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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.

I, the undersigned, hereby declare that:

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• I have fully acknowledged and referenced the ideas and work of others, whether published or unpublished, in my thesis.

• I have prepared this thesis specifically for the degree of Doctor of Philosophy while under supervision at Czech Technical University in Prague.

• This thesis does not contain work extracted from a thesis, dissertation or research paper previously presented for another degree or diploma at this or any other university.

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Abstract

Ecodistricts – principles of planning and designing based on case studies

Through detailed analysis of the selected case studies, this thesis examines ecodistricts, which are city components that bear the load of offering the solutions that the cities themselves, due to their complex and rather complicated structure and organization, can not offer. This thesis focuses on the ecodistricts as a concept of sustainable development, their particular role on finding balanced elements that enable high quality of life for residents and at the same time are in line with the climate neutral goals that the society is pursuing.

Although there has been enormous technological development, and certainly many cities have harnessed any possible benefits, there are still limitations to the extent that technological innovations have been applied. But, at the same time there is a huge potential that cities can tap into in their path towards a sustainable and green future.

Therefore, this thesis draws upon specific aspects of the ecodistrict structure that contribute to green solutions. Aspects that have been taken into consideration and given a great deal of analysis 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 analyzed 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.

This thesis 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 analyses of each category and its respective indicators. This should provide solid 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 indicator and category has been given relevant prominence and elaboration based on 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;

Abstrakt (Česky)

Ekodistrikti – principy plánování a projektování na základě případových studií

Prostřednictvím podrobné analýzy vybraných případových studií, se tato práce zabývá ekodistrikti, které jsou městskými složkami, které nesou zátěž nabízení řešení, která samotná města vzhledem ke své složité a značně komplikované struktuře a organizaci nabídnout nemohou. Tato práce se zaměřuje na ekodistrikti jako koncept udržitelného rozvoje, jejich konkrétní roli při hledání vyvážených prvků, které umožňují vysokou kvalitu života obyvatel a zároveň jsou v souladu s klimaticky neutrálními cíli, které společnost sleduje.

Přestože došlo k obrovskému technologickému rozvoji a jistě mnoho měst využilo všech možných výhod, stále existují omezení v rozsahu, v jakém byly technologické inovace aplikovány. Zároveň však existuje obrovský potenciál, který mohou města využít na své cestě k udržitelné a zelené budoucnosti. Tato práce proto čerpá ze specifických aspektů struktury ekodistriktu, které přispívají k zeleným řešením. Aspekty, které byly v této studii zohledněny a podrobeny rozsáhlé analýze, jsou obecná data, urbanistický přístup, architektonický přístup, energie, mobilita, veřejná prostranství a krajina. Každá z těchto složek byla analyzována pro každou případovou studii a později syntetizována pro všechny tři případové studie. Vybrané ekodistrikt lokality představují případy, které jsou celosvětově uznávanými modely, které úspěšně integrovaly architektonické inovace, vysoké hodnoty v přístupu k udržitelnosti, uhlíkově neutrální dopravu a energetickou účinnost a řešení obnovitelné energie, vysoce zaměřené na obyvatelnost, kvalitu ovzduší a zeleň a mnoho dalších.

Tato práce pojednává a zkoumá tři zastřešující a vzájemně propojené výzkumné otázky. Které klíčové urbanistické a architektonické kategorie a indikátory lze vzít na základě vyhodnocení případových studií v úvahu při přípravě zásad plánování a navrhování ekodistrikti? Jak by měly být navrženy ekodistrikti? Které principy na základě získaných zkušeností slouží jako základ pro plánování a navrhování ekodistrikti?
První otázka se práce zabývala výčtem a rozpracováním několika urbanistických a architektonických kategorií a jejich sad indikátorů, zatímco poslední dvě otázky důkladnou analýzou zásad plánování a projektování ekodistrikti.

Tato práce analyzovala koncepty návrhu ekodistrikti pro vybrané případové studie a prozkoumala určitý počet kategorií a jejich relevantní sady indikátorů, které by byly použity jako součást přístupu udržitelného návrhu. Výstup práce je propojen s cíli výzkumu. Prvního cíle bylo dosaženo zvýšením obecného porozumění potenciálu ekodistrikti. Součástí druhého cíle byla identifikace klíčových urbanistických a architektonických kategorií a indikátorů. Třetího cíle bylo dosaženo prozkoumáním a rozpracováním toho, jak by měly být navrženy ekodistrikti, a navržením principů plánování a navrhování ekodistrikti.
Hlavními výstupy, které byly v této práci prezentovány, jsou podrobné výsledky z analýz jednotlivých kategorií a jejich příslušných ukazatelů. To by mělo poskytnout spolehlivá data odborníkům, architektům a komunitě designérů při plánování a rozvoji ekodistrikti. Výsledek velmi podrobně zkoumá potenciál kategorií a indikátorů v kombinaci s novými nástroji a technologiemi při realizaci ekodistrikti a měst budoucnosti, vybudovaného prostředí zcela v souladu s bezuhlíkovými cíli a ekologicky šetrnými cestami.

Výsledky technických závěrů zahrnují řadu výhod a nevýhod podrobně rozepsaných v zásadách plánování a projektování ekodistrikti. Ty zahrnovaly návrhy týkající se obecných údajů, podmínek na místě, oblasti, populace; o urbanismu, poloze, blocích, hustotě, výšce, smíšeném využití; o architektuře, projektování budov a majitelích budov; o energetice, o nízkoenergetických a pasivních domech, bio energii a větrné energii; o mobilitě, ve veřejné dopravě, silnicích, garážích, kolech a chodcích; o veřejných prostranstvích, na náměstích a dalších funkcích; o krajině, zelených plochách, zelených střechách, dešťové vodě a zeleném zahradničení. Každému indikátoru a kategorii byla věnována náležitá důležitost a byly propracovány na základě případových studií.

A konečně, prostřednictvím tohoto podrobného zkoumání toho, jak jsou plánovány, navrhovány a implementovány ekodistrikti, naplňuje výsledek práce zastřešující cíl nabídnout nové poznatky o daném tématu s nadějí a motivací, že tyto znalosti budou prakticky využity při rozvoji budoucích ekodistrikti.

Klíčová slova: ekodistrikti; ekosousedstvi; ekocity; principy návrhu; kategorie a ukazatele; udržitelná architektura; Cíle Udržitelného Rozvoje (SDGs); klimatická změna;

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1. Introduction

1.1. Problem Identification

Many human activities have negative impacts on the environment. According to 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 CO_2 emissions will almost double by 2050 (IPCC, 2014c). Cities and urban areas are highly energy intensive, approximately two thirds of the total energy consumed in the globe will be used by cities and urban areas (GEA, 2012) and (Bottero et al., 2019).

As such, the building sector has 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 obvious 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 vast varieties of definitions and characterizations in the literature as well as the planning documentations from different cities, however in this study an ecodistrict is 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. It

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 (Rama, 2022).

In addition to increasing quality of life, social inclusivity, equity, access to green spaces, the main goal is to tackle climate change by offering 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 planning and design of buildings and infrastructure is done based on the ecofriendly solutions and sustainable technologies.

Ecodistricts play an enormous role in expanding climate action in a city they belong to, as well as encourage other cities and regions worldwide to do the same. As a result we see 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 offering practical responses and sustainable pathways.

Planning and designing ecodistricts must be a collaborative effort of many fields of expertise that introduce and include state of the art green technologies. The process must include strategies that call for innovative urban planning and architectural solutions. But above all, 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 case studies of already implemented ecodistricts. 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 this study will propose.

1.2. Research Questions and Hypothesis

Through this research it is aimed to 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.

The research hypothesis can be formulated as follows:
By analyzing and examining data from the existing case studies we could identify a number of categories and indicators which enable proposing a set of principles for planning and designing ecodistricts.

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, natural gas heating system and 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 lucky to get admitted as a PhD student of the Department of Design Studios 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 a 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 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 offering 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

This research started by collecting data from the literature review and desk research, which include, among others, books, reports, journal articles, papers, online sources and similar. Then by complementing with data from the onsite observation as well as the structured questionnaires with general open questions at the end that assist in overall exploration and description of collected data.

Three case studies of ecodistrict sites (Chapter 3) have been selected from a much larger number of sites that were reviewed in this study. 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, inter alia, 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 so they are included in design principles.

The literature review and online research helped identify the best suitable case studies that would fit within the margins of the research goal parameters. Then 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 offering 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.

Collection of data continued with a physical survey of the ecodistrict locations as part of the onsite observation. Onsite visits to the locations were organized with the intention to experience the 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.
In addition, during the physical survey, onsite structured questionnaires with general open questions at the end with several occupants were done. This step was part of collection of both quantitative and qualitative data and enriching information on many aspects (i.e. livability, green spaces, mobility, socioeconomic, and many other), and in support of the data outcome from desk research. The onsite survey has been critical in reaching a deeper understanding of the case studies specifics and their spatial context, and in complimenting the questionnaire results. (O'Cathain and Thomas, 2004) value the general open question at the end of structured questionnaires known as "any other

comments", and claim that it 'has the potential to increase response rates, elaborate responses to closed questions,' it also enables identification of any concerns that might not have been addressed in the closed questions.
The personal observation helped in the process of identifying the main categories and indicators that would potentially be selected for inclusion in the research.

The collected data has gone through mixing and synthesizing or as referred to as, process of integration. 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.

Overall, the eminence of the topic in current literature, the collected data, and the background of the research, facilitated definition of perspective towards the study topic as well as the scope of this research. They all helped predetermine the methodological framework for this research that incorporates concentration on the current state of knowledge of the implemented ecodistrict sites with all techniques, tools, materials, technologies, urban and architectural approaches applied up to date. However at the same time offering a structure that allows and is open to possibilities for future consideration of new cutting-edge technologies that are currently either in the test phases or within limited site application, but which are potentially going to be widespread in the very near future. This approach is in line with the current trends that foresee technological innovation and advanced solutions having a significant influence on our everyday life and how we carry out our daily services. It also is in line with the struggle to tackle issues attributed to rapid urbanization, as well as on many aspects of how cities and urban areas will be managed, how the services will be run and how the infrastructure will be installed and maintained.

Infrastructure such as, charging stations for electric vehicles, recycling, waste compost and reuse that have already penetrated cities' services and infrastructure, but also, the bidirectional vehicle-to-grid operation which helps in balancing the grid load and the use of renewables. New technologies such as, autonomous electric vehicles, aerial vehicles, drone delivery, that will change traditional transportation. New sectors such as urban farming that will potentially relieve the stress of local farms to cope up with production and help in reducing transportation cost and at the same time reduce carbon emissions. Use of recently introduced nature-based solutions to fight biodiversity

loss, and support many other aspects in fighting climate change, urban heat islands and other indirect health and wellbeing issues that the urban population is currently facing.
The introduction of these innovative technologies triggers the need for buildings and built environment to account for and incorporate new infrastructure features, such as landing pads and drone ports, smart waste recycling network, urban farm structures (stand alone or on top of existing buildings), smart electrical grids and many other design features that will enhance urban sustainable development.

Connected vehicles include technologies that generate real-time data and facilitate bidirectional communications with devices and infrastructure. They communicate with parking meters, plug-in and charging stations to indicate the closest available places. Similarly, decreasing traffic congestion by utilizing connected traffic lights which receive real-time data and arrange traffic accordingly. Other aspects such as use of smart trash containers that signal the need for pick-up once they are full.
Smart city pilot projects probably are one of the best ways to address the rapid urbanization and the need for change. They mainly focus on Information and Communications Technologies to enhance services across sectors and with that to increase the quality of life of citizens. In addition to technology, the smart city framework includes participation of and relies on the data provided by citizens.

As such, it is anticipated that many other developments could be occurring in the coming years that have not been part of the existing case studies, therefore it is deemed of the importance that the formulation of this research framework accounts for and acknowledges the potentials and likelihood of these future technological applications.
However, given the fact that all of the above-mentioned new innovative technologies are relatively novel and some might still be in the testing and developing phase, as well as the extent to which this technological advancement has expanded, they will not be in the part of this research, but at least this offers an ‘open framework’ and recommendation to future research on ecodistricts and smart cities.

2. Theoretical background

Based on the elaborated case studies, the author is convinced that ecodistricts have a remarkable power to offer a variety of solutions that would help cities to tackle climate issues.
Cities and the built environment have an enormous potential to contribute to the fight against climate change, and provide a social, sustainable and eco-friendly living. However, there are barriers that cities, as a whole, 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. That's where the ecodistricts come into play, as they neither are at the big city scale nor at the small single building scale, therefore they are considered a perfect scale to deal with many issues and barriers when aiming to achieve urban sustainable development and carbon neutral society.

2.1. Sustainable development

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, Cooper, Davey, & Wootton, 2006; Sharifi & Murayama, 2013; Valentin & Spangenberg, 2000; Sharifi, 2016)

One of the major definitions in the history of sustainable development and that is probably most widely used, most likely 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).

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 on their messages and objectives that are directly connected to how cities and buildings are planned and designed and the impact of them in realizing those objectives. Therefore, below is a quick 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.

"Goal 3. Ensure healthy lives and promote well-being for all at all ages" - which calls for, among others, treatment and promotion of mental health and well-being, while "Goal 6. Ensure availability and sustainable management of water and sanitation" – asks for, inter alia, access to safe and affordable drinking water, access to sanitation and hygiene, improvement of water quality and water-use efficiency, increasing recycling and safe reuse globally. "Goal 7. Ensure access to affordable, reliable, sustainable and modern energy" - relates to, among others, increase of the share of renewable energy and doubling the global rate of improvement in energy efficiency.

In the same nature, "Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" – asks for development of qualitative, sustainable and resilient infrastructure, as well as paying attention to the scientific research and technological capabilities. Of all the ones listed, goal 11 is probably the most critical one to address the importance of the relationship between planning and management of cities and its components, including building complexes and singular building, and the achievement of the targets of this particular goal. "Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable" – accounts for access to adequate and affordable housing, access to and expansion of sustainable public transportation, access to green and public spaces, decent air quality, increase of planning and management of sustainable urban and rural settlements, enhancement of sustainable urbanization, further asks for more cities to adopt and implement policies towards inclusion, resource efficiency, mitigation and adaptation to climate change, which is linked with "Goal 13. Take urgent action to combat climate change and its impacts" – that calls for, among others, resilience to climate-related hazards and natural disasters, as well as making climate change measures part of the national policies, plans and strategies. (UN General Assembly, 2015)

As it can be clearly indicated, there is a direct link between the achievement of the above described goals and the way sustainable buildings, sustainable complexes and districts are planned and executed, as parts of the smaller scale, but as important components of the entire city at a larger scale.

2.2. Sustainable Architecture

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 the right path, 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 & 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 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 & Karvonen, 2008).

Sustainable architecture as well as many other similar terms (eco, green, etc), have been mentioned in the literature for quite some time. Those terms get used interchangeably to basically refer to the same topic. 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.
As we can see, while the term is heavily used, it is difficult to come up with a definition. In general, as built environment and cities are major contributors to energy consumption and greenhouse gas emissions, as well as generating waste and other negative impacts contributors, the sustainable architecture is not only seen as problem solving tool and strategic approach to address those issues, but above all, to increase the quality of life and wellbeing as well.

2.3. Built Environment

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 on 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 and a preference for 'brownfield rather than greenfield sites' are suggested by many authors (Wheeler, 2004) and (Winston, 2012).

However, without doubting the fact that buildings are one of the most important components of the built environment, (Castanheira & 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 perspective, (Moore & Karvonen, 2008) claim that the built environment embodies human intentions and understandings of the world.

2.4. Cities

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.

We are well aware, and more than ever convinced, of the massive human impacts on the environment (Holling, 2000) and (Bakshi et al., 2014). To address this and to help mitigate the impacts, cities should play a critical role 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 views on tackling climate change and the approaches that need to be taken.

Cities' structures are complex, they consist of, on the one hand, physical components that include buildings, roads and other infrastructure elements, and on the other hand, 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, & 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.

2.5. Ecocities

Ecocities and other similar concepts have, in the last two decades, gained global popularity. Be it in the literature as well as 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 deemed as less important. Further, a careful combination of both, could be the approach that might yield the best results.

2.6. Smart Cities and Neighborhoods

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 & Cocchia, 2013) and (Jucevicius et al., 2014) this was as a result of the launch of smart city projects supported by the European Union.
As we know, 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. In terms of focus, (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 on the other hand, operate on a smaller scale compare 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.

2.7. Ecodistricts

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 & Lenhart, 2015) and other sustainable measures. Basically, 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) and (Fitzgerald & Lenhart, 2015).

The implementation of sustainable development at the city or regional level is closely related to the sustainable development in districts (Hamedani & Huber, 2012). 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, we have a vast number of cities that have successfully implemented ecodistricts, have launched projects and taken actions that showed invaluable and hands-on lessons and knowledge on multi levels of city sustainability planning.

From the urban design and technical standpoint, an ecodistrict 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 (Brickman, 2009) and (Toros, 2011). Further, 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) and (Toros, 2011).

2.8. 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).

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 & Dempsey, 2007) nor on its definition, although it is frequently used in literature and in everyday life (Kearns and Parkinson, 2001) (Jenks & Dempsey, 2007). Therefore, depending on the location and the perspective that is being looked from, it allows room 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 & Reith, 2013). They represent a "good practice of architecture and urban sustainability"(Higueras Garcia & 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. Similarly, there is no set recommendation or requirements in the definition of the neighborhood concerning the number of inhabitants (Choguill, 2008) and (Bottero et al., 2019).

(Briggs, 1997), (Galster 2001) and (Jenks & 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, that recently there is a growing focus in practicing sustainability goals through planning at the neighborhood level (Luederitz et al., 2013) and (Sharifi, 2016) and the second, 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 take actions and be responsible according to their common vision, and how they organize life within the community. It's always with the goal of using resources in such a way that would be sustainable for current and future generations.
Recently, there is a high interest in achieving sustainability goals through planning at the community and neighborhood level. According to (Luederitz et al., 2013) and (Sharifi, 2016) sustainability principles are widely used to guide neighborhood planning and development. However, this reminds us of the important interrelations between planning of the whole city as a bigger scale and its districts and smaller components which need to be addressed and taken into account. This is important as 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 link with the sustainability principles at the neighborhood/community level.

2.9. Sustainable buildings

To be 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 key components. As such,

attention and focus is rightfully placed on how to generate high quality buildings that consume low energy and have small carbon footprint, but above all, healthy buildings that enhance livability, quality of life and wellbeing of their inhabitants. Thus, aiming for a built environment that is composed of sustainable/green buildings.

It is argued that focusing on just a single building's sustainability is not sufficient to achieve the general sustainability goals (Wu, Song, Hu, & Wang, 2018). Going from a single building to the district scale increases affordability and diversity of the built environment. On further exploration, it shows us the features of social life that happen in the spaces between buildings (Gehl, 2011) and (Holden et al, 2015), and the interaction between the buildings and their surroundings (Castanheira & Bragança, 2014).

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 and it is highly on the rise, their prominence will continue to expand. Green buildings are seen as an approach to the recent demands rather than an attractive trend. Green buildings include many features, but it might be worth mentioning at least a few here. They provide good comfort due to the fact that they are highly energy efficient and are free of drafts. Further, passive house design incorporates highly efficient heat recovery ventilation that constantly brings fresh air indoors. Green buildings can be aesthetically pleasing as, if properly installed, there are no restrictions on the usage of facade elements. 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. 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.

2.10. Building Design

Building design is quite a wide topic, and it covers a huge 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 zero GHG emissions.

Building performance simulation offers designers and building owners an early stage scenario and model where projections can be generated. Thus offering clues and assessments of how the actual building will be 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 of the sustainable building complexes, as a scaled up and much more complex process. Thus, careful

integration of this aspect at the design phase, will result in less complications and better outcome at the end of the process.

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

2.11. Building Sustainability Assessment

As the sustainable built environment gained traction and got introduced more and more over time, so it was the need for some kind of evaluation system of sustainability measures within a building or larger systems. Although initially the sustainability assessment tools were developed for the evaluation of single buildings, recently the same have been expanded to building complexes, neighborhoods, and city districts.
Assessment tools seek to collect, analyze and provide information that is critical for guiding the decision making process at different phases, such as initiation, design, construction and operation.

As noted by (Castanheira & Bragança, 2014), the building sustainability assessment tools and frameworks include among others, rating systems, assessment frameworks, technical guidelines, LCA based tools, checklists, and many others. These sustainability assessment tools offer exclusive possibilities for all of the stakeholders in the construction industry, such as architects and designers, building owners, developers and contractors, and end users, to select options and take decisions on numerous building sustainability features during different phases. Maybe the definition of ‘quantitative standards to measure the concept of sustainable development in each area’ by (Hamedani & Huber, 2012) summarizes in short the key concept and use of the building sustainability assessment tools.

Over time, we see a progressive move and development of the sustainable assessment systems from smaller scale (building) to a larger one (neighborhood or city). Assessments at different scales apart from identifying the sustainability features on environmental, social, and economic aspects at a single scale, when combined and carefully synchronized, they offer assessment of the same sustainability features, however now for the built environment in its entirety.

Certification for sustainable districts and neighborhoods

With development of sustainable district/neighborhood assessment certification frameworks, the assessment is no longer focusing on a single building, but it now expands to the whole city component, which would be a district or a neighborhood.

Many scholars identify the importance of this scale increase and provide their reasoning and support. (Fraker, 2014) states that shifting the scale of certification to the wider scale (neighborhood) addresses criticisms that the single building certification system was exposed to. In the same line, (Wu et al., 2018) reflects on the attention that the sustainable neighborhood assessment has gained due to the understanding that single buildings sustainability is not the right scale to 'achieve the general sustainability goals for the whole society'.

There are a number of certification systems / frameworks for sustainable urban districts already on the market, such as LEED ND (Leadership in Energy and Environment Design Neighborhood Development), CASBEEUD (Comprehensive Assessment System for Building Environment Efficiency Urban Development), Deutsche Gesellschaft für Nachhaltiges Bauen Urban Districts (DGNB UD), BREEAM Communities (Building Research Establishment's Environmental Assessment Method Communities), SCTool (Sustainable Communities Tool), and many others.

It's interesting to point out that due to the nature of their approaches to assessing challenges at different levels as well as circumstances where they operate, none of the above mentioned systems/tools addresses the same characteristics and features of the sustainability criteria.

Below is one example of what a certification system for sustainable districts (SBTool) might include. It, for example, encompasses several categories spread in all three (environmental, social, and economic) dimensions of sustainability. Categories that cover different elements (naming only few elements here): Urban Form (among others, covers: passive solar planning, natural ventilation, reducing distances and travel times); Land Use and Infrastructure (land use efficiency, urban sprawl); Ecology and Biodiversity (green spaces, protection of local biodiversity); Energy (energy efficiency and renewable energy); Water (drinking water consumption and the treatment of wastewater); Materials and Waste (materials' life cycle, use of sustainable materials, urban solid waste); Comfort of Outdoor Areas (social dimension, health of inhabitants, air quality, thermal and acoustic comfort); Safety (public health, safety and crime prevention); Amenities (proximity of residential and work areas to key amenities); Mobility (public transport, pedestrian and cycling networks). (Castanheira & Bragança, 2014)

2.12. Livability

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 any assessment scale from the best all the way to the worst living quality. 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, Haveriku, Dreifus Zaluski, Chen, & Dietrich, 2018).

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) and (Martino, N., Girling, C., & Lu, Y. (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 seen 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’ (AARP, 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 well being'.

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.

2.13. 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).

Through potentials for improvements in urban form and building design, cities can achieve sustainable solutions that would result in energy savings. Enabling and encouraging more sustainable lifestyles and any other social forms is the other potential that cities can contribute to. (Grimm et al., 2008; WBGU, 2011; Weisz &Steinberger, 2010; Williams et al, 2010; Luederitz et al., 2013), however it is recognized that 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 & Bragança, 2014)

As a response to the negative environmental impact of architecture and urbanism, the ecology has been included in theories of architectural and urban design in the last quarter of the last century (Ingersoll, 2012).

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 & 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 we evaluate our 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'.

2.14. 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 seen 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 myriad benefits of green infrastructure, two scale-based concepts have been suggested, one being the urban and the other, landscape scale. Further, it is argued that 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, in a recent report the (IPCC, 2022a) it is stated that the 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, there are a few suggestions that point towards similar goals. (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, M. and McMahon. E., 2006). (US EPA, 2008) goes further to define it as a wet weather management approach that incorporates greenery and soils to enhance the natural hydrological infiltration and reuse.

As it can be concluded, the green infrastructure concept helps us further understand benefits that ecosystems can offer and how to best make use of and manage those benefits. It can be seen that 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.

2.15. Open/Green Spaces

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 the green spaces offer. As we know the land area is scarce and the tendency is always to increase the built up surface versus the open spaces, however all the cities that truly want to achieve sustainable districts, do take this very seriously and allocate ample amount of green spaces.
The advantage is that green spaces are not only on the dedicated zones, but they occupy all the areas between the buildings as well, that often serve as green corridors that connect adjacent larger spaces within borders of an ecodistrict or even better, connecting the ecodistrict to a much larger green park or simply, green fields.

It is argued that 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 & 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 once again shows 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. Therefore, it can be said that green spaces are rightfully highly valued when evaluating the sustainability of a city component.

2.16. Social and Cultural Dimensions

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 in development of the 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 & 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 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.

2.17. Human behavioral

In 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 the energy consumption and subsequently on the 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 the 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 & 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 & 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.

We are well aware of the massive human impacts on the environment, and the need for a fundamental lifestyle change (Holling, 2000) and (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 & 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 & Buys, 2008; Pretty, 2003; Miller & 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.

2.18. Sustainable Development Paradigm Shift

Analyzing the sustainable development paradigm from holistic and other various research viewpoints, (Pisano, 2012) and (Constantinescu & Platon, 2014) concludes that 'sustainable development is a civilizing idea, with continuous improvement possibilities'.

In a simple phrase, the sustainability paradigm considers a future in which environmental, social and economic aspects are balanced (Basera, 2016). However, the current sustainable development paradigm, has received its fair share of criticism by many researchers, they argue that this paradigm is not properly addressing social, economic, environmental and climate change issues in cities and urban areas.

It is claimed that the advancing ecological worldview should have a holistic approach, be deep and geocentric oriented (Devall & Sessions, 1985) as well as the need for the change in paradigm to be more regenerative and resilient. Similarly, (Constantinescu & Platon, 2014) state that within all evolving concepts of the Sustainable Development paradigm, the most widespread is resilience. A circular economy, and reuse and repurpose of materials is part of the paradigm shift as well, it calls for employment of innovation in the quest for efficient use of materials and energy (Morone & Yilan,2020).

In response, Smart Sustainable Development has recently appeared in the Sustainable Development paradigm, which, by utilizing information and communications technology as well as human interaction, offers prospects of practical application as well as builds on the quest to address future long-term ecological issues mainly caused by rapid urbanization and other impacts.

3. Case studies: Analysis of selected ecodistrict sites

3.1. Research methodology

Many cities in Europe have successfully implemented ecodistricts, these projects presented valuable information and practical lessons on city sustainability planning. To learn more about details concerning planning and implementation of ecodistricts, three case studies explored in this research have been taken from those existing initiatives in cities within the European context. These cases represent the sites that are globally recognized and highly evaluated models for their sustainable approaches which focus on, among others, sustainable land use, preservation of water and ecosystems, green spaces, eco-friendly transportation, energy efficiency and renewable energy strategies, architectural solutions that integrate good building orientation and daylighting, thermal comfort, indoor air quality and ventilation.

The first phase of the study began early 2016 with the literature review and online research, this helped identify the best suitable case studies that would fit within the margins of the research goal parameters. Then it continued with utilizing the desk/secondary research data on ecodistrict sites from various sources, among others, books, reports, journal articles, papers and similar. A site visit in 2017 to one of the case study sites, Vauban ecodistrict, represented the beginning of the second phase, which is the onsite observations and the structured questionnaires with general open questions at the end with inhabitants of the ecodistricts. Further site visits to all three case studies followed in the coming years.

The three cases are included 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.

3.2. Case Study A1: Vauban – Freiburg

A.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 A1.1**)** 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 seems to have been 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 A1.1 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 A1.2).

Figure A1.2 The view of Vauban district from the nearby hills (source: Bardhyl Rama)

A.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.

A.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 building in the entire district area, Figure A1.3.

Figure A1.3 The use of different types of architectural approaches in buildings (source: Bardhyl Rama)

A.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 A1.4.

Figure A1.4 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, materials, offering a pleasing view and a good architectural and urban design harmony in different parts of the district. Figure A1.5.

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 A1.5 Property developers apartment buildings (source: Bardhyl Rama).

A.1.4. *Energy*

A.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 year timeframe, thus considered plus-energy houses.

The use of highly energy-efficient buildings and the 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 A1.6)

Figure A1.6 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 A1.7 depicts the sustainable residential complexes within the ecodistrict, the color-coded view is based on their energy efficiency standard approach, which includes passive house, zero energy houses and plus-energy house.

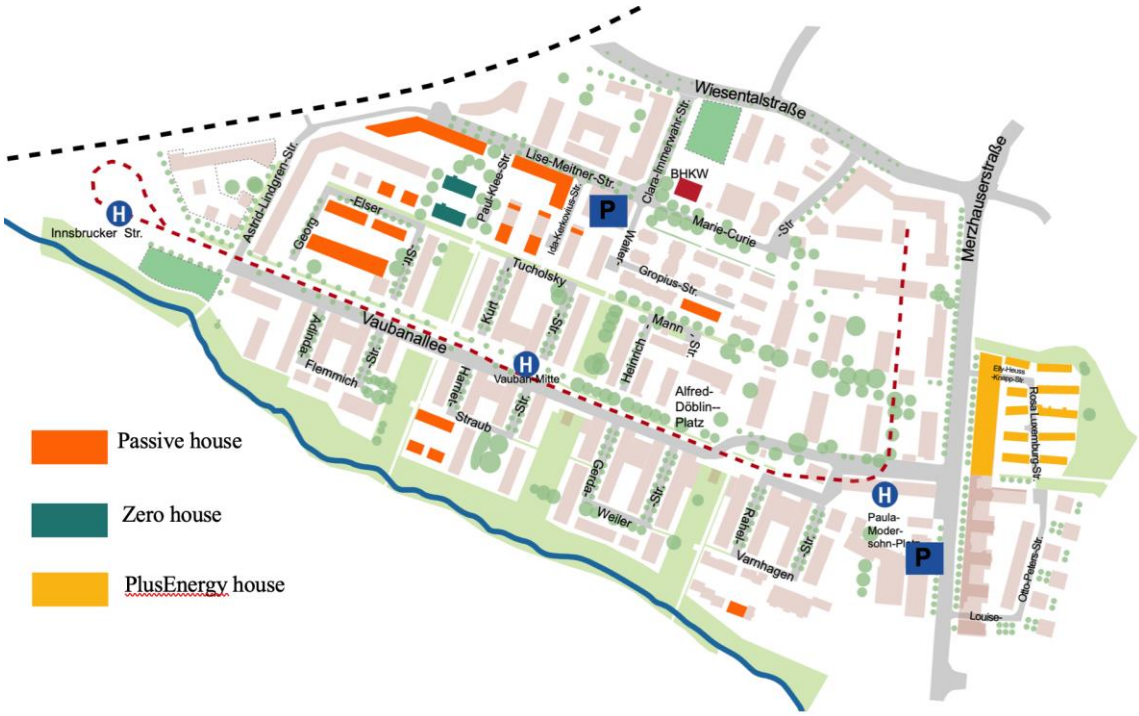

Figure A1.7 Sustainable residential complexes based on their energy efficiency standard approach. (source: (City of Freiburg, 2008))

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.

A.1.4.2. **Combined Heat and Power (CHP) Plant**

The biomass Combined Heat and Power (CHP) Plant (Figure A1.8) 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 A1.8 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.

A.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 A1.9).

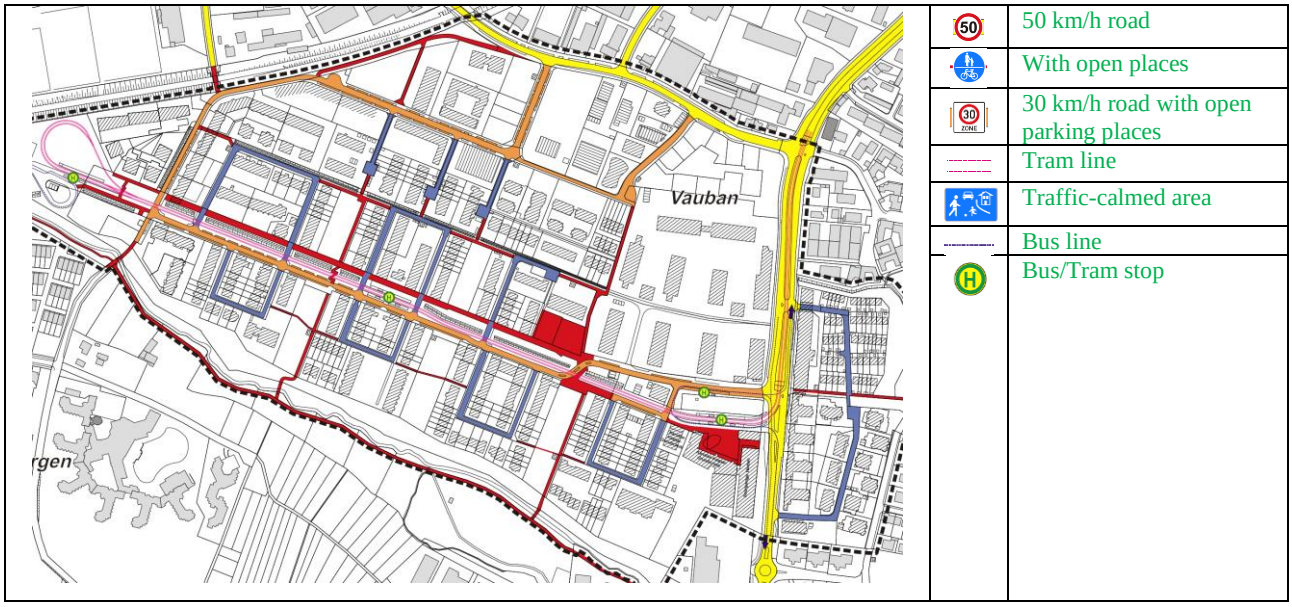

Figure A1.9 Schematic view of the traffic concept (source: (City of Freiburg, 2008))

A.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 A1.10) 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 A1.10 View of the tram and bus line and the stops at different points (source: Bardhyl Rama)

A.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 (Figure A1.11), in the traffic-reduced residential roads, unless for loading and unloading, there are not parking spots available.

Figure A1.11 Parking spaces available along the 30km/h speed limit road (source: Bardhyl Rama)

Thanks to very good public transportation service, the concept of the car-reduced district (Figure A1.12) could be implemented.

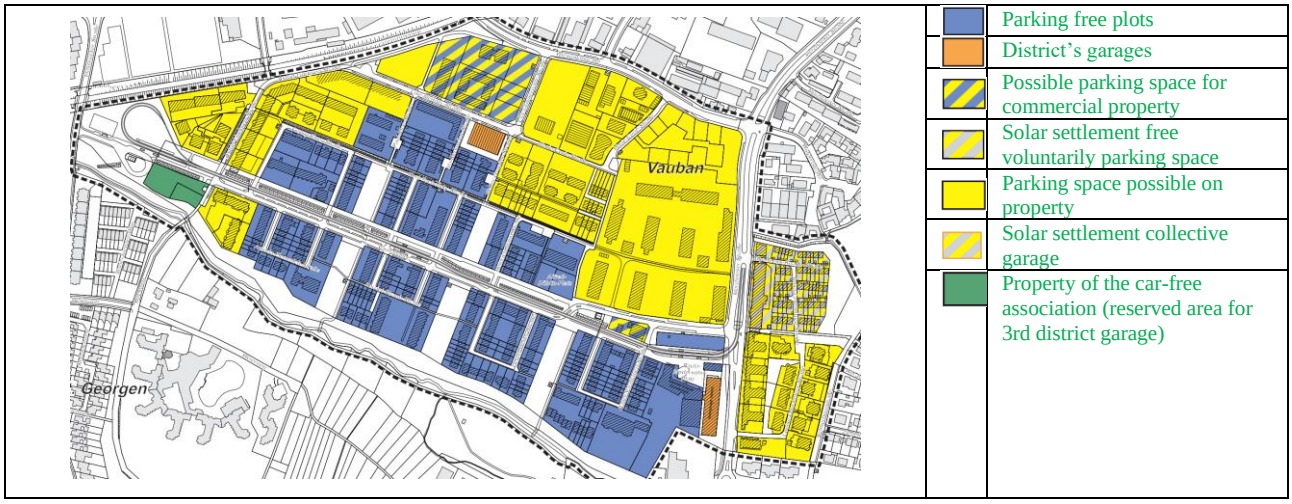

Figure A1.12 Schematic view of the parking concept (source: (City of Freiburg, 2008))

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

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.

A.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 thru 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 A1.13).

Figure A1.13 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.

A.1.6. ***Public spaces***

Vauban has two main squares, one is the “Alfred-Doblin-Platz” (Figure A1.14 left), which is regarded as the district’s central market and community gathering area, and the other the “Paula-Modersohn-Platz” (Figure A1.14 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 the 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 the district.

Figure A1.14 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).

A.1.6.1. ***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, grassroot 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.

A.1.7. ***Landscape***

A.1.7.1. **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 the nature. This is important in particular for the elderly people as well as children (Figure A1.15).

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 A1.15 Open green spaces (source: Bardhyl Rama)

There are numerous children playgrounds (Figure A1.16) places 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 A1.16 Open playgrounds (source: Bardhyl Rama)

A.1.7.2. **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 A1.17).

Figure A1.17 Green gardening space (source: Bardhyl Rama)

A.1.7.3. **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 A1.18 Rainwater collection, infiltration area (left) (source: (City of Freiburg, 2008)); view of functioning open water collection/drainage ditch (source: Bardhyl Rama)

Table 1. 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 / m²) in accordance with the city's standards
Passive house standard (15 kWh / m²a) 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

A.1.8. *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 physically being present in a location and by observing all aspects and interactions that happen. In the ecodistrict, buildings are a key component, nevertheless the infrastructure, the 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 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 observing the site from different angles. Additional data has been gathered by interacting with the residents during the site visit. As expected, structured questionnaires yielded interesting results. Outcomes from the onsite observation as well as from the structured questionnaires with general open questions at the end have been presented in this subsection.

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 start experiencing the ecodistrict from the resident's perspective. Pathways, bike lanes, road crossings, playgrounds, the green and open spaces as well as, 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

Vauben 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 stander buildings, some are energy neutral and some other are even energy positive. Vauban´s energy comes the Combined Heat and Power (CHP) biomass Plant as well as from wind turbines, which when combined with high efficiency buildings, it 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 a 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 gathering 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 equipments 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 (ICLEIeurope, 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.

3.3. Case Study A2: Kronsberg – Hanover

A.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 A2.1), 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 K. et al, 2013) .

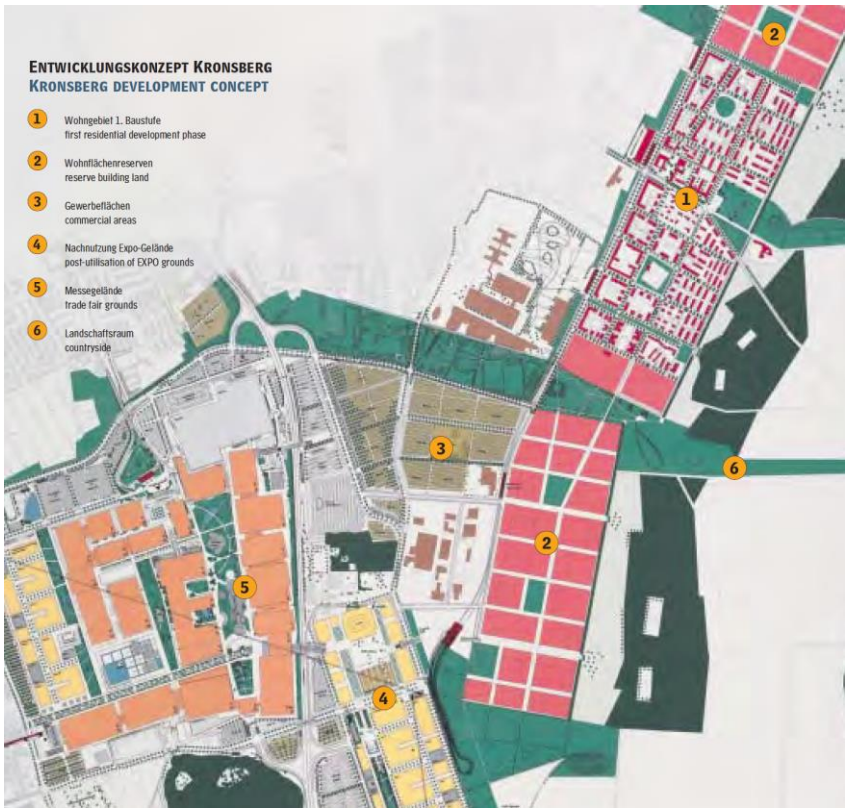

Figure A2.1 View of Kronsberg development concept (source: (Schottkowski-Bähre, 2000))

A.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 A2.2) 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.

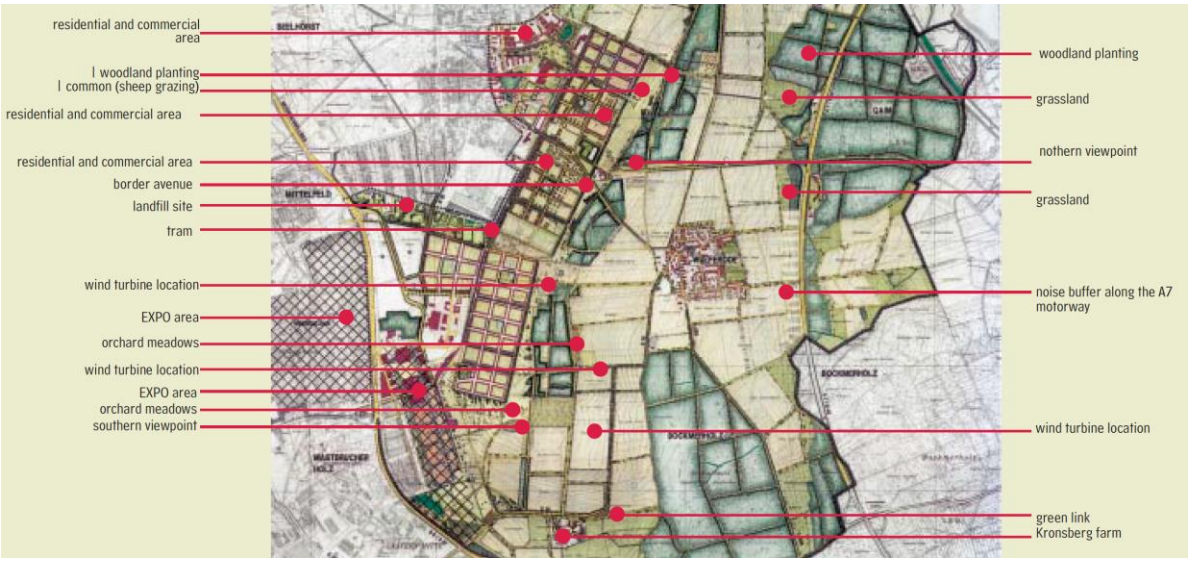

Figure A2.2 View of wider area surrounding Kronsberg ecodistrict (source: (Rumming K. et al, 2004b))

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.

A.2.3. ***Architecture***

As already mentioned above under the urban planning section and shown in Kronsberg general plan (Figure A2.3), 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.

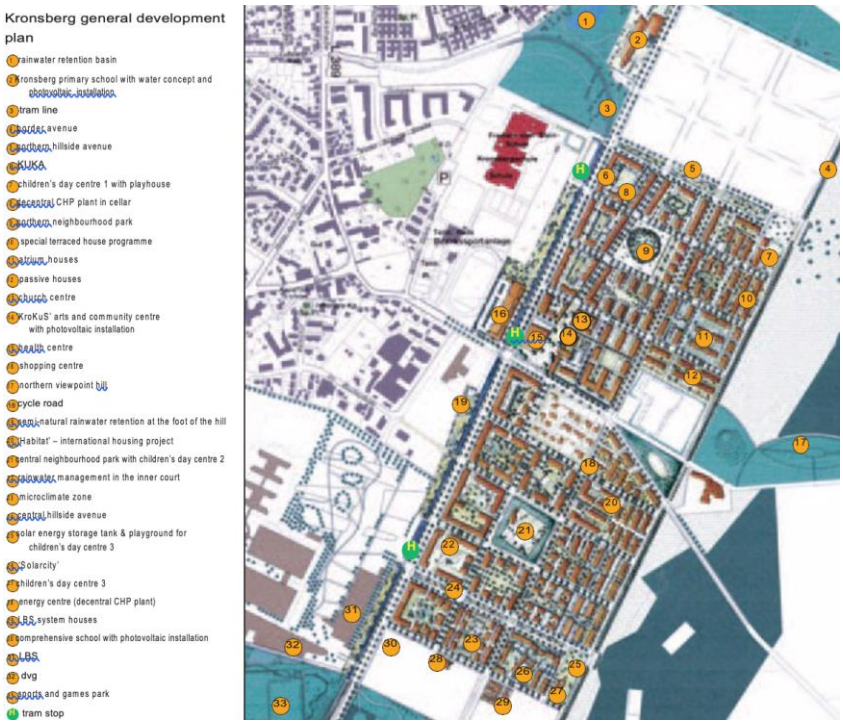

Figure A2.3 Kronsberg general development plan (source: (Rumming K. et al, 2004a))

A.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 A2.4) 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 A2.4 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 A2.5)

Figure A2.5 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 A2.6)
Their floor plans vary from one to five-room apartments with two to three apartments on each landing.

Figure A2.6 Apartment blocks – view of a sample façade (source: Bardhyl Rama)

Solarcity (Figure A2.7), 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 A2.7 View of Solarcity building (source: Bardhyl Rama (left), (Rumming K. 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 K. 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 A2.8)

Figure A2.8 View of Passive house settlement (source: Bardhyl Rama)

A.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 a perfect 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 that its actual needs, therefore feeding the excess electricity back to the power grid.

A.2.4.1. **Energy Efficiency, Solar Installation and Wind Energy**

The district energy efficiency concept (Figure A2.9) 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 K. 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.

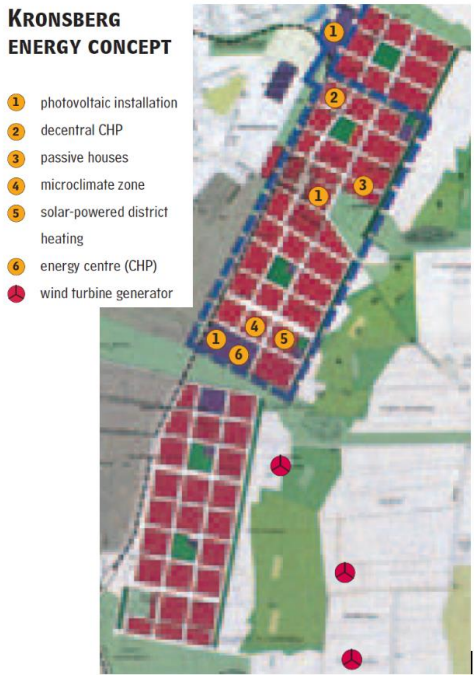

Figure A2.9 Kronsberg energy concept (source: (Rumming K. et al, 2004a))

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 K. 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 A2.10). 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 K. et al, 2004a).

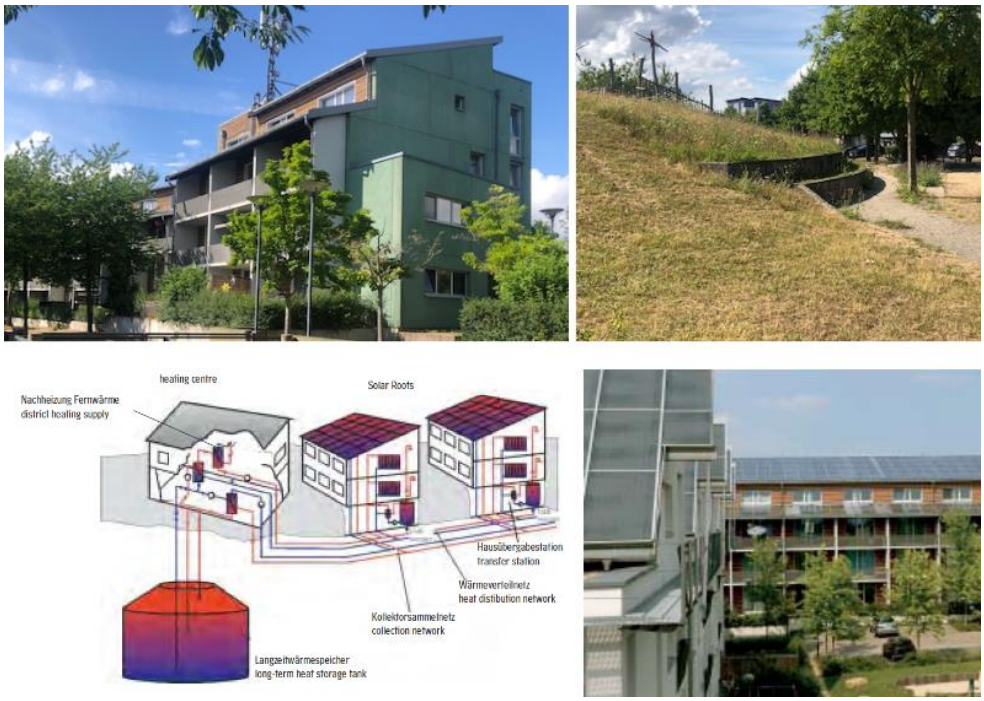

Figure A2.10 Solar thermal collectors (left) (source: Bardhyl Rama (top), (Rumming K. et al, 2004b) (bottom right); Schematic view of the system (bottom left) (source: (Schottkowski-Bähre, 2000))

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 A2.11). The power generated by the PV panels is supplied into the district's electricity grid.

Figure A2.11 Photovoltaic installation at KroKuS (source: Bardhyl Rama (left), (Rumming K. et al, 2004b) (right))

Wind Energy

With its three large-scale wind turbines installed in 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 K. 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.

A.2.4.2. **Combined Heat and Power (CHP) Plants**

Two decentralized natural gas-powered combined heat and power (CHP) stations (Figure A2.12), 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 K. 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 A2.12 The Combined Heat and Power (CHP) Plants – standalone structure (left), included in apartment building basement (right) (source: Bardhyl Rama)

A.2.5. ***Mobility***

Given the ambitious environmental goals with the development of the 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 a perfect example of how the ecodistrict should plan and implement mobility.

A.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 kilometers from any of the residential units to one of the tram stops.

The main tram stop (Figure A2.13) 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 A2.13 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 K. 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.

A.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 A2.14) 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.
Approximately 30% of cars are placed in underground parking (Rumming K. et al, 2004a).

Figure A2.14 Private parking spaces along the road (source: Bardhyl Rama)

A.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 A2.15) 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 A2.15 View of the main bike lanes (source: Bardhyl Rama)

A.2.6. ***Public spaces***

There are several places in the district that serve as public spaces, such as the district square (Figure A2.16), 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. This main public square (Figure A2.17) 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 vicinity that host a number of shops that help creating a very busy and lively square.

Figure A2.16 Plan view of the district public areas (source: (Rumming K. et al, 2004a))

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 A2.17 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 (Schottkowski-Bähre, 2000).

A.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 ´a direct impact on their immediate life situation can be 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.

A.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 K. 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 K. et al, 2004b) . Several site elements such as perimeter avenue (Figure A2.18), the viewpoint hill and similar, are models of creative landscape design on the urban verges (Schottkowski-Bähre, 2000).

Figure A2.18 Perimeter green avenue (source: Bardhyl Rama)

A.2.8.1. *Green spaces and playgrounds*

A lot of green spaces as well as playgrounds (Figure A2.19) 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 A2.19 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 A2.20).

Figure A2.20 Hiking path to the northern viewpoint (source: Bardhyl Rama)

A.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 A2.21) 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 A2.21 View of Kronsberg farm (source: (Schottkowski-Bähre, 2000))

A.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 A2.22).

Figure A2.22 Rainwater collection area (source: Bardhyl Rama)

Table 2. 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 m2 per year
Passive house standard (15 kWh / m²a) buildings	Lummerlund consists of 32 terraced family houses
Energy plus housing	105 apartment units in the Solarcity complex are heated from about 1,350 m2 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

A.2.9. *Onsite observations and structured questionnaires with general open questions at the end*

As with the previous case study, the 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 eldery people claiming, 'Maybe a little bit more activities can encourage interaction with eldery 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 K. 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.

3.4. Case Study A3: Bahnstadt - Heidelberg

A.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 A3.1).

Spreading over 116 hectares of land 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 Pasivhouse 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 A3.1 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 A3.2).

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 A3.2 Bahnstadt district aerial view (source: (City of Heidelberg))

A.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 makes it a perfect 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 offering 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 %. Bahnstadt total area is 116 hectares, however only 60 hectares managed by city established development body EGH (Development Company Heidelberg), which are spread to 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.

A.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 A3.3).

Figure A3.3 Types of buildings and architectural approaches in Bahnstadt (source: Bardhyl Rama)

Bahnstad'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).

A.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 offering 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 A3.4). 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.

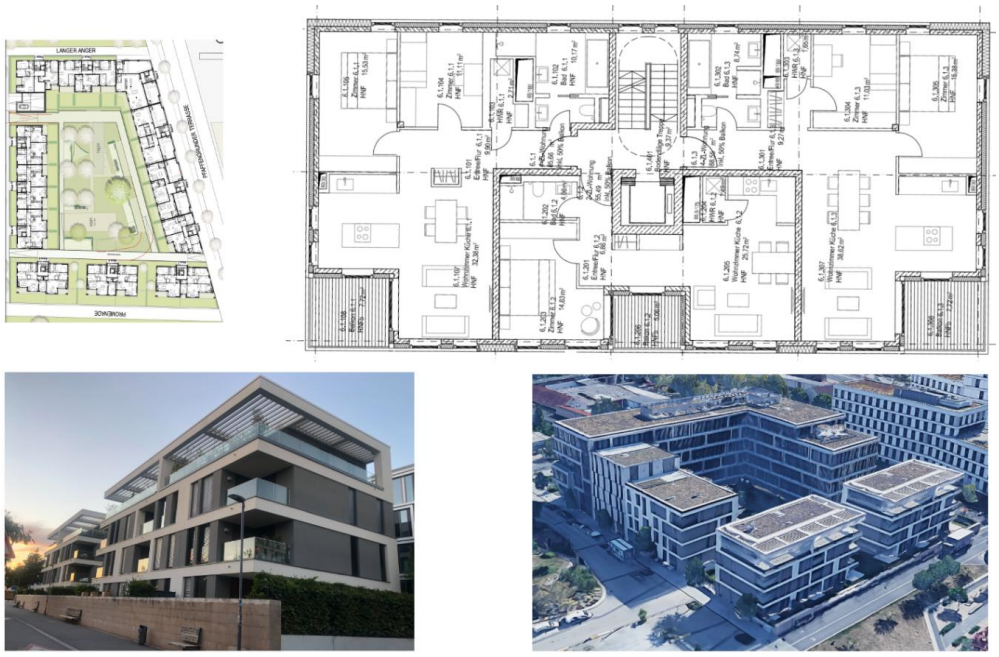

Figure A3.4 Mixed-use complex ‘Colors’, site plan and a sample floor plan and perspective views (source: Heinze (top), Bardhyl Rama (bottom left), google map (bottom right))

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 A3.5) contains 284 one-to-five room rental apartments that provide modern space for residents in their 30 to 146 square meters floor plans.

Figure A3.5 The Westarkaden shopping and rental apartments (source: Bardhyl Rama)

One distinct residential complex is the "Junges Wohnen" (Figure A3.6), 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 to primarily young people.

Figure A3.6 The "Junges Wohnen" apartments (site plan, alternative floor plans (top), floor plan (middle) (source: Heinze), 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 A3.7) 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 A3.7 City villas floor plan and street view (source: Heinze (left), author (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 A3.8).

Figure A3.8 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.

A.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.

A.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 A3.9). 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, 2022)

Figure A3.9 Photovoltaic solar panels arrays (source: city of Heidelberg (top), Frey Architekten (bottom))

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.

A.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 A3.10 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 A3.10 right) has been distributed throughout Bahnstadt.

Figure A3.10 Combined Heat and Power (CHP) wood-fired thermal power station (right), 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)

A.3.5. *Mobility*

One of the key points in Bahnstad'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 offering 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.

A.3.5.1. *Public Transportation*

Heidelberg's public transportation network (Figure A3.11) 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 green gas emissions reductions and in achieving climate protection goals.

Figure A3.11 Schematic view of the public transportation (source: City of Heidelberg)

All three Bahnstadt stops (Figure A3.12), 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 A3.12 View of the tram line stops (source: Bardhyl Rama)

A.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 A3.13) are mainly along the main streets 'Grune 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 'Grune Meile' and 'Langer Anger' is 30 km/h. Other secondary roads are at much slower speed.

Figure A3.13 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.

A.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 A3.14). 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 A3.14 Bike lane along the road and the tram tracks (source: Bardhyl Rama)

A.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 Bahnhofsplatz Süd and Europaplatz (City of Heidelberg, 2019).

Pfaffengrunder Terrasse and Godamaplatz (Figure A3.15) are in the central part of the ecodistrict. Both squares, which are located along one another, serve as community gathering points offering a wide range of possibilities for different kinds of functions.
Located in Gadamerplatz and operated by the Bahnstadt residents' association, B³ community center (Figure A3.15) 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 A3.15 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 Schwetzinger Terrasse daycare center. Placed in the central part of the Schwetzinger 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.

A.3.7. **Social and *cultural* interaction**

Bahnstat'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 offering 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.

A.3.8. ***Landscape***

A.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 track 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 A3.16)
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 A3.16)

Figure A3.16 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 A3.17).

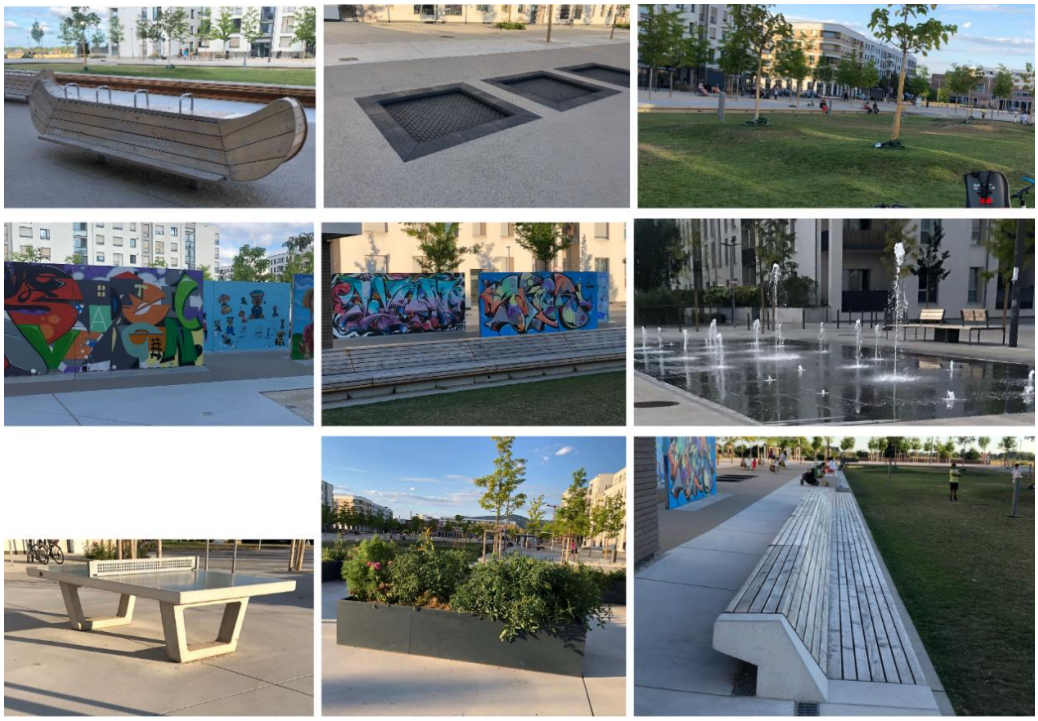

Figure A3.17 Playground equipment, trampolines, ‘bumpy’ lawn places (first row), graffiti walls, water fountains (second row), table tennis, raised beds for vegetation, many seating areas, trees and open lawn playground (source: Bardhyl Rama)

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 A3.18). The railway playground includes red coloured train structures. The other popular one, also with red color, is the fire brigade playground near the Schwetzinger 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 A3.18 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.

A.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 sent up a corner in Pfaffengrund Terrace for this purpose (Figure A3.19). 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 A3.19. Raised beds with plants as part of the Banstadt's urban gardening project in the Pfaffengrund Terrace (source: Bardhyl Rama)

A.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 A3.20) 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)

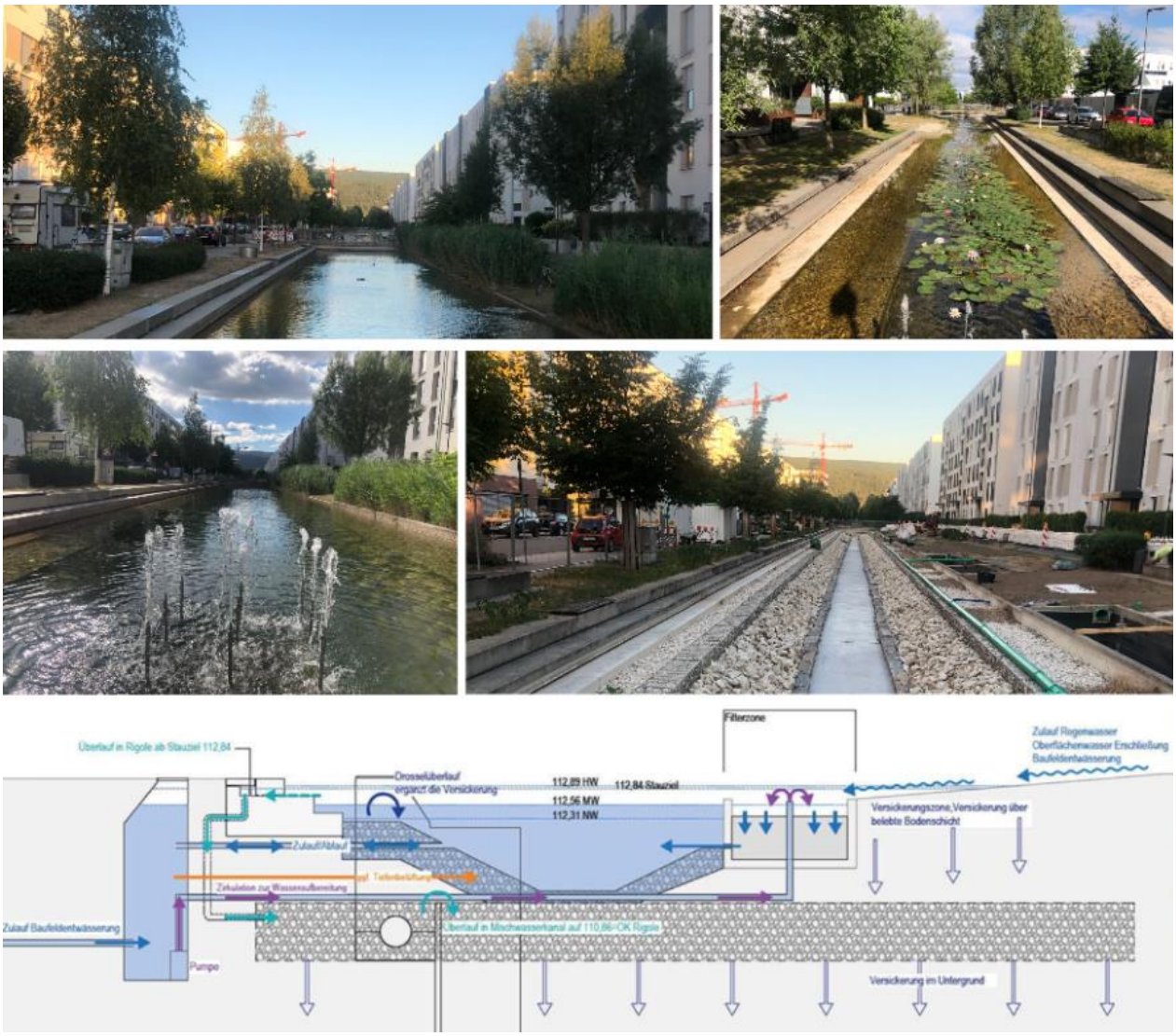

Figure A3.20 The view of the water lagoons (top and middle) (source: Bardhyl Rama), and sectional detail drawing (bottom) (source: City of Heidelberg)

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

General data	
Site condition	Brownfield
Area	116 hectares (of that only 60 hectares managed by city Development Company)
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 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^2a) 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 function
Daycare/Kindergarten	Several daycare centers
Youth and community center	One building with three integrated function (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

A.3.9. *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 ‘Grune 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 thru the three public squares, Gadamerplatz, Pfaffengrunder Terrasse and Schwetzinger 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 hight and all of them have roof terraces facing the greenfields. One of 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 be 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 tran station withing 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 Schwetzinger 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, Schwetzinger 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. 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 1, 2, and 3), 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 4 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, while a category includes all the indicators that are grouped within a particular theme.

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 & 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 1, 2 and 3), a more comprehensive assessment and elaboration is presented visually in Table 4 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 1, 2 and 3), while introducing several variations to the list of initially proposed indicators. Table 4 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 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 that have 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 4. 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. Principles of planning and designing of ecodistricts based on case studies

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.

Further, there is a lot of research and abundant literature on participatory design as well as collaborative design, that addresses their particular role and importance during the process of planning and designing ecodistricts and are considered relevant parts in sustainable development as a whole.
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)

Therefore, it is claimed that 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.

Following the analysis and findings from Chapters 3 and a list of categories and their indicators in Chapter 4, as part of one of the research goals, a thorough elaboration 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 5. Compiled 'General' data for the three case studies (source: Tables 1, 2 and 3)

General data			
	Vauban	Kronsberg	Bahnstadt
Site condition	Brownfield	Greenfield	Brownfield
Area	41 hectares	70 hectares	116 hectares (of that only 60 hectares managed by city Development Company)
Population	Approx. 5,500 residents in 2,531 households	7,150 residents, over 3,200 apartments	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 analysis of the three case studies indicates that an ecodistrict area varies, size could be from 41 hectares (Vauban) to almost double that, about 70 hectares (Kronsberg) to a much larger area of 116 hectares (Bahnstadt). About 40% planned for residential, while the rest includes public spaces, green areas, traffic, industrial use and similar (Vauban and Kronsberg). Whereas Bahnstadt 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 bigger the area the greater the number of residents. 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 Bahnstadt 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 are mostly used, what is the density? Is mix-use introduced?

Table 6. Compiled 'Urban planning approach' data for the three case studies (source: Tables 1, 2 and 3)

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	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,

	which is designed in a free (irregular) building shapes.		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 brownfields, old harbors or sites no longer in use, or in a suburb area that is planned as new development.

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.

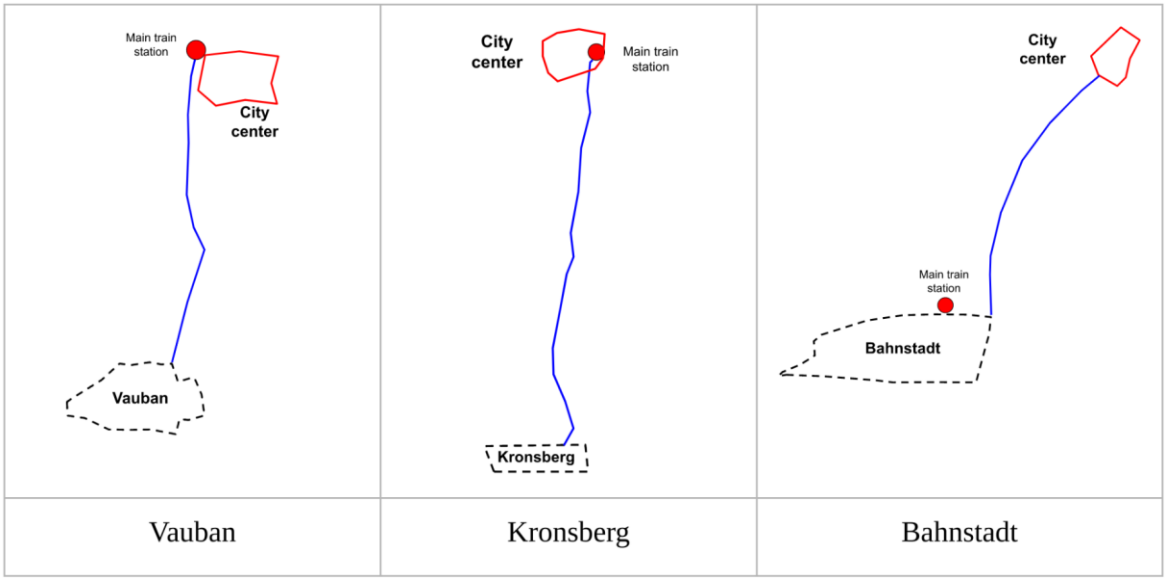

Figure 5 .1 Case study ecodistricts position in relation to the city center and the main train station. *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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 &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 form to include court, close, and cul-de-sac.
It is not common to design a perimeter block with an uninterrupted line. Therefore, 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 show 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.

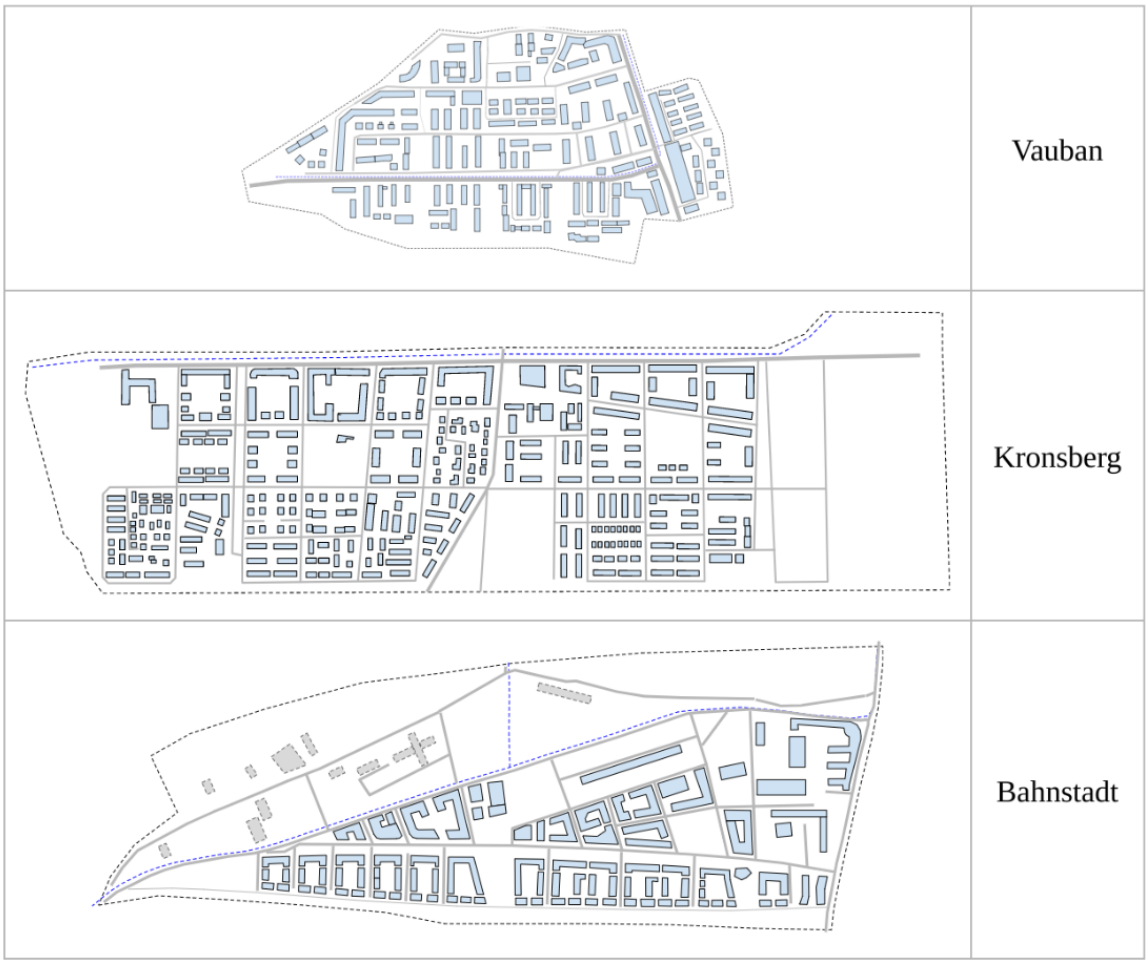

Figure 5.2 Arrangement of urban blocks for all three case studies *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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*

Urban density is a significant factor that determines a lot of parameters in an ecodistrict. 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).

The three case studies indicate that the urban density has been given considerable attention at the start of the planning of each ecodistrict. The numbers slightly differ 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.
Similarly 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 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 6) 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 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 & Henderson, 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.

5.3. Architectural approach

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

Table 7. Compiled 'Architectural approach' data for the three case studies (source: Tables 1, 2 and 3)

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 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’.

		Individual builders
		Developers
		Construction groups
		Student Services
		Cooperative-oriented property developers

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.

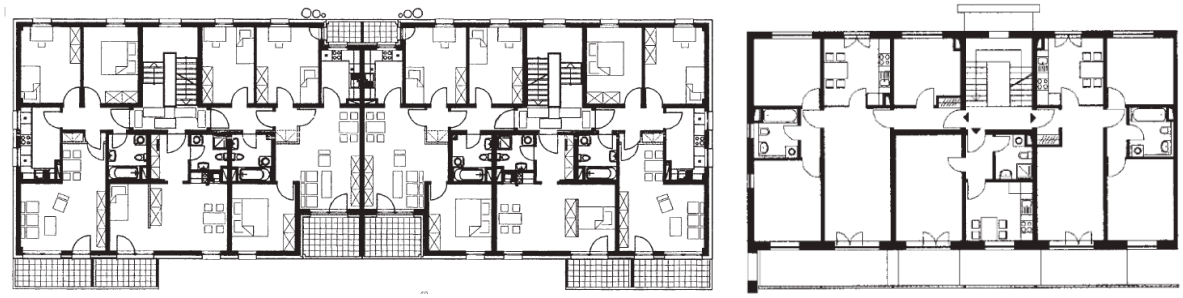

Figure 5.5 Floor plan view of residential complexes (left) and apartment block (right) (source: (Schottkowski-Bähre, 2000))

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 (Bahnstadt), 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 are commonly used? What kind of renewable energy strategies are applied?

Table 8. Compiled 'Energy' data for the three case studies (source: Tables 1, 2 and 3)

Energy			
	Vauban	Kronsberg	Bahnstadt
Low-energy buildings	Mandatory requirement - construction of low-energy buildings (not more than 65	All residential buildings in the Kronsberg district were built as Low Energy Houses. Each building requires a proven	All Bahstadt's buildings have been built in accordance with the Passive house standard.

	kWh / m²) in accordance with the city's standards	maximum heating energy of 55 kWh per m2 per year	
Passive house standard (15 kWh / m²a) 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 m2 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

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: What are sustainable mobility strategies? How are public transportation, biking and walking addressed?

Table 9. Compiled 'Mobility' data for the three case studies (source: Tables 1, 2 and 3)

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, offering 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.

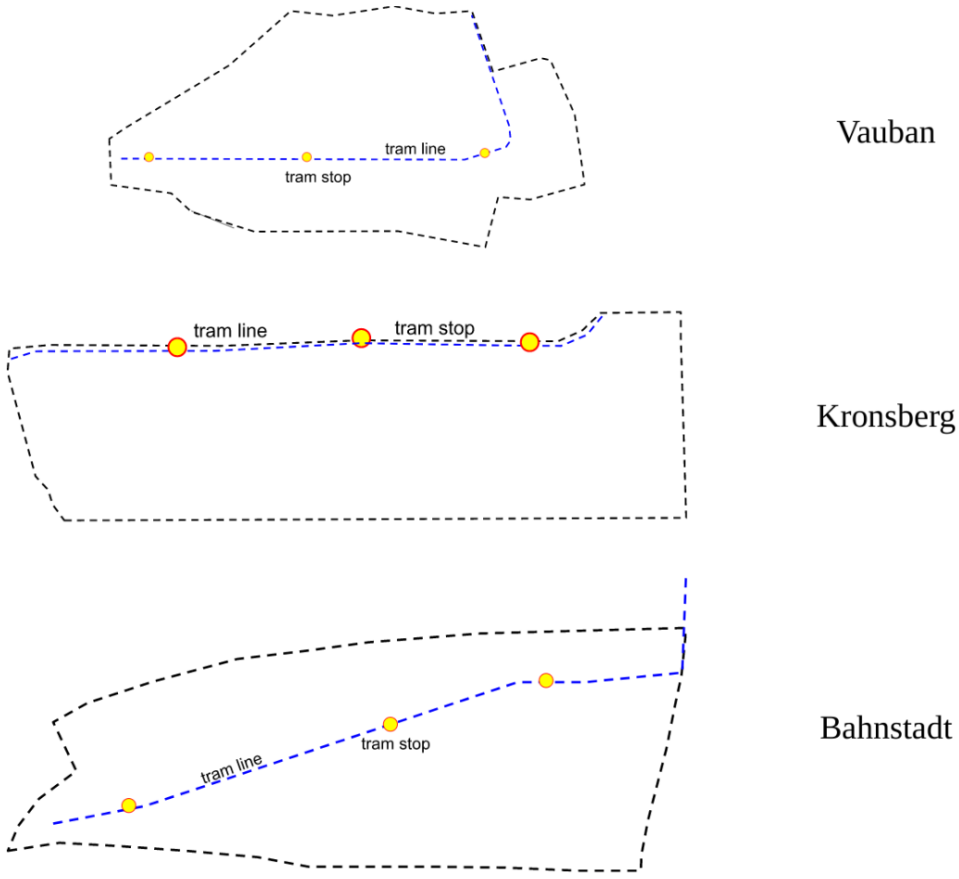

Figure 5.6 Public transportation lines in relation to the ecodistrict, for all three case studies *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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 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.

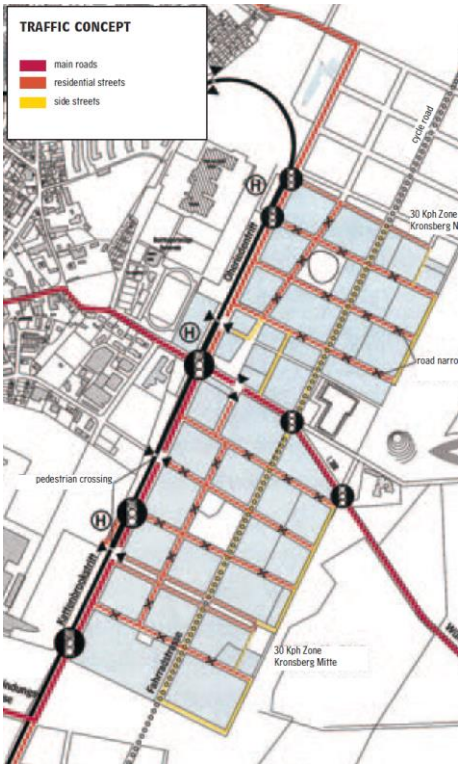

Figure 5.7 Kronsberg car traffic concept (source: (Rumming K. et al, 2004a))

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, offering 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 K. 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 we learn 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 are public functions and services planned? How many public squares each case study has?

Table 10. Compiled 'Public spaces' data for the three case studies (source: Tables 1, 2 and 3)

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.

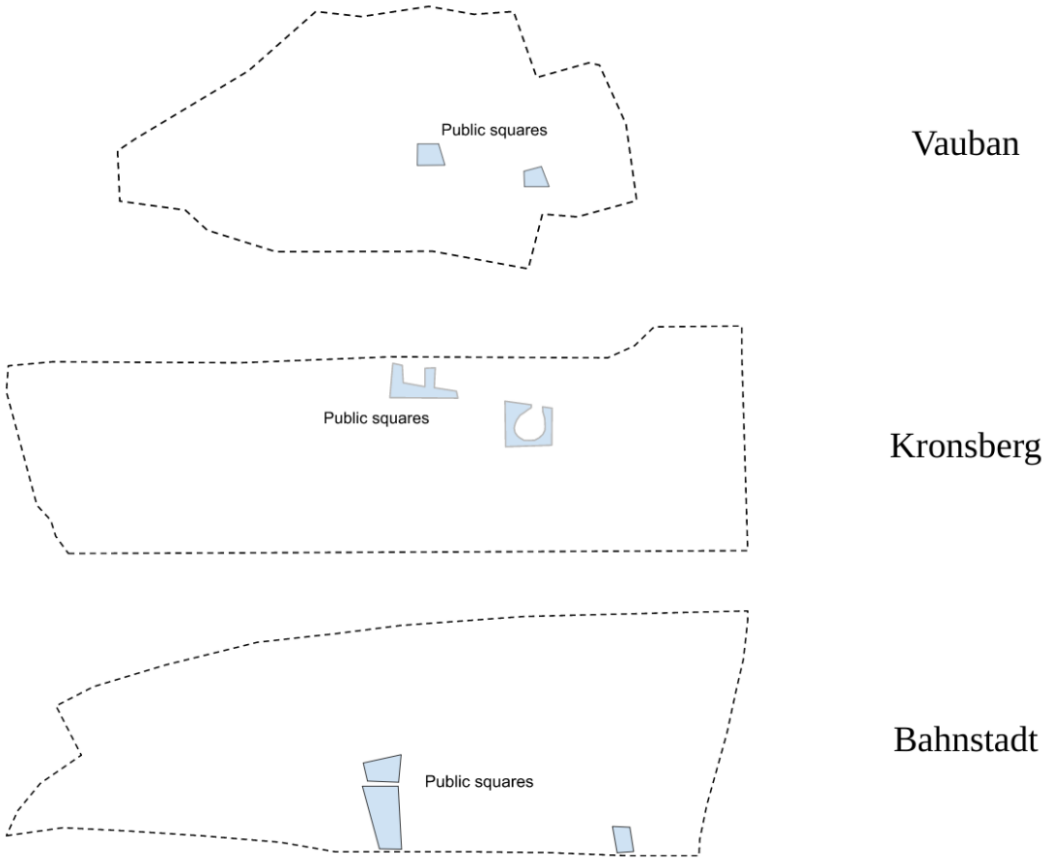

Figure 5.8 Public squares position within the ecodistrict for case studies *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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

Table 11. Compiled 'Landscape' data for the three case studies (source: Tables 1, 2 and 3)

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 spaces 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.

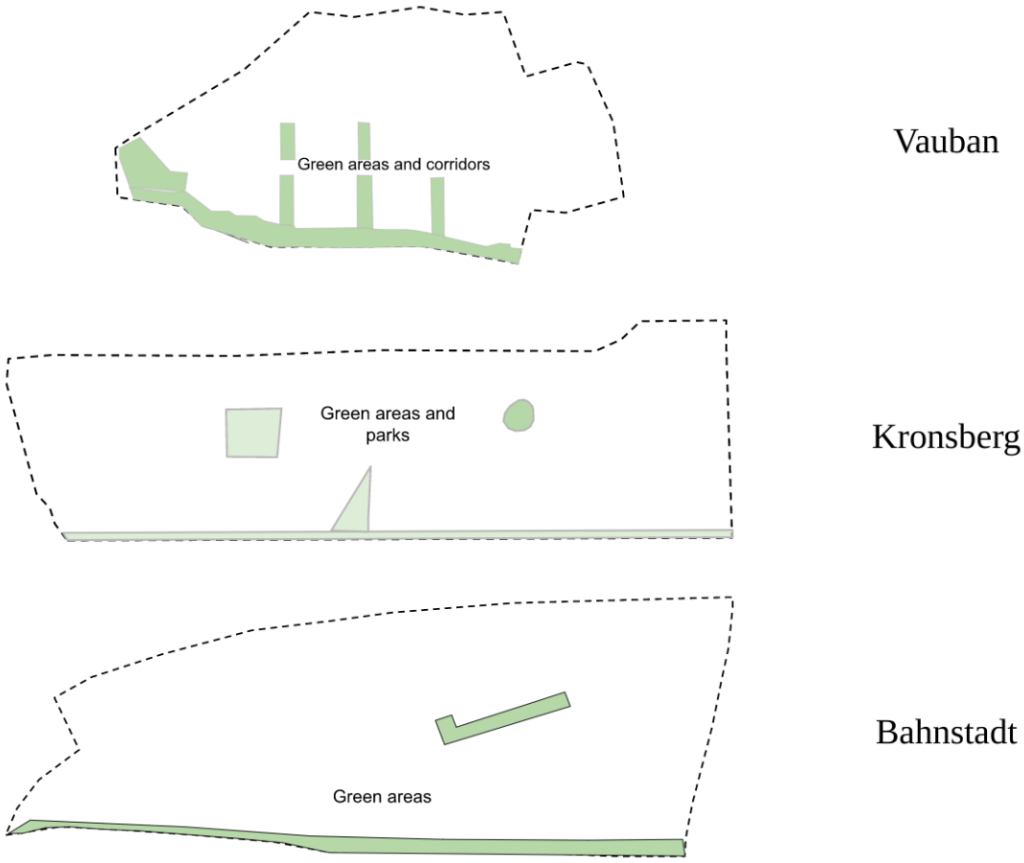

Figure 5.9 Main green areas distribution on three case studies *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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 the 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 equipments. Additional elements for all residents include sitting areas, such as fixed chairs, benches and many picnic tables. Sports areas and equipments 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).

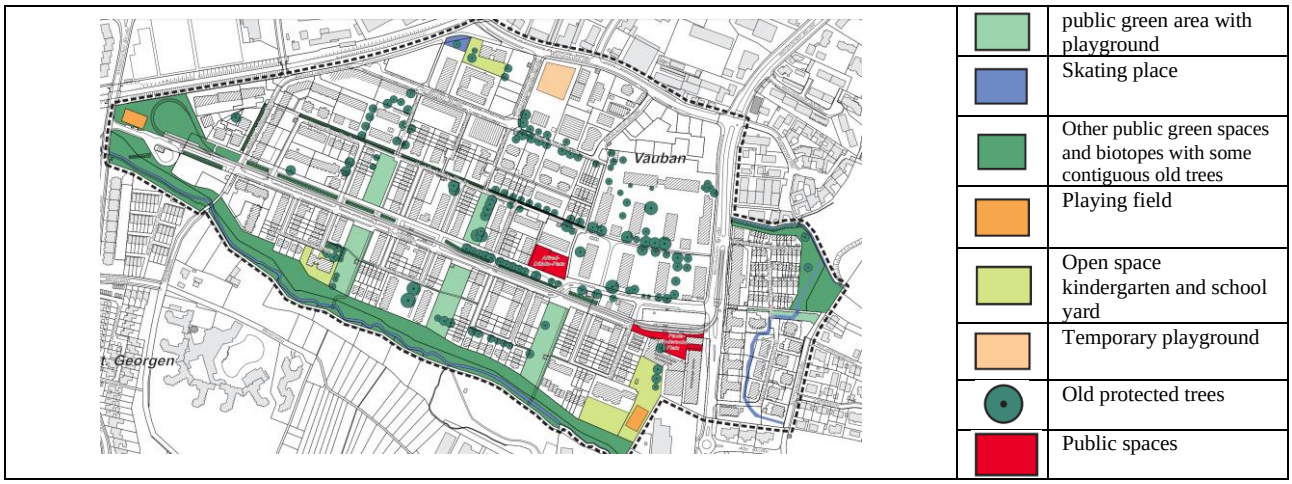

Figure 5.10 Open spaces and green areas (source: (City of Freiburg, 2008))

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, Kendal, Hahs, & Threlfall, 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, & 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, & 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.

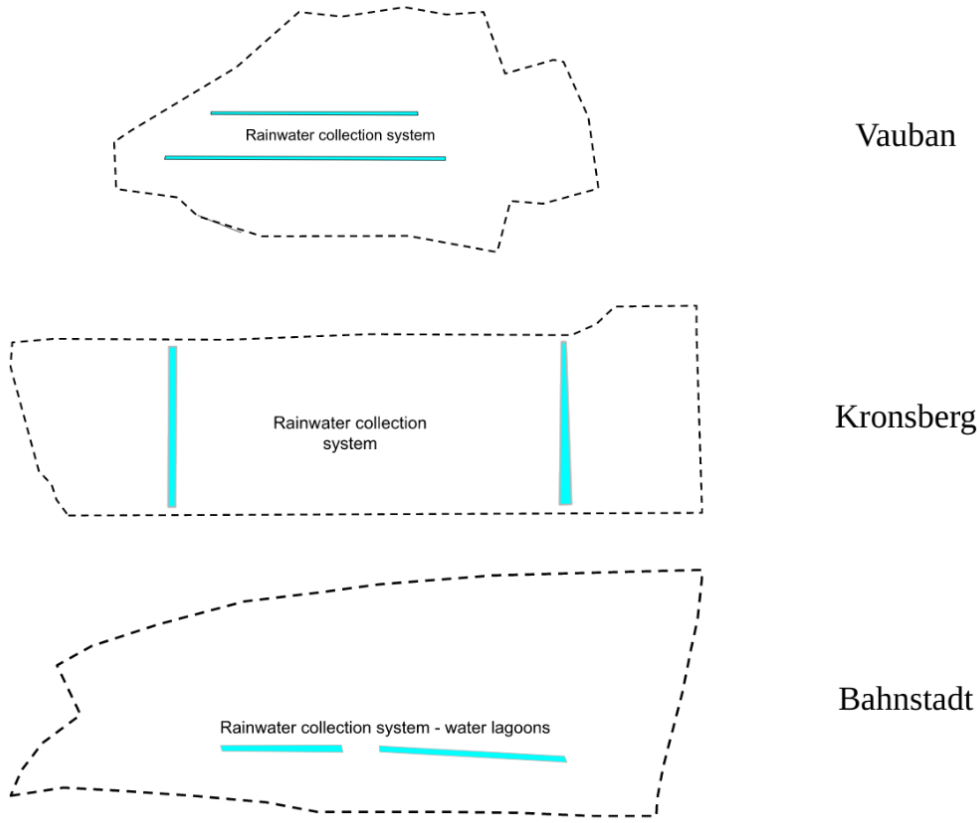

Figure 5.11 Rain water collection systems and approaches for three case studies *(*Not to scale)* (source: compiled by Bardhyl Rama, info from the literature)

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 K. 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.

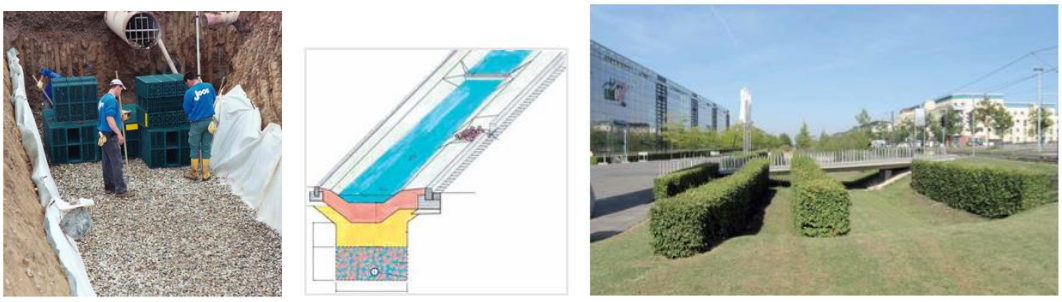

Figure 5.12 Rainwater collection drainage ditch construction (left) (source: (City of Freiburg, 2008)); the hollow-trench system (middle), rainwater retention (right) (source: (Rumming K. et al, 2004b))

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. 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 right 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 offering 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. Most importantly, 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. As such, the main goal is to tackle climate change by offering solutions that reduce man-made emissions and impacts on the environment and overall carbon footprint.

We witness the extensive role that the ecodistricts play in inspiring and encouraging cities to expand climate action. We also see the impact that the existing ecodistricts have in many cities around the globe, by inter alia, applying most advanced architectural and urban planning approaches and testing innovative technologies, and learning from the pilot projects of similar nature.

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, and observations from site and interaction with residents confirm that certain features do have a level of functional potency that the designers of ecodistricts can be harnessing.
Data input and my observations indicate that site conditions vary. Two are commonly found in the case studies, 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. 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.

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.

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 multi family houses, and a variety of apartment buildings.

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.

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.

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.

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 perfect 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.

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 deemed relevant currently or in the near future, so the whole knowledge on this topic becomes more comprehensive and complete.

Also, I purposely formulated an open framework for this research to recognize, acknowledge and account for potentials and likelihood of the future technological applications as well as the extent to which this technological advancement has expanded, therefore it is recommended that future research on ecodistricts and smart cities builds on this research an expands and interlinks further studies to include the cutting edge technological innovations and enlightens the advantages and disadvantages of harnessing those in future projects.

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

Appendix 1. Structured questionnaires with general open questions at the end

To complement the data collected from the literature review and desk research it was decided to include the onsite observation and a questionnaire. The questionnaire form contained some basic 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 ensuring 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. The type of data that was collected included some demographic and social questions, but generally the questionnaire was focused on satisfaction of residents with different aspects of the three case study ecodistricts, therefore only data that was useful to complement the research was presented here. Optional responses in the structured questionnaire for collecting quantitative data included: 'Very satisfied', 'Satisfied', 'Neither satisfied nor dissatisfied', 'Dissatisfied', 'No opinion' and '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'.

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 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.

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.

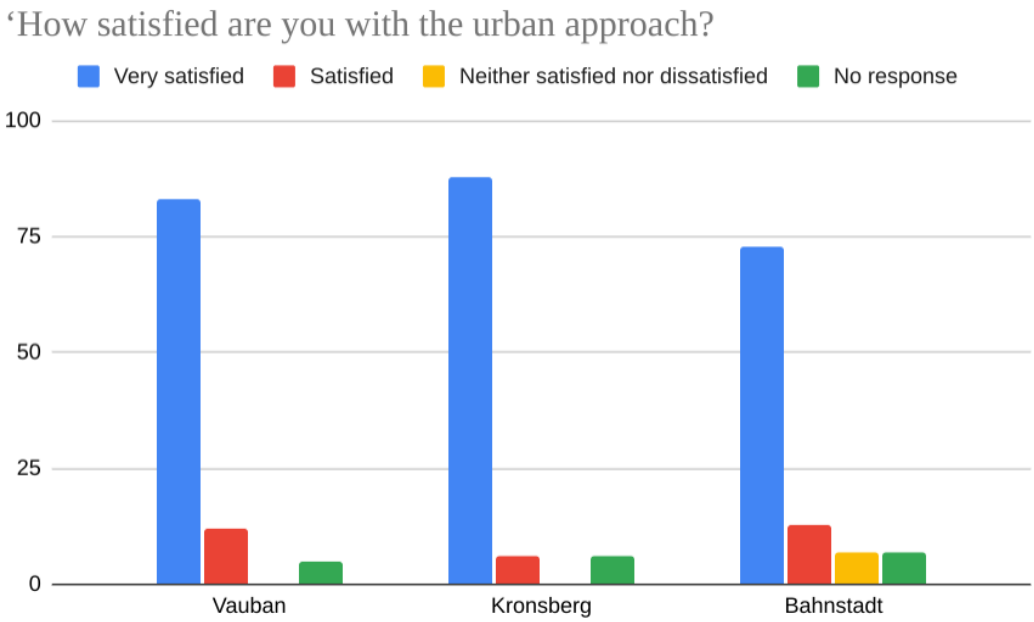

Figure 7.1 Urban planning responses and feedback (source: Bardhyl Rama)

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 on 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 were none.

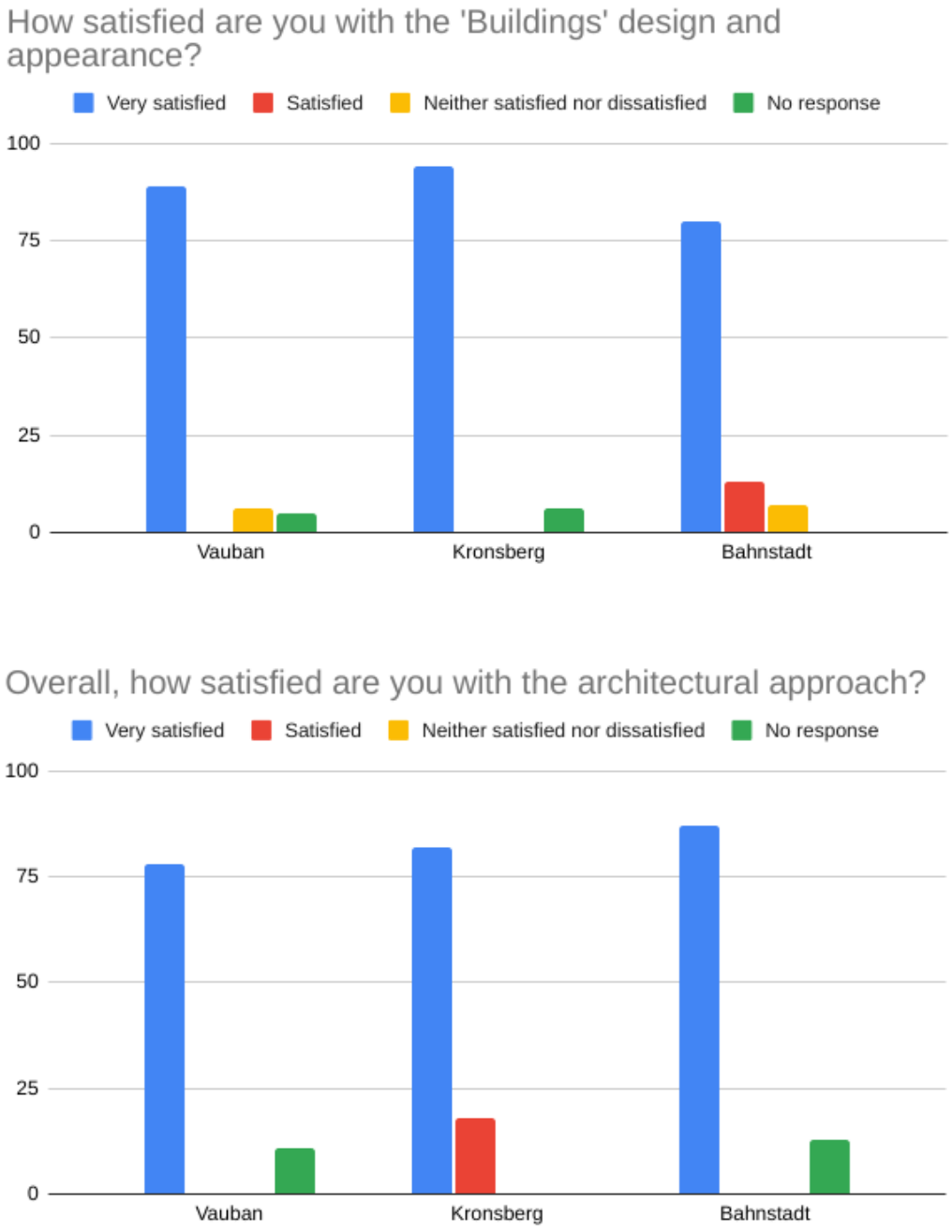

Figure 7.2 Architectural approach responses and feedback (source: Bardhyl Rama)

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.

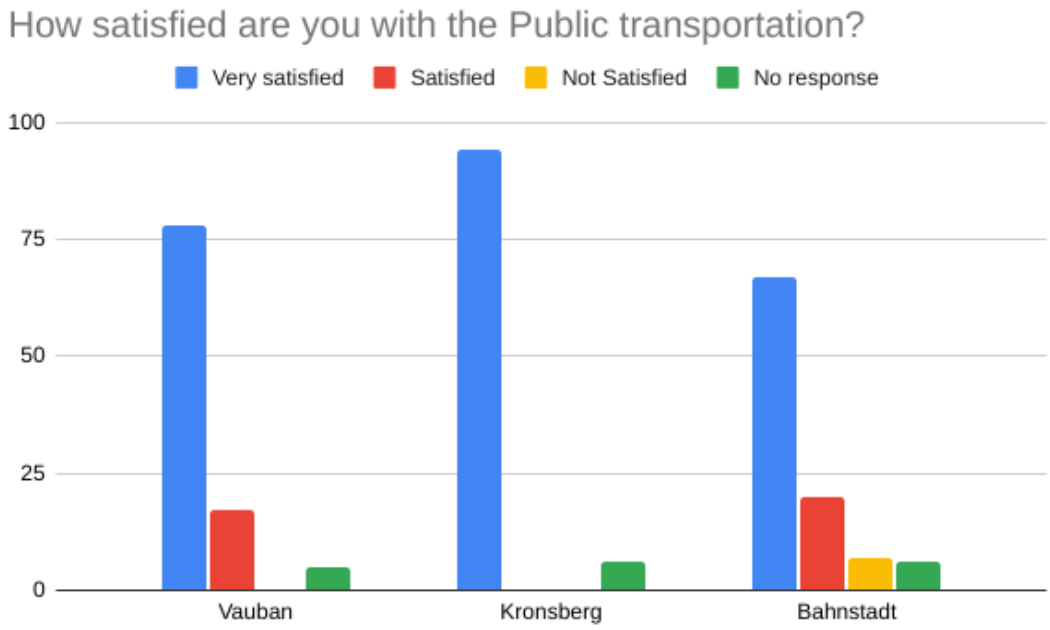

Figure 7.3 Mobility responses and feedback (source: Bardhyl Rama)

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'.

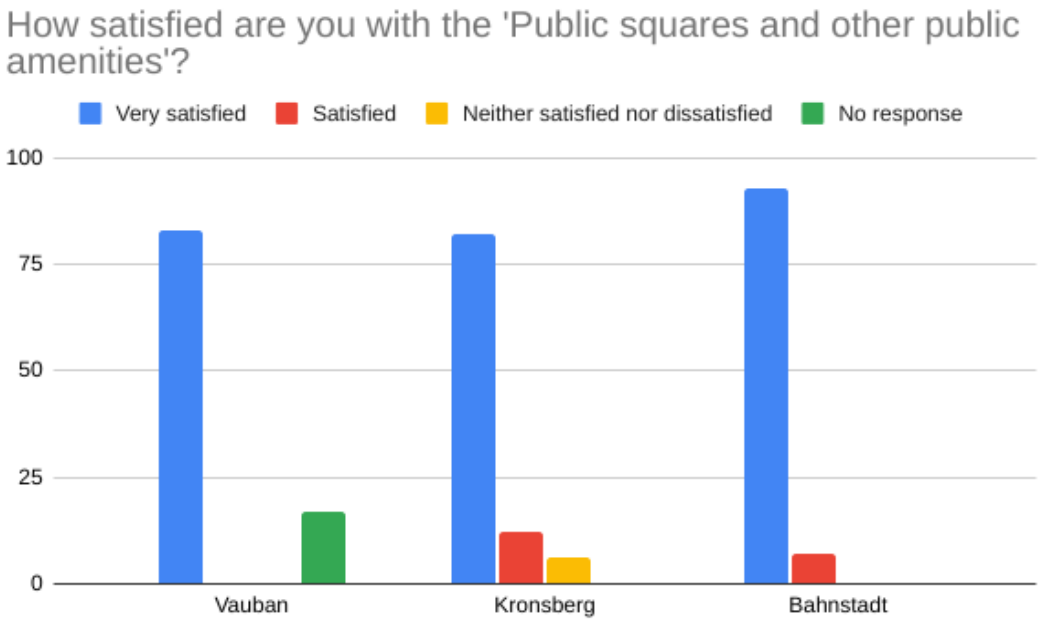

Figure 7.4 Public spaces responses and feedback (source: Bardhyl Rama)

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.

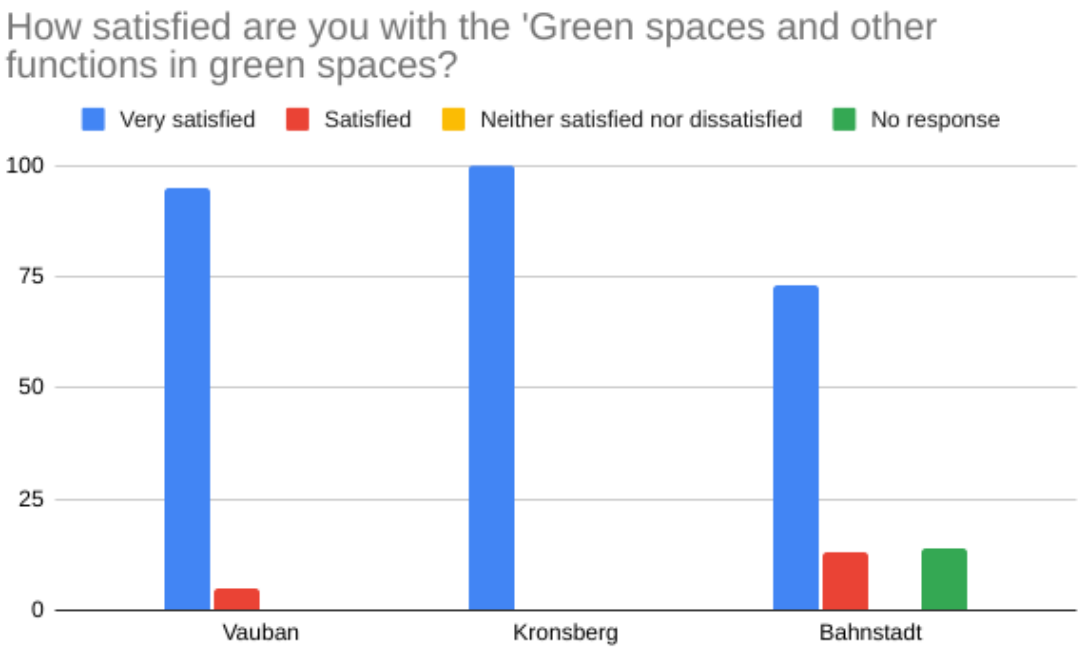

Figure 7.5 Landscape responses and feedback (source: Bardhyl Rama)

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Curriculum Vitae

BARD RAMA, PMP, INTL' ASSOC AIA,PHD CAND,

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Experience:

09-2016- present: **Director of Operations**; WGII TSU, UN IPCC – United Nations Intergovernmental Panel on Climate Change/ Alfred-Wegener-Institute - AWI, Bremen, Germany.

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 –09 2016; **Project Lead**; Consultant work for WORLD BANK & Local Government: Sustainable and Energy Efficiency & Renewable Energy Project

Providing 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 to 03-2016; **Operations Supervisor/Deputy Director**; Public Works Directorate (DPW) Facility Management; NATO / KFOR (US Army Europe).

Supervisory authority over the department employees, as well as tasking authority of the DPW staff as a whole.

Managed base camp facility management operation activities to ensure efficiency, cost-effectiveness and customer satisfaction in the areas of operations, engineering, environmental and real estate. 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 DPW Director and other key 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.

Supported Base Camp Planning Board, as both secretariat and subject matter expert for on-going and future engineering and public works projects and ongoing facility management. A core member of master planning team, participating in a comprehensive assessment of base camp facilities, creating current and envisioned land use maps, and providing technical advice on planning, design, construction, reconstruction, and infrastructure modernization. Quality Assurance for several parts of the Base Camp Maintenance. Provided support to US Army bases: MK Airbase (Constanta, Romania).

02-2003 to 10-2010; **Operations and Plans Officer**; DPW, NATO/KFOR (under USACE).

Managed DPW new work requests/projects. Received all work requests and assigned them to DPW Engineers. Prepared architectural CAD drawings, SOWs, BOQs, requests for NTP, and processed them. Served as the primary POC for all facility management and planning matters within the area of responsibility.

Appointed COR and Site Engineer on different JCC contracts (HA projects).

06-2003 to 11-2016; **Freelance Architect**

Designed a large number of 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).

04-2001 to 11-2001; Field Officer; International Rescue Committee – CPI Program; Monitored Youth and Child Groups. Provided Training for Children, Youth and their facilitators. Designed ramps for disabled and wheelchair users in several buildings. Responsible for designs, cost estimates, and the contracts management for all buildings rehabilitated by IRC-CPI Program.

10-2000 to 04-2001; **Shelter Engineer**; IRC – European Agency for Reconstruction Program 2001 Reconstruction of 563 houses;

Onsite Technical assessments: measurements and pictures, estimated the category of damage for the destroyed houses. Material Specifications: cost estimates for each house, quantities and type of materials. Prepared project documents, and design specifications. Prepared architectural briefs, bill of quantities, technical specifications for projects. Participated in tender preparation, technical evaluation and recommendation. On site materials and work quality inspection, monitored work progress.

Act as a Team leader, supervise and task IRC Engineers and Field officers during the last phase of the project. Responsible for constructing of more than 20 houses at the Labor Assistance Program, and for managing program budget over 100 thousands DM.

06-2000-10-2000; Field Officer; IRC – EAR; Completed Social Assessments. Based on collected information, prepared recommendations to International Field Officer about the priority of beneficiaries. Entered data from the field, prepared weekly reports, ordered materials to supplier. Maintained the shelter program access database.

Education

PhD studies, Faculty of Architecture, Prague Technical University

Faculty of Architecture and Civil Engineering, UP, (5 years studies)

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.

Language and Computer Skills

Languages: English-fluently (spoken/written), TOEFL test grade score 573; German (basic knowledge), Croatian (basic knowledge)

Computers: MS Word, Excel, Power Point, Project, Outlook and Access Applications; Auto Cad, ArchiCad, ArcGIS; SAP; Use of online conferencing tools, Zoom, Webex, GoToMeeting. Designed and maintained MS Access databases.

Typing: +40 words per minute.

Certificates of appreciation

Received over twenty certificates of appreciation.

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 & 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 Chair/Member

Cities and Climate Change Science Conference, City of Edmonton, Canada.

Organizing Committee Member and Session Moderator – AIA International Region Virtual Conference on 'Catalyzing Change'- Nov 2020

PLEA 2017 and 2018 – International Scientific Committee Member

Spring 2018 AIA Continental Europe Conference Committee Chair and Moderator

Peer Reviewer

Building Technology Educators' Society (BTES) – 2021 Conference

AASHE 2016, 2018,2019 and 2020 Conference & Expo (Association for the Advancement of Sustainability in Higher Education)

USGBC Greenbuild 2016 International Conference and Expo – evaluated 13 proposals.

2016 and 2017 AIA National Convention Peer Reviewer Program

Greenbuilding Brasil 2016 education session proposal reviewer.

Green School Conference and Expo - GSCE 2016 education.

Presenter and Participant (only a few listed)

Presenter: 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 – GAP Meeting. Providing feedback as GAP member on NEW URBAN AGENDA zero draft recently published.

For more: https://www.youtube.com/channel/UC9ZbsoblIV5G6z8C1IncdHg

Publication Summary

1. RAMA, B. *Sustainable residential complexes/ECO - VILLAGES* [research poster, 1st PhD Students' Workshop, FA CTU, Prague, 2017] (100%)

2. RAMA, B., Andoni, D., Affordable housing and housing affordability in Europe. *YAF Connection*. 2017, (Q1-2017), (50%) YAF Connection.

3. RAMA, B. *Housing and urban planning in early modernism – an essay on green and sustainable approaches*. 2017 [Unpublished paper] (100%)

4. 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%)

5. RAMA, B. *Sustainable approaches in Contemporary Architecture*. [Unpublished paper], 2017, (100%)

6. 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):

7. *IPCC, 2019: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*. Cambridge: Cambridge University Press, 2019. ISBN 9781009157964. [contribution only]

8. *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]

9. *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]

10. *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:

11. *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]

12. *International Virtual Conference Catalyzing Change - Honorary Fellows Keynote Lecture - Jan Gehl - Cities For People*. [Conference Hosting - Session Moderation] 2020. (33%)

13. *International Virtual Conference Catalyzing Change - Impact of Climate Change in Cities and Urban Areas*. [Conference Hosting - Session Moderation] 2020. (25%)

14. *International Virtual Conference Catalyzing Change - How will future change affect the architect's profession - experience from Europe*. [Conference Hosting- Session Moderation] 2020. (15%)

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%)

16. *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* [Conference Presentation], (33%)

17. *Grassroots 2020 - American Institute of Architects Leadership Conference, Representing AIA CE as 2020 President*. [Conference participation] 2020.

18. AIA Europe Eastern Section participation at Austrian Kosovo Architecture Day, 2015, [Conference Presentation], (100%)

19. Presentation at Prishtina Architecture Week (PAW) on AIA, 2015, [Conference Presentation], (100%)

20. *ECO-SEE Indoor Environmental Quality Workshop*. [Workshop participation] 2016.

21. *Direction Final Event - Achieving high performance based on real buildings and results*. [Workshop participation] 2016.

22. *European Habitat Conference in Prague, Active participation in Workshops and activities*. [Conference] 2016.

Peer Reviewer Contributions:

23. GSR2022, Renewables 2022 Global Status Report, REN21 [Peer Reviewer]

24. *2021 ACSA/EAAE Teachers Conference,* [Conference - Session Peer Reviewer] 2021.

25. *2021 Building Technology Educators' Society Conference - BTES, Out of Bounds: Crossing Disciplines in Teaching Technology, Session Peer Reviewer*. [Conference] 2021

26. *Journal of Transportation and Land Use - JTLU*. World Society for Transport & Land Use Research, [Reviewer], 2019

27. *PLEA2018 - Smart and Healthy within the 2-degree Limit*. [Conference- Session Peer Reviewer] 2018.

28. *AIA Conference on Architecture*. [Conference - Session Peer Reviewer] 2017

29. *AIA Convention 2016*. [Conference - Session Peer Reviewer] 2016.