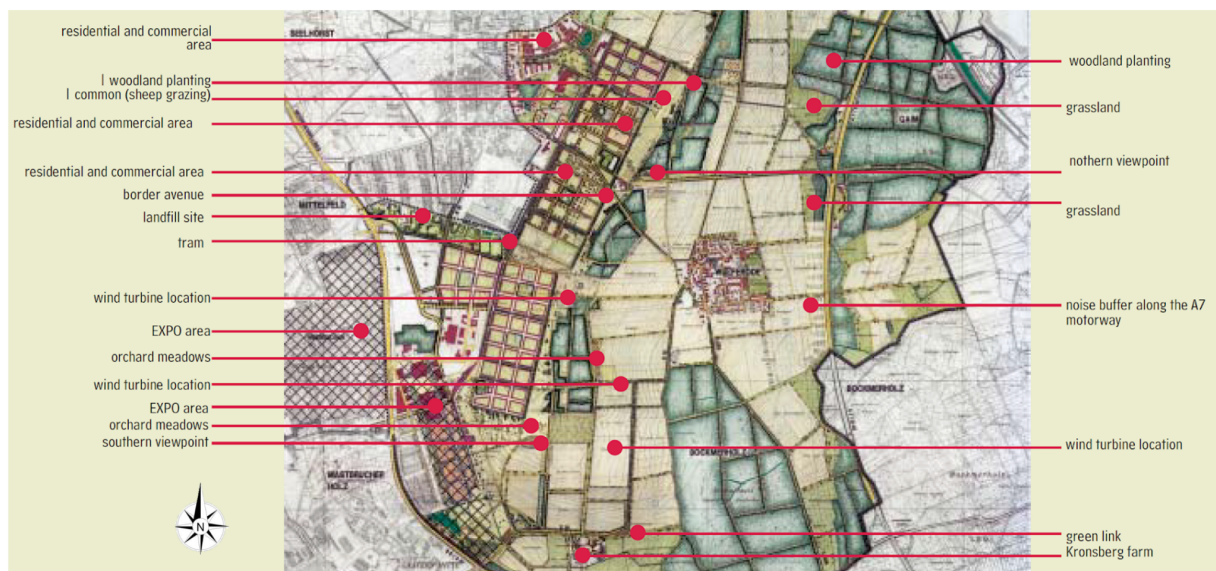


Figure 3.2.2 View of wider area surrounding Kronsberg ecodistrict (source: (Rumming et al., 2004b))

As it can be seen from the site development maps, the district is roughly three kilometers long and about half a kilometer wide, which makes it an ideal site for a grid road planning approach.

The envisioned urban appearance of the district with its well-defined contours is enabled by the grid block layout.

In terms of the height, the urban planning approach seems to follow a simple trend. Start with the highest buildings, the apartment complexes with floor space index at 1.2, in the west side of the district, then continue with gradually reducing the height towards east side, where most of the individual housing units, with floor space

index at 0.7, are placed. This technique allows for focusing a higher number of residents on the first half of the district while a lower number in the second half.

Other features in the district are the roads with over a thousand trees alongside that look like avenues and the plentiful open spaces, inside courtyards as well as the open public spaces.

At the current stage Kronsberg North and Middle have been entirely developed and in full use, however Kronsberg South, which faces the Hannover Messe (EXPO-Plaza), is now under the development phase. This indicates that the area was well planned for future expansion, which should be the case for all future ecodistricts.

3.2.3. Architecture

As already mentioned above under the urban planning section and shown in Kronsberg general plan (Figure 3.2.3), the density and the building height is developed roughly in a linear line, from downhill to uphill. Starting with the high-density housing blocks at the lowest point, then the three-story detached houses in the middle and ending with the single-family houses at the highest point.

This approach in many ways shows how careful consideration of details in the planning phase, enables achievement of a high-quality space and better value of living.

In terms of architectural approach, the city set certain parameters of possible architectural forms with the aim on a high density and space-saving. The highest density is along the west perimeter of the district, parallel to the tram line. Buildings with the four and five floors that are built in a strict linear distance from the main street shape the high and dense edge of the district townscape.

According to (Schottkowski-Bähre, 2000), the residential building stock in the district is quite various, however in general about ten percent is comprised of single-family houses while the rest, ninety percent is multi-storey apartments buildings.

Diverse architectural proposals and solutions were initiated and realized by over forty architectural and landscape design offices. The variety of styles, forms and approaches is quite visible, starting with the apartment buildings largely comprised as block structures facing the streets in one side and the inner courtyards on the other, then with

several rows and pavilion arrangements and generally oriented on the west and east sides, while the single-family and terrace houses shaped in a variety of layouts and orientation.

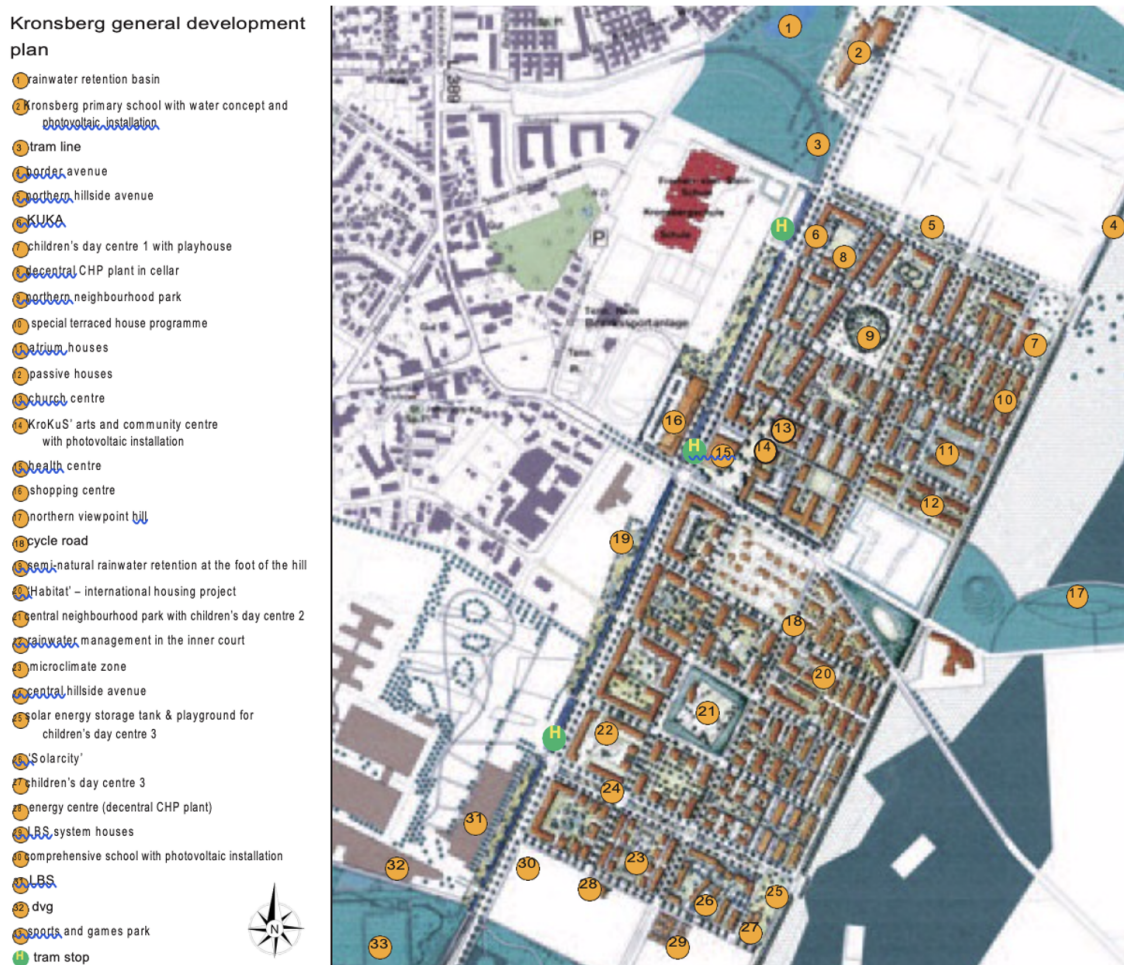


Figure 3.2.3 Kronsberg general development plan (source: (Rumming et al., 2004a))

3.2.3.1. Typology of multifamily residential buildings

There is a variety of colors and textures and architectural forms used in the residential buildings throughout the ecodistrict. The variations (Figure 3.2.4) are so many that it would take quite long to analyze all in detail, therefore while it was attempted to mention all groups of buildings, only a few cases were further explored.

It is important to state that introducing the concept of free and unrestricted style has produced a myriad of very interesting, colorful non-monotonous structures with high architectural values that has made a huge impact on the living experiences for the residents.



Figure 3.2.4 Different building styles, facades, textures and colors (source: Bardhyl Rama)

In addition to the public, commercial and other buildings, the district has a wide range of categories of residential buildings, it contains among others, the residential complexes, apartment blocks rows, smaller residential buildings, as well as numerous types of terraced buildings and several detached buildings.

Residential complexes, generally four-to five story buildings are conventional massive constructions, insulated and in variation of brick or rendering facades. With one set of windows on the street side and the other on the courtyard. Some with concrete while others with steel balconies.

Their floor plan offers maximum flexibility. Organized in different layouts, including some with two apartments and others with three apartments on each landing, with a variety of number of rooms per apartment from two to five rooms. (Figure 3.2.5)



Figure 3.2.5 Residential complexes (source: Bardhyl Rama)

Apartment blocks rows, include the ones covered in red brick, but also those that have front and back covered in white rendering. The distanced penthouses with single-pitch roofs and rooftop terraces are characteristics of all apartment blocks. (Figure 3.2.6)

Their floor plans vary from one to five-room apartments with two to three apartments on each landing.



Figure 3.2.6 Apartment blocks – view of a sample façade (source: Bardhyl Rama)

Solarcity (Figure 3.2.7), as determined by its name, is characterized by a large number of solar panels on the building roofs. The block comprises buildings of two to four floors, with mainly two to three apartments per landing, including maisonettes. Parts of the façade are prefabricated concrete sandwich elements, the others have white rendering, the non-solar parts of the roofs are green.



Figure 3.2.7 View of Solarcity building (source: Bardhyl Rama (left), (Rumming et al., 2004b) (right))

Terraced houses include several types of construction. The masonry and wood ones, have prefabricated walls, ceilings and roof structures to lower the construction costs. Other types include, terraced houses in wood panels, those with staggered one-pitch roofs, with long balconies and with extension options.

Lummerlund passive house settlement, is much more aspiring compare to the 'Kronsberg Standards', its goal is to set new energy and cost-saving standards (Rumming et al., 2004b).

The site has four rows of eight terraced houses each, all buildings have green roofs and are covered with vertical wooden sidings on the upper floor. The heating demand is fifteen kilowatt-hour per square meter annually. (Figure 3.2.8)



Figure 3.2.8 View of Passive house settlement (source: Bardhyl Rama)

3.2.4. Energy

Kronsberg district was one of the early examples of how energy efficiency and low energy consumption can be achieved and the energy use can be based mainly on renewable energy means.

The district is known as the first residential development in Germany that was based on low-energy principles.

The combination of the highly energy efficient buildings which minimize the energy use altogether in the one hand and the focus on the renewable means of energy production such as: combined heat and power plants, the solar array installation with seasonal water storage tank, photovoltaic installation, as well as wind power turbines summarizes an exemplary case of how the current energy systems should be arranged in residential complexes but also on all other parts of the city.

Apparently, the ecodistrict's energy model was in line with energy policy set by the city at the time of Kronsberg construction. The policy calls for prioritizing the energy efficiency, use of combined heat and power systems as the primary energy source, and of course use other sources of renewable energy.

One of the key features in the design of Kronsberg was the successful incorporation of the energy infrastructure and energy efficiency measures as main part of the urban design of the district (Coates, 2013). This concept resulted in the fact that overall the district would generate more power than its actual needs, therefore feeding the excess electricity back to the power grid.

3.2.4.1. Energy Efficiency, Solar Installation and Wind Energy

The district energy efficiency concept (Figure 3.2.9) was given high priority when planning and designing Kronsberg. The city's stringent rules about the low energy housing applied to all developers, including individual house owners.

The maximum heating-energy requirement of 55 kilowatt hours per square meters per year was the set standard for all buildings (Rumming et al., 2013).

As it seems this has paid off and given tremendous results. The district infrastructure has stood up to this challenge and has met all the requirements. This was achieved thanks to the good engineering work oversight and management as well as the pre-occupancy tests that verified the goals.

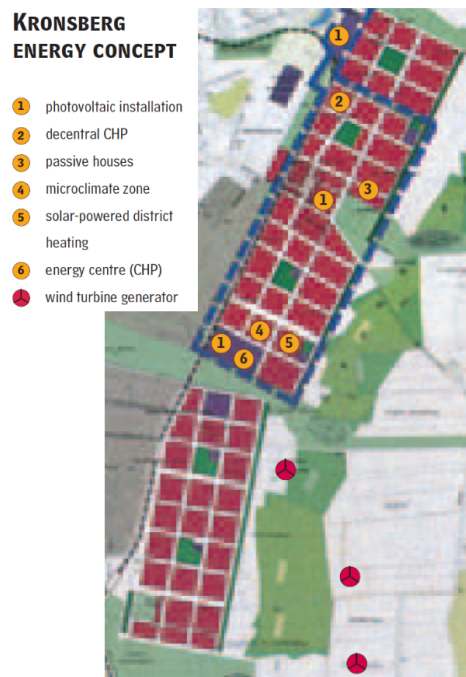


Figure 3.2.9 Kronsberg energy concept (source: (Rumming et al., 2004a))

Passive house standard, although not a direct requirement, was successfully implemented in a small part of the district. The “Lummerland” passive house block has just over thirty terraced houses.

According to (Rumming et al., 2004a) the three year survey showed that these housing units were even lower than the 15 kilowatt-hour per square meter heating energy consumption.

Solar energy

As part of the ecodistrict’s mission to demonstrate alternative highly efficient means of energy accumulation, the solar building complex, which was erected in the south-eastern part of the district, showcases the ability of the residential complexes to accommodate combined heating models that include solar collectors and large seasonal underground storage tank.

The model is quite straight forward and not complicated (Figure 3.2.10). The excessive summer solar energy captured in the solar collectors is stored in a very well insulated storage tank, and then gradually used throughout the year (Rumming et al., 2004a).

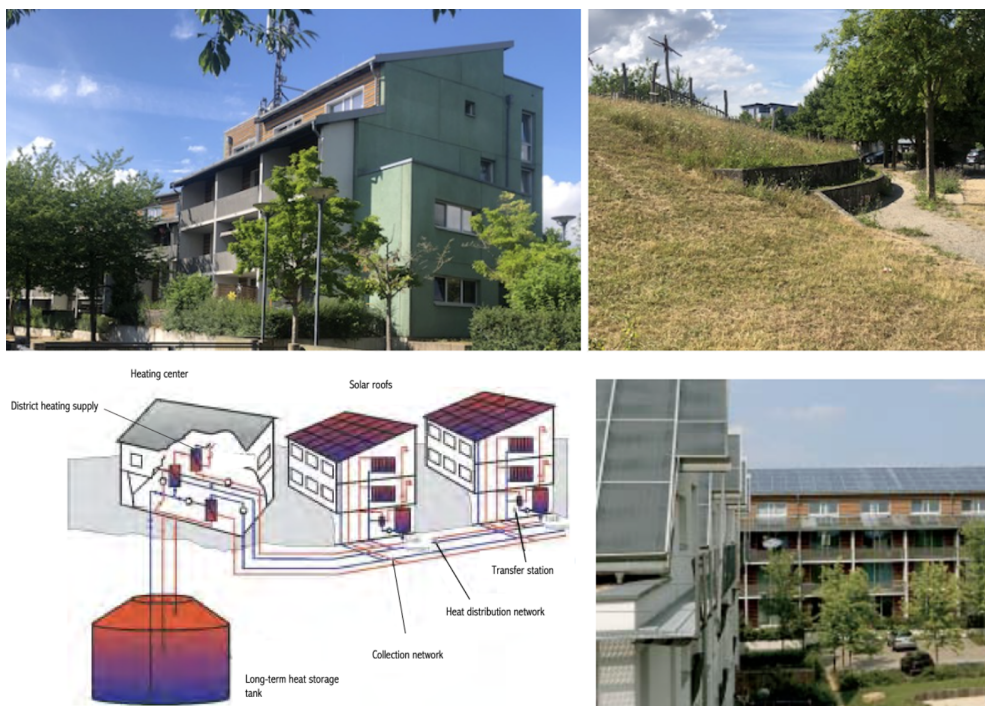


Figure 3.2.10 Solar thermal collectors (left) (source: Bardhyl Rama (top), (Rumming et al., 2004b) (bottom right); Schematic view of the system (bottom left) (source: (Schottkowski-Bähre, 2000))

This energy model in Kronsberg includes over a hundred apartments that are provided heat via solar collector panels, overall it covers almost half of the total heating demand for those apartments. This is another characteristic of all the energy efficiency and renewable energy measures that the district was set up with. It shows that a combination of several measures allows for a proper distribution of the energy load at different times and seasons.

Similar to the solar collector panel installation, however in much smaller scale is the installation of the photovoltaic energy (PV) panels. Several public buildings have photovoltaic panels installed on their roofs (Figure 3.2.11). The power generated by the PV panels is supplied into the district's electricity grid.



Figure 3.2.11 Photovoltaic installation at KroKuS (source: Bardhyl Rama (left), (Rumming et al., 2004b) (right))

Wind Energy

With its three large-scale wind turbines installed in the vicinity of the district, which constitute main electricity source, Kronsberg is proud of its renewable energy production. The wind energy production generates about half of the district's energy needs.

The wind energy production began at early stages, the first turbine was active in spring while the second in summer of 2000 (Rumming et al., 2004a). A social aspect concerning the wind turbines is the observing platform at the height of 60 meters, which offers an interesting view of the surrounding landscape and the city, and is open to the public.

3.2.4.2. Combined Heat and Power (CHP) Plants

Two decentralized natural gas-powered combined heat and power (CHP) stations (Figure 3.2.12), that in addition to the electricity production, provide the energy for district heating. The district heating grid enables distribution of the space heating and hot water to individual units. The CHPs provide approximately half of the electricity needs of the district.

Running on an on-demand basis, the two CHP plants provide the additional needed electricity, however allowing for the excess electricity to be fed back into the grid. (Rumming et al., 2013)

This approach ensures that the grid stays at the stable condition, avoiding the high peaks and grid overloads, which is usually the case with the traditional communities.



Figure 3.2.12 The Combined Heat and Power (CHP) Plants – standalone structure (left), included in apartment building basement (right) (source: Bardhyl Rama)

3.2.5. Mobility

Given the ambitious environmental goals with the development of Kronsberg, the achievement of sustainable and eco-friendly transport was one of its vital components on the entire planning of the ecodistrict and its traffic concept.

The results, an ecodistrict with a well established public transportation service with direct connection to the city center, pedestrian and bikers friendly streets and pathways as well as minimized and discouraged vehicular traffic, this is an exquisite example of how the ecodistrict should plan and implement mobility.

3.2.5.1. Public Transportation

The direct tram line from the district to the city center provides a very comfortable ride and the journey takes less than 20 minutes, giving Kronsberg a very convenient connection and fast access to the city center. The three tram stops are distributed in the strategic locations within the district, so it would be about half a kilometer from any of the residential units to one of the tram stops.

The main tram stop (Figure 3.2.13) is very close by the public infrastructure and the main square, thus increasing the value of the public spaces via the high amount of pedestrian traffic in the area. In addition, grocery stores and other nearby shops give even more popularity to this spot.



Figure 3.2.13 View of one of the main Kronsberg tram stop (source: Bardhyl Rama)

In addition to the tram line, the further cross connecting routes in the district are covered by a bus line (Rumming et al., 2004a).

Overall, with the tram line service at every 10 minutes intervals and the bus line at the similar level, Kronsberg district commuters enjoy an excellent public transportation service.

3.2.5.2. Private cars

In addition to the excellent public transportation, careful planning at the early stage of design was dedicated to vehicle traffic. By focusing the main vehicular traffic on the perimeter of the district and not allowing high traffic within the district, many goals are achieved, freeing community space, cleaner air, less noise and overall minimum disturbance for the communities. To further maximize the space use for leisure and other community activities, the residential blocks do not have any routes.

As this is a community-oriented district, with focus on the pedestrians and biker's easy access and user-friendly roads, the traffic-calming and other free access measures were implemented.

It is obvious that the application of numerous speed impeding barriers in road lanes, the right-before-left turning priorities and above all, the 30 km/h speed limit signs, are good samples of the successful traffic slowing techniques used in Kronsberg.

Generally as a rule, the provision of car parking spaces (Figure 3.2.14) is organized in small clusters, at the ground level, underground garages, along a number of roads or even at the hillside and covered by trees to minimize appearance. Kronsberg has around 0.5 to 0.7 parking spaces per housing unit.

Approximately 30% of cars are placed in underground parking (Rumming et al., 2004a).



Figure 3.2.14 Private parking spaces along the road (source: Bardhyl Rama)

3.2.5.3. Biking and Walking

The urban design elements and road traffic arrangements have been done in such a way that they promote biking and walking throughout the whole ecodistrict. From the planning of the access to the residential blocks and the commute within blocks, it can be seen that the pedestrian movement is at the core of the district's mobility plan. Bike lanes (Figure 3.2.15) allow for smooth and safe biking. The main and the longest bike lane is on the west side of the district, it runs in parallel with the tram line. While most of the roads that run across the district, from west to east, also have the designated bike lanes on both sides, this is not true for the inner roads that run along the district, from north to south, however they allow biking on the road.

In addition to the inner district biking lanes and walking pathways, there is a wide array of streets and pathways in the nearby farmland.



Figure 3.2.15 View of the main bike lanes (source: Bardhyl Rama)

3.2.6. Public spaces

There are several places in the district that serve as public spaces, such as the district square (Figure 3.2.16), parks on the north and middle parts of the ecodistrict and other smaller spaces, however the main one is the so-called central district square 'Thie', it is located in the corner facing Bemerode and Kronsberg-Mitte and is very close to the tram stop.



Figure 3.2.16 Plan view of the district public areas (source: (Rumming et al., 2004a))

The 'Thie' (main public square, Figure 3.2.17) includes a community center which hosts art and youth and many other activities, in addition there is a shopping mall, a health care, mixed use buildings in the vicinity that host a number of shops that help creating a very busy and lively square. The central position of this square has many benefits, among others it is equally reachable to all residents of the districts, it encourages people to gather in the area due to the proximity of many shops so residents can always combine trips to different functions and services as well as walking thru when commuting by tram in and out of the district.



Figure 3.2.17 Public areas - central district square 'Thie' (source: Bardhyl Rama)

In addition, there are many indoor spaces in the apartment buildings that have been dedicated to the community to be used for different activities (Schotchkowski-Bähre, 2000).

3.2.7. Social and cultural interaction

Making social infrastructure as part of the Kronsberg housing development was a key principle for the City of Hannover. One of the focal places that keeps the ecodistrict's social and cultural spirit alive is the social and cultural center 'KroKuS'. A meeting and gathering location and a central event center for the community and all generations, for families, seniors, youth and children. It includes a library, cultural, social and children and youth activities as well as spaces for conferences, different parties, and club gatherings.

Soon it was realized that KroKuS and other Kronsberg's social and cultural infrastructure serve not only the ecodistrict's residents, but it expands by far to the whole city. A common place where people of all ages, social and nationality backgrounds get together. The center is also recognized as a regional and national conferencing venue (City of Hanover, 2013).

As noted by (City of Hanover, 2020), residents are interested in social engagement in their surrounding living environment and are keen on involving in cases where an impact on their life situation is expected. This of course requires suitable and functional spaces, which enable various social and cultural events. Fifteen community areas are made available to residents in different locations of the ecodistrict for community activities and engagement. Those areas promote the social and cultural dimensions and overall a strong sustainable community spirit.

All social and cultural activities in addition to engaging the local community, they also promote inclusivity through education, advising, music and dancing, theater, painting and many other courses. Including disabled children and young people, disadvantaged communities and refugees.

The local library offers thousands of media, such as novels, magazines and daily newspapers, non-fictional books, audio books, various games and many others. Cultural activities include concerts by Kronsberg Choirs that for over twenty years have entertained the community.

Kronsberg is rich in outdoor social and cultural activities, where the community is very active in many various events. One of the best cases is the 'Autumn festival' that gathers large crowds not only from the ecodistrict, but from the entire city.

3.2.8. Landscape

The current Kronsberg site used to be an agricultural land before it was developed as a residential ecodistrict, therefore the connection with the surrounding landscape had to be kept alive. This not only has respected the surrounding area but it was also reflected in the approach taken designing the inner parts of the district. Plenty of green, that's the motto, with this concept the public and private green spaces are spread all over the district and designed and implemented in all kinds of ways, grassy areas in the courtyards, bushes, trees and many variations.

While the local community can enjoy and use the green spaces that are in many other 'communal' areas, the two public green parks, the northern and central ones are the main spaces in the ecodistrict that are positioned to be equally reachable by the residents in the nearby residential complexes. Both offer a variety of spaces for different leisure and recreational activities. Their designs are unique and appalling, as (Rumming et al., 2004a) point out, the designs of these two parks represent striking and unmistakable appearance.

Semi-public and private green spaces are found everywhere as well, by using pedestrian walkways and other forms, there is a seamless connection between the two in such a way that it is hard to notice where one ends and the other begins. The district green corridors play an important role in making a valuable connection with the surrounding green areas as well as transitioning from one space to the other within the district. To add even more value to this, the perimeter alleys with trees serve as both physical division between the district and the grassland but at the same time as the 'gate' to the greenery.

The soil management during the construction phase was carefully planned in such a way that the transportation cost and carbon emissions for soil removal were avoided, but at the same time the excess soil was used for creation of various landscape design elements.

The soil that was dug out from the construction sites was collected and used to create an elevated hill that serves as a point where people can view the city and the surrounding landscape (Rumming et al., 2004b). Several site elements such as perimeter avenue (Figure 3.2.18), the viewpoint hill and similar, are models of creative landscape design on the urban verges (Schotchkowski-Bähre, 2000).



Figure 3.2.18 Perimeter green avenue (source: Bardhyl Rama)

3.2.8.1. Green spaces and playgrounds

A lot of green spaces as well as playgrounds (Figure 3.2.19) have been allocated throughout the ecodistrict. Many of the children playgrounds are either within the apartment blocks courtyards or in a very close proximity to them. This makes it very convenient for parents to spend their free time and leisure activities while their children play in nearby areas moving within different courtyards and enjoying the diverse playing areas.



Figure 3.2.19 Various playgrounds (source: Bardhyl Rama)

The open spaces, playgrounds, green parks and other recreational areas are linked by the pedestrian pathways, which constitute a network of various landscapes for the residents to experience on a daily basis.

The perimeter tree avenues provide additional play and leisure spaces, casual walking while experiencing the view of the grassland as well as hiking path to the viewpoint (Figure 3.2.20).



Figure 3.2.20 Hiking path to the northern viewpoint (source: Bardhyl Rama)

3.2.8.2. Green gardening

While other housing developments initiate and promote green gardening within their communities, Kronsberg was fortunate enough to have an organic farm (Figure 3.2.21) within a very short and convenient walking distance. This farm offered the Kronsberg residents fresh locally produced organic food in a very sustainable way. This way the residents would be able not only to visit the farm, but also attend the organized workshops and learn first-hand all the magic as well as the challenges of producing organic food.



Figure 3.2.21 View of Kronsberg farm (source: (Schotchkowski-Bähre, 2000))

3.2.8.3. Rainwater

Conventional settlements usually have their buildings and paved areas drain the rainwater into the collection system, however this causes shortages in groundwater and prevents the water table to naturally refill, knowing that drinking water is getting scarce in many places this is a real concern, in addition during the storm seasons the excess water from the roofs and paved areas causes major problems by clogging up the water collection systems and flooding parts of or entire cities. Therefore, many cities are looking at creative ways to address those two important issues.

The simplified description would be summarized as, the rainwater from buildings roofs and terraces as well as ground surface pavements is collected and gradually drained and discharged in open ponds or waterways in the green areas (Figure 3.2.22).



Figure 3.2.22 Rainwater collection area (source: Bardhyl Rama)

Table 4. Kronsberg ecodistrict compiled data (source: compiled by Bardhyl Rama, info from the literature research)

General data	
Site condition	Greenfield
Area	70 hectares
Population	7,150 residents, over 3,200 apartments

Urban planning approach	
Position in relation to the city	9 kilometers from the city center - 20 minutes by tram
Urban planning competition criteria	Set by the city
Density	102 residents/hectare; 2.2 residents/apartment; 45 apartments/hectare. Medium to high density
Floor space index	1.2 floors (0.7 for individual buildings)
Blocks of residential complexes	Several 'semi-open' blocks, 'classic' closed blocks not used, many linear arrangement blocks, few other forms such as point blocks are present as well
Building height limit	Not specified (highest approx 15 m)
Street spaces an edge-to-edge	25 m (main green corridor 40 m)
Non-public green areas	Various (50 m for large ones, 22-25 m smaller ones)
Mix use	Mixed-use blocks up to five stories high
Architectural approach	
Building design	Architecturally varied townscape - different colors and textures
Individual owner buildings	Planned and constructed uphill (10% of dwellings)
Group owners buildings	Buildings of two to four floors - including maisonettes - mainly placed in the middle of the district
Property developers buildings	4-5 floor residential complexes - generally allocated at the lowest ground
Cooperative-oriented property developers	N/a
Energy	
Low-energy buildings	All residential buildings in the Kronsberg district were built as Low Energy Houses. Each building requires a proven maximum heating energy of 55 kWh per m ² per year
Passive house standard (15 kWh / m ² a) buildings	Lummerlund consists of 32 terraced family houses
Energy plus housing	105 apartment units in the Solarcity complex are heated from about 1,350 m ² of thermal solar collector panels
Combined Heat and Power (CHP)	Two natural gas-powered CHP units provide district heating as well as electricity to the entire community
Wind Power	Three large wind generators (3.58 MW), which provide a significant portion of the electrical power needs of the community
Mobility	
Public transportation	Hanover city center by tram line (less than a 20-min ride). Furthest residential unit within 600 meters to one of the three tram stops
Car-reduced concept	The roads in the district are traffic calmed - discourage car use
Bike and pedestrian friendly	Traffic calmed roads encourage walking and biking - a well-shaded pedestrian and bicycle lane runs through on the north-south axis -network of off-street pedestrian paths connects the open playgrounds and parks of the green interior courts with the gridded streets, offering residents richly varied paths for walking

Main access and inside roads	Inner roads speed limit is 30 km/h, parking spaces along the road
Quiet residential streets	Through traffic on the urban blocks not allowed
Parking garages	On the building basements (no designated garage building), open space parking as well
Public spaces	
Public squares	One public square ('Thie') and two neighborhood parks
School	One school
Daycare/Kindergarten	Several daycare centers
Youth and community center	One designated building.
Landscape	
Rainwater	Rigorous standards for on-site rainwater retention - the community's open spaces maximize on-site water collection
Green roofs	Several buildings
Green spaces	The ecodistrict includes a large amount of open space as well as a variety of intensively used green spaces.
Other functions in green spaces	A number of playgrounds are located close to the apartments throughout the district in each neighborhood
Green gardening	Nearby Kronsberg organic farm and rural workshops

3.2.9. Personal onsite observations and structured questionnaires with general open questions at the end

As with the previous case study, the personal onsite observation of Kronsberg ecodistrict and the additional data gathered from the questionnaires with the residents has complemented the literature review and desk research.

Urban planning

As noted earlier, the site is only about nine kilometers from the city center. It can be easily reached by bike, car and especially via tram line. When reaching from the city center via tram line, the site does not feel far away at all. The infrastructure, the buildings arrangement, traffic, public spaces, green areas, as well as other social and cultural dimensions have all been given adequate attention. Once you reach the main square, at first it's the impression that the district is very densely populated, however after walking towards the remote areas you realize that everything has been carefully planned so the population density is balanced. The residential complexes and higher apartment buildings are all located at the lower part of the ecodistrict, while as you go uphill the number of stories

declines to three stories, and further at the higher part goes down to one and two story buildings. The semi-open blocks create some private spaces for block residents, in some cases even 'Private area' signs have been posted. The linear arrangement blocks and point blocks are more open to the public and people can walk through. Mixed-use has been applied in many blocks, with the higher concentration near the main square.

In a similar way, the structured questionnaires with residents confirm the outcomes of the literature review. In response to the question 'How satisfied are you with the urban approach?', 88% responded 'Very satisfied', while 6% 'Satisfied', 6% did not respond. The additional comments from general open questions at the end provided valuable feedback from the responders. About 31% stated that the current urban solution was very adequate for the site, 63% did not provide any additional comments, however about 6% think that other solutions and block arrangements might have been better.

Architecture

The ecodistrict consists of buildings of different sizes, shapes, forms, materials, colors and facades. This variety of styles, designs and construction materials that are applied offers the residents and visitors a pleasant feeling and makes walking around the district much more enjoyable. The arrangement of buildings and their exteriors creates contrasting views. Residents that responded to the questionnaire clearly expressed their admiration about the architecture of the ecodistrict. When asked 'How satisfied are you with the 'Buildings' design and appearance?', 94% were 'Very satisfied', 6% did not provide any response. Similarly, on the question 'How satisfied are you with the 'Environmentally friendly designs'?' 88% were 'Very satisfied'. Finally, when asked 'Overall, how satisfied are you with the architectural approach?', 82% were 'Very satisfied' while 18% 'Satisfied'. Additional feedback was provided by 19%. It is worth mentioning statements such as 'The ecodistrict is very architecturally pleasing', 'It's different from other parts of the city', and 'I really like the colorful approach'.

Energy

Residents speak highly of the energy efficiency measures in the ecodistrict. All responded 'Very satisfied' with the level of energy efficiency and low consumption of the buildings they live in or they use for community activities. Further feedback in general open questions at the end, provided by 31%, includes 'As far as I know, Kronsberg has different levels of energy efficient buildings. I do not know the details, but all of them should be very low energy consumption'. Another one stated 'Thermal water storage tank provides hot water for the community exactly when

it's needed', while the third one stated that 'Combination of highly efficient buildings and plenty of vegetation creates a comfortable ambiance indoors and outdoors, especially during the hot summer days'.

Although you can not actually tell anything about the energy efficiency of a building just by passing by, some facade elements that promote shading and energy efficiency are noticeable. In addition to low-energy buildings throughout the ecodistrict, you can not help but noticing the Passive house and energy plus housing with their distinguished design and facade features. Other visible energy 'elements' are the two natural gas-powered CHP units and the thermal water storage, that are located in the district, as well as the wind power turbines that are a bit farther but still visible from the location.

Mobility

Although Kronsberg public transportation is very reliable and bike lanes as well as pedestrian pathways are spread in every corner, the number of cars in the district seems surprisingly high. It looks like all parking spots along the streets are filled with cars, which is a bit disappointing. However the number of cars on the streets at the time of the visit was not that high, while the tram, the walkways and bike lanes seemed quite busy as a lot of people were using them. All the residents interviewed are proud of their ecodistrict. While some do see the car as a crucial means of transportation for further destinations, not everyone is pleased with the number of cars in the district. Around 56% think the number of cars could go down as the public transportation is very good, still 32% think car is a necessity for those commuting to remote areas. Yet, 94% think public transportation is very reliable and are 'Very satisfied' with it, including the bike lanes and pedestrian walkways. During general open questions at the end, interesting views surfaced. Statements such as, 'Although there are a lot of cars, because the traffic is regulated and the slow speed signs postage, you barely notice them', the other one stated that 'People are more and more aware of the fact that burning fossil fuel is not good for the environment, so cars will be used less', and to a very ambitious one who stated 'We have all what is needed for a car-free commute, I wish to live the day when I either see no cars or at least only electric ones in Kronsberg'.

Public spaces

The heart of an ecodistrict is its public square. In Kronsberg, the public square ('Thie') is very busy and full of people. Other neighborhood parks are the favorite places as well. The district school sits in an open area on the western side of the district, while the daycare centers are spread in different places in the district. The youth and

community center plays a vital role in all community social and cultural activities. Residents openly express their favorite places, with the 'Thie' and community center being the main ones. Overall 82% are 'Very satisfied', 12% 'Satisfied' while 6% 'Neither satisfied nor dissatisfied' with the quality of the public spaces of the district. General open questions at the end feedback that is worth mentioning is 'The public square and community center offer a variety of activities which are very interesting not only for ecodistrict residents, but also for the surrounding districts residents and other visitors'. However, one feedback focused on the elderly people claiming, 'Maybe a little bit more activities can encourage interaction with elderly people'.

Landscape

While all residents might not be in the position to pay attention to some of the other aspects of the ecodistrict, such as energy or urban planning, they all in fact are fully aware of the landscape and its elements. If there is something that can be fully appreciated by the residents of Kronsberg, are

indeed the green spaces and leisure activities areas. All interviewed residents expressed their maximum level of satisfaction for the high quality of all landscape elements. Additional feedback was provided by 25%, some statements to be noted here are, the 'Perimeter green avenue is the lifeblood of the physical activities of the Kronsberg residents', the other on about open spaces stating 'Open spaces increase and promote health and wellbeing'. One responder noted the fact that the viewing point at the top of the hill, considering it as 'An attractive feature that makes people come and visit Kronsberg'.

Other features that can not be missed when walking around, are without a doubt, the on-site rainwater retention and collection systems, that seem to be functioning very well, not only avoiding water table depletion but also promoting vegetation growth. The round shaped community park is full of trees and greenery. Abundant open and green spaces, a number of playgrounds and many other landscape infrastructure elements make Kronsberg a much wanted place to live.

As stated in the previous case study, although interviews with any city officials and other professionals are not part of the scope of this research, a very few of them have been selected to add their perspective and to provide further insights on the achieved success of the ecodistricts. As an example, the statement by Hans Mönninghoff, Deputy Chief Executive, Director of Economic and Environmental Affairs of the City of Hanover, in celebration of fifteen years after construction started. Where he stated (Rumming et al., 2004b) that due to the success that the

Kronsberg has achieved so far, countless experts from around the world have already visited the district. He also referred to the mentioning by the 'World Cities Summit 2012' judges as 'all-encompassing example of visionary urban planning and architecture'. The excellent quality of life coupled with high ecological standards that the district offers, makes it one of the most advanced urban development projects in Europe. Further, he explained that the city had focused on 'developing and implementing standards on a widespread scale for an entire area' rather than on a single case.

He recalls that when the project started it had drawn some criticism and was not particularly endorsed by some urban planners and architects, however, now after twenty years Kronsberg has shown the sustainable urban development viability and offered a crucial basis for advanced urban planning.

3.3. Case Study 3: Bahnstadt - Heidelberg

3.3.1. History

Located in the south-west of Heidelberg city center only two kilometers away from the old town and a few minutes walk from the main train station, Bahnstadt sits on a former wasteland site that used to be a marshaling and freight yard, railway facilities no longer in use. Its unique position in relation to the city center and the greenfields makes Bahnstadt a pleasant location to live, work, and much more. On the one side, it connects with the main train station and the city, while on the other side it has a long stretch bordering the nearby greenfields (Figure 3.3.1).

Spreading over 60 hectares of land (area managed by Heidelberg Development Company - EGH) and thanks to its planner's rich aspirations and goals, it can easily be said that Bahnstadt district is one of the largest and most important urban development projects in Germany. It certainly, along with some other ecodistrict projects, is a world example in sustainable development and urban planning. The mixture and variety of functions and spaces that includes offices and laboratories, different shops, a community center, several municipal daycare centers, a primary school, many playgrounds, plenty of green spaces, a movie theater and of course a large number of housing buildings and their surrounding areas.

The "Bahnstadt Heidelberg" urban development competition was launched in 2001, while results of the competition were transferred to a framework plan which was approved by the Heidelberg municipal council in 2003 (City of Heidelberg, 2007).

According to the 2010 urban development plan that the city of Heidelberg prepared, the goal was to develop a new city district based on sustainable urban development principles. A site with a unique identity that encourages mix-use buildings and advances social and ecological needs. The planned new ecodistrict is envisioned as an urban European city component that includes a relatively dense and mixed-use city functions rather than another conventional suburban district.

Since one of the requirements for buildings was that all of them have to be energy efficient and in accordance with the Passivehouse standard, Bahnstadt is one of the largest Passivehouse settlement projects in the world. Thus the energy spent is down to minimum. The additional energy needs are supported by biofuel energy, via the wood-fired thermal power station. The tram line and bike-friendly traffic offer great climate friendly mobility options. Shopping, amenities and many other community services are within short walking distances. (City of Heidelberg, 2007)

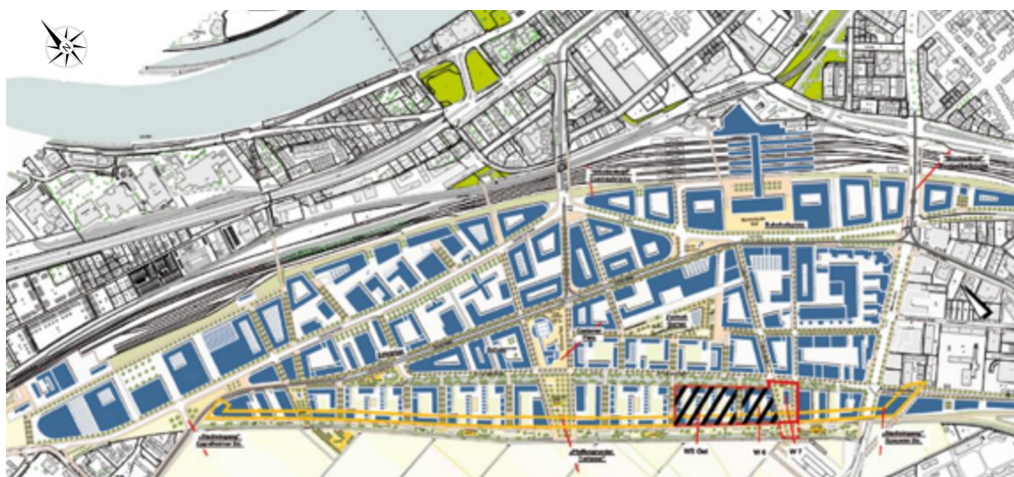


Figure 3.3.1 Bahnstadt district map (source: City of Heidelberg)

As noted by (City of Heidelberg, 2019), Bahnstadt's lifestyle is reflected in many ways, in the architectural approach, public spaces and squares, as well as housing. Its planning encompasses traditional and well spaced accommodations such as apartments, townhouses and villas to please different needs of its inhabitants. Providing the much needed privacy through gardens, courtyards with plenty of greenery, as well as green roof terraces. In addition, plenty of green open spaces for sure enrich the ecodistrict quality (Figure 3.3.2).

In conclusion, Bahnstadt is a pioneering ecodistrict that showcases the quality of life as well as demonstrates how to support climate protection. Due to the short distances and great connections with surrounding areas, and the way it combines jobs, housing, supporting services as well as taking climate protection measures, this urban

redevelopment project is clearly a great example for other cities in facing and overcoming urban planning challenges.

All these features that have been included make it clear that Bahnstadt planners' goal to achieve quality of life and wellbeing for its occupants is successfully realized.



Figure 3.3.2 Bahnstadt district aerial view (source: (City of Heidelberg))

3.3.2. Urban planning

The city of Heidelberg prepared the urban framework plan, which was published in 2007. This framework plan was based on the document prepared by the winner of the 2001 urban design competition. Several detailed planning specifications and goals were made mandatory for the future developers. Those required that Bahnstadt, among others, should be a 'sustainable and urban district with a high quality environment activity for living, working', with good services and supply, recreation, leisure and cultural activities. And that it is a 'sustainable urban development', with its development suitable for different usage requirements and many generations (DSK, 2018).

Further, it guides that different functions be grouped into smaller subdistricts and that would be reflected even in the public spaces typology and buildings appearance. Therefore, regardless of a good portion of commercial functions and the vital network of transportation roads, the focus should be on creating a green and climate neutral ecodistrict that is planned for a mix-use and with diversity in mind. Important aspects in this framework are also the requirements for high quality design and functional buildings, as well as calling for flexible planning and monitoring instruments during the implementation of the project, instruments that allow room for improvements for any unforeseen issues that might come up.

As mentioned above, the ecodistrict includes much more than housing buildings. The site is planned based on functions and that is reflected in the building structures applied. The site has an elongated shape which enshrines all the desirable elements, qualities and characteristics, as well as an unrivaled way to plan buildings and infrastructure. Allocation of commercial building areas in the north side creates a buffer between the rest of the district and the railway tracks. The main train station serves the district as a functional connecting point with the rest of the city, as well as an extending visual connectivity between the two. Most residential areas are allocated on the south side of the ecodistrict. With the allocation of the main road axis in the longitudinal direction, the designer's idea was to resemble the old railway tracks and connect to the historical use of the site. The two interventions on the crossing direction intend to cut the long views and sequences into smaller sections and most importantly visually connect the ecodistrict to the city to make it an integral part of it. The prominent part along the longitudinal axis is Langer Anger street. It does not only have the traffic lanes and car parking spots, but it also includes the water lagoons that is a great feature for inhabitants to enjoy their free time. While the 'Green Meile' street has a much higher level of traffic and that goes along the tram line. The other lower level/service road is along the promenade, which provides the occupants the much needed connection with the green fields. The cross roads connect the main roads at different intervals creating smaller urban blocks. There is a variety on the height of the buildings. Footpaths and bike lanes are designated all over the ecodistrict and make individual traveling very easy. A maximum of 20 m height for residential buildings is applied for the buildings along the main road, while the other parts are at lower height (16 m or lower). The distance between buildings in the main street is 40 m, while in the crossroads, it stops at 20 m.

The school is designated in the central area of the ecodistrict, while the day-care centers have been allocated in different residential areas, with immediate access to green spaces. Free time activities areas are placed in several spots within the green spaces but the bigger leisure activities areas are planned as part of the promenade. According to (City of Heidelberg, 2019) Bahnstadt is designed to host a total of 6,800 residents that will be accommodated in 3,700 residential units. Of the total area, buildings occupy 61 %, green area and open spaces 18 %, while traffic networks 21 %. As listed in (City of Heidelberg, 2017), Bahnstadt's area managed by city established development body Development Company Heidelberg (EGH) is 60 hectares, which are spread as follows: 9 hectares for residential, 16.5 hectares commercial, 4.5 hectares campus, open spaces occupy 16 hectares, social infrastructure 3 hectares, while the road network is up to 11 hectares.

3.3.3. Architecture

The urban framework plan 'Bahnstadt 2007' is the ecodistrict's urban planning baseline. Planning specifications and goals stipulate resilient planning, mix-use and diversity, high quality design and functional buildings zone according to their function.

Many parameters played their role on how the ecodistrict was shaped. Density and the number of floors has a logical approach. Generally, buildings on main roads are of five floors, in the Zollhof quarter between four to six floors, while along the promenade belt between three to five floors. Another interesting aspect is the higher buildings are placed in the perimeters of the public squares.

Design guidelines concerning building facades materials gave architects and designers the freedom and flexibility to express their design ideas freely and unrestrictedly. Although it seems the white color dominates throughout the ecodistrict, different gray and other colors are present as well. Building facades are mainly of the rendered facade, but some are out of bricks, as well as structural facades for non residential buildings (Figure 3.3.3).



Figure 3.3.3 Types of buildings and architectural approaches in Bahnstadt (source: Bardhyl Rama)

Bahnstadt's structural urban development approach is mainly based on the urban blocks or also sometimes referred to as building complexes, which are implemented either as a group of individual buildings or a nearly continuous building with some openings at certain points. Distinct architecture approach and the facade elements applied to building complexes attempts to associate the functional use of that particular complex, whether is a mixed use, or just residential, educational, commercial and other functions (City of Heidelberg, 2019).

3.3.3.1. Typology of multifamily residential buildings

Bahnstadt has been planned, designed and implemented generally as a residential mixed-use neighborhood. Although most of the residential buildings are along the Langer Anger street, other parts of the ecodistrict have many residential buildings, too. Especially the belt of buildings along the promenade, which are mainly

residential, except for the mixed use buildings around the public squares. Residential buildings are characterized by a wide variety of housing types and forms of living such as, single family housing, townhouses, multifamily apartments, student dormitories, multi generation living apartments, and similar.

Courtyard concept is a distinguished approach that has been successfully implemented in Bahnstadt. This approach is implemented by grouping and allocating the residential units in an inner courtyard, which has many benefits by providing residents a higher level of privacy, but also a calm and quiet place to spend their free time. Courtyards feature a variety of designs, themed differently and, while usually designed by architects, in some cases even designed by the community itself.

Although mainly consisting of residential functions and buildings, Bahnstadt does not lack public, office, commercial, campus and other types of buildings (Figure 3.3.4). Residential buildings come in many forms and varieties. As such, here it is not intended to provide a detailed analysis of all types of buildings and their characteristics, but rather a general overview of several types of buildings including the residential complexes, courtyard apartment complexes, apartment buildings, city villas, as well as a number of terraced buildings.

Designed and built as a mixed-use complex and in accordance with the urban planning concept based on the specifications from the development plan, the 'Colors' is a pleasant place where living, working, shopping, and other leisure activities interact with each other and where the community thrives.

Building height varies, it depends on the location within the complex. While the lowest buildings, three stories, have been dedicated to city villas on the promenade side, the four and five storey buildings are on the Pfaffengrunder Terrasse and street side respectively. The facade is light plastered with some contrasting sections, the full height windows provide ample amount of light in all areas. Buildings are arranged around the inner courtyard which offers a private area that the community can use at any time.

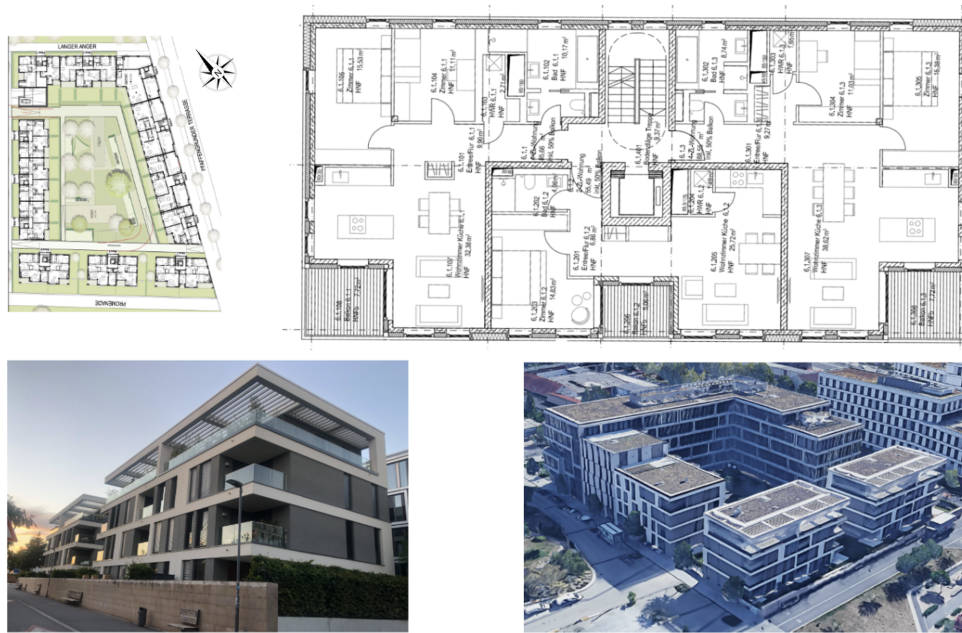


Figure 3.3.4 Mixed-use complex 'Colors', site plan and a sample floor plan and perspective views (source: Heinze, 2020 (top), Bardhyl Rama (bottom left), google map (bottom right))

Eleven six story high mixed use buildings are part of the 'Elf Freunde' complex. There are around 166 apartments and a few commercial areas at the ground floor. Combining living and working under the same roof, the two to five room apartments and townhouses contain work-and-life units that fulfill all modern needs of their inhabitants. The individual character of the eleven buildings is predetermined by the design principles and the use of materials and colors. Facades of the perimeter buildings are made of bricks while the ones in the middle rendered facades. The weather-protected area in front of the commercial zone provides much needed cover during the raining season, but also shade during the summer. Like many other building complexes, this one too surrounds a courtyard that contains open spaces for private and community use.

Rental building complexes such as, "Meilen.Stein" a residential and business complex offer a combination of an attractive mix of living, working, and leisure, also an offer for a quiet retreat at its inner courtyard. It has 185 rental apartments, but also other mix functions to include daycare, commercial, restaurants, an office building and a hotel. A mixture of floor plans of one to four rooms apartments creates individual spaces for singles, couples or wider families. Similarly, 'Europaplatz' with its position close to the main train station, will serve as the focal point for all people using the train. This complex of buildings offers 105 rental apartments of various sizes, about twenty percent of which are subsidized, on the residential portion of it, while offices, shops, restaurants and a hotel on the

commercial part. In addition to a shopping center and retail, the "Westarkaden" building complex (Figure 3.3.5) contains 284 one-to-five room rental apartments that provide modern space for residents in their 30 to 146 square meters floor plans.



Figure 3.3.5 The Westarkaden shopping and rental apartments (source: Bardhyl Rama)

One distinct residential complex is the "Junges Wohnen" (Figure 3.3.6), which is dedicated to youth living. Its 104 rent apartments represent a variety of living options through the rich variation of the floor plans offered primarily to young people.



Figure 3.3.6 The "Junges Wohnen" apartments (site plan, alternative floor plans (top), floor plan (middle) (source: Heinze, 2021), front view (bottom) (source: Bardhyl Rama)

'Wohn Gut' offers places for different forms of living. A multi-story apartment building that help transition to the other parts of Bahnstadt, then three story terraced apartments, and city villas along the promenade. City villas (Figure 3.3.7) have an open concept living room with integrated kitchen and dining area in the same large space, a master bedroom, a kids bedroom, two other rooms that can serve as guest room or office, a bathroom, an additional separate toilet room, utility room, and of course a large balcony. Apartments are accessed via the main stairwell and elevator. Large and floor to ceiling windows provide plenty of light however privacy and sun protection ensured via the external venetian blinds.



Figure 3.3.7 City villas floor plan and street view (source: Heinze, 2020 (left), Bardhyl Rama (right))

A somewhat 'special' location is the 'Urban' four building complex. It contains the 'Urban Four' which has 78 two-to-five room apartments and the 'Urban Green' with 118 nicely arranged apartments. Both buildings offer several commercial spaces as well. Modern urban living is also present in 'Urban Element' and 'Urban View' which have 90 apartments and 79 rental apartments respectively. Like most of the other buildings in Bahnstadt, buildings of this complex are dominated by white facades.

Terraced houses are very few in numbers compared to the other types of residential buildings, however they seem to have been placed in the best possible locations in the promenade area. The east side location includes about 24 units including two linear rows in the inner part and 8 units along the promenade. While the west location contains 29 units in three linear rows in the inner part of the complex. All buildings have green roofs and have a unique architecture that distinguishes them from the apartment buildings (Figure 3.3.8).



Figure 3.3.8 Terraced houses site plan (top left) (source: City of Heidelberg), front view (top right) (source: Bardhyl Rama) and aerial view (bottom) (source: City of Heidelberg)

Other non residential buildings are quite a lot, such as the SkyLabs and SkyAngle lab and office buildings that offer a pleasant work environment. The B3 community center offers three functions in one place. Also, the conference center that is planned to be the modern congress venue for large national and international events.

It's worth mentioning that, as referred in many cases by the City of Heidelberg, all the buildings in Bahnstadt are constructed in accordance with the Passive house standard. To avoid mentioning this at every complex described above it was deemed more appropriate to be listed here. Almost all of them have green roofs, and quite a few have solar panels installed on the roof. Although brick facades are present as well, the majority of buildings have white facades which gives Bahnstadt a distinct identity as a contemporary ecodistrict.

3.3.4. Energy

Heidelberg's energy concept 2020/2030 covers different aspects of energy generation, conversion and transition. The wood-chip combined heat and power plant and the energy storage facility are the main components, however

the Pfaffengrund Energy Park includes integrated solar systems, biogas and natural gas cogeneration plants, and other similar additional components.

3.3.4.1. Energy Efficiency, Solar Installation and Wind Energy

Bahnstadt was conceptualized and designed based on the idea to become a passive house settlement. The whole ecodistrict has been developed, and its buildings constructed according to the passive house standard, featuring high insulation, heat recovery ventilation system and overall high energy efficiency, therefore a very low energy demand for the entire district. Compared to conventional residential construction the passive house standard enables an energy saving level ranging from 50-90%. Thus, a fundamental reduction in building energy needs for the entire ecodistrict.

Solar energy

In addition to solar panel systems in Pfaffengrund Energy Park, many Bahnstadt buildings have solar panels installed on their green flat roofs and some buildings even in the facades (Figure 3.3.9). Solar panels are an important component in increasing the renewable energy power generation and help in a carbon neutral energy transition. In addition to power generation, solar panels also provide shades during the hot sunny days. Two large solar systems (at around 3.6 MWp) have been installed and an additional over twenty MWp is planned to be installed by 2025.(Stadtwerke Heidelberg, 2021)



Figure 3.3.9 Photovoltaic solar panels arrays (source: City of Heidelberg, 2022)

Wind Energy

Heidelberg is considering two wind turbine sites. The current proposal is to have two to three wind turbines in each location. When those two sites get implemented, the wind power generation will have a good contribution to the whole city's energy mix.

3.3.4.2. Combined Heat and Power (CHP) Plants

To cover Bahnstadt's energy needs, the city of Heidelberg utilities company has constructed a highly efficient wood-chip combined heat and power (CHP) plant in Pfaffengrund, near Bahnstadt. The CHP (Figure 3.3.10 left) uses organic waste accumulated during the year-round landscape maintenance as well as from other sources of bio waste to generate power and heat for the ecodistrict and some other parts of the city. In addition, several biogas and natural gas cogeneration plants feed Heidelberg's district heating systems.

Due to the fact that all ecodistrict buildings are constructed based on passive house standard, the energy requirements are very low. That, in combination with the application of a wood-chip CHP plant to generate heat and power, makes Bahnstadt the first carbon-neutral district in the city of Heidelberg. District heating network (Figure 3.3.10 right) has been distributed throughout Bahnstadt.



Figure 3.3.10 Combined Heat and Power (CHP) wood-fired thermal power station (left), district heating network (right) (source: City of Heidelberg)

Heidelberg's utility company employs high end technology for generating, distributing and managing its electricity supplies. Over three thousand smart meters are part of the power grid in Bahnstadt, making it one of the largest smart meters using districts in Germany. This enables users to get a better understanding of their

consumption and expenses, and offers them an opportunity to discover and highlight the energy saving potentials. (City of Heidelberg, 2019)

3.3.5. Mobility

One of the key points in Bahnstadt's planning was the solution of mobility in the future ecodistrict. The city of Heidelberg has addressed this in a very clever way. Putting the main efforts in encouraging the development of the best possible options for the public transportation via the tram and bus lines, but also creating a well structured network and connections for the bikers. Thus reducing the reliance on the fossil fuel option.

3.3.5.1. Public Transportation

Heidelberg's public transportation network (Figure 3.3.11) is highly integrated and is constantly being expanded and modernized. Trams and buses connect districts with each other as well as with the city center and main train station. The tram lines 22 and 26 with three stops provides Bahnstadt with a very reliable connection to the city network. The transfer from Bahnstadt to the old town takes only a few minutes. In addition, bus lines 33 and 721 connect Bahnstadt with other nearby destinations. The ecodistrict's public transportation has been carefully planned to best serve the residents as well as reduce the use of private cars, thus contributing to the greenhouse gas emissions reductions and in achieving climate protection goals.



Figure 3.3.11 Schematic view of the public transportation (source: City of Heidelberg)

All three Bahnstadt stops (Figure 3.3.12), Eppelheimer Terrasse, Gadamerplatz and Hauptbahnhof Süd, have digital boards for passenger information and are barrier-free. Both tram lines 22 and 26 have a direct connection to the main station, which is very convenient for Bahnstadt residents traveling to further destinations outside the city.



Figure 3.3.12 View of the tram line stops (source: Bardhyl Rama)

3.3.5.2. Private cars

Although the ecodistrict is designed with the idea of prioritizing public transportation, biking and walking, the number of parking places for cars is quite high. Open parking spaces (Figure 3.3.13) are mainly along the main streets 'Grüne Meile' and 'Langer Anger', but also along the other secondary streets between the blocks. While also, there are quite a lot of indoor parking spaces in the underground parking garages at different locations. The speed limit of the ecodistrict access road 'Speyererstrasse' is 50 km/h, while the 'Grüne Meile' and 'Langer Anger' is 30 km/h. Other secondary roads are at much slower speed. Bahnstadt has between 0.5 and 1.0 parking spaces per housing unit.



Figure 3.3.13 Parking spaces along the streets (source: Bardhyl Rama)

Promotion of electric vehicles has been part of the city's commitment to reduce the reliance on fossil fuel, therefore Bahnstadt has provided a few charging stations and the city administration encourages developers to install charging points in the underground car parks. Bahnstadt also promotes car sharing, as such it already has four locations where the residents can use this service.

3.3.5.3. Biking and Walking

As with many other cities, Heidelberg's citizens are proud to have bicycles as the mobility medium of choice. As a result, the city has expanded the bicycle lanes network which includes the newly added over four kilometers grid in Bahnstadt. In many cases bike lanes are allocated along the roads and tram line forming a somewhat myriad of types of traffic users (Figure 3.3.14). Multiple bike lanes and pedestrian pathways link the ecodistrict with the nearby districts as well as the city center. The bicycle parking garages further promote use of bicycles. Through the ramp on Europaplatz bikers can safely park their bikes at the garage below with around 1,600 parking spaces. Other bike parking places in Bahnstadt make it very convenient for bikers to store their bikes and to use them as the main means of commuting.

Pedestrian sidewalks and paths are designated throughout the entire ecodistrict. Safe passage across the roads is enabled by the pedestrian crossings in the main roads as well as traffic slowing barriers in secondary roads, that clearly give priority to pedestrians. A lot of pathways connect inner courtyards and blocks of the ecodistrict. One of the most prominent area is the "Promenade", which is located in the southern edge of the ecodistrict. It borders the "Pfaffengrund fields", a very calm and pleasing area for walking and biking.

A bicycle and footpath bridge connection is being planned by the city. It will connect Bahnstadt and the nearby areas with the rest of the city. Starting from the west side of the main train station and ending on the northern bank of the river. The design features which include several open spaces around the bridge would highly improve the quality of life.



Figure 3.3.14 Bike lane along the road and the tram tracks (source: Bardhyl Rama)

3.3.6. Public spaces

Bahnstadt has numerous locations that function as public spaces for community gatherings and for other events and activities. The more prominent ones, Pfaffengrunder Terrasse, Gadamerplatz and Schwetzinger Terrasse, but also Zollhofgarten, Promenade, and recently planned Bahnhofplatz Süd and Europaplatz (City of Heidelberg, 2019).

Pfaffengrunder Terrasse and Godamaplatz (Figure 3.3.15) are in the central part of the ecodistrict. Both squares, which are located along one another, serve as community gathering points extending a wide range of possibilities for different kinds of functions.

Located in Gadamerplatz and operated by the Bahnstadt residents' association, B³ community center (Figure 3.3.15) with functions related to education, daycare and community is a gathering point for ecodistrict residents. The mixture of a school, a daycare and community center functions is a pioneering concept for the city as well as a model for the whole region. A venue for social events, sports activities and meetings, it offers spaces for multiple purposes. Its hall can be used for concerts, theater, lectures and similar. Other spaces can support sports activities, birthday parties, corporate meetings and many others.



Figure 3.3.15 Gadamerplatz and the B³ center (top) and Pfaffengrunder Terrasse (bottom) (source: Bardhyl Rama)

One of the objectives of Heidelberg city's planning policy is to offer parents a balance between family life with a career. As a result, a number of daycare services have been established in Bahnstadt. The most prominent one is the Schwetzingen Terrasse daycare center. Placed in the central part of the Schwetzingen Terrasse with its outdoor areas and wooden facades, it is a very welcoming and attractive place. 'First Steps' and 'Zollhofgarten' daycare centers offer places and rich educational programs for kindergarten children. The 'Gadamerplatz' daycare center,

which is part of the B³ community center, with its indoor and outdoor space of over a thousand square meters altogether, provides kids a decent playing area. Similarly, the daycare center inside one of the pre-existing buildings, offers spaces that serve as workshops, research labs, and many other activities, as well as access to one of two outdoor playgrounds. Other daycare places include the ones in 'Junges Wohnen' and 'Heidelberg Village' housing complexes in Langer Anger, one in 'Meilen.Stein' housing area, one in 'Westarkaden' shopping center as well as an additional one in Pfaffengrunder Terrasse.

3.3.7. Social and cultural interaction

Bahnstadt's rich social and cultural activities go well beyond the ecodistrict borders. Social and cultural facilities including numerous small gathering places as well as meeting venues, strengthen Heidelberg's standing as a city of culture.

As a result of the development of the Bahnstadt area, the legacy culture and event house 'Halle 02' is active again with hundreds of events each year visited by a lot of people. The range of events includes exhibitions, concerts and any other social and cultural programs. (City of Heidelberg, 2019)

With an idea of mixing culture and business under one roof, and by providing space for concerts, and different workshops and seminars, Tankturm, a former water tower, is another place for cultural activities. It perfectly reflects the case of renovation and adoption of an industrial building into a cultural venue for events and conferences.

Bahnstadt hosts one of the biggest and most modern cinemas in the region, which offers a very rich program with the latest movies. In addition to its main function, this cinema includes a seawater aquarium, glass skywalk and hanging gondolas.

Another venue of meetings and events as well as a 'neighborhood café in one' is the LA33, which is located in the B³ community center. Gaming group, the district choir, a boules group and many other one-off events, such as improvisation shows and neighborhood breakfasts are regularly organized here. (City of Heidelberg, 2019)

As expected, the Bahnstadt community is very active in all social and cultural activities not only indoors but outdoors as well.

3.3.8. Landscape

3.3.8.1. Green spaces and playgrounds

Bahnstadt has been established on an old railway freight site, as such green spaces, landscape and vegetation needed a particular attention. When planning, a distinct identity was aimed for the green open space concept. Its well thought and executed open space concept with a mixture of green areas, playgrounds, sports terrains and open spaces invites residents and visitors to dedicate time for outdoors activities.

One of the key landscape features, the promenade, resonates the old tracks but now as a green structure, it connects the ecodistrict with the wide open natural greenery. It serves as both a pedestrian pathway as well as a bike lane, its park-like approach is very welcoming to inhabitants and others to bike, walk, play, skate or simply spend free time there. (City of Heidelberg, 2019)

In addition to different functional areas for leisure, playing and recreation in the promenade, the 'compensatory areas' are planned to serve as extension habitats for plants and wildlife. (Figure 3.3.16)

Further, the ecodistrict microclimate and the habitat for animals and plants has been improved by planting different kinds of trees, shrubs and other greenery plants within the ecodistrict area.

Other green 'pockets' in the ecodistrict include places along the water lagoons, green inner courtyards, gardens and other similar places. (Figure 3.3.16)



Figure 3.3.16 Promenade landscape (top left), greenery along the water lagoons and inner courtyards (bottom left) (source: Bardhyl Rama), compensatory areas as habitats for plants and wildlife (bottom right) (source: City of Heidelberg).

Spread over seven thousand square meters in a prominent part of the ecodistrict, the Zollhofgarten park provides a pleasant place for all kinds of free time and activities. Whether using the climbing wall, the beach volleyball court or any other green features, users can enjoy their free time.

Areas for sports activities include among others, tennis courts, a small soccer court, and other similar features as well as a well planned location of calisthenics facility for street workout.

Playground equipment, trampolines, 'bumpy' lawn places, graffiti walls, water fountains, raised beds for vegetation, many seating areas, trees and open lawn playground are all provided in the Pfaffengrunder Terrasse (Figure 3.3.17).



Figure 3.3.17 Playground equipment, trampolines, 'bumpy' lawn places (first row), graffiti walls, water fountains (second row), table tennis, raised beds for vegetation, many seating areas, trees and open lawn playground (source: Bardhyl Rama)

The Bahnstadt's promenade hosts three playgrounds. Each one of them is designed and constructed based on a distinct idea and theme, such as railway, farm and fire brigade (Figure 3.3.18). The railway playground includes red coloured train structures. The other popular one, also with red color, is the fire brigade playground near the Schwetzingen Terrasse. While the third one, the farm playground, includes a shack for playing, a number of carefully wooden carved animals and a tractor with a hay cart, it connects children's experience with the open green fields nearby, creating a specific experience. (City of Heidelberg, 2019)



Figure 3.3.18 Open playgrounds of various themes (source: Bardhyl Rama)

All three playgrounds offer different kinds of playing experiences with elements such as climbing ropes, nets, slides and similar features.

3.3.8.2. Green gardening

In recent years urban gardening has become an attractive feature for ecodistricts and cities. Although initially Bahnstadt did not have a designated place for green gardening, recently the city has set up a corner in Pfaffengrund Terrace for this purpose (Figure 3.3.19). Several raised beds (boxes) properly filled with soil and arranged for easy access by residents offer a place for urban gardening. The boxes are placed in a well suited area in the platform very close to the Promenade and are visually linked to the nearby green fields, enriching the experience of urban gardening.



Figure 3.3.19 Raised beds with plants as part of the Bahnstadt's urban gardening project in the Pfaffengrund Terrace (source: Bardhyl Rama)

3.3.8.3. Rainwater

We are aware of the importance of the rainwater for the local vegetation as well as the water table. Cities and districts approach this in different manners. Certainly, Bahnstadt's solution to this is highly innovative. Nearly a kilometer long, the water lagoons complex along the Langen Angers, promoted as design elements of the ecodistrict, serve as a pleasant place for the resident's leisure activities, but it also has a primary function to collect and store rainwater. It helps replenish the local water table, but also in relieving the sewage system and the treatment plant, especially during the heavy storms. The resident's experience is enriched by planting many trees along the ponds as well as aquatic vegetation and different types of fish in the ponds.

The lagoon system collects (Figure 3.3.20) the surface water through filter basins or designated pipes. Once the pond fills up, the excess water is drained to the nearby green area via trenches. The lagoon filtration system cleans the surface water prior to releasing it. Another 'cool' feature of this element is the cooling effect that the water evaporation from the ponds offers to the ambient air during high temperature days. (City of Heidelberg, 2019)

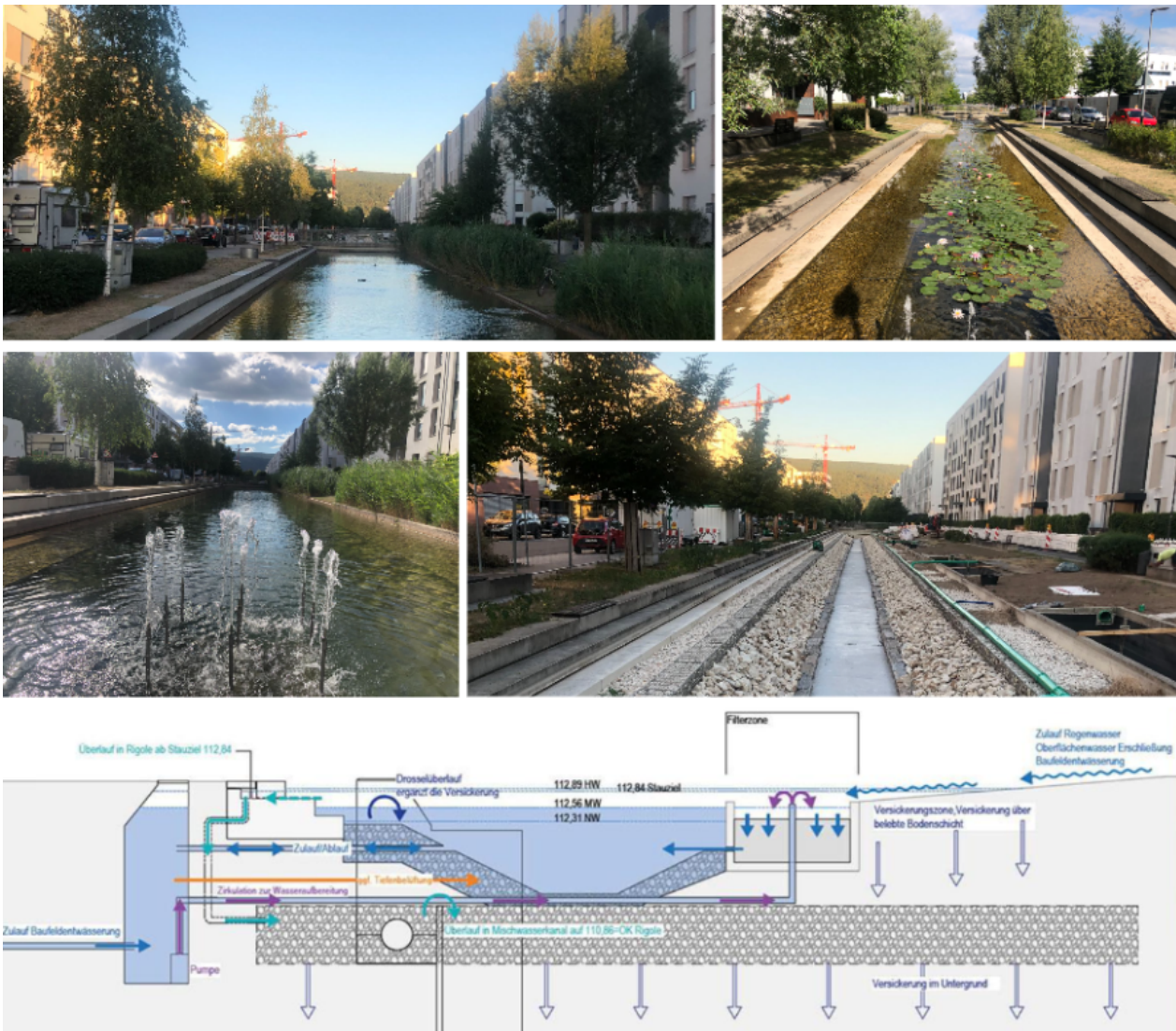


Figure 3.3.20 The view of the water lagoons (top and middle) (source: Bardhyl Rama), and sectional detail drawing (bottom) (source: City of Heidelberg)

However, upon learning from experience and noticing some issues, the city of Heidelberg has decided to renovate the lagoon system, with the aim to simplify maintenance and improve water quality. The renovation will take care of filtering and regulating the rainwater before reaching the water pond, reducing the potential for algae growth. Further, the lagoons will have flat floor surfaces for easier maintenance compared to the existing gravel substrate. (City of Heidelberg, 2019)

Table 5. Bahnstadt ecodistrict compiled data (source: compiled by Bardhyl Rama, info from the literature research)

General data	
Site condition	Brownfield
Area	60 hectares (area managed by City Development Company - EGH)
Population	6,800 residents, over 3,700 apartment units
Urban planning approach	
Position in relation to the city	Less than 4 kilometers from the city center - about 23 minutes by tram
Urban planning competition criteria	Set by the city
Density	113.3 residents/hectare; 1.84 residents/apartment; 61.6 apartments/hectare
Floor space index	Varies between min. 0.6 to max. 3.0
Blocks of residential complexes	'Semi-open' blocks, with a courtyard and openings at certain points, are used in most cases, a very few linear arrangement blocks, a few cases of combined u-shaped, and one long line of a pre-existing building.
Building height limit	Approx. 20 m height for residential buildings along the main road, lower height (16 m or lower) for other locations
Street spaces an edge-to-edge	40 m (in the main road)
Non-public green areas	Approx. 30m - varies for different inner courtyards
Mix use	Mixed-use blocks between three to six stories high
Architectural approach	
Building design	Unique ecodistrict identity, dominated by white colors, but some other light variation present as well. Inner courtyard used as an enriching feature of quality of life.
Individual owner buildings	Only on terraced buildings (row houses)
Group owners buildings	Three to four stories buildings - maisonettes as well - mainly placed in the promenade area
Property developers buildings	Four to six stories residential complexes - mainly allocated along the main streets and the main public squares. Mix of condos and rented apartments
Cooperative-oriented property developers	N/a
Energy	
Low-energy buildings	All Bahstadt's buildings have been built in accordance with the Passive house standard.
Passive house standard (15 kWh / m ² a) buildings	All buildings
Energy plus housing	N/a
Combined Heat and Power (CHP)	Highly efficient wood-chip burning CHP unit provides power and district heating for the ecodistrict
Wind Power	The city is considering two wind turbine sites, two to three wind turbines in each location
Mobility	

Public transportation	City center by tram line (around 23 minutes ride). Furthest residential unit within 550 meters to one of the three tram stops or bus line stops
Car-reduced concept	The roads in the district are traffic calmed - discourage car use. However, as it seems cars are quite present on all the streets. Given the great public transportation and bike possibilities, car owners might be encouraged to consider shifting to those climate friendly options.
Bike and pedestrian friendly	Over four kilometers of bike lanes, and the network keeps expanding. Traffic calmed roads encourage walking and biking. Promenade is a convenient pedestrian and bicycle lane along the whole southern line of the ecodistrict Pedestrian pathways interlink the sidewalks along the street network with the open playgrounds, small parks, inner courtyards and other green parts, enriching the whole walking experience.
Main access and inside roads	Inside roads speed limit is 30 km/h, parking spaces along the road
Quiet residential streets	Quiet streets exist, however some small level of car traffic in the urban blocks is allowed
Parking garages	A lot of car parking space in underground garages in the building basements (no designated garage building), open street parking space as well
Public spaces	
Public squares	Three public squares and two neighborhood parks
School	One building with three integrated functions
Daycare/Kindergarten	Several daycare centers
Youth and community center	One building with three integrated functions (education, daycare and community center)
Landscape	
Rainwater	On-site rainwater retention - the water lagoon is a particular feature, other open spaces help with on-site water collection as well
Green roofs	Almost all of the buildings
Green spaces	Green and open spaces are of a particular importance and increase the quality of life in the ecodistrict
Other functions in green spaces	Many playgrounds, designed and constructed based on different themes, are present throughout the ecodistrict
Green gardening	Offered in the raised beds (boxes) in one of the main squares

3.3.9. Personal onsite observations and structured questionnaires with general open questions at the end

Urban planning

Bahnstadt might be a different site compared to the other two case studies for the fact that the mixture of functions is much more diverse, especially the inclusion of the campus and dedicated high rise office buildings. However, in terms of urban planning, Bahnstadt like Vauban and Kronsberg includes key urban aspects that make it successful as an ecodistrict. The site is easily reachable from the city center and its borders literally touch the main station, so

based on author's own experience, only a few minutes walk from the main train station gets you at the heart of the ecodistrict. When on site, it is noticeable that longitudinally there are three 'corridors', the 'Langer Anger' and the 'Grüne Meile' that function as traffic arteries for the district, and of course, the much higher value and multifunctional 'belt' at the end of the district, the 'Promenade'. All these three corridors are visually and functionally interconnected sectionally through different streets and alleyways and especially through the three public squares, Gadamerplatz, Pfaffengrunder Terrasse and Schwetzingen Terrasse. This urban solution surprisingly makes walking from one end to the other end of the ecodistrict a very pleasant experience and not tiring at all. The choice of buildings and their allocation is completely in line with this approach, where the two corridors along the streets contain the higher buildings, whereas the buildings along the promenade are at lower height and all of them have roof terraces facing the greenfields. One of the urban characteristics of Bahnstadt are the semi-opened urban blocks, that not only 'compartmentalize' the areas in the urban aspect, but also create the inner courtyards that offer semi-private spaces just for the block residents. In many cases those inner courtyards contain playground equipment as well as other urban features that enable children and families to spend their leisure time in a quiet way.

The structured questionnaires provide rather interesting feedback. When questioned 'How satisfied are you with the urban approach?', 73% responded 'Very satisfied', 13% 'Satisfied', 7% 'Neither satisfied nor dissatisfied', and 7% did not provide any response. The summary of the additional comments from the general open questions at the end can be considered as a very positive experience. Statements such as, 'I have a feeling that the Bahnstadt urban approach is very carefully planned. I personally do not think there was a better way to do it.' Another interviewee claims that 'The whole district infrastructure offers an unrivaled experience. You can notice it when walking or doing daily errands, everything is within quick and convenient reach'. Other overall comments on the urban planning that are worth mentioning include the statements about the public squares and the promenade, such as 'I think everything is very well thought here, but the inclusion of the public squares and the promenade and their connectivity with other parts makes the residents wonder outdoors much longer than they would normally stay, so that's a great thing' and the other simply stating 'Without the promenade Bahnstadt quality of life would have been much lower. I jog everyday and for me that's my favorite place'.

Architecture

Bahstadt's architecture in the eyes of its residents, or at least of those interviewed, gets a mixed evaluation. Although the majority really like everything about the ecodistrict's architecture, there are those who would not mind to see it a bit different, the least to say. As we know, there are many different aspects that the architecture can be viewed from, and many components that could be considered as part of the architecture. So not all of them could be covered here, however addressing at least some visible ones should provide valuable residents' insights. Once one starts walking in the ecodistrict, the first thing that is noticed is how the seamless transition from one place to the other is. The walking progress from the busy residential areas to the bustling public squares and green parks, the office and commercial areas, as well as campus buildings happens in a matter of minutes and without actually noticing the change. The various residential buildings offer a myriad of modern housing varieties, such as terraced housing, city villas, rental apartments, residential complexes, all of them with many types or interior arrangements of different number of rooms per apartment. Also, application of courtyards which are shaped, designed and themed almost distinctively, adds even more value to the residential building design. Overall, the building facades in Bahnstadt are light plastered with some sections with brick and contrasting sequences complemented by the large windows that offer the light flooded effect in the apartments. Standing out, especially from the facade appearance are the nonresidential buildings, are buildings such as lab and office buildings, daycare, community center and conference center. All Bahnstadt buildings are built as per the passive house standard, elements, such as thick insulation, ventilation equipment and vents, high quality windows and shades can be noticed from the outside. Flat and green roofs are mainly used for almost all the structures. The water lagoons are one of the best architecturally pleasing elements in the ecodistrict. When walking by or sitting in the benches nearby, you get a whole different experience. By watching the fish and the vegetation in the lagoons, especially when the water fountains are running, your mind calms down, you get a sense of deep relaxation and a distinct feeling. Questionnaires with the residents surfaced different opinions. Majority in favor of how the ecodistrict architecture turned out, but some with suggestions on how they would have liked some elements to be. So, additional feedback includes 'Buildings in Bahnstadt look really good. The colors in the facade are very calm and natural.', 'I like the view from the terraced roofs in the promenade area. Once you get out on the rooftop see the whole greenfields in front of you. That's what I like most.', 'I think I like everything here, but to name one that I can think of is our courtyard. Our children and us, the adults, can spend time in the calm and quiet courtyard without worrying of any danger from cars or anything. I spend a lot of time there.' and another comment about the water

lagoons, 'The water ponds are invaluable, people gather there and spend quality time, at any given time but especially during the hot summer days. Sometimes it feels quite busy and a bit noisy, but still very pleasing to hang around'. However, some different opinions include 'I do not know why it was decided that the majority of buildings would be white or light shaded colors, so obviously the white nuance dominates, but personally I would have preferred to have some more colors in the facades.', the other one suggested that it would be great if one of the commercial buildings would open the roof terrace for the public, so all the residents enjoy the top view.' Questioned 'How satisfied are you with the 'Buildings' design and appearance?', the interviewed residents responded as follows. 80% were 'Very satisfied', 13% 'Satisfied' and 7% 'Neither satisfied nor dissatisfied'. While, when asked 'Overall, how satisfied are you with the architectural approach?', 87% were 'Very satisfied' while 13% did not provide any answer.

Energy

As stated in the other two case studies, during the site visit you can not actually tell anything about the energy efficiency of a building just by passing by, except for noticing different facade elements that help towards the energy efficiency. Although all the buildings are supposed to be built in accordance with the passive house standard, when spending a night at Campus Viva, the author has experienced it slightly differently. It could be because the Campus land was not managed by the city, but obviously the building might not have been built following the principles of passive house, as there was no actively running central ventilation, but instead the room was equipped with an electric fan and the window was opened to keep up with the excessive heat in the room. The responses from the residents indicate positive experience concerning the energy efficiency in Bahnstadt. The question 'Overall, how satisfied are you with the 'Energy' approach?' was responded 'Very satisfied' by 93%, whereas 7% did not provide an answer. The feedback from general open questions at the end includes statements like 'Energy consumption is not high, buildings are quite well insulated and we are very happy with it', another one stated 'I used to live in an old building in the city before I came here, the level of energy consumption and the costs are not comparable which is very good economically, but above all the quality of life and the comfort are something that are highly valuable emotionally and physically'. One interesting insight is from another resident, 'We live in one of the buildings near Pfaffengrunder Terrasse, I will be honest, it used to be quite hot during the summers, maybe because of the reflection from the paved area, but now that the city has replaced it with grass and planted trees, it feels much cooler'.

Mobility

When it comes to mobility in Bahnstadt, residents are very open to all options and means of transportation. While majority speak highly of the reliability and convenience of public transportation network, as well as biking and walking infrastructure, a few others admit that cars still play an important role in Bahnstadt's mobility. Those who speak about cars would prefer to have electric cars replace the fossil fuel cars, however currently the former still remain a few in numbers. 'I do not understand why someone would need a car when the local tram and bus lines are so reliable and follow a regular schedule, there are a lot of bus and tram stops so walking distance is very short, same is for any regional traveling, we have the main tram station within a few minutes walk' says one of the residents. Another added that 'I am not very happy with the number of cars we have here, I also think residents could do with less cars. I also think we should block most of the parking slots near the streets and just allow the underground parking garages'. When asked 'Overall, how satisfied are you with the 'Mobility' approach?' 67% responded 'Very satisfied', 20% 'Satisfied', 7% 'Not satisfied' while 6% did not answer.

Public spaces

Depending on how you access Bahnstadt, you might experience its public squares and parks differently, when accessing from the main train station, you will most likely be visiting the Zollhofgarten park which is really inviting and has a lot to offer. If you prefer tram service, you might end up in the Gadamerplatz and then continue to the Pfaffengrunder Terrasse which are literally a few steps between, or if you'd rather prefer the bus line, you might choose to go to Schwetzingen Terrasse, however if biking is your preferred mode of travel, the Promenade might be your entry point from the Weststadt or from the other districts thru the green fields. Whichever way you access and whichever location you visit, one thing is for sure, you would see a decent number of people walking around and spending quality time and enjoying everything what Bahnstadt has to offer.

Resident's response to the question 'Overall, how satisfied are you with the 'Public spaces?' gave an unquestioned satisfaction with 93% responding 'Very satisfied', and 7% 'Satisfied'. The feedback from the general open questions at the end to mention here are as follows, 'Bahnstadt offers a lot to young parents, there are a lot of daycare centers that we can choose to take our children. That's extremely helpful and relieving for working parents.' Another one commented on the community activities stating 'We have really good community spaces as well as plenty of activities. Sometimes I feel like we do not need to look at the city for any cultural and social activities as everything

is here. Even residents from nearby districts and other parts of the city come and join us.' Also, a comment about the new conference center claiming that 'The city is building one of the best conference centers in the region, that will bring a lot of visitors. I am not sure if that's good or bad for the community, but I am sure they will generate a lot of income for the local businesses, so it should still be fine.'

Landscape

Compared to the other two case studies, Bahnstadt's landscape might give you the impression that it is still not fully developed. As it seems, there is no lack of trees but most of the trees are not fully grown yet, which is understood given the 'age' of the ecodistrict. So, in some places it feels a bit empty, such as the Promenade area, Schwetzingen Terrasse and especially in Pfaffengrunder Terrasse, however that might be compensated by a bit taller trees in some inner courtyards, water lagoons and Zollhofgarten, that provide shaded areas, increase quality and cool the ambient air. Interviewees show their satisfaction with the Bahnstadt's landscape but also provide some critical insights. 'The Promenade is everything for us, we spend a lot of time jogging, walking, biking or just going out with our kids to spend time in one of the three playgrounds. My kids love them.' states one of the residents, she also offered further comments on the connection with the green fields where residents and visitors can easily continue their walk into the green fields. Another one talked about the water lagoons stating 'Water ponds are a nice place to just hang around, lot of us move from one place to another depending how we feel like, and what time of the day it is'.

One resident claims that 'Zollhofgarten is our favorite place, there are trees, shaded areas, grass, kids playground, and some small sports equipment and courts, so everything is there and very close to our apartment'. Overall 73% responded 'Very satisfied' to the question 'How satisfied are you with the 'Green spaces and other functions in the green spaces?', 13% were 'Satisfied', while others did not provide any response.

A few selected city official interviews have shed light on the feedback provided by the people involved in the project. Dr. Eckart Würzner, Heidelberg Mayor, in an interview with (Stadt Heidelberg, 2019) finds the citizen dialogue and participation very important. He states that citizens' envisioning and desire to develop the district was crucial, the height that we wanted to go with, water and green spaces, the role of the central meeting place, community center and school building at Gadamerplatz, were important aspects which were all integrated into the

planning and implementation, therefore we have a district that was realized based on how the citizens thought and desired.

In another interview (Stadt Heidelberg, 2016) concerning the new tram line in Bahnstadt, Winfried Hermann, Baden-Württemberg Minister of Transport, claims that the Bahnstadt sustainable urban development is a great case where such an opportunity was used. He further suggests that the city and the municipal council should be complemented for having the courage in taking matters into their own hands and developing the site. In the same line, Dr. Eckart Würzner, Heidelberg Mayor, emphasizes the enormous importance of the tram line for the city of Heidelberg, which offers a direct connection to the city center without having to change trams. 'I am happy that we will finally be able to put the tram into operation', he states, and goes on to say that it enables barrier-free access and is friendly for people with disabilities.

4. Chapter 4 - Identification of key urban and architectural categories and indicators

Drawing from the analysis and findings in preceding chapters, and using the compiled data from the comparison tables (Table 3, 4, and 5), in this chapter, the objective is to identify only the key categories and their sets of indicators that are significant and should be further included as part of the design principles. Table 6 provides an overview of thorough assessment and evaluation of all individual categories and indicators based on the criteria of relevance, measurability, sustainability and frequency of use in the case studies. The proposals on inclusion of the main categories and indicators as part of the design principles for ecodistricts have been discussed in section (4.1). In this chapter, the assessment and selection criteria are based on the assumption that an indicator is considered an element (index) that addresses a specific issue individually and better specifies its content, while a category includes all the indicators that are grouped within a particular thematic cluster.

As most of the elements concern climate change and environmental stewardship, to prevent duplication, the environmental components have been spread into all categories, and included as appropriate.

The research community shares different views on what the best approach in presenting the outcomes of the researched data is, and how it would benefit planners and designers of ecodistricts. There are views that the outcome could be a generic checklist approach or a more comprehensive and elaborative way. Also, there are different suggestions on how this data would be best utilized in the future. As such, there are different opinions on the tools and how to approach sustainability initiatives, mainly in favor or against the use of a checklist.

The checklist approach is not seen as appropriate for an integrative model of practice, however setting ambitious targets and checklist approach can trigger innovation. (Oliver, 2018)

(Kyrkou and Karthaus, 2011) note the recent emergence of urban assessment systems in support of sustainable solutions for wider urban scale developments, but advise that beside serving as tools with a simple checklist of

requirements, those systems should offer a 'framework for achieving successful sustainable solutions'. As such, they argue that systems are more powerful than a simple checklist.

The outcomes of this research will be shared in a combined form, a list of categories and indicators, but followed up by a thorough textual elaboration of every single one in both chapter four and five.

4.1. Categories and indicators to be considered for design principles

The analysis of the selected case studies has identified a number of categories, each with a set of indicators that would be considered when preparing design principles. Using the compiled data from the comparison tables (Table 3, 4 and 5), a more comprehensive assessment and elaboration is presented visually in Table 6 and is described in the following paragraphs.

This elaboration and assessment leads to a proposal to include all the main categories as presented in previous comparison tables (Table 3, 4 and 5), while introducing several variations to the list of initially proposed indicators. Table 6 contains relevant data on 'category' and 'proposed indicator'.

'General data' as a main category, contains three relevant indicators that have been proposed to be considered in the design principles for ecodistricts. Indicators such as: 'Site condition' (the actual site conditions, whether the site is, a formerly used land for other commercial, industrial or military purposes or as otherwise known as 'brownfield', or agricultural land that had no other purpose which is labeled as 'grassland', or other type); 'Area' (size of available land which has been planned for an ecodistrict purpose); 'Population' (the number of planned population of the residential development, and plans for axillary services that support jobs, social and economic, and other aspects).

Not all the initial indicators have been proposed for inclusion in the 'Urban planning approach' category. Due to coverage under green spaces 'Non-public green areas' has been excluded from the initial indicator list, while 'Floor space index' and 'Street spaces from an edge-to-edge' have been combined with 'Urban density' and 'Building height limit' respectively.

Therefore, this category contains six relevant indicators that have been proposed to be considered in the design principles for ecodistricts. Indicators such as: 'Position in relation to the city' (as indicated by the name, this

concerns position of the ecodistrict in relation to the city, distance from the city center and surrounding districts, access by public transport, main access roads etc); 'Urban planning competition' (if the criteria and design requirements are to be set by the city and what should they include); 'Blocks of residential complexes' (arrangement of urban blocks, such as 'semi-open' blocks, 'classic' closed blocks, linear arrangement blocks, point blocks or free form blocks); 'Urban density' (analyze number of residents and apartments per hectare, residents per apartment, as well as if low, medium or high density; focus the majority of population in proximity to the public transportation hubs and public squares; floor space index); 'Buildings height limit and distance of spaces between them'(specification of height limit, distances of the edge-to-edge street spaces and similar); 'Mix-use' (mix-use blocks with public, office and commercial functions, help in avoiding travel to further parts of the city, combination of residential use in higher floors, offices, studios in first floors, commercial in ground floor, storage areas and parking garage underground.

In the 'Architectural approach' category, two relevant indicators have been proposed to be considered in the planning and design principles for ecodistricts. Indicators such as: 'Building design ' (buildings sizes, detached houses, terraced houses, multi-family houses and apartment buildings; flexibility in solutions and diverse architectural appearance; different colors and textures); 'Individual owners, group owners, and property developers' buildings (position in the district, percentage, use of different plot sizes and shapes). As a result of differences between the case studies and less prominence, the 'Cooperative-oriented property developers' has been excluded and will not be part of the design principles discussion.

'Energy' as a main category, contains three relevant indicators that have been proposed to be considered in the planning and design principles for ecodistricts. Three initial indicators 'Low-energy buildings', 'Passive house standard buildings' and 'PlusEnergy housing' have been combined into one indicator 'Low-energy, passive house, and plus-energy buildings'. Indicators such as: 'Low-energy, passive house, and plus-energy buildings' (if mandatory requirements set by the city standards for low energy buildings or passive house standard and plus-energy housing, solar settlements, thermal solar collector panels) combined heat and power – CHP (combined heat and power system, number of units, renewable fuels (natural gas, wood-chip or other), heat pumps and a thermal storage systems), wind power (wind turbines location - nearby fields or in the hills, size and capacity).

Almost all of the initial indicators have been included in the 'Mobility' category. The 'Public transportation' (proximity to the city, distance and time it takes to reach city center, tram line service placed on the long axis of the ecodistrict, 500 m' radius walking distance tram or bus stops, one stop near the main public square); 'Main access and inside roads' has been combined with 'Car-reduced concept' (discourage car use, more community space, better air quality, lower noise levels and less disturbance for residents, sidewalks, traffic calming measures, adequate lighting, allocating vehicular traffic on the perimeter, no high traffic within the ecodistrict, a minimum number of parking spaces for loading and unloading); 'Quiet residential roads' (walking speed, parking is not allowed, possibility to use an additional open space); 'Parking garages' (whether focus on large car parking garages or several underground parking garages at the basements of the apartment buildings, or other alternatives); 'Bike and pedestrian friendly' (promote bicycling and walking, plan for biking lanes and pedestrian walkways, include proper traffic signage, bike parking spots, network of off-road paths).

'Public spaces' category has four initial indicators that have been combined into one relevant indicator which has been proposed to be considered in the planning and design principles for ecodistricts. Four initial indicators 'Public squares', 'School', 'Kindergartens' and 'Youth and community centers' have all been combined into one indicator 'Public squares and other public amenities' which includes (main public square (function as multipurpose: gatherings, green market etc), additional community parks, commercial functions, common indoor spaces, primary school, daycares and kindergartens, community centers).

Last category on the list, 'Landscape' has four relevant indicators that have been proposed to be considered in the planning and design principles for ecodistricts. First two initial indicators 'Green spaces' and 'Other functions in green spaces' have been combined into one indicator 'Green spaces and other functions in green spaces' (connection between the surrounding green areas and the district green parks, network of semi-public and private green spaces within the urban blocks, green corridors, provide leisure and recreational spaces and walking paths, plan for fresh air circulation deep into the ecodistrict, perimeter tree alleys for recreational walking and biking, children playgrounds throughout the ecodistrict, possible use of excavated soil for creation of various onsite landscape design elements); 'Green roofs' (green roofs applied in as many buildings as possible, consider green roofs in reducing heat from the air, moderate the urban heat island effect, lower energy consumption, quality of

life, rainwater management); 'Rainwater' (on-site rainwater retention, discharged into the open and naturally drain into the ground, green roof rainwater collection and storage); Green gardening (green gardening within the district or use of nearby farm).

Table 6. Identification of key urban and architectural categories and list of proposed indicators for further use in principles of planning and designing of ecodistricts (source: Bardhyl Rama)

Category	Proposed Indicator for use in design principles
General data	Site conditions
	Area
	Population
Urban planning approach	Position in relation to the city
	Urban planning competition criteria
	Blocks of residential complexes
	Urban density
	Buildings height limit and distance of spaces between them
	Mix-use
Architectural approach	Building design
	Individual owners, group owners, and property developers buildings
Energy	Low-energy, passive house, and plus-energy buildings
	Wind Power
	Combined Heat and Power (CHP)
Mobility	Public transportation
	Car-reduced concept
	Quiet residential roads
	Parking garages
	Bike and pedestrian friendly approach
Public spaces	Public squares and other public amenities
Landscape	Green spaces and other functions in green spaces
	Green roofs
	Rainwater
	Green gardening

5. Chapter 5 - Principles of planning and designing of ecodistricts based on outcomes of case studies comparison

Cities and the built environment have an enormous potential to contribute to the action against climate change, and provide a social, sustainable and eco-friendly living. However, there are barriers that cities face when tackling those issues. In many cases, cities are considered too big of a scale to address these problems especially when there is an 'experimental' phase. On the other hand, buildings alone, while they can contribute individually, it is considered that they are too small to address those challenges. Ecodistricts neither are at the big city scale nor at the small single building scale, therefore they are considered a suitable scale to deal with many issues and barriers when aiming to achieve urban sustainable development and carbon neutral future.

The comprehensive elaboration and analysis of three case studies of ecodistricts in the third chapter, has opened the way for the study to continue in the fourth chapter with further assessment and preparation of a recommended list of specific categories and indicators that encompass valuable design information and are essential to be included in the design principles. This compiled recommended list has thoroughly been assessed and elaborated in detail in this chapter, as part of the research goal of exploring the lessons learned and proposing ecodistricts design principles.

It is essential to point out that, it is not the intention of this research to discuss and elaborate the guidelines, regulations and parameters of urban and architectural aspects of standard and conventional design, but rather elements of ecodistrict design that encourage, promote, initiate, enable and implement sustainable strategies and climate friendly approaches and solutions. The follow-on discussion in this chapter will be drawn from this point of view.

Following the analysis and findings from Chapter 3 and a list of categories and their indicators in Chapter 4, as part of one of the research goals, a thorough elaboration and analysis of the lessons learned has been carried out, and a set of principles of planning and designing of ecodistricts has been presented in this chapter.

5.1. General data

Highlights: What are the site conditions and the land size? How many residents?

Table 7. Compiled 'General' data for the three case studies (source: Tables 3, 4 and 5)

General data			
	Vauban	Kronsberg	Bahnstadt
Site condition	Brownfield	Greenfield	Brownfield
Area	41 hectares	70 hectares	60 hectares (area managed by City Development Company-EGH)
Population	Approx. 5,500 residents in 2,531 apartment units	7,150 residents, over 3,200 apartment units	6,800 residents, over 3,700 apartment units

5.1.1. Site conditions

As it can be learned from the case studies, depending on a number of conditions that a city has put forward, ecodistricts can be planned on different sites. Most commonly found in the case studies are two, brownfield and greenfield areas. Each one has its own specifics and would need to be treated differently in the planning and design phase. While when developing an ecodistrict on the greenfield, the design and planning are, inter alia, mainly focused on challenges in minimizing the biodiversity loss and saving water table finding ways to replenish it, development of ecodistricts in the brownfields has its own additional challenges, from dealing with the soil remediation due to potential pollution from previous functions such as city harbors or old military bases, to addressing the existing infrastructure. The reuse of any existing structures would be highly recommended. Looking from the land use perspective, while the former has to do with loss of greenfield and its biodiversity, the latter, although more challenging, entails reclaiming the unused pieces of land and giving life and natural biodiversity back to them.

On the one hand, Vauban and Bahnstadt districts as case studies which were developed on brownfields, clearly show the challenges that the city and the community faced and the successful design and practical solutions applied. On the other hand, Kronsberg, as an ecodistrict that was developed on greenfield, demonstrated design solutions that, among many others, successfully prevented biodiversity loss and water table depletion.

5.1.2. Area

The planned area for an ecodistrict development is an important aspect, as it really determines what other functions could be planned as part of the housing development. The size of the area differs and is based on a number of factors, but first and foremost on the availability of city land. Then other factors such as the city needs for current development and future expansion, the follow-on infrastructure planning and construction and other similar issues. All those and many more, generally influence the decision on overall size and land area that will be dedicated to an ecodistrict.

The size of the analyzed three case studies varied from 41 hectares (Vauban) to almost double that, about 70 hectares (Kronsberg) to a relatively similar area of 60 hectares (Bahnhofstadt). About 40% planned for residential, while the rest includes public spaces, green areas, traffic, industrial use and similar (Vauban and Kronsberg). Whereas Bahnhofstadt mixture of functions includes much more office spaces as well as a campus, therefore of the 60 hectares managed by the city company, 15% are for residential use, 27.5% for commercial, 7.5 % campus, the rest is dedicated to open spaces and public infrastructure.

5.1.3. Population

The population size of an ecodistrict is in direct proportion with its allocated land area. The case studies have a solid number of residents, Vauban has approximately 5,500 residents in 2,531 apartment units, Kronsberg approximately 7,150 residents in 3,200 apartment units, while Bahnhofstadt has a total of 6,800 residents spread in 3,700 apartment units.

As it is shown in the case studies, a mixture of household types, ethnicities, cultures, ages, occupations, educational and income levels, is a successful population plan that is suitable for an ecodistrict. While the average age is quite young, the ecodistrict case studies host residents of all age levels.

Case studies also show that population size, composition and allocation within the city and parts of the city reflects the overall planning of population structure, and can help determine the services demand.

Plans for a residential development with a certain level of population shall be followed up with a careful planning of adequate housing amenities, social services, public transportation, roads, water and power supply, public and green spaces need to be planned to meet the needs of new households.

5.2. Urban planning approach

Highlights: What is the best distance in relation to the city center? Which block forms have been mostly used, what is the urban density? Has the mix-use been introduced?

Table 8. Compiled 'Urban planning approach' data for the three case studies (source: Tables 3, 4 and 5)

Urban planning approach			
	Vauban	Kronsberg	Bahnstadt
Position in relation to the city	4 kilometers from the city center - 20 minutes by tram	9 kilometers from the city center - 20 minutes by tram	Less than 4 kilometers from the city center - about 23 minutes by tram
Urban planning competition criteria	Set by the city	Set by the city	Set by the city
Density	Approximately 134.9 residents/hectare; 2.2 residents/apartment; 61 apartments/hectare	102 residents/hectare; 2.2 residents/apartment; 45 apartments/hectare. Medium to high density	113.3 residents/hectare; 1.84 residents/apartment; 61.6 apartments/hectare
Floor space index	Around 1.4	1.2 floors (0.7 for individual buildings)	Varies between min. 0.6 to max. 3.0
Blocks of residential complexes	'Classic' closed blocks not used, dominates the linear arrangement blocks, few other forms are present, such as point blocks and one 'semi-open' block which is designed in a free (irregular) building shapes.	Several 'semi-open' blocks, 'classic' closed blocks not used, many linear arrangement blocks, few other forms such as point blocks are present as well	'Semi-open' blocks, with a courtyard and openings at certain points, are used in most cases, a very few linear arrangement blocks, a few cases of combined u-shaped, and one long line of a pre-existing building.
Building height limit	Approx. 13 m	Not specified (highest approx. 15 m)	Approx. 20 m height for residential buildings along the main road, lower height (16 m or lower) for other locations
Street spaces an edge-to-edge	20 m - distance	25 m (main green corridor 40 m)	40 m (in the main road)
Non-public green areas	20 m - between the individual buildings	Various (50 m for large ones, 22-25 m for smaller ones)	Approx. 30m - varies for different inner courtyards
Mix use	Yes. Sun Ship a case of the multifunctional use concept.	Mixed-use blocks up to five stories high	Mixed-use blocks between three to six stories high

5.2.1. Position in relation to the city

For obvious reasons, the distance from and position in relation to the city center is crucial when choosing an ecodistrict development site. Proximity to city services, jobs, commercial, educational and recreational areas is one of the key factors for people when choosing where to live.

Depending on the availability of land, the ecodistricts might be located within the city, cases of old harbors, former military bases, urban wasteland or sites no longer in use (generally known as brownfields), or in a suburb area that are planned as new development (also known as greenfields).

In the case of the city center, many advantages exist. The proximity to the city center allows for more flexibility in planning more commercial functions within the district, thus making the jobs available even at the location. Another better aspect, among others, is mobility, being close to the city offers very good public connections and also easy and convenient walking and biking, sometimes within a few minutes from the city center. However, green spaces and open areas, although should be adequately planned, might have some shortages compared to the sites in greenfield areas. Noise might be another issue that is related to all city activities including traffic, railway and highway connection as well as any nearby industrial functions.

In cases where an ecodistrict is developed in the suburbs in open greenfields, there would be plenty of green areas and qualitative spaces for leisure activities, quieter ambiance and much less noise, however the job opportunities and options might be far less. Another less convenient aspect is of course travel to and from the city center.

The three case studies (Vauban, Bahnstadt and Kronsberg) show that any site that is located between 4-10 kilometers from the city center with a good public transportation connection, allowing to reach the city center in about 20 minutes, is a suitable site (Figure 5.1).

It is understood that not all the cities have the possibility to select sites in this proximity, however having a dedicated direct and faster public transportation lines would be able to mitigate this and still cut the travel time for cases with a little bit of a longer distance.

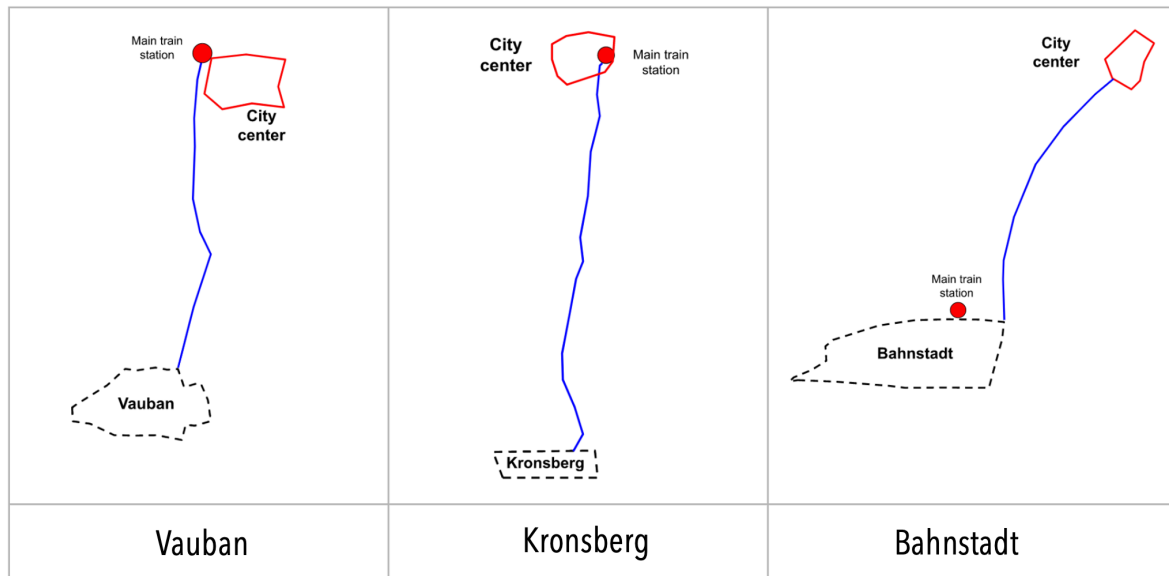


Figure 5.1 Case study ecodistricts position in relation to the city center and the main train station. (**Not to scale*)
(source: compiled by Bardhyl Rama, info from the literature)

5.2.2. Urban planning competition criteria

The decision to expand the residential capacity and its follow-on infrastructure and services is by default a responsibility of the city planning office. However, to avoid any issues, timing is of the essence. Phenomena such as 'informal settlements' while not so much encountered in the Western Europe, are a common issue in different developing countries around the world. Therefore, cities in Europe strive to keep the balance between offer and demand for new housing, this allows for proper allocation of financial resources to construct the needed infrastructure, but also careful planning on land use. In addition to this, due to many environmental issues and climate change concerns, cities around the world have stepped up and increased their efforts to contribute to reduction of the carbon footprint and offer long-term mitigation solutions. As a result, in addition to many other measures, ecodistricts are seen as a tool for cities to offer their contribution on zero carbon society ambition.

The urban planning competition criteria in the case studies have been set by the respective city planning office, their focus was the overall sustainability, but included specific factors, such as encourage use of public

transportation, biking and walking, minimize car use, increase livability, proximity to the job places, public spaces, green areas and similar.

A good approach in the design criteria, is purposely leaving open certain specifications, like exterior appearance, materials, colors, roof plan. It has shown that this has allowed designers to express more creativity in their own designs, and offer flexibility and a variety in architectural solutions for buildings as part of the whole ecodistrict.

5.2.3. Blocks of residential complexes

Livable and energy efficient cities have characteristics such as small sized urban blocks and street aligned buildings that create diverse street frontages and lively walkways (ESMAP, 2014). (Tarbatt and Tarbatt, 2020) identify a number of block forms such as, perimeter block, row block, point block, ribbon block, courtyard block, as well as other variants of urban forms to include court, close, and cul-de-sac.

It is not common to design a perimeter block with an uninterrupted line. (Lehmann, 2016) states that medium-density perimeter block provides a range of advantages, including smaller land use footprint and less building envelope surfaces, reducing summer heat gain and winter heat loss, reduced construction impact, lower embodied energy and energy consumption.

The 'classic' closed blocks have not been used in the case studies, however linear arrangement blocks and a few other forms, such as point blocks and a 'semi-open' block are present in all case study ecodistricts, with Bahnstadt being the best case for making use of the inner courtyards (Figure 5.2). These indicate that the use of diverse urban block forms helps achieve high quality urban spaces while combining different urban approaches that enable seamless transition from one block to the other and present architecturally pleasing buildings.



Figure 5.2 Arrangement of urban blocks for all three case studies (**Not to scale*) (source: compiled by Bardhyl Rama, info from the literature)

Depending on the city they are developed for, there is a variety of urban blocks sizes. In some of the European historical cities, block size is around 70 to 100 meters, which coincides to the scale of a walkable and livable urban space. The much bigger size (200 to 500 meter) blocks that are found in a number of high-rise urban developments as well as residential areas in outskirts, are no longer pedestrian friendly and do not promote walking thus encouraging use of cars. (ESMAP, 2014)

These large size blocks should be avoided when planning and developing future ecodistricts, as pedestrian friendly blocks, among others, are core sustainable measures of the ecodistrict.

5.2.4. Urban density

In urban planning and design, planners use 'urban density' as a scale to depict the number of inhabitants and the quantity of floor area built on a defined urbanized area (Lehmann, 2016). According to (Alexander et al., 1987) sustainability of a neighborhood and its urban livability are highly reliant on urban density.

A number of studies promote high density with the aim to minimize land use and allow for more green areas (Bottero et al., 2019). To address this, a useful instrument is the general development plan of an ecodistrict, which helps in setting urban and architectural parameters. When evaluating the density of a district, a number of diverse methods have been employed. Residential units per hectare, number of residents per hectare, habitable rooms per hectare and beds per hectare, have all been used in literature to express the urban density (Woodford et al., 1976) and (Dempsey et al., 2009). Urban density is a significant factor that determines a lot of parameters in an ecodistrict.

Analysis of the three case studies indicate that the urban density has been given considerable attention at the start of planning of each ecodistrict. Numbers attributable to each ecodistrict are slightly different from one case to the other. In Vauban there are about 135 residents per hectare and 61 apartments per hectare, in Kronsberg there are about 102 residents per hectare and 45 apartments per hectare, while in Bahnstadt 113 residents per hectare and 61 apartments per hectare, which translates to medium-to-high density. Interestingly both Kronsberg and Vauban cases share about the same number (2.2) of residents per apartment, but Bahnstadt number of residents per apartment is a bit lower (1.84).

This clearly indicates that the majority of the ecodistrict planning elements are based on and start from almost the same benchmarks in terms of urban parameters. Similar approach is suggested in the literature. (ESMAP, 2014) points out that in order to avoid overloading and clogging up the infrastructure, proper planning of urban density in relation to its infrastructure is essential and must be accounted for when planning an ecodistrict.

Case studies also clearly elaborate the fact that starting with the high-density housing blocks along the public transportation line, then lower density in the middle and ending up with the family houses at the furthest point, helps concentrate the majority of population near the public transportation hubs and public squares.

5.2.5. Building height limit and distance of spaces between buildings

Building type, height and other factors can have an effect on a number of issues (Dempsey et al., 2009), as such building characteristics and its surroundings impact urban living.

Above shown table (Table 8) represents a comparison of data of the building height limit and distance of spaces between buildings for case study ecodistricts. As it is indicated, the numbers are not too far apart. In general, Kronsberg and Bahnstadt's buildings are a bit taller (15 and 20 m respectively) compare to those of Vauban (13 m), similar difference is noticeable on the street spaces edge-to-edge distance, 40 m (in the main road) for Bahnstadt, 25 m (main green corridor 40 m) for Kronsberg, and 20 m distance for Vauban. The semi-private green areas are at various distances with 50 m for large ones and 22 m smaller ones, in Kronsberg, while 20 m and 30 m for Vauban and Bahnstadt respectively.

The comparison table indicates that these three parameters play critical functions in the urban planning and design and should be prudently studied when designing the ecodistricts.

5.2.6. Mix-use

Ecodistricts should encompass a well-adjusted number of mix-use buildings, a cautiously planned mixture of residential, office, commercial and other public functions.

Mixed-use is one of the crucial elements in defining the urban livability and sustainability of a neighborhood (Alexander et al., 1987). Mixed-use developments play an important role in reducing the travel distances, thus encouraging walking and biking, while minimizing driving (ESMAP, 2014), as well as making best use of infrastructure by creating urban spaces that are active at any given time (Grant, 2002).

The case studies show that mix-use is applied throughout the ecodistricts. Public, office and commercial functions such as supermarkets, restaurants, cafes, medical practices, pharmacies, offices, daycare, kindergartens, school, community center and similar. Those provide educational, cultural, shopping and retail services, avoiding travel to further parts of the city (Foletta and Henderson, 2016), and are more likely to offer employment locally (Lehmann, 2016).

In Vauban, a really good example is the 'Sun Ship', a three-to-five story mix-use complex (Figure 5.3). The designer, (Rolf Disch SolarArchitektur, 2000) explains that this is a combination of residential use (penthouses) in higher floors, offices, studios and medical practices in two upper floors, while commercial use (supermarket, pharmacy, bank and similar) in ground floor), underground floors are used for storage areas and parking garage.



Figure 5.3 View of 'Sun Ship' mix-use complex in Vauban (source: (Rolf Disch SolarArchitektur, 2000))

While in Kronsberg and Bahnstadt, mix-use is mainly applied around the main public squares, it includes the community center, the shopping mall, medical facilities, and other mixed-use buildings in the area that include daycare, kindergartens, offices, shops and other commercial services.

With this, it can be concluded that mix-use application is vital for the success of an ecodistrict. The approach and the mix of functions varies and depends on the case study, however all aim at providing the residents with quick and easy access to various services, thus increasing the quality of life and urban environments, while reducing travel and minimizing car dependency.

Finally, many public buildings, such as schools, kindergartens, community and youth centers and other amenities are part of the public spaces category in this study. However, it is worth mentioning that their physical volume, follow on infrastructure connected to them as well as the spatial arrangement and access is very significant for urban planning aspects, therefore should be considered as functional areas in this respect as well. Same should be taken into consideration when it comes to sports facilities and recreational areas, such as football, basketball, handball, tennis courts, other smaller sports such as table tennis as well as biking sports and recreation paths, equipment and facilities.

5.3. Architectural approach

Highlights: How has the building design been addressed, what kind of buildings, and what size plots are used?

Table 9. Compiled 'Architectural approach' data for the three case studies (source: Tables 3, 4 and 5)

Architectural approach			
	Vauban	Kronsberg	Bahnstadt
Building design	Flexibility in solutions and varieties (lively character and diverse architectural appearance)	Architecturally varied townscape - different colors and textures	Unique ecodistrict identity, dominated by white colors, but some other light variation present as well. Inner courtyard used as an enriching feature of quality of life.
Individual owner buildings	Yes. constructed on 6 m and 9 m wide parcels	Planned and constructed uphill (10% of dwellings)	Only on terraced buildings (row houses)
Group owners buildings	Four-story multifamily houses (two two-story housing units - maisonette)	Buildings of two to four floors - including maisonettes - mainly placed in the middle of the district	Three to four stories buildings - maisonettes as well - mainly placed in the promenade area
Property developers buildings	Apartment buildings, mix of both condos and rented apartments	4-5 floor residential complexes - generally allocated at the lowest ground	Four to six stories residential complexes - mainly allocated along the main streets and the main public squares. Mix of condos and rented apartments
Cooperative-oriented property developers	SUSI	N/a	N/a

5.3.1. Building design

The design approach of a building and its location should integrate and offer solutions on how the building is accessed, understood and used by all people regardless of their age, size or disability, this approach is also called 'universal design'.

Building design along with infrastructure design are important elements in planning and implementing ecodistricts. All three case studies, Vauban, Kronsberg and Bahnstadt, indicate that building design, apart from many other functions, contributes to the originality and identity of an ecodistrict.

That is also reflected in many cases in literature. The key design ambition is to create visually appealing apartment buildings that will provide proper shelter and high quality living environments for future residents (DoEHLG, 2007; DoEHLG, 2009). Buildings need to be designed and configured to support day-lighting, ventilation, and other energy efficiency measures (ESMAP, 2014). Further, (BMUB, 2016) concludes that a holistic approach needs to be considered when contemplating plans for a sustainable building. A purposeful building design concept optimizes the use of spaces, functions, interiors, infrastructural accessibility and similar.

Residential buildings characteristics can impact living experience, studies show that the urban environment experience of the residents living in the detached houses with large gardens, is different from the residents of high-rise apartments in the city center. (Dempsey et al., 2009)

An interesting approach is noticed in Vauban, which is known for promoting building cooperatives formed by groups of residents. This way residents could actively participate in designing and constructing their homes (Llewelyn, 2000).

As depicted in Figure 5.4, residential buildings with typologies shaped by individual builders, developers, construction groups, cooperative-oriented property developers, SUSI and Student Services are spread throughout the Vauban ecodistrict. (Lemes de Oliveira, 2017) indicates that Vauban is a case of a 'less urban appeal but with openness and smaller size buildings'.



Figure 5.4 Schematic view of the distribution of residential buildings with different typologies in Vauban (source: (City of Freiburg, 2008))

Kronsberg and Bahnstadt are great examples of the role and importance of building design in the whole ecodistrict impressions and experience not only by the inhabitants, but visitors as well.

Residential complexes

Several types of residential buildings appear to be applied in the case study ecodistricts.

Four-to-five story conventional massive structures for residential complexes, very well insulated, bricks or renderings facades with combinations of different colors (Vauban and Kronsberg), and generally white facades with some contrasting sections (Bahnstadt). Openings on the street side and on the courtyard, and with concrete or steel construction loggias and balconies. Floor plans organized in different layouts, from two to three apartments on each landing, and two to five rooms per apartment (Figure 5.5 left).

Apartment blocks

Apartment block rows, could have facades out of bricks or renderings, could contain the setback penthouses with single-pitch roofs and rooftop terraces, but in some cases green roofs as well. Floor plans vary from two to three apartments on each landing and one to five room apartments (Figure 5.5 right).

A typical apartment layout includes standard and commonly found apartment spaces and functions such as, living room, kitchen, dining area, bedroom(s), bathroom, hallway and terrace(s). Access is from the stairs that are usually placed in the middle of the building block to avoid long distances and maximize space usage.

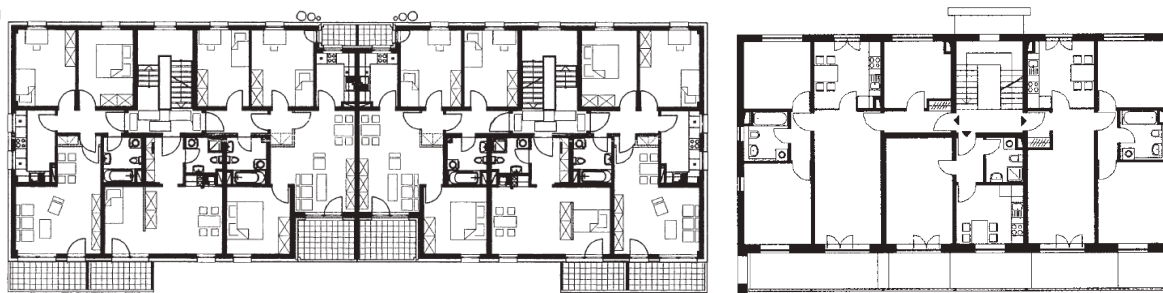


Figure 5.5 Floor plan view of residential complexes (left) and apartment block (right) (source: (Schottkowski-Bähre, 2000))

Smaller size residential building

Another type found in the ecodistricts is the smaller size residential building, where the block comprises buildings of two to four floors, with mainly two to three apartments per landing, with apartments spread across two or three

floors (maisonette). Could have prefabricated concrete sandwich elements or rendering facades, as well as green roofs.

Terraced houses

Constructed out of masonry and wood (Kronsberg) and concrete construction (Bahnhofstadt), terraced houses are also found to be a good approach to attract individual builders, who, not only increase the variety of building design, but also help at the initial phase with making a good appearance of the whole site by building and occupying their buildings ahead of others in the ecodistrict.

A special type of buildings are the 'exclusive penthouses' (Figure 5.3) constructed on top of the commercial building roof (Rolf Disch SolarArchitektur, 2000).

Attached two-family homes and detached single family buildings, although used in one of the case studies, due to the space they occupy and other planning aspects, do not seem to be a preferred building form for an ecodistrict. Case studies clearly elaborate that, although some of the parameters were predefined, the fact that the city planning offices chose to leave many architectural design features unspecified, had resulted in more flexibility in design solutions and opened room for a vast variety of building designs with lively characters and diverse architectural look. Another aspect, that contributes to these myriad of creative ideas, is allowing multiple (over forty in Kronsberg) architectural and landscape design offices to take part in the design and development of the ecodistricts.

These strategies should be contemplated by city planning authorities when planning new ecodistricts.

5.3.2. Individual owners, group owners, and property developers' buildings

Architectural diversity and variety in an ecodistrict have their values and advantages. This is achieved through many ways, however the approach taken in Vauban, has shown really good results.

When discussing achieving diversity through small development parcels, (Llewelyn, 2000) concludes that Vauban ecodistrict has accomplished a 'rich variety of building types and styles' by promoting 'self-build projects' and initiating 'small development parcels'.

Almost similar approach was taken in Kronsberg as well, there are various types of residential buildings. However Bahnstadt seems to be organized much more thru developers and construction companies rather than groups of owners.

Based on the analysis from the case studies, use of different individual plot sizes and shapes is highly recommended. The plot sizes may vary from 160 m² for individual builders, to over 5,000 m² for plots allocated to commercial investors. Building stock might include a percentage of terraced houses, while the majority consists of four-story multi family houses and apartment buildings. As indicated above, for a number of reasons detached single family houses and two family buildings are not necessarily recommended to be part of the ecodistrict.

5.4. Energy

Highlights: Which types of energy efficient buildings have been commonly used? What kind of renewable energy strategies have been applied?

Table 10. Compiled 'Energy' data for the three case studies (source: Tables 3, 4 and 5)

Energy			
	Vauban	Kronsberg	Bahnstadt
Low-energy buildings	Mandatory requirement - construction of low-energy buildings (not more than 65 kWh / m ²) in accordance with the city's standards	All residential buildings in the Kronsberg district were built as Low Energy Houses. Each building requires a proven maximum heating energy of 55 kWh per m ² per year	All Bahnstadt's buildings have been built in accordance with the Passive house standard.
Passive house standard (15 kWh / m ² a) buildings	Over 30 passive houses	Lummerlund consists of 32 terraced family houses	All buildings
Energy plus housing	Solar Settlement a terraced house complex is the very first PlusEnergy housing community	105 apartment units in the Solarcity complex are heated from about 1,350 m ² of thermal solar collector panels	N/a
Combined Heat and Power (CHP)	The biomass (natural gas and wood-chip) CHP plant supplies the district with electricity and heating, incorporates heat pumps and a heat storage system.	Two natural gas-powered CHP units provide district heating as well as electricity to the entire community	Highly efficient wood-chip burning CHP unit provides power and district heating for the ecodistrict

Wind Power	The six wind turbines built in 2003 on Mount Rosskopt produced 12.9 million kWh in 2007, i.e. 1.29% of the city's energy needs.	Three large wind generators (3.58 MW), which provide a significant portion of the electrical power needs of the community	The city is considering two wind turbine sites, two to three wind turbines in each location
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5.4.1. Low-energy, passive house, and plus-energy buildings

In the city standards, setting the mandatory requirement at a certain amount of energy for the ecodistrict buildings as part of the overall sustainability vision for the new housing developments, seems to be very effective. The buildings in the case study ecodistricts (Kronsberg and Vauban) were built not only to meet the minimum low-energy buildings requirement (65 kWh/m²a) set by the city, but a lot of them went beyond this requirement and constructed passive houses (15kWh/m²a) and even so-called solar settlements which are plus-energy buildings that, overall, they produce more energy that they consume in a year-round.

Solar panels installation has found good application in all three case studies, however much more visible in Kronsberg and Vauban, and in only a few buildings in Bahnstadt.

Bahnstadt, on the other hand, was entirely built based on the Passivehouse standard, which results in overall low energy demand. Therefore, further improvements for future ecodistricts can be suggested to make passive house standard mandatory for all the buildings in the district.

5.4.2. Combined Heat and Power (CHP)

The Combined Heat and Power Act (Federal Ministry of Economy and Energy, 2016), among others, focuses on combating climate change and increasing flexibility. CHPs are low-carbon technology therefore contribute to low emissions ambitions, while flexibility is possible as CHPs are a mini grid installation and operate independently, but can feed the excess power into the city grid.

In all three case studies, Kronsberg, Vauban and Bahnstadt, the CHP plants provide the ecodistrict with clean and carbon free power.

Concerning the electricity production and district heating for future ecodistricts, in addition to the wind power, employing one or two decentralized combined heat and power (CHP) plants that run using renewable fuels is highly recommended. This would diversify the energy production and ensure that back up power is available for

any emergency cases. Distribution of the space heating and hot water to individual units is enabled by the district network.

5.4.3. Wind Power

Case studies show that wind turbines are a critical source of clean electricity. They should absolutely be planned at the very beginning of the ecodistrict energy plans. Whether nearby grass areas (Kronsberg) or up in the hills (Vauban case), it really depends on the source of the wind currents, but planning for multiple wind turbines is highly suggested. The number of the wind turbines and their sizes is related to the ecodistrict's power needs, but even if more power is produced than what is needed, it can always be shared on the grid providing other places with clean energy. In Bahnstadt's case, the city is considering two wind turbine sites that will not only support Bahnstadt, but also contribute to the whole city's energy mix.

The lessons learned from the case studies are, among others, that they all promote a micro grid power system and plan for the district not only to be fully energy independent from the city, but even be able to contribute to the city's power needs. This strategy helps cities be much more resilient and responsive to any natural or man-made disasters and fight climate change, with minimum interruption in services and very quick recovery.

5.5. Mobility

Highlights: Which sustainable mobility strategies have been applied? How have public transportation, biking and walking been addressed?

Table 11. Compiled 'Mobility' data for the three case studies (source: Tables 3, 4 and 5)

Mobility			
	Vauban	Kronsberg	Bahnstadt
Public transportation	Yes. Tram and bus stops within 500 meters	Hanover city center by tram line (less than a 20-min ride). Furthest residential unit within 600 meters to one of the three tram stops	City center by tram line (around 23 minutes ride). Furthest residential unit within 550 meters to one of the three tram stops or bus line stops

Car-reduced concept	The district has followed a car-reduced approach.	The roads in the district are traffic calmed - discourage car use	The roads in the district are traffic calmed - discourage car use. However, as it seems cars are quite present on all the streets. Given the great public transportation and bike possibilities, car owners might be encouraged to consider shifting to those climate friendly options.
Bike and pedestrian friendly	Many streets and the majority of areas are designated as pedestrian and biking friendly zones. Bicycle parking places.	Traffic calmed roads encourage walking and biking - a well-shaded pedestrian and bicycle lane runs through on the north-south axis -network of off-street pedestrian paths connects the open playgrounds and parks of the green interior courts with the gridded streets, providing residents richly varied paths for walking	Over four kilometers of bike lanes, and the network keeps expanding. Traffic calmed roads encourage walking and biking. Promenade is a convenient pedestrian and bicycle lane along the whole southern line of the ecodistrict Pedestrian pathways interlink the sidewalks along the street network with the open playgrounds, small parks, inner courtyards and other green parts, enriching the whole walking experience.
Main access and inside roads	Main access and inside roads speed limit is 30 km/h, parking spaces along the road	Inner roads speed limit is 30 km/h, parking spaces along the road	Inside roads speed limit is 30 km/h, parking spaces along the road
Quiet residential streets	Residential streets the traffic at walking speed, no parking spaces, only loading/unloading	Through traffic on the urban blocks not allowed	Quiet streets exist, however some small level of car traffic in the urban blocks is allowed
Parking garages	Two designated parking garages. Open space parking places on some streets.	On the building basements (no designated garage building), open space parking as well	A lot of car parking space in underground garages in the building basements (no designated garage building), open street parking space as well

5.5.1. Public transportation

Recent studies indicate that although there is a lot of literature in this field, the need for further knowledge of how to assist 'people's judgments as regards switching to sustainable alternatives' is still present (Friman et al., 2018). A good ecodistrict mobility plan with the focus on public transportation can increase the influence on people's decision to use sustainable means of transportation.

Case study ecodistricts used in this research (Vauban, Kronsberg and Bahnstadt) are located in relatively close proximity to the city center, it takes roughly about 20 minutes by public transportation to reach the main part of the

ecodistrict (Figure 5.6). These might represent some of the 'best case scenarios' in terms of site locations, however shorter and quicker commute distances to and from the city center should be aimed for during the planning phase. Most of the residents employed in the city have to use the public service on a daily basis, therefore studies show that less time spent on daily travel means more time available for family and other free activities.

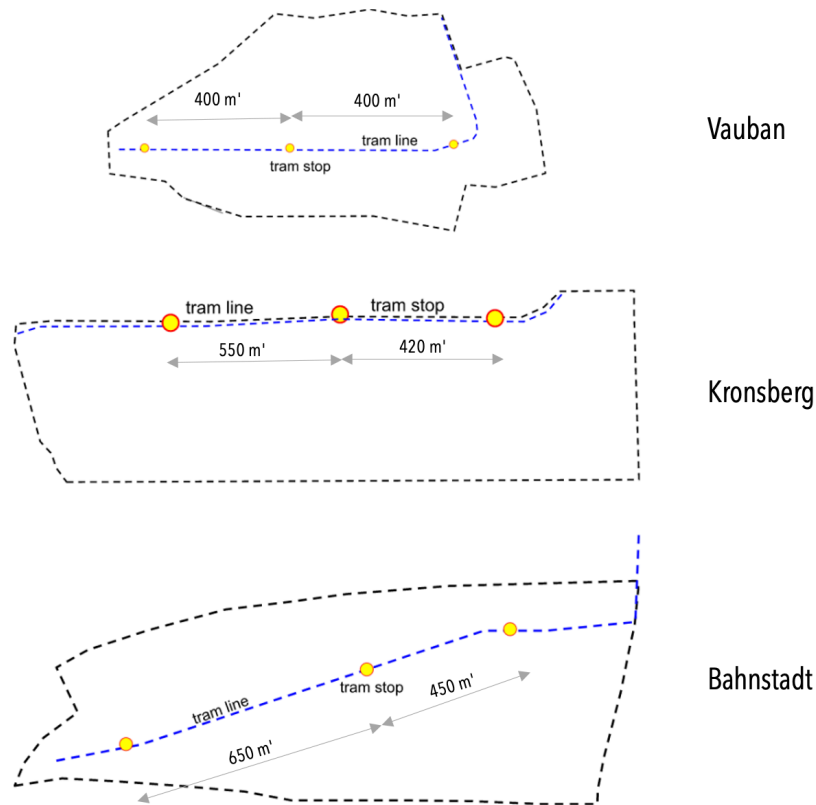


Figure 5.6 Public transportation lines in relation to the ecodistrict, for all three case studies (**Not to scale*) (source: compiled by Bardhyl Rama, info from the literature)

It is recommended that the tram line service is placed along the long axis of the ecodistrict. Depending on the size of the ecodistrict, and with an aim of not more than a 500 m' radius walking distance between the furthest residential unit and any of the tram/bus stops, three stops might cover the whole district. Also, for the purpose of ease of access, it is suggested that one of the stops be located near the public infrastructure and the main square. Bus line service complements the tram line, and in Bahnstadt's case, it connects some of the areas deeper in the ecodistrict, shortening the commuting time.

5.5.2. Car-reduced concept

Ecodistricts by default discourage car use, while focusing on more community space, better air quality, lower noise level and less disturbance for residents.

The quality of a street, as (ESMAP, 2014) emphasizes, is enriched by sidewalks, traffic calming measures, adequate lighting, as well as different outside activities. Car-reduced concept is widely accepted and embraced by an increasing number of people (Kunze and Philipp, 2016).

A successful approach includes allocating vehicular traffic on the perimeter and only one main road in the middle (Figure 5.4), no high traffic within the district and not at all within the residential blocks (Kronsberg). In Vauban, the main access road as well as inside the district roads' speed limit is 30 km/h, whereas in the other quiet residential streets the traffic is at walking speed. No through traffic is allowed within the building blocks in all three case studies, Vauban, Kronsberg and Bahnstadt.

In all cases, application of the traffic slowing techniques, such as barriers in road lanes, the right-before-left turning priorities and of course the obligatory speed signs, shows that a car-reduced concept can be achieved and should be given high consideration. A minimum number of parking spaces along the roads should be available for guests, for quick loading and unloading, but preferably those would be covered and hidden by trees and vegetation.

5.5.3. Quiet residential roads

As stated above the traffic at the 'quiet residential roads' is at walking speed and parking is not allowed (Figure 5.7). This shows that the road lane is basically an additional open space that the residents can freely walk along, and children can use it as a playing area as well as other leisure activities (Vauban and Kronsberg). Therefore, including more 'quiet residential roads' as part of the mobility plan in future ecodistricts means more open space for residents.

Bahnstadt does not seem to have a similar approach for the residential roads, however vehicles are not allowed to be parked along the public squares, making it much safer for children to play on the entire public square area.

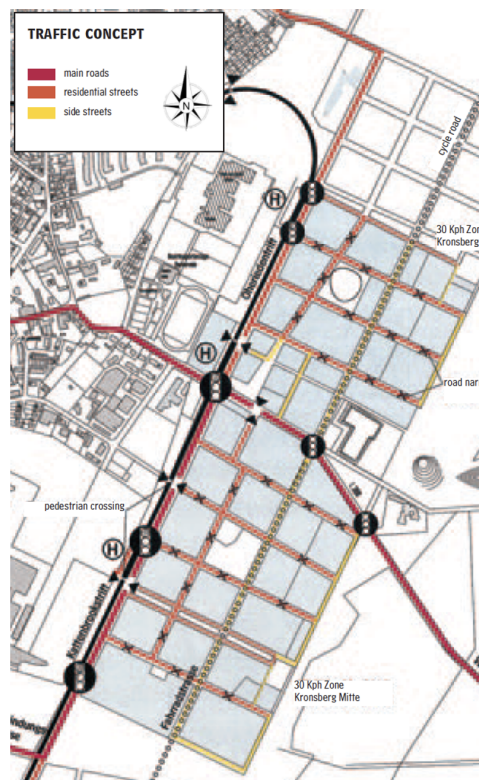


Figure 5.7 Kronsberg car traffic concept (source: (Rumming et al., 2004a))

5.5.4. Parking garages

Different approaches have been taken by the individual case studies, while in one ecodistrict (Vauban) the solution was to concentrate the car parking in two large car parking garages, the preference on the other two ecodistricts (Kronsberg and Bahnstadt) was to go with several underground parking garages at the basements of the apartment buildings or other commercial buildings.

Both, have their advantages and disadvantages, while in Vauban the two main car garages might seem to 'filter' the amount of traffic circulating thru the district, in fact this might have increased the frequency of car traffic, by moving in and out to bring goods to and take from the apartment buildings, therefore loading and unloading and then going back to parking garages. On the other hand, having the parking garages in the basement under your apartment building (Bahnstadt and Kronsberg) would avoid multiple runs when carrying stuff, but that means all the cars in the district will be much more on the community roads.

This analysis of the case studies suggests that when planning the car parking garages, a careful traffic and mobility assessment and elaboration is needed before taking a decision on the best course of action.

5.5.5. Bike and pedestrian friendly approach

When designing streets, sidewalks, bike lanes, and other traffic elements, all users should be taken into account, including pedestrians and bicyclists (ESMAP, 2014).

To promote bicycling and walking in and around the district, biking lanes and pedestrian walkways have been carefully planned and constructed and are visible features in the whole ecodistrict area, proper traffic signage along the roads and on the pavements as well as bike parking spots, are important elements in emphasizing the level of importance that is given to biking in the district. In places where there is no designated biking lane along the streets, the whole streets are marked as biking priority zones. Off-road paths offer a good connection between the paved bike lanes and the green areas, facilitating a network of passageways for recreational biking.

Complementing the inner district biking lanes and walking pathways, the surrounding areas provide a network of safe biking and walking, expanding much further in the nearby grassland and connecting with other nearby settlements and the city. As (Rumming et al., 2004a) states for Kronsberg, 'it offers a condensed rural footpath network'. Bahnstadt too, is part of the local and wider network that interconnects different districts as well as all of them with the city center.

Studies show that pedestrians and bikers indicate trip satisfaction. A study by (Fordham et al., 2018) shows that pedestrians and bikers report that their life satisfaction is affected by their commute. Further, (ESMAP, 2014) notes that good urban forms contain 'safe, connected, and continuous pedestrian network'.

What one learns from Vauban, Kronsberg and Bahnstadt case studies is that the ecodistrict mobility planning has to be mainly based on public transportation. It needs to plan for and promote biking and walking throughout the whole ecodistrict and nearby areas, provide car sharing services, however discourage and minimize the use of individual cars. Walking and biking network should be planned from the main road axis as well as the public transportation stops towards the inner district and all the way to each and every one of the residential units, it should also include public parks and squares, and recreational areas.

5.6. Public spaces

Highlights: How have public functions and services been planned? How many public squares each case study has?

Table 12. Compiled 'Public spaces' data for the three case studies (source: Tables 3, 4 and 5)

Public spaces			
	Vauban	Kronsberg	Bahnstadt
Public squares	Two main squares (House No. 037 and Alfred-Doblin-Platz)	One public square ('Thie') and two neighborhood parks	Three public squares and two neighborhood parks
School	One school	One school	One building with three integrated function
Daycare/Kindergarten	Several day care centers	Several daycare centers	Several daycare centers
Youth and community center	One. Existing building was converted into a community center.	One designated building.	One building with three integrated function (education, daycare and community center)

5.6.1. Public squares and other public amenities

Based on the outcome of the review of the case studies, public squares are a key part of the public spaces in an ecodistrict. All case studies (Figure 5.8) have at least one main public square, central district square 'Thie' in Kronsberg, Alfred-Doblin-Platz in Vauban and Gadamerplatz in Bahnstadt. In addition, Vauban has another public square, Kronsberg has two additional community parks, while Bahnstadt has two more public squares and a community green park. Commercial functions such as a nearby shopping mall, as well as other shops, cafes and restaurants increase the public value of the square, and should be included in the ecodistrict planning.

The interesting fact about the public squares is that those spaces function as multipurpose areas, which can serve as community areas for all kinds of gatherings, but also as places for green market, seasonal festivals, and similar functions. In the squares in all case studies, there are community centers where many local organizations offer educational, social and cultural events.



Figure 5.8 Public squares position within the ecodistrict for case studies (**Not to scale*) (source: compiled by Bardhyl Rama, info from the literature)

A really good example of additional common indoor spaces (Kronsberg), are areas in the apartment buildings that have been dedicated to the community to be used for different activities. These indoor spaces were created as a result of an agreement by the developers to provide one per cent of their residential areas to the local community. This is a good example that should be considered for future ecodistricts.

Other public spaces that should follow in an ecodistrict planning are the educational, social and cultural functions that are carried on each community, those include a primary school, several kindergartens/daycare centers located in strategic places in the district to serve the needs of the entire community and be equally reachable, and a youth and community center that would develop educational and learning programs, as well as other social and cultural events.

The lessons learned from case studies concerning the public squares can be considered their use as multifunctional and gathering areas and the inclusion of a youth and community center, however creating additional community

spaces within the residential buildings is an added value and should be encouraged and planned for in the future ecodistricts developments.

5.7. Landscape

Highlights: Where have the green spaces and playgrounds been allocated? What measures have been taken to prevent biodiversity loss and water table depletion?

Table 13. Compiled 'Landscape' data for the three case studies (source: Tables 3, 4 and 5)

Landscape			
	Vauban	Kronsberg	Bahnstadt
Rainwater	Discharged into the open and naturally drains into the ground	Rigorous standards for on-site rainwater retention - the community's open spaces maximize on-site water collection	On-site rainwater retention - the water lagoon is a particular feature, other open space help with on-site water collection as well
Green roofs	Several buildings - retained green roof rainwater is collected and stored	Several buildings	Almost all of the buildings
Green spaces	Main open green spaces (green corridors), supplemented by smaller scale green spaces	The ecodistrict includes a large amount of open space as well as a variety of intensively used green spaces.	Green and open spaces are of a particular importance and increase the quality of life in the ecodistrict
Other functions in green spaces	Playgrounds, public green spaces, open space kindergarten	A number of playgrounds are located close to the apartments throughout the district in each neighborhood	Many playgrounds, designed and constructed based on different themes, are present throughout the ecodistrict
Green gardening	Designated location	Nearby Kronsberg organic farm and rural workshops	Offered in the raised beds (boxes) in one of the main squares

5.7.1. Green spaces and other functions in green spaces

One of the fundamental characteristics of energy efficient and livable cities are green spaces, therefore access to and proximity of green spaces is critical (ESMAP, 2014).

Green spaces and their supportive functions in the ecodistricts were part of the urban planning competitions that were prepared and announced by the respective city planning offices.

Case studies expose several elements that are of importance and that should be considered when planning green spaces in an ecodistrict. First of all, the interconnection between the surrounding green areas to the district green parks and then to the semi-public and private green spaces within the urban blocks (Kronsberg and Bahnstadt), similarly in Vauban, where the smaller scale usable green spaces are connected with three wide green corridors, which then continue to much bigger green area on the south (Figure 5.9). All three cases offer a green concept that leads and guides inhabitants from their own housing units to the public wide-open green spaces. This concept, in addition to providing leisure and recreational spaces and walking pathways, supports fresh air circulation deep into the ecodistrict.

Another good example of one of the case studies (Kronsberg) is the perimeter tree alley that serves as 'border line' between the district and the grassland, but is highly used for recreational walking and biking

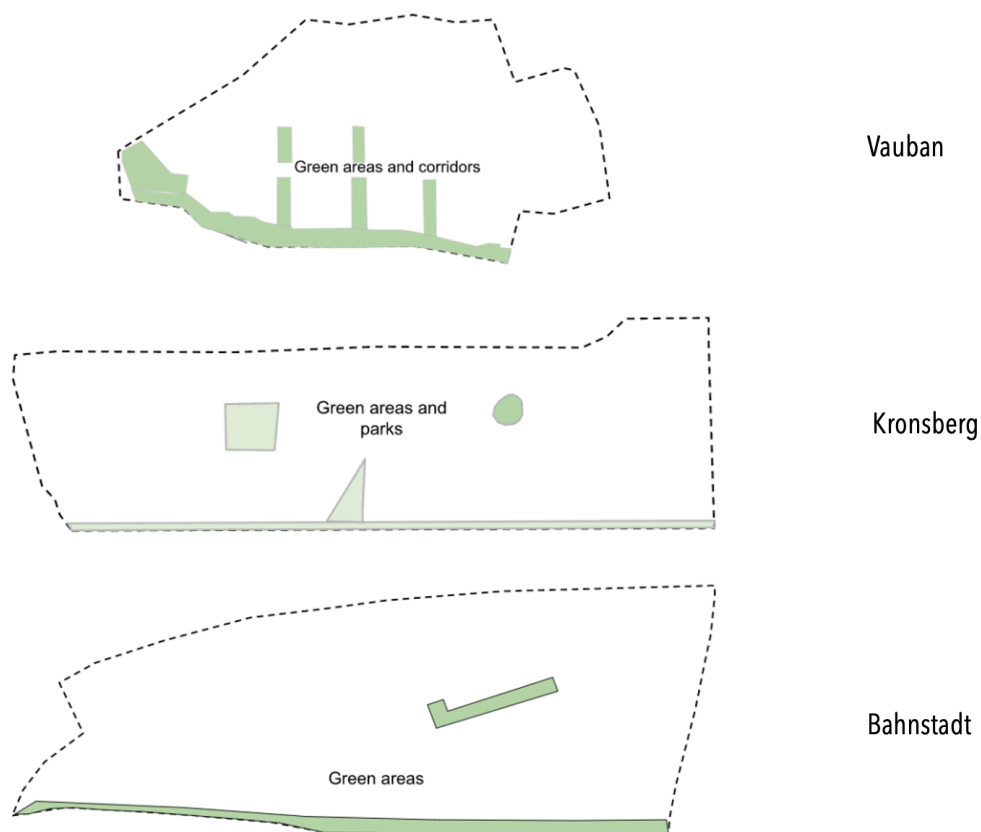


Figure 5.9 Main green areas distribution on three case studies (**Not to scale*) (source: compiled by Bardhyl Rama, info from the literature)

The three case studies show us that children's playgrounds can and should be spread around the ecodistrict, to be as accessible as possible to all children. The main ones are located in the public areas, however additional ones are in the kindergarten yards as well as within the apartment blocks courtyards. This offers the district children a quick and easy access at any given time of the day.

Playground equipment could include any custom-made elements with whole variety of colors shapes and functions, sand boxes and other sand creativity pits, however some standard equipment include, swings, see-saws (two and four children), spinning merry-go-rounds, climbers (horizontal ladders, ring, and parallel bars), boulders, rock climbers, ropes, spring riders, tubes and tunnels as well as slides (straight line, spiral or tunnel). To make sure a universal design is applied, it is needed to plan for use by children with disabilities when planning playground equipment.

Additional elements for all residents include sitting areas, such as fixed chairs, benches and many picnic tables. Sports areas and equipment are present as well, table tennis, basketball courts and other sports are just a few mentioned. In addition, Bahnstadt even offers a location of calisthenics facility for street workout.

Kronsberg has another feature that is really worth considering when planning ecodistricts. The excavated soil during the construction phase was used for creation of various onsite landscape design elements, this approach helped remodel the landscape, but most importantly minimized cost and carbon emissions by avoiding transportation.

This should serve as a lesson learned for future ecodistricts, as minimizing soil movement and transport while making onsite use of the soil to enrich the landscape and urban elements should be one of the priorities when planning.

Figure 5.10 presents a schematic view of the many aspects of the open spaces and public green areas (to include playgrounds, public green spaces and old trees, open space kindergarten and school yard, etc).



Figure 5.10 Open spaces and green areas (source: (City of Freiburg, 2008))

Vegetation

Urban vegetation includes collection of plants and greenery found within and on the perimeter cities, it entails a variety of plants and habitats (Carne, 1994). Vegetation and urban greenery increase outdoor involvement of the community and enrich the recreation areas in an ecodistrict. They improve aesthetics appeal (Drillet, 2020), and positively affect residents' well-being and quality of life. Additionally, vegetation contributes in reducing the urban heat island effect (UHI) in the area, and decrease the energy usage in nearby buildings, mitigating carbon emissions, lowering air temperature and creating fresh breezes, thus playing an important role in bringing fresh air into the neighborhood. As concluded by (IPCC, 2022) and (Dodman et al., 2022), 'the urban heat island also elevates temperatures within cities relative to their surroundings'.

Planting trees, shrubs, grass and other plants in different places of the district such as, open spaces, green parks, courtyards, zones along the streets, sidewalks, public squares, playgrounds and other, not only has positive effects on residents wellbeing, but also helps increase the local wildlife. Planning landscapes that benefit people and nature is also mentioned in (Harris et al., 2018) where they conclude that areas of dense vegetation contain rich and valuable habitats for wildlife.

It can be concluded that planning and designing landscape and vegetation in the whole city in general and ecodistrict in particular is of a high value and should be given a prominent role.

To be able to assess which services are most valued, urban planners need to apprehend how ecosystem services are understood by residents (Lis, 2019).

All three case studies have given an important focus on vegetation. While Vauban made it mandatory to keep a lot of pre-existing trees and plant many more in the ecodistrict, Kronsberg ensured that trees are included in the inner parks as well as on the perimeter green avenue. Bahnstadt has planted a lot of trees, but due to its relatively new age in existence, trees are less 'visible' when comparing with the other two case studies.

5.7.2. Green roofs

Ecodistricts employ a lot of green roofs, and that is for really good reasons. Green roofs are known for their function that contribute to sustainable design and construction. In addition to their primary function of protecting the building from the weather elements, they offer many other benefits. They successfully contribute in reducing the roof surface temperature and provide cooling effect of the surrounding air.

In cities, green roofs with proper vegetation can moderate the urban heat island effect, other benefits include, energy consumption, human health, quality of life, rainwater management, as well as air and water quality (EPA, 2019). Daytime surface temperature of a green roof is largely lower than that of a conventional roof (Li, Bou-Zeid, and Oppenheimer, 2014), other indirect effect for green roof strategies is the increase of the humidity in urban areas.

The phenomena where cities or other urban areas have higher temperature and are considerably warmer than the nearby rural areas is known as the urban heat island (UHI) effect.

However, proper design strategies and application of different materials and colors can offer solutions for reducing the UHI effects and improvement of the urban quality of life. As (Santamouris, Synnefa, and Karlessi, 2011) state, highly reflective and emissive light and cool colored materials can contribute to the UHI effects mitigation.

Green roofs offer a pleasing appearance of the building exterior, that's another reason why, architecturally, they are often used as a first choice.

All three case studies have successfully implemented green roofs in many buildings (Vauban and Kronsberg), and almost all buildings (Bahnstadt). They have demonstrated the benefits of use in practice, such as, energy efficiency, rainwater collection, decrease the heat in the building, improve the air quality. Therefore green roofs are considered a significant element in the ecodistrict design.

5.7.3. Rainwater

The ecodistricts' approaches to the rainwater collection are carefully planned and executed. As it can be seen from the three case studies, water table depletion was expressed as a real concern at the very beginning of the development planning. The environmental study (Kronsberg) showed that to maintain the same level of the groundwater table, an innovative approach must be applied.

Although different methods applied (Figure 5.11), the solution for the three cases had a similar approach, the rainwater from buildings roofs and terraces as well as ground surface pavements is collected in specially designed drainage ditches and then is gradually drained and discharged in open ponds or waterways in the green areas.

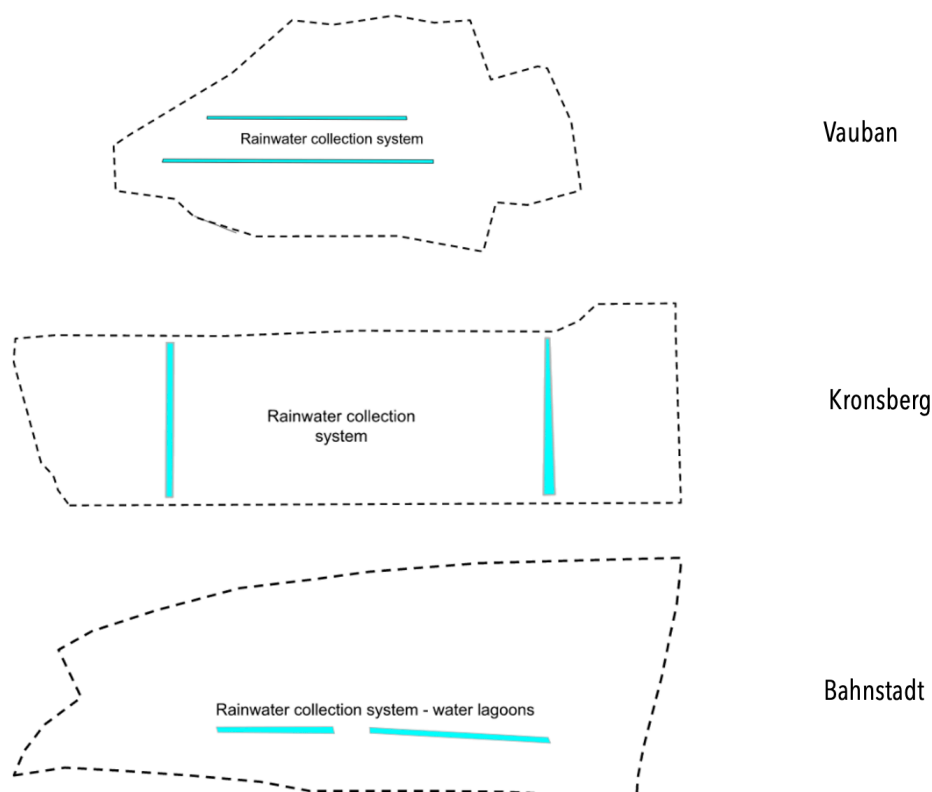


Figure 5.11 Rain water collection systems and approaches for three case studies (**Not to scale*) (source: compiled by Bardhyl Rama, info from the literature)

In Kronsberg district this issue has been tackled in a very sustainable way. It was focused on creating the balance of on-site water absorption and recharge of the ground water table or as (Rumming et al., 2004a) expressed it 'a semi-natural drainage concept'.

This concept has another important function, it helps reduce the excess storm water from the roofs and paved areas that is released in the water collection systems, avoiding clogging up the latter.

In many cases residents collect and store the green roof rainwater in their individual tanks (Hofmeister et al., 2014). While in Vauban and Kronsberg the respective cities have chosen a more of a natural approach (Figure 5.12), in Bahnstadt, by implementing the open water lagoon's concept, water has been introduced as an additional urban design feature where, apart from important water collection and retention function, it offers a not less important element for leisure activities for occupants and cooling effect in the residential areas, which altogether increase the quality of life.

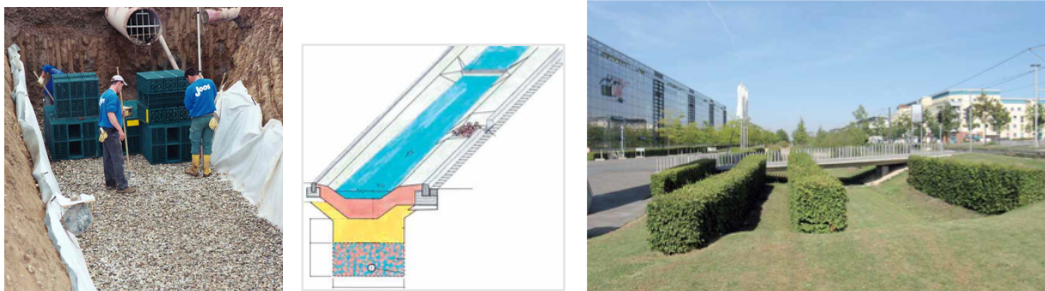


Figure 5.12 Rainwater collection drainage ditch construction (left) (source: (City of Freiburg, 2008)); the hollow-trench system (middle), rainwater retention (right) (source: (Rumming et al., 2004b))

The three case studies show that particular attention must be paid to prevent biodiversity loss and water table depletion, organize rainwater collection at a very early stage, whether use existing environmental studies or generate a new one just for the ecodistrict planning purpose, can be determined at the city planning level. On-site construction is of the same importance, however since this is part of the infrastructure, it is the city's responsibility to oversee and execute the work based on the development plans.

Encouraging home owners to collect rainwater on individual water tanks should be clearly part of the planning process. Tanks as low as 2,000 liters would serve the purpose, however it depends on the availability of the space and the actual needs of the families.

5.7.4. Green gardening

In Vauban's case, occupants get their own little gardening area that they can use for the whole year round. Kronsberg's proximity to an organic farm offers residents fresh locally grown organic food, in addition workshops on producing the organic food are offered by the farm personnel. As stated by (Schottkowski-Bähre, 2000), the

farm expresses 'visionary and environmentally-friendly agriculture using modern technology'. In Bahnstadt, as part of the urban gardening project, the city has offered raised beds (boxes) in the public space (Pfaffengrund Terrasse).

Whether green gardening spaces within the district space (Vauban and Bahnstadt) or any farming area nearby (Kronsberg), both options offer the ecodistrict occupants the space and urban gardening alternatives that are a good part of increasing livability, self-sustainability and as a free time activity, therefore green gardening is a must when planning an ecodistrict. Gardening boxes as small as 2 x 3 m' or similar dimensions are enough and serve the purpose.

6. Chapter 6 - Conclusion

The built environment is one of the main sectors responsible for the total final energy use and consequently for the greenhouse gas emissions. Therefore, buildings, urban areas and cities are part of the problem that is causing climate change, however by addressing the issue in a proper way, they could also be part of the solution when striving to reduce the carbon emissions and head towards a carbon neutral future. Building sector has a real potential to address climate change in both adaptation and mitigation, thus presenting an enormous contribution to the worldwide efforts of achieving the climate neutral goal.

Latest technological innovations and approaches have enabled buildings, ecodistricts and cities to rightfully prove that applying advanced smart and sustainable strategies, such as implementing energy efficiency measures on existing and new buildings, using renewable energy sources, selection of smart solutions and many other similar approaches, is possible, and most importantly, is economically viable.

Although the ecodistrict is labeled and defined in many ways in the literature and cities' policies and documents, in this study an ecodistrict has been seen as a city component that applies green strategies, and urban and architectural solutions, by employing most advanced ecofriendly techniques, tools and technologies. An ecodistrict takes measures to collect rainwater and incorporate water saving measures and devices, it generates energy from onsite renewables and saves energy by applying energy efficiency measures, it uses public transportation, biking and walking as the main mobility tools. Essentially, an ecodistrict is developed with people in mind as a core value of each planning phase, it values the citizens' needs, quality of life, social inclusivity, equity, and uninterrupted access to service and qualities.

The existing ecodistricts play an extensive role in inspiring and encouraging cities to expand climate action. They impact many cities around the globe by, inter alia, demonstrating application of most advanced architectural and urban planning approaches, testing innovative technologies, and learning from the pilot projects of similar nature.

6.1. Conclusions and findings

Analysis of the three case studies expose many aspects of planning and designing ecodistricts. It shows that this process must be a collaborative effort of many fields of expertise, and it must include strategies that lead towards innovative urban planning and architectural solutions. Approaches that have been tested, used and implemented in existing ecodistricts and how they should be applied to future ecodistrict sites.

This thesis examined specific aspects of the ecodistrict that contribute to sustainable solutions. The aspects elaborated and analyzed here are: general data, urban planning approach, architectural approach, energy, mobility, public spaces and landscape. The thesis also analyzed the design concepts and approaches of the three selected case studies of ecodistrict sites and listed the findings through a number of categories and their sets of indicators.

My findings from the literature review, onsite personal observations and interaction with residents confirm that certain features have a level of functional potency that the designers of ecodistricts can take advantages of.

Conclusions and findings - general data

Data input from literature review indicate that site conditions are various. Commonly found in the case studies, are two types, which are generally referred to as, brownfield and greenfield sites. Each option dealing with, among many others, either challenges in minimizing the biodiversity loss and land use, in case of greenfield, or with the soil remediation due to potential pollution from previous functions and repurposing any existing structures, in brownfields. As noted in sub-section (1.4.10) brownfields and greenfields do not necessarily represent any particular proportion of the actual implemented ecodistrict sites. The area size varies and is based on a number of factors, but mainly on the availability of land. The results demonstrate that the dedicated area for an ecodistrict development determines what other functions could be planned as part of the housing development.

The study confirms that the population size of an ecodistrict is in direct proportion with its allocated land area.

Residential development plans should be accompanied with a careful planning of adequate infrastructure, transportation, water and power supply, public and green, and any other services. Case studies stipulate a mixture of household types including ethnicity, culture, age, occupation and education, as well as income levels.

Conclusions and findings - urban planning approach

Valuable outcomes have been identified on the urban planning aspect. Data shows that distance from and position in relation to the city center is highly important when allocating an ecodistrict site. The site might be within the city or in a suburb. This thesis argues for sites within ten kilometers from the city center, with about a twenty-minute ride on reliable public transportation. Semi-open blocks, linear arrangement blocks, point blocks and a few other forms are all present in the case studies, demonstrating that the use of diverse urban block forms enables high quality urban spaces. This thesis highlights the relevance of managing the urban density by placing high-density housing blocks along the public transportation line, then lower density in the middle and ending up with the family houses at the furthest point. Also, mix-use application is vital for the success of an ecodistrict, it gives residents quick and easy access to various services, reduces travel and minimizes car dependency.

Conclusions and findings - architectural approach

Architectural approach is another category that this thesis collected interesting data for, and offers a few suggestions. It claims that building and infrastructure design, in addition to many other functions, contribute to the originality and identity of an ecodistrict. It also argues that leaving some architectural design features unspecified by the city planning offices results in more flexibility in design solutions and a variety of building designs with diverse architectural appearances. Further, allowing multiple architectural and landscape design offices to take part in the design and development of the ecodistricts diversifies the architectural design and enables emergence of creative ideas. Diversification of ownership and plot sizes is another point that this thesis calls for and recommends. Types of residential buildings include terraced houses, maisonettes, townhouses and villas, four-story multifamily houses, and a variety of apartment buildings.

Conclusions and findings - energy

A paradigm shift could be postulated when energy in the ecodistricts is concerned. Shifting from fossil fuel based energy to a zero carbon energy generation is a big step, and all case studies have achieved it. Setting a mandatory energy requirement for the ecodistrict buildings has proven successful however when considering future ecodistricts this thesis demonstrates that passive house standard should be the minimum requirement for all the buildings in the district. Installing photovoltaic solar panels and solar collectors brings buildings to fully net zero or

even energy positive level. Lessons learned from this study call for diversification of the power generation and district heating by employing biomass based combined heat and power plants, and use of wind turbines, both systems sized based on projected ecodistrict's power needs.

Conclusions and findings - mobility

I would argue that mobility is a very sensitive aspect. On the one hand residents are in favor of using public transportation, on the other hand many do admit that reliance on cars is still a concern to some, and a necessity to others. This thesis shows that a good ecodistrict mobility with focus on public transportation and biking can influence people's decision to use sustainable means of transportation. Case studies suggest placing the main tram line along the long axis of the ecodistrict, arranging tram stops that enable a maximum of a half a kilometer radius walking distance, and locating one of the stops near the main square and where the services are located. Additional bus lines could help connecting some of the areas deeper in the ecodistrict. Traffic slowing techniques are recommended. A careful traffic and mobility assessment and elaboration would be strongly suggested before taking a decision on the location of car parking garages. This thesis proved that mobility plans should promote public transportation, biking and walking, include car sharing services, and discourage the use of individual cars. The networks of biking and walking paths should be distributed from the main roads and tram stops towards the inner district and all the residential units.

Conclusions and findings - public spaces

This thesis confirms the importance of public spaces. Ecodistricts should have at least one main public square. Including additional public squares or community parks increases the value and offers options. Should incorporate commercial and other functions such as, supermarkets, restaurants, cafes, medical practices, pharmacies, offices, and similar. Public squares serve as community gathering places as well as green market, seasonal festivals, and similar functions, which makes them truly multipurpose and multifunctional areas. Allocating a community center enables local organizations and community groups to offer educational, social and cultural events. A good example from one of the case studies shows the inclusion of additional common indoor spaces in the apartment buildings, dedicated to the local community activities. This thesis identified further educational, social and cultural functions, those include a primary school, several kindergartens/daycare centers placed in well thought locations to serve the needs of the entire community and be equally reachable and accessible.

Conclusions and findings - landscape and green areas

In my personal view, I see the landscape as one of the ecodistrict categories that all of the case studies have most of the aspects in common with. Regarding green spaces and other functions, the case studies illuminate several relevant elements. The interlinkages between the surrounding green fields and the district green parks, and then further with the semi-public and private green spaces within the urban blocks, in addition to providing walking pathways, leisure and recreational spaces, they also support fresh air circulation deep into the ecodistrict. One good element from one case studies elaborated in this thesis, which is recommended to be included in future ecodistricts, is the perimeter tree alley between the district and the grassland which is heavily used by bikers and pedestrians for recreation. Another really interesting landscape feature applied in one of the case studies is creation of an artificial observation hill and other landscape elements by using the excavated soil during the construction phase. A lessons learned case to be used for future ecodistricts in efforts to minimize soil movement and transportation while creating interesting landscape and urban elements. This thesis identified two options of green gardening, within the district space or in a farm nearby, both offer the ecodistrict occupants the opportunity to experience urban gardening. Green roofs, as the study has confirmed, are considered a significant feature of the ecodistrict design, benefits in practice include rainwater collection, cooling effect, air quality, and many others. On site observation as well as other data highlight the importance of rainwater management, which simply stated, is the collection of rainwater from roofs, terraces and paved surfaces in specially designed drainage ditches and then gradually discharging it on site. Special elements worth addressing are the water lagoons which not only introduce water as an urban design feature but also offer a leisure activities place, with ambiance cooling effect which increases the quality of life. The three case studies show that early stage planning should include measures that prevent water table depletion and biodiversity loss, and also encourage homeowners to collect rainwater on individual water tanks.

6.2. Suggestions on personal visits, hybrid approach to methodology and data collection

My onsite personal visits to several ecodistricts gave me the opportunity to observe, take note of and learn valuable lessons. They provided insights into the practical application, means of implementation and how they relate to the planning and designing principles.

Having done both, literature review and onsite visits, it might be valuable to share some of my lessons learned, experiences and the 'surprises' that I encountered onsite.

In terms of urban planning and design, take note of how the ecodistricts have been planned, how public shared spaces and community areas are always in a central part. Also, how building height has been organized, the highest ones in the center and lowest one further on the far ends, usually public transportation follows the same approach, with trams and bus stops near higher concentration of population. Building orientation, covered and shaded areas, and green spaces are all experienced differently while on site, especially on a hot summer day or rainy season. One urban green feature in Vauban is particularly impressive, the way the green belts have been arranged. When you walk downhill, every few blocks you are exposed to different surroundings and experience the fresh breeze and greenery that compartmentalizes the ecodistrict into smaller blocks.

Depending on your area of interests and the viewpoint, it might be helpful to prepare yourself to view the ecodistricts based on what you might be able to identify as unexplored features that have not been seen as relevant by others, or the other way around. As an example, many research papers might point out to the promotion of social mixing, and the risk of gentrification phenomena. I was prepared to encounter that during the site visits, however a well mixture of household types and communities is present in the visited case studies. That can be said as far as can visually be seen in terms of ethnicity, culture, age, however not on the types of occupation and education, or income levels.

Other features that have multiple functions that are somewhat not easily recognized to while onsite, include cases such as seasonal solar thermal storage tank. Which is placed on a public playground and is designed as a climbing wall, since half of its height is above ground, while the rest of it covered and integrated in the playground landscaping. Also, the artificial hill that was constructed by using excess soil from building foundations, which now is a landmark and serves as an observation point for visitors and residents.

There are many benefits of exploiting a variety of research methods and hybrid approaches. Using mixed methods and employing three data collection techniques impacted the site visits planning and experience. Looking from the viewpoint that a case study investigates a phenomenon within its real-life context, utilizing both, onsite

physical survey and structured questionnaires with general open questions at the end, in addition to the desk research/literature review, was critically important for generating relevant data, for increasing my awareness of surroundings while onsite, as well as the way I interacted with residents.

A potential pocket checklist to carry along onsite visit, I find it helpful and would recommend using it with data from Table 6. which identifies and lists some of the key urban and architectural categories and list of proposed indicators. Depending on the research objective and the purpose of the visit, the list would most likely need to be complemented with other items, but nevertheless might be helpful as a tool to capture the visitor's observations and take onsite notes.

On a slightly unenthusiastic note, during the site visit in Bahnstadt, on a really hot summer day, I witnessed that there was no central ventilation in the building I was staying in, but instead the room had an electric fan and the windows had to be kept opened in an attempt to get rid of excessive heat. That was disappointing, as I had been under the impression that all buildings in the ecodistrict were claimed to have been built in accordance with Passivehouse standard, therefore I was not prepared to experience things like that. Similarly, when talking to one resident who was living in one of the buildings near Pfaffengrunder Terrasse, I learned that it used to get quite hot in those buildings during the summer, but it feels much cooler now that the city has replaced the pavement with grass and planted trees.

Lastly, based on my experience with multiple visits to the ecodistrict sites, I would suggest that planning your trip and equipping yourself with prior information beforehand is very helpful. Most importantly, plan some additional time, use it to explore all the corners and do not be shy to interact with people.

6.3. Recommendations for future research

While it can be argued that the list is not all comprehensive due to limitations in the scope of this research, it can clearly be stated that the categories and indicators addressed and the outcomes presented here provide valuable material and guidance regarding principles of planning and designing of future ecodistricts. Therefore, future research should consider expanding the list of components that are regarded relevant currently or in the near future, so the whole knowledge on this topic becomes more comprehensive and complete.

Also, this research recognizes and acknowledges potentials and likelihood of the future technological applications as well as the extent to which this the same will expand and magnify, therefore it is recommended that future research on ecodistricts and smart cities builds on the outcomes of this study and also further incorporates, examines, and interlinks the inquiry to include cutting edge technological innovations and enlightens the advantages and disadvantages of harnessing those in the future projects.

6.4. Potential use of research data outcomes

The detailed results from the analyses of each category and its respective indicators in this thesis should offer the baseline data regarding principles of planning and designing of future ecodistricts to experts, architects, landscape architects, engineers, and all design community professionals, researchers and students.

The outcomes might be motivating and encouraging different communities and non-governmental organizations around the world to initiate such projects and use the lessons learned from the elaborated case studies to implement their ideas.

The results should also find use among the city urban planning offices to get additional insights on how to plan the ecodistricts and their role in the interaction of the city components among each other as well as the city as a whole.

Finally, the results from this research should be useful to the urban planning department within the ministry and any other departments at the government level, when preparing policies and regulations and especially when designing any incentive instruments or funding opportunities for such projects.

7. Appendix

7.1. Appendix 1. Onsite structured questionnaires with general open questions at the end

To complement the data collected from the literature review and desk research, the author included personal onsite observations and questionnaires (see also sub-section 1.4.2.2). The questionnaire form contained relevant data on targeted sub-topics, but also data informing the participants on the purpose of the study, the type of information that will be collected as well as what happens to the collected data. The first step was to ensure that the participants are informed that no personal information will be asked for or collected, and making it clear that only statistical data or summaries will be presented. Generally, the questionnaire was focused on the level of residents' satisfaction with different aspects provided by and found in the three case study ecodistricts, therefore even though some demographic and social related questions were part of the questionnaire form, only data that was relevant to complementing the desk research has been presented here.

7.1.1. Questionnaire Development and Administration

The qualitative data collection part of this study used a questionnaire survey method. Although questionnaires have many uses, (O'Leary, 2014) states that the prominent one is to find out the communities and masses opinions, feedback and evaluations.

Studies suggest that the researcher doing the qualitative questionnaires prepares a list of questions of the topics concerned and hands out a copy to the respondent (Stake, 1995). Therefore, a detailed and well composed questionnaire that contained questions on each sub-topic was prepared and hard copies were readily available for each participant who agreed to take part on. The questionnaire form contains optional responses to the general question 'How satisfied are you with the...?'. The range of possible responses includes: 'Very satisfied', 'Satisfied', 'Neither satisfied nor dissatisfied', 'Dissatisfied', 'No opinion' as well as the option 'Other'. While the open question at the end for collecting qualitative data stated 'Please specify if you selected 'other' or if you have any additional feedback'. As it can be noticed, the questionnaire follows the Likert scale model. (Bell et al., 2014) states that Likert

scales are usually expressed on several-point ranges as such respondents can select the appropriate response depending on their satisfaction level.

Participants were offered two options for self-completion of questionnaires, a hard copy that would be filled in by pen or they could use the author's notebook computer if they preferred to enter data directly on the questionnaire form. Usually the discussion about questionnaires was started with general questions about the ecodistrict and the community, which served as an entry point to introduce the purpose and the theme of the questionnaire as well as a way to establish initial communication and build trust with participants.

The questionnaire was prepared in English, however knowing that the population is mainly German speaking, translated German version forms were offered as well. No issues were noted with translation. Similar approaches have been reported in literature by other studies (Talmage et al., 2018).

7.1.2. The role of general open questions at the end

Researchers may use general open questions at the end to offer respondents an opportunity to voice their opinion.

The use of 'any other comments' may regulate the power balance between researchers and research participants.

Respondents may take this opportunity to ask for clarification or information. (O'Cathain and Thomas, 2004)

An open question provides and offers participants more options for responding (ADJP Quad., 2016), give more details about the subject than the structured questions allow (O'Cathain and Thomas, 2004) and might 'produce unexpected items' (Bell et al., 2014), while on the other hand closed-ended questions may unintentionally 'force participants to answer in a particular way' (McNamara, 1999). In addition, when analyzing 'Do you have any further comments...?' question (Semyonov-Tal and Lewin-Epstein, 2021) claim that 'we make use of verbal responses to this question in order to interrogate the meaning attached to the closed-ended satisfaction items'. Further, (O'Cathain and Thomas, 2004) note that concerns about potentially missing any important issue might be a driver for including a general open question.

In this research, inclusion of general open questions at the end proved the above-mentioned statements to be correct. It showed that participants were willing to provide more details on the themes addressed, were pleased to have more options, and as a result the process produced and highlighted a few points which have been brought up by participants.

7.1.3. Survey questions randomization

To prevent the issue of potential systematic position bias which might influence the amount of time taken by the respondents to answer each question, the author decided to randomize or purposely change the order of appearance of questions in the questionnaire for each participant. That way it was attempted to potentially give equal prominence to each listed question.

7.1.4. Piloting and pre-testing the questionnaire

Questionnaires should be pre-tested and piloted to find out details such as how long it takes to complete as well as see if the questions are clear and offer an opportunity to revise and adjust as needed. (Stake, 1995) claims that testing the questions in pilot questionnaire form should be routine. This step enables the researcher to 'remove any items which do not yield usable data' (Bell et al., 2014). Further, (O'Cathain and Thomas, 2004) caution that piloting might fail to address some concerns, such as if the latter affect only a small number of people, but other causes as well.

The questionnaire form was piloted and tested with some community members in one of the first visits to an ecodistrict as well as with some volunteers in a university campus. All critical feedback was included and reflected in the revised/final version of the questionnaire form.

During the piloting it was also found out that, depending on the respondent, it takes between 10-15 minutes to complete the questionnaire form.

7.1.5. Sampling technique - simple random sampling

(Acharya, 2013; Noor et al., 2022) claim that in an ideal scenario one would include the whole population to probe and research a topic, nevertheless in practical terms, that is not always possible. Therefore, one can choose a representative sample. Sampling is used as a technique to systematically select a smaller group to acquire data with regards to the goals of the research (Sharma, 2017).

One of the extensively utilized sampling methods is simple random sampling. This selection method gives all the individuals an equal opportunity to take part in the questionnaire, as such the selection of participants is fully rooted on luck. This assures that the process is unbiased and that the sample is representative and the population

has been given equal probability. (Noor et al., 2022) Further, (Acharya, 2013; Yates et al., 2008) state that by using a simple random sampling method every individual from the targeted population has been given an equal chance and probability of being selected. The sample can be representative of the whole population (Sharma, 2017; Fink, 2003).

Simple random sampling has been used as a sampling method to carry out this questionnaire. As such every resident of all three ecodistricts had the same probability to be invited for an interview. In a study concerning ecodistricts (Goel, 2013) carried out interviews in a similar approach.

When using simple random sampling, there is a need to specify 'general common characteristics of the individuals that can participate in the study' (Cohen et al., 2002). Therefore, two main criteria were set as. The participant had to be over 18 years old, as well as be a resident who had lived at least six months or more in the ecodistrict where the questionnaire was being completed. See the 'limitation' (sub-section 7.1.10) below for further details on potential inclusion of any non-resident participants who have been working in the ecodistrict for a long time.

7.1.6. Self-administration of questionnaire and face-to-face interaction with participants

Distribution of questionnaires to respondents personally by the researcher offers particular advantages.

Establishing personal contact with respondents increases the likelihood of better cooperation. The researcher can elaborate the aim of the research, and the questionnaire form can be filled in on the spot. (Bell et al., 2014)

There are a lot of studies that support face-to-face interaction, as the most instantaneous and often experienced social encounter and reality (Denzin and Lincoln, 2017), as they state 'the heart of our social and personal being lies in the immediate contact with other humans'. (Heritage and Raymond, 2005) argument face-to-face interaction to expose the immersed norms of conduct. Further, in addition to posted mail, e-mail or other online options, (O'Leary, 2014; Bell et al., 2014) value personally distributing questionnaires face to face with respondents as a typical method. While justifying the in-person or face-to-face interaction (Stake, 1995) simply claims that most people are pleased to be listened to.

Motivated by many cases in literature, the author chose to self-administer the questionnaire, personally distribute and collect the questionnaire forms and interact face to face with respondents.

7.1.7. Data collection, extraction and sorting

As stated before, participants were offered two options, a hard copy that could be filled in by a pen or an electronic version that the participants could complete using the author's notebook computer if they preferred to enter data directly on the questionnaire form.

The process was not very easy and straightforward, as approximately only one in four approached residents actually decided to take part in the survey and complete the questionnaire form (therefore it could be stated that there is about 25% response rate). As hindering and time consuming as it might seem, the process was still manageable and the author was able to successfully collect 49 valid responses, (out of that Vauban 18, Kronsberg 16, and Bahnstadt 15 responses).

Many studies refer to 'saturation' as a point in data collection. They recognize it as a qualitative research methodological principle which has gained extensive affirmation. Different authors (Guest et al., 2006; Saumure and Given, 2008; Grady, 1998) highlight saturation as the stage when further collection of data brings no new or relevant ideas and does not add any new findings. Thus indicating as a point at 'which no more data need to be collected' (Saumure and Given, 2008), or further collection of data is unnecessary (Saunders et al., 2018), or as (Sandelowski, 2008) refers to 'informational redundancy'.

Some views refer to saturation as a 'rule' of qualitative research (Denny, 2009). Other views as 'either applicable or non-applicable to different approaches' (Walker, 2012), are considered too simplistic by (Saunders et al., 2018).

Further literature suggests that the reach of saturation point in data collection might be considered subjective and dependent on personal interpretation and author's discretion. During the qualitative data collection in this research, the author believes that the saturation was reached. Therefore, it was considered that, as (Saunders et al., 2018) suggest, 'it was time to stop collecting information and to start analyzing what has been collected'.

Extracting collected data from the electronic form was relatively easy, while from the physical hard copies required a little bit more time, however all collected data was entered in one Microsoft excel spreadsheet table. The data in the table was then assembled, sorted and tabulated as a necessary preparation step before data analysis.

Given the fact that the questionnaire's purpose was to either validate (or challenge) the outcomes from the desk research and literature review, the collected data from the participant responses formed a solid basis for further analysis and assembling of the outcome results.

7.1.8. Data analysis

When undertaking content and data analysis the researcher reads the comments, formulates a coding frame to relate the comments to the thematic content (Fink and Kosecoff, 1996; Moser and Kalton, 1971). The coding frame can be applied using software (Bazeley, 2003) or manually (O'Cathain and Thomas, 2004). Studies suggest that there are no set ways of coding the data, therefore it is up to the researcher to decide on a system which will suit the collected data and the way to manage it, therefore it is advised to keep things as simple as possible (Bell et al., 2014).

The data gathered from the survey was tabulated and organized into a table using the Microsoft excel spreadsheet. The excel table contains the data extracted from each completed questionnaire form. Since the survey forms contain both closed-ended and open-ended responses, the selection and analysis of data outcomes from both, needed a slightly different approach.

The structured/closed-ended part of the survey contained a set of responses which have been grouped into a number of columns, filtered and sorted so the subgroups could be compared in an analytical way. While, using the bar charts in Microsoft excel (see below Figure 7.1 through 7.5) enabled displaying the distribution of responses and the representation of data analysis in a graphical way. Detailed analytical elaboration for each grouped theme have been provided in below paragraphs.

In a questionnaire, responses from the open-ended questions may provide only slightly more than the closed-ended ones (Thomas et al., 1996), but that should not prevent the researcher from doing a preliminary analysis and reading the responses, in order to consider the contribution that the open-ended responses make to the overall research (O'Cathain and Thomas, 2004). (Stake, 1995) argues that it is more important to capture what the respondents mean rather than trying to get the exact words. However, many other studies claim that 'verbatim comments can be displayed to illustrate the themes' (Knowles et al., 2002; Malin et al., 2001), and that 'publication can involve the display of verbatim quotes' (O'Cathain and Thomas, 2004).

All open ended verbal responses from this questionnaire were coded, grouped and classified by respective themes. Extensive elaboration of the majority of the textual part of the open ended responses have been captured in three sub-sections (A.1.9, A.2.9 and A.3.9) in Chapter 3. The sub-sections titled '*Personal onsite observations and*

structured questionnaires with general open questions at the end' elaborated resident questionnaire responses from all three ecodistricts, Vauban, Kronsberg and Bahnstadt.

As stated above, the form contains further questions which, among others, mainly focus on the satisfaction of residents with their ecodistricts. For the purpose of not taking too much space here, the rest of the questions have not been included, however a summary of responses and their percentages are listed below.

Urban planning responses and feedback

The main question in the urban planning section was 'How satisfied are you with the urban approach?', to which (Figure 7.1) in Vauban's case 83% responded 'Very satisfied', while 12% 'Satisfied', 5% did not provide any response. And in Kronsberg 88% responded 'Very satisfied', while 6% 'Satisfied', 6% did not respond. While in Bahnstadt 73% responded 'Very satisfied', 13% 'Satisfied', 7% 'Neither satisfied nor dissatisfied', and 7% did not provide any response. The percentage of additional feedback is slightly higher in Vauban (at 39%), versus Kronsberg (about 37%) which has about 31% who stated that the current urban solution was very adequate for the site, about 6% who think that other solutions and block arrangements might have been better.

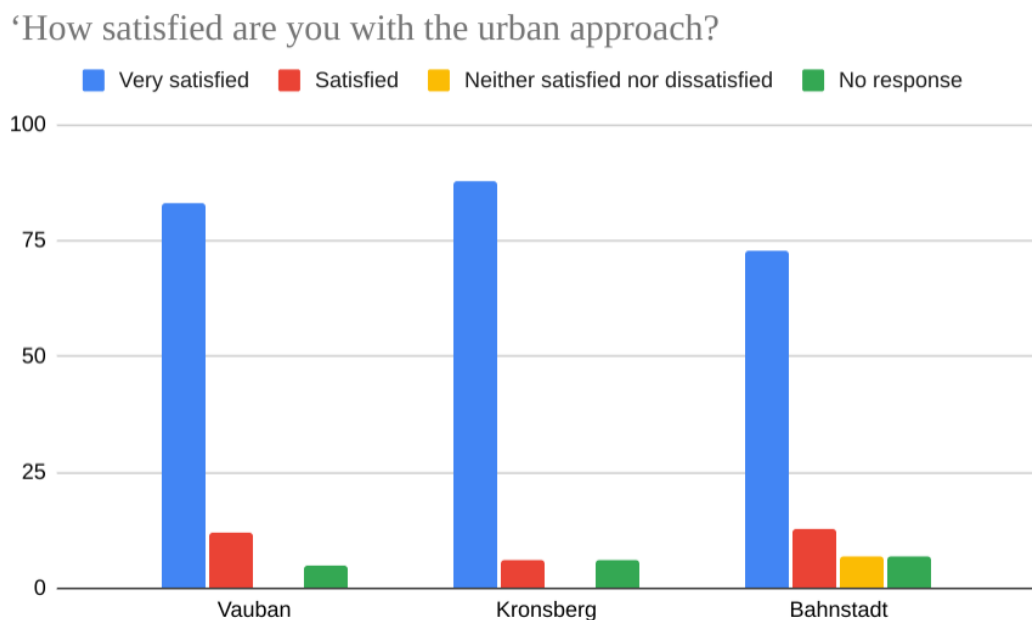


Figure 7.1 Urban planning responses and feedback (source: Bardhyl Rama)

Architectural approach responses and feedback

In the question 'How satisfied are you with the 'Buildings' design and appearance?', about 89% responded 'Very satisfied', while 6% responded 'Neither satisfied nor dissatisfied', and 5% did not provide any response in Vauban. In Kronsberg, 94% were 'Very satisfied', 6% did not provide any response. While in Bahnstadt 80% were 'Very satisfied', 13% 'Satisfied' and 7% 'Neither satisfied nor dissatisfied'.

About 78% were 'Very satisfied' while 11% 'Satisfied' and 11% did not respond to the question 'Overall, how satisfied are you with the architectural approach?' in Vauban. In Kronsberg 82% were 'Very satisfied' while 18% 'Satisfied' and Bahnstadt 87% were 'Very satisfied' while 13% did not provide any answer. Additional feedback was provided by 28%, 19%, in Vauban and Kronsberg respectively, while in Bahnstadt there was none.

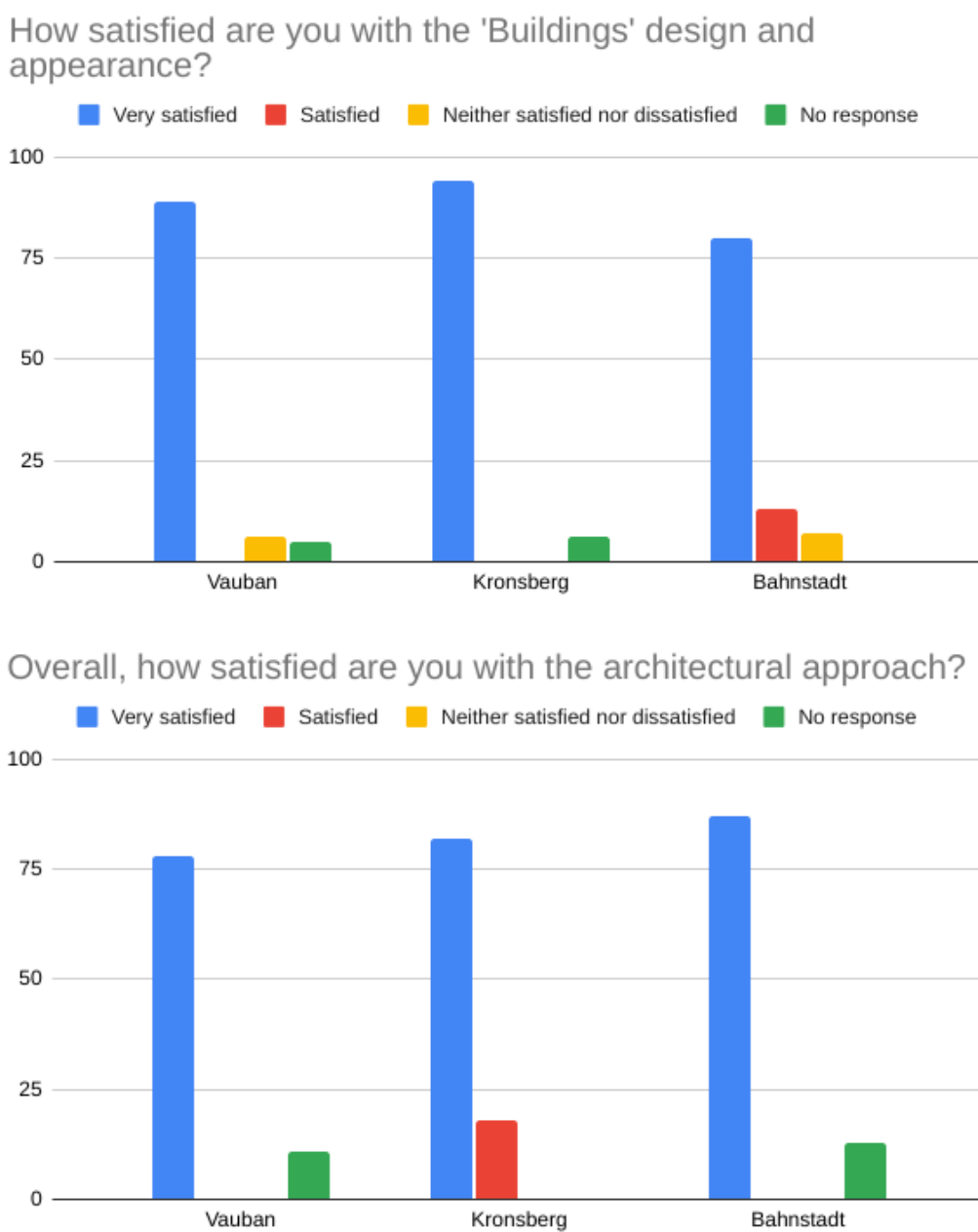


Figure 7.2 Architectural approach responses and feedback (source: Bardhyl Rama)

Energy responses and feedback

All interviewees in Vauban and Kronsberg responded 'Very satisfied' with the level of energy efficiency and low consumption of the buildings they live in or they use for community activities. In Bahnstadt, question 'Overall, how satisfied are you with the 'Energy' approach?' was responded 'Very satisfied' by 93%, whereas 7% did not provide an answer.

Mobility responses and feedback

When asked 'How satisfied are you with the Public transportation?', 78% responded 'Very satisfied', 17% 'Satisfied', 5% did not respond in Vauban, whereas in Bahnstadt 67% responded 'Very satisfied', 20% 'Satisfied', 7% 'Not satisfied' while 6% did not answer. 94% of Kronsberg's responders think public transportation is very reliable and are 'Very satisfied' with it. Finally, 100% of responders in Vauban are satisfied with the car-reduced concept and quiet residential roads.

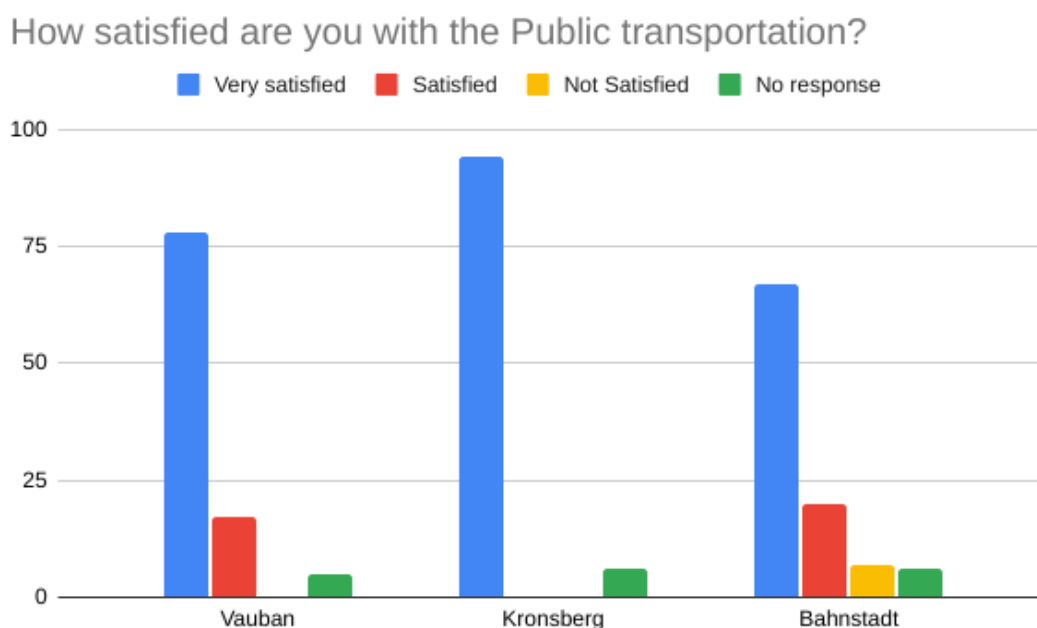


Figure 7.3 Mobility responses and feedback (source: Bardhyl Rama)

Public spaces responses and feedback

When asked 'How satisfied are you with the 'Public squares and other public amenities'?' the highest was Bahnstadt with 93% responding 'Very satisfied', and 7% 'Satisfied', while 83% were 'Very satisfied' in Vauban, followed by Kronsberg with 82% 'Very satisfied', 12% 'Satisfied' while 6% 'Neither satisfied nor dissatisfied'.

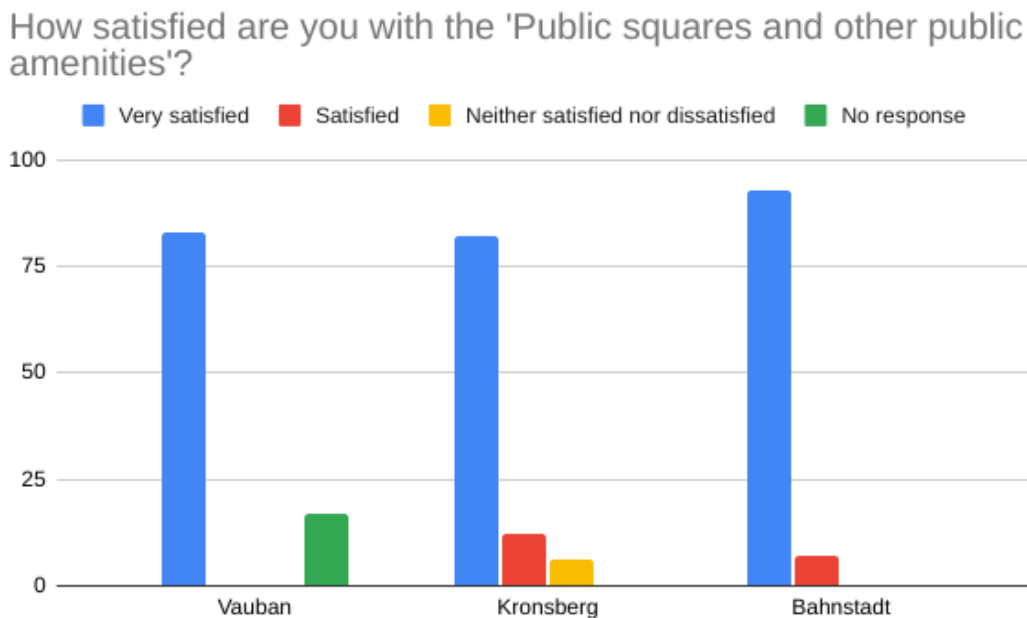


Figure 7.4 Public spaces responses and feedback (source: Bardhyl Rama)

Landscape responses and feedback

In Vauban 95% were 'Very satisfied' and 5% 'Satisfied' when responding to the question 'How satisfied are you with the 'Green spaces and other functions in green spaces?'. In Bahnstadt 73% responded 'Very satisfied', 13% were 'Satisfied', while others did not provide any response.

All interviewed residents in Kronsberg expressed their maximum level of satisfaction for the high quality of all landscape elements. Additional feedback was provided by 23% and 25% in Vauban and Kronsberg respectively, none in Bahnstadt.

How satisfied are you with the 'Green spaces and other functions in green spaces?

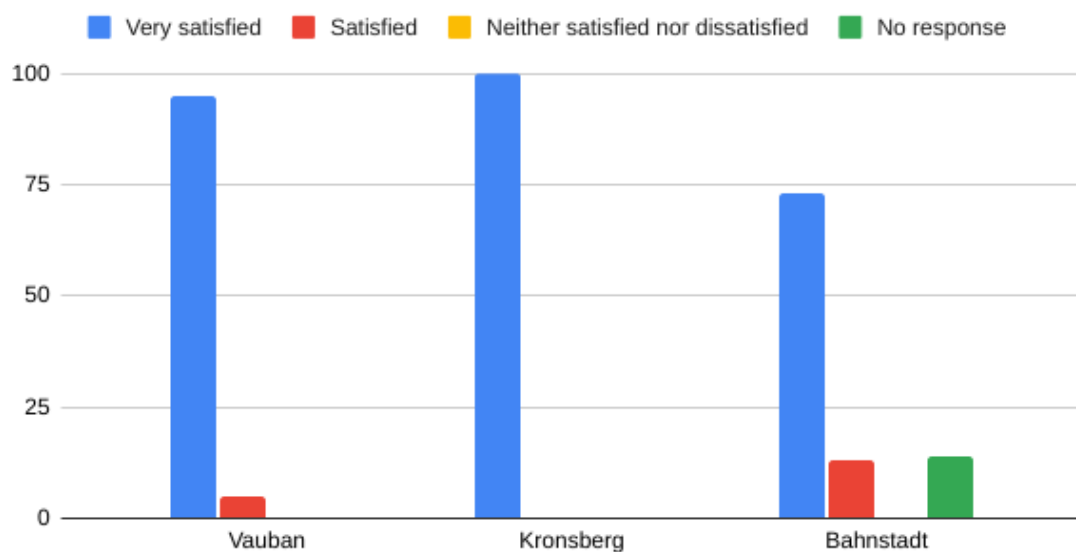


Figure 7.5 Landscape responses and feedback (source: Bardhyl Rama)

7.1.9. Ecodistrict occupant feedback questionnaire form

The Ecodistrict Occupant Feedback Questionnaire form included the following information:

1. BACKGROUND PURPOSE OF THE STUDY

The questionnaire aims to collect feedback from the occupants on their experience and satisfaction of living in an ecodistricts. Feedback collected in this questionnaire will assist in validating the outcome from the desk research and personal onsite observation.

2. WHAT TYPE OF INFORMATION WILL BE COLLECTED?

Feedback will be collected via the google form (online and written form). Precautions are taken to protect participants' anonymity and confidentiality. No personal information will be asked for or collected. Only, statistical data or summaries will be presented. Participants are free to decline to answer any or all of the questions. Participants will not be identified in the research findings either directly or indirectly. Information collected will be restricted to topics relevant to the sections of the research.

3. IS THERE ANY RISKS IF I PARTICIPATE?

Since confidentiality is being provided, there is no risk anticipated in relation to participation.

4. WHAT HAPPENS TO THE INFORMATION I PROVIDE?

All information collected will be temporarily stored electronically in password-protected space. (Note: No personal information (e.g. name and contact details) will be collected or saved). Summaries of feedback or statistical data will be included in the research, therefore no identity can be ascertained.

You declare that:

- 1) You understand the information provided to you about your participation in this research project.*
- 2) You understand that your participation is voluntary, that you can choose not to provide feedback and that you can withdraw at any time.*
- 3) You consent to the processing of the information for the purposes of this research study.*

7.1.10. Limitations

First, since the data has been collected by a single researcher, chances for subjectivity and unintended bias cannot be ruled out.

Second, although simple random sampling has been used as a sampling method, and every resident of all three ecodistricts had the same probability to be invited for an interview, it must be noted that the researcher carried out the survey mostly during the daylight hours and early evenings, therefore there is a possibility that people working in night shifts or any first responders jobs might have missed the opportunity.

Third, it would have been interesting to include any non-resident participants who have been working in the ecodistrict for a long time, that way it might have provided a different perspective, nevertheless no such a case has been encountered during the survey.

Finally, concerning the data analysis (Goel, 2013) argues that it is generally based on the researcher's interpretation. Therefore, the outcome of analysis should be viewed from this perspective as well.

Researchers who have done similar questionnaires (Nghiningwa, 2019) report other limitations such as respondents claiming to not have the time to answer the questionnaire, and expressing concerns that the form was too long, as a result the researcher could not achieve the targeted number of responses. Another limitation noted by the same author was the challenge of capturing the respondents' attention.

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Curriculum Vitae

BARD RAMA, PMP, ING. ARCH.

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Experience:

09-2022-present: Expert | Evaluator | Senior Consultant

Expert at various EU funded organizations and projects, including ICLEI European Secretariat GmbH, Freiburg im Breisgau, Germany – Expert on adaptation (built environment), and many other expert and evaluator assignments related to New European Bauhaus, European Green Leaf Awards (EGCL), Culture Moves Europe, NetZeroCities and URBACT.

Contributor to the UNECE Group of Experts on Renewable Energy (GERE). Expert/Member of Task Force - Implementation Working Group (IWG5) within the European Strategic Energy Technology Plan (SET Plan), preparation of a IWG5 Active Module White paper, scheduled to be released by the end of June 2023.

09-2016 - 09-2022: Director of Operations; WGII Technical Support Unit, UN IPCC – United Nations Intergovernmental Panel on Climate Change.

Coordinate the administrative, financial and technical aspects of the Technical Support Unit (TSU). Responsible for guiding the operational aspects of the scoping, preparation, review and publication of the reports produced by Working Group II (WGII), as well as coordinating all activities and meetings organized by WGII during the IPCC Sixth Assessment cycle. Providing operational advice to and working closely with the two Co-Chairs and the Bureau of WGII. Coordinating with the government representatives and local organizers on planning and organizing international meetings (WGII Bureau meetings, Expert Meetings, Workshops, Lead Author Meetings). Supervising and Leading Operations Team in providing operations and logistical support as well as performing daily activities. Liaising with the TSUs of Working Groups I and III of IPCC, as well as with the IPCC Secretariat in Geneva. Member of the Operations Actions Team (OAT), representing WGII TSU at regular meetings. Participated in IPCC Bureau and Panel meetings.

09-2014 – 08-2016; Project Lead; Consultant work for WORLD BANK and Local Government: Sustainable and Energy Efficiency and Renewable Energy Project

Provided strategic planning on the first ever phase of the public building renovations at higher scale on the World Bank supported Energy Efficiency Project. Coordinated work and meetings with World Bank officials and Local Government staff. Lead the team of architects in providing technical specification and sustainable renovation designs, bill of quantities (BOQs), onsite inspection and work oversight, as well as providing final inspection, training facility managers and facilitate building commissioning.

11-2010 - 03-2016; Operations Supervisor/Deputy Director; Public Works Directorate (DPW); NATO / KFOR (US Army Europe).

Supervisory authority over the department employees, as well as tasking authority of the DPW staff as a whole. Strategic planning and leadership on the overall real estate approaches to the base camp, with the focus on the Environmental aspects. Served as a focal point for all the DPW related issues. Coordinated and monitored implementation and work progress. Provided overall continuity in office leadership, technical advice and counsel to higher officials in the AST.

Acted as DPW Director and represent the department in higher management meetings. Managed DPW new work requests/projects. Received all work requests and assign them to DPW Engineers.

02-2003 - 10-2010; Operations and Plans Officer; DPW, NATO/KFOR (under US Army Corps of Engineers).

04-2001 - 11-2001; Field Officer; International Rescue Committee – CPI Program; Monitored Youth and Child Groups.

10-2000 - 04-2001; Shelter Engineer; IRC – European Agency for Reconstruction Program - Reconstruction of 563 houses;

06-2000 -10-2000; Field Officer; IRC – EAR;

06-2003 - 11-2016; Freelance Architect

Prepared a large number of architectural designs of different types of buildings such as: private houses, 6 story apartment buildings, swimming pools, restaurants, monuments, and other infrastructural projects. Responsible for design, material specification, work oversight and final acceptance/ building commissioning. With the team of three other engineers, prepared projects with all phases from building permits to the final construction (including: architectural designs, static calculation, electrical, plumbing and mechanical installation).

Education

PhD studies, Faculty of Architecture, Prague Technical University

Faculty of Architecture and Civil Engineering, University of Prishtina, Faculty of Civil Engineering and Architecture (5 years studies – Ing. -Dipl.)

Training and Certifications

Project Management Professional – **PMP Certified**

Contracting Officer's Representative (COR) Training course for Services/ Construction.

GIS (Geographic Information System) Training course, Wiesbaden, Germany

Online training certificates on: Contracting Overview CLM024, Cost Estimating CLM016, Quality Assurance Auditing CLM103, Overview of Acquisition Ethics CLM003, Contracting Officer Representative with a Mission Focus CLC106, AcqDemo AQD101, Online Training for COR- CLC222, Cost Estimating CLM016, Completed numerous online courses on different topics.

International Professional Organizations Membership

AIA Europe Chapter - Board of Directors since 2015 – served as **2020 President** – Coordinating AIA Europe activities throughout Europe. Chairing Board Meetings. 2021 Board Member at the AIA International Region (AIA IR).

AIA-American Institute of Architects and AIA Europe Chapter – Int'l Assoc Member

Member of the Committee of Corporate Architects and Facility Management (CAFM) since 2012, the CAFM facilitates.

Project Management Institute (PMI) – Member; ULI – Urban Land Institute – Member; ASCE – American Society of Civil Engineers – Affiliate Member, Dec 10; NIBS – National Institute of Building Sciences - Individual Public Interest Membership, Mar 13; IAPMO – International Association of Plumbing and Mechanical Officials Member, Nov 12; APWA – American Public Works Association Member; ASHRAE – American Society of Heating, Refrigerating, and Air-Conditioning Engineers Member; CIBSE YEPG - Steering Committee - Eastern Europe Regional Officer (2015-16); GRC-Geothermal Resources Council ; BTES- Building Technology Educator’s Society ; ENHR - European Network for Housing Research

International Conferences

Organizing Committee Member Cities and Climate Change Science Conference, City of Edmonton, Canada.

Organizing Committee Member and Session Moderator – 2020 AIA Int. Region Virtual Conference on ‘Catalyzing Change’

PLEA 2017 and 2018 – International Scientific Committee Member

Spring 2018 AIA Continental Europe Conference Committee Chair and Moderator

Presenter/Speaker

World Arch. Festival (WAF), Berlin; Austrian Arch. Day; PAW Week; EcoWeek

Participant - High-Level Conference 'RE- Energizing the Future' - hosted by the European Commission (EC) and the International Renewable Energy Agency (IRENA), side events at COP21.

Participated in European Habitat Conference in Prague and General Assembly of Partners Meeting on NEW URBAN AGENDA.

Publication Summary

RAMA, B., *Sustainable residential complexes/Eco-Villages* [research poster, 1st PhD Students' Workshop, FA CTU, Prague, 2016] (100%)

RAMA, B., Andoni, D., Affordable housing and housing affordability in Europe. *YAF Connection*. 2017, (Q1-2017), (50%) YAF Connection.

RAMA, B. Housing and urban planning in early modernism – an essay on green and sustainable approaches. 2017 [Unpublished paper] (100%)

RAMA, B. The life of a city: A short essay on the role of seasonal structures as temporary Urban Design elements and the city soundscape in the pedestrian personal experience. [Unpublished paper] (100%)

RAMA, B. Sustainable approaches in Contemporary Architecture. [Unpublished paper], 2017, (100%)

RAMA, B. (2022); Ecodistricts: A proposed list of categories and indicators for principles of planning and designing. (unpublished, in prep) (100%)

Contribution to the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6):

IPCC, 2019: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Cambridge: Cambridge University Press, 2019. ISBN 9781009157964. [contribution only]

IPCC, 2022: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2022. [contribution only]

Contributors to the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, Cambridge University Press, 2019. [contribution only]

Contributors to the Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2022. [contribution only]

International Conference Contributions:

Cities and Climate Change Science Conference - Intergovernmental Panel on Climate Change (IPCC), Future Earth, C40, Cities Alliance, City of Edmonton, ICLEI - Local Governments for Sustainability, Sustainable Development Solutions Network (SDSN), United Cities and Local Governments (UCLG), UN-Habitat, UN Environment, World Climate Research Programme (WCRP), [Conference program preparation, Organizing Committee Member], 2018. [contributor]

International Virtual Conference Catalyzing Change - Honorary Fellows Keynote Lecture - Jan Gehl - Cities For People. [Conference Hosting - Session Moderation] 2020. (33%)

International Virtual Conference Catalyzing Change - Impact of Climate Change in Cities and Urban Areas. [Conference Hosting - Session Moderation] 2020. (25%)

International Virtual Conference Catalyzing Change - How will future change affect the architect's profession - experience from Europe. [Conference Hosting- Session Moderation] 2020. (15%)

Youth Space and Urban Transformation. AIA Continental Europe - International Conference and Chapter Meetings. 2018, [Conference program preparation and moderation, Student Charrette and Conference Hosting]. (70%)

World Architecture Festival 2017: AIA, AIA Int and AIA Europe at World Architecture Festival #WAF2016, Panel on: Temporary housing – refugee response. What long- and short-term needs should architects take into account when designing for refugees and the communities that they join? Paul Finch, Bernhard Franken, Bard Rama [Conf. Presentation]. (33%)

Grassroots 2020 - American Institute of Architects Leadership Conference, Representing AIA CE as 2020 President. [Conference active participation] 2020.

AIA Europe Eastern Section participation at Austrian Kosovo Architecture Day, 2015, [Conference Presentation], (100%)

Presentation at Prishtina Architecture Week (PAW) on AIA, 2015, [Conference Presentation], (100%)

ECO-SEE Indoor Environmental Quality Workshop. [Workshop participation] 2016.

Direction Final Event - Achieving high performance based on real buildings and results. [Workshop participation] 2016.

European Habitat Conference in Prague, Active participation in Workshops and activities. [Conference] 2016.

Peer Reviewer Contributions:

GSR2022, Renewables 2022 Global Status Report, REN21 [Peer Reviewer]

2021 ACSA/EAAE Teachers Conference, [Conference - Session Peer Reviewer] 2021.

2021 Building Technology Educators' Society Conference - BTES, Out of Bounds: Crossing Disciplines in Teaching Technology, Session Peer Reviewer. [Conference] 2021

Journal of Transportation and Land Use - JTLU. World Society for Transport and Land Use Research, [Reviewer], 2019

PLEA2018 - Smart and Healthy within the 2-degree Limit. [Conference- Session Peer Reviewer] 2018.

AIA Conference on Architecture. [Conference - Session Peer Reviewer] 2017

AIA Convention 2016. [Conference - Session Peer Reviewer] 2016.

AASHE 2016, 2018, 2019 and 2020 Conference and Expo (Association for the Advancement of Sustainability in Higher Education)

USGBC Greenbuild 2016 International Conference and Expo

Greenbuilding Brasil 2016 education session proposal reviewer.

Green School Conference and Expo - GSCE 2016 education.

Submitted/accepted various articles, abstracts and posters:

Rama, Bard (2023a). Indicators and categories as input for the design of districts: Approaches from three ecodistrict case studies from Central Europe. Accepted poster in The International Conference on Bioclimatic Materials and Buildings: Energy efficiency and global industry value chain, (ICBMB 2023) May 03-05, 2023, Ifrane – Morocco

Rama, Bard (2023b). Ecodistricts and Green Places: Outcome of analysis of green places and amenities in three Central European Ecodistrict case studies. QUAERE 2023 Interdisciplinary Scientific Conference for PhD students and assistants. Conference Proceedings QUAERE 2023, vol. XIII, (forthcoming). ISBN: 978-80-87952-38-2.

Rama, Bard (2023c). Addressing Urban Design, Public Space and Walkability - Experiences from the Central European Ecodistrict Case Studies. Accepted abstract in New York – Livable Cities - A Conference on Issues Affecting Life in Cities, Organized by New York City College of Technology, City Tech

Rama, Bard (2023d). Ecodistricts, People and Places - a reflection from Central European case studies, Stream 1: Neighbourhoods in comparative perspective. Accepted abstract in The People, Place and Policy (PPP) Annual Conference (21 June 2023. Hosted in Sheffield by the Centre for Regional Economic and Social Research (CRESR) at Sheffield Hallam University. Programme available at <https://sites.google.com/view/ppp-conference-2023/programme>

Rama, Bard (2023e). Achieving sustainable urban design through Ecodistricts - what can we learn from Central European Case Studies. Submission ID: sciforum-072853, Section: Architectural Design, Urban Science, and Real Estate, IOCBD2023. Accepted abstract in The 1st International Online Conference on Buildings: Advances in Building Planning, Design, Construction, and Operation.

Rama, Bard (2023f). Are urban mobility approaches in line with SDG Goals? Perspectives and solutions offered by three European Ecodistrict sites. IFAU23 Topics: T2: City and Landscape (Environment, Landscape, Planning, Resilience, Territory, Urban Planning). Accepted abstract in IFAU23 Climate Change and Cultural Heritage Conference.

Rama, Bard (2023g). Zero Carbon Ecodistricts - Experiences from Central European Case Studies, ID: 1103. Accepted abstract in 7th International Conference on Carbon Accounting 2023. <https://icarb.org/2023-conference/>

Rama, Bard (2023h). Using Nature-Based solutions in an Ecodistrict as a tool for Climate Change Adaptation. ECCA Paper #59, Accepted session under theme 3. Nature-Based Solutions for Climate Change Adaptation in 6th European Climate Change Adaptation Conference 2023, Dublin, Ireland

Rama, Bard (2023i). The role of public spaces in the ecodistricts planning and designing process. Accepted abstract in the International Conference "Centrality in the Age of Dispersion". Wrocław University of Science and Technology, Faculty of Architecture, Chair of Urban Planning and Spatial Development, Bolesława Prusa 53/55, 50-317 Wrocław, Poland, centrality-dispersion.pwr.edu.pl

Rama, Bard (2023j). The Ecodistricts and Their Contribution to the Sustainable Development of Energy Systems. SDEWES2023-0640. Submission reviewed by the editors and accepted for presentation and publication on digital proceedings of the 18th SDEWES Conference on Sustainable Development of Energy, Water and Environment Systems, September 24 - 29, 2023 in Dubrovnik, Croatia. www.dubrovnik2023.sdewes.org

- Rama, Bard (2023k). Ecodistricts' architectural and practical examples - contribution from three Central European case studies. Accepted poster in the World Congress of Building Greening 2023, 27-29 June 2023. Organized by the Federal Association of Green Buildings (BuGG) with the support from World Green Infrastructure Network (WGIN) and the European Federation of Green Roof & Wall Associations (EFB). <https://www.bugg-congress2023.com/>
- Rama, Bard (2023l). Can Ecodistricts Help Cities Act Locally: Analysis of Case Studies. IFLA WC Paper#9. Accepted abstract Accepted for Oral presentation virtual for the IFLA World Congress 2023 (28-29 September 2023). International Federation of Landscape Architects (IFLA).
- Pracucci, A., Dugué, A., Richet, N., Abdullah, T., Başer, E., Caneva, S., Deneyer, A., Dias, P., Diygu, C., Fakhari, M., Földváy-Bándy, E., Founti, M., Gynning, S., Madsen, H., Marambio, C., Posset, U., **Rama, B.**, & Salvalai, G. (2023). Integration of prefabricated active modules and "skins" on buildings. White paper. The Strategic Energy Technology Plan (SET-Plan) Implementation Working Group on Energy Efficiency in Buildings (IWG5) Task Force on Active Modules.