A Comprehensive Model for Nudging Towards Pro- Environmental Behavior in Architecture

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1 Introduction

1-1 Problem Statement

Human behavior and the increase in population growth have become the main driver of environmental problems and pose a threat to the stability of the Earth system since the Industrial Revolution (Rockström et al., 2009). Continuing the use of natural resources, the current rate of greenhouse gas emissions and industrialized forms of agriculture will lead to undesirable consequences that will increase over time, such as global warming, urban air pollution, freshwater shortages, environmental noise, loss of biodiversity. These current demands on nature are compromising the well-being of humanity's future and putting the existence of mankind at risk (Rockström et al., 2009; Steg & Vlek, 2008; Gardner & Stern, 2002; Swim et al., 2011; Wackernagel & Rees, 1996).

More recently, a report of the Intergovernmental Panel on Climate Change (IPCC, 2013) has shown that a majority of 95% of the UN's climate researchers agrees that human activity is "the dominant cause of observed warming since the mid-20th century". This means that the environmental problems are attributable to human actions and are rooted in our behavior (Swim et al., 2011). To create more awareness about sustainability and the current negative impact of human behavior, policy tools are used such as the provision of information and value-based communication (Goepel, Rahme & Svanhall, 2015). Despite these tools, a majority of the people who understand the link between human behavior and climate change are unaware of their current behavior and significant negative impact on planet Earth. This can be seen as the main reason why our daily behavior continues in an unsustainable way (Page & Page, 2014).

This undesired result can be explained by the complexity of human behavior. The way humans act and behave is influenced by a variety of different factors, such as social norms, habits and values, infrastructural and institutional context, and economic and political debate (Mont & Power, 2013). Research over the past decades raised sincere questions about the rational behavior models these policy tools rely on. Counter to this rational decision-making process that is based on individuals seeking to maximize their utility and making choices that result in the optimal level of benefit, research in behavioral economics demonstrated that decisions are often based on heuristic processes, unconscious associations, automatic and learned responses (Marchiori et al., 2017). Human decisions are dependent on the context of the decision, often biased, flawed and have a strong tendency to follow the herds, and go along with the default option or status quo (Marchiori et al., 2017; Hofmann et al., 2009; Smith & DeCoster, 2000).

These theoretical and psychological insights of behavioral economists help to understand this complexity of human behavior. Behavioral economists Richard Thaler and Cass Sunstein understood the complexity and shared their theoretical insights in the book Nudge: Improving decisions about health, wealth, and happiness. This book sparked the attention of governments interested in influencing and helped policy makers in devising policies to enhance the decision-making process of people in favor of smarter, healthier, and more preferred, sustainable behavior (Hofmann et al., 2009; Smith & DeCoster, 2000). According to Thaler and Sunstein (2008), the Nudge theory is a gentle push towards the desired direction. "A nudge is a small aspect in the

context of an individual that alters their behavior predictably without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, an intervention must be easy and cheap to avoid." A nudge, when correctly applied, can counteract the negative impact and reduce behavior that is seen as undesirable and can stimulate certain behavior that is seen as desirable (Mont et al., 2014).

Thaler and Sunstein (2008) follows by explaining that the Nudge theory is applied by the so-called choice architect who is responsible for organizing the environment in which people make decisions. Since the decision-making process of people is mostly influenced by their direct environment, choice architects play a serious role in changing behavior at the individual as well as the population level. Every choice the architects make in the design process will influence or change the way people experience the environment. Therefore, there is no such thing as "neutral design" (Thaler & Sunstein, 2008). While designing environments, architects should understand how their choices will affect the daily life of the user and architecture should therefore have a moral responsibility for how they steer people. Once the concept of nudging is correctly implemented, architects can improve people's lives and promote sustainable behavior that mitigates the current societal and environmental challenges humanity is facing today (Neutel, 2017).

Nonetheless, current studies on nudging and its potential for sustainable behavior are mostly focusing on either the policy-making process or small aspects in the field of architecture. Therefore, the purpose of this research is to explore the role of nudging in changing behavior towards sustainable living in architecture in a residential setting. The aim is to take a closer look at the relationship between nudging, sustainability to evaluate the role of nudging in architecture and the built environment that fosters pro-environmental behavior.

1-2 Research Questions

Based on the problem statement, and its objective, the following research question is formulated: *What is the role of nudging in changing behavior towards sustainable living in architecture?*

Several supporting sub-questions are formulated in order to answer the main research question. These are:

- *What principles of the nudge theory can be applied in architecture?*
- *How can the nudge theory be integrated into sustainable architecture?*
- *What is the concept of sustainability and sustainable behavior in architecture?*
- *What is the relationship between nudging, sustainability and architecture?*

1-3 Research Method

To answer the main research question, the research is divided into four sections. Each of these sections is answering one of the four supportive research questions and is built on each other. In this paragraph, the different methodologies for each of the supportive questions are outlined.

Chapter 2 begins with an outline of the theoretical understanding on the concept of nudging, determined through literature review. The purpose of this methodology is to examine several theories about the nudge theory, such as i) Nudge, Improving Decisions about Health, Wealth and Happiness from behavioral economists Richard Thaler and Cass Sunstein, ii) The

Ecological Approach to Visual Perception by psychological ecologist James Gibson, iii) Nudging: A Tool for Sustainable Behavior by Oksana Mont, Matthias Lehner, and Eva Heiskanen, iv) Nudging to Move by Forberger, Resich, Kampfmann and Zeeb, v) Nudging: A Way to Encourage Public Tenants to More Sustainable Behavior? By Albin Haglund, vi) Altering Micro-Environments to Change Population Health Behavior Towards an Evidence Base for Choice Architecture Interventions by Hollands et al., and a few more studies looking into the theory of nudging and its implementation. The aim of this chapter is to, first of all, understand what theoretical approaches exist to behavior change and positions the role of the situational context within these frameworks. Secondly, this chapter will examine nudging as a behavior tool by looking into the definition, the different categories and various types of nudging. Here, the objective is to establish an overview of nudges that can be implemented in architecture. Finally, this chapter explores how nudges can be strategically implemented in the design process that incorporates sustainability.

Chapter 3 deals with the notion of sustainable development and pro-environmental behavior. Since the notion of sustainability and sustainable development is a ubiquitous development paradigm (Mensah, 2019), the meaning and goals of sustainable development are examined through a literature review. This chapter, aims to look into how sustainable household behavior and its determinants can contribute to sustainable development by exploring the following two concepts: pro-environmental behavior and sustainable development. Having this knowledge is required for an architect, since the nudge theory focuses on activating a desired behavior. Without having a clear understanding of what the desired behavior might be, implementing successful nudges that encourage a pro-environmental lifestyle will be a complicated task for an architect.

Chapter 4 explores the role of the wider scope of the physical environment and how sustainable buildings in general are able to act as a supportive environment for shaping pro-environmental behavior. This chapter, therefore, examines the relationship between the concept of nudging, pro-environmental behavior and the role of architecture by bringing these together into one comprehensive framework.

Chapter 5 is about exploring the Comprehensive Model for Nudging towards Pro-Environmental Behavior in Architecture by looking into four case studies. Here, several aspects are explored. The aim of analysing four case studies is to offer additional insights in the forming of sustainable behavior through architecture and tries to connect the theory with the practical implementation of the framework. Four case studies have been chosen, because of their strong vision towards sustainable living: 1) Recipe for a Future Living by MAD Arkitekter, 2) Sundsholmerne by architect C.F. Møller, 3) Urban Village Project by Effekt Architects and SPACE10, and 4) Solaris developed by Huggenbergerfries Architekten AG.

With regard to priming, the following questions will be answered: How does the architecture prepare occupants for participation in sustainability and adoption of pro-environmental behavior? How does the environment encourage social support and design for attention restoration? How is sustainable ethos communicated within the design?

Furthermore, the case studies also analyse how occupants are encouraged to elicit pro-environmental behavior through the implementation of informational and structural nudges. Here, the following questions are addressed: What type of nudges are implemented and how do these relate to the forming of pro-environmental behavior? What is the objective of implementing these

behavioral prompts?

Moreover, these case studies also look into how pro-environmental behavior is formed by looking into the five underlying key areas: waste generation & recycling, transport, residential energy use, food consumption, domestic water use.

Four different case studies have been chosen, because of their vision towards sustainable living: i) Urban Village Project by Effekt Architects and SPACE10, ii) Recipe for a Future Living by MAD Arkitekter, ii) Sundsholmerne by architect C.F. Møller, and iv) Solaris developed by Huggenbergerfries Architekten AG. Analyzing these will result in a better understanding of the relationship between nudge theory and sustainable living in architecture and will define the role of nudge theory in changing behavior towards sustainable living in architecture.

1-4 Significance & Relevance

Although many studies have been done on the concept of nudging, not much research appears to have been done on nudging towards sustainable living in architecture. Most of these studies are focusing on either the policy-making process or small aspects in the field of architecture. Hansen and Jesperson (2013), for example, focused on the policy-making process by describing the characters of different nudge types to create a framework for the responsible use of the nudge theory in public policy. Furthermore, a study by Mont, Lehner and Heiskanen (2014) analyzed the existing evidence of nudging in fiscal and social policy, as well as environmental and consumer policy. Although the research offers valuable insights into the way nudging contributed to devising more successful policies for sustainable consumption, none of it is focusing on the relation with sustainable living in the built environment.

While several studies are focusing on the concept of nudging concerning the built environment, very little has been done on the relationship between sustainability and its implementation architectural interventions. Forberger, Reisch and Kampfmann (2019), for example, focused on the promotion of physical activity in the built environment by reviewing the use of choice architecture interventions. Besides, a study by Klege, Visser, Datta and Darling (2018) is focusing on a non-residential building in which they focus on a small aspect of sustainability, namely the use of behavioral insights to design nudges aimed at reducing electricity consumption.

To summarize, not much research appears to have been done on the role of nudging in changing behavior towards sustainable living in residential architecture, and the relationship between the nudge theory and choice architecture interventions that stimulate pro-environmental behavior. The objective of this research is to explore the role of nudging in this field. The aim is to take a closer look at the relationship between nudging, sustainability and architecture to evaluate what role nudging plays in the built environment.

One of the practical contributions of this study is an in-depth analysis of four case studies that are analyzed on the three pillars of sustainability and substantiated with the nudge theory. These case studies offer additional insights that try to close the gap between theory and practical interventions. Therefore, this research will be relevant to architects and students who are interested in learning more about the psychology of human behavior, their impact in the daily life of the users they are designing for, and the different sustainable nudge interventions they can implement.

1-5 Ethical Considerations

Given the concept of the nudge theory, there are several ethical considerations the reader needs to take into consideration. Literature and several practitioners raise their concern about the transparency of nudges because it steers people in a direction they might not be aware of. The concept of nudging can be intrusive, lack transparency, be manipulative, and research shows that nudging can clash with moral values, such as liberty, autonomy, respect, and dignity (Goepel, Rahme & Svanhall, 2015; Engelen & Schmidt, 2020). To explain, nudging influences the context of the decision-making process, rather than the decision being made by the people themselves. The choice architect pulls the strings and uses psychological strategies to get people to do what the choice architect desires. Therefore, nudging makes people not personally responsible anymore for their actions.

Moreover, scholars have questioned to what extent the individual behavior change approach can solve complex environmental problems, such as climate change, or whether these problems need more structural and systematic changens of society. Moreover, solving these problems with individual behavior change is suggested to be too simplistic, from which the impact is too little to change the status quo (Csutora, 2012; De Young, 2014).

Nevertheless, many state that small changes in the decision-making process of individuals create demand for systematic changes and can lead to a bottom-up approach for sustainable development (Stoknes, 2015) To make a nudge ethically acceptable, The House of Lords believes that choice architects should inform people about the interventions or make them aware of the implementations. Besides, it should also be the moral responsibility of an architect to preserve important values, such as liberty, autonomy, respect, and dignity, and to be aware of the influence and impact they have on shaping the context of the user and directly also their behavior (Marchiori, Adriaanse & De Ridder, 2017).

2 Nudging: A Theoretical Behavior Change Model in Architecture

This chapter outlines the theoretical understanding of the concept of nudging, determined through literature review. The aim of this chapter is to, first of all, understand what theoretical approaches exist to behavior change and positions the role of the situational context within these frameworks. Secondly, this chapter will examine nudging as a behavior tool by looking into the definition, the different categories and various types of nudging. Here, the objective is to establish an overview of nudges that can be implemented in architecture. Finally, this chapter explores how nudges can be strategically implemented in the design process that incorporates sustainability.

2-1 Theoretical Approaches to Behavior Change

In literature, there are several theoretical approaches that describe the creation of behavior change. These approaches can be seen as "coordinated sets of activities designed to change specified behavior patterns (Michie et al., 2011). Understanding these "action models" or "action determination models" is extremely important for architects, as it informs how behavior is formed, and how people make decisions and act on them (Klöckner & Blöbaum, 2010). Therefore, the aim of this section is to give a short overview of the theoretical approaches that exist to behavior change and to position the role of the situational context within these frameworks. In literature, two different behavior theories can be found (Klaniecki et al., 2018). The first group explains behavior that focuses on motivational factors, the second group includes contextual factors to explain the forming of behavior.

Behavior Theories Focusing on Motivational Factors

A number of different behavior theories focusing on motivational factors can be found. Ajzen's Theory of Planned Behavior (1991) is one that explains behavior as a result of individual intentions, see Figure 2-1. Ajzen states that an intention is formed in a rational choice process by taking into account three factors: the attitude (Attitudes) towards the behavior, the person's perception of social pressure (Social Norms), and the person's perception of behavioral control (Perceived Behavioral Control). The latter describes the perception of having control of a situation, or being controlled by other people or situational conditions (Ajzen, 1991).

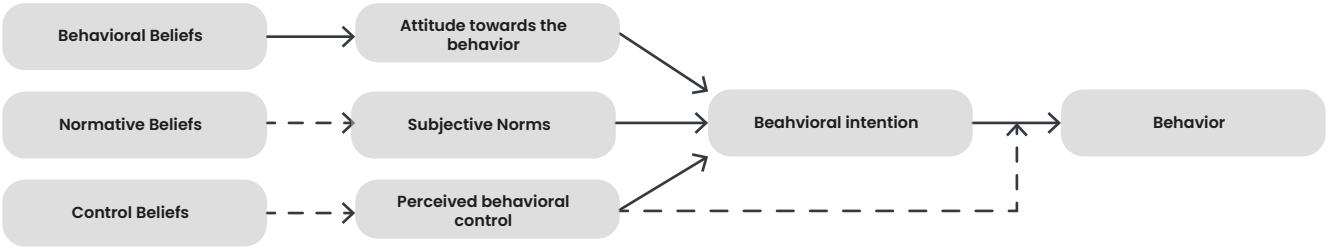


Figure 2-1: Ajzen's Theory of Planned Behavior. Adapted from "The theory of planned behavior", by Ajzen, I., 1991, Organizational behavior and human decision processes, 50(2)."

Triandis' Theory of Interpersonal Behavior (1980) includes habits to the Theory of Planned Behavior as an additional variable, see Figure 2-2. According to Triandis, actions that occur

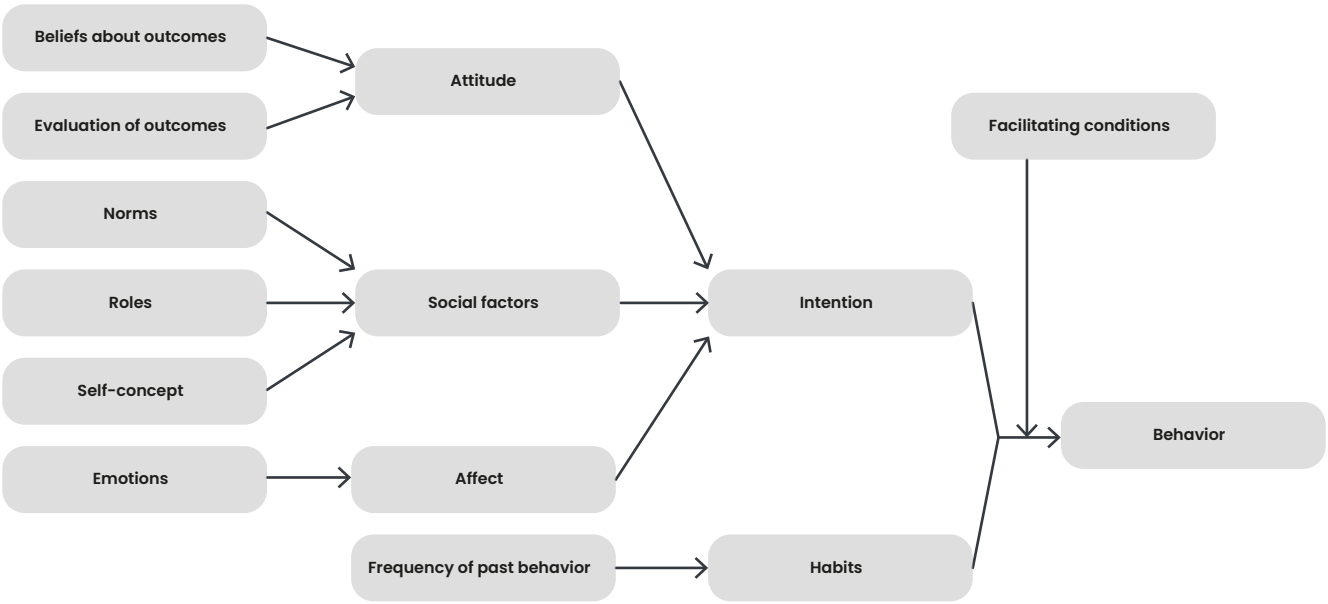


Figure 2-2: Triandis' Theory of Interpersonal Behavior. Adapted from "Values, attitudes, and interpersonal behavior", by Triandis, H. C., 1980, in Howe, H. E., & Page, M. M., (Eds.), Nebraska symposium on motivation. Lincoln, NE: University of Nebraska Press.

frequently in the same set of conditions with a satisfying outcome will have less influence in the process of deliberate decision making, because these behavioral patterns become more automated.

Moreover, theories such as Schwartz's Norm Activation Theory (NAM) (1977) suggests that the feeling of moral obligation is a driving force of positive social behavior. The theory includes the concept of social comparison, norms, and identity. According to Klaniecki et al. (2019) , "such norms are activated by awareness of consequences of performing or withstanding a particular behavior and the perceived responsibility of the behavior and its consequences". In other words, a norm is activated when a person is being triggered by someone or something in need (Awareness of Need), or when a person sees a causal relationship between one's actions and the consequences. Then, the person activates the personal norms after experiencing perceived behavioral control.

Similarly to NAM, The Value Belief Norm Theory (VBN) by Stern (1999) also explains behavior

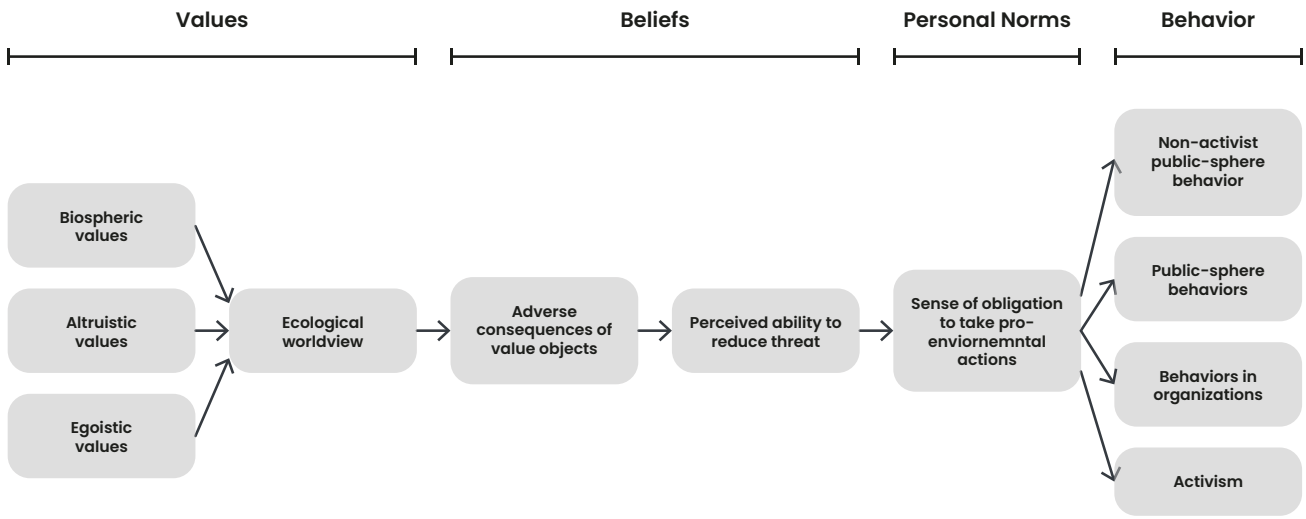


Figure 2-3: Value Belief Norm. Adapted from "A value-belief norm theory of support for social movements: The case of environmentalism", by Stern, P., Dietz, T., Abel, T., Guagnano, G. A., Kalof, L., 1999, in Human ecology review, 6.

based on having a moral obligation to act. However, Stern adds to this theory by postulating that values influence behavior through environmental beliefs and personal norms. The framework includes the individual's degree of ecological worldview as an extra variable, which comprises three values: biospheric values, altruistic values, and egoistic values, see Figure 2-3.

Furthermore, Cialdini et al.'s (2000) Focus Theory of Normative Conduct emphasizes the importance of social norms as a way to promote environmentally beneficial behavior. The theory decomposes social norms in two groups: Injunctive and Descriptive social norms. The first one, injunctive norms, describe behaviors that are expected to ought to be done in a specific social situation, while descriptive norms refer to behaviors that describe how people typically act and behave in a certain situation. Here, a distinction is made between how people should behave versus how they actually behave (Kallgren, Reno & Cialdini, 2000).

Figure 2-4: Focus Theory of Normative Conducts. Adapted from "A focus theory of normative conduct: When norms do and do not affect behavior", by Kallgren, C. A., Reno, R. R., & Cialdini, R. B., 2000, Personality and Social Psychology Bulletin, 26(8).

Behavior Theories Focusing on Contextual Factors

In contrast to behavior theories including motivational factors, there are behavior theories focusing on contextual factors. Although these frameworks, referred to as "situational context", are less clearly defined in literature, they are important in eliciting pro-environmental behavior (Klöckner, 2015). According to Kaiser (1996), the situational context is defined as "...a collection of variables beyond a person's control (e.g. policies, economic conditions, and other aspects of the built and natural environment) that may support or hinder environmentally responsible behavior."

One of the theories that includes the situational context is developed by Hines, Hungerford, and Tomera (1987), under the name of the Model of Responsible Environmental Behavior, see Figure 2-5. The model combines the theory of The Planned Behavior with environmental knowledge

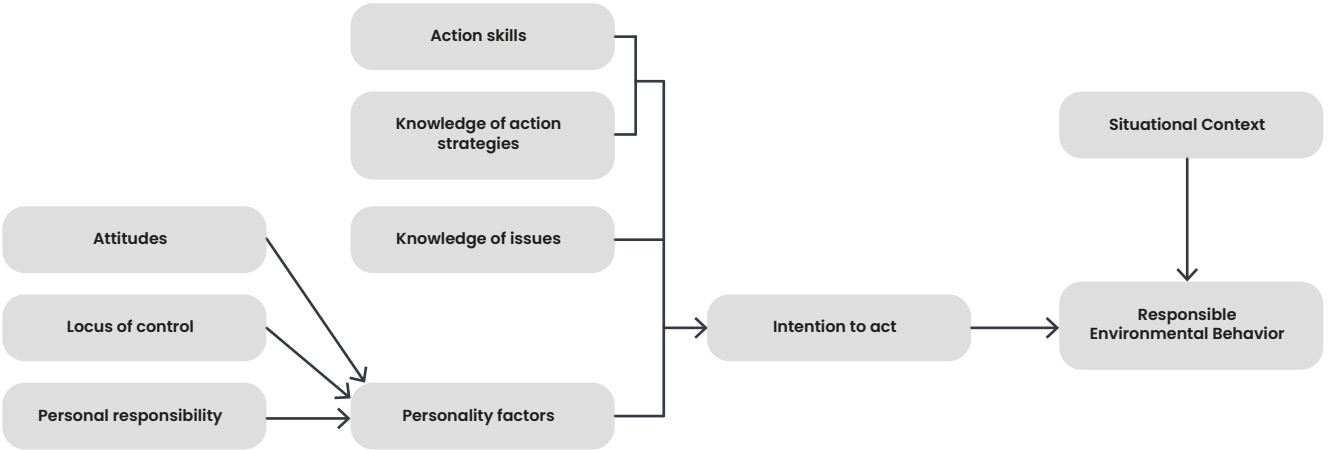


Figure 2-5: Model of Environmental Responsible Behavior. Adapted from "Analysis and synthesis of research on responsible environmental behavior: A meta-analysis", by Hines, J. M., Hungerford, H. R., & Tomera, A. N., 1987, The Journal of Environmental Education, 18.

and skill components. It suggests that environmentally responsible behavior is affected by the intention to act and situational factors. Here, the intention to act is influenced by personality factors (Attitudes, Locus of Control, and Personal Responsibility) and variables such as action skills, knowledge of action strategies and knowledge of issues.

Based on the model of Responsible Environmental Behavior, Kollmuss and Agyeman designed a holistic approach of pro-environmental behavior which includes both internal and external factors (Klöckner & Blöbaum, 2010). The internal factors combine variables such as environmental knowledge, values, attitudes and emotional involvement, while external factors consist of political, social, cultural and economic factors.

Finally, the most recent and complete behavior theory is called the Comprehensive Action Determination Model of ecological behavior (Klöckner & Blöbaum, 2010), see Figure 2-6. This theory combines the model of Planned Behavior, the Norm Activation Model, the concept of Habits and the situational context. This integrated theory determines individual behavior by influences from three potential variables: intentional, situational, and habitual. In contrast with other theories, all four variables do not exist independently of each other, but there is a strong interaction happening. First of all, normative processes (e.g. social norms, personal norms, awareness of need, awareness of consequences) influence habitual processes and intentional processes. Klöckner and Blöbaum (2010) further state that the "habitual and situational processes interfere with intentional processes and moderate the impact of intentions on behavior". The theory also assumes the role of the situational context in influencing normative and intentional processes, for instance that personal norms adjust to situational conditions over the long term. Although these relationships between the different variables seem complex, the situational context plays an important role in shaping individual behavior.

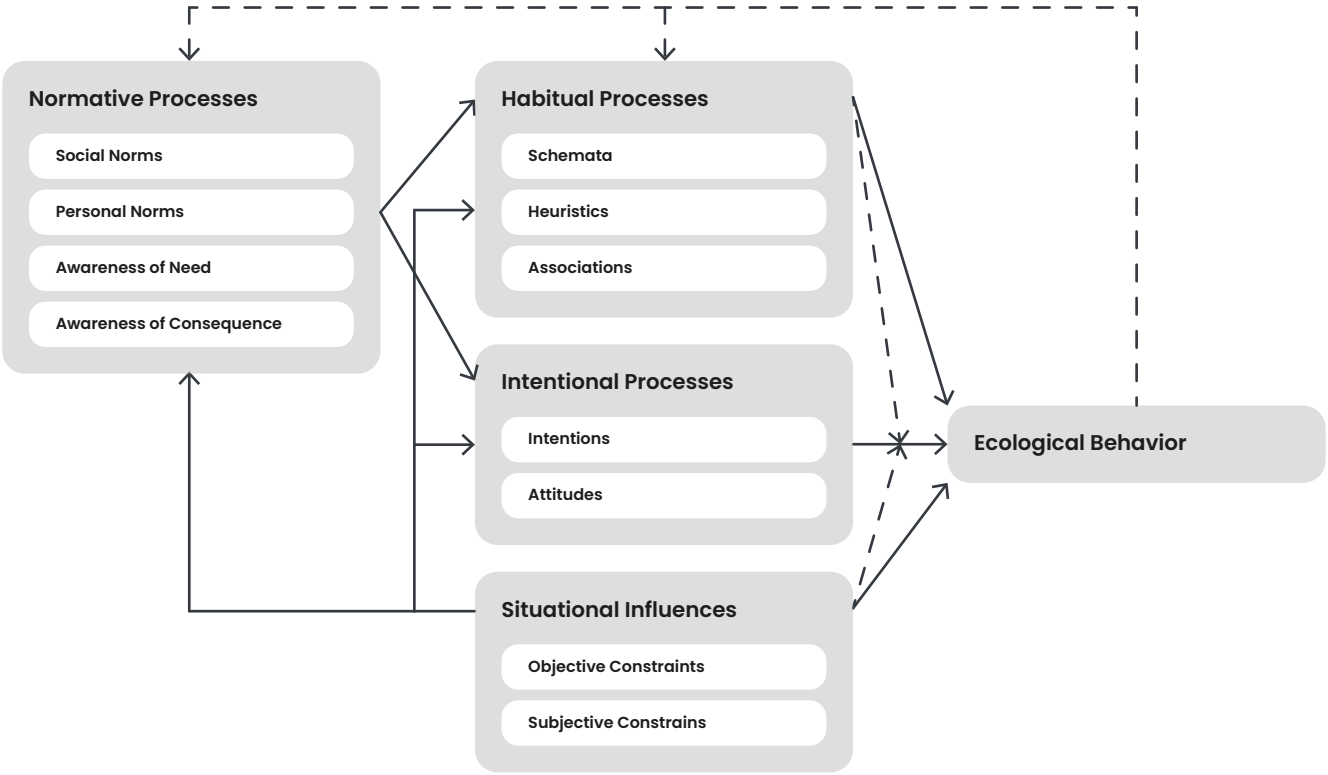


Figure 2-6: A Comprehensive Action Determination Model. Adapted from "A comprehensive action determination model: Toward a broader understanding of ecological behavior using change interventions", by Klöckner, C.A., Blöbaum, A. I., 2010, Journal of Environmental Psychology, 30.

To summarize, based on the above mentioned theoretical frameworks for behavior change, The Comprehensive Action Determination Model takes into account most of the theories. It appears that the situational context, from an architectural perspective also known as the built environment, plays an extremely important role in eliciting pro-environmental behavior. Situational influences directly impact normative processes, habitual processes and intentional processes and eventually one's behavior. We can conclude that the development of individual behavior is very complex, and depends on countless factors. Even when all these factors are considered, individual attitude and intention differ greatly, resulting in no certainty at all that the desired behavior is always achieved. Most importantly, for an architect it is crucial to have an understanding of these theories, and to know what variables determine and predict the activity and behavior of a building's occupant. This will eventually help to understand the strategy behind the concept of nudging and how it affects people's behavior.

2-2 Nudging: A Behavior Change Tool

The nudge theory utilized the decision-making process of people that is often based on heuristic processes, unconscious associations, automatic and learned responses. These decisions are often biased, flawed and have a strong tendency to follow the herds, and go along with the default option or status quo (Marchiori et al., 2017; Hofmann et al., 2009; Smith & DeCoster, 2000). The nudge theory uses the so-called dual-process theory that plays a crucial role in contemporary cognitive, personality, and social psychology (Korhonen, 2020; Hofmann et al., 2009). One of the most popular theories about the dual-process theory in behavioral science is developed by Kahneman (2003) and published in his book Thinking, Fast and Slow. Thaler and Sunstein refer to this dual-process theory and use it as the theoretical foundation of the nudge theory. The theory makes a distinction between two systems of thinking: System 1 is intuitive and automatic, and System 2, which is reflective and rational. The first system is also called the automatic systems and the second system the reflective system (Thaler & Sunstein, 2008). The main principles of each system are shown in Table 2-1.

Table 2-1: Two cognitive models of thinking.

System 1: Automatic Thinking	System 2: Reflective Thinking
Uncontrolled	Controlled
Effortless	Effortful
Associative	Deductive
Fast	Slow
Unconcscious	Self-aware
Skilled	Rule following

Note. Adapted from "Nudge and the Manipulation of Choice: A framework for the responsible use of the nudge approach to behavior change in public policy", by Hansen, P., & Jespersen, A., 2013, in European Journal of Risk Regulation, 4(1).

System 1: The Automatic System

The automatic system, System 1, is the part of the brain that is rapid, automatic, intuitive, emotional, effortless, instinctive, and operates without thinking and with no sense of voluntary control (Kahneman, 2012). This system generates impulsive behavior and is able to perceive the direct

environment, recognize objects, orient attention, and avoid losses (Hollingworth & Barker, 2019). This quality enables the individual to evaluate and respond to the environment in a quick manner in accordance with one's needs and previous learning experiences (Hofman et al., 2009). To illustrate, you are using the automatic system when you duck, because a ball is thrown at you unexpectedly, or when you get nervous while the airplane hits turbulence, or when you smile after seeing a cute puppy (Thaler & Sunstein, 2008).

System 2: The Reflective System

The reflective system, System 2, is more deliberate, self-conscious, reflective, controlled, slow, and logical (Kahneman, 2012). This part of the brain allocates attention to the effortful mental activities that demand it, such as complex computations, making deliberate judgments and evaluations, creating strategic action plans overriding dominant responses such as habits. These relatively slow, controlled processes require conscious mental exertion and provide a feeling of control over our decisions and actions (Kahneman, 2012; Hofman et al., 2009; Hollingworth & Barker, 2019).

2-3 Definition of Nudging

There are several definitions of nudging suggested in literature. The notion of nudging was first used in the book *Nudge: Improving Decisions about Health, Wealth, and Happiness* by behavioral economists Richard Thaler and Cass Sunstein. According to Thaler and Sunstein (2008), the nudge theory is a gentle push towards the desired direction. They define a nudge as "...any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid". In other words, the aim of nudging is to steer people's behavior and decisions towards better choices and a more desired direction for the individual, judges by themselves, without restricting or forbidding any choices.

Thaler and Sunstein (2008) follow by explaining that the nudge theory is applied by the so-called choice architect. A choice architect is someone who is responsible for organizing the environment in which people make decisions. Since the decision-making process of people is mostly influenced by the direct environment, the situational context, choice architects play a serious role in changing behavior. Every small and apparently insignificant detail created by the choice architect influences or changes the way people experience the environment. This means that there is no such thing as a neutral design and, therefore, the idea of an anti-nudge position, not influencing people's choices and behavior, is a literal non-starter (Thaler & Sunstein, 2008). This results in someone being a choice architect that must have a pro-nudge position, someone who recognizes the feeling of responsibility in organizing the environment and influencing people's behavior and decisions and actively incorporates such knowledge when designing the environment.

Furthermore, Thaler & Sunstein (2008) believe that the nudge theory respects the liberal principles and claim that their theory is a type of "libertarian paternalism". Libertarian paternalism is libertarian because nudges preserve freedom of choice and is paternalistic, because the interventions are so-called pro-self, which means that they aim to steer people's behavior in what is best for the individuals as well as the population (Barton & Grüne-Yanoff, 2015). Thaler & Sunstein (2008) also state that "we strive to design policies that maintain freedom of choice. When we use the term libertarian to modify the word paternalism, we simply mean liberty-preserving".

They state that libertarian paternalism is a soft, and nonintrusive type of paternalism because the choices are not closed off. People are still able to do what they prefer, and libertarian paternalists will not force them to do the opposite. Since these nudges do not interfere with the freedom of choice, many supporters of behavioral economics agree with Thaler and Sunstein and the original definition of nudging (Prabhakar, 2021).

On the other hand, there have been several debates about being too general and imprecise (Mont et al., 2014). Hausman & Welch (2010), for instance, question whether the nudge theory is truly libertarian and freedom preserving since the choice architect is able to limit the choices that are available to individuals. They state that "nudges are ways of influencing choice without limiting the choice set or making alternatives more costly in terms of time, trouble, social sanctions, and so forth. They are called for because of flaws in individual decision-making, and they work by making use of those flaws. When intended to benefit the person who nudges, they constitute instances of what Thaler and Sunstein call libertarian paternalism". Hausman & Welch (2010) conclude that nudges are mostly not paternalistic at all, and focus more on rational persuasion. When these nudges are paternalistic and shape the choices of people, they question the libertarian aspect, even though these nudges do not close off other alternatives.

Furthermore, Hansen and Jesperson (2013) insist that the nudge theory provides an ethical, politically non-controversial tool to influence the choices and behavior of people in accordance with their own interests. They argue that intentional intervention aimed at influencing behavior change ascribes certain responsibilities to choice architects that are not addressed by Thaler and Sunstein (Hansen & Jesperson, 2013; Marchiori, Adriaanse & De Ridder, 2016). Hansen and Jesperson (2013) further explain that these responsibilities can not be dismissed by simply addressing that these nudges are liberty preserving. Although they agree that people still have the freedom to choose, the characterization of nudging is too simplistic since the nudge approach works by making use of the flaws of human behavior and is applied precisely in the context where people tend to fall short in such principles (Hansen & Jesperson, 2013; Hansen, SKov & Skov, 2015).

Additionally, Marchiori, Adriaanse & De Ridder (2016) looked into the definition of nudging and considered the suggestions above for defining the original definition of the nudge theory. Based on these arguments of different authors, they state that "..nudging is an umbrella term for deliberate and predictable methods of changing people's behavior by modifying the cues in the physical and/or social context in which they act". They imply that "...none of the choices in nudging should be difficult to avoid, made mandatory, incentives economically or socially, and make significantly more costly in terms of time or trouble" (Marchiori, Adriaanse & De Ridder, 2016).

2-4 Categorization & Types of Nudging

Identical to the definition of the nudge theory, there are also several debates and suggestions about the categorization and different types of nudging within the environment. In this section, several suggestions are outlined to get a better understanding of the categories and techniques of the nudge theory that are described in literature, resulting in a framework that can be used in the design process.

First of all, Thaler and Sunstein (2014) suggests that the nudge theory can be divided into three categories: i) nudges that maintain freedom of choice, ii) nudges that are transparent and effective, and iii) nudges that rely on evidence that have been tested. Furthermore, Thaler

and Sunstein (2014) give a catalogue of the 10 most important nudges, these are: default rules, simplification, use of social norms, increase in ease and convenience, disclosure, warnings, graphic or otherwise, precommitment strategies, reminders, eliciting implementation intentions, and informing people of the nature and consequences of their own past choices. See Table 2-2 for an overview of these nudge interventions.

Table 2-2: Nudge interventions by Thaler and Sunstein.

Intervention type	Example
1 - Default rules	Automatic enrollment in programs, including education, health, savings.
2 - Simplification	In part to promote participation in existing programs.
3 - Use of social Norms	"Most people pay their taxes on time", "Nine out of ten hotel guets reuse their towels".
4 - Inrease in ease and convenience	Making low-cost options or healthy foods visible.
5 - Disclosure	Economic or environmental costs associated with energy use, or the full cost of certain credit cards.
6 - Warnings, graphic or otherwise	Pictures on cigarette packages.
7 - Pre-commitment strategies	Pre-commit to engaging in certain activities such as smoking cessation.
8 - Reminders	Email or text message, as for overdue bills and coming obligations or appointments.
9 - Eliciting implementation intentions	"Do you plan to vaccinate your child?"
10 - Informing people of the nature and consequences of their own past choices.	Expenditures on health care or on electric bills.

Note. Adapted from "Nudge: Improving decisions about health, wealth, and happiness", by Thaler, R. H., & Sunstein, C. R., 2008, Yale University Press.

In addition, Hansen & Jesperson (2013) introduce a framework that informs its adoption in public-policy making by making a distinction between four types of nudges: transparent type 2 nudges, non-transparent type 2 nudges, transparent type 1 nudges and non-transparent type 1 nudges. The first distinction is based on the distinction between System 1 and System 2, as is explained by Thaler and Sunstein (2008). Here, type 1 nudges aim to influence behavior that is not conscious and deliberate by facilitating automatic behavior, without reflective thinking. To the contrary, type 2 nudges also engages with the automatic system, but is more conscious by triggering reflective thinking and thus attempts to change deliberate choices and actions (Hansen & Jesperson, 2013).

Additionally, another group of researchers present four different kinds of nudges with the aim of enhancing the choice architect's comprehension of a wide variety of different nudges. House, Lyons and Soman (2013) introduce a framework based on four descriptive categories of nudging, boosting self-control versus activating a desired behavior, self-imposed versus externally-imposed, mindful versus mindless, and encouraging versus discouraging (Marchiori, Adriaanse & De Ridder, 2016).

Moreover, Dolan et al. (2010) propose a checklist of influences on human behavior that can be utilized when designing interventions. This checklist consists of nine robust influences that are substantiated with research from the fields of social psychology, cognitive psychology,

and behavioral economics. These principles are captured in the mnemonic called MINDSPACE, consisting of: Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitments, and Ego.

Another framework developed by Münscher et al. (2016) wants to provide an understandable method to structure and evaluate interventions that enable choice architects to successfully integrate an intervention, see Table 2-3. Münscher et al. (2016) suggest three different categories of choice architecture interventions: i) decision information which is covery a variety of techniques that target the presentation of decision-relevant information without adjusting the options themselves, ii) decision structure which arranges the options and the decision-making format by altering an modifying the available options in the decision situation, and iii) decision assistance, which consists of techniques that provide choice architects with further assistance, that aims to helping them to achieve their intentions to change certain behavior by encouraging engagement, feedback or reminders.

Table 2-3: Model from Münscher et al. that comprises three categories.

Category	Intervention Type
A - Decision Information	**A1 Translate information** - Includes: reframe, simplify.
	A2 Make information visible - Includes: make own behavior visible (feedback), make external information visible.
	A3 Provide social reference point - Includes: refer to descriptive norm, refer to opinion leader.
B - Decision Structure	**B1 Change choice defaults** - Includes: set no-action default, use prompted choice.
	B2 Change option-related effort - Includes: increase/decrease physical/financial effort
	B3 Change range or composition of options - Includes: change categories, change grouping of options.
	B4 Change option consequences - Includes: connect decision to benefit/cost, change social consequences of the decision.
C - Decision Assistance	**C1 Provide reminders** - Includes: reminders.
	C2 Facilitate commitment - Includes: support self-commitment/public commitment

Note. Adapted from "A review and taxonomy of choice architecture techniques", by Münscher, R., Vetter, M. & Scheuerle, T., 2016, in Journal of Behavioural Decision Making, 29.

Furthermore, Hollands et al. (2013) propose nine types of nudging, divided into three categories, see Table 2-4: i) nudges that primarily alter the properties of objects or stimuli, ii) nudges that primarily alter the placements of objects or stimuli, and iii) nudges that alter both the properties as well as the placement of object or stimuli. The nine intervention types of choice architecture are ambience, functional design, labelling, presentation, sizing, availability, proximity, priming, and prompting. In comparison with previous categories and intervention types, this provisional typology is based on the physical and social dimensions of micro-environments instead of focusing on the policy-making context (Hollands et al., 2013).

In addition to the previous provisional typology, Hollands et al. (2017) introduce the TIPPME framework that further describes the development of this work, which improves and replaces the typology, see Table 2-5. TIPPME aims to provide a means of classifying and categorizing the

Table 2-4: Model from Hollands et al. propose nine types of nudging, divided into three categories.

Category	Intervention Type
Primarily alter **properties** of objects or stimuli.	**Ambience** - Alter aesthetics or atmospheric aspects of the surrounding environment.
	Functional Design - Design or adapt equipment or function of the environment.
	Labelling - Apply labelling or enclosement information to product or at point-of-choice.
	Sizing - Change size or quantity of the product.
Primarily alter **placement** of objects or stimuli.	**Availability** - Add behavioral options within a given micro-environment.
	Proximity - Make behavioral options easier (or harder) to engage with, requiring reduced or increased effort.
Primarily alter **properties** and **placement** of stimuli.	**Priming** - Place incidental cues in the environment to influence a non-conscious behavioral response.
	Prompting - Use non-personalized information to promote or raise awareness of a behavior.

Note. Adapted from "Altering micro-environments to change population health behavior towards an evidence base for choice-architecture interventions", by Hollands, G.J., Shemilt, I., Marteau, T.M., Jebb, S.A., Kelly, M. P., Nakamura, R., Suhrcke, M., & Ogilvie, D., 2013, in BMC Public Health 13, 1218.

different classes of interventions to change human behavior across different scales. Although the framework of TIPPME aligns with some of the principles of nudging, it is not the main focus, but rather instead connected to a broader concept of the physical environment in which human behavior can be altered. TIPPME consists of six intervention types: availability, position, functionality, presentation, size, and information. These intervention techniques are divided into two classes (placement and properties) across three different areas (product, related objects and the wider environment).

Four of the seven frameworks shared similarities in how potential choice architecture strategies and principles were categorized. The other frameworks are less relevant to the objective of this study given that Hansen and Jesperson examined ethical issues of nudging, the MINDSPACE framework focused primarily on the underlying processes to explain individual behavior strategies, and the framework of House et al. presents an overview of four different categories of nudges. This report combines the four frameworks described previously to develop a strategic behavior tool for architects to utilize in the built environment. Table 2-6 shows an adapted choice architecture framework that comprises two different intervention categories: informational and structural nudges. Both categories can be categorized even further. In the following paragraphs, these segments and definitions of 13 nudges are operationalized, including Information & Education, Social Norms, Feedback, Rewards, Default, Behavioral Commitments, Prompting, Availability, Proximity, Priming, Size, Presentation and Functional Design.

Informational Tools:

The first intervention category represents informational intervention tools that focus on "...changing perceptions, motivations, knowledge and norms, without actually changing the external context in which choices are made" (Steg & Vlek, 2009). These tools can also be seen as antecedent tools, tools changing factors that precede a behavior (Lehman & Geller, 2004). Based on the framework of Münscher et al. (2012), this segment consists of three categories: Decision Information

Table 2-5: Overview of the TIPPME Framework by Hollands et al.

		Intervention Focus		
Category	**Intervention Type**	**Product**	**Related Objects**	**Wider Environment**
		Interventions to influence behavior by changing the product that is selected, purhcased or consumed. The product comprises the consumable substance and its immediate or integral packaging and tableware.	Interventions to influence behavior by changing objects that associated with the product and typically form part of its proximal surroundings.	Interventions to influence behavior by changing objects and stimuli that are external to the product and related objects and are not used to store, display, select, purchase or consume the product.
Placement	**Availability**			
	Add or remove (some of all) products or objects to increase, decrease, or alter their range, variety or number.	Adding non-alcoholic options to a bar's range of drinks, or removing less healthy snack options from a vending machine.	Add baskets, trolleys or trays to a shop or restaurant, to increase the number of products that people can select and carry.	Removing some of the entrance doors leading to a bar or cafetaria.
	Position			
	Alter the position, proximity or accessibility of products or objects.	Place less healthy options further away from seating, entrance, or main thoroughfare.	Move refrigerators containing sugary drinks to a less convenient location in a supermarket.	Move dividing walls or fixed furniture to alter layout of a supermarket, restaurant or bar.
Properties	**Functionality**			
	Alter functionality or design of products or objects to change how they work, or guide or constrain how people use or physically interact with them.	Allowing easier opening or pouring or demarcate plate to provide guidance for amounts of vegetables versus meat selected.	Demarcate shopping trolley space to indicate designated space for fruit and vegetables.	Alter functionality of entrance and exit doors (e.g. change their opening mechanism).
	Presentation			
	Alter visual, tactile, auditory or olfactory properties of products, objects or stimuli.	Plain packaging for cigarettes or alcohol products.	Colours, textures, and visual design of shelf displays, menus, and other related objects.	Indoor climate: temperature, humidity, air pressure, lighting.
	Size			
	Alter the size or shape of products or objects.	Change size of portions, plates, packages.	Change size of shoppin trolleys or baskets, cafeteria trays, or food and drink storage equipment.	Size and shape of windows, or fixed furniture.
	Information			
	Add, remove, or change words, symbols, numbers or pictures that convery information about the product or object or its use.	Health warnings on cigarette packets, alcohol consumption units on glasses.	Nutritional information on menus or menu boards.	Information on posters, leaflets, or computer screens, in the wider environment.

Note. Adapted from "The TIPPME intervention typology for changing environments to change behavior", by Hollands, G.J., Bignardi, G., & Jognston, M., 2017, in Natural Human Behavior, 1, 0140.

(Information & Education, Social Norms, Feedback), Decision Structure (Default, Rewards), and Decision Assistance (Behavioral Commitments, Prompting).

Information & Education

Providing information and education is widely used to encourage pro-environmental behavior (Stern, 1992; Klaniecki et al., 2018). It appears that the provision of information leads to changes in attitudes, motivation and knowledge (Abrahamse et al., 2007). For instance, providing information about behavioral options to reduce household's energy use or information about energy-related problems, can help households to acquire more knowledge about a specific topic. In addition, Geller (1981) discovered that giving workshops about energy conservation resulted in an increase of knowledge. Although providing information does not necessarily result in behavior change (Steg & Vlek, 2009), informational and educational interventions tailored to the needs, worldviews of occupants are more effective (Abrahamse et al., 2007; Nisbet, 2009; Klaniecki et al., 2019).

Table 2-6: Adapted choice architecture framework that comprises two different intervention categories: informational and structural nudges.

Category	Intervention Type	Explanation
Informational Tools	**Information & Education**	Providing information and education is widely used to encourage pro-environmental behavior.
	Social Norms	Social norms are defined as cognitive representations, beliefs, attitudes, and behaviors that are considered acceptable in a specific group.
	Feedback	By informing occupants about their environmental related behavior, the consequence of the behavior becomes more salient.
	Change Choice Default	Default rules are a pre-set of options that individuals will obtain when they choose to not specify a particular action.
	Rewards	By receiving a positive consequence of one's actions, individuals recognize achievement and are becoming motivated to continue.
	Behavioral Commitments	Behavioral commitment strategies are based on verbal or written commitments to perform a desired behavior.
	Prompting	A strategy that aims to influence or persuade an individual with stimuli (verbal or written antecedent messages) to encourage desired behavior.
Structural Tools	**Availability**	Add or remove (some or all) products or objects to increase, decrease, or alter their range, variety or number.
	Proximity	Altering the position, or accessibility of features in the environment with the aim of making the decision-making process of an individual easier or harder to engage with.
	Priming	Placing a stimulus, also known as incidental cues (words, images, features), in the environment to encourage behavioral change.
	Sizing	Altering the properties of objects or stimuli in physical environments and is being defined as a tool to alter the sizes or shape of objects.
	Presentation	Alter visual, tactile, auditory, olfactory or other atmospheric properties of objects that comprise the environment.
	Functional Design	Alter the functionality or design of objects that comprises to change how they work, or guide or constrain how people use or physically interact with them.

Social Norms

Social norms are defined as cognitive representations, beliefs, attitudes, and behaviors that are considered acceptable in a specific group. According to Schultz et al. (2007), social norms aim to "...reduce the occurrence of deleterious behaviors by correcting target's misperceptions regarding the behaviors' prevalence. The perception of prevalence is commonly referred to as the descriptive norms governing a behavior". Referring back to section 2-1, descriptive norms relate to behaviors that describe how people typically act and behave in a particular situation, while injunctive norms explain behaviors that are expected to be done in a specific social situation (Kallgren, Reno & Cialdini, 2000). It appears that social support and role models are able to strengthen social norms resulting in enhancing pro-environmental behavior (Steg & Vlek, 2008; Lehman & Geller, 2004).

Feedback

Another effective informational strategy is providing feedback (Abrahamse et al., 2005), which informs occupants about their environmental related behavior. By showing data (e.g. energy monitoring system), the consequence of the behavior becomes more salient and increases the possibility of behavior change (Lehman & Geller, 2004). For instance, research has shown the effectiveness of feedback, which resulted in a reduction of energy consumption (Geller et al., 1982; Dwyer et al., 1993). Besides giving individual feedback about one's behavior, comparative or group feedback has emerged as another effective strategy. By showing how others are actively engaged in the development of pro-environmental behavior, a social norm is made salient and increases the likelihood of behavior change (Abrahamse et al., 2005).

Change Choice Default

Default nudges are a powerful and ubiquitous strategy introduced by Thaler and Sunstein (2008). Default rules are a pre-set of options that individuals will obtain when they choose to not specify a particular action (Hermann et al., 2011). Since individuals often choose to take the path of the least resistance or choose the options with the least effort, a large number of individuals are most likely to go along with the starting points or status quo setting (Thaler & Sunstein, 2008; Hale, 2018). For instance, Brown et al. (2013) tested the effects of default settings on office thermostats and concluded that such interventions are capable of minimizing the energy consumption.

Rewards

Rewards are able to contribute to behavior change. Skinner (1953) states that "...incentivizing or rewarding progress toward a particular goal is likely to lead to desirable behavior change, particularly when the individual has prior knowledge that this incentive will be administered" (Brown et al., 2018). By receiving a positive consequence of one's actions, individuals recognize achievement and are becoming motivated to continue. This creates confidence in one's own worth or abilities, also known as self-esteem. Geller (2002) adds that rewards are more effective than punishments, since sanctions are resulting in negative attitudes and countercontrol measures (Brehm, 1972; Lehman & Geller, 2004).

Behavioral Commitments

Behavioral commitment strategies are based on verbal or written commitments to perform a desired behavior. According to Cialdini (2006), "Once we have made a choice or taken a stand, we will encounter personal and interpersonal pressures to behave consistently with the commitment. Those pressures will cause us to respond in ways that justify our earlier decision". In other words, commitments help individuals to behave in a manner that aligns with their decisions or behaviors in the past. To illustrate, Pardini and Katzev (1983-1984) show the effectiveness of written and verbal commitments that resulted in an increase of the recycling rate. According to Bell et al. (2001), written commitments appear to be more effective than verbal commitments (Lehman & Geller, 2004).

Prompting

Prompting is a strategy that aims to influence or persuade an individual with stimuli (verbal or written antecedent messages) to encourage desired behavior (Lehman & Geller, 2004). According

to Geller et al. (1982), prompting is most effective when the target behavior is in close proximity to the individual, easy to perform, and clearly defined. For instance, clearly defined instructional signs with information about recycling in buildings proved its effectiveness to increase the rate of paper recycling and decrease the level of contamination (Werner, Rhodes and Partain, 1998; Austin et al., 1993; Lehman & Geller, 2004).

Structural tools

The second intervention category represents structural tools that "change the costs, benefits, and availability of different behaviors by modifying physical, technical, and organizational systems, legislations, and price mechanisms" (Steg & Vlek, 2009). This proposed framework only utilizes the physical environment, since this is the primary focus of an architect. Structural tools influence perceptions of control and play an important role in changing attitudes and motivation (Klöckner and Blöbaum, 2010). Based on the TIPPME framework, structural tools are divided into to categories: interventions that primarily alter the placement of features (Availability, Proximity, Priming) in the built environment and interventions that primarily alter the properties of features (Size, Presentation, Functional Design) in the built environment.

Availability

The TIPPME framework defines availability as: "add or remove (some or all) products or objects to increase, decrease, or alter their range, variety or number" (Hollands et al., 2017). For instance, O'Connor et al. (2010) suggest that by increasing the number of recycling bins in a particular environment, it increases the saliency of the bins. Consequently, it results in more convenience and ease for people to recycle, thus a higher recycling rate can be achieved.

Proximity

Proximity is defined as altering the position, or accessibility of features in the environment with the aim of making the decision-making process of an individual easier or harder to engage with. This will result in reducing or increasing effort and convenience for people. Proximity refers to a state of being proximate, close to something (Hollands et al., 2017). A study by Brother et al. (1994) examined the effects of proximity of recycling bins in an office building. When the recycling bins were placed apparently closer to the point of consumption, the recycling rate increased by over 85%. From these findings, we can conclude that the specific location of recycling bins affect the decision-making process of people and have the potential to be an effective structural tool.

Priming

Priming is about placing a stimulus, also known as incidental cues (words, images, features), in the environment to encourage behavioral change (Hollands et al., 2017). Priming is a nonconscious approach in which an individual is exposed to something that influences their behavioral response in time. For instance, Kieboom implemented the picture of a fly in the urinals at Schiphol Airport to reduce the amount of spilling around urinals. It appears that this small strategy reduced urinal spillage by 80%, which resulted in a total reduction of cleaning costs at the airport with 8% (Ridder, 2014). In addition, a study by Hansen (2014) examined how green footprints on the floor could lead to less litter in the environment. It appeared that by priming individuals towards recycling bins, the amount of litter on the street was reduced with 46%. This highlights again that priming is an effective tool for behavioral change.

Size

Sizing is an intervention that alters the properties of objects or stimuli in physical environments and is being defined as a tool to alter the sizes or shape of objects (Hollands et al., 2017). For instance, by altering the shape and sizes of windows, more daylight can enter the apartment and significantly reduce the need for artificial lighting. This indirectly affects the energy consumption of a household (Alhagla et al., 2019).

Presentation

The presentation of objects and features in the physical environment can affect behavioral change. Presentation is a tool to "...alter visual, tactile, auditory, olfactory or other atmospheric properties of objects that comprise the environment" (Hollands et al., 2017). For instance, research demonstrated that color can influence the perception of space, wayfinding and ambience. It appears that color with warmer hues can increase the feeling of temperature in a space, while cooler colors are able to decrease the perceived temperature (Charnofsky, 2012). According to Augustin (2009), this psychological effect is able to increase or decrease the thermostat by five degrees which has a huge impact on energy consumption.

Functional Design

The last intervention tool that alters the properties of objects means to "...alter the functionality or design of objects that comprises the wider environment to change how they work, or guide or constrain how people use or physically interact with them (Hollands et al., 2017). For instance, an architect could change the type or design of seating within restaurants, alter the functionality of doors by changing their opening mechanism, or design stairs that enhance physical movement or social interaction by providing spaces to take a moment to sit and have a talk with a neighbor.

2-5 The Implementation of a Strategic Nudge Design that Incorporates Sustainability

Now we know what type of nudges to implement in architecture, there is a need for understanding how to implement strategic nudges that also incorporate the notion of sustainability. In literature, there are several studies looking into how to implement the nudge theory in the design process. These step-by-step guidelines aim to guide the choices of architects in designing intervention techniques. Looking into these publications will help form an overview of the different methods that are available and which methods are looking into how to integrate the nudge theory that enhances sustainability in architecture. Therefore, this section outlines several suggestions to get a better understanding of the theories and frameworks.

Theoretical Frameworks on the Implementation of a Nudge

First of all, Ly, Mažar, Zhao and Somain (2013) created an overview of different steps to give the choice architect guidelines on how to develop a nudge. This process comprises four steps: i) map the context, ii) select the nudge, iii) identify the levers for nudging, and iv) design and iterate. The aim of the first step of the process is to create a map of the decision-making process of the individual that outlines the factors from following through with their intentions and decisions. This map will help understanding the motivations of the decision-maker and the context in which the nudge will take place (Soman et al., 2013). This will result in the second phase of the design process,

which aims to select the nudge by thinking about solutions to the bottlenecks that the decision-maker might possibly face. The third step is about determining the levers for nudging that will accelerate the development process of designing a nudge. Finally, several potential nudges are determined that need to be prioritized and tested for effectiveness, since most of the choices are based on a theoretical framework. By testing nudges, documenting the results and sharing these with others will help create an overview of nudges that are proven to be effective in a certain context.

Moreover, the Behavioral Insights Team under the guidance of Halpern (2012) developed the EAST framework, which aims to provide choice architects with a simple framework that describes how to effectively implement behavioral approaches. The EAST framework stands for four simple principles for applying behavioral insights: make it Easy, Attractive, Social and Timely (EAST). In order to implement these insights into practice, Halpern (2012) created a methodology for developing, which consists of four stages: i) define the outcome, ii) understand the context, iii) design the intervention, and iv) test, learn, adapt. The first step aims to clarify the purpose of integrating the intervention and what change the choice architect wants to achieve. Secondly, the context of the individual should be analyzed, since small aspects in the direct environment have a major impact on the daily behavior. This will help get a deeper understanding of the context of the problem. The third step is about designing the intervention with the use of the EAST framework. After designing the intervention and performing many iterations, the intervention should be tested in order to understand the impact. Analyzing the impact of the intervention in stage four will help choice-architects determine the cost-effectiveness (Halpern, 2012).

Additionally, another group of researchers (Mont et al., 2014) presents a framework on behavioral insights and aiming at behavior change developed by Darnton. This framework consists of nine principles and provides a starting point for implementing intervention techniques. Although these nine steps seem very logical and discrete, Darnton (2008) suggest that this framework must be used as a cyclical process, one that is iterative where interventions are continuously refined as a result of evaluating and monitoring the interventions (Mont et al., 2014). The nine principles are:

- Identify the audience groups and target behavior;
- Identify relevant behavioral models (both individual as societal models);
- Select the key influencing factors and use these to design objectives in a draft strategy for the intervention;
- Identify effective intervention techniques which have been proven to work in the past on the influencing factors that are selected;
- Engage the target audience for the intervention in order to understand the target behavior and the factors influencing from their perspective;
- Developed a prototype intervention based on engagement with the target audience and evaluate it against policy frameworks and assessment tools;
- Pilot the intervention and monitor results;
- Evaluate impacts and processes;
- Feedback the lessons learned in order to get a deeper understanding of the intervention and the target behavior.

Finally, Dolan et al. (2010) describe a methodology for applying the MINDSPACE framework into practice, which has been discussed in a previous section. This framework is based on Defra's 4

E's model and provides choice architects with a checklist on how to successfully implement new intervention techniques (Darnton, 2008). The 4 E's of Defra consists of: Enable, Encourage, Engage and Exemplify. Dolan et al. (2010) adds to this framework two supporting actions: Explore and Evaluate. Together, these six tools enable choice architects to implement the nudge approach into practice. To elaborate, step 1 (Explore) is about exploring and understanding the behavior of the target audience. Secondly, Enable, concerns the understanding and recognition of the structural and practical constraints people face. The third step, Encourage, covers the actions that can be implemented in order to change behavior. Next, Engage, is about engaging with the target audience in order to explore what actions are acceptable. The fifth step of the process, Exemplify, concerns changing the behavior itself and piloting the intervention technique. Finally, the last step of the process is Evaluate. This step concerns finding out what the effectiveness of the intervention is and how the effect interacts in specific surroundings and context. Evaluating will help understanding a complex range of factors that will stimulate further improvement of the nudge (Dolan et al., 2010).

These four methods are summarized in Table 2-7. Here, an overview is created that brings into vision the frequency of mentions of each step in the guides. Although these methods and frameworks create a clear understanding of the steps, most of these guides are not geared towards sustainability, nor provide a process that is easily replicable (Goepel, Rahme & Svanhall, 2015). Instead, Goepel et al. (2015) suggest in Strategic Recommendations for the Design of Nudges Towards a Sustainable Society that the nudge design process should adopt a strategic approach that implements a shared vision for success in which the integration of nudges leads towards a sustainable society, see Table 2-8. In the next section, the strategic framework that incorporates sustainability will be explained.

Table 2-7: Overview that brings into vision the frequency of mentions of each step in the guides.

Intervention steps	Practitioner's Guide	EAST Framework	Nudges as practical application	MINDSPACE	Strategic Recomm. for design of nudges
1 - Data collection and analysis	X	X	X	X	X
2 - Understanding behavior	X	X	X	X	X
3 - Define desired behavior		X	X		X
4 - Define succes matrix					X
5 - Identify barriers and drivers using behavioral insights					X
6 - Brainstorm interventions	X		X		X
7 - Select intervention		X	X	X	X
8 - Pilot and monitor	X	X	X	X	X
9 - Evaluate		X	X	X	X
10 - Feedback	X	X	X	X	X

The Integration of Sustainability in the Implementation Process of Nudges

Goepel, Rahme & Svanhall (2015) utilize a five-level planning and decision-making framework called Framework for Sustainable Development (FSSD) and the strategic ABCD Planning Process for developing nudges strategically towards sustainability. The FSSD is a five-level structuring and inter-relational model that facilitates an understanding of the sustainability challenge and acts as

Table 2-8: Overview of the phases and steps of a nudge process that strategically integrates sustainability.

Nudge process: phases and steps		ABCD Step	Guidelines for a sustainable nudge design
Target Behavior	Define desired behavior Define succes metrics Analyze behavior using behavioral insights	A	Frame the target of the intervention with the Sustainability Principles to enable nudges that lead society towards sustainability and help prevent adverse effects.
Current Reality	Data collection and analysis Understanding behavior	B	Relate behaviors to the larger sustainability scope. Ensure nudge is not contributing to violations in other areas or that issue is moved elsewhere.
Design Intervention	Brainstorm interventions	C	Frame the brainstorm with the question: "what nudge intervention would help close the gap to a sustainable society?"
	Select intervention	D	Apply an evaluation to assess if the selected nudge intervention will provide a strategic step towards sustainable society
Project Phase	Pilot and monitor	N/A	
Evaluate	Measure success	N/A	
Feedback	Apply lessons learned	N/A	
Scale up/out	Repear intervetnion in larger scale	ABCD	Adopt a systems thinking approach, using backcasting to strategically plan and coordinate nudges with other behavior change tools, to create a shared vision for success with stakeholder engagement and plicy buy in.

Note. Adapted from "Strategic Recommendation for the design of nudges towards a sustainable society", by Goepel, N., Rahme, M. R., & Svanhall, F., 2015, Blekinge Institute of Technology, Karlskrona, Sweden.

an operational procedure for creating a strategic transition towards sustainability (Robert et al., 2013). Besides, the ABCD Planning Process is a key element of the FSSD and consists of four steps which guides users strategically towards sustainability: i) A-step: Awareness & Defining Success, ii) B-step: Baseline Current State, iii) C-step: Creative Solutions, and iv) D-step: Decide on Priorities. The nudge process consists of seven phases and eleven steps, which will be further explained in the following paragraphs.

1. Target Behavior

The first phase comprises three steps: define the desired behavior, create a benchmark for success, and analyze the behavior using behavioral insights. Goepel et al. (2015) suggest that the first step of the nudge process should align with the sustainability principles, which are principles stating that in a sustainable city, people are not subject to systematic barriers to integrity, influence, competence, impartiality and meaning. Besides, the intervention should not only focus on the betterment of the individual, but must also align with the vision of a sustainable society in a wider context.

Goepel et al. (2015) continue by explaining that the A step of the Strategic ABCD Planning Process helps to understand the sustainability challenge by creating a vision for success that

aligns with the principles of sustainability. By consciously looking at how the vision of success aligns within the sustainability principles, the choice architect is guided to come up with the right solutions that are for the betterment of not only the individual but for the whole society.

2. Current Reality

The second phase of the process consists of two steps: i) data collection and analysis, and ii) understanding behavior. In this phase, choice architects analyze the current behavior and the context in which the behavior takes place, and create a benchmark for measuring success. By utilizing the B-step of the ABCD Planning Process, it aims to relate the behaviors to the larger sustainability scope and to ensure that the implementation of the nudge will not lead or contribute to unsustainable behaviors.

3. Brainstorm Interventions

After establishing an overview of the target behavior and understanding the current reality, the goal of this phase is to brainstorm interventions that will close the gap between the current and target behavior (Goepel et al., 2015). Here, the choice architect could make use of previous lists that provide an overview of previous successful established nudges towards sustainability.

4. Select Intervention

The fourth phase of the nudge process concerns selecting the intervention by evaluating the proposed interventions and prioritizing them, based on possible long-term effectiveness, operational costs and cost-efficiency, and breadth or reach (Goepel et al., 2015). In order to assess if the selected nudge enhances sustainability, the D-step of the strategic ABCD Planning Process offers a tool with three FSSD Prioritization Questions: i) Does the nudge proceed in the right direction with respect to the Sustainability Principles?, ii) Does this nudge provide a stepping stone for future improvements?, iii) Is the nudge likely to produce a sufficient return on investment to further catalyze the process? By answering these criteria questions, the choice architect is able to evaluate the proposed nudges.

5. Further Steps

Executing the previous four phases will lead to an action plan with interventions that will be put into practice. Goepet et al. (2015) continue by stating that the nudge process contains additional steps, which consists of: testing (pilot and monitor), evaluating (evaluate and measure), learning from feedback, and scaling up successful interventions. By doing so, the proposed interventions are tested and improved. Together with the previous phases and steps, these form a framework for designing nudges that integrates sustainability.

To conclude, the framework as proposed above has the potential of developing nudges that support the large-scale, systematic change that is needed to mitigate the current societal and environmental challenges we are currently facing and to address the sustainability challenge. Therefore, it is crucial for architects to understand the steps that need to be taken in order to create a sustainable nudge design.

2-6 Conclusion

This chapter addresses several issues and conclusions. First of all, various theoretical approaches exist to behavior change and we can conclude that the development of individual behavior is a very complex one, one that is iterative and depends on countless factors. Literature suggests that the built environment plays an extremely important role in eliciting pro-environmental behavior and architects should have an understanding of these theories and the variables within that determine and predict the activity and behavior of a building's occupant.

Secondly, this chapter looked into nudging as a behavior change tool. Nudging utilizes the decision-making process of people that is often based on heuristic processes, unconscious associations, automatic and learned responses, based on the dual-process theory. Nudging is defined as an umbrella term for a deliberate and predictable method of changing people's behavior by modifying the cues in the physical and/or social context in which they act.

Furthermore, this chapter shared similarities in how choice architecture interventions and principles are categorized. Based on these frameworks, this study introduces an adapted choice architecture framework that comprises two different intervention categories and can be utilized in architecture: informational and structural nudges. The informational nudges include: Information & Education, Social Norms, Feedback, Rewards, Default, Behavioral Commitments, and Prompting. The structural nudges include: Availability, Proximity, Priming, Size, Presentation and Functional Design.

Finally, this chapter examined several theoretical frameworks for implementing strategic nudges that also incorporate the notion of sustainability. Here, one framework suggests that the process of implementing nudges should adopt a strategic approach that implements a shared vision for success in which the integration of nudges leads towards a sustainable society.

3 Towards a Definition of Sustainable Household Behavior and its Determinants

Household consumption has a profound environmental impact, according to a study from Ivanova et al. (2016). The report provides a comprehensive insight about the significance of environmental pressures arising from households in 43 countries around the globe. To illustrate, households are responsible for more than 60% of the global GHG emissions and between 50% and 80% of total water, material and land use. Besides, mobility, food and shelter (the consumption of electricity, wood products, housing fuel, and real estate services) account for up to 65% of the total impact on resources. Therefore, in order to successfully reduce the environmental impact of household consumption, a shift is required in consumer behavior, lifestyles and daily routines. Since nudging appears to be a strategic tool towards behavior change, an architect must understand what the desired behavior and outcome must be. Without having a clear definition of sustainable household behavior, implementing successful nudges that encourage a pro-environmental lifestyle will be difficult to accomplish (Paço & Laurett, 2018). This chapter, therefore, aims to look into how sustainable household behavior and its determinants can contribute to sustainable development by exploring the following two concepts: pro-environmental behavior and sustainable development.

3-1 Pro-Environmental Behavior

Environmental behavior includes all activities of human behavior, regardless of the impact it has on the environment (Krajhanzl, 2010). Most of the time, people are unaware of the environmental impact of their actions. When individuals are aware of their actions, the term intentional environmental behavior can be utilized. However, in most cases, a distinction is made between behavior that is being judged as environmentally friendly and unfriendly (Krajhanzl, 2010), see Table 3-1.

Table 3-1: Types of environmental behavior.

	Environmentally friendly impact		**Environmentally unfriendly impacts**
Environmentally insignificant impacts	Environmentally insignificant behavior		
Environmentally significant impacts	Pro-environmental behavior	controversially labeled pro-environmental behavior	Environmentally unfriendly behavior

Note. Adapted from "Environmental and Pro-environmental Behavior", by Krajhanzl, J., 2010, School and Health, 21.

Environmentally friendly behavior is also known as pro-environmental behavior, behavior that aims to protect the environment. Other terms are environment-protective behavior, environment-preserving behavior, environmentally responsible behavior, ecological behavior and sustainable behavior. On the other hand, environmentally unfriendly behavior aims to deconstruct the environment, which is also known as environment-destructive behavior (Krajhanzl, 2010).

Other authors have also contributed with definitions. Kollmuss and Agyeman (2002), for instance, define environmental behavior as a type of "...behavior that consciously is looking for ways on minimizing the impact of one's actions on the natural and built environment (e.g. minimize resource and energy consumptions, use of non-toxic substances, reduce waste production)".

Furthermore, Lee & Khan (2020) define pro-environmental behavior (PEB) as a type of behavior in which individuals take protective actions toward the environment, for example recycling household waste, purchasing sustainable products, conserving water or energy, and changing travel modes.

Additionally, Wang et al. (2014) sees environmental behavior as an umbrella term comprising several aspects: "meeting needs, enhancing the quality of life, improving resource efficiency, increasing the use of renewable energy sources, minimizing waste, taking a life cycle perspective and taking into account the equity dimension" with the goal of changing the habits and patterns of consumers, reducing the total volume of the consumption of goods, or by improving the efficiency of products (Paço and Laurett, 2018; Nagypál et al., 2015).

Finally, a report referred to as the Oslo Symposium (1994) was developed which acts as an action plan for sustainability that addresses sustainable consumption and production. It implies changing the household patterns through changes in lifestyles and consumer behavior, and defines sustainable consumption as: "the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the lifecycle, so as not to jeopardise the needs of future generations" (Nevison, 2010).

To conclude, pro-environmental behavior can be seen as a type of behavior that is consciously looking for ways to minimize the impact of one's actions on the natural and built environment, and where individuals take a protective stand towards the environment.

3-2 Sustainable Development

The notion of sustainability has become a ubiquitous, equivocal, dominant and indispensable paradigm, which is defined primarily by literature in the past decades (Ukage, Maser & Reichenbach, 2011; Mensah, 2019; Castro, 2004). While the definition, history and origin has been described in-depth elsewhere, a brief review of sustainability, in particular sustainable development, is first required to be able to understand the roots from which the concept emerged (Purvis, Mao & Robinson, 2009).

Although the concept of sustainability and sustainable development has been defined in a plethora of ways, the most popular and cited definition is proposed by the World Commission on Environment and Development in 1987 (Mensah, 2019). Its report Our Common Future, also known as the Brundtland Report, defines sustainable development as "...development that meets the needs of the present, without compromising the ability of future generations to meet their own needs". This report calls for "a new era of economic growth, growth that is forceful and at the same time socially and environmentally sustainable" (WCED, 1987). Its holistic approach comprises three dimensions, the environmental, social and economic dimensions, and by integrating these in a balanced way, lasting prosperity will be found (UN, 2015; Dimoska & Dimoska, 2018). After publishing the Brundtland report, Edward Barbier (1987) introduced a visual representation of the definition

of sustainable development through a Venn diagram of intersecting circles in the same year, see Figure 3-1. This well-known model consists of the three interconnected pillars, namely the pillar of environmental development, social development, and economic development.

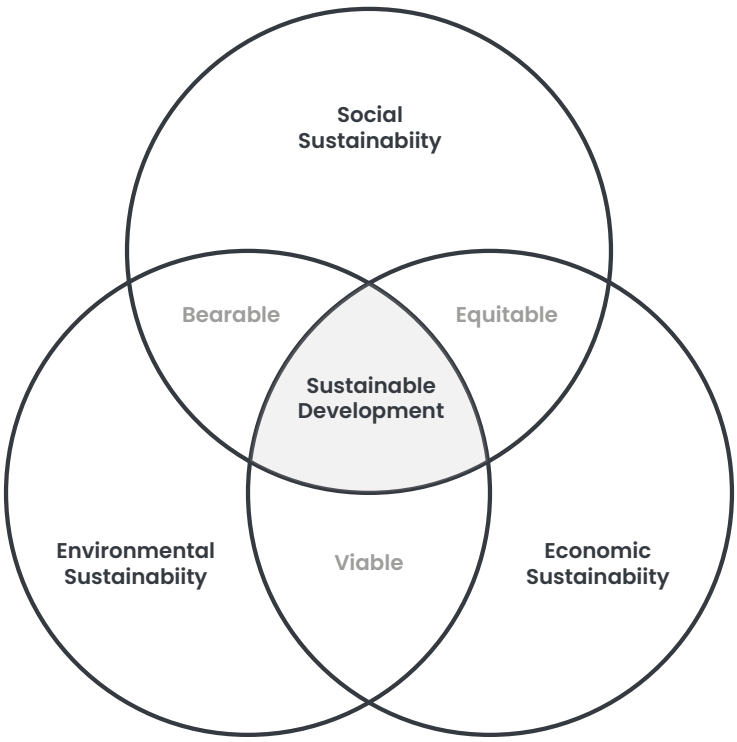


Figure 3-1: Visual representation of Triple Bottom Line Model from Elkington (own illustration).

The incorporation of the notion of sustainable development continued and it became a global agenda during the UN conference on Environment and Development (UNCED) in 1992 in Rio de Janeiro. The establishment of Agenda 21 as a strategic global plan asked for the need to link social and economic development with environmental protection and the implementation of processes towards sustainable development (UN, 1992; Purvis, 2019). The objective of Agenda 21 was to "...improve the social, economic and environmental quality of human settlements and the living and working environments of all people, in particular the urban and rural poor" (UN, 1992). By doing so, the three universally accepted, interconnected pillars for sustainable development were officially established and integrated (Pérez del Hoyo, Visvizi & Mora, 2021).

In 2015, the United Nations (UN) introduced Transforming Our World: The 2030 Agenda for Sustainable Development. The 2030 Agenda features 17 Sustainable Development Goals aiming to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030 (Mensah, 2019). These 17 principles aim at achieving social progress, environmental equilibrium and economic growth and are to be adopted at international, national, regional and local levels (UN, 2015). The 17 Sustainable Development Goals are: No Poverty; Zero Hunger; Good Health and Well-Being; Quality Education; Gender Equality; Clean Water and Sanitation; Affordable and Clean Energy, Decent Work and Economic Growth; Industry, Innovation and Infrastructure; Reduced Inequalities; Sustainable Cities and Communities; Responsible Consumption and Production; Climate Action; Life below Water; Life and Land; Peace, Justice and Strong Institutions; and Partnerships for the Goals (UNDP, 2016). Specifically, Goal 11 is interesting for architects and urbanists, which defines cities as important catalysts and actors to achieve sustainable, inclusive and resilient cities and communities (Pérez del Hoyo, Visvizi & Mora, 2021).

Doughnut Model

After the expansion and establishment of new global development goals, there was a growing debate on how to implement these renewed goals with a strategic action plan. There was a need for a framework that brought a new perspective on sustainable development, one that brought together both human rights and environmental sustainability (Raworth, 2012). Kate Raworth (2012) introduced the Doughnut Model, which is an idealistic guide of what sustainability and sustainable development could look like. The framework from Raworth (2017) states that we have to avoid two basic problems at all cost: i) repair the current social shortfalls in fulfilling human and social needs, and ii) stop the environmental overshoot by preserving our planet's resources. The model consists of two circles, see Figure X. The inner circle represents our social foundations, the basic needs we have, for instance energy, water, food, and housing. The outer circle represents our ecological ceiling in which we have to stay inside (e.g. climate change, air pollution or land conversion, biodiversity loss), based on the framework on 'planetary boundaries', scientifically evaluated by Johan Rockström and Will Steffen (2009). Between these two circles is an environmentally safe and social space for humans to thrive in, a state in which "...environmental change occurs naturally and Earth's regulatory capacity maintains the conditions that enable human development" (Rockström et al., 2009). This area is where inclusive and sustainable economic development takes place (Raworth, 2012).

Triple Bottom Line Model

Another definition of sustainability and sustainable development emerged after the establishment of Agenda 21 and comes from Elkington (1994) who states that sustainable development rests on three interconnected pillars: economic sustainability, social sustainability, and environmental sustainability (Mensah, 2019). His framework, the Triple Bottom Line Model, is an accounting framework that describes the relationships among the environmental, economic and social aspects of Sustainable Development. Every human action should be environmentally and economically viable, economically and socially equitable, as well as socially and environmentally bearable (Porter & Van der Linde, 1995). If our actions are made within the three pillars of sustainability, a mutually beneficial relationship is made, one that preserves natural resources, protects the environment, boosts economy and respects human rights and needs (Mensah, 2019). The following paragraphs will examine these three universally, interconnected pillars.

Environmental Sustainability

The concept of environmental sustainability is about the natural environment in which ecological integrity is maintained, natural resources are conserved and global ecosystems are protected, in order to support health and well-being for current generations and for the future. It is also about the carrying capacity of the natural environment and creating an optimal balance between the harvesting and regeneration of natural resources and the emission and assimilation of waste by the environment (Diesendorf, 2000; Evers, 2018; Bassiago, 1999). From an architectural perspective, an environmentally sustainable city is one that reaches agreement on levels of natural resource use.

Economic Sustainability

The concept of economic sustainability implies a system that aims to satisfy present consumption

levels without compromising future needs (Mensah, 2019; Lobo, Pietriga & Appert, 2015). It aims to support long-term economic growth while also protecting our environment and conserving resources. From an architectural perspective, an economically sustainable city promotes local economic growth, is financially viable, offers affordable housing, and favors quality employment. It is about creating an inclusive city with a high participation rate of citizens in economic life (Pérez del Hoyo, Visvizi & Mora, 2021).

Social Sustainability

Finally, the pillar of social sustainability aims to include notions of equity, empowerment, accessibility, participation, cultural identity and institutional stability (UN, 2000a; Daly, 1992). Healthcare, education, gender equality, peace, and stability are other notions that are included in the development of social sustainability. The social pillar puts human beings at the center and focuses on enhancing the development of people, communities and cultures. From an architectural point of view, social sustainability focuses on preserving equal rights of all people, ensuring equal access to basic resources, for instance housing, access to public open spaces and sustainable public transport (Benaim & Raftis, 2008; Pérez del Hoyo, Visvizi & Mora, 2021). Kolk (2016) states that social sustainability focuses on enabling conditions for everyone to realize their needs, instead of making sure that everyone's needs are met.

3-3 Sustainable Household Behavior and its Determinants

This chapter examined the concept of pro-environmental behavior and sustainable development with the aim of describing how sustainable household behavior is able to contribute to sustainable development. Based on the described sections above, we can conclude the following: sustainable household behavior can be seen as behavior that is consciously looking for ways to minimize the impact of one's actions while meeting the needs of the present, without compromising the ability of future generations to meet their own needs and taking into account the three interconnected pillars of sustainable development.

An architect can encourage this type of pro-environmental behavior through nudging by focusing on five determinants where households exerts pressures on the environment. According to the introduction of this chapter (Ivanova et al., 2016), and a study on Household Behavior and Environmental Policy, initiated at the OECD Environment Directorate (2005) aimed at better understanding household environmental behavior, the five key areas are: waste generation and recycling, personal transport choices, residential energy use, food consumption, and domestic water use. By making changes in the household consumption pattern, architects can have a profound effect on the quality of the environment, the preservation of natural resources and the adoption of sustainable household behavior. See Figure 3-2 for a visual representation of the five key determinants.

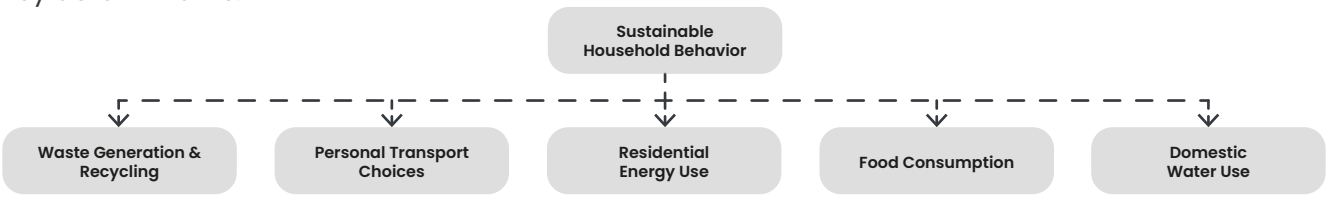


Figure 3-2: Visual representation the five key areas that determine sustainable household behavior (own illustration).

4 The Relationship between Nudging, Pro-Environmental Behavior and Architecture

Recent research frames sustainable buildings as important catalysts for providing a supportive environment for the adoption of occupant's environmentally responsible behavior (Hamilton, 2018). Thus far, this study looked into the theory of nudging as a potential strategic tool for encouraging pro-environmental behavior in the situational context through small aspects in the environment. However, less is known about the role of the wider scope of the physical environment and how sustainable buildings in general are able to act as a supportive environment for shaping pro-environmental behavior (Hamilton, 2018). Therefore, this chapter examines the relationship between the concept of nudging, pro-environmental behavior and the role of architecture by bringing these together into one comprehensive framework. A brief overview and understanding of several frameworks is first required before bringing all aspects together.

4-1 The Role of Sustainable Architecture as a Supportive Environment for Adoption

In literature, three relevant theoretical approaches can be found that describe the role of sustainable architecture as a supportive environment for adoption. The first theory presents a framework of connections between sustainable architecture and pro-environmental behavior (Chansomsak & Vale, 2008). The second one describes an alternative perspective of the situational context by proposing the conditions underlying a supportive context for behavior change to happen (Basu & Kaplan, 2015). The last one frames sustainable buildings as active contexts and supportive environments for the emergence of behavior (Hamilton, 2018).

Sustainable Architecture and Responsive Sustainable Behavior

According to Chansomsak and Vale (2008), architecture should be utilized as a tool that encourages people to live more sustainably. In order to establish pro-environmental behavior, actions for sustainability are first required. Based on the model of responsible environmental behavior by Hines, Hungerford and Tomera (1987) as is described in Chapter 2, Chansomsak and Vale (2008) introduce a framework that connects sustainable architecture to sustainable behavior that can indirectly influence the internal and external factors, through: "direct experiences from sustainable design, indirect experiences of sustainable design and related issues from the architectural media and participation in the design and construction process" (Chansomsak & Vale, 2008), see Figure 4-1.

First, sustainable architecture is able to indirectly influence external factors (e.g. infrastructure, political, social, cultural factors, economic situation). It states that sustainable architecture can provide benefits for occupants, such as the reduction of environmental impacts, strengthening the local economy and community and providing an opportunity to act sustainably. These benefits will have a profound effect on the external factors which directly impacts the adoption of responsive sustainable behavior.

Secondly, sustainable architecture can influence the internal factors through three different scenarios. First, sustainable architecture provides direct experiences to promote constructive attitudes towards sustainability. Second, experiencing sustainable architecture is able to increase

knowledge through verbal communication, publications and media. Finally, Participation in the design process in sustainable architecture can involve occupants and create a sense of belonging. These three together have the potential to influence the internal factors, which indirectly affects the adoption of responsive sustainable behavior.

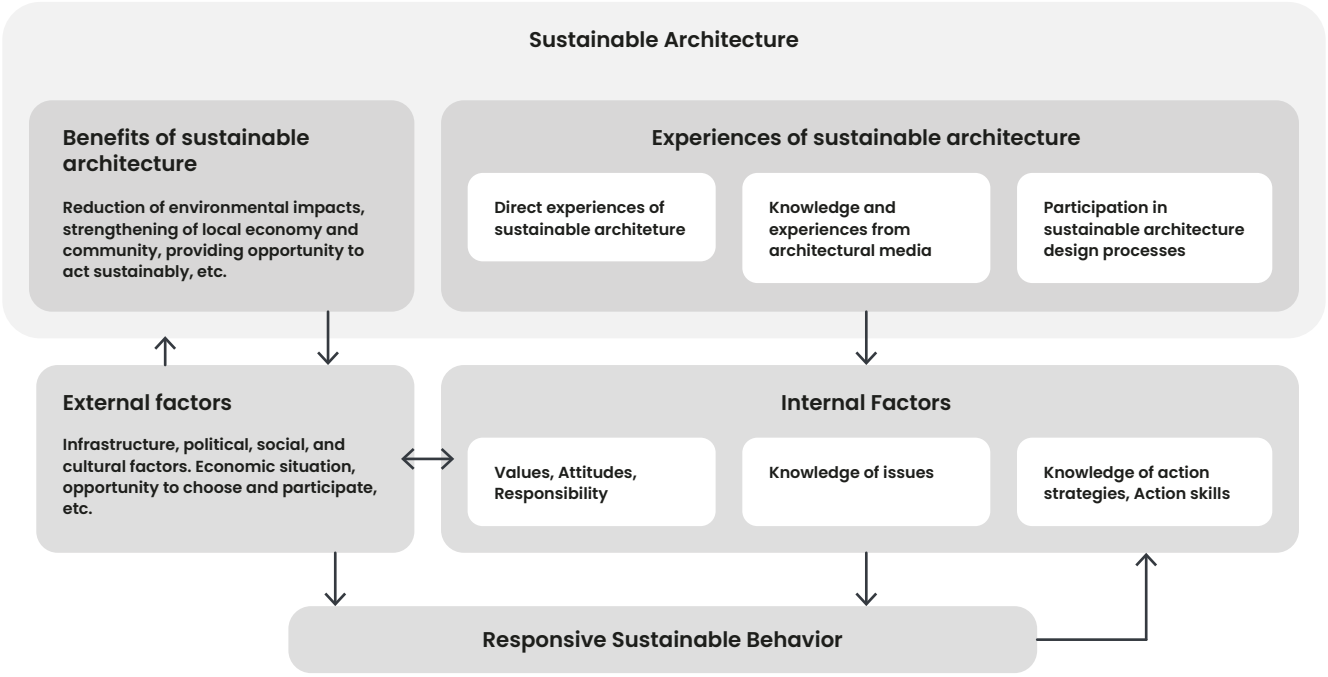


Figure 4-1: Relationship between sustainable architecture and fostering of responsive sustainable behavior. Adapted from "Can architecture really educate people for sustainability", by Chansomsak, S. & Vale, B., 2008.

Reasonable Person Model (RPM)

The Reasonable Person Model (RPM) is a framework that considers the essential ingredients that are needed to create a supportive context for desired behavior to emerge (Hamilton, 2008; Kaplan & Basu, 2015). The model consists of three interconnected domains that can be considered while designing a physical, social and informational environment, these are: model building, being effective and meaningful action, see Figure 4-2.

First, model building refers to the human need to understand and explore the world, solve problems, and make decisions. Humans are dependent on knowledge and environments that provide information, help occupants to fulfill their innate needs (Kaplan & Basu, 2015).

Secondly, being effective refers to a state of mental clarity that enables people to absorb information (Hamilton, 2018). A person who is mentally fatigued is not able to focus or plan ahead, and is also less likely to establish pro-environmental behavior (Kaplan & Basu, 2015). Therefore, environments should support mental clarity and provide opportunities for occupants to establish mental restoration (Hamilton, 2018).

Finally, meaningful action is defined as the human need to utilize knowledge and competence to add meaningful value in the world. By involving people and letting them participate in actions, will allow them to apply knowledge and skills in action that contributes to the development of knowledge (Hamilton, 2018; Kaplan & Basu, 2015).

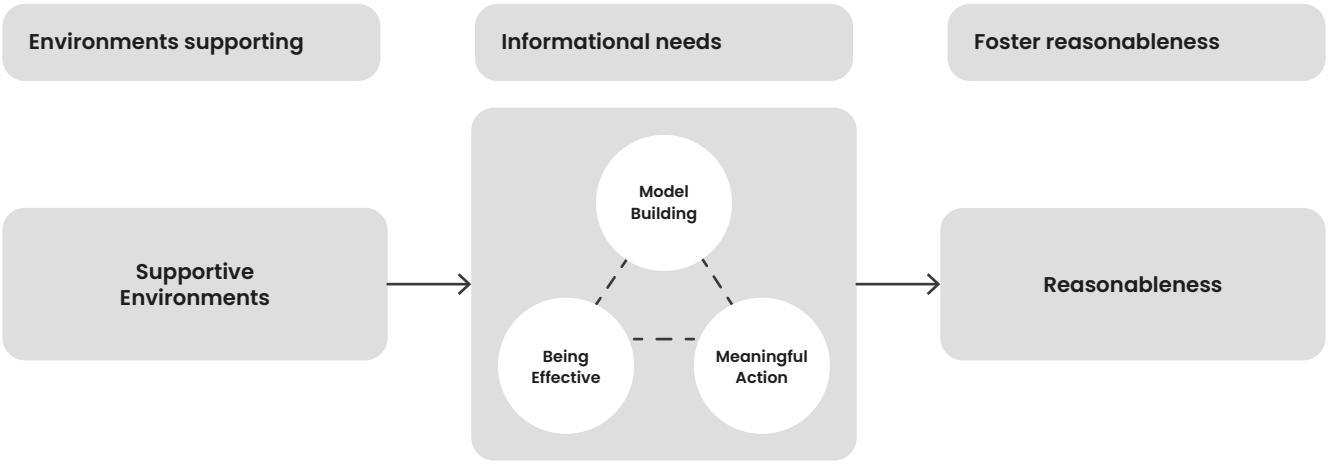


Figure 4-2: The RPM framework. Adapted from "Fostering Reasonableness: Supportive Environments for Bringing Out Our Best", Kaplan, R., & Basu, A., 2015, Ann Arbor, MI: Michigan Publishing, University of Michigan Library.

Positive Sustainable Built Environment (PSBE) Model

The Positive Sustainable Built Environment (PSBE) Model defines sustainable buildings as supportive environments for the development of pro-environmental behavior, see Figure 4-3. This framework is also one of the first attempts to "...define the situational context as a collection of characteristics of sustainable buildings that may support ERBs" (Hamilton, 2018). The model also takes various intervention techniques into account, based on the conclusions of empirical research that states that behavior change is more likely to occur when several psychological channels are targeted.

According to Corral-Verdugo and Frías-Armenta (2015), positive environments can be defined as environments that provide benefits to the occupants that also evoke positive behavior in return. In other words, they describe the positive environment as "the context that provides individual and collective benefits, also influencing human actions to conserve the present and future socio physical milieu (Corral-Verdugo and Frías-Armenta, 2015).

The theoretical framework consists of three domains that describe how sustainable buildings can be designed to support, allow and encourage pro-environmental behavior (Hamilton, 2018). The first domain is called priming, which means to prepare occupants for participation in sustainability by including two aspects: 1) communicating a sustainable ethos through the provision of informational and educational tools and the communication of positive social norms. The second domain is called permit, which means having the ability to participate in pro-environmental behavior in a sustainable built environment. This includes having behavioral control (e.g. cultivate personal responsibility, develop competence, and realize intrinsic satisfaction). The third domain describes how environments can invite, or encourage, the adoption of pro-environmental behavior through behavioral prompts (nudges), such as goal setting, feedback, framing, and norm messaging.

To summarize, the above mentioned frameworks share similarities in how sustainable buildings, the wider physical context, play a role in creating a supportive environment for the adoption of pro-environmental behavior. The Positive Sustainable Built Environment Model, for example, includes the underlying conditions as is described in the Reasonable Person Model. Besides, The PSBE model even positions the role of nudging within the wider context.

These three frameworks can be utilized to explain the relationship between the role of architecture, the concept of nudging, the concept of sustainable household behavior and its determinants. In the following section, a comprehensive model for nudging towards pro-environmental behavior in architecture is explored.

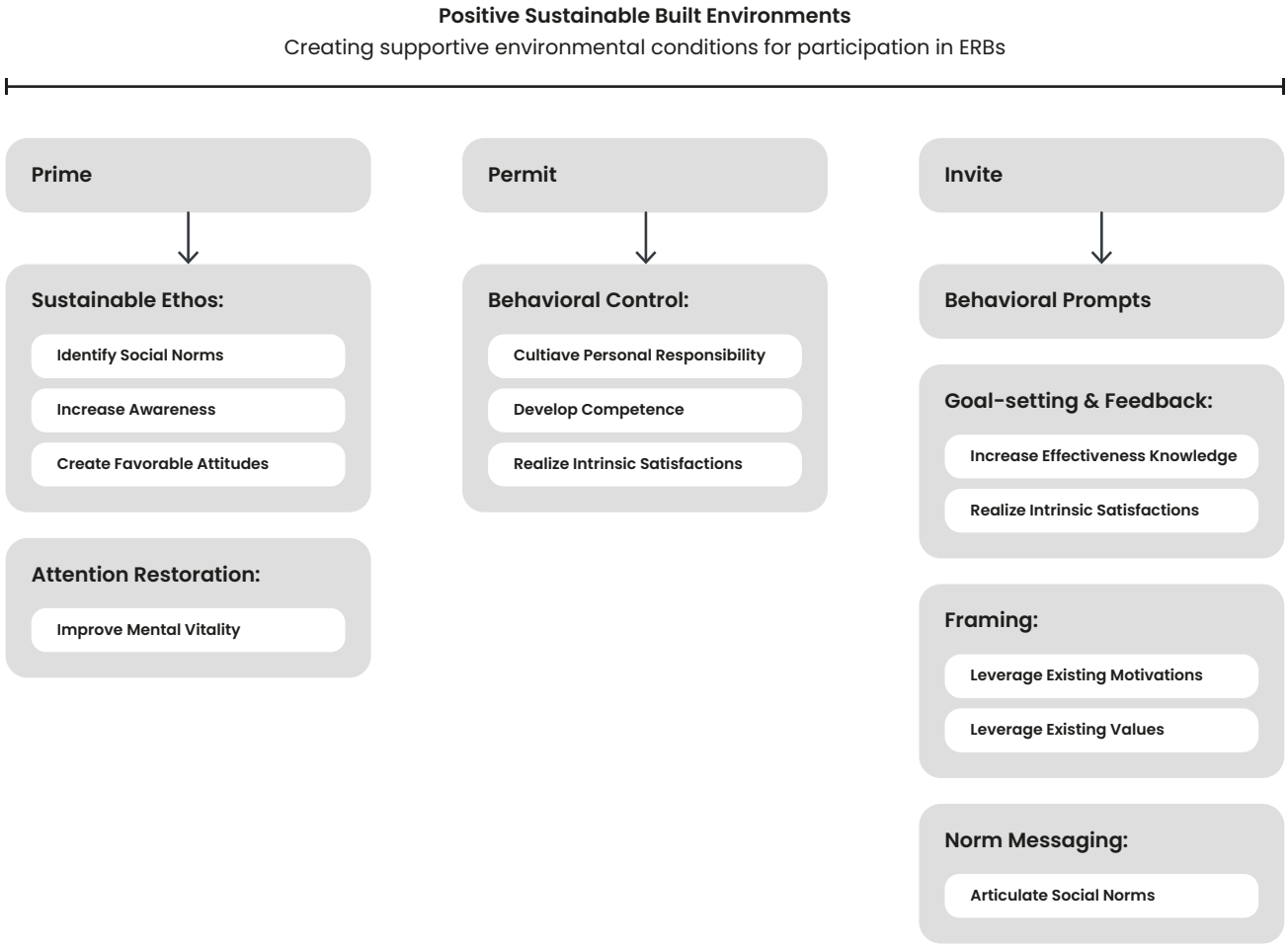


Figure 4-3: The Positive Built Environments Model. Adapted from "Green building. Green behavior? An analysis of building characteristics that support environmentally friendly behavior", by Hamilton, E. M., 2021, in Enironment and Behavior, 53(4).

4-2 A Comprehensive Model for Nudging towards Sustainable Household Behavior in Architecture

This section outlines the role of nudging in changing behavior towards sustainable household behavior in architecture, through a comprehensive framework, see Figure 4-4. This model builds on literature and frameworks that are addressed in this study. Therefore, this model will not be discussed in detail, but instead, will refer to previous chapters and sections.

First of all, the foundation of the framework is based on the Comprehensive Action Determination Model of ecological behavior by Klöcker and Blöbaum, see section *2-1 Theoretical Approaches to Behavior Change*. The framework includes four interdependent variables that affect the development of sustainable household behavior and focuses primarily on the role of architecture, the situational context. Architecture directly impacts the normative processes, habitual processes, intentional processes and the development of pro-environmental behavior. Furthermore, the model visualizes the continuous process of eliciting sustainable behavior by describing the (in)direct relationships between each variable. Here, the impact and role of

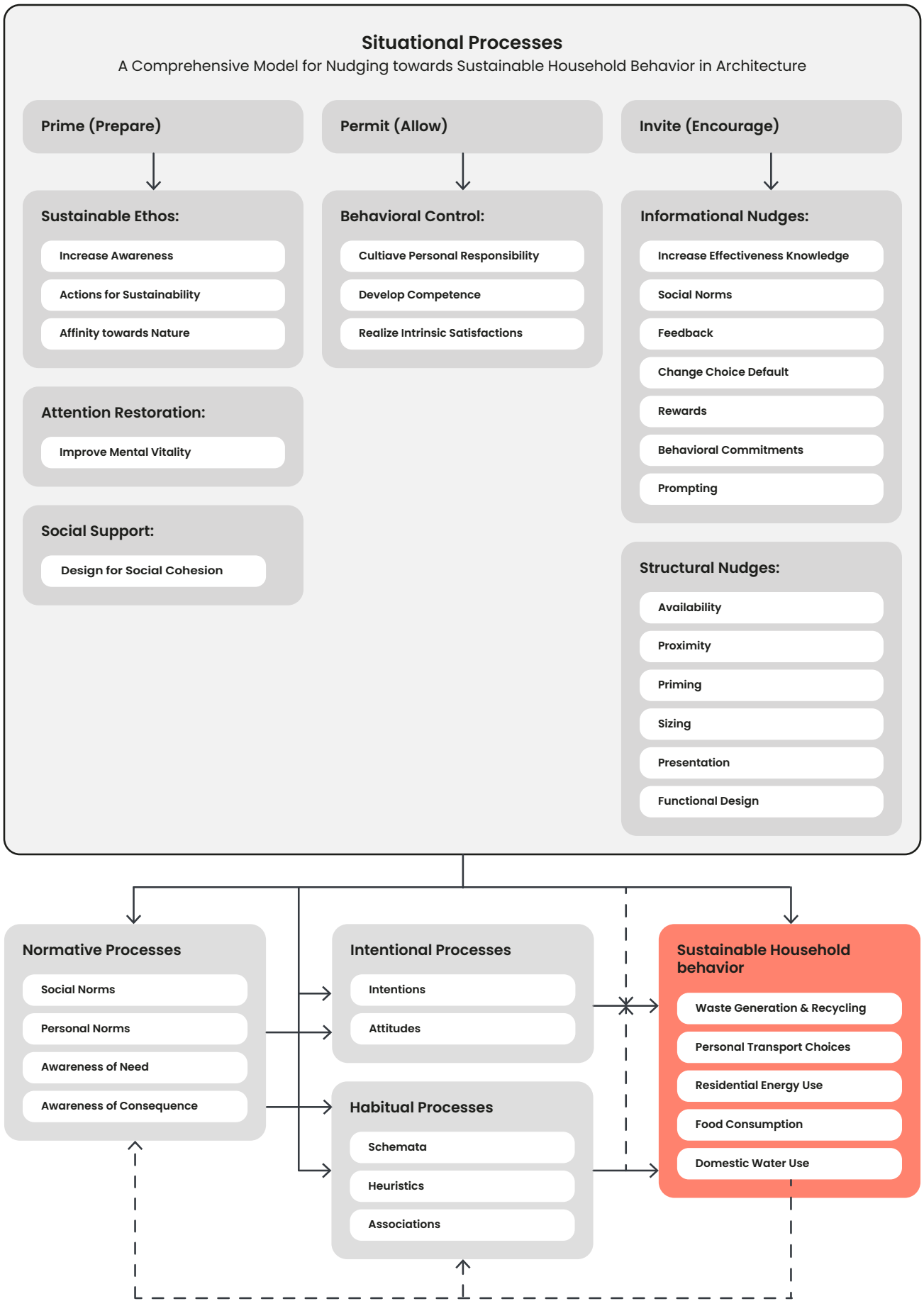


Figure 4-4: A Model for Architecture & Sustainable Household Behavior: Defining the role of nudging in changing behavior towards sustainable household behavior in architecture (own illustration).

architecture in developing pro-environmental behavior becomes truly visible.

Secondly, the framework defines the architecture as a collection of characteristics of sustainable buildings that may elicit sustainable behavior. Based on the Positive Sustainable Built Environment (PSBE) Model by Hamilton, three domains, underlying conditions, are required for creating a supportive environment for the development of environmental sustainable behavior: Prime, Permit and Invite. These three domains will be, to some extent, explained in the following sections.

Prime (Prepare)

The first underlying condition or domain is called priming, which means to prepare occupants for participation in sustainability and adoption of pro-environmental behavior. This domain includes three aspects: communicating a sustainable ethos, restoring attentional capacity, and creating social support. All three will be outlined in the next paragraphs.

Communication a Sustainable Ethos

Communicating a sustainable ethos is about cultivating a sustainable spirit. Research suggests that architecture has been proven to be able to act as a medium of nonverbal communication. The notion that architecture can form a connection with occupants and establish a form of communication is not a novel one (Cranz, Lindsay, Morhayim & Lin, 2014, Cooke, 2012). Architectural features in the environment can communicate a sustainable ethos, a set of moral beliefs and attitudes towards sustainability. Normalizing sustainability through architecture is a strategic way for connecting people to the natural environment.

Moreover, David Orr (1997) defines architecture as a "hidden curriculum" to influence environmental education and behavior, by incorporating natural materials, indoor vegetation and several views towards nature. Hamilton (2018) examined other theoretical work to articulate architectural features that communicate sustainability. He suggests to implement "...an organic sensibility interdependent with regional and local landscape features, sustainable materials and technologies relevant to location, the celebrations of variety in design and composition, as would occur in nature, the use of local and found materials relevant to place, an apparent connection between human and environment needs."

Besides, providing information and education about sustainability through signage can also be utilized to encourage pro-environmental behavior (Stern, 1992; Klaniecki et al., 2019). According to Khashe et al. (2015), signage is often used in buildings to "...draw attention to sustainable building features, conveying a message of institutional commitment to sustainability".

Attention Restoration

Cultivating mental states conducive to adopting a pro-environmental lifestyle requires a supportive environment for people in which mental restoration is achieved (Hamilton, 2018). Mental restoration, or mental clarity is needed to stay focused, and having the ability to be intentional and considerate towards long-term goals. This condition is also known as mental vitality, or being effective, based on the Reasonable Person Model (Kaplan & Basu, 2105). According to Hamilton (2018), the impact of preserving mental clarity can not be undervalued. He states that "...a person who is mentally fatigued may opt to toss the bottle in the nearby garbage bin, whereas an

individual who is equally busy, yet-clear headed, may seek out the less convenient recycling bin or plan to take the bottle home to recycle". Additionally, Arbuthnott (2009) explains that people who are mental fatigued believe that their actions will not make any difference, especially when the behavior is inconvenient or effortful. Consequently, this belief will result in less adoption of pro-environmental behavior. By creating opportunities for attention restoration, architects are able to restore and maintain the cognitive capacity of occupants which may result in behavior towards sustainability.

Kaplan (1995) states that natural environments are perfect places to restore the attentional capacity (mental fatigue and concentration) of people. Nature is also known as restorative environments and research has been able to link these restorative environments to an increase in pro-environmental behavior (Kaplan & Kaplan, 1989, Kaplan, 1995, De Young, 2010).

To further explain, the built environment can provide physical and visual connections to nature. For instance, a view out of a window towards the garden, walking paths around the building that bring people in contact with nature, or a view towards indoor plants can support mental clarity. Empirical research has demonstrated that even nature enjoyed briefly, such as a view towards a tree or indoor plants, is beneficial for restoring mental clarity (Kaplan, 2001; Raanaas et al., 2011). Augustin (2009) states that when "people can see grass and other natural things from their windows, they are more satisfied with their neighborhood and generally feel better. Humans relax when they look out over nature that has some water in it and some mown field".

Furthermore, according to Frances Ming Kwo (2010), "access to nature and green environments yield better cognitive functioning, more self-discipline and impulse control, and greater mental health overall. Less access to nature is linked to exacerbated attention deficit/hyperactivity disorder symptoms, higher rates of anxiety disorders, and higher rates of clinical depression."

To conclude, a connection to the natural environment, whether it is visual, physical or psychological, will theoretically result in mental clarity and attention restoration, and enhance pro-environmental behavior.

Social Support

The current environmental problems cannot be solved by single individuals. The belief that other individuals are willing to help mitigate the climate crisis influences people's willingness to change. A strong social context is needed to establish an environment including the cooperation of others. Research suggests that creating social cohesions and a strong sense of identity and belonging will lead to the development of pro-environmental behavior (Uzzell et al., 2002; Bratt., C., 1999).

Designing for social cohesion asks for a smart spatial configuration of the environment that encourages social interaction by facilitating meeting points and defining potential points of interaction (Hiller et al., 1987). They state that "through the arrangement of paths, nodes of activity and physical barriers, the arrangement of space permits the experiences of encountering others". These points of interaction also provide a way to facilitate the communication of social norms, which develop an understanding of the expected behavior in a specific social setting (McMakin et al., 2002).

Permit (Allow)

The second domain, permit, is about giving the opportunity to allow occupants to act upon their environment. According to Hamilton (2018), permit "...addresses the extent to which occupants are afforded control over their environmental conditions and opportunities to perform actions that conserve resources in the built environment". Augustin (2009) defines control as having the opportunity and ability to adapt an environment to their needs. Augustin further explains that "... personality, sensory differences, and culture determine the general level of control desired at various times, though all people are more comfortable and satisfied in space when the control they have matches the control they want". Consequently, when occupants lack control, they become stressed, discouraged, and frustrated (Augustin, 2009).

To further explain, a study from Monfared and Sharples (2011) demonstrated the effect of automated systems on the attitude of the occupants. It appeared that occupants who were present in highly automated and less-engaging environments were more dissatisfied due to the lack of control they were afforded.

In contrast to this belief, other research suggests that building automation is an important tool for sustainability. Smart systems control the environment based on the needs of occupants, and are able to maintain the energy-efficiency within buildings (Becker & Knoll, 2014). Nevertheless, automated systems are designed to take away the control of people, for instance in energy usage and comfort. According to Hamilton (2018), this results in two undesirable outcomes: i) it affects the attitude of occupants resulting in less satisfying behavior because they feel a lack of control, and ii) the systems are ultimately less efficient. Similarly, Truelove et al. (2014) state that unsupportive environments have the ability to result in a lack of interest, in which behavior patterns, such as turning off the light, slowly disappear from practice.

Moreover, De Joanna and Francese (2012) suggest that "a dynamic and responsible interaction between inhabitants and architecture can lead to important energy and carbon reductions". Environments that allow user control, such as adjustable work places, lighting, operable windows and window coverings, contribute to creating comfortable and healthy spaces (Charnofsky, 2012).

Invite (Encourage)

The third domain describes how environments can invite, or encourage, the adoption of pro-environmental behavior through behavioral nudges, small aspects in the environment that cue a behavioral response (Aronson & O'Leary, 1983). This domain is based on the findings in section 2-4, which gives an overview of two different categories of nudging. The first intervention typology implies the use of informational tools that focus on changing perceptions, motivations, knowledge and norms, without actually adapting the physical environment (Steg & Vlek, 2009). Based on the framework of Münscher et al. (2012), this segment consists of three categories: Decision Information (Information & Education, Social Norms, Feedback), Decision Structure (Default, Rewards), and Decision Assistance (Behavioral Commitments, Prompting).

The second intervention category represents structural tools that influence perceptions of control, attitudes and motivation (Klöckner and Blöbaum, 2010; Steg & Vlek, 2009). This category makes adaptations in the physical environment through altering the placement and/or properties

of features. Based on the TIPPME framework, structural tools are divided into to categories: interventions that primarily alter the placement of features (Availability, Proximity, Priming) in the built environment and interventions that primarily alter the properties of features (Size, Presentation, Functional Design) in the built environment.

Since these nudges have been widely discussed in section 2-4, it is unnecessary to outline these again. To conclude, behavioral interventions play a crucial role in enhancing pro-environmental behavior and have a profound impact on the decision-making context.

4-3 Conclusion

This chapter explored how sustainable buildings in general are able to act as a supportive environment for shaping pro-environmental behavior, by bringing several frameworks together into one that addresses the relationship between the concept of nudging, pro-environmental behavior, and the role of architecture.

A Comprehensive Model for Nudging towards Sustainable Household Behavior in Architecture is introduced. This framework describes the role of architecture that, together with three other interdependent variables, affect the development of sustainable household behavior. Here, the role of nudging, and the positioning of nudging within the wider framework becomes salient. According to these findings, the role of nudging plays a pivotal role in changing behavior towards sustainable living in architecture.

5 Analysis of Sustainable Case-Studies

This chapter is about to explore the Comprehensive Model for Nudging towards Pro-Environmental Behavior in Architecture as is described in section 4-2 by looking into four case studies. Here, several aspects in the three domains (Prime, Permit, Invite) are explored.

With regard to priming, the following questions will be answered: How does the architecture prepare occupants for participation in sustainability and adoption of pro-environmental behavior? How does the environment encourage social support and design for attention restoration? How is sustainable ethos communicated within the design?

Furthermore, the case studies also analyse how occupants are encouraged to elicit pro-environmental behavior through the implementation of informational and structural nudges. Here, the following questions are addressed: What type of nudges are implemented and how do these relate to the forming of pro-environmental behavior? What is the objective of implementing these behavioral prompts?

Moreover, these case studies also look into how pro-environmental behavior is formed by looking into the five underlying key areas: waste generation & recycling, transport, residential energy use, food consumption, domestic water use. Although not every case study will have answers to these questions, it will definitely offer additional insights and provide useful information as input for the design phase.

The aim of analysing four case studies is to offer additional insights in the forming of sustainable behavior through architecture and tries to connect the theory with the practical implementation of the framework. Four case studies have been chosen, because of their strong vision towards sustainable living: 1) Recipe for a Future Living by MAD Arkitekter, 2) Sundsholmerne by architect C.F. Møller, 3) Urban Village Project by Effekt Architects and SPACE10, and 4) Solaris developed by Huggenbergerfries Architekten AG.

1. Recipe for a Future Living

Architects: Ineo Eiendom AS, Mad Arkitekter, Asplan Viak AS, Vill Energi AS, Léva Urban Design AS, Resirqel AS, Mad Communication AS, Deichman Bibliotek, Stovner and Landskap+ AS.

2. Sundsholmerne - EcoVillage

Architect: C.F. Møller Architects

3. Urban Village Project

Architects: EFFEKT Architects and SPACE10

4. Solaris

Architect: Huggenbergerfries Architekten

5-1 Analysis of Recipe for a Future Living

The project Recipe for a Future Living has won the first prize of the international, environmental and climate competition called Reinventing Cities (C40) in 2019. The project is developed by a team consisting of Ineo Eiendom AS, Mad Arkitekter, Asplan Viak AS, Vill Energi AS, Léva Urban Design AS, Resirqel AS, Mad Communication AS, Deichman Bibliotek, Stover and Landskap+ AS.

Recipe for a Future Living is a demonstration of a project that benefits society, the environment, as well as the local economy. Their goal is to create a healthy and inclusive city that achieves a variety of sustainable goals. By coming up with solutions for mobility, a green and compact structure, and by reusing materials from buildings planned for demolition, this project lowers the amount of CO2 emission while integrating structures and materials into innovative, sustainable architecture. Their approach is to focus on creating a vibrant living environment by having a mix of public, communal and residential. By adding an ecosystem of local jobs and activities in the plinth, the project fosters a sustainable lifestyle.

Architects:
Ineo Eiendom AS, Mad Arkitekter, Asplan Viak AS, Vill Energi AS, Léva Urban Design AS, Resirqel AS, Mad Communication AS, Deichman Bibliotek, Stovner and Landskap+ AS.

Client:
Ineo Eiendom

Realization Phase:
2019

Site and Address:
Stovner, Oslo

Size:
7.350 m2

Residential Units:
approx. 150 units

Figure: Mad Arkitekter (2019). Visualisation of the courtyard showing the orangery made from the reused roof of Galleri Oslo.


JACK

Figure (top left): Mad Arkitekter (2019). Visualiation of the project that promotes eco-friendly, values and interprets and translate.

Figure (top right): Mad Arkitekter (2019). Visualisation along the pedestrian street showing the Mobility hub.

Figure (bottom left): Mad Arkitekter (2019). Visualisation of the courtyard showing the orangery made from the reused roof of Galleri.

Context of the Project

The project is situated in Stover, a small town in the suburbs of Oslo which consists of more than 32.000 inhabitants with approximately 140 different nationalities, which is also one of the reason why this Competition, called Reinventing Cities, was very interesting because of the cultural diversity making this project very unique compared to others towns in the suburbs of Oslo.

At the beginning of the project, the architects asked several residents to participate in the design process by highlighting pleasant and unpleasant spaces in the surrounding environment. In figure X, the results of the input of the participants are shown. Here, two circles are drawn that emphasize the distance from the plot to the highlighted areas. The spaces in Stovner that are experienced as pleasant are highlighted with a 'heart', while the unpleasant spaces are highlighted with a 'green circle and a white line'.

The architects discovered that the area is close to the center of Stovner, which is experienced as an important meeting place and public transport hub for the people. Around the center, there are a lot of meeting spaces for children and young people to come, such as schools, kindergartens, sports and other activities. These form the connection between the different living environments in Stovner.

Besides these positive meeting spaces, there are also mental barriers where negative social activity takes place. Another pressing issue is the lack of affordable and adequate housing for the eldertly and the younger people. Most of the houses in Stovner focus on family apartments or detached houses. Therefore, this project will offer housing facilities that suit the different needs and wishes of the residents. One of the needs the architects discovered by talking to the residents in the areas, was the need for more diversity in the physical environment that really reflects this socio-cultural diversity.

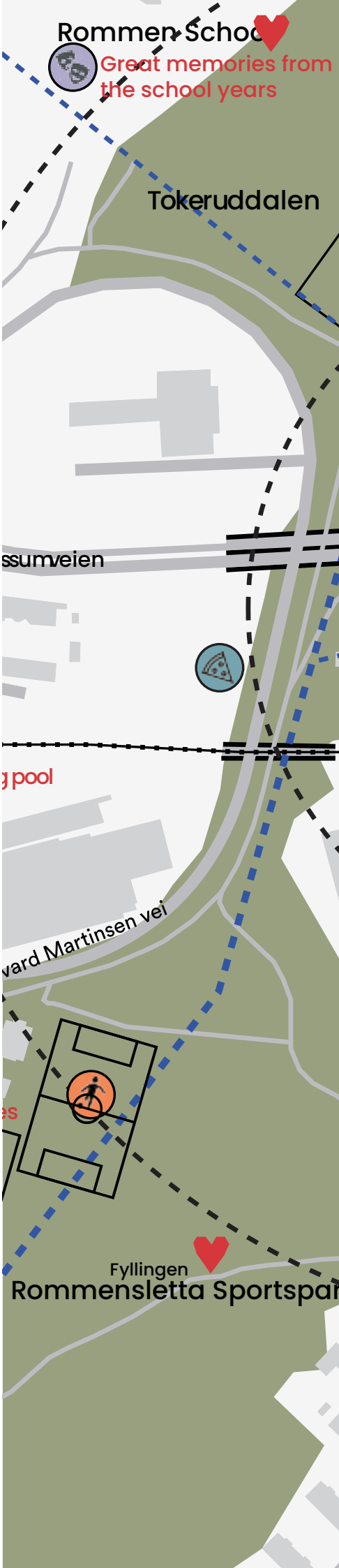


Figure: Mad Arkitekter (2019). Situation Plan and analysis of Stovner. Adapted by the author.


Sinister,
Dark forest
TOKERUD
Tokeruddalen
Tokerudberget
Visiting great friend
Meeting point
Kindergarten
Sinister
gangs, drugs,
drinking
Sinister,
narrow corridor
Kiwi
Asian grocery
store
'Sanctuary'
surrounded by forest
playing volleyball,
meeting point
Fossumdumpa
Fossum Church
Youth
club
Drugs,
drinking
Junior
club
Kindergarten
Meeting
point
Library
Sentergata
Adminstration
Doctors
Stovner
Mosque
Police
Important
meeting point/
arena for a lot
of people
Establish safety
COOP
StovnerSenter
(shopping centre)
Fossumveien
Karl Fossums vei
Great mem
from the sc
Ok space, but too much traffic
Open with out shielding
Stovner
Highschool
Riding sc
500m
Karl Fossums vei
Kindergarten
Nedre Fossumfarm
Øvre Fossum Fa
Fjellstuveien
Meeting point
Tante ulrikkesvei
Olaus Fjørtofts vei
1000m
Fossumveien
Scale 1:300(A4, Portrait)
0m
50m
100m

Priming (Prepare)

This section looks into the domain of priming and tries to answer how the case study prepares occupants for participation in sustainability and adoption of pro-environmental behavior? How is sustainable ethos communicated within the design? How does the environment encourage social support and design for attention restoration? We start by exploring the communication of a sustainable ethos.

Communicating a Sustainable Ethos

The building increases awareness by taking direct actions towards sustainability. Their concept integrates the three pillars of sustainability, which is communicated through architecture. Below, some of the pillars are shortly described to understand how the building prepares occupants for participation in a sustainable environment.

Environmental Pillar

Materialisation - Mad Arkitekter wants to develop a building by reusing and upcycling materials. They mapped the materials of different buildings in the surrounding area that are planned for demolition and want to reuse those to reduce the material use with 90% compared with the amount of materials that is needed for a new building. Furthermore, there are solar powered facades and roofs that are generating the needed energy. The solar powered facades and the reused materials become salient in the direct experience of the building.

Figure: Mad Arkitekter (2019). Solar-powered facades and different reused materials.

Program - Furthermore, looking at the program of the building, there is a waste food cafe that orders food that is produced from waste in the kitchen, tea shop that sells locally grown tea and fruit that are produced on the roofscape. By integrating these functions, it communicates a sustainable ethos.

Energy - Moreover, the architect prepares occupants for sustainability by designing a energy efficient building that generates clean energy supply. The goal of becoming energy-neutral depends on the number of integrated BIPV panels, in other words building integrated photovoltaic panels. In the first phase of the project, the architect includes 3.700 m2 of BIPV, which has the potential to achieve a plus-energy project. 1.200 m2 is integrated in the stairwell towers, railing and greenhouses and 2.500 m2 of the BIPV panels are integrated in the glass and facade elements.

The PV panels are used on the roofs as well as the facades. The produced energy is used for heating and stationary purposes. However, the first step in achieving a zero-energy building is by reducing the energy demand. Therefore, the main concept is to minimize energy use by applying passive and low-tech solutions, such as the utilization of daylight, thermal mass, tall ceiling heights,

and natural climatization.

The energy that is being produced is stored in a battery, that will take care of a surplus on sunny days. The building is also connected to the electrical grid in case of periods with either a surplus or shortage of electrical energy. By doing so, the building can give back to the surrounding if needed.

Figure: Mad Arkitekter (2019). Solar-powered facades and PV panels on the roof.

Water - In this project, water is managed in a sustainable way. First, the rainwater on different levels on the roof is collected and reused for irrigation or recreational purposes. This water will be filtered before it will be utilized in greenhouses and for flushing the toilets. The water consumption in the building is reduced by water-saving toilets and water-saving tap equipment. The architect is also exploring the idea of implementing vacuum toilets, which will reduce the water consumption by over 70%. After reusing the rainwater, the water will be infiltrated into the ground. These implementations increase awareness and knowledge about sustainable systems.

Nature - The project covers 43% of the site (courtyard, roofs, and greenhouses) area in vegetation and gardens. The other part of the area consists of a wooden boardwalk and permeable tiles that infiltrate rainwater. Local vegetation plays a major role in this concept since the architect wants to strengthen the ecological value of the area. Edible plants and local vegetation will also be planted on the roofs and in the courtyard. Creating a connection with nature will enhance people's emotional affinity towards the natural environment.

Figure: Mad Arkitekter (2019). Integration of nature and water in the communal garden.

Economic Pillar

The project stimulates the local economy because of the implementation of commercial functions on the ground floor. By reusing the materials from other buildings, the costs of purchasing new materials is very low. This solution will help develop a viable plan that provides enough financial return. This project wants to achieve two goals: green services and clean growth.

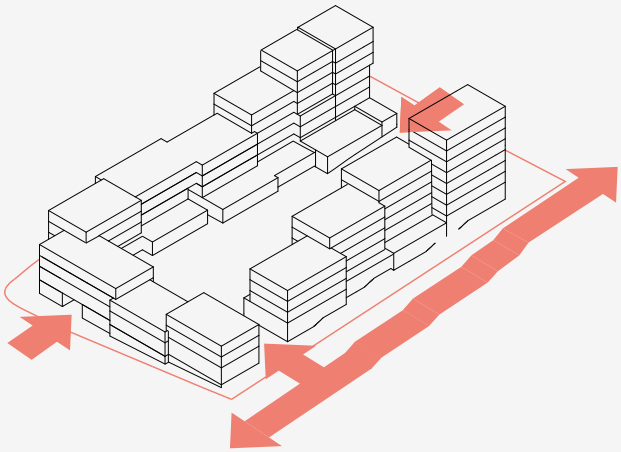
Program - Integration of green services for the site and the neighborhood. The project focuses on establishing new jobs for the people in Stovner. This will enhance social sustainability as well as economic sustainability. Residents who are unemployed have the chance to work. Besides, cooperation is made with The Red Cross which will also create opportunities for employment.

The architect encourages start-up companies to take place, focussing on the local green businesses, such as a bike-repair shop, and a kitchen that produces food for the elderly. Workshops are being held in the courtyard to create a strong community. An app will be made that informs residents about their environmental impact and the possibility to make use of green services, such as the use of shared cars. The project also encourages the implementation of sustainable interiors and furniture which is locally made.

Figure: Mad Arkitekter (2019). Overview of envisioned startups that created employment. Adapted by the author.

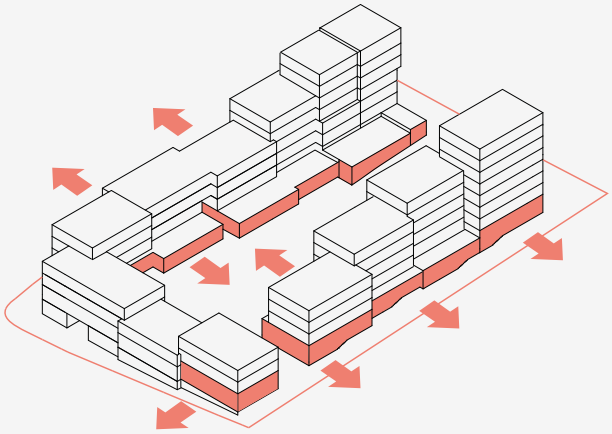
Social Pillar

Program - The project focuses on creating social cohesion. The ground floor is programmed with different public spaces, such as a repair shop, and other neighborhood activities. These different spaces stimulate social interaction and offer jobs for unemployed people that are given a change to work. The following section looks into the creatin of social support through social cohesion.



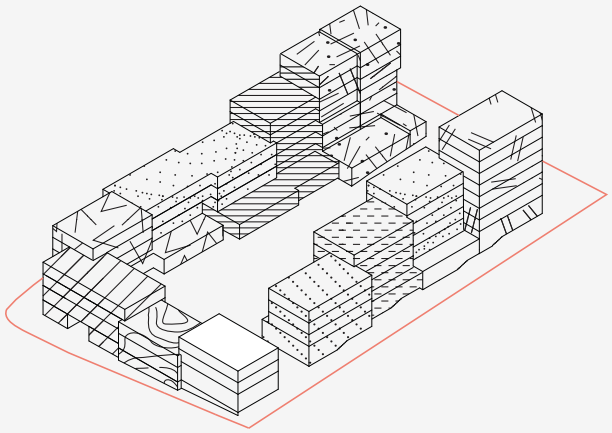
1. Contextual

Relation to context, openings and fall in terrain



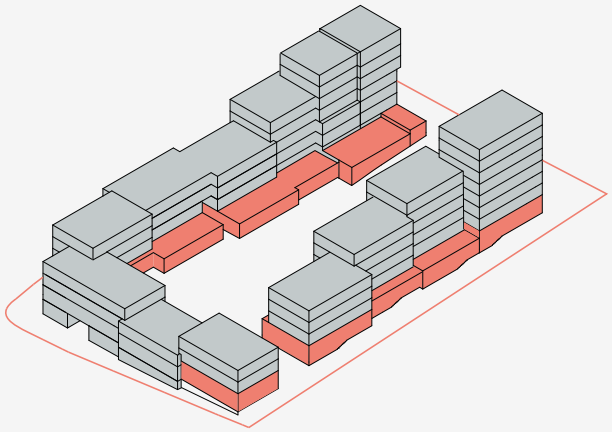
2. Social Sustainability

Activation of street level with public functions



3. Environmental Sustainability

Reuse of different materials in each buiding block.



4. Economical Sustainability

Ratio of housing to commercial for an economically sustainable project.

Attention Restoration

The sustainable project creates a supportive environment for people in which mental restoration and mental clarity is achieved through the implementation of nature. The roof provides the following functions: agriculture, greenhouses that provide edible plants, beehives, aquaponics and seating areas for people to take a moment to relax. The terraces provide fruits and berries. In the courtyard, people are in direct contact with nature through the implementation of seating areas, playscapes, and marked square. It also includes wooden boardwalks, and permeable tiles. People are in direct contact with nature and have the ability to create mental clarity, which plays a role in eliciting pro-environmental behavior. The image below and on the next page show the different functions that are implemented in the plan.

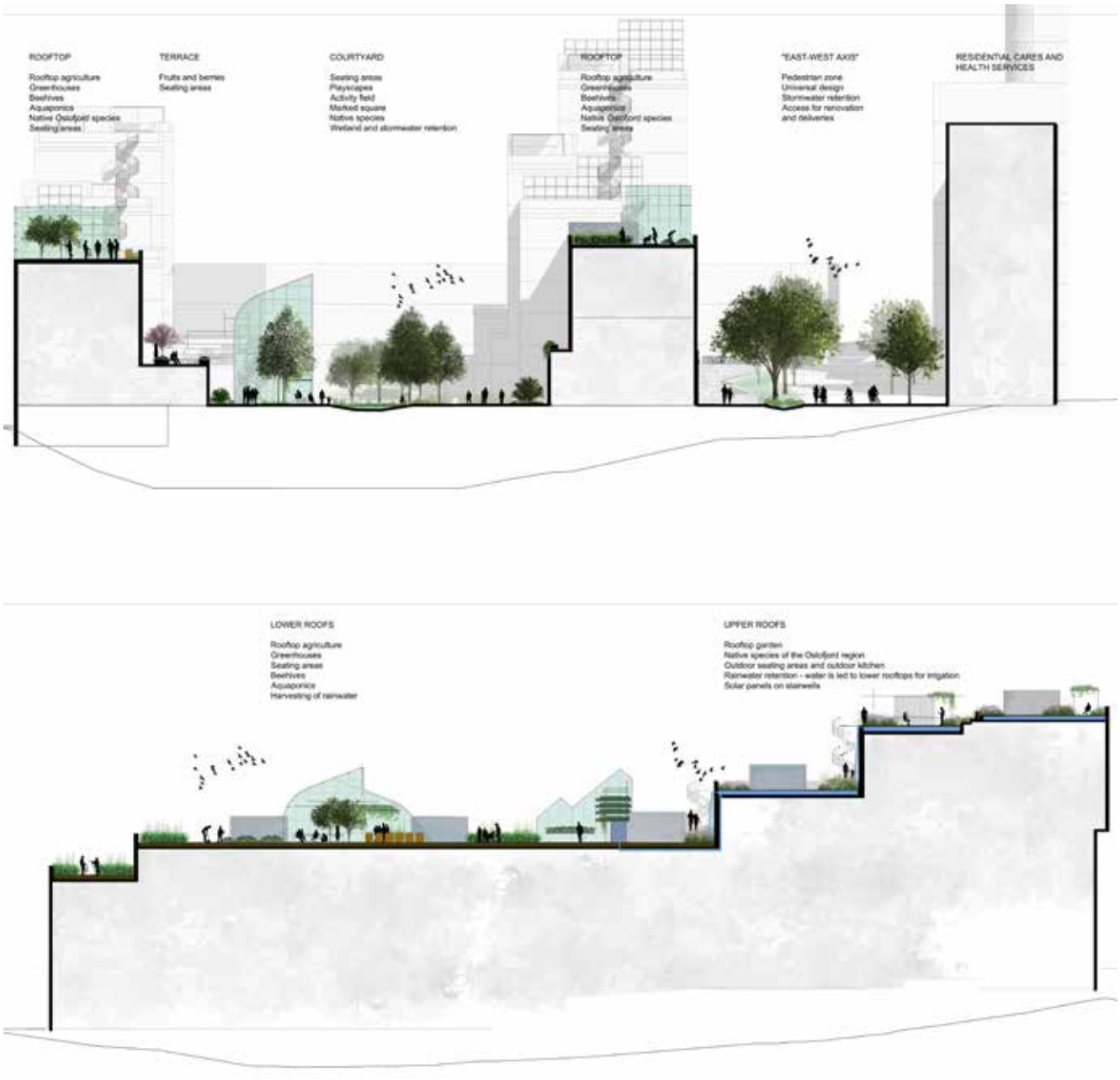


Figure: Mad Arkitekter (2019). Adding biodiversity on the roof of the building.

Figure: Mad Arkitekter (2019). Inmplementation of natural elements in the environment. These elements increases emotional affinity towards nature and increase attententional restoration.

Social Support

This project aims to establish social cohesion and a strong sense of identity and belonging. By doing so, it will lead to the development of pro-environmental behavior. Recipe for a future living strives to serve the needs and wishes of the residents and the neighborhood, by offering green services, and shared facilities, producing food for the local community and providing work and attractive interaction possibilities for the residents and community.

The courtyard and the public plinth on the ground floor consists of start-ups, shops, selling locally grown food, cafes, and a bike shop. Here, the residents meet each other through beer brewing courses, yoga sessions, boardgames, and events. This project envision achieving high involvement of residents and participation that gives a feeling of belonging and ownership.

Figure: Mad Arkitekter (2019). Social functions happening in the courtyard.

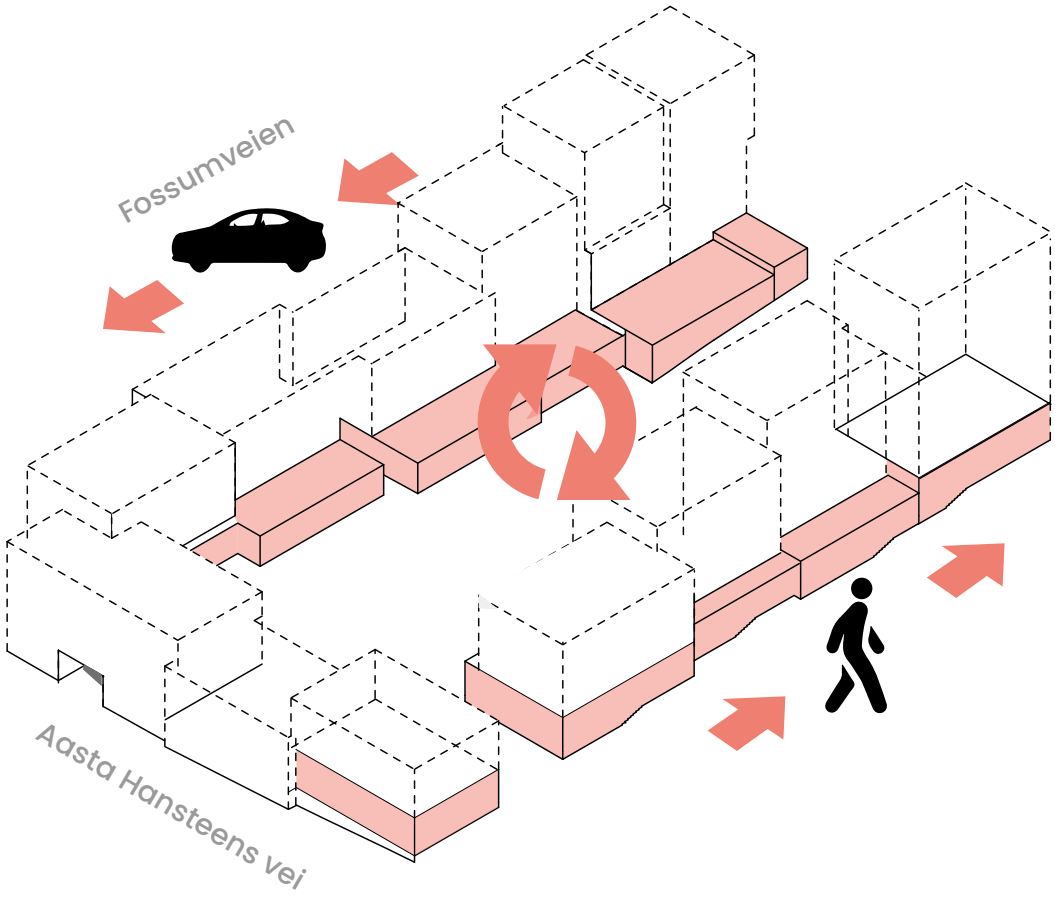


Figure: Mad Arkitekter (2019). Activation of the ground floor. Adapted by the author.

In total, there are 13.000 m2 or residential and communal areas (residential, community center, greenhouse, balconies, corridors, and staircases). There are 3.000 m2 of commercial spaces in the building (start-up businesses, maker-space, cafe, production kitchen, shop, bike-repair and bike-hotel, storage for bike hotel). Finally, there is 2.800 m2 of basement space for storage of the production kitchen, club and exchange room, start-up storage, access and parking spots. Combining these different functions in one building results in social diversity.

Furthermore, The activation of the ground floor with social functions, startups, and other facilities, will help to create an ecosystem of local jobs and meeting spaces for the residents. The center of the courtyard is the meeting place for the residents as well as visitors from the surrounding neighborhood. The plinth consists of several functions, such as a startup hub, community center, teashop, club, mobility hub, pimp my bike area, waste food production, and a waste food cafe or community center. These functions are shortly explained on the next page.

Startup hub

The project facilitates eight small spaces for startups, which share a kitchen, toilets, and large wardrobe. Each building block serves two startups. These startups will contribute to the local economy of Stovner.

Tea shop

This shop sells locally grown tea and fruits that are produced on the roofscape.

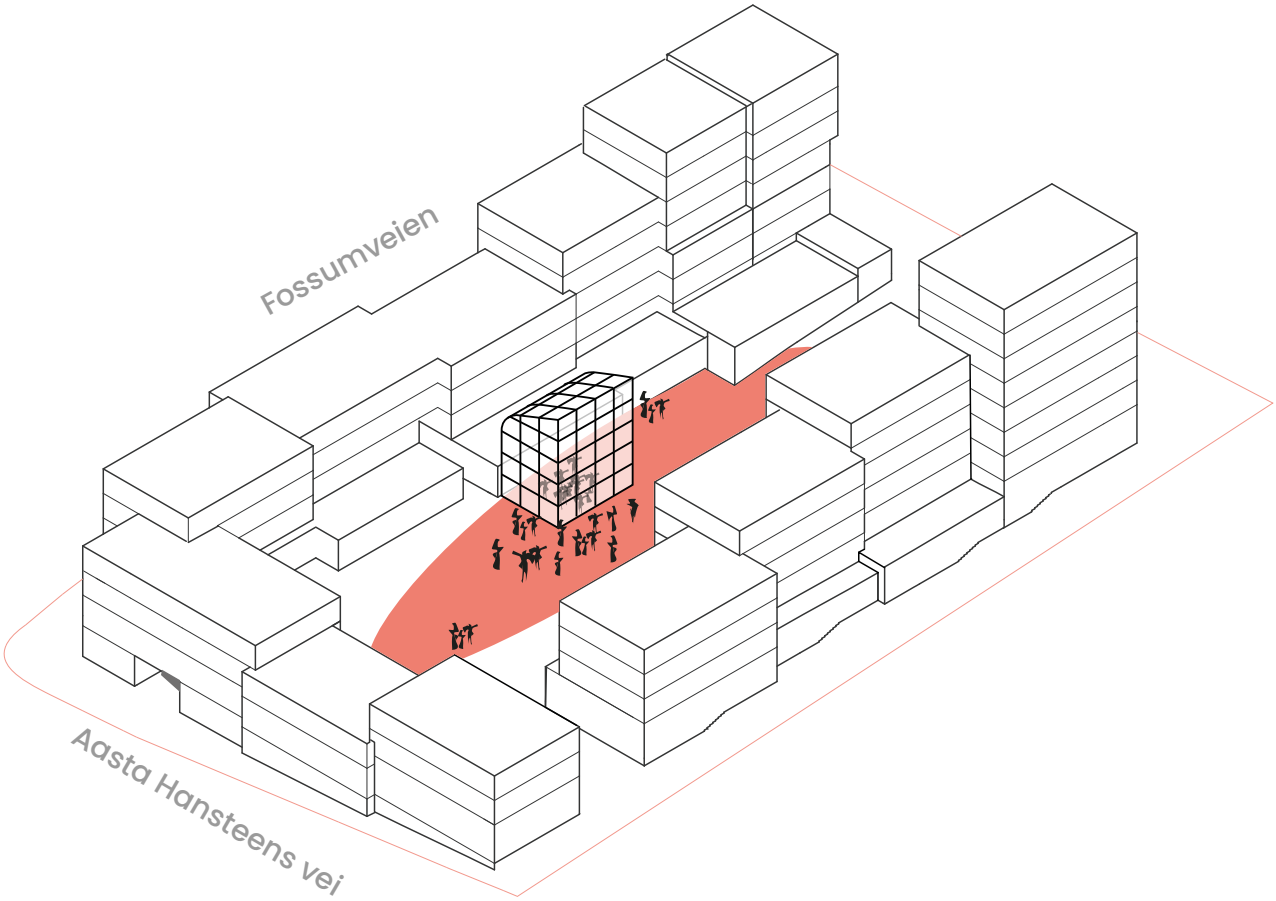


Figure: Mad Arkitekter (2019). Vibrant courtyard. Adapted by the author.

Waste food cafe / Community Center

The community center is the meeting place for residents where they can organize an event, hold gatherings, or do their own thing, such as reading, writing, and studying. This meeting place is also accessible for visitors and locals, who are able to facilitate lectures, exhibitions and co-working.

Club

The club is a place where residents can game or hang out together.

Mobility hub

The mobility hub is placed alongside the pedestrian zone, where people can hire bicycles, electric bicycles, electric scooters, and electric cars. This process of hiring is organized through an online app, accessible for all residents.

Bicycle workshop

This shop is for residents and people from outside that want to reuse, and repair bikes for residents and neighbors. This space, therefore, is also an opportunity for people to work that enhances the local economy.

Waste food production

In the basement of the building, there is waste food production. This is a kitchen where food is made with waste food from local suppliers. Some of the food is also locally produced on the roof. The kitchen also has the possibility to create meals for the elderly in the community.

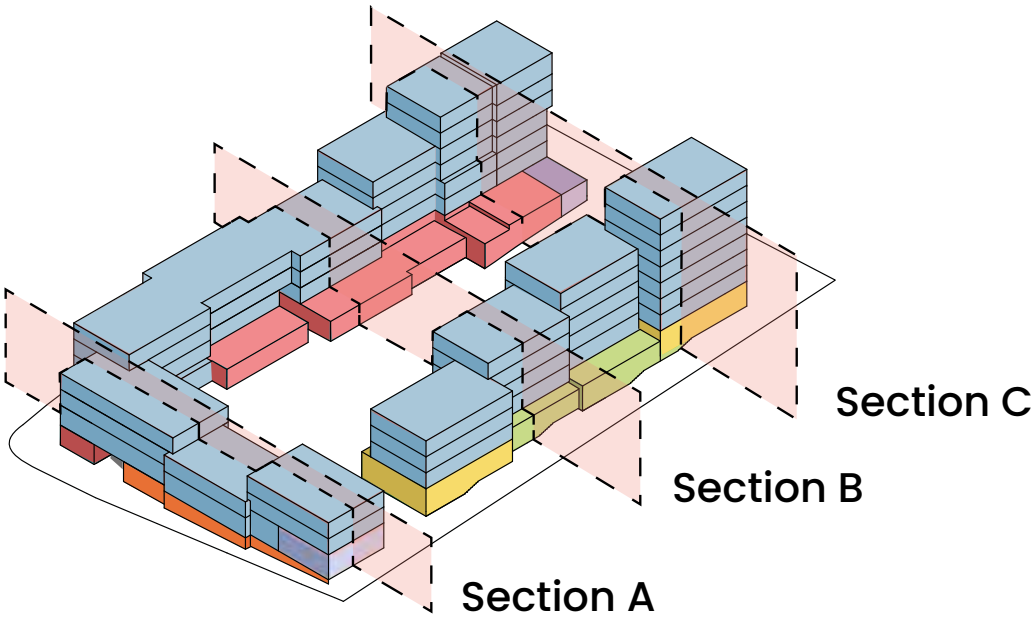
In the images below, several sections are shown. Most of the commercial functions are placed on the ground flour and all the residential units are placed on the floors above. By doing so, the ground floor is activated and fully accessible for visitors and residents.

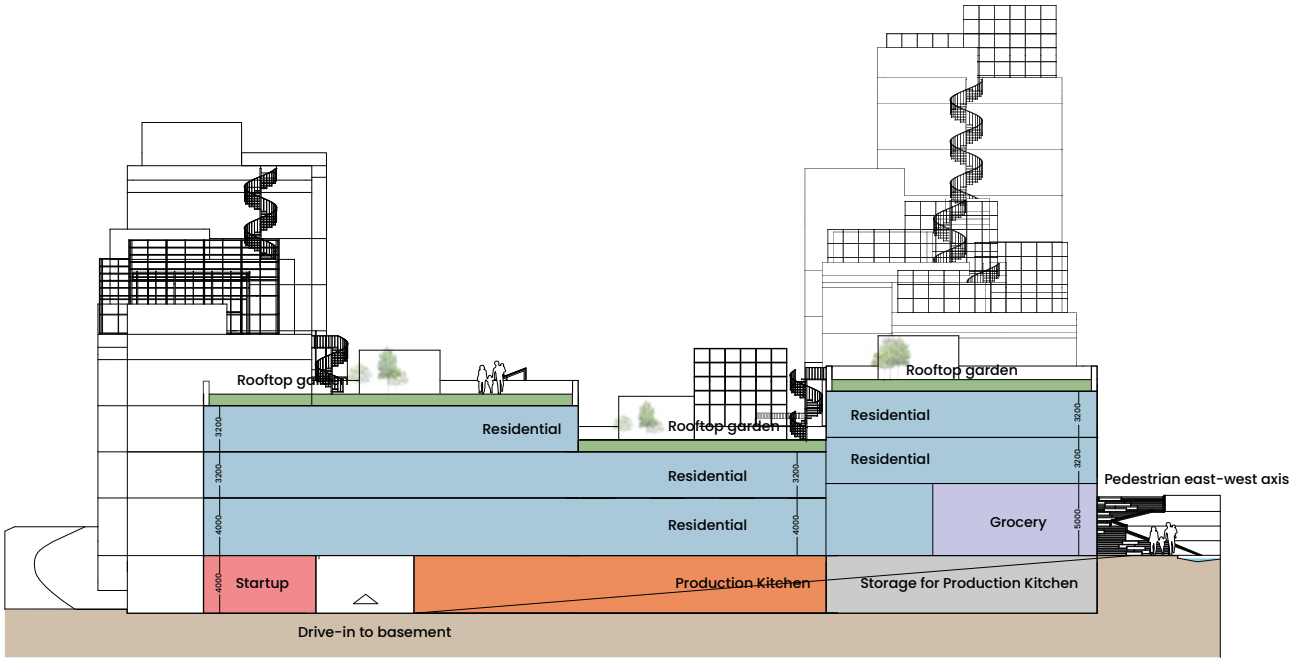
Figure (top left): Mad Arkitekter (2019). Functional diagram. Adapted by the author

Figure (bottom left): Mad Arkitekter (2019). Section A. Adapted by the author

Figure (top right): Mad Arkitekter (2019). Section B. Adapted by the author

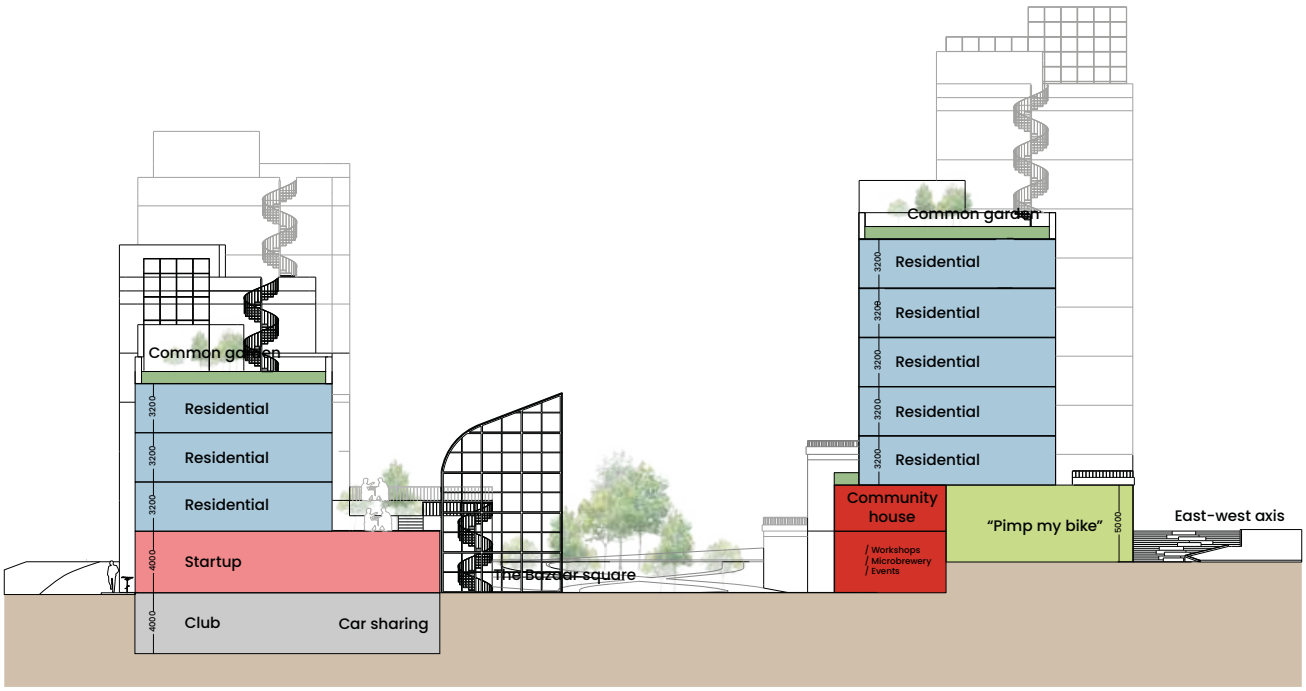
Figure (bottom right): Mad Arkitekter (2019). Section c. Adapted by the author

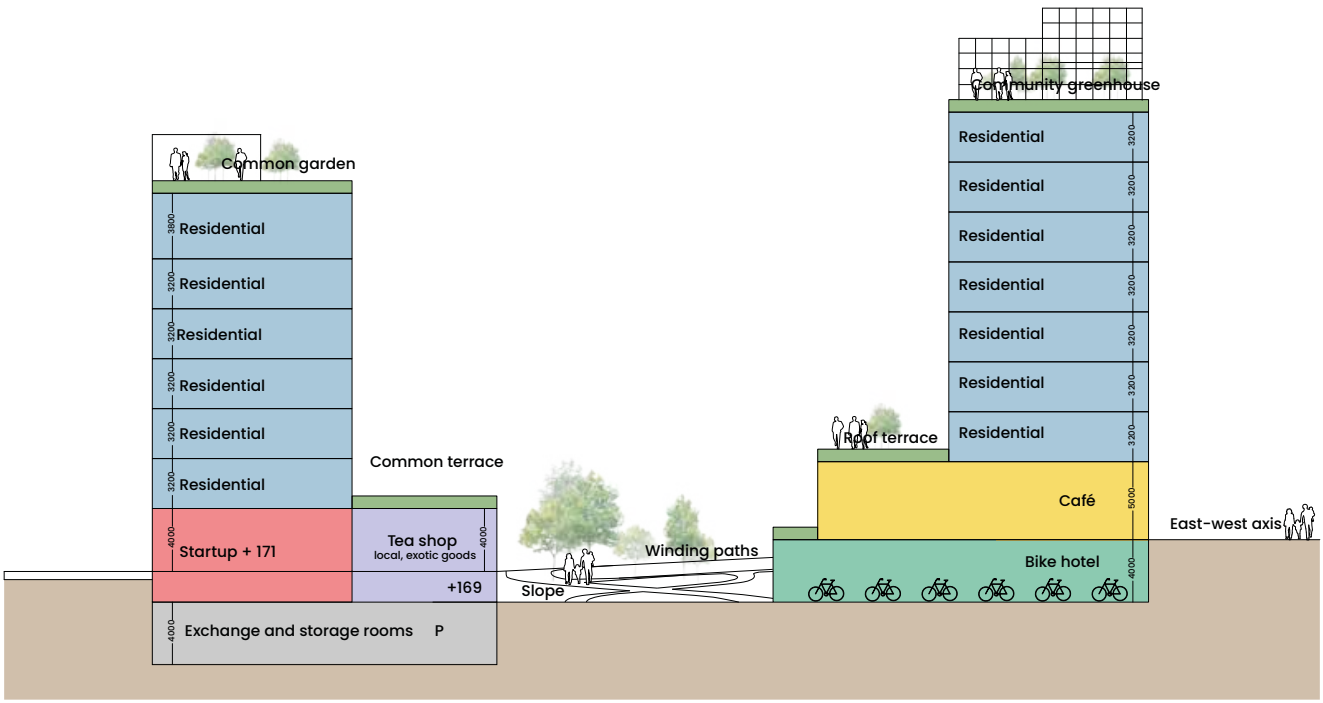




Legend:

- Residential
- Community House
- Grocery
- Café
- Bike Workshop
- Bike Hotel
- Startup & Commercial
- Production Kitchen
- Cellar





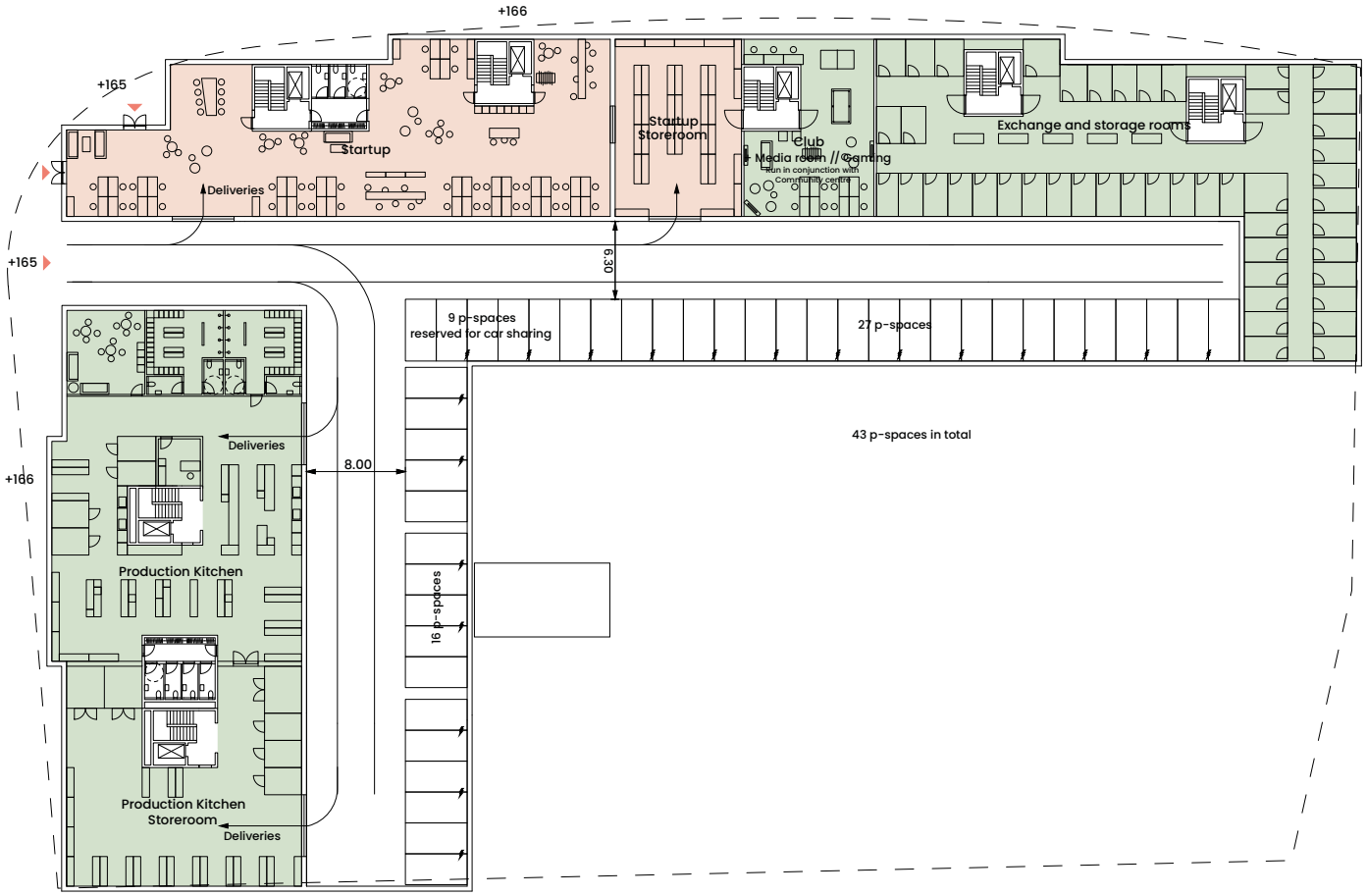
Basement

The basement of the building concerns startup space, exchange and storage room for the residents and a big production kitchen. Besides, residents can park their electric cars and bikes.

Figure: Illustration based on the architectural drawings of Mad Arkiteker. Ground Floor.

Legend:

- Entrance
- Bike Store and Storage
- Community Spaces
- Housing
- Commercial Spaces



Scale 1:600 (A4, Portrait)

0m 6m 12m 24m

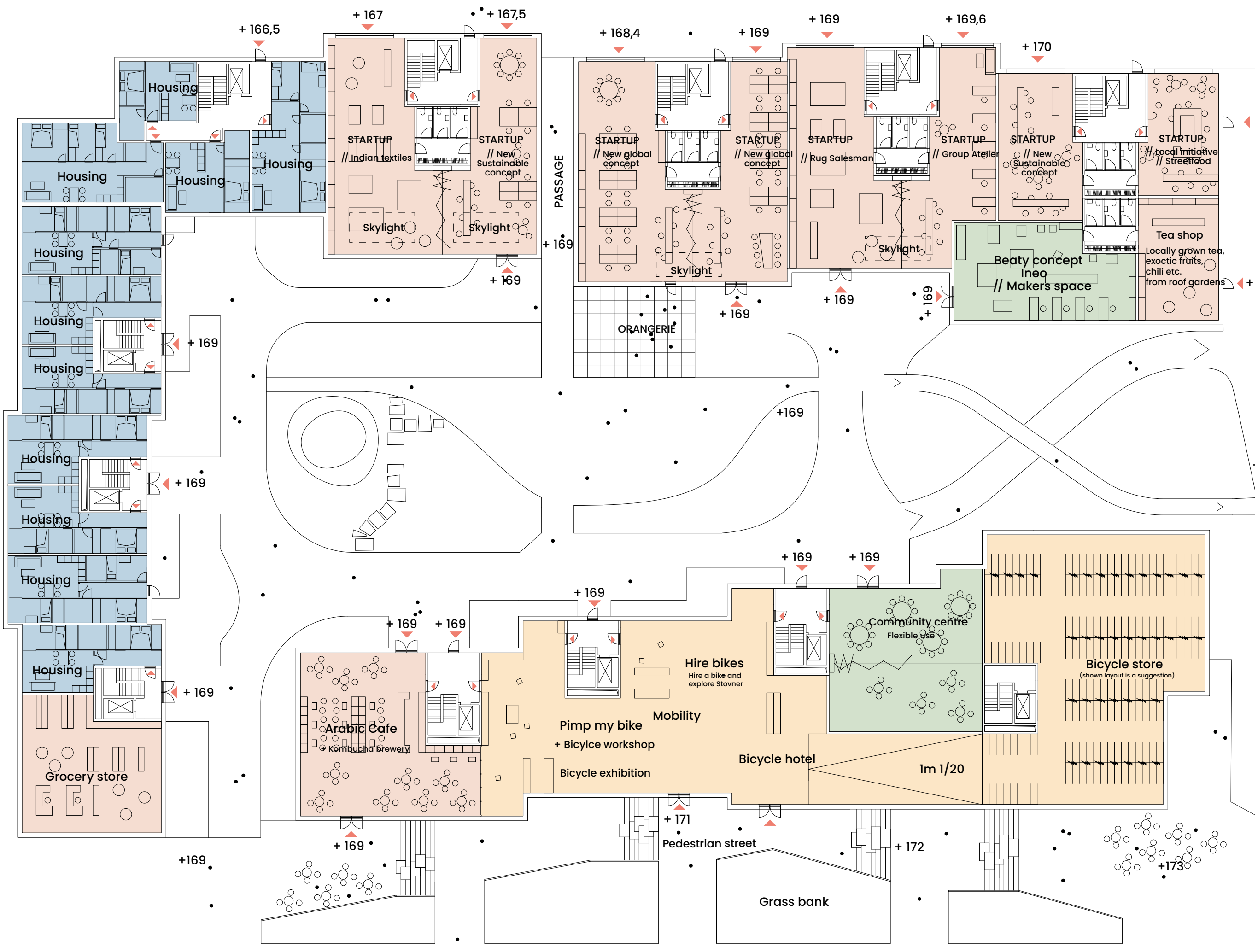
Ground Floor

On the ground floor, there is a mix of communal, commercial and housing spaces.

Figure: Illustration based on the architectural drawings of Mad Arkiteker. Ground Floor.

Legend:

- Entrance
- Bike Store and Storage
- Community Spaces
- Housing
- Commercial Spaces



Scale 1:600 (A4, Portrait)

0m 6m 12m 24m

First Floor

The first floor mainly consists of housing. In the bottom right of the building, the southern sight, a community centre is placed, as well as a place to have a drink with the neighbors.

Figure: Illustration based on the architectural drawings of Mad Arkiteker. First floor.

Legend:

- Entrance
- Bike Store and Storage
- Community Spaces
- Housing
- Commercial Spaces

Scale 1:600 (A4, Portrait)

0m 6m 12m 24m

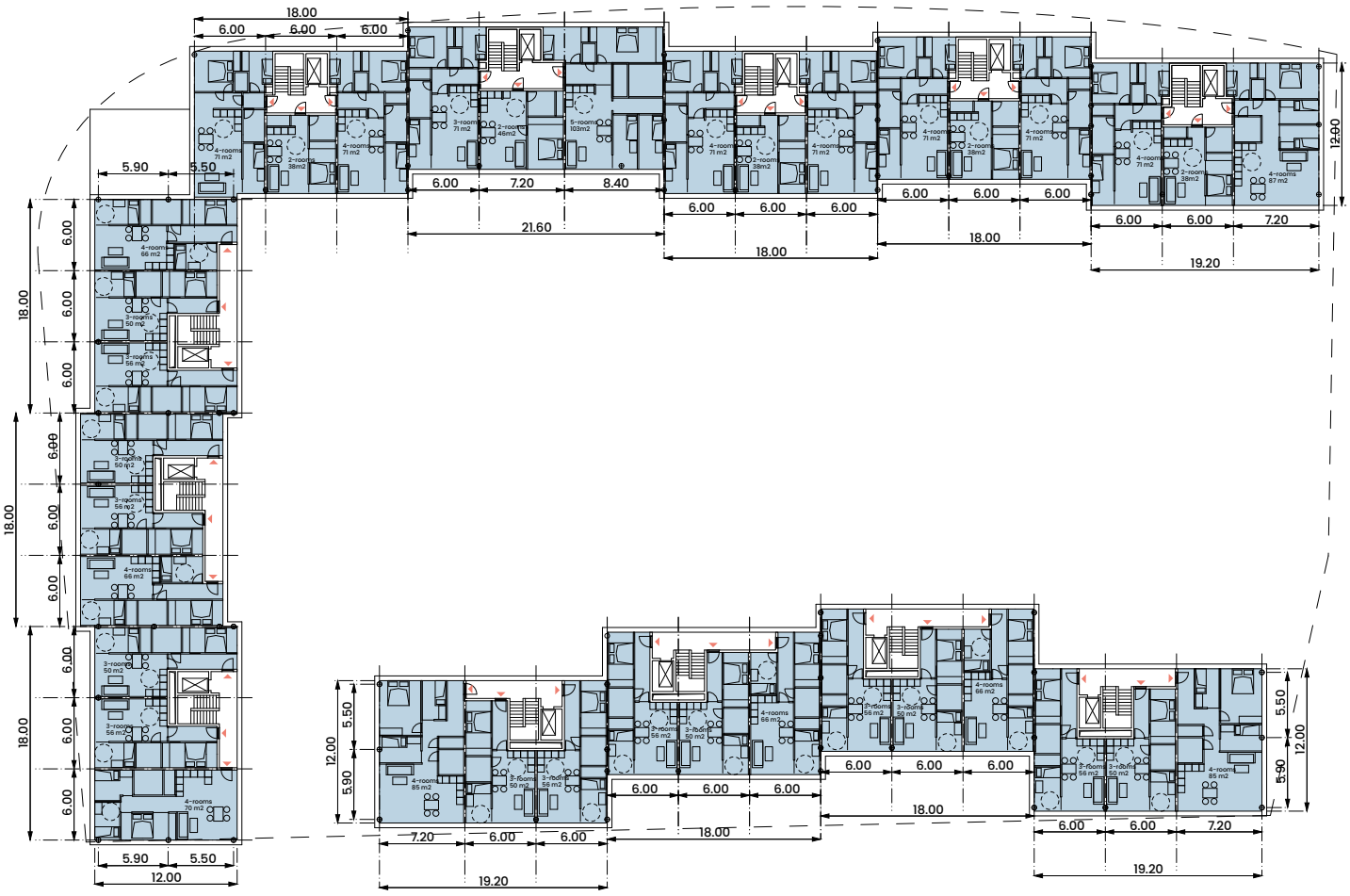
Upper Floors

The other upper floors consists of housing. These apartments are shown in more detail on the next pages.

Figure: Illustration based on the architectural drawings of Mad Arkiteker. Upper levels.

Legend:

- Entrance
- Bike Store and Storage
- Community Spaces
- Housing
- Commercial Spaces



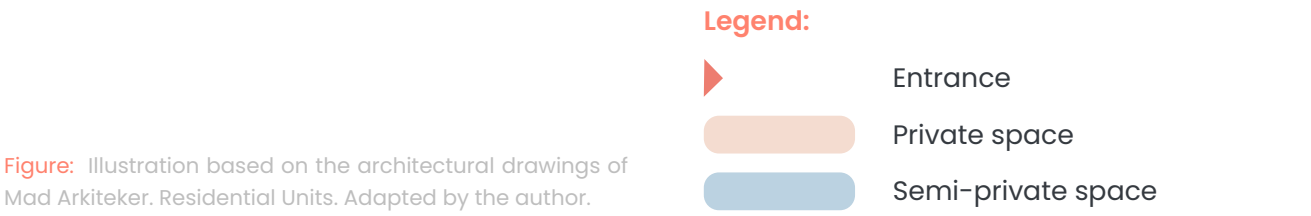
Scale 1:600 (A4, Portrait)

0m 6m 12m 24m

Floor plans residential units

All floorplans are developed within a grid to make future redevelopment of the building as easily as possible. The apartments are designed with a big living room on the end. The more private rooms are based around the living room. In order to stimulate interaction between the residents, the apartments in the south block therefore have a external corridor towards the courtyard. Since it was not allowed to have a corridor facing the public street, the corridor on the northern blocks are placed in the middle of the building.

Figure: Illustration based on the architectural drawings of Mad Arkiteker. Residential Units. Adapted by the author.



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

Legend:

Entrance

Private space

Semi-private space

Figure: Illustration based on the architectural drawings of Mad Arkiteker. Residential Units. Adapted by the author.

Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

Invite (Encourage)

This section describes how the designed environment can invite, or encourage, the adoption of pro-environmental behavior through behavioral nudges, small aspects in the environment that cue a behavioral response. In general, this is done by looking at the five underlying areas for sustainable household behavior and how the design affects these aspects. With regards to this project, nudges are utilized to focus on two of the five key areas: Waste Management & Recycling, and Transport.

Waste Generation & Recycling

In the basement of the building, there is a kitchen that produces waste food. Here, food is made with waste from local suppliers.

Transport

The project has a strong vision towards green, low carbon mobility and ensures to make alternative methods of transport, such as walking, cycling, or taking the public transport accessible, counter to the use of private cars. The cars are also parked below the courtyard, out of sight (nudge: proximity).

For the use of cars, the project envisions car-sharing pools for electric cars and electric bicycles and scooters. The number of parking spaces is held to a minimum (nudge: availability), which is in alignment with the vision of the municipality. There is a norm of a minimum of 0.4 parking spaces per 100 m2.

For the use of bicycles, bicycle racks are installed to facilitate the parking of all types of bikes (nudge: position). Besides, there is also a place for the placement of bicycles from guests. Besides, there is also the possibility to repair and recharge bikes (nudge: position, salience). The mobility hub is placed alongside the pedestrian zone, where people can hire bicycles, electric bicycles, electric scooters, and electric cars. This process of hiring is organized through an online app, accessible for all residents (convenience and ease).

For pedestrians, the project offers a diverse range of facilities, such as seating, street games, and pathways that encourages walking (nudge: functional design). By opening up certain parts in the courtyard, logical connections are made between the site and public transport (nudge: priming). In the building, monitors are shown with data of the subway and bus departures. This will encourage residents to use green mobility (nudge: prompting).

Figure: Mad Arkitekter (2019). Functional design of stairs to enhance social interaction. Bike storage is placed in a convenient space that stimulates use of bicycles.

5-2 Sundsholmerne: EcoVillage

The project Sundsholmerne, developed by architect C.F. Moller is part of the biggest coastal development plan in Aalborg. This area, which will also be redeveloped by the same architect, is 54 hectares in total and will be a district with many institutions, schools, community centers, shops, fjord, water activities, and a park. The park, called Stigsparken, will form the lungs of the city that are connected to both schools and residential life, such as schoolyards, sports facilities, and more. This area was known for being an industrial site and this redevelopment plan uncovers the former pollution of the area and makes place for new spaces for activities, nature, and life.

The building consists of 63 dwellings that suit the needs of a diverse group of residents, by having units of different sizes. In other words, there will be small homes for single people, and bigger homes for families and single-parent households. The sustainable housing community varies in height and is based on the courtyard typology. The courtyard forms the center of the building with several communal functions, such as greenhouses and a barbecue place. The active floor alongside Bygaden street helps to create a vibrant life on the ground floor. On the roof, there is space for a communal room and another greenhouse where residents can grow their own food.

Across the street, a parking hub will be developed. This car park will be one of the three mobility houses in the neighborhood and are part of the parking strategy of the urban plan. In this mobility hub, residents make use of car-sharing and electric charging in combination with services such as a local recycling station and bicycle workshop.

Furthermore, green rain beds are created around the building, which cleans the dirty water from the street with treatment basins before entering the sewer. The main street ends in a flexible green space and acts as the main traffic connection.

The client of this project is EcoVillage, who is a specialist in creating sustainable housing communities in Denmark.

Architects:
C.F. Møller Architects

Client:
EcoVillage

Realization Phase:
2019-2021

Site and Address:
Aalborg, Denmark

Size:
5.000 m2

Residential Units:
64 units

Figure: C.F. Møller Architects (2019). Urban Masterplan Stigsborg. Adapted by author.

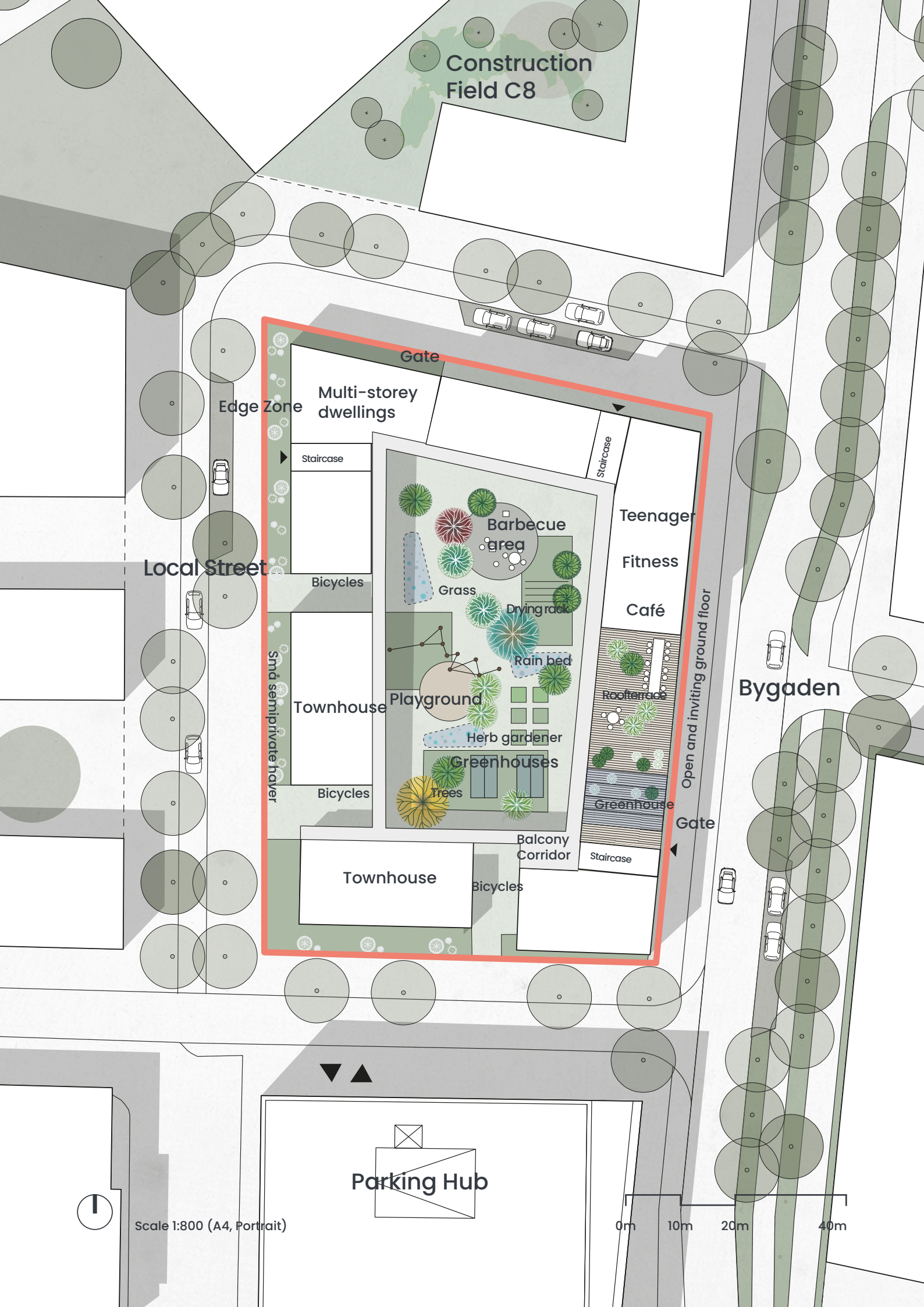

Construction Field C8
Gate
Edge Zone
Multi-storey dwellings
Staircase
Staircase
Local Street
Barbecue area
Teenager
Fitness
Café
Bicycles
Grass
Drying rack
Rain bed
Små semiprivate haver
Townhouse
Playground
Rooftterrace
Open and inviting ground floor
Herb garden
Greenhouses
Trees
Bicycles
Greenhouse
Gate
Balcony Corridor
Staircase
Townhouse
Bicycles
Bygaden
Parking Hub
Scale 1:800 (A4, Portrait)
0m
10m
20m
40m

Figure (top left): C.F. Møller Architects (2019). Visualiation of the gallery and the stairs that are connecting the different floor with each other.

Figure (top right): C.F. Møller Architects (2019). Visualisation of the communal courtyard towards the gallery.

Figure (bottom left): C.F. Møller Architects (2019). Visualisation of the gallery and the shared roof terrace with a greenhouse where residents produce their own organic food.

Priming (Prepare)

This section looks into the domain of priming and tries to answer how the case study prepares occupants for participation in sustainability and adoption of pro-environmental behavior? How is sustainable ethos communicated within the design? How does the environment encourage social support and design for attention restoration? We start by exploring the communication of a sustainable ethos.

Communicating a Sustainable Ethos

The building increases awareness by taking direct actions towards sustainability. Their concept integrates the three pillars of sustainability, which is communicated through architecture. Below, some of the pillars are shortly described to understand how the building prepares occupants for participation in a sustainable environment.

Environmental Pillar

The building will become DGNB Gold certified, by receiving points for every sustainable choice the architect makes, such as recycling of materials, choice of materials, indoor climate, and energy supply.

The interior of the building is fully flexible with lightweight inner walls, which gives the resident the possibility to change the interior to their needs and wishes (an example for providing behavioral control: permit). Furthermore, the heat source of the building will be district heating which is in the long term environmentally friendly. Next, water-saving fittings are installed in the kitchen and bathrooms, and the rainwater is being recycled for the laundry room and flushing the toilets. Furthermore, the courtyard includes vegetations, trees and plants that enhance biodiversity. These sustainable implementations increases the occupant's knowledge thant elicit pro-environmental behavior.

Figure: Mad Arkitekter (2019). Green courtyard in which the environment can thrive.

Economic Pillar

The heating and electricity costs are reduced for the residents, by creating compact modules that are provided with only the essential facilities. All the others functions a resident does not need on a daily basis are places in the communal areas, such as guestrooms, workspaces, teenager spaces, party spaces, and more. By making these units smaller and more compact, it needs less heating, lighting, cleaning, and maintenance which results in a reduction of costs. Living not only in an affordable house, but also in a sustainable environment positively affect how people are experiencing the setting. This has a direct impact on the attitude and intention of individuals that are living there.

Social Pillar

Community and diversity are the main focus of this project. The courtyard helps to enhance social interaction between the residents. On the ground floor, several communal functions are placed, such as a guest room, workshop, fitness room, shared office space, and a shared kitchen and dining area. Here, the communal meals are made between Monday and Thursday with organic food that suits vegans, vegetarians, people with allergies, and people that eat meat. Each resident receives a meal plan for every three weeks. On the top floor of the building, there is another large communal area, such as a media room, cafe, greenhouse, and kitchen garden.

Figure: Mad Arkitekter (2019). Communal roof terrace, where people can come together.

Attention Restoration

The sustainable project creates a supportive environment for people in which mental restoration and mental clarity is achieved through the implementation of nature. The courtyard provides a green space for occupants to take a moment to relax. For children, there is a playground in which they are in direct contact with nature. Furthermore, the greenhouse produces food for the whole community. Vegetation is also grown on the roof and the gallery of the building. By doing so, the occupants are in direct contact with nature and have the ability to create mental clarity, which plays a role in eliciting pro-environmental behavior. The image below and show the different functions that are implemented in the courtyard.

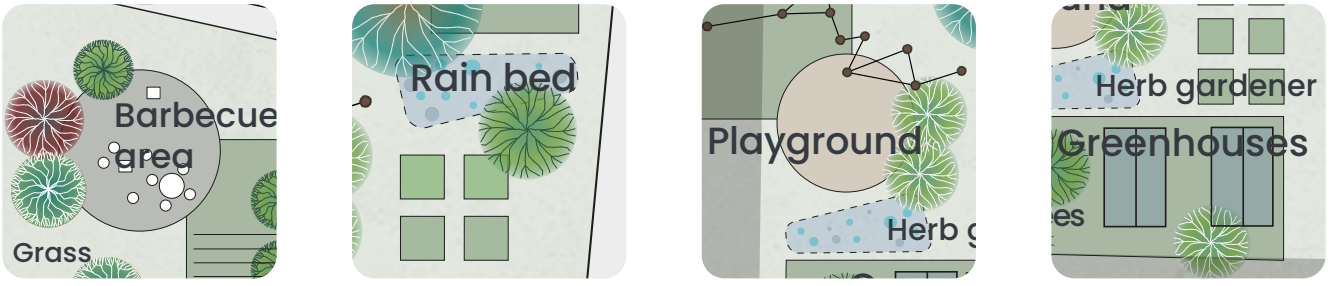


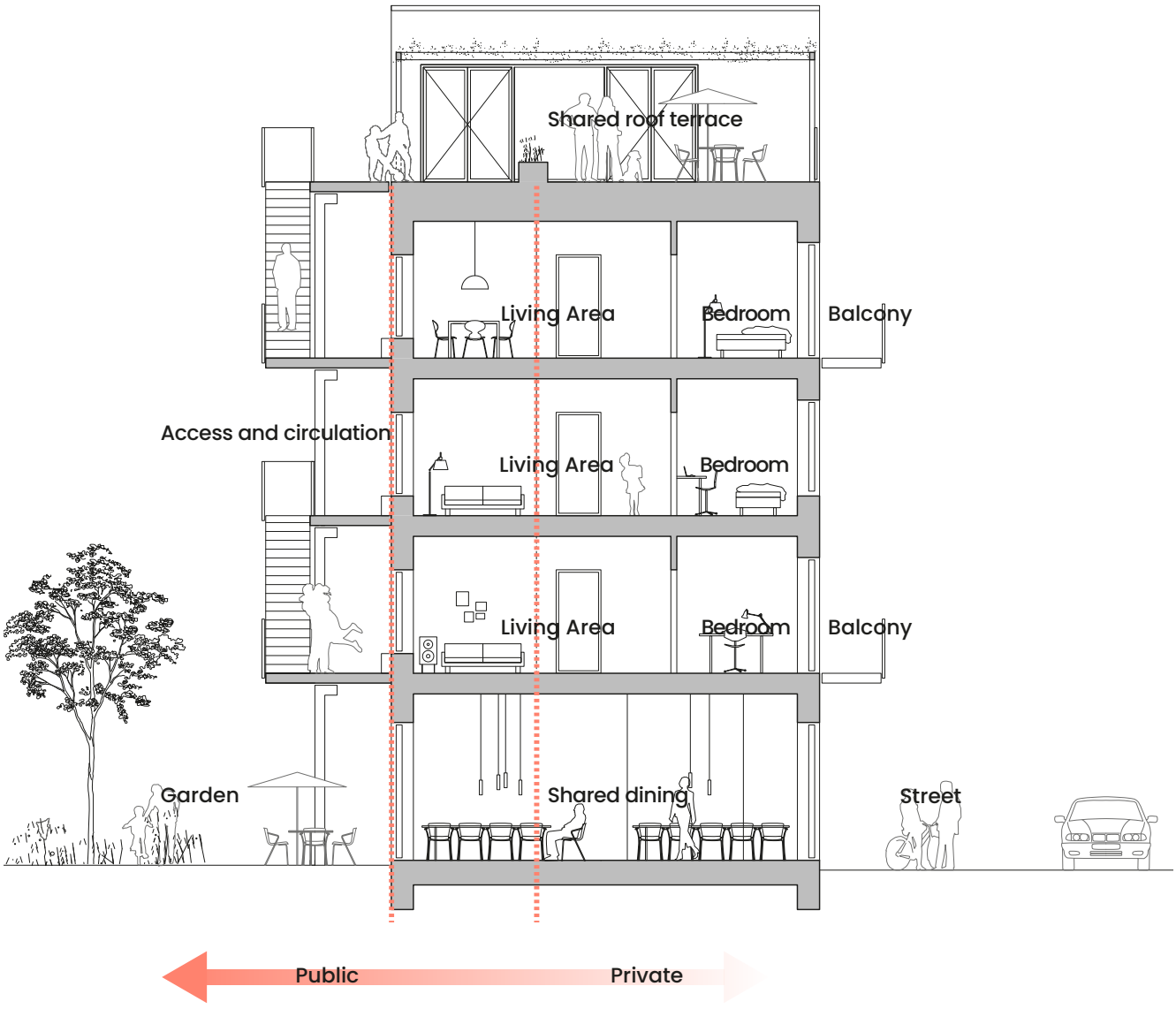
Figure: C.F. Møller Architects (2019). Functions in the courtyard that connects people to the natural environment.

Social Support

This project aims to establish social cohesion and a strong sense of identity and belonging. By doing so, it will lead to the development of pro-environmental behavior. As is said before, the

courtyard brings the occupants together. The implementation of communal functions also increases the feeling of beloning (e.g. guest room, workshop room, fitness room, shared office space, and a shared kitchen and dining area). The top floor also provides a shared area for people, such as a media room, cafe, greenhouse and kitchen garden.

Social cohesion is also created through the spatial configuration of the building. For every apartment, the living room and/or kitchen is faced towards the center of the building. This enables visual connectiong with neighbors and a feeling of safety. Besides, In order to create more social interaction between the residents, a wide gallery connects the building on a horizontal level. This gallery serves as an addition to the open areas provided for all the dwellings and forms the link between the public courtyard and the private area of each residential unit. The private spaces such as a bedroom and a bathroom are facing the street, while the more public spaces, such as the kitchen and living room are facing the courtyard. By doing so, social interaction between the residents is stimulated. See the image below and the image on the next page for an illustration. The following pages focus on the spatial configuration of the floor plans of the building and residential units.



Scale 1:300 (A4, Portrait)

0m 3m 6m 12m

To conclude, throughout the settlement, emphasis has been placed on:

- The social community
- Flexibility in the decor
- Possibility of translucent rooms
- Graduation of privacy
- The balcony entrance as an extension of the living space
- Shortcut stairs between the floors
- Common penthouse floor with roof terrace
- Ground floor with communal dining

Figure (left page): Illustration based on drawings of C.F. Møller Architects. Transition zone private to public space. Adapted by author.

Figure (below): C.F. Møller Architects (2019). Visualiation of the gallery and the stairs that are connecting the different floor with each other.

Floor Plans

In this paragraph, the floorplans of the building and the residential units are analyzed. This section is part of the first pillar of sustainability: social sustainability.

Ground Floor

The groundfloor consists of several housing units and a large community area alongside the main street. There are three circulation cores that connect with the upper floors. A large communal courtyard in the middle of the building brings the residents together.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Ground Floor.

Legend:

- Entrance
- Community Spaces
- Housing

Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

First Floor

Next to the circulation core on the east side of the building, a guest room is placed. Furthermore, the second floor consists mainly of residential units.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. First Floor.

Legend:

- Entrance
- Community Spaces
- Housing

Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

Second Floor

The second floor of the building mainly consists of residential units. In terms of circulation, all units are facing the courtyard. By doing so, the architect wants to encourage social interaction.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Second Floor.

Legend:

- Entrance
- Community Spaces
- Housing

Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

Third Floor.
The third floor has residential units on the east side of the building and is a repetition from the second floor. There are no apartments on the west side of the building on the third floor because of the sunlight that can now enter the courtyard.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Third Floor.

Legend:

- Entrance
- Community Spaces
- Housing

Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

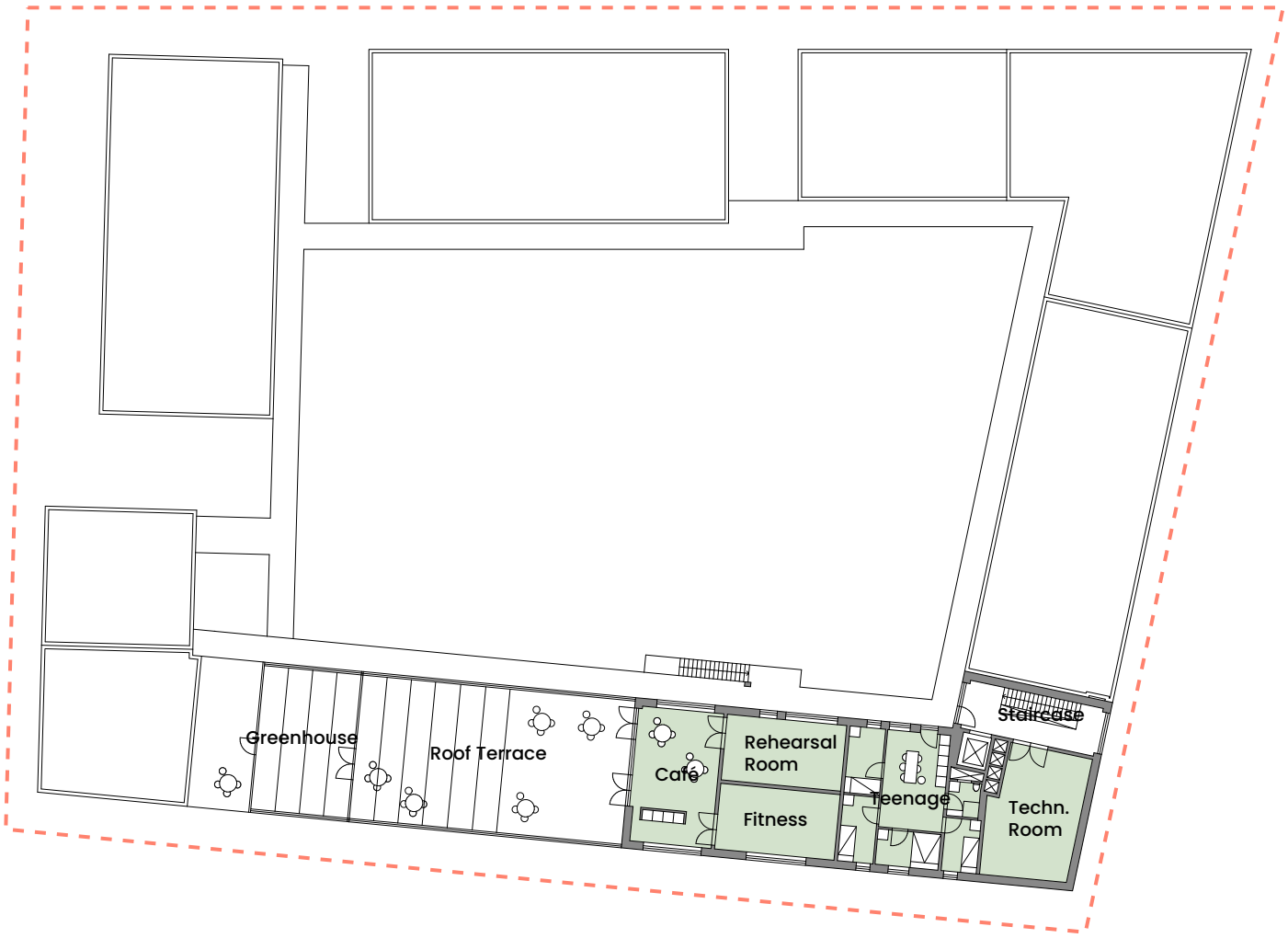
Fourth Floor

The top floor is fully communal and consists of a rehearsal room, cafe, fitness room, teenage room, technical room, a greenhouse where residents can grow their own food and a large roof terrace where residents are able to enjoy the sun.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Fourth floor.

Legend:

- Entrance
- Community Spaces
- Housing



Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

Residential Unit - Type A

The floorplan on the bottom left of this page shows unit A, which is a single-person household. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

Residential Unit - Type B

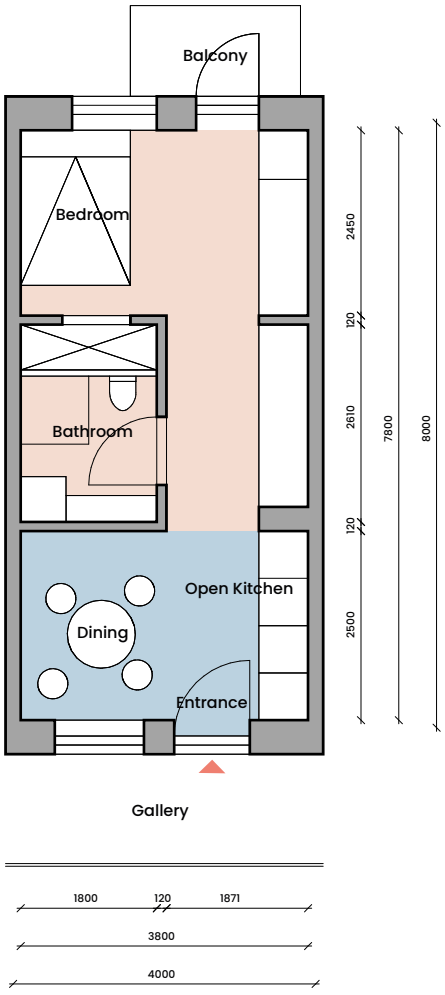
The floorplan on the bottom right of this page shows unit B, which is a single-parent household. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

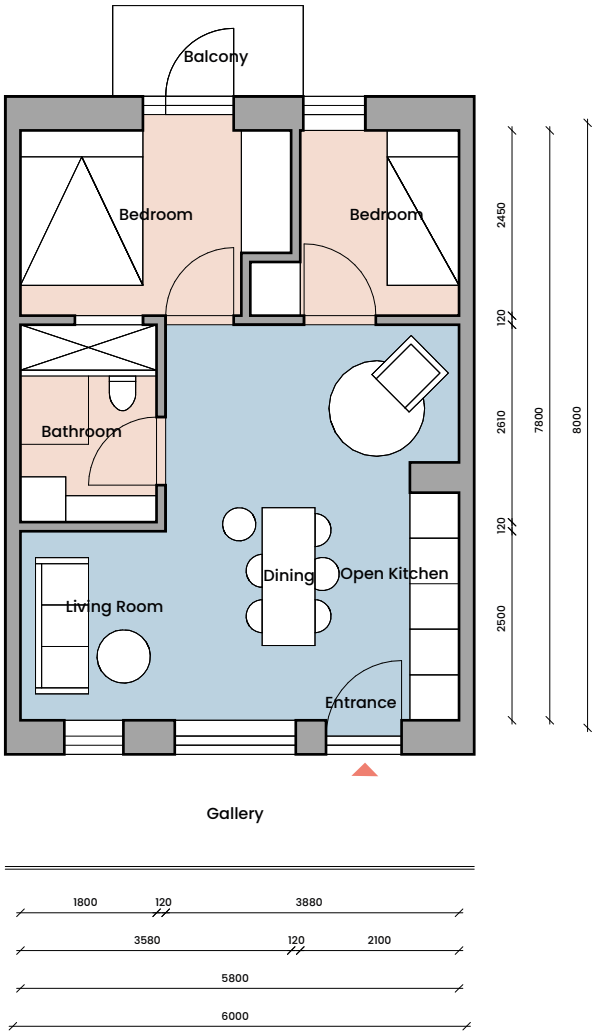
Figure (bottom left): Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type A. Adapted by the author.

Figure (bottom right): Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type B. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space





Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

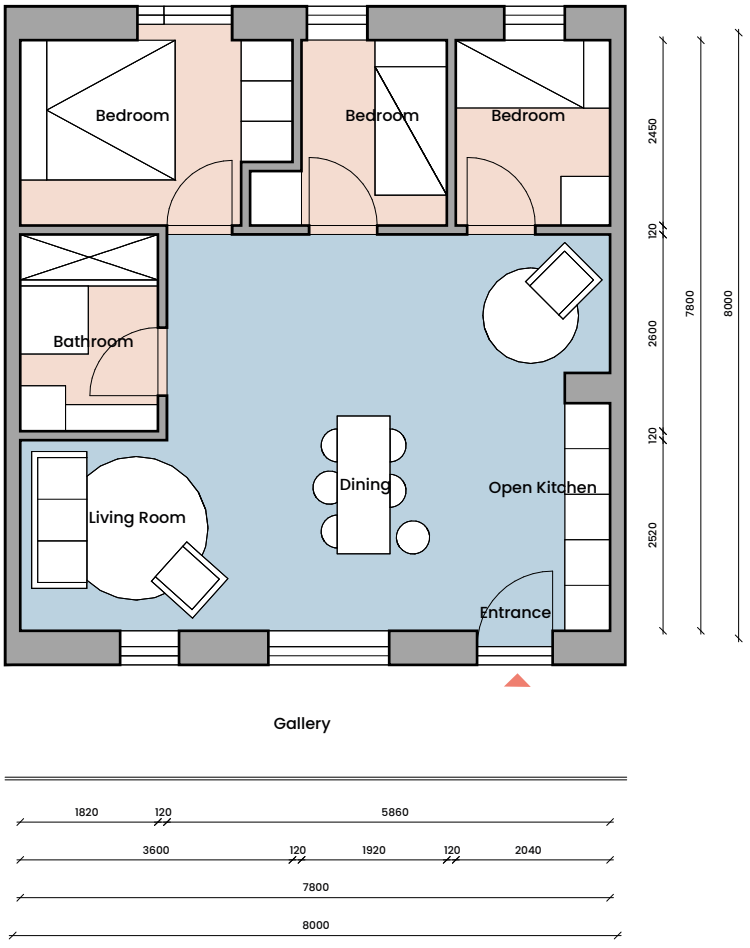
Residential Unit - Type C

The floorplan on the bottom of this page shows unit C, which is a family-sized apartment. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type C. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

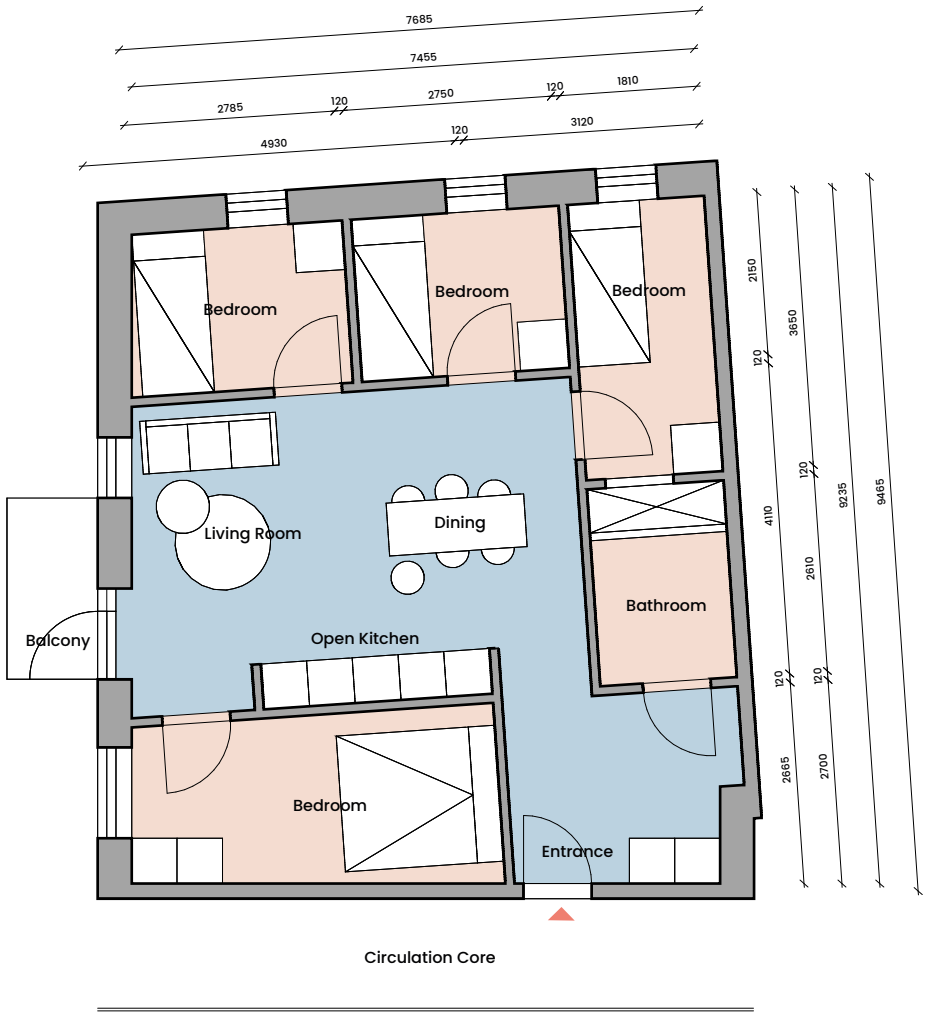
Residential Unit - Type D1

The floorplan on the bottom of this page shows unit D1, which is a family-sized apartment. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type D1. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

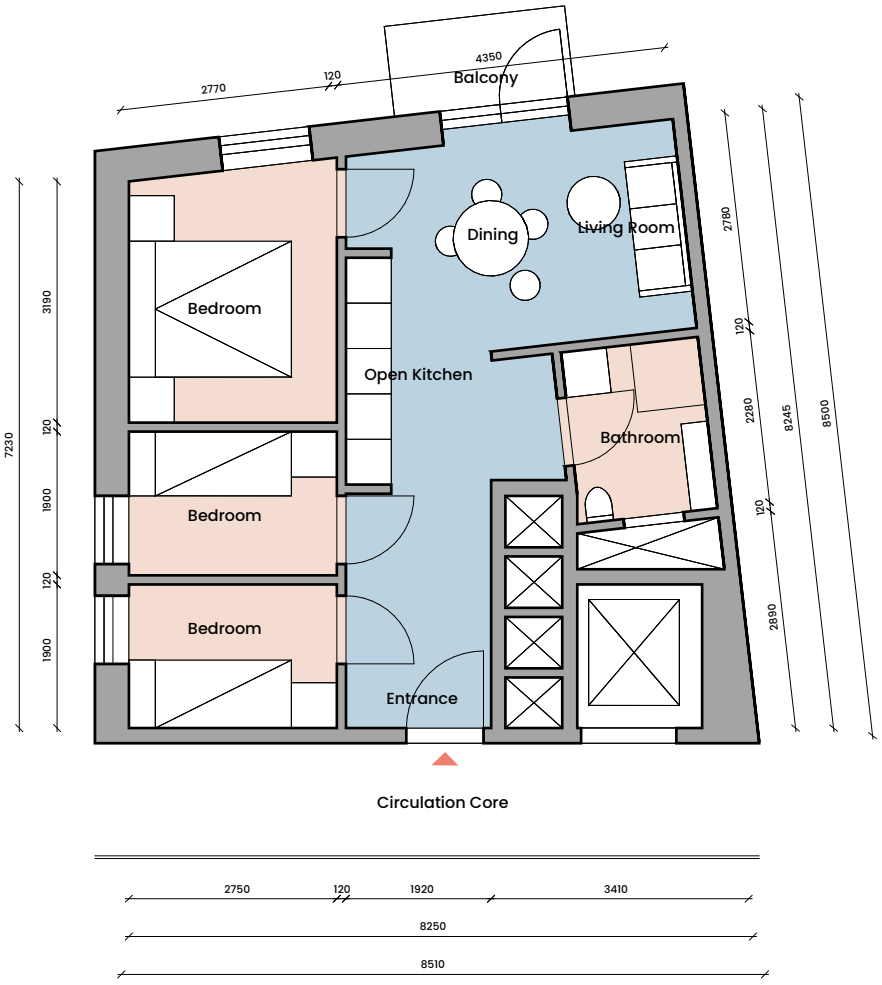
Residential Unit - Type D2

The floorplan on the bottom of this page shows unit D2, which is a family-sized apartment. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type D2. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

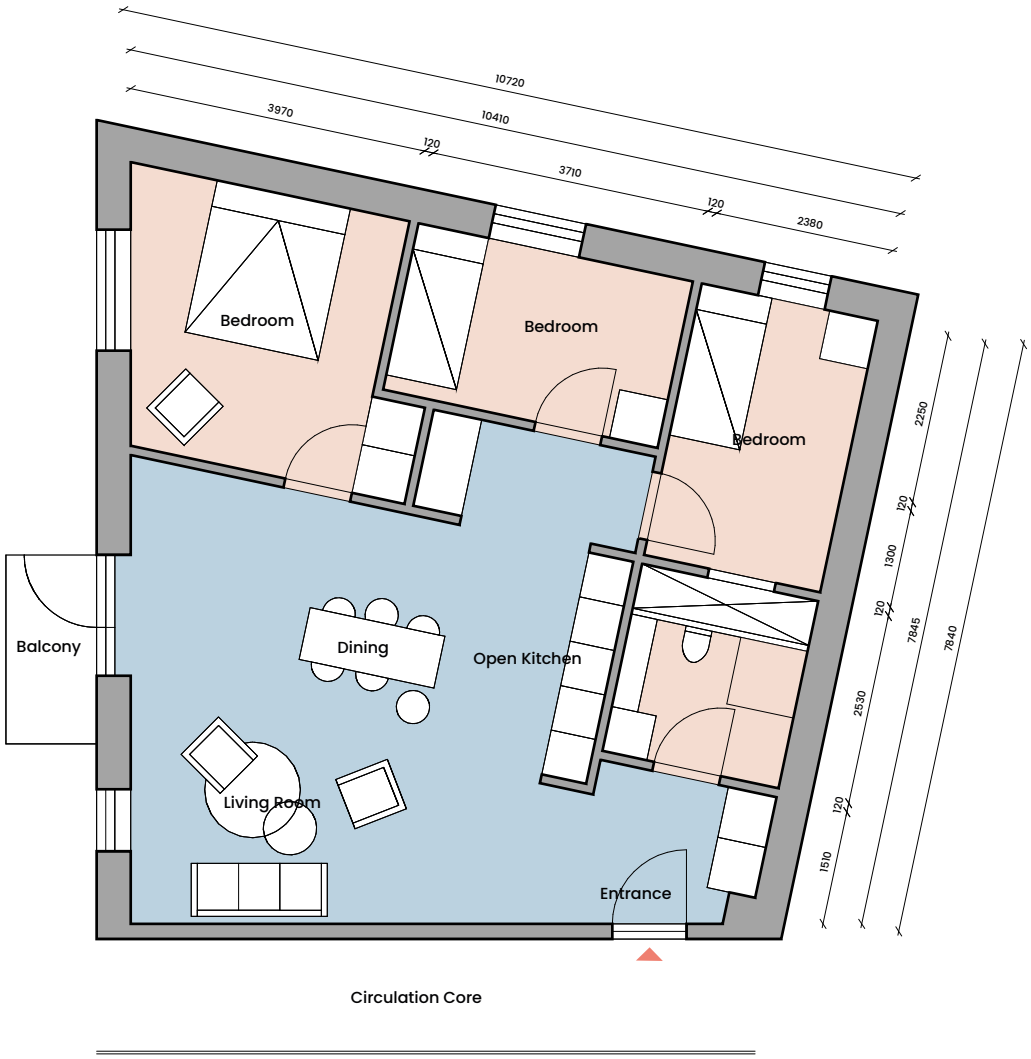
Residential Unit - Type D3

The floorplan on the bottom of this page shows unit D3, which is a family-sized apartment. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type D3. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

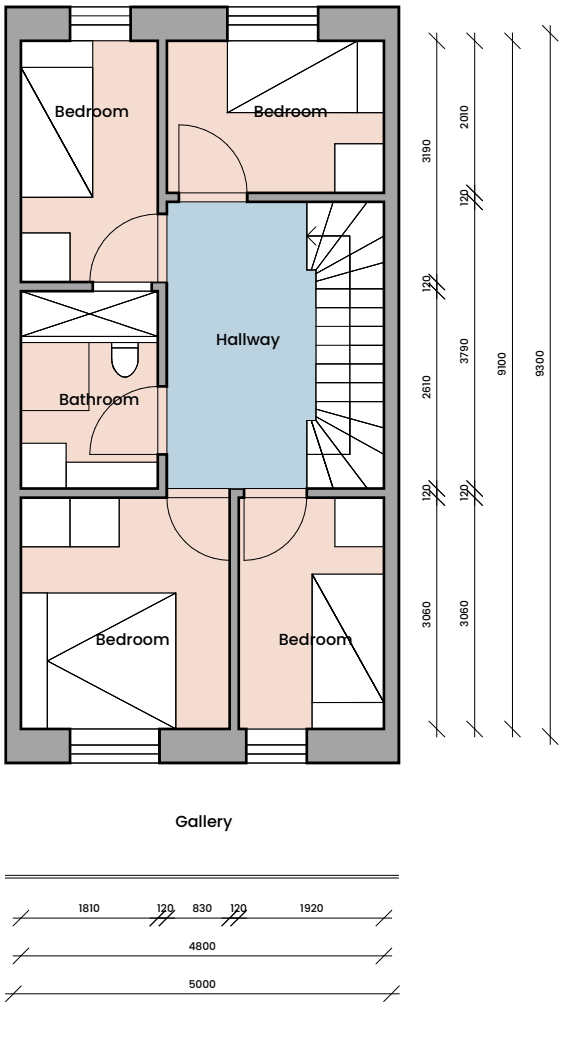
Residential Unit - Type E

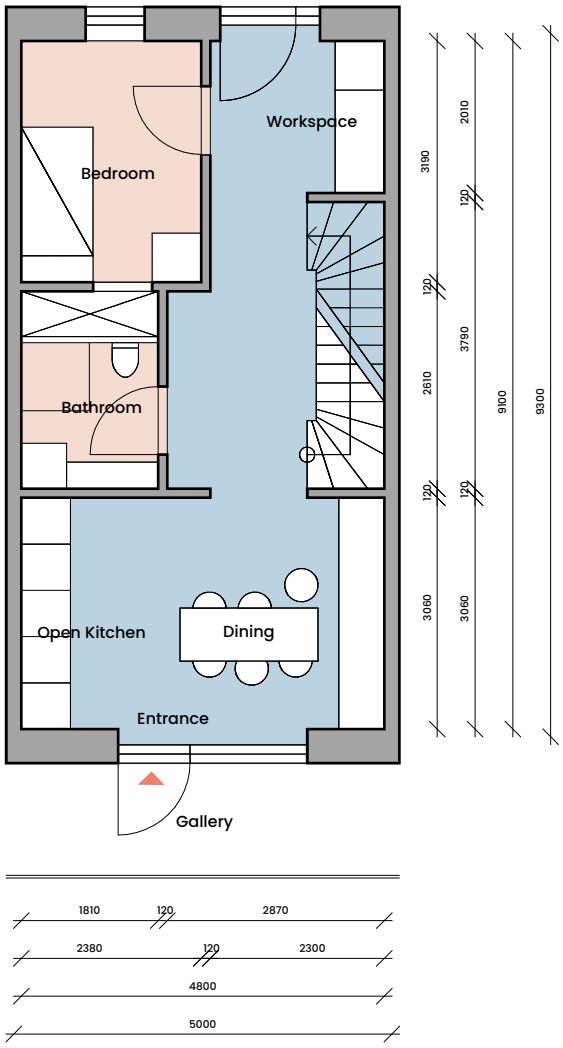
The floorplan on the bottom of this page shows unit E, which is a family-sized apartment. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom. This is an example of a duplex dwelling. The staircase in the middle connects with the floor above, where most of the bedrooms are placed.

Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type E. Adapted by the author.

Legend:

- Entrance
- Private space
- Semi-private space





Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

Residential Unit - Type F

The floorplan on the bottom left of this page shows unit F, which is a bigger single-person household compared to type A. The more public spaces are facing the courtyard and the more private spaces are facing the street, such as the bedroom.

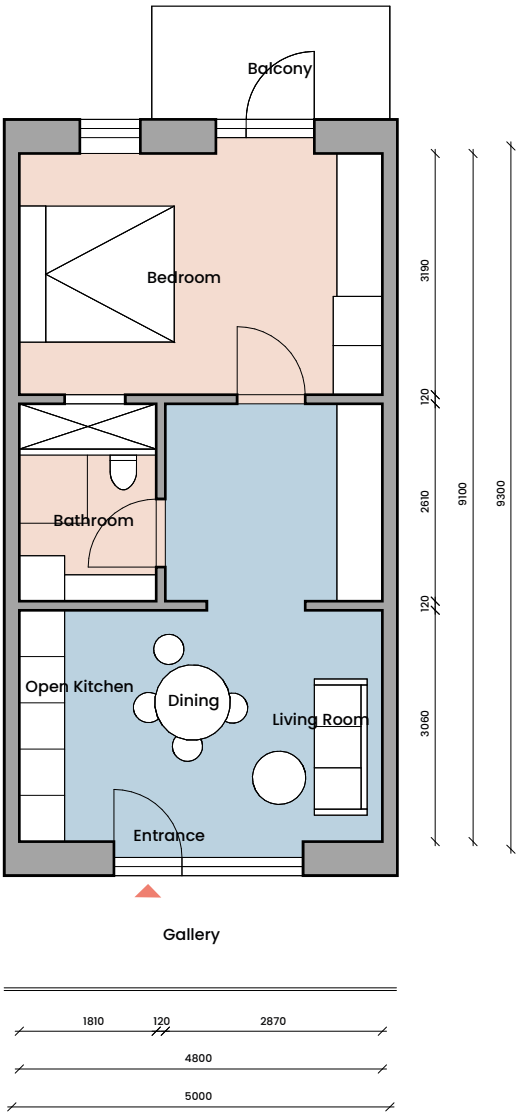
Figure: Illustration based on the architectural drawings of C.F. Møller Architects. Residential Unit Type F. Adapted by the author.

Legend:

Entrance

Private space

Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

Invite (Encourage)

This section describes how the designed environment can invite, or encourage, the adoption of pro-environmental behavior through behavioral nudges, small aspects in the environment that cue a behavioral response. In general, this is done by looking at the five underlying areas for sustainable household behavior and how the design affects these aspects. With regards to this project, nudges are utilized to focus on two of the five key areas: Food Consumption, Transport.

Food Consumption

By placing greenhouses in the courtyard and on the roof, people become familiar with the idea of growing their own organic food (nudge: proximity, availability, priming). By providing occupants every three weeks with meal plans for the whole community (nudge: information, prompting), it enhances social interaction and social cohesion.

Transport

A mobility hub is placed across the street, and only a few parking spots are reserved around the building. By decreasing the amount of parking spots and placing the parking hub further away, it wil be less convenient to use cars (nudge: proximity, availability). Furthermore, spaces for storing bicycles are salient throughout the building. This increases the convenience and makes it easier for residents to take the bike (nudge: proximity, availability).

Figure: Mad Arkitekter (2019). Placement of greenhouses.

5-3 Urban Village Project

The urban village project is developed by Effekt Architects and SPACE10. This visionary project envisions a model for developing sustainable, affordable, and livable homes. Cities all around the world are facing major challenges, such as loneliness, climate change, lack of affordable housing. Buildings and the construction of the built environment account for more than 35% of global energy use and nearly 40% of CO2 emissions. Since the amount of housing stock will be expanded in the coming years, 3 billion people will need to have a new dwelling by 2050. Even though people are living closer and more connected than ever, people feel more lonely and stressed. Effekt architects rethink the built environment and the future of the cities by integrating solutions for sustainability, affordability, and livability.

The project introduces a modular wooden building, a new financial model, cross-generational shared living communities, a digital platform, and integrated solutions, such as local food production, localized composting, and water harvesting.

Architects:
EFFEKT Architects

Client:
SPACE10

Realization Phase:
2018

Site and Address:
Worldwide

Size:
3.744 m2

Residential Units:
36 m^2 up to 144 m^2

Figure: EFFEKT and SPACE10 (n.d.). Urban Village Project.


COFFEE

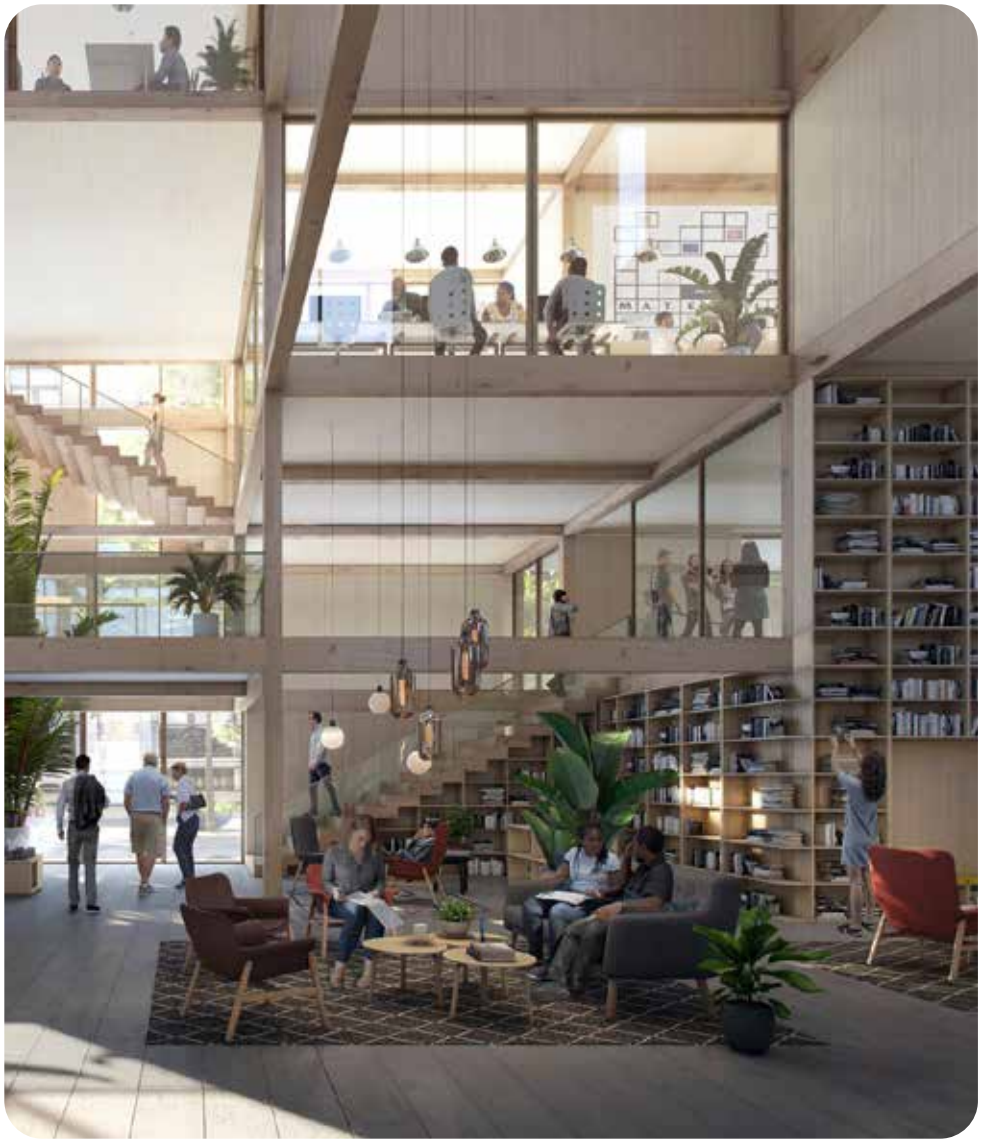


Figure (top left): EFFEKT Architects and SPACE10 (2018). Visualisation of public spaces at the ground floor (event space and library).

Figure (top right): EFFEKT Architects and SPACE10 (2018). Visualisation of the raised courtyard where residents meet each other.

Figure (bottom left): EFFEKT Architects and SPACE10 (2018). Visualisation of the green house where residents buy and produce their own organic food.

Priming (Prepare)

This section looks into the domain of priming and tries to answer how the case study prepares occupants for participation in sustainability and adoption of pro-environmental behavior? How is sustainable ethos communicated within the design? How does the environment encourage social support and design for attention restoration? We start by exploring the communication of a sustainable ethos.

Communicating a Sustainable Ethos

The building increases awareness by taking direct actions towards sustainability. Their concept integrates the three pillars of sustainability, which is communicated through architecture. Below, some of the pillars are shortly described to understand how the building prepares occupants for participation in a sustainable environment.

Environmental Pillar

The main focus of Effekt Architects is the implementation of a wooden modular building system that is designed for disassembly. This modular system is prefabricated and can be quickly assembled on the construction site. This will result in a cleaner way of building and a reduction of gas emissions. The modular system consists of all kinds of elements, from facade elements to the interior, that are reusable.

Furthermore, the Urban Village project stimulate sustainable living with integrated solutions. There is water harvesting, renewable energy, local food production, and localised composting. This project will be build entirely from cross-laminated timber because of its environmental advantages. Integrating these solutions will increase the occupant's knowledge about sustainable systems.

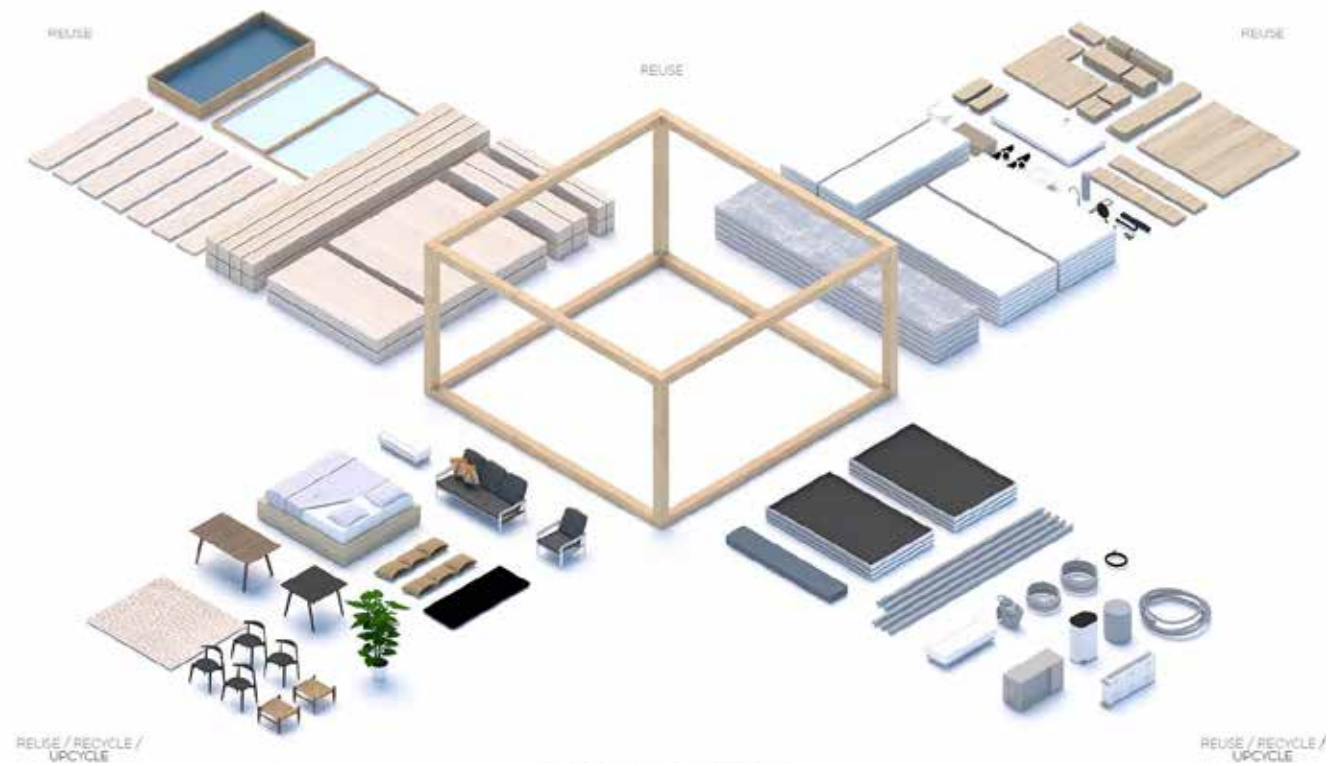


Figure: Effekt Architects (2018). A modular home.

Economic Pillar

Effekt Architects wants to implement a new financial model that will lower the threshold for starters. This will ensure affordable housing for users of all income classes. They introduce the home as a service model, which offers the developer regular recurring sales and greater predictability of revenue streams on a long-term basis. This will reduce the risk and investors can focus more on building a more diversified investment portfoliio. In this financial model, the user can subscribe to their new home, thus eliminating the need for expensive down payments. Furthermore, the residents are able to turn their subscription payments into equity stock. Consequently, affordable housing can be achieved.

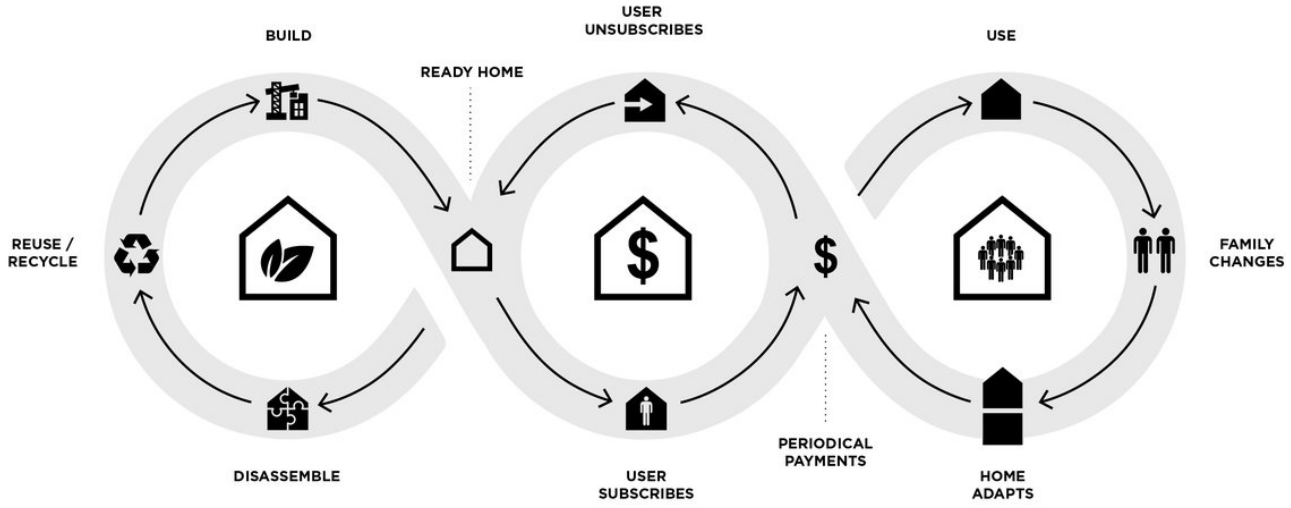


Figure: Effekt Architects (2018) A new financial model.

Social Pillar

This project encourages social interaction and cross-generational living by implementing a flexible floor layout and providing a variety of different public and private services. The implementation will be discussed under the section Social Support.

Attention Restoration

The sustainable project creates a supportive environment for people in which mental restoration and mental clarity is achieved through the implementation of nature. The project provides many natural spaces to engage with nature, such as playscape for children, a winter garden, an allotment garden, sensory garden, waterscape, recreational space, food forest and multiple green roofs. These features enables occupants to be in direct contact with nature which has the strength to create mental clarity. The images below and on the next page show the different functions that are implemented in the building.

Figure: Mad Arkitekter (2019). Inmplementation of natural elements in the environment. These elements increases emotional affinity towards nature and increase attententional restoration.

Figure: Mad Arkitekter (2019). Inmplementation of natural elements in the environment. These elements increases emotional affinity towards nature and increase attententional restoration.

Social Support

This project enhances social cohesion by providing living for a diverse group of households. The modular building system is very flexible and provides enough space for single-persons, extended family, single parents, divorced living, family, co-living, work-living, couple and multi-generational living, see the image of the right page. These floorplans are mapped on the next pages.

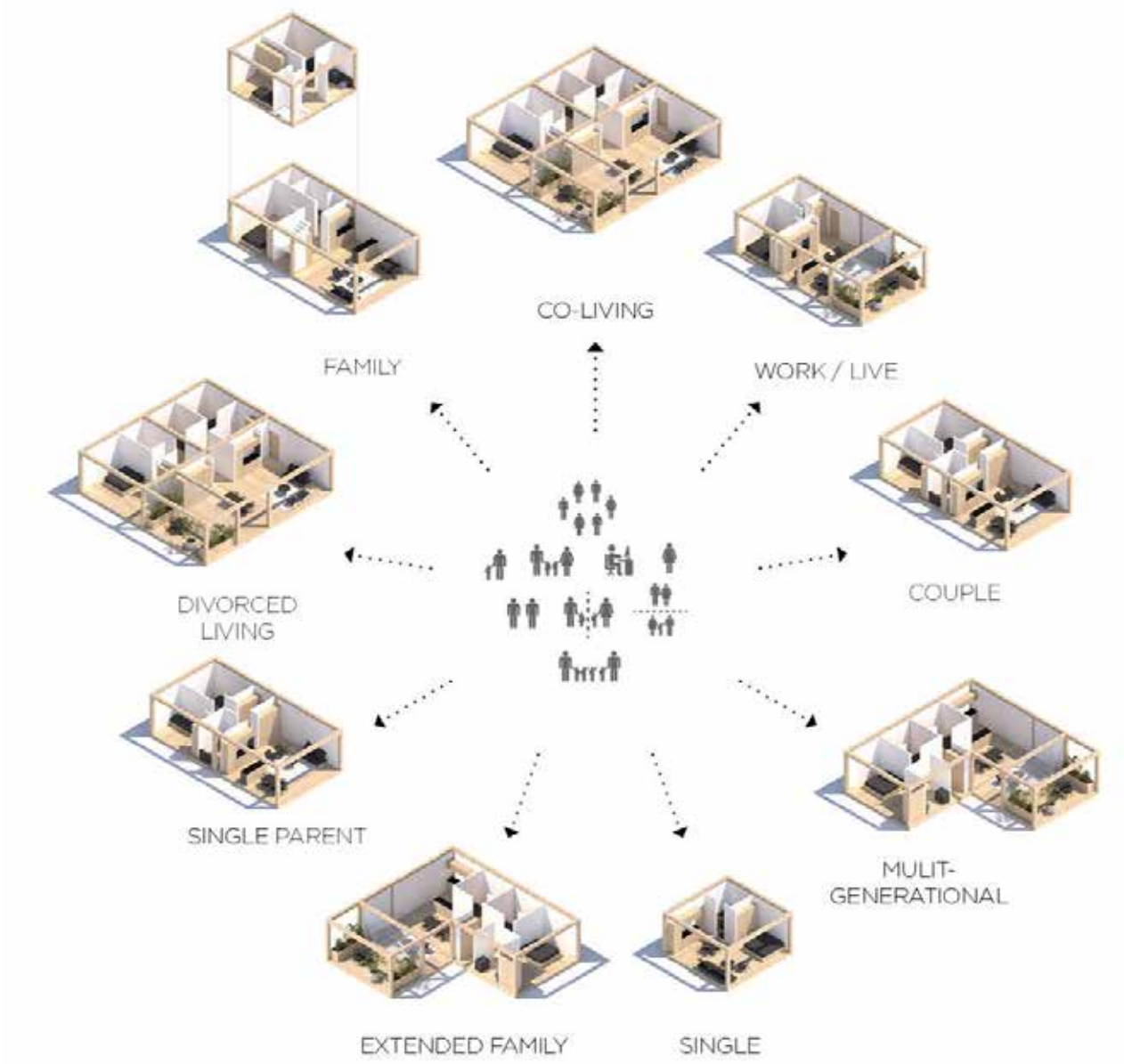


Figure: Effekt Architects (2018). Overview of different house typologies

Furthermore, the project provides a variety of different public and private services on the ground floor, under the raised courtyard. Residents have access to private services, such as a shared laundry room, a tool shed, sharing living room, eBike station, shared kitchen, storage room, media room and electric car parking. Furthermore, they are able to suscribe to public services, such as futness, cafe and coworking space, event space, maker space, communal dining, a mini market, health clinic and a swap station. By making these services accessible for the user, it stimulates social interaction between the residents.

Figure: Effekt Architects (2018). Overview of utilities and services.

Figure: Effekt Architects (2018). a variety of different public and private services on the ground floor that enhances social interaction.

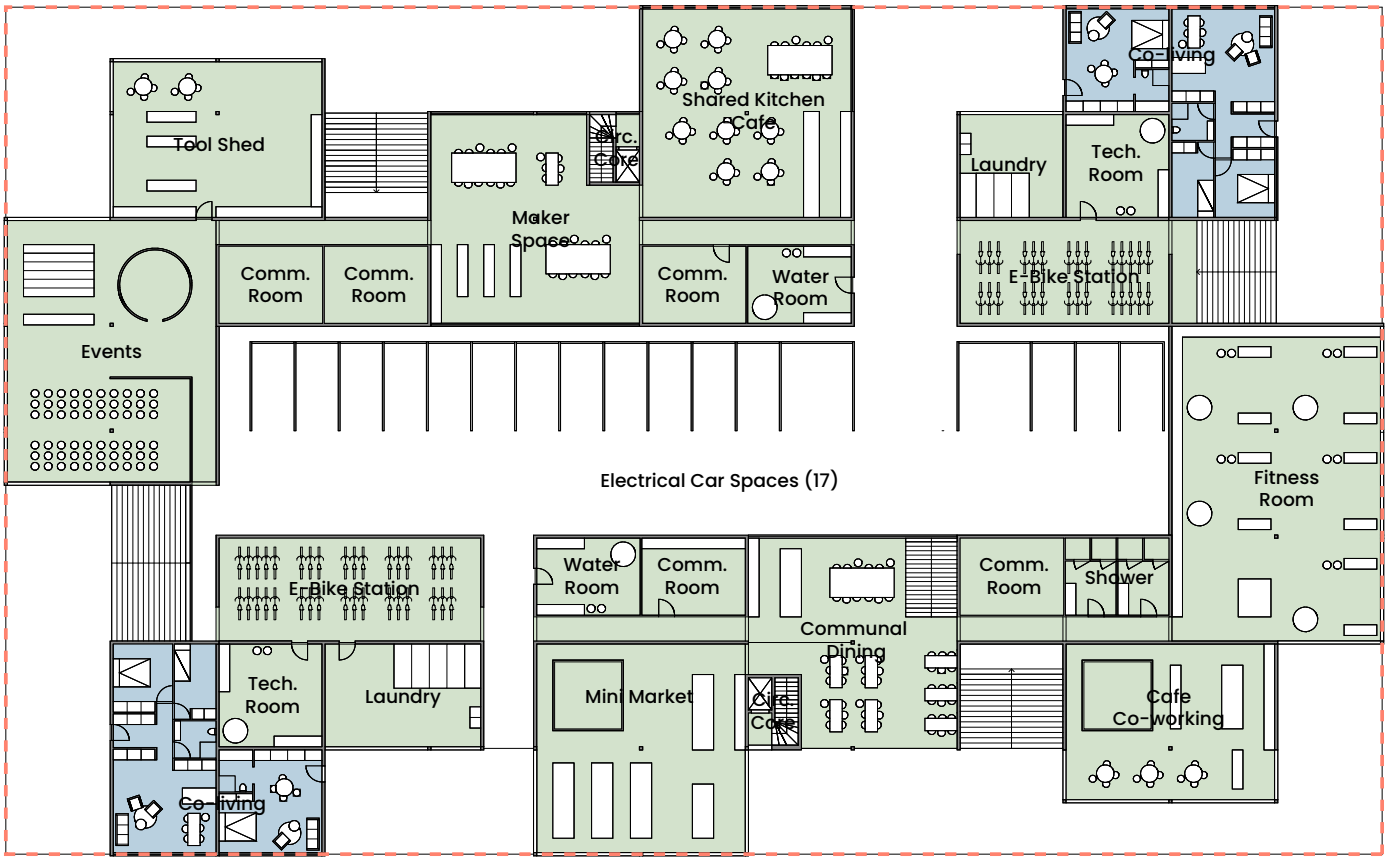
Ground floor

The ground floor is activated with public and commercial functions, such as a tool shed, event space, shared kitchen area, laundry room, e-bike station, fitness room, co-working space, communal dining, mini market, and electrical car spaces that are shared between the residents. There are also two co-living residential units on the corners of the design plot.

Legend:

- Entrance
- Community Spaces
- Housing

Figure: Own illustration based on drawings from Effekt Architects. Ground floor.



Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

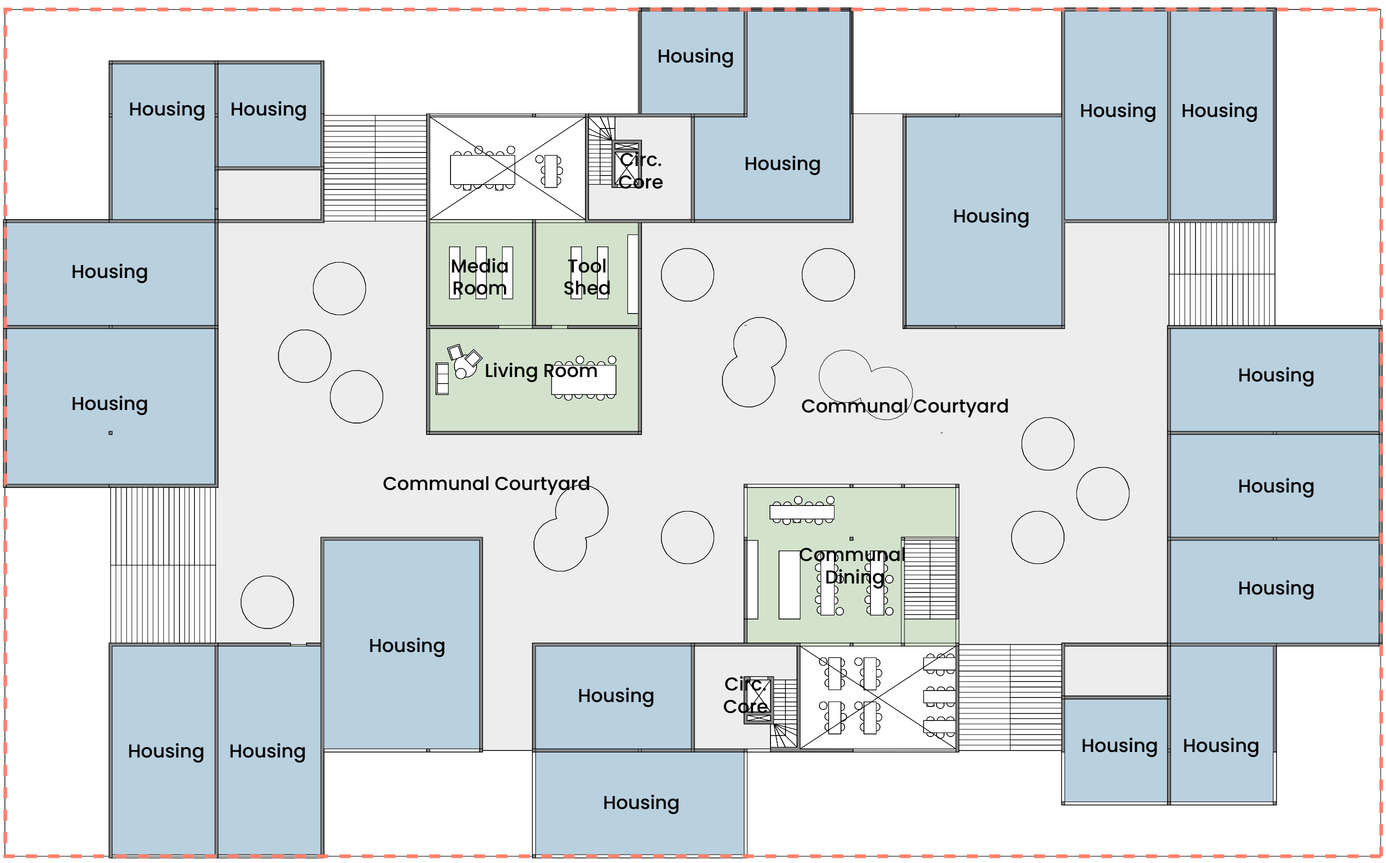
Ground floor

There is a communal courtyard on the first floor. Here, residents have access to the media room, tool shed, living room, and communal dining area. The spaces highlighted in blue are the residential areas. Unfortunately, no drawings have been made on the interior of the units in relation to this floor plan.

Figure: Own illustration based on drawings from Effekt Architects. First floor.

Legend:

- Entrance
- Community Spaces
- Housing



Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

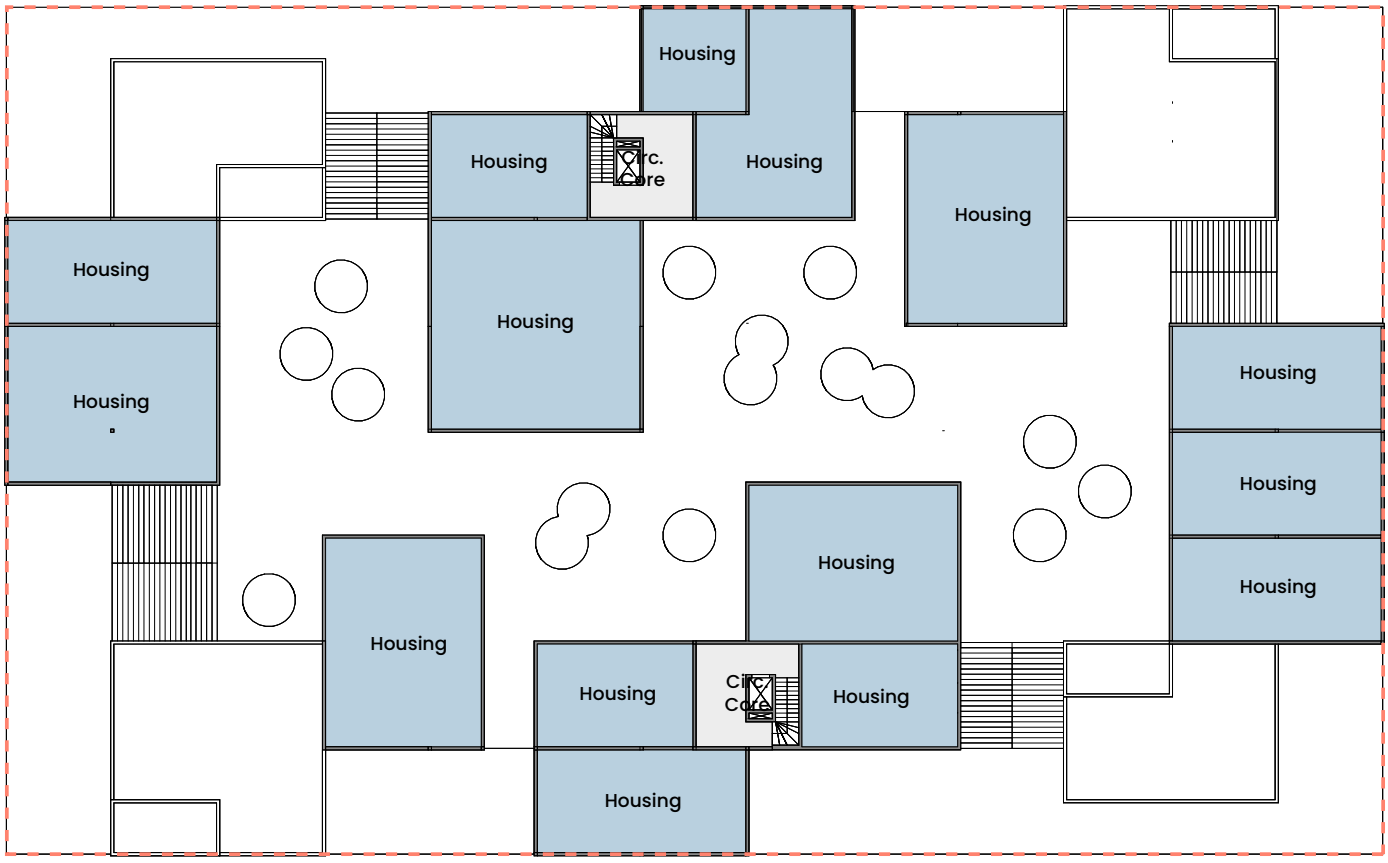
Second floor

The second floor fully consists of residential units. Only some of them have access to the vertical circulation core with an elevator.

Figure: Own illustration based on drawings from Effekt Architects. Second floor.

Legend:

- Entrance
- Community Spaces
- Housing



Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

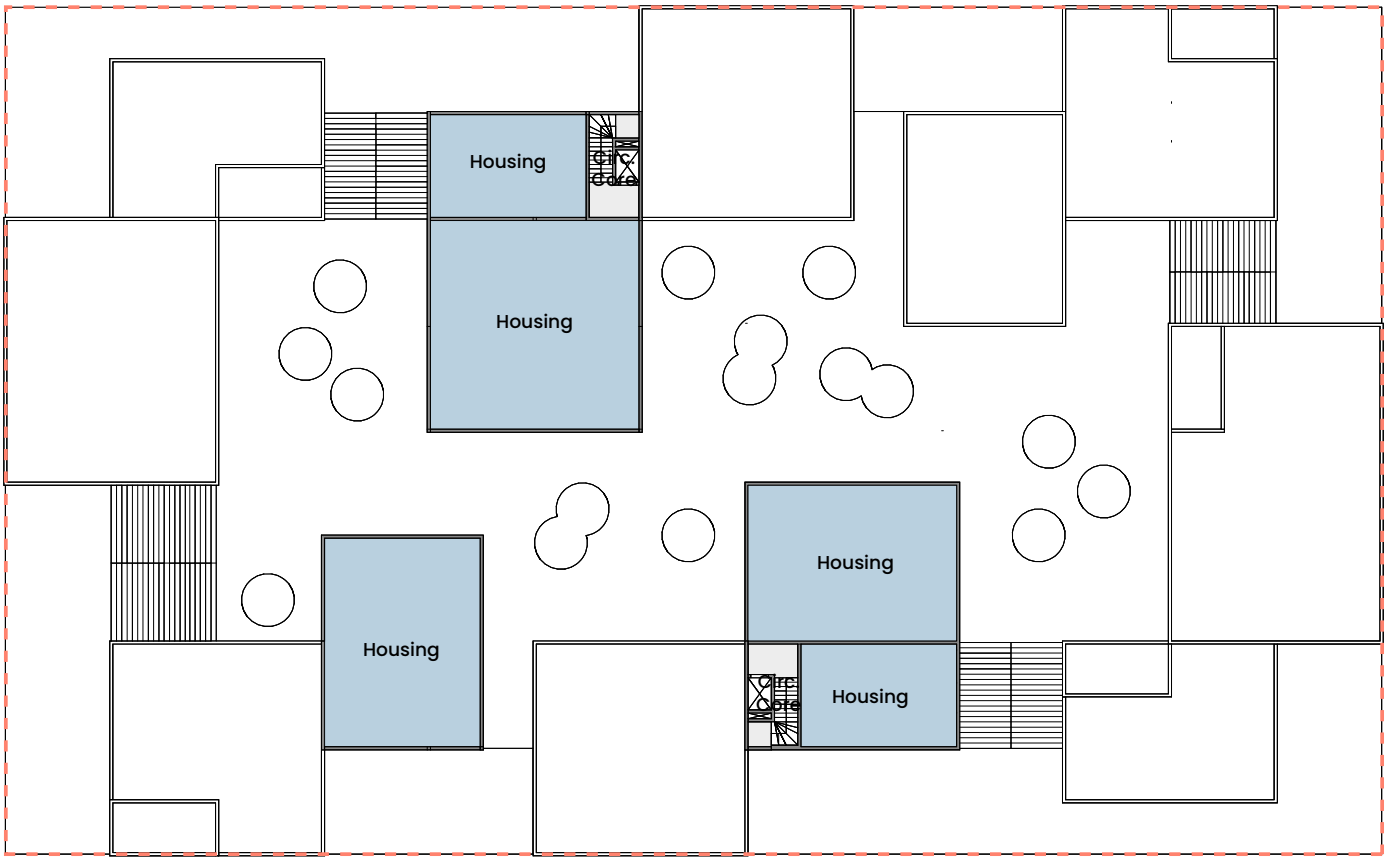
Third floor

The third floor fully consists of residential units. Only some of them have access to the vertical circulation core with an elevator.

Figure: Own illustration based on drawings from Effekt Architects. Third floor.

Legend:

- Entrance
- Community Spaces
- Housing



Scale 1:400 (A4, Portrait)

0m 4m 8m 16m

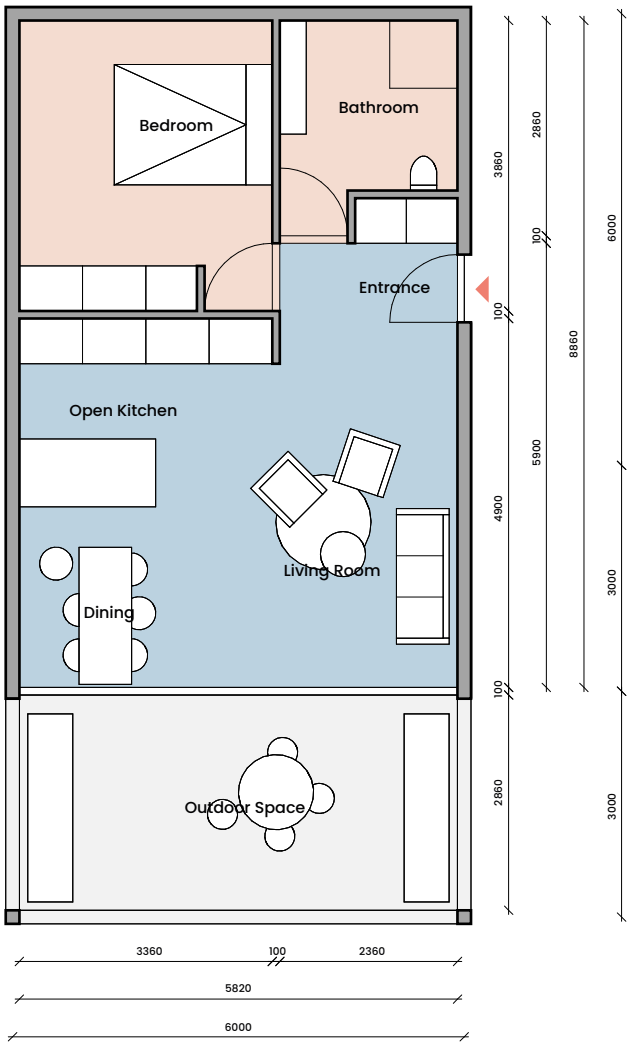
Single Persons

In the figures below, the interior of the single-person households are shown. This includes a bathroom, bedroom, open kitchen with dining table and a living room. There are also bigger single-person households, including a balcony.

Figure: Own illustration based on drawings from Effekt Architects. Single-person household.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

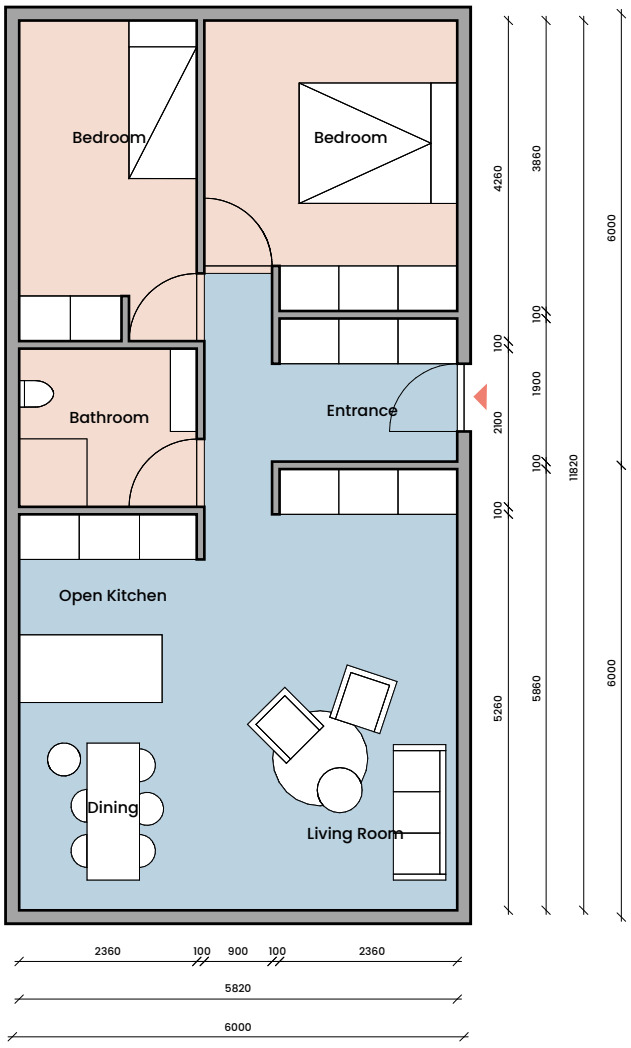
Single-parent

In the figures below, the interior of the single-parent households are shown. This includes a bathroom, 2 bedrooms, open kitchen with dining table and a living room.

Figure: Own illustration based on drawings from Effekt Architects. Single-parent household.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

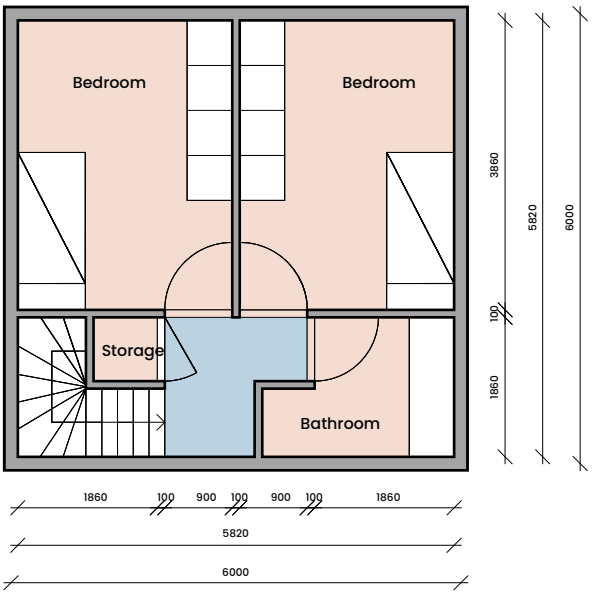
Family

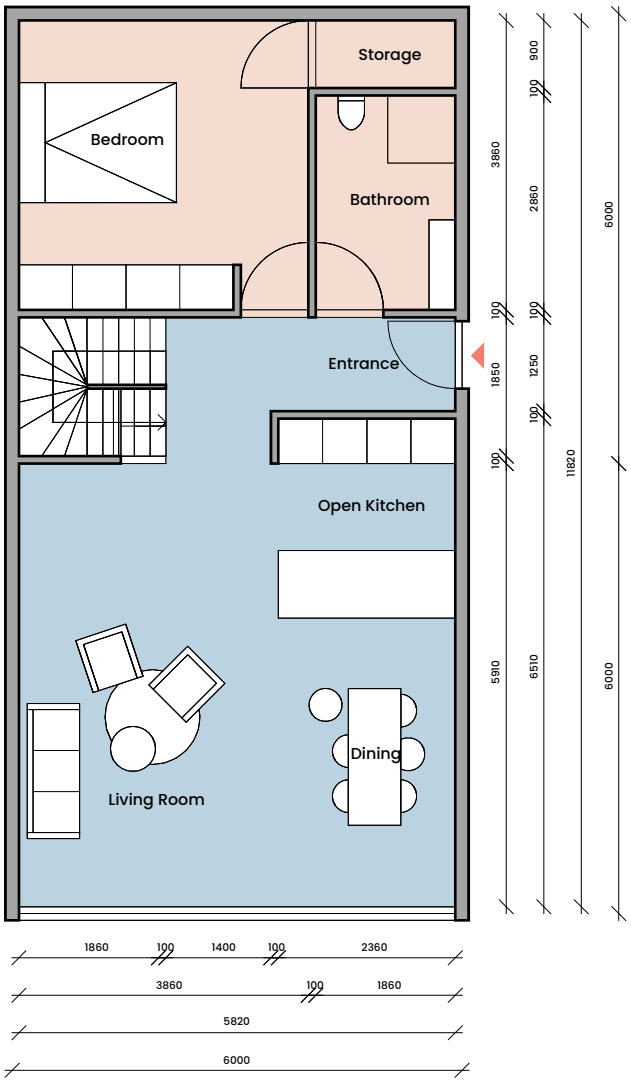
In the figures below, the interior of the family-sized apartment is shown. This includes a bathroom, 3 bedrooms, open kitchen with dining table and a living room. This unit has two floors, which are connected with an inner staircase.

Figure: Own illustration based on drawings from Effekt Architects. Family-sized apartment.

Legend:

- Entrance
- Private space
- Semi-private space





Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

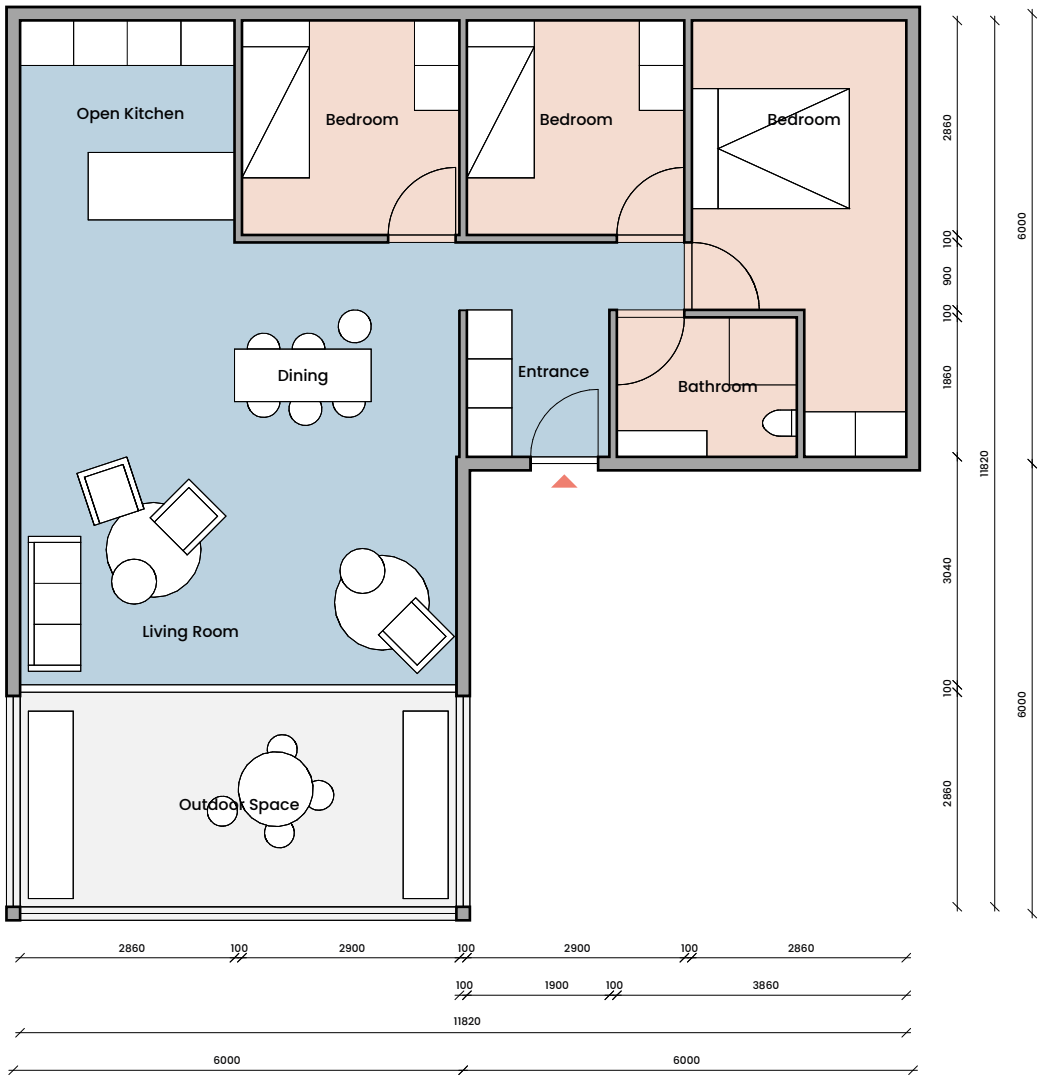
Family

In the figures below, the interior of another family-sized apartment is shown. This includes a bathroom, 3 bedrooms, open kitchen with dining table and a living room.

Figure: Own illustration based on drawings from Effekt Architects. Family-sized apartment.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

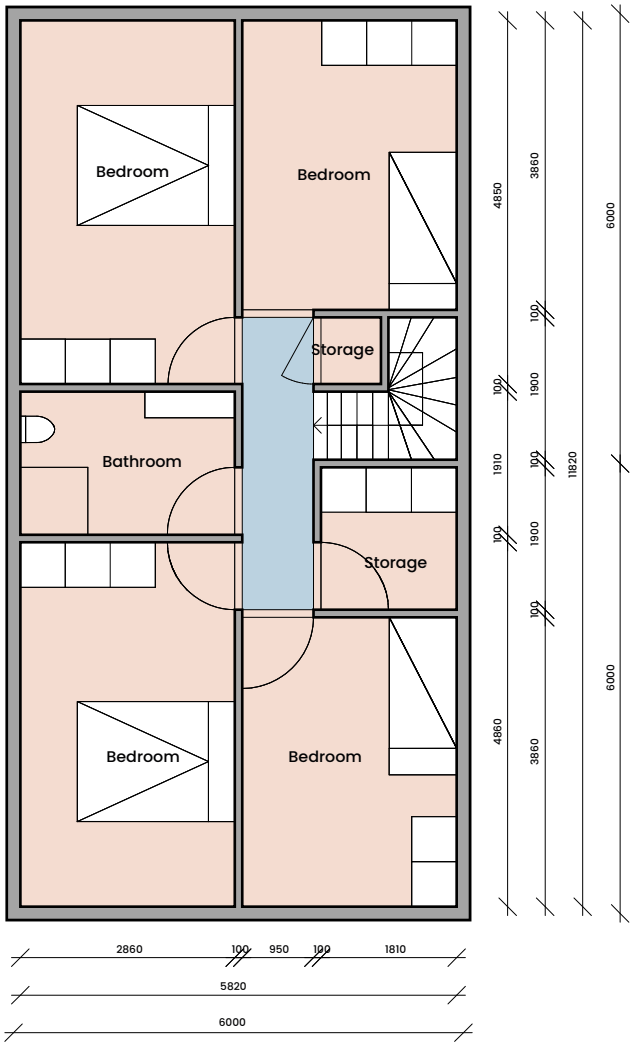
Family / Duplex

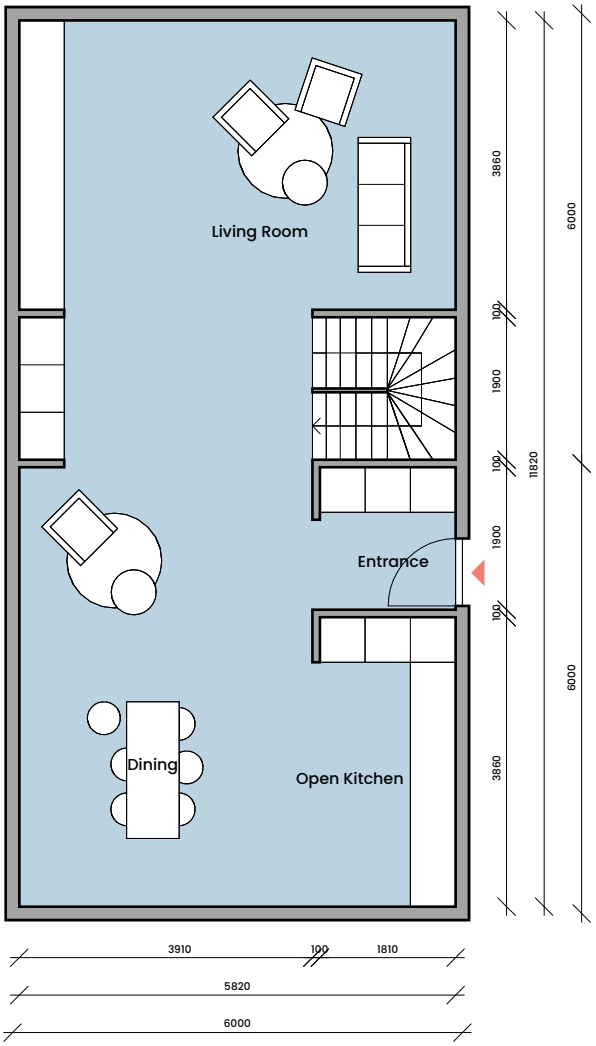
In the figures below, the interior of the family-sized apartment is shown. This includes a bathroom, 4 bedrooms, open kitchen with dining table and a living room. This unit has two floors, which are connected with an inner staircase.

Figure: Own illustration based on drawings from Effekt Architects. Family-sized apartment.

Legend:

- Entrance
- Private space
- Semi-private space





Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

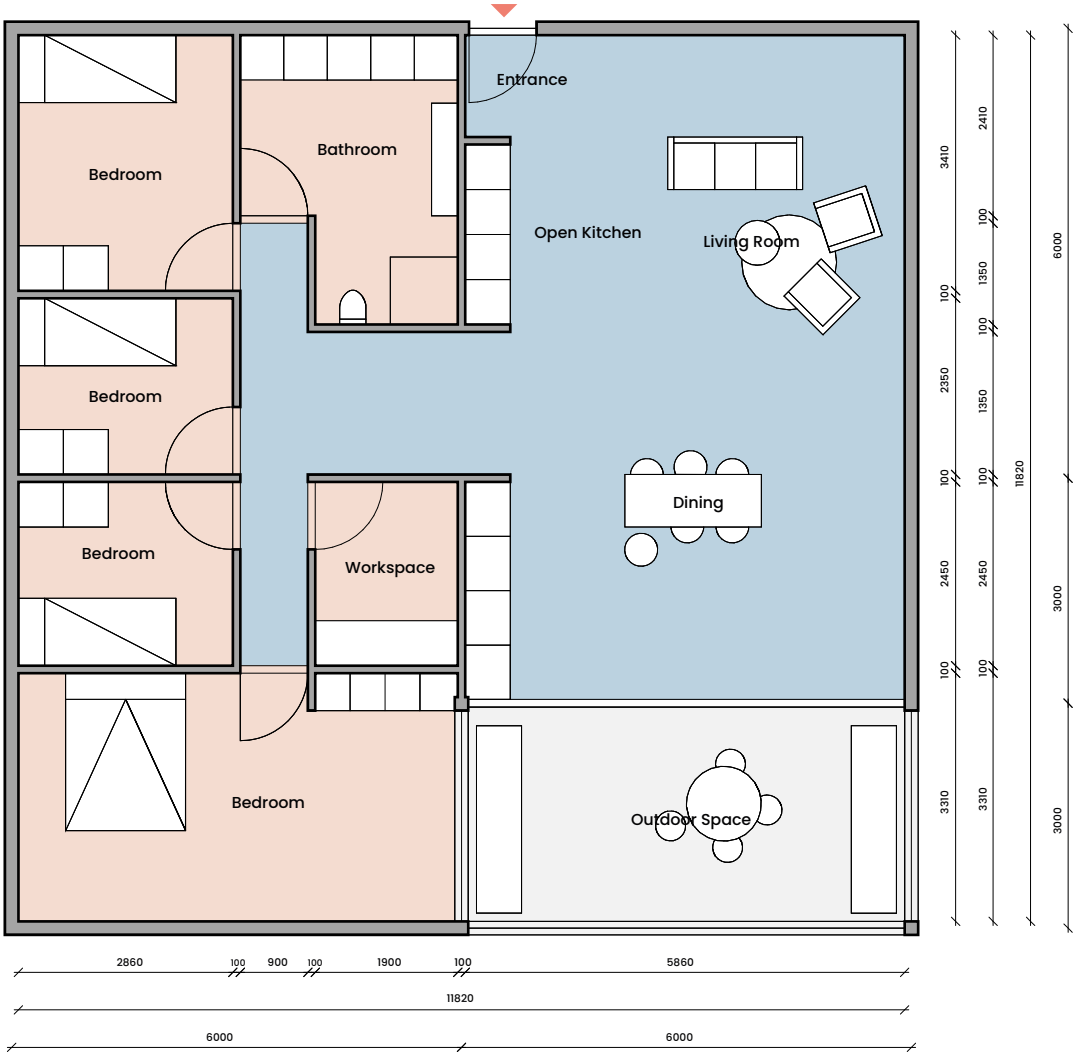
Co-living

In the figures below, the interior of co-living unit is shown. This includes a bathroom, 4 bedrooms, open kitchen with dining table and a living room, a balcony and a workspace.

Figure: Own illustration based on drawings from Effekt Architects. Co-living.

Legend:

- Entrance
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

Invite (Encourage)

This section describes how the designed environment can invite, or encourage, the adoption of pro-environmental behavior through behavioral nudges, small aspects in the environment that cue a behavioral response. In general, this is done by looking at the five underlying areas for sustainable household behavior and how the design affects these aspects. With regards to this project, nudges are utilized to focus on all five key areas: Waste Generation & Recycling, Transport, Food Consumption, Residential Energy Use and Domestic Water Use.

Waste Generation & Recycling

The building provides attractive spaces to recycle waste and compost food waste. By utilizing icons and different colors for different waste purposes, it increases convenience and ease (nudge: prompting, information, social norms, presentation, proximity).

Figure: Mad Arkitekter (2019). Waste generation and recycling

Transport

The project has a strong vision towards green, low carbon mobility. Electrical vehicles are being shared and parked under the courtyard out of sight (nudge: proximity). For the use of bicycles, bicycle racks are installed to facilitate the parking of all types of bikes (nudge: position). Besides, there is also the possibility to repair and recharge bikes (nudge: position, salience). This process of hiring is organized through an online app, accessible for all residents (convenience and ease).

Figure: Mad Arkitekter (2019). Car-sharing and bike storage.

Food Consumption

The building provides food production and makes it salient on the ground floor. By placing food production on the ground floor (nudge: proximity, presentation) it increases knowledge about sustainable living and creates affinity towards nature.

Figure: Mad Arkitekter (2019). Online app that informs residents, gives feedback and rewards, and prompts.

Residential Energy Use & Domestic Water Use

In order to make sustainable living part of the daily lifestyle of the resident, there is an online app. This will help you residents stay connected within the community and enables them to track the monthly energy bill, water usage, subscriptions, services and facilities. This app provides utilizes the following informational nudges: feedback, information & eduation, rewards, and prompts.

Figure: Mad Arkitekter (2019). Online app that informs residents, gives feedback and rewards, and prompts.

5-4 Solaris

The project Solaris is a residential building, developed on the shores of Lake Zurich by Huggenbergerfries Architekten, between the Seestrasse and the railway line. The building offers space for ten units. The name 'Solaris' comes from being a solar house. Although it is not directly visible, the roof and the facades are all solar panels, producing electricity for the whole building. The solar panels are made of structured glass. The color and material of the changing, glittering skin refers to the shattering light on the surface of Lake Zurich. Besides functioning as a solar house that produces twice as much energy as needed per year, there is an electric shared car for the tenants. If there is more energy produced than needed, the electricity is fed back into the grid for the surrounding buildings. This allows the building to have a positive influence in its environment.

The multi-storey building has a slim and well-designed structure. By bending the shape horizontally and vertically, all 10 apartments have all-day sunshine and diverse views towards Lake Zurich. The building opens up towards the street and residents can access the building through the main staircase with an elevator in the middle of the building. A split level is created to give each apartment their own entrance space.

Architects:
Huggenbergerfries Architekten

Client:
HBF Futur AG

Realization Phase:
2017

Site and Address:
Seestrasse 416, Zürich

Size:
814 m2

Residential Units:
10 units

Figure: Own illustration. Situation plan of the building Solaris in Zürich.


Clubraum
Aktionshalle
Rote Fabrik
Rote Fabrik
Rote Fabrik
Rote Fabrik
Schule
Wollishofen
Seestrass
Zellerstrasse
Notwasserbrunnen
Hoffnungs trasse
Ho nung weg
Zellerstrasse
Strandbad
Wollishofen

Figure (top left): Photographer, Beat Bühler (n.d.). Visualisation of the front of the building with big window opening towards the lake.

Figure (top right): Photographer, Beat Bühler (n.d.). Visualisation of the front of the building, including the car parking area.

Figure (bottom left): Photographer, Beat Bühler (n.d.). Visualisation of the red solar powered facade of the building.

Priming (Prepare)

This section looks into the domain of priming and tries to answer how the case study prepares occupants for participation in sustainability and adoption of pro-environmental behavior? How is sustainable ethos communicated within the design? How does the environment encourage social support and design for attention restoration? We start by exploring the communication of a sustainable ethos.

Communicating a Sustainable Ethos

The building increases awareness about sustainability through the materalisation of the facade, which is fully covered in BIPV panels. The architects envisioned a facade that does not look like a solar house at first sight. The 8 facades of Solaris, which are oriented differently to the position of the sun, are equipped with 1.300 photovoltaic modules. The facades generate approximately 31.832 kWh per year. This means that the building produces more energy than needed for 10 residential units. The excess electricity is stored in a 10kW battery, as well as in the battery of the shared

Figure (right page): Own illustration. Example of the solar-powered east facade.

Scale 1:100 (A4, Portrait)

electric car. If there is still energy left, it is fed back into the grid. By doing so, the building plays a beneficial role for the surrounding neighborhood. The material of the facade and the roof is made of structured brown-colored cast glass and creates a glittering, changing skin effect that refers to the play of light on the surface of Lake Zurich. The red-brown color printed on these PV panels refers to the relationship with the Red Factory and the roofs of the surrounding town villas.

Furthermore, the house is not heated with a normal electrically operated heat pump, but with biogas. Therefore, Solaris is 100% CO2 free. In addition, the wooden floors used in the central hallway, the corridors, and the stairs were recycled from the building that stood here before. All these integrations inform and educate residents about sustainability, and aim to change their attitudes towards sustainable living. Below are some images that show the solar powered facade.

Figure: Photographer, Beat Bühler (n.d.). Solar powered facades.

Attention Restoration

The sustainable project creates a supportive environment for people in which mental restoration and mental clarity can be achieved. The building provides visual connections to nature, the lake in the surrounding area, by creatings different views in the dwelling (e.g. explore the different viewlines towards the wider environment. This implementation brings people closer to nature and elicit mental clarity.

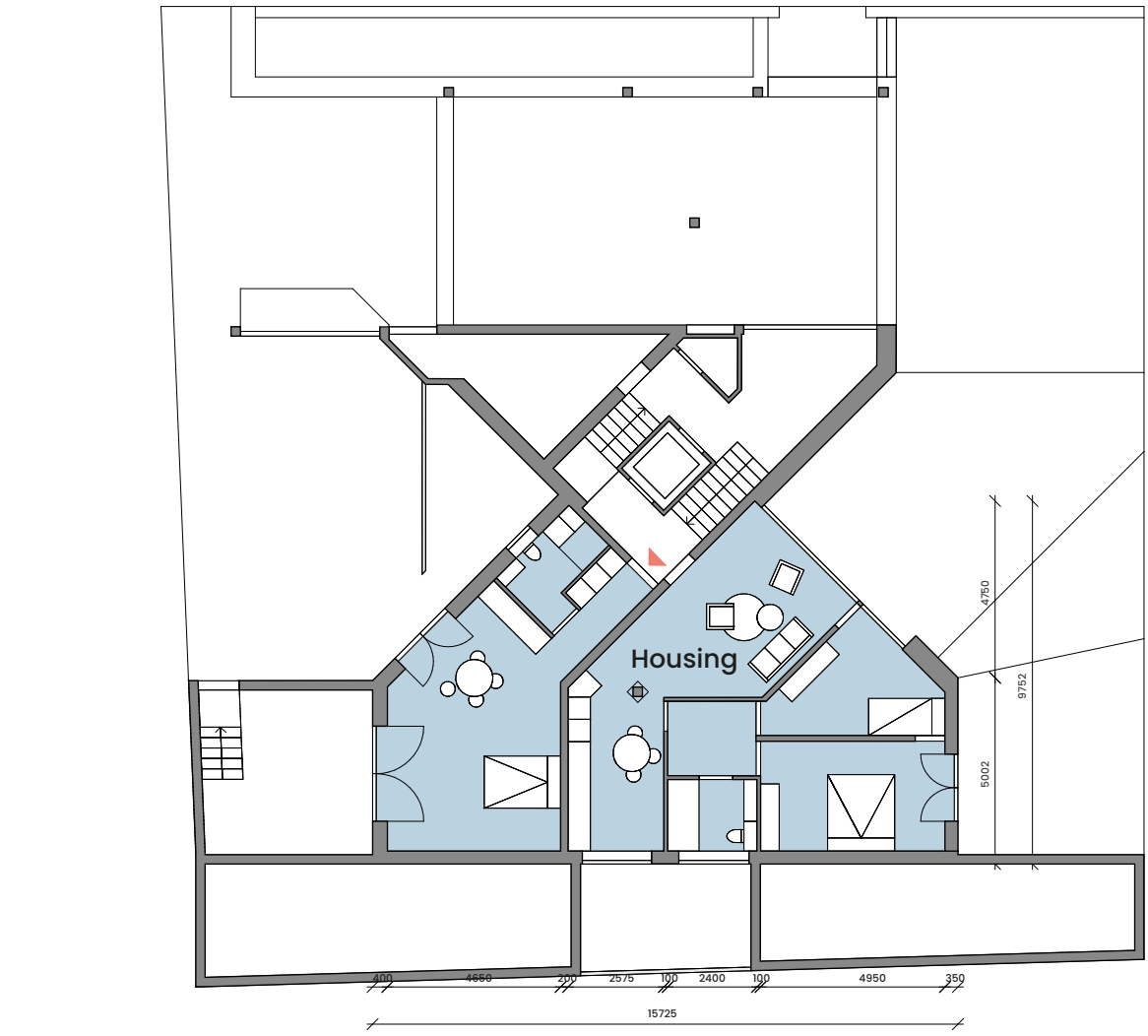
Social Support

This project tries to create a strong sense of identity and belonging. Looking at the program of the building, there are 10 residential units, making this building quite dense and compact compared with the other three case studies. All residents have access to one share car. The spatial configuration of the dwellings are shown in the next pages.

Ground Floor

The ground floor offers space for two units, see the figure below. There is a small apartment for a single person and a bigger apartment for a small family. Both apartments are connected with the vertical core in the middle of the building. There is also an electrical car available which can be shared between the tenants. The battery of this car is charged with energy produced by the facades and roof of the building. The front part of the ground floor opens up towards the street, called Seestrasse. The back of the building is facing the railway line.

Figure: Own illustration. Ground floor of Solaris, based on drawings of the architect.



Scale 1:200 (A4, Portrait)

0m 2m 4m 8m

Middle Floors

The figure on the bottom left shows the middle floors of the building. By creating a split level, each apartment has their own entrance space. Besides, looking at the floorplan, it has become clear that the front of the building is smaller than the back of the building. By creating this shape, the residential unit at the back has several viewlines alongside the facade at the front part of the building towards the lake.

Upper Floor

The figure on the bottom right shows the upper floor of the building. These two residential units are a bit smaller compared with the units of the middle floors.

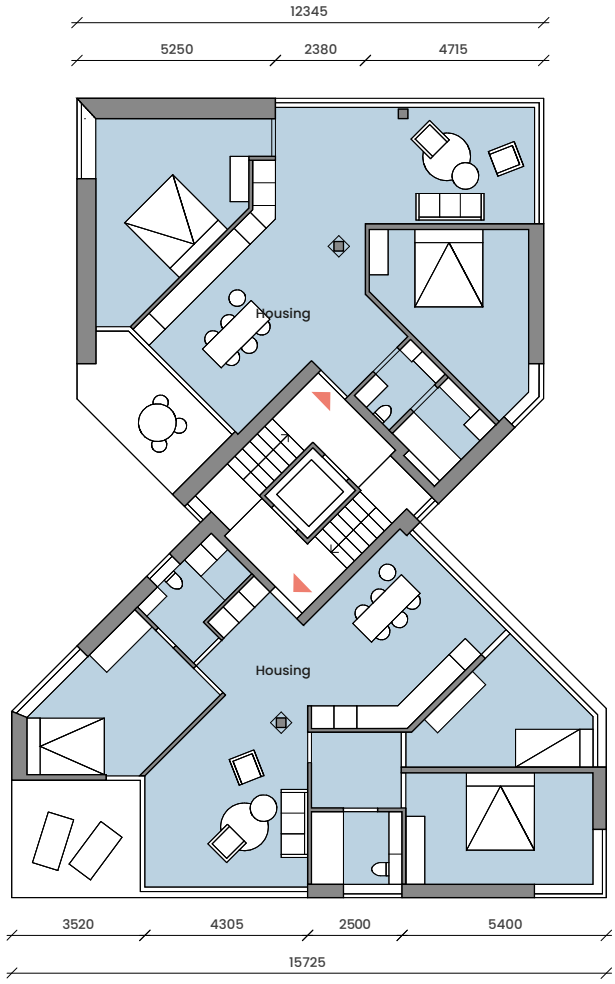
Figure (bottom left): Own illustration. Middle floors of Solaris, based on drawings of the architect.

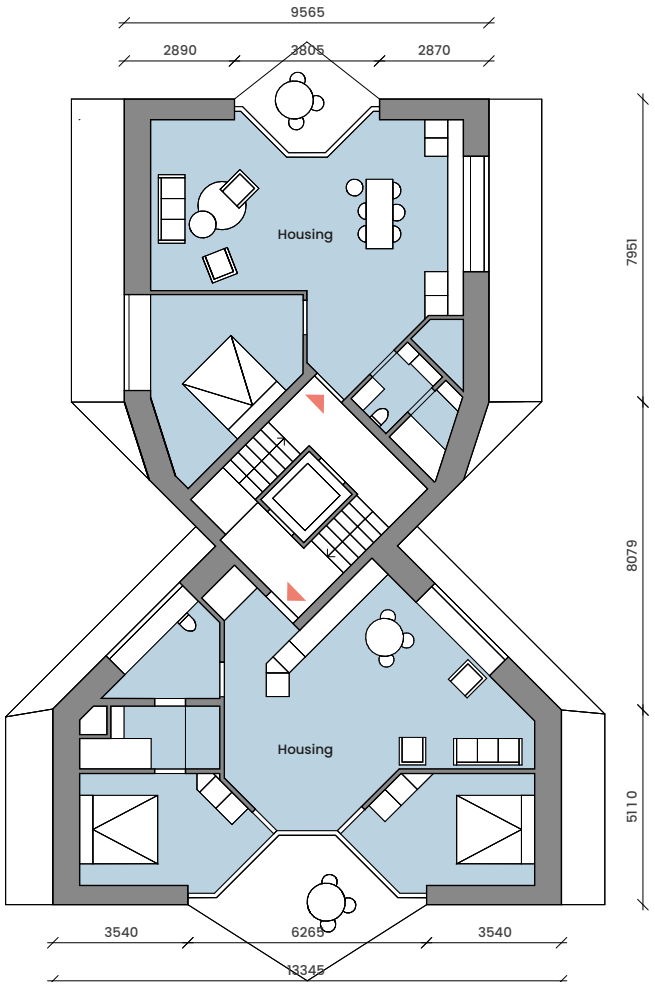
Figure (bottom right): Own illustration. Upper floor of Solaris, based on drawings of the architect.

Legend:

Entrance

Semi-private space





Scale 1:200 (A4, Portrait)

0m 2m 4m 8m

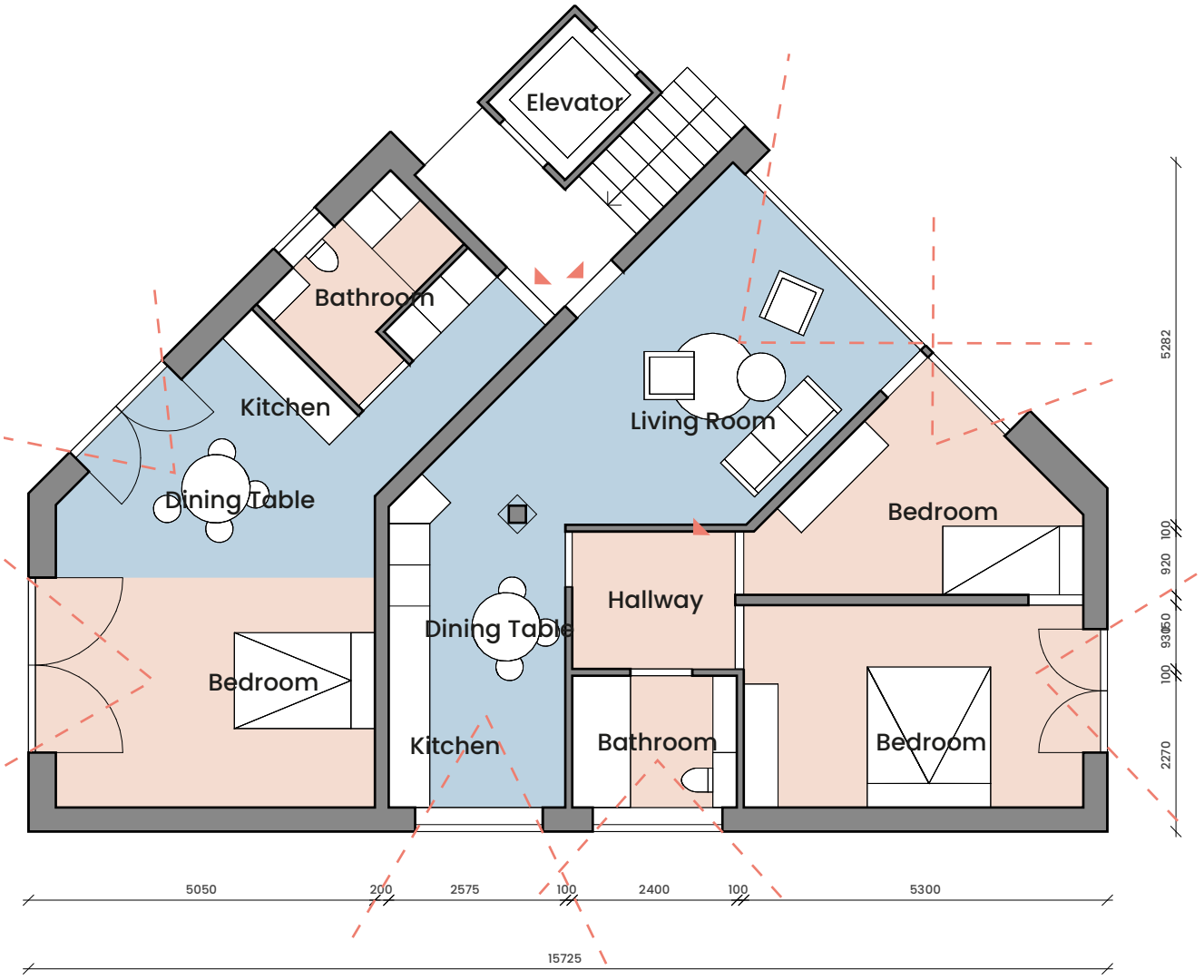
2. Semi-private vs Private spaces

There are two residential units at the ground floor. Both entrances are connected with the semi-private spaces (e.g. kitchen, dining table and living room). These spaces are highlighted in blue. Around these spaces, the private spaces are situated, such as a bedroom and bathroom, highlighted in orange. There is a soft transition from semi-private to private in the smaller apartment. Here, there is no hard egde (e.g. inner wall) between the living area and the bedroom. Furthermore, every area in the house has a different viewline towards the surrounding neighborhood.

Figure: Own illustration. Residential units at ground floor.

Legend:

- Entrance
- Viewlines
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

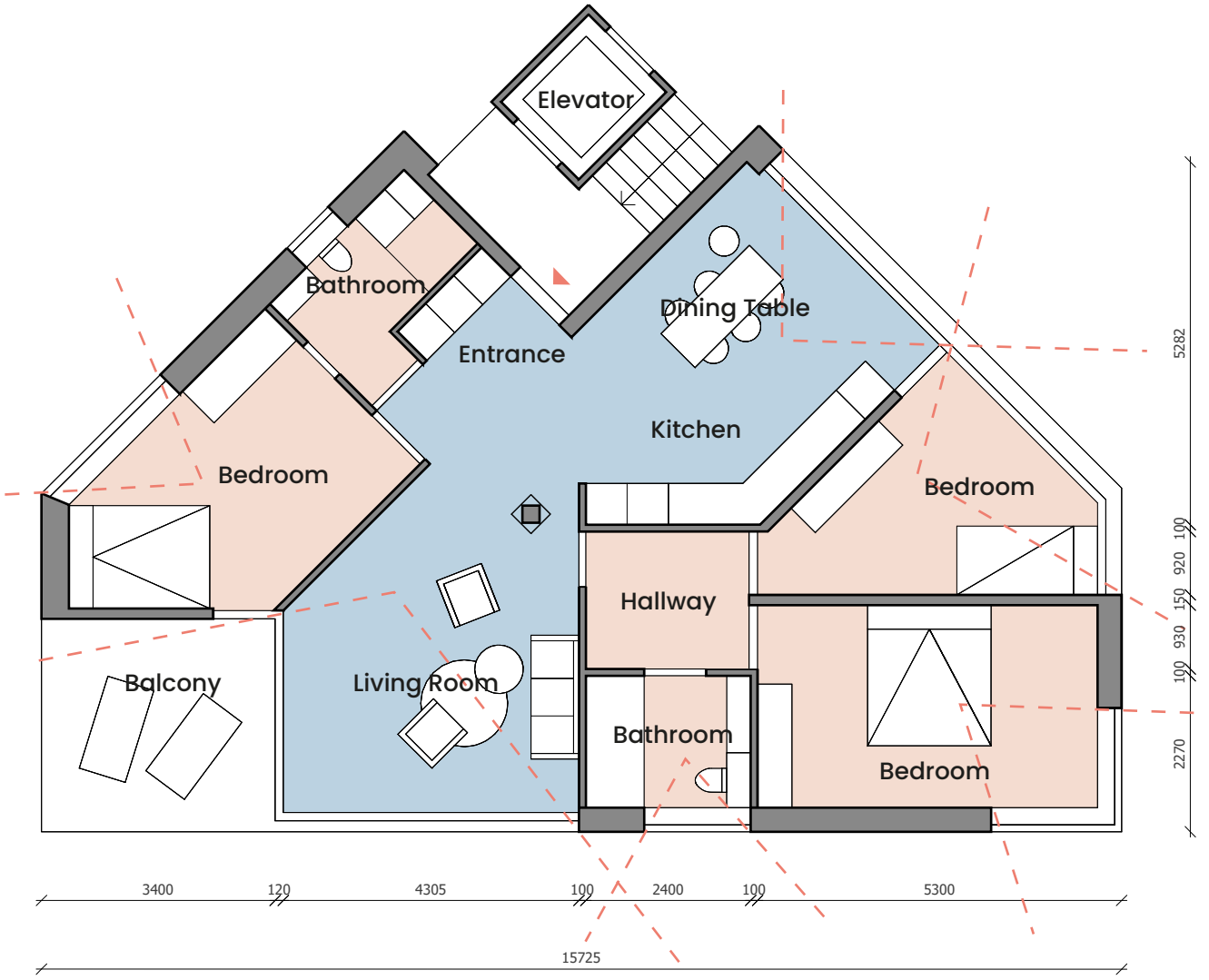
0m 1m 2m 4m

There are two residential units on the middle floors. The figure below is showing one unit at the bottom part of the middle floor. Just like to residential units at the ground floor, the tenant enters the space in the semi-private area: the kitchen, dining table and the living room. Next to the living area, a balcony is placed to offer outside space. Around the semi-private spaces there more private spaces are situated: 3 bedrooms and two bathrooms.

Figure: Own illustration. bottom residential unit on the middle floors.

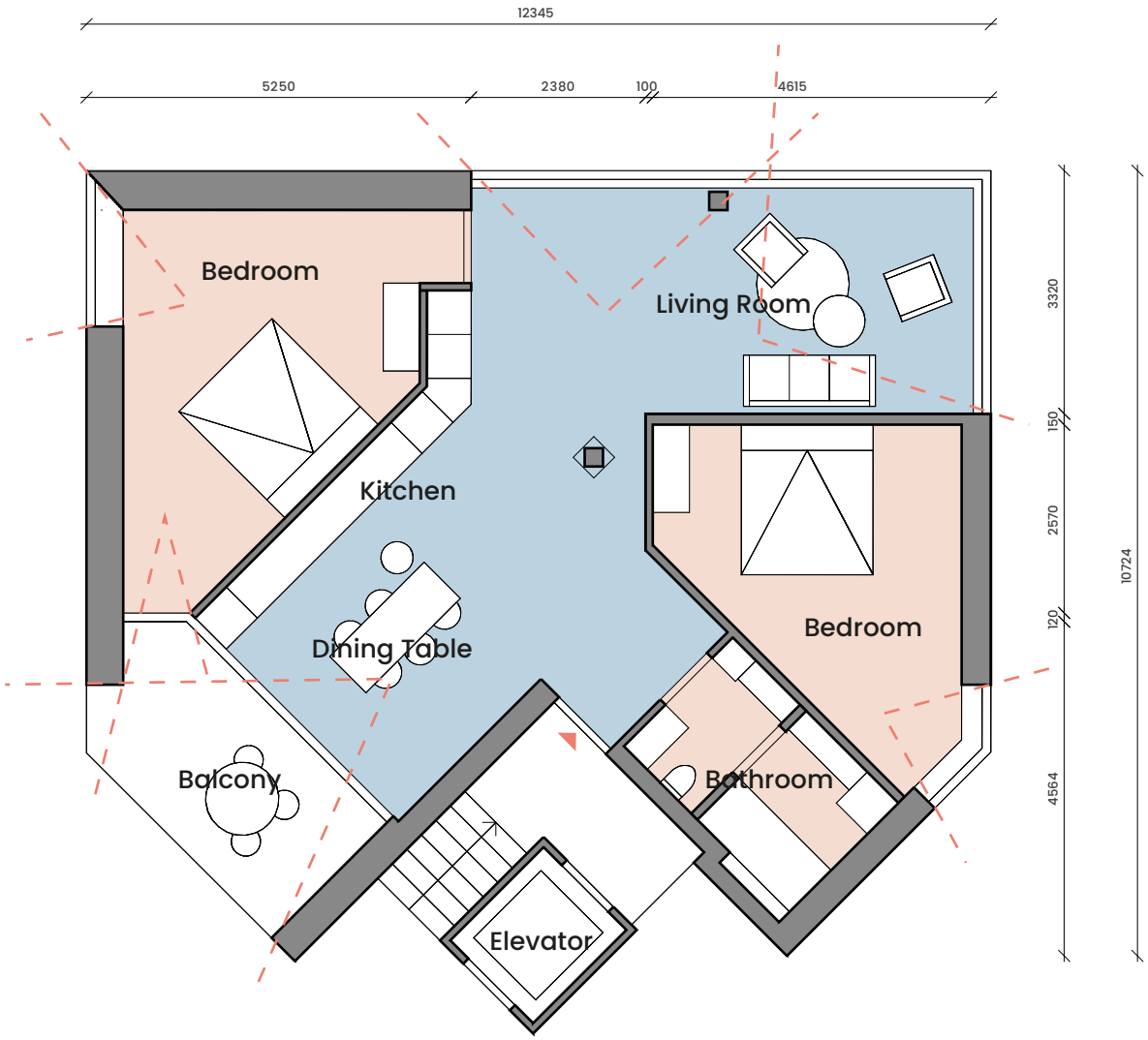
Legend:

- Entrance
- Viewlines
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

The figure above shows the upper residential unit on the middle floors. This unit is offering space for a small family or single parent houshold. The semi-private space is placed centrally. Around this space, the more private spaces are placed: 2 bedrooms and 1 bathroom. The living area has a view towards lake Zurich, while the balcony and the dining table has a view towards the railway line.

Figure: Own illustration. Upper residential unit on the middle floors.

Legend:

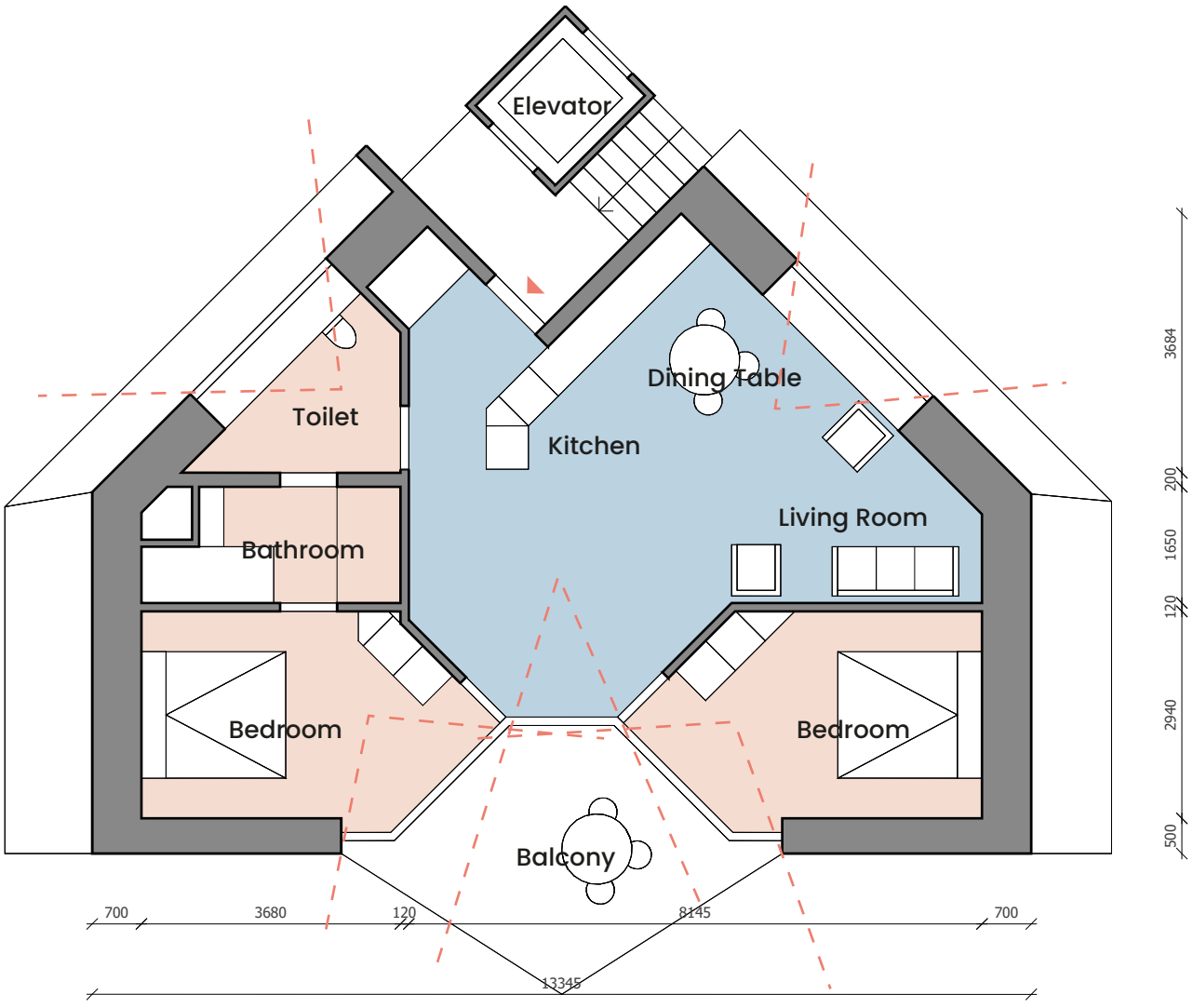
- Entrance
- Viewlines
- Private space
- Semi-private space

The figure below shows one of the residential units on the upper floor. The tenant enters the space in the semi-private space: the kitchen, dining area and living space. A balcony is placed centrally in the building offering a view towards the railway line. Around the semi-private space, the more private rooms are situated: 2 bedrooms, 1 bathroom and 1 toilet. Both bedrooms are connected with the balcony. Each room has a different viewline towards the outer space.

Figure: Own illustration. Bottom residential unit at the upper floor.

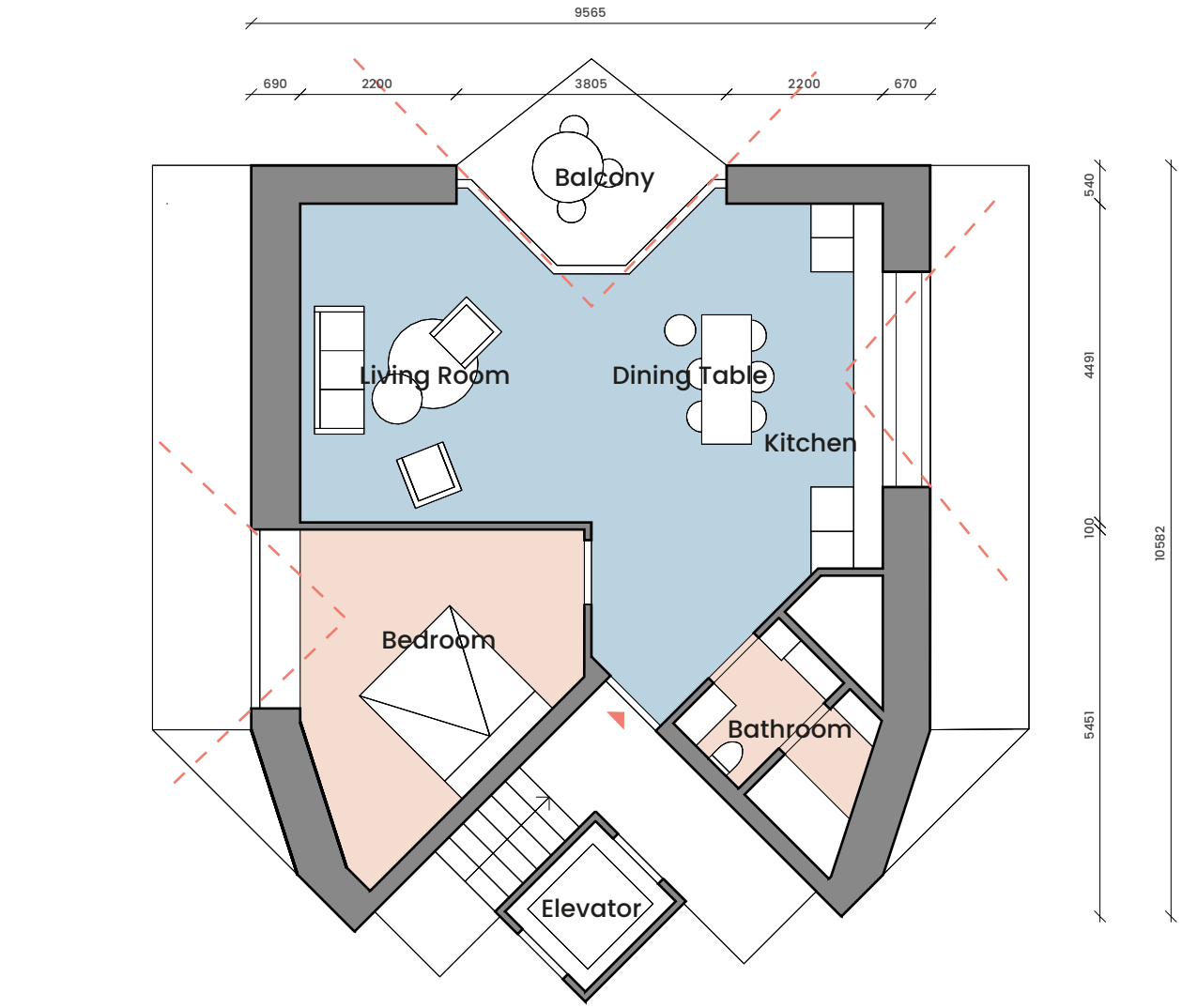
Legend:

- Entrance
- Viewlines
- Private space
- Semi-private space



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m



Scale 1:100 (A4, Portrait)

0m 1m 2m 4m

The figure above presents the upper residential unit on the upper floor. This unit is ideally for starters, couples without children or a single person. There is only 1 bedroom and 1 bathroom. The tenant enters the unit in the semi-private space. The balcony, connected with the living room and dining table, has a view towards Lake Zurich and Seestrasse.

Figure: Own illustration. Upper residential unit on the upper floor.

Legend:

- Entrance
- Viewlines
- Private space
- Semi-private space

5-5 Conclusion

The aim of this chapter was to examine the Comprehensive Model for Nudging Towards Pro-Environmental Behavior in Architecture through the analysis of four case studies. Here, several aspects were explored that try to answer how architecture is able to prime occupants for participants in sustainability, invite residents to adopt a pro-environmental lifestyle using informational and structural nudges, and how architecture is able to minimze the effect of five key determinants in household behavior (waste generation & recycling, transport, residential energy use, food consumption, and domestic water use).

The analysis of four case studies offered additional insights in the forming of sustainable behavior through architecture. It appears that architecture plays a key role in preparing residents for sustainability. First of all, by communicating a sustainable ethos, through the provision of information and education, integration of a sustainable materialisation, a smart programme, and the creation of sustainable architecture. Secondly, the case studies showed how architecture is able to integrate nature through visual and physical connection that enhance mental clarity and restore attention. Furthermore, several case studies showed how to improve social support, for example, by adapting the spatial layout of an apartment to enhance social interaction, or by creating not only horizontal connections but also vertical connections to stimulate social cohesion and points if interaction. Lastly, some case studies showed how behavioral nudges can be implemented to minimize the impact of the five key determinants of household behavior.

However, the analysis of four case studies showed more insights in how architecture can prime occupants to participate is a sustainable building than how architecture is able to nudge, or invite, people towards desired sustainable behavior. Nevertheless, the findings provide valuable information that can be taken into consideration while designing sustainable environments that elicit sustainable household behavior.

6 Conclusion & Discussion

This chapter will provide the conclusion of this research report, whereby the theoretical supportive research questions will be answered. Then, limitations and future research possibilities will be proposed.

6-1 Conclusion

The objective of this research was to explore the role of nudging in changing behavior towards sustainable living in architecture. The thesis's scope was primarily focused on residential architecture. Ultimately, the aim was to take a closer look at the relationship between nudging, sustainability to evaluate the role of nudging in architecture and the built environment that fosters pro-environmental behavior. Therefore, this report addresses the following main research question:

What is the role of nudging in changing behavior towards sustainable household behavior in architecture?

Several supporting sub-questions are formulated in order to answer the main research question. These are:

- *What principles of the nudge theory can be applied in architecture?*
- *How can the nudge theory be integrated into sustainable architecture?*
- *What is the concept of sustainability and sustainable behavior in architecture?*
- *What is the relationship between nudging, sustainability and architecture?*

1) What principles of the nudge theory can be applied in architecture? 2) How can the nudge theory be integrated into sustainable architecture?

Chapter 2 tried to answer the first two supportive research questions by outlining the theoretical understanding of the concept of nudging, determined through literature review. The aim of this chapter was to, first of all, understand what theoretical approaches exist to behavior change and position the role of the situational context within these frameworks. Secondly, this chapter examined nudging as a behavior tool by looking into the definition, the different categories and various types of nudging. Here, the objective was to establish an overview of nudges that can be implemented in architecture. Finally, this chapter explored how nudges can be strategically implemented in the design process that incorporates sustainability.

It appears that various theoretical approaches exist to behavior change and it can be concluded that the development of individual behavior is a very complex one, one that is iterative and depends on countless factors. Literature suggests that the built environment plays an extremely important role in eliciting pro-environmental behavior and architects should have an understanding of these theories and the variables within that determine and predict the activity and behavior of a building's occupant.

Secondly, nudging utilizes the decision-making process of people that is often based on heuristic processes, unconscious associations, automatic and learned responses, based on the dual-process theory. Nudging is defined as an umbrella term for a deliberate and predictable method of changing people's behavior by modifying the cues in the physical and/or social context in which they act.

Furthermore, this chapter shared similarities in how choice architecture interventions and principles are categorized. Based on these frameworks, this study introduces an adapted choice architecture framework that comprises two different intervention categories and can be utilized in architecture: informational and structural nudges. The informational nudges include: Information & Education, Social Norms, Feedback, Rewards, Default, Behavioral Commitments, and Prompting. The structural nudges include: Availability, Proximity, Priming, Size, Presentation and Functional Design.

Finally, this chapter examined several theoretical frameworks for implementing strategic nudges that also incorporate the notion of sustainability. Here, one framework suggests that the process of implementing nudges should adopt a strategic approach that implements a shared vision for success in which the integration of nudges leads towards a sustainable society.

3) What is the concept of sustainability and sustainable behavior in architecture?

This chapter examined the concept of pro-environmental behavior and sustainable development with the aim of describing how sustainable household behavior is able to contribute to sustainable development. Based on the findings in literature, it can be concluded that sustainable household behavior can be seen as behavior that is consciously looking for ways to minimize the impact of one's actions while meeting the needs of the present, without compromising the ability of future generations to meet their own needs and taking into account the three interconnected pillars of sustainable development. An architect can encourage this type of pro-environmental behavior through nudging by focusing on five determinants where households exerts pressures on the environment: waste, transport, energy, food, and water.

4) What is the relationship between nudging, sustainability and architecture?

This chapter explored how sustainable buildings in general are able to act as a supportive environment for shaping pro-environmental behavior, by bringing several frameworks together into one that addresses the relationship between the concept of nudging, pro-environmental behavior, and the role of architecture.

A Comprehensive Model for Nudging towards Sustainable Household Behavior in Architecture is introduced. This framework describes the role of architecture that, together with three other interdependent variables, affect the development of sustainable household behavior. The model visualizes the continuous process of eliciting sustainable behavior by presenting the (in)direct relationships between architecture and normative processes, habitual processes and intentional processes.

Secondly, the framework defines three domains, underlying conditions, that are required for creating a supportive environment for the development of environmental sustainable behavior: Prime, Permit and Invite. The first underlying condition or domain is called priming, which means to prepare occupants for participation in sustainability and adoption of pro-environmental behavior. This domain includes three aspects: communicating a sustainable ethos, restoring attentional capacity, and creating social support. The second domain, permit, is about giving the opportunity to allow occupants to act upon their environment, known as behavioral control. The third domain describes how environments can invite, or encourage, the adoption of pro- environmental behavior through behavioral nudges, small aspects in the environment that cue a behavioral

response. This domain is based on two different categories of nudging that includes 13 types. The first intervention typology implies the use of informational tools consisting of three categories: Decision Information (Information & Education, Social Norms, Feedback), Decision Structure (Default, Rewards), and Decision Assistance (Behavioral Commitments, Prompting). The second intervention category represents structural tools that comprises two categories: interventions that primarily alter the placement of features (Availability, Proximity, Priming) in the built environment and interventions that primarily alter the properties of features (Size, Presentation, Functional Design) in the built environment.

In this framework, the role of nudging, and the positioning of nudging within the wider framework becomes salient. According to these findings, the role of nudging plays a pivotal role in changing behavior towards sustainable living in architecture.

Built on this, the Comprehensive Model for Nudging Towards Pro- Environmental Behavior in Architecture was tested through the analysis of four case studies. Here, several aspects were explored that try to answer how architecture is able to prime occupants for participants in sustainability, invite residents to adopt a pro-environmental lifestyle using informational and structural nudges, and how architecture is able to minimize the effect of five key determinants in household behavior (waste generation & recycling, transport, residential energy use, food consumption, and domestic water use). Although the analysis showed more insights in how architecture is able to prime occupants instead of how architecture is able to nudge, or invite, people towards desired sustainable behavior, it provided additional insights in the forming of sustainable behavior through architecture.

6-1 Limitations and Further Research

In regards to theoretical limitations, further research is needed on the model proposed in this report which presented an overview of 13 different nudges that can be utilized by an architect in the built environment. It would be interesting to further develop this framework by deepening the knowledge on more theoretical frameworks. Due to time limitations, the proposed framework was only based on several theories that exist in literature without looking into more examples and implementations of nudges in the architectural environment. It would help architects if an overview is established of nudges that exist or have been implemented in architecture, specifically in the scope of housing and dwelling. For instance, developing an online accessible dashboard for architects would be interesting to develop in a next phase.

Furthermore, the proposed framework in this report, A Comprehensive Model for Nudging towards Sustainable Household Behavior in Architecture, should be developed further, since it was only based on three theoretical models. From what we have seen in this framework, the role of architecture on individual behavior is much broader than the concept of nudging and can have a bigger impact on behavior change than nudging alone. Therefore, further research in the role of architecture, primarily in the domains of priming and permitting, is needed to explore how architecture and with what means can enhance sustainable behavior.

Lastly, in regards to the analysis of the chosen case studies, the report focused on testing the Comprehensive Model for Nudging Towards Pro-Environmental Behavior in Architecture in action. Although these findings provided valuable information that can be used while designing sustainable environments to enhance pro-environmental behavior, the results showed more

insights in how architecture can prime occupants to participate in a sustainable building than how architecture is able to nudge occupants towards desired sustainable behavior. Therefore, it is recommended that future research takes another approach in discovering nudges in existing buildings. Based on the four case studies that were chosen in this report, it is recommended to analyze and choose buildings that exist or in which it has been proven that the concept of nudging is addressed and implemented.

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