FUTURE OF DETACHED HOUSE. URBAN SINGLE-FAMILY HOUSING IN KOPLI

ÜKSIKELAMU TULEVIK. LINNALIKUD ÜHEPEREMAJAD KOPLIS

Master's Thesis

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ABSTRACT

In the last years, with the growth of awareness of the climate change problem, more and more tactics for sustainable design and restrictions are introduced. The main movement is to densify the cities and eliminate the need for cars to reduce CO^2 production. Previously designed single-family houses do not fit such criteria, so a shift toward apartment buildings can be seen; some even suggest leaving single-family houses as a relic of the past.

The following master's thesis examines why and where such radical solutions were implemented and asks what the future for detached houses can be. The thesis is showing the results of different studies that disprove the correlation between density and CO^2 production. Yet, since the changes for better solutions can be found, the thesis produces several principles for the urban house, give a possible number for the adequate floor area per capita, and give principles for low carbon footprint planning in houses. When all the principles are described, in the practical part of the thesis all principles are implemented in the project of urban single-family housing in Kopli. The project is giving six different plausible variants of houses. The design is also targeting the problem of under-occupancy, producing the solutions with a possible division into two separate apartments in the same building.

Keywords: Single-family house, urban, density, greenhouse gas emissions, floor area.

ANNOTATSIOON

Viimastel aastatel, koos teadlikkuse kasvuga kliimamuutuste probleemist, võetakse kasutusele üha enam säästva disaini taktikaid ja piiranguid. Peamine liikumine on linnade tihendamine ja autode vajaduse kaotamine CO2 tootmise vähendamiseks. Varem projekteeritud ühepereelamud sellistele kriteeriumidele ei vasta, seega on näha nihet kortermajade suunas; mõned isegi soovitavad jätta ühepereelamud mineviku reliikviaks.

Järgnev magistritöö uurib, miks ja kus nii radikaalseid lahendusi rakendati ning küsib, milline võib olla eramute tulevik. Lõputöös on välja toodud erinevate uuringute tulemused, mis lükkavad ümber tiheduse ja CO2 tootmise vahelise seose. Kuna aga on võimalik leida muudatusi paremate lahenduste poole, toodab lõputöö linnamaja jaoks välja mitmeid põhimõtteid, annab võimaliku arvu piisava põrandapinna kohta elaniku kohta ning annab põhimõtted madala süsiniku jalajälje kohta. Kui kõik põhimõtted on kirjeldatud, rakendatakse lõputöö praktilises osas kõiki põhimõtteid Kopli linna ühepereelamu projektis. Projekt annab kuus erinevat usutavat maja varianti. Disain on suunatud ka alaasustusprobleemile, pakkudes lahendusi võimaliku jaotusega kaheks eraldi korteriks samas majas.

Märksõnad: Ühepereelamu, linn, tihedus, kasvuhoonegaaside heitkogused, põrandapind.

CONTENTS

THEORETICAL PART

1. INTRODUCTION

1.1 Context and Actuality

According to European statistics, in 2021 38.5% of Estonians lived in a house and 61.1% lived in a flat. In 2008 only 25% of Estonians lived in a house. In the last 13 years, the percentage of people in houses grew by 13.5%. Such development is not unique to Estonia. Almost in every European country, the share of single-family dwellings in total stock is growing. But the development of single-family houses has several downfalls. Compared to apartment buildings, single-family houses take up more space, need more materials and infrastructure around them, and need more energy per capita than apartment buildings. All these aspects affect climate change, and since the topic is of current interest, people are trying to decide what will be the best solution in development for the future.

1.2. Problem statement

This thesis will be analysing the question of the future of single-family houses. In the past decade, the question of climate change has become a priority for a lot of countries, and everyone is trying to find the solution, as well as the one who is responsible for climate change. Along with gasoline cars, detached housing is found to be an unsustainable way of living by more and more sources. However, this thesis will analyse what was the foundation for such assumptions and if the ban on all future single-family houses will create a more sustainable future or if is there a different approach that might be used. This thesis aims to find a solution for single-family houses that will provide a more sustainable future.

1.3. Approach and methodology

For this thesis the main chosen research method is quantitative. The theoretical part of this work is based on the overview of diverse thematic literature and scientific articles.

1.4 Structure of the master thesis

The first part will provide information about the current situation in the world, and the political decisions that lead to the banning of detached housing and will be analysed research papers that disproof the connection between low-density housing and greenhouse gas emissions. In the second part will be introduced the potential division between rural and urban single-family houses. In addition will be analysed and suggested optimal floor area for a single-family house, which will be later used in the design for the current thesis. The third part will be provided principles for a low carbon footprint and will be selected materials for the project.

2. BANNING OF SINGLE-FAMILY HOUSES

In 2018 Politicians of Minneapolis were creating the Minneapolis 2040 plan, which decided the path of city development for the next 20 years. On December 7, 2018, the Minneapolis City Council adopted the idea of ending single-family zoning citywide. In a city before this decision, 70 percent of residential land was set aside for single-family homes. With new regulations, some of the plots will be allowed to build duplexes and triplexes instead of detached houses. Three main reasons for such development are "addressing the affordability crisis", "reducing economic and racial segregation" and "fighting climate change". The idea of fighting climate change had special resonance with young people. As one observer noted in writing about Minneapolis, single-family zoning, is "a policy that has done as much as any to entrench . . . sprawl." Single-family zoning policies, by artificially inflating housing prices and pushing families to seek affordable options farther away, contribute to increased greenhouse gas emissions. This is primarily due to the longer commuting distances required, leading to a higher reliance on cars and consequently more carbon emissions. On the other hand, multifamily housing units have a smaller carbon footprint compared to accommodating the same number of residents in single-family homes. This is because apartments have fewer exterior walls, making them more energy-efficient and easier to heat and cool. The reduced energy consumption in multifamily units contributes to lower greenhouse gas emissions when compared to single-family homes. (Kahlenberg, 2019) The solution of ending single-family zoning found a lot of support in the USA and even worldwide, accomplished what many thought to be impossible, creating a precedent for other cities in America. In 2019, Seattle made changes to its zoning regulations by modifying 27 single-family zones to permit the development of multi-family units. This adjustment aimed to increase housing density and diversify housing options within the city. Meanwhile, in Texas, the City Council approved a plan that allows developers to construct up to six units on plots originally zoned for single-family homes. However, this allowance comes with the condition that builders must allocate a portion of these units for families with lower incomes, ensuring housing affordability and accessibility for modest-income households. In July 2019, the City Council of Montgomery County, Maryland, made a unanimous decision to ease regulations on constructing in-law flats in areas that were previously zoned for single-family homes. This move was met with controversy but aimed to provide more housing options in the suburb of 1 million people outside Washington, D.C. (Kahlenberg, 2019) Similarly, the State of Oregon took a significant step in July 2019 by enacting a state-wide ban on single-family zoning in cities with populations of at least 10,000 residents. This ground-breaking development led to the requirement of allowing duplexes on parcels that were previously designated for single-family homes in these cities. Moreover, in cities with populations larger than 25,000, lots previously restricted to single-family homes were mandated to also permit multifamily units, including fourplexes. These policy changes reflect efforts to increase housing diversity and density in urban areas. (Bliss, 2019).

During the next year, German politicians decided to go even further with the restrictions on urban planning. According to Archywordys.com, starting the 2020 green party under the leadership of Michael Werner-Boelz agreed to not allow any new single-family homes (archywordys, 2021). The main reasons for that are the inefficiency of single-family houses in terms of energy use and the big amount of space and materials required for each house. According to "the guardian" Anton Hofreiter told Der Spiegel magazine in an interview "Single-family homes consume a large surface area, a lot of construction material and energy and they lead to urban sprawl and therefore generate more traffic." (Connolly, 2021) Hofreiter is concerned that living space in German towns and cities is getting smaller, while rents are getting higher and purposes that the country needed to radically rethink its residential development policies. "Local authorities should be ensuring in their development planning in congested urban areas that where there is a lack of space this is used optimally to create affordable living areas," he said. "This is a central, social question, particularly in our large cities." (Connolly, 2021). Instead of single-family houses politicians propose more dense apartment buildings.

Even though the ideas behind these restrictions were good at first sight, a lot of people were concerned about how it will affect living conditions and economics in the future. One of the concerns was the inability in the future to choose a way of living since all the choices were restricted and people are forced to live in apartments. Christian Baldauf, the lead candidate for the CDU (Christian Democratic Union) in the state of Rheinland-Pfalz, expressed the view that Germans who wish to build their own homes should have the freedom to do so without being subjected to excessive regulations or restrictions. "This is an example of an anti-family, ideological policy." Daniel Föst of the pro-business FDP accused the Greens of "wanting to put people off the dream of owning their own home" (Connolly, 2021). Another concern was said by Lars Feld, one of Germany's leading economists, who warned that a ban on family homes was not the solution and would likely lead to more social inequality. The reason for that is that already existing houses will rise in value significantly and more people will be forced to rent therefore rents will rise even further.

All these news and decisions are relevant to the current thesis topic because they create questions about the future development of cities not only in their towns but in the world in general. If the ban on single-family houses has such good improvement to the environment, then should they be banned everywhere? Will it be more environmentally friendly for the whole population of Earth to live in one huge apartment megapolis with skyscrapers, where the density is much higher than in most cities, instead of separate cities, towns, and villages, where the usually dominant part of the housing is single-family houses?

3. IMPLICATIONS OF URBAN STRUCTURE ON CARBON CONSUMPTION IN METROPOLITAN AREAS

The topic of climate change is not new. The overarching goal of the Paris Agreement was to strengthen the global response to the threat of climate change and keep the global temperature rise below 2 °C above pre-industrial levels. In addition to that Paris Agreement also proposed to pursue efforts to limit the temperature increase even further to 1.5 °C. As a significant contributor to global GHG emissions, the building sector will need to be addressed with urgency, including the change of typical construction of buildings. Currently, the sector is responsible for 38 percent of global emissions; 17 percent are from the operation of residential buildings (UNEP, 2020). Before that scientists were creating predictions about how bad the situation on Earth will be for more than half of the last century. The biggest problem with climate change is that to fix it, all the countries and all people in them need to unite and agree on changing the common way of living. For that should be increased awareness of the problem and then they should be proposed the solutions. One such solution, proposed by the politicians in the first stages, was to densify the cities, since by early calculations dense metropolitan areas were seen as the ones that produce less carbon emissions on a per capita basis than surrounding, less dense rural areas. The solution seemed simple and beneficial for the developers, but in 2010 Jukka Heinonen and Seppo Junnila from Aalto University made research and published it in IOP Science on 28 March 2011 under the name "Implications of urban structure on carbon consumption in metropolitan areas". In this research, instead of typical production-based studies, was decided to calculate greenhouse emissions according to consumption-based assessments. The main reasons for that were the numerous studies that demonstrated that a significant share of all greenhouse gases (GHGs) attributable to a certain product or a service is produced at the second or third tier of the supply chain.

In their research, J Heinonen and S Junnila analyzed the two largest metropolitan areas in Finland – the Helsinki metropolitan area with the surrounding cities of Espoo and Vantaa, and the Tampere metropolitan area with the seven surrounding cities, divided according to the level of urbanization into two groups, urban cities in the Tampere Region (UCT) and rural cities in the Tampere Region (RCT). (Heinonen, 2012) The purpose was to analyze the effects of density, dominant building type, private driving, and income on carbon consumption. The study results are interesting in that they indicate a relatively small impact on carbon emissions based on the type of urban structure, whether it's a densely populated metropolitan area with apartment buildings or a less dense suburban area with detached housing (Figure 1).

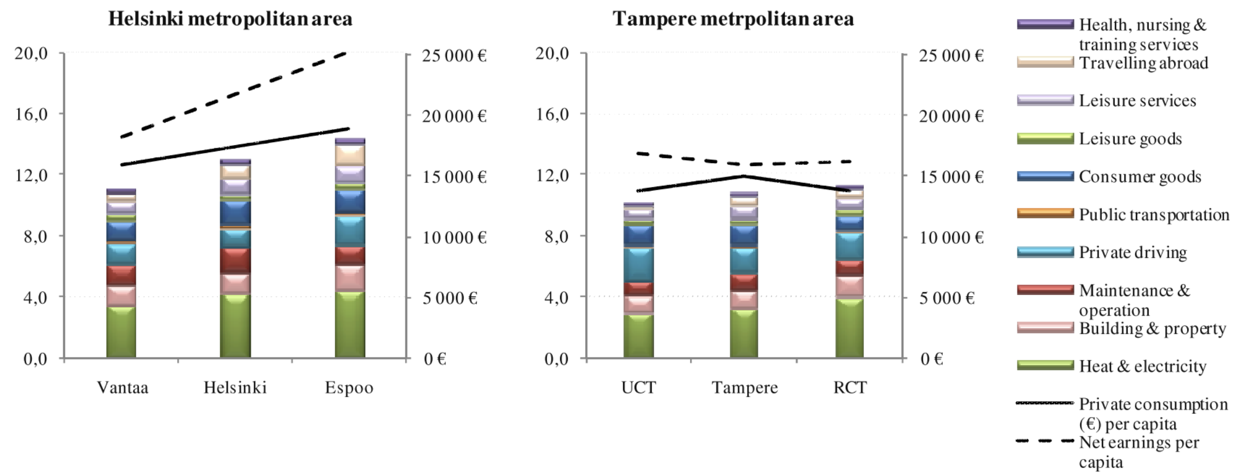


Figure 1. The annual carbon consumption per capita (tons CO2-ekv), private consumption (€), and net earnings (€) in the two metropolitan

Authors: Jukka Heinonen and Seppo Junnila

Unlike previous production-based studies, that found significant differences between these two types of urban structures, this study found no clear pattern between them. There are two main reasons for this. First, when communal building energy is included in the energy consumption per capita, the differences in energy consumption and emissions between building types decrease significantly. Second, although there is a slight increase in energy-related carbon consumption in the Tampere metropolitan area compared to the denser metropolitan core and UCT, this difference is overshadowed by the strong correlation between income and carbon consumption. (Junnila, 2011)

In the Helsinki metropolitan area, the emissions from energy use are 3.4 tons of CO2-ekv in Vantaa and 4.4 tons in Espoo, while in the city center of Helsinki, it is 3.7 tons, as per the hybrid model. Similarly, in the Tampere area, the emissions are 3.0 and 4.0 tons of CO2-ekv in UCT and RCT, respectively, and 3.2 tons in Tampere. This suggests that a high density of the city structure is not necessarily required to create low-carbon urban structures. However, as the density of the city decreases, the living space per capita tends to increase, which has a reverse effect on carbon consumption. Nevertheless, this effect is insignificant compared to the impact of income.

Therefore, creating low-carbon urban structures requires other means besides just intensifying the urban structure. Since emissions from housing energy have the highest potential for mitigation, increasing living space per person theoretically increases the demand for heating and cooling. However, the lifestyles and choices of occupants can significantly alter the outcome of the theoretical assessment. (Heinonen, 2012)

A similar conclusion was made by Wang et al. (2020). They found that, although conventional thinking suggests that population shifts from rural to urban settlements typically result in higher aggregate residential energy consumption due to a higher living standard in urban areas, this is not always the case. Continuing urbanization at what is projected to be a rapid pace is expected to increase the residential energy demand in this region beyond that found in any other region in the world. In developed regions and developing regions that are already highly urbanized (e.g. in Europe and Central Asia), further urbanization is insignificant because there is already a narrow gap between energy use in rural and urban residential sectors (Wang, 2020).

Considering all the mentioned above results, a single ban on single-family houses without changes in people's way of living and amount of consumption will not give the desired result of reducing GHG. Most likely, this decision will only cause the growth of the floor areas in apartments and therefore the amount of consumed energy will also increase. Since the ban on single-family houses will not give the needed results, this thesis will suggest what changes might be done to reduce GHG emissions without radical decisions, such as a complete ban on detached housing.

4. WHAT DIFFERENCES SHOULD BE BETWEEN THE URBAN AND RURAL SINGLE-FAMILY HOUSE

According to Jukka Heinonen's works, it is possible to say that houses in rural areas are producing less GHG than houses in cities. The reason for such a conclusion is Figure 2, from the paper "A Carbon Consumption Comparison of Rural and Urban Lifestyles". In this table, Jukka Heinonen brought results of his research which show that in rural areas only private driving is producing more CO2 than the city and metropolitan areas. All other aspects in rural areas are consistently lower in GHG emissions.

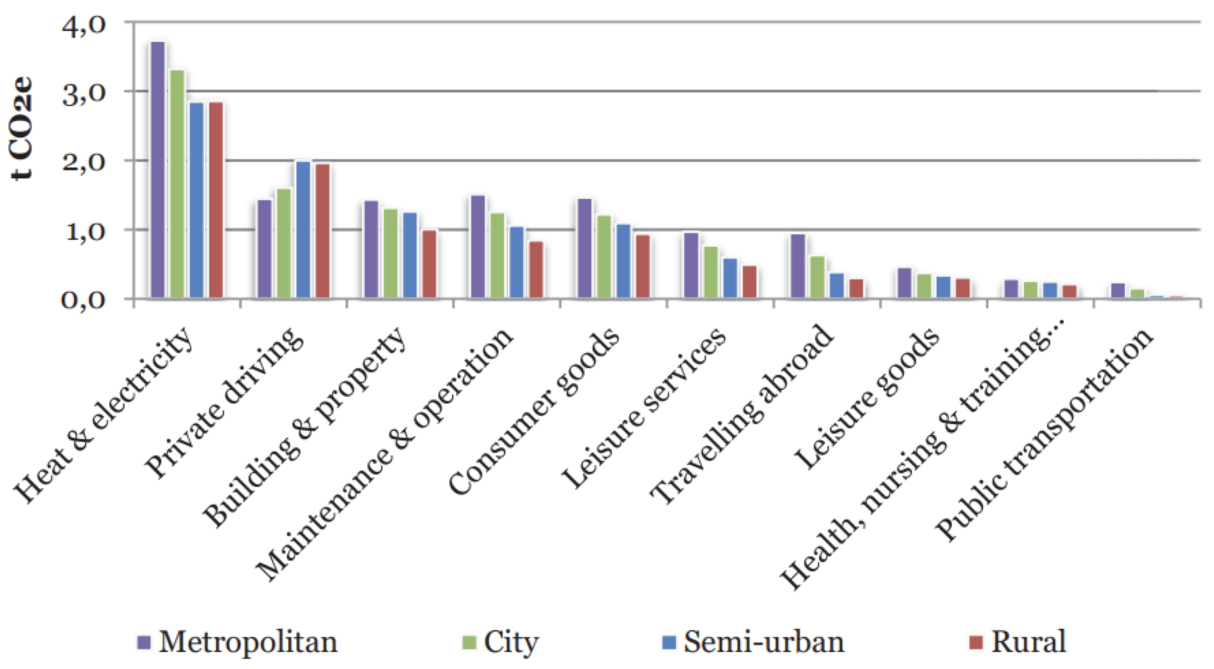


Figure 2. The annual per capita sectoral emissions (t CO2-eq.) in the reference year 2006 of the average consumers of the four area types. Author: Jukka Heinonen

The results give us perspective on the current situation in Finland but do not show the solutions for current problems. The city provides a big variety of goods and jobs that would be impossible in a small village. The creation of rural areas near the city will not be a good solution, since it will create a spread. The city will be spreading and the usage of land for individual houses as well as some additional parts, such as barns and storage spaces, will be unnecessary and simply unusable in the city. Like how the construction of a skyscraper in a village is illogical, the construction of rural houses in the city is also not a solution. Thus, single-family houses in rural areas and urban areas should not be the same and have differences suitable to the needs of the people to whom they were built. In this chapter will be provided possible aspects of division between rural single-family houses and urban single-family houses.

Possible aspects of division between rural single-family houses and urban single-family houses are:

- Plot area
- Number of houses on the plot
- House position on the plot
- Density of residents to floor area
- Garage

Plot area

The main difference between the city dwellers and the villagers is the interdependence of the first ones. Towns and cities newer were designed to be self-sufficient. The idea behind them is a community where people collectively are doing the most suitable for them jobs and help each other. In the village people also help each other, but the common way of living includes farming and individual solving of everyday needs. Thus, the average villager needs more plot area for his way of living than an average city dweller. In this thesis, the proposed plot area for the new neighbourhood will be roughly 350 m^2, which is enough for the city. Commonly, plot areas are from 600 m^2 to 2000 m^2 in the city which seems unnecessary and is causing city spreading.

Number of houses in the plot

Since the lifestyle in rural areas presupposes more farming and garden activities, the number of needed instruments and storage space is commonly greater than in a typical household in the city. Additional barns and storage might be needed also for the animals but keeping them in the city would be unreasonable. This way can be suggested that plots in rural areas could be originally proposed to have from two to four separate houses. Meanwhile, the plot for the single-family houses in the city could be designed for one or a maximum of two separate houses. In this thesis, the proposed plots for the new neighbourhood will have only one house per plot. Additionally will be put a small storage room in the fence (look at the site plan).

House position on the plot

The usual position of a house in the plot is determined by the possible building area and the preferences of a client. Nevertheless, in semi-urban and rural areas houses tend to be located further from the road and near to the centre of the plot. In this thesis the houses' location was proposed to be near the road, thus creating the feeling of a denser road, more common for the cities. Similar house locations on the plots in cities might be found across Europe, especially in Great Britain and the Netherlands, or in Asian countries, such as Japan.

Density of residents to floor area

According to Statistics Estonia, a little less than one in two families have underage children. The statistics reveal that when families with underage children are broken down by settlement region, all regions contain the highest proportion of families raising one minor child, but the trend is more pronounced in cities, and as you move from cities through small towns towards the countryside, the percentage of large families in the family statistics also goes up. (Statistics Estonia, 2023). From this statistic was concluded that in urban areas single-family houses could be designed with a smaller number of separate rooms and with fewer square meters in general, since the families in cities are smaller, and thus require less area. In the rural areas opposite would be true – houses will most likely need more separate rooms and overall square meters. Proof of this was shown by Eurostat: "An ad-hoc module that formed part of the EU statistics on income and living conditions (EU-SILC) survey in 2012 shows that the average size of a dwelling in a rural area of the EU-28 was, on average, larger than the average size of dwellings in towns and suburbs or cities. In 2012, dwellings in a rural area measured an average of 104.3 m², which was 5.2 m² more than in towns and suburbs, and 15.2 m² more than in cities." (European comission, 2017)

Garage

Since rural areas usually provide their dwellers with less variety of goods and services than the cities, it is more likely that rural dwellers will need personal transport. Common rides for big distances and poorly developed public transport leave villagers with no choice and encourage them to have multiple cars. Also, the winters in rural areas are generally colder and snowier. As a result, single-family houses in rural areas have more reasons for heated garages. In the city, houses do not have such an urge for a garage. Winters are warmer and less snowy, and public transport is developed to the stage where people usually do not need to wait longer than ten minutes at a bus stop. Additionally, such services as car sharing or electrical scooters fill the need for quick city travel to such an extent that a lot of young people are considering surrendering the idea of owning personal transport. Considering such development in the cities, in this thesis, single-family homes will not be provided with a garage, but instead, each house will be given a parking slot.

5. HOW MUCH M2 DOES A PERSON NEED

According to the Enerdata statistics, in 2008 average residential floor area per capita in Estonia was 27.87 m², which was one of the lowest results In Europe. For comparison, the average residential floor area per capita in Finland was 36,24 m². The lowest result was in Romania with 21.23 m² per capita and the highest was in Denmark – 54.36 m² per capita. (Enerdata, n.d.) The difference between the lowest and highest results is 33 m², which brings up a question – what would be the optimal size of floor area per capita?

A similar question was asked in the concept paper "Energy sufficiency in buildings". The authors of this paper, Anja Bierwirth and Stefan Thomas were analyzing how energy sufficiency could be brought into the building construction and usage. The definition of energy sufficiency was taken from the concept paper "Energy sufficiency: an introduction" (Darby & Fawcett, 2018). The paper was prepared for eceee´s energy sufficiency project and proposes the following definition of energy sufficiency as an outcome:

Energy sufficiency is a state in which people's basic needs for energy services are met equitably and ecological limits are respected. (Darby & Fawcett, 2018)

Anja Bierwirth and Stafan Thomas are trying to implement the idea of energy sufficiency in building design and construction. The demand for energy and subsequent emissions are on the rise due to improved access to energy and the proliferation of energy-consuming devices. Additionally, the continuous growth of both floor area and population contribute to this increase. Furthermore, as global temperatures have been rising and are projected to increase further, there has been a noticeable surge in the need for cooling. Consequently, greenhouse gas (GHG) emissions continue to escalate, exacerbating the climate emergency we are facing. Since buildings are meant to provide room, security, usability, and a certain level of comfort, the authors chose four aspects that determine how well a building serves these functions. These aspects also determine the level of energy and resources needed to fulfill them. Chosen four aspects are space, design and construction, equipment, and use of the building. The most relatable aspect of the previously asked question in this thesis is space.

By comparing several European statistics from different years, can be made a statement that in European countries the sizes of buildings have been continuously growing over the last decades (Enerdata, n.d.) (European comission, 2017) Such development increased energy consumption for heating and cooling, as well as the number of needed materials for construction. Furthermore, because of the population aging and the fact that elderly households often stay in houses they used to live in for years, a higher percentage of houses could become under-occupied. This is especially relevant when a single-family house is designed with a lot of additional and often unnecessary floor area. In Germany, a continuous increase in living space per capita can be observed from 35 m² in 1991 to 46 m² in 2015 (status 2016) with a projection of 47 m²/cap (BBSR 2015) to 52 m²/cap (Deschermeier & Henger, 2015) in 2030. (Thomas A. B., 2019)

For a better understanding of people's feelings about floor area, this thesis used answers of interviewees to the question of how they would assess their flat concerning the size to the per capita living space they live on. The question was asked by Stefan Thomas for the "Energy sufficiency policy: how to limit energy consumption and per capita dwelling size decently". The results are shown in a graphic below (figure 3) (Thomas S. B.-A., 2017). The particular interest in these results for the current thesis is the fact that flats with floor area starting from 30 m² to 49 m² per capita are commonly seen by inhabitants as "exactly right". Based on this information can be assumed that 30-49 m² per capita can be considered a suitable amount of area for comfortable living. One thing that should be considered is the fact that gathered information is referring to living in a flat and not in a single-family house.

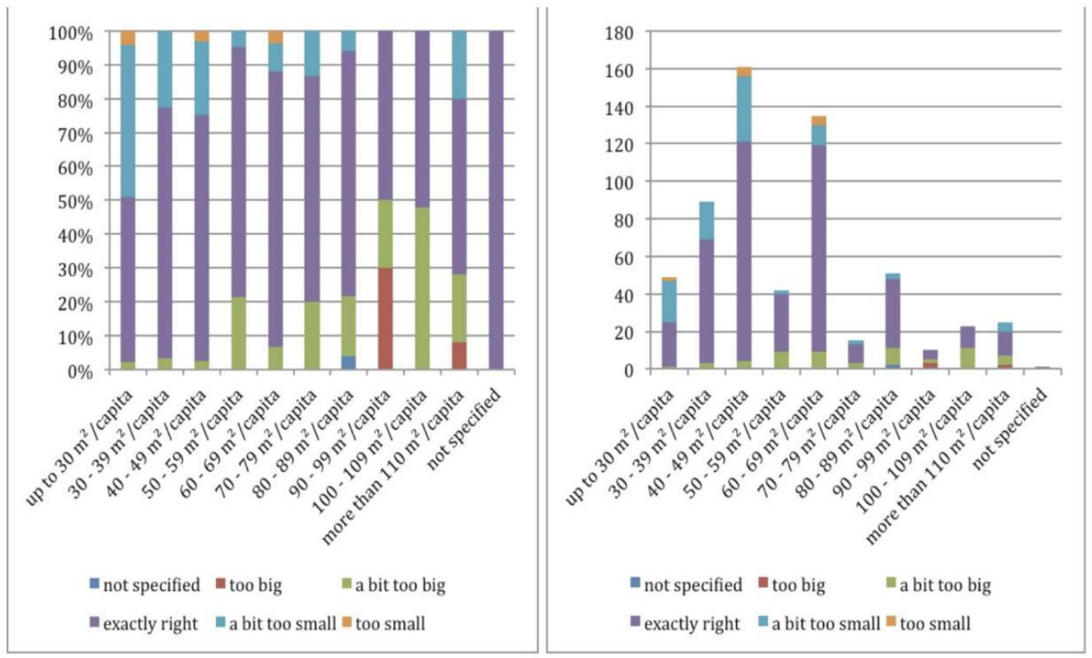


Figure 3. Answers of interviewees to the question of how they would assess their flat with. Authors: Anja Bierwirth & Stefan Thomas

The Zurich study shows that total household primary energy is reduced by 15% when the chosen floor area per person is 30 m^2 instead of 45 m^2. Reduction in heating energy alone might be even higher, closer to approximately 33 %. (Pfäffli, 2012). Since Estonia's average floor area is 27.8 m^2 per capita, unlike in the other countries in Europe, overall Estonia's average floor area might be even expanded for more adequate usage without dramatic changes in energy consumption.

When considering the average floor area per person, it's important to consider the number of people living in a household. Single individuals tend to occupy more space compared to members of larger households because they typically use common areas like the kitchen, bathroom, and corridor. This is also reflected in the definition of "adequate floor area" for households and single individuals who receive housing allowances in Germany:

'Adequate' … are the following sizes of flats: (a) for a single person: 50 m2 living space, (b) for a household with two persons: 2 rooms or 65 m2 living space. For every person that belongs to the household the living space increases by 15 m2. The number of rooms is in addition to a kitchen (up to 15 m2) and secondary rooms. (§8 (2) Wohnraumnutzungsbestimmungen (living space usage regulation) of the Federal State of North Rhine-Westphalia)

In addition to the German regulations, several sources can be found that provide recommendations for adequate floor area per capita for a private house. One such source is the International Code Council (ICC), which publishes building codes and standards that are widely adopted in the United States and around the world. The ICC's International Residential Code (IRC) provides minimum requirements for habitable rooms and spaces in residential buildings, including requirements for minimum floor area per occupant. According to them, the adequate floor area per capita for a private house can vary depending on several factors such as the number of people living in the house, their age, lifestyle, and cultural expectations. However, a general guideline is to provide a minimum of 100 square feet (9.3 m^2) of living space per person. This means that a family of four would require a minimum of 400 square feet (37.16 m^2) of living space, not including common areas like the kitchen, living room, and bathroom. However, this is only a minimum guideline, and many factors can influence the actual required floor area, such as the number of rooms, the quality of life desired, and the budget available. (International Code Council, 2021)

The Ernst and Peter Neufert reference book Architects' Data, Updated by Professor Johannes Kister on behalf of the Neufert Foundation with support from the University of Anhalt Dessau Bauhaus, can be also found in suggested sizes for subsidized households (figure 4). In the book can be found information that "Housing subsidy is carried out at the state level: the extent of grants, the size details of subsidized houses and application conditions can therefore differ from state to state and are laid down in the relevant housing subsidy regulations. The target housing subsidy group are households whose income does not exceed the level stipulated in the laws and regulations and households with two or more children and households with disabled members. The subsidy is in the form of loans at preferential rates, grants, guarantees, housing entitlement certificates, and the provision of cheap building land." (Neufert, 2012)

Household size	Maximum living area	
1 person	50 m^2	for each further person belonging to the household, the living area can be exceeded by max. 10 m^2.
2 persons	60 m^2	
3 persons	75 m^2	
4 persons	85 m^2	

Figure 4. Limits on the living area in subsidized housing (example) Source: Architect's Data

Since the example from the Architects' data refers to subsidized housing, the suggestion is to consider the maximum living area as a minimal starting point for an adequate and comfortable living area.

Estonian regulations do not provide information for the adequate or comfortable floor area for living, but Riigi Teataja does provide minimum requirements for the dimensions and floor area of the living space. According to it, in general, every living, working, and bedroom of a living space must:

1) be at least 8 m² in the floor area;

2) be at least 2.4 m in width (distance between opposite walls);

3) be at least 2.5 m the height, in the case of a one-apartment dwelling at least 2.3 m.

In a room with sloping walls on the attic floor, the minimum height must be ensured for at least half of the surface of the room, while when calculating the surface, only parts of the room where the height of the room is at least 1.6 meters are taken into account (Majandus- ja taristuminister, 02.07.2015)

Considering all the mentioned above information, was decided to develop several designs of floor plans with accumulative floor area between 100 m^2 and 120 m^2. This amount of square meters allows it to cover all the needs of a family in the city, produce comfortable living space for a family of four or five people, yet will not create too much unusable floor area nor will it consume too much energy for cooling and heating or building materials.

6. PRINCIPLES FOR LOW CARBON FOOTPRINT

The building sector is responsible for more than a third of the world's final energy consumption and carbon dioxide emissions. This includes emissions from the direct and indirect burning of fossil fuels in buildings, as well as the embodied energy in building construction. Residential buildings alone contribute to over 60 percent of the energy consumed within the building sector. The increasing demand for space cooling and air conditioners poses a significant challenge in terms of energy consumption. Emissions from housing are influenced by various factors, including the local climate, characteristics of buildings, occupant behaviour, and sociodemographic factors. These emissions encompass both embodied energy and carbon emissions during the construction phase of buildings. However, there are multiple barriers, often unique to specific local circumstances, that hinder the widespread adoption of mitigation approaches. As a result, suboptimal solutions become entrenched instead of implementing more effective measures. Housing plays a significant role in a society's infrastructure and serves as a valuable component of its social and cultural heritage. It not only fulfils present needs but also holds importance for future generations (Boydell, 2020). Therefore, it is crucial to prioritize the construction of housing that promotes health, durability, and resilience to climate change. By creating homes that are designed to withstand the test of time and incorporate measures to mitigate and adapt to climate change, we can ensure a sustainable and beneficial living environment for both current and future generations.

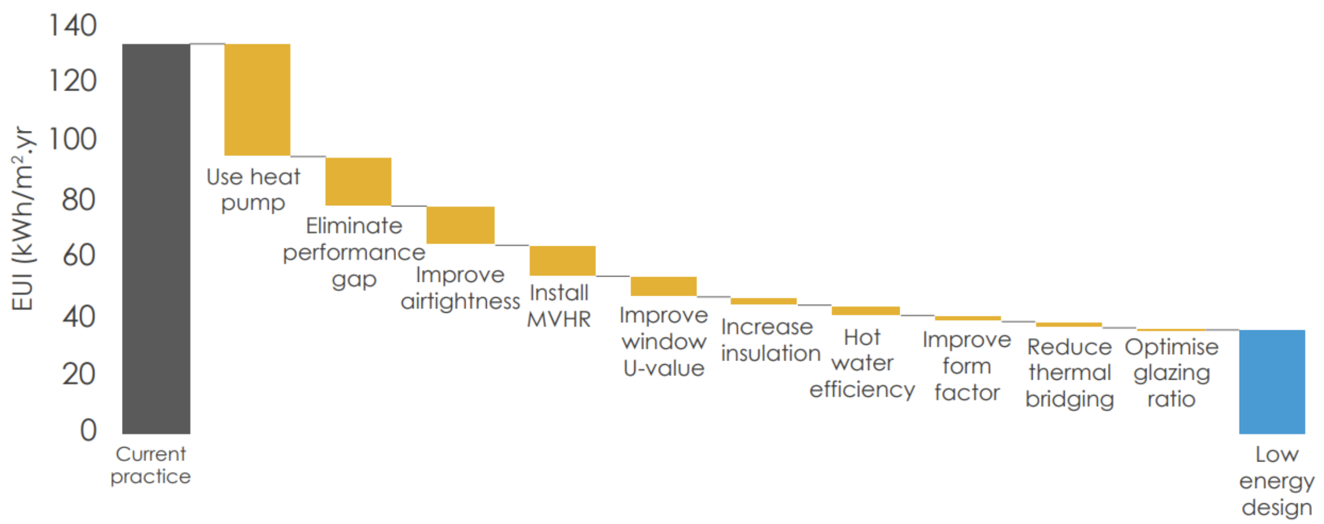


Figure 5. Opportunities to reduce energy consumption in a new residential development. Source - LETI, 2020

The specification of the fabric, materials, and HVAC systems will all have a significant impact on the energy demand of a building. However, even more, fundamental are some key design decisions that are typically shaped very early on. These are orientation, form factor, and glazing ratio. The orientation and glazing ratio of a building are crucial factors in reducing energy demand. North-facing windows typically result in net heat loss throughout the year, while South-facing windows can be designed to achieve net heat gain. However, it is important to optimize the amount of South-facing glazing to avoid the risk of overheating during summer months. East/West windows can provide beneficial heat gains, but they can also lead to overheating due to the low angle of the sun during the early morning and late afternoon. Careful consideration and design strategies are necessary to strike a balance between maximizing heat gain and minimizing the risk of excessive overheating in a building. (LETI, 2020) . In Estonia in living rooms and bedrooms, the glazed area of the windows that face west and south amounts at most to 30% of the total area of the westward and southward exterior walls of the room (Riigi Teataja, 2012)

LETI (2020) suggests that effective strategies for minimizing embodied emissions involve utilizing recycled materials in construction and designing buildings that can be easily disassembled at the end of their life, aligning with the principles of the circular economy. However, In this work, recycled materials will not be used since the technology of reuse is not common and has a lot of challenges in use. Additionally, it would complicate the calculations of greenhouse gas emissions. The principles that were used during the designing stage for lower amounts of greenhouse gas emissions are:

- No underground floor
- Reusage of excavated earth
- Light constructions for walls and roofs
- No heated garage
- Proper insulation
- Solar panels
- Minimal calculated adequate floor area
- Sun shading

No underground floor

At the construction stage, a lot of energy goes towards excavation works. Since the energy used in excavation is mostly produced by burning fossils in Estonia, to lower greenhouse gas emissions, the excavation part should be minimized in construction. Therefore, was decided to exclude the underground floor from the design. Not only it will reduce the amount of consumed energy, but also will eliminate part of the materials that otherwise would be used for the insulation, additional walls, and ceiling. In addition, the amount of excavated earth will also decrease, which will reduce the number of needed earth relocations.

Reusage of excavated earth

Even with the elimination of underground floors, some excavation works will be needed for the fundament and the roads. That is why one of the proposed design ideas is to use rammed earth as a material for the fence walls between houses. Commencing construction with rammed earth necessitates a deep comprehension of the climate and geographical context in which the structure will be built. Generally, the rammed earth technique achieves optimal results in regions characterized by high humidity and moderate temperatures. In colder climates, it may be necessary to incorporate additional insulation in rammed earth walls, while areas with abundant rainfall require supplementary measures to protect against precipitation. (Cao, 2020) The needed insulation will increase the width of the walls, so the main building will not be using rammed earth as a possible construction material, since the chosen plots and the floor area for construction were as small as possible. The walls of fences on the other hand do not need insulation, therefore rammed earth will be used for them, as an alternative to the typical fences, commonly done with the usage of metal, concrete, or brick.

Light construction for walls and roofs

United Nations Secretariat in 2020 low-emission report suggests, that in general, lightweight building construction methods like timber framing tend to have lower embodied energy compared to heavyweight construction such as concrete. However, there are some exceptions to this rule. Materials like aluminum and steel, although lightweight, have higher embodied energy. On the other hand, certain heavyweight construction techniques like rammed earth can be low in embodied energy.

It is essential to strike a balance and carefully evaluate different factors. For instance, while lightweight construction may have lower embodied energy, the thermal mass provided by heavyweight construction can offer significant advantages, particularly in climates with large temperature variations throughout the day. Each design should consider the optimal combination of materials based on factors such as climate, material composition, transportation distances, and other relevant considerations. (UNFCCC. Secretariat, 2020) For the current project will be considered the usage of ecococon as the main solution for the external walls.

No heated garage

Similar to the underground floor, in this project was decided to eliminate the heated garages. As was mentioned in the chapter "What differences should be between the urban and rural single-family house" in the text above, In the city houses do not have such an urge for a garage. Winters are warmer and less snowy, and public transport is developed to the stage where people usually do not need to wait longer than ten minutes at a bus stop. Furthermore, the availability of services like car sharing and electric scooters adequately fulfills the requirements for convenient city travel. These factors have led many young individuals to contemplate abandoning the notion of owning personal vehicles altogether. At the same time, the needed floor area even for the smallest garage would be 20 m^2, since the minimum width for a car near the wall must be 2,7 m and the depth for a parking spot is 5 m (EVS843, 2016). Since the chosen floor area for the houses is between 100 and 120 m^2, an additional 20 m^2 will increase the floor area and the needed amount of energy for heating by 16 % minimum. With the trends going towards rental cars this amount of floor area might be wasted and create additional unusable space for people with no cars. Considering all the mentioned above aspects was decided to provide each plot with one parking plot with a possibility of additional overhang. Families with more than one car on the plot of the new development will be created additional parking, which might also be used by guests.

Proper insulation

Dwelling fabric choices interrelated with climate, form, and occupant behavior have an impact on energy consumption through conduction, convection, and radiation of heat. All materials have a level of thermal conductivity, but insulation is the most effective at slowing the transfer of heat. Appropriate insulation decisions are made in consideration of the climate. (UNFCCC. Secretariat, 2020). In climates where there is a need for heating in low-energy buildings, such as Estonian, it is crucial to ensure that the entire building envelope is effectively insulated. The building envelope comprises all the elements that separate the interior from the exterior of the building. Its primary purpose is to create a comfortable indoor climate regardless of external weather conditions.

During cold periods, which typically occur from mid-October to the end of April in colder climates, the temperature inside the building envelope is usually higher than the temperature outside. Consequently, heat is lost through the envelope, and unless this heat is replaced, the interior of the building cools down and adjusts to the outdoor temperature. Conversely, in hot climates or during hot periods, excessive heat enters the building through the envelope. Therefore, it is essential to limit heat transfer in buildings regardless of the climate, and this is where thermal protection becomes crucial. A typical Passive House compact heating system can provide a heating power of about 1,000 W (that's the typical output of a hair dryer). The U-value of a Passive House wall needs to be quite low; otherwise, a considerable portion of this power would be used up by the external wall: For typical Central European buildings, U-values of Passive House walls should range between 0.10 and 0.15 W/(m²K); depending on the climate, these figures may be somewhat higher or lower. (Passive House Institute, 2021)

Solar panels

Solar energy is the cleanest, most abundant renewable energy source available. Photovoltaic (PV) technologies directly convert energy from sunlight into electricity. When sunlight strikes the PV module, made of semiconductor material, electrons are stripped from their atomic bonds. This flow of electrons produces an electric current. PV modules contain no moving parts and generally last thirty years or more with minimal maintenance. According to Eesti Energia, solar panels can reduce annual electricity costs by up to 70%. Almost all new residential-detached buildings in Estonia use PV panels to achieve A-class in energy consumption labels. To generate up to 7000 kWh/year the minimum required free space on the roof should be about 32 m^2. For solar panels both flat and pitched roofs are suitable, but on the pitched roofs, only the southern side is suitable. (Eesti Energia AS, n.d.)To generate the maximum possible area for the solar panels, most of the houses are designed with flat roofs. That way the same building can be rotated in different directions for the best position on the plot without losing the needed for the solar panels area.

Minimal calculated adequate floor area and plot size

As was mentioned in the chapter "How many m2 does a person need", the Zurich study shows that when chosen floor area per person is 30 m^2 instead of 45 m^2, total household primary energy is reduced by 15%. With that in mind, to create a more sustainable design for the new development, the accumulative floor area for the single-family houses was chosen between 100 m^2 and 120 m^2. This amount will be considered in this work as a minimal adequate floor area for a family of four or five people. To not create too much of under-occupied space, all the variants for the new development were created in two different variants. The first one will be used for a family with kids, but when the overall number of residents will come to only two, who will be most likely the old parents, the house can be divided into two separate apartments. This way unused space will not be generating only losses through heating energy costs but will serve as an additional living space for new residents and will generate additional income for the house owners. The sizes of the plots were considered according to the fire department regulations, so between each house, the minimal distance is 8 m. Neuferts Architects data gives an example of a plot size for a detached house, as a demonstration of low density that will be created in the neighbourhood with single-family houses. The used size is between 350 and 450 m^2. (Neufert, 2012) Even though these numbers purpose was to demonstrate how few people can be living in such development, in this work the 350m^2 plot will be considered as a proper and adequate size for a house. In reality, in Estonia, almost all plots for single-family houses are starting from 600 m^2. Commonly size of a plot is between 1000 and 1500 m^2. Because of this, the chosen plot size will allow an increasing number of dwellings on the building plot almost 3 times.

Sun shading

According to the United Nations report, Shading is an effective strategy to reduce heat gain from direct sunlight, particularly for glass surfaces, which are often the primary source of heat entering a home. In regions with composite or temperate climates that experience varying seasons, it is important to consider the use of shading elements that can be adjusted seasonally or fixed shading that corresponds to the sun angles. The orientation of the glazing (glass surfaces) plays a significant role in determining whether fixed or operable shading elements are more beneficial. Fixed shading, such as overhangs or awnings, can be designed to block the high summer sun while allowing the lower winter sun to enter, which helps with passive heating during colder months. This is particularly advantageous when the glazing is facing south in the Northern Hemisphere or north in the Southern Hemisphere. On the other hand, operable shading elements, such as blinds or curtains, can be adjusted by occupants to control the amount of sunlight and heat entering the space.

These are especially useful in situations where the orientation of the glazing is not ideal for fixed shading or when there is a need for flexibility in adapting to changing weather conditions. It is important to strike a balance with shading, as excessive shading during summer can reduce the amount of natural daylight entering the space. This can result in increased reliance on electric lighting, thereby offsetting any potential energy savings achieved through reduced cooling needs. Therefore, careful consideration should be given to the extent and design of shading systems to ensure they provide the desired thermal comfort and energy efficiency benefits without compromising daylighting requirements. (UNFCCC. Secretariat, 2020) In this project, preference was given to operable outdoor shading. The reasons for this solution are the limited buildable area and privacy. Since the overhangs needed to be included in the buildable area, their amount was minimized. The exterior shutters give not only needed shading in summer without consuming the building area but also provide privacy for the residents. Since the distance between houses is minimal, shutters will provide an additional barrier between houses.

7. CO2 COMPARED WITH THE QUALITY

During the studying of the materials for this thesis, a lot of sources were leaning towards the creation of more dense cities. The main goal of this thesis is not to argue with these solutions. The chosen design for the single-family houses in this work also implements the idea of more dense cities. The logical question that is occurring is why row houses, semi-detached or terraced houses were not considered in this work, since they seemed to be the logical solution for cities. The reason for the exclusion of such houses in this work is the attempt to show, that single-family houses are also can be built in more sustainable and suitable for cities manner. The proposed solution of single-family houses might be providing a smaller number of dwellings and requires more materials for the construction, than a dwelling with semidetached houses or row houses would. But life in a car or a tent would be even more sustainable. The main goal of this work is not only to create a sustainable solution but also a desirable and comfortable living space. A single-family house does have some characteristics that even a semidetached house cannot. The feeling of privacy and ownership is important for people and needed to be respected, as well as the opportunity for a choice. The majority of people are preferring to live in a house, but simply do not have an option of choice, because of their financial situation. In the last decade the quality of life was increasing and at the same time can be seen a growth in house ownership. According to European statistics, in 2008 only 25% of Estonians lived in a house. In 2021 already 38.5% of Estonians lived in a house. In the last 13 years, the percentage of people in houses grew by 13.5%. The desire of owning a house is not gone, but the proposed solutions are the reason for the city's spreading and are usually accessible only to a wealthier part of the Estonian population. That is why the goal of this work is to suggest an alternative to a common new house and give a solution that will cover people's needs and desires for a house but at the same time will not be a burden to the environment. This work is not a complete solution that might be considered the best solution for the future house. That is not the goal of this work. It should be considered as the only first step towards better solutions in the future. The list of principles for the city house as well as the list of principles for low carbon footprint need to be evaluated and, in the future, should be extended or changed if some of the suggested solutions will not be the best way to achieve sustainable future without losing a comfort of a single-family house.

8. MATERIALS

Addressing the whole life cycle of a building is crucial for effective climate change mitigation. In addition to operational energy and emissions, the embodied greenhouse gas (GHG) emissions associated with the construction, maintenance, and disposal of buildings need to be considered. These embodied emissions are released throughout the life cycle of a building and include emissions from extracting and manufacturing building materials, transportation, construction processes, and end-of-life disposal. According to the “Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation”, the share of embodied GHG emissions in buildings following current energy performance regulations is approximately 20-25% of the total life cycle GHG emissions. This means that a significant portion of the emissions associated with a building's life cycle comes from activities other than its operational energy consumption. However, as buildings become more energy-efficient and operational energy consumption decreases, the relative contribution of embodied emissions to the overall life cycle emissions increases. The paper suggests that for highly energy-efficient buildings, the share of embodied emissions can reach 45-50% of the total life cycle GHG emissions. This highlights the importance of addressing embodied emissions to achieve comprehensive climate change mitigation in the building sector. To effectively reduce embodied emissions, strategies can include using low-carbon and recycled materials, optimizing construction processes to minimize waste and energy use, implementing circular economy principles, and considering the entire life cycle of materials and components when designing and constructing buildings (Martin Röck, 2020). With that in mind, the chosen materials are EcoCocon straw wall systems, equine fiber cement boards, and thermowood vertical siding.

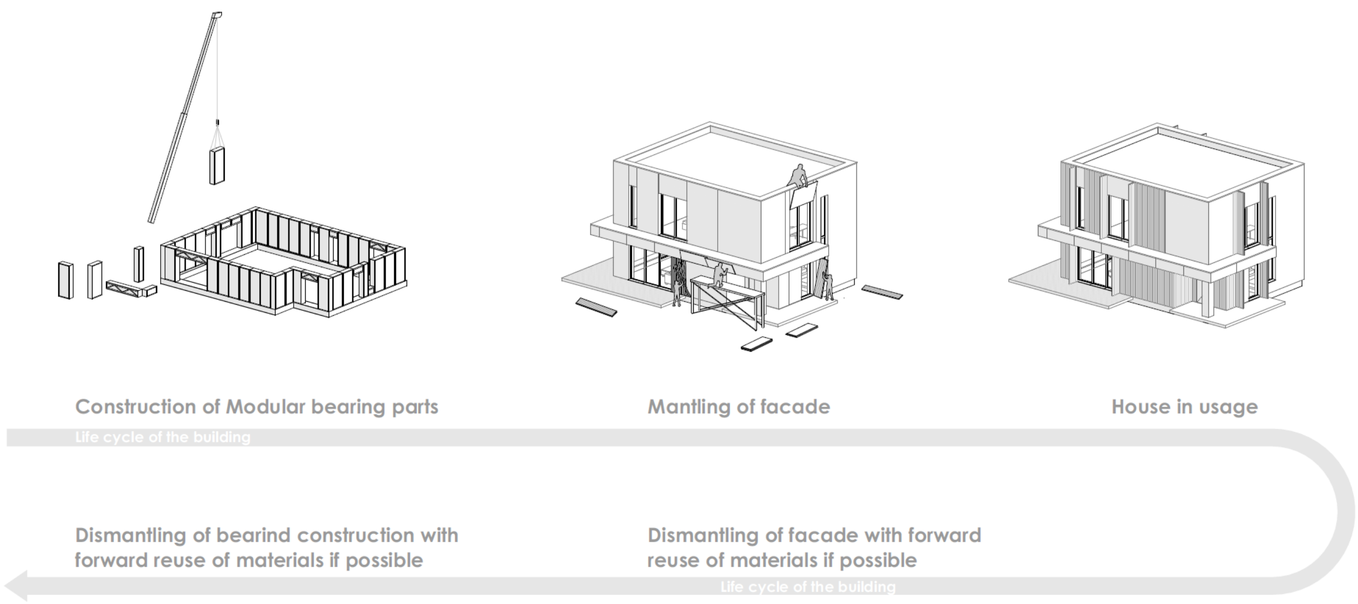


Figure 6 Life cycle of the building. Author's drawing

EcoCocon straw wall system

One of the main parts of construction that should be considered by architects already at the early stages of design is the materials chosen for the main walls and roofs. In this work, the main chosen building material is the EcoCocon straw wall system. The product has a lot of benefits. The first of them is the fact that EcoCocon produces verified solutions that can be easily applied at the building site, which gives creative freedom to the architects. EcoCocon is easier in transportation than modular houses and does not put architects into frames, as it is with modules. The second benefit is the fact that the materials, chosen for this type of wall are mostly wood and straw, which are renewable, and instead of producing the $CO^{2,}$ they store it inside due to the vegetation's natural abilities (97.6 kg of CO2 is sequestered per m2 of the panel). (EcoCocon, 2021). The third benefit of this material is the fact that in April 2016 it was certified by the Passive House Institute as a suitable material for a passive house design (Passive House Institute, 2021).

Figure 7. Ecococon wall system. Source – Ecococon, 2021

EQUITONE fibre-cement boards

Centre for Industrialised Architecture (CINARK) at the Royal Danish Academy has developed a digital version of the Construction Material Pyramid, which is similar to the food pyramid. The pyramid was published as a poster in 2019. The digital version of the Construction Material Pyramid makes it possible to compare, for example, CO2 footprints between different categories of materials or between material types within the same category. It also makes it possible to view different kinds of environmental impacts across different materials. The goal is that provides a simple way to gain a quick overview of the relative sustainability of the individual building materials. Based on Environmental Product Declarations (EPD), the Construction Material Pyramid shows the environmental impact of several relevant building materials. (CINARK, 2019)According to this pyramid, shown below, Equitone fibre-cement boards have a lower CO^2 impact than a majority of the façade cladding materials.

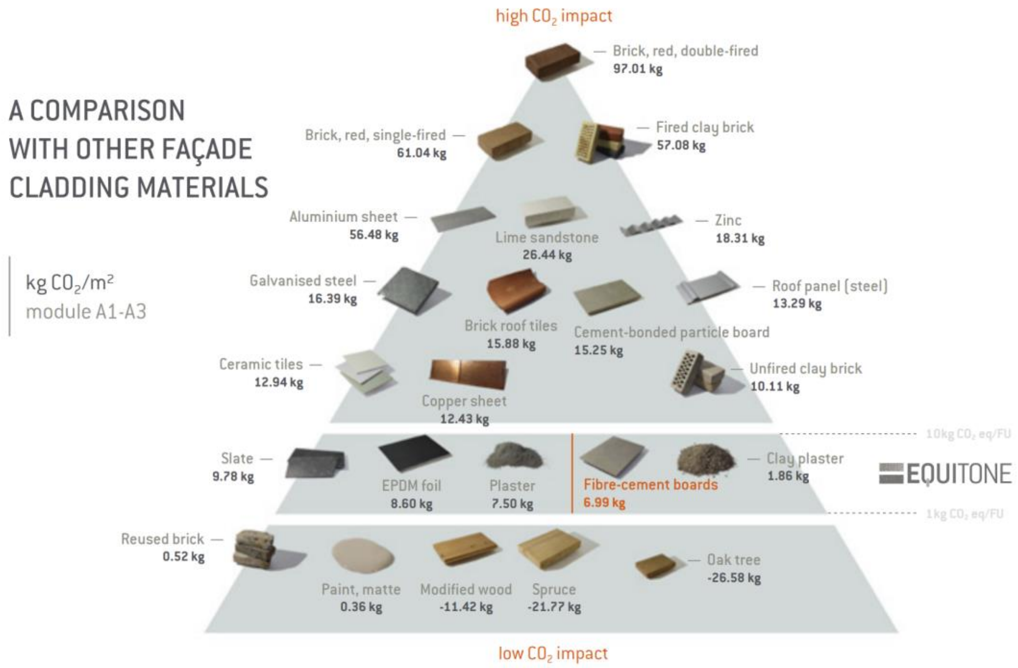


Figure 8. An Equitone comparison with other facade cladding materials. Source: EQUITONE

Another reason for choosing this material is that EQUITONE panels are known for their durability and longevity, often exceeding the expected lifetime of a building, typically 50 years. Their robust construction and resistance to weathering and degradation contribute to their extended lifespan. Because of that EQUITONE panels are designed with a disassembly in mind, facilitated by reversible fixation systems. This means that the panels can be easily removed from the building's façade without causing damage or irreversible changes. The ability to disassemble the panels opens opportunities for their reuse in various applications, including but not limited to façade cladding. (EQUITONE, 2022)

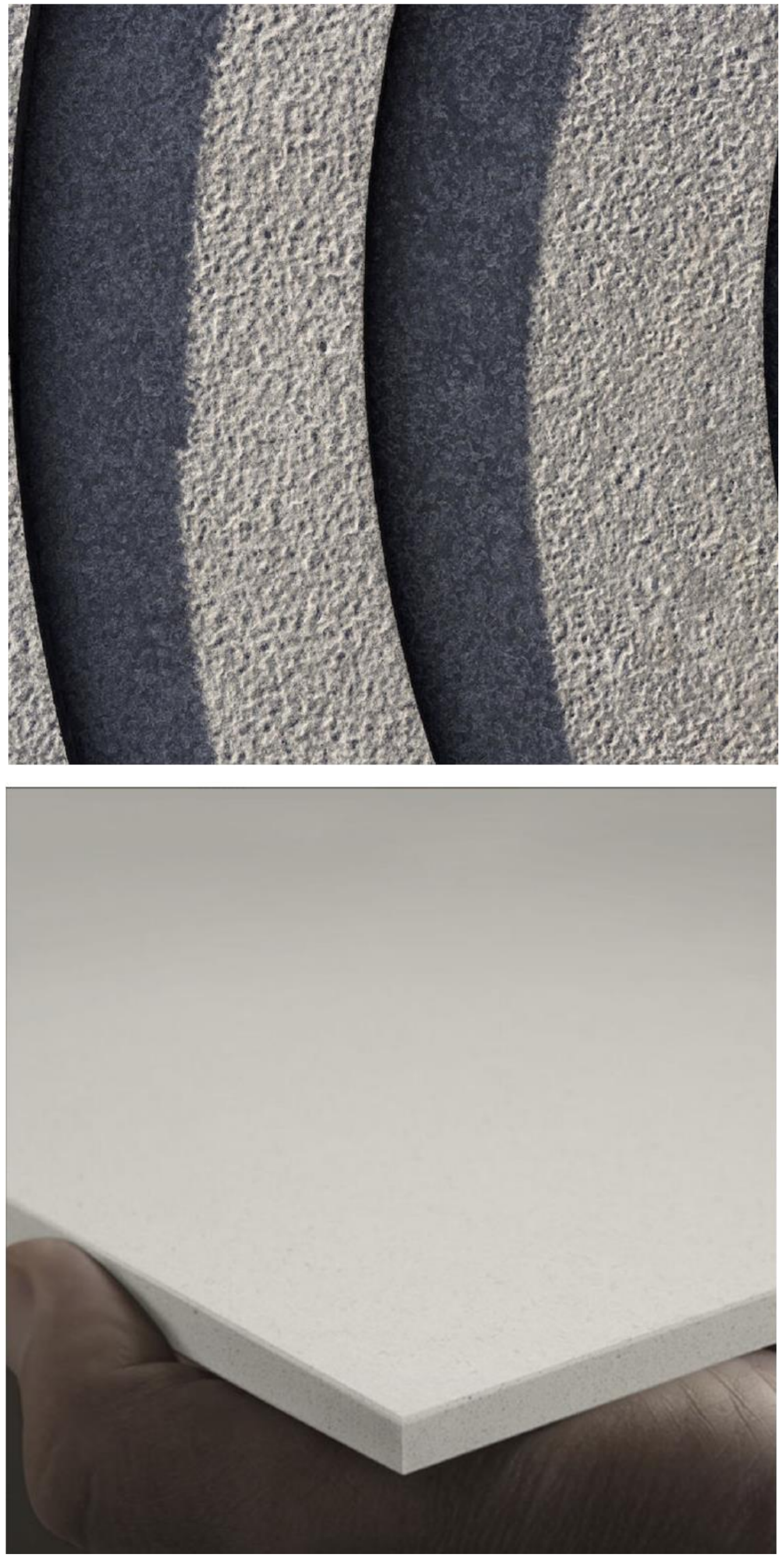


Figure 9. EQUITONE panels. Source - EQUITONE, 2022

Thermowood vertical siding

Thermowood, developed in Finland, is a sustainable wood product that has gained popularity for its diverse indoor and outdoor applications. It is created by subjecting softwood, typically pine or spruce, to a controlled thermal modification process involving heat and steam. Notably, this process is free from chemicals or additives, making Thermowood an environmentally friendly choice. It offers improved durability and stability compared to chemically treated or tropical hardwoods. The thermal modification alters the wood's structure, resulting in enhanced resistance to decay, rot, and fungal growth. Thermowood is known for its exceptional durability, making it suitable for a wide range of indoor and outdoor applications. The thermal treatment also gives the wood an appealing appearance, characterized by consistent color and texture. It often exhibits a darker tone, providing an aesthetically pleasing option for various design projects. Furthermore, Thermowood has a low resin content, contributing to its resistance to decay and rot. Importantly, it is free from toxic chemicals or preservatives, ensuring a safe and non-toxic material choice for construction and design purposes.

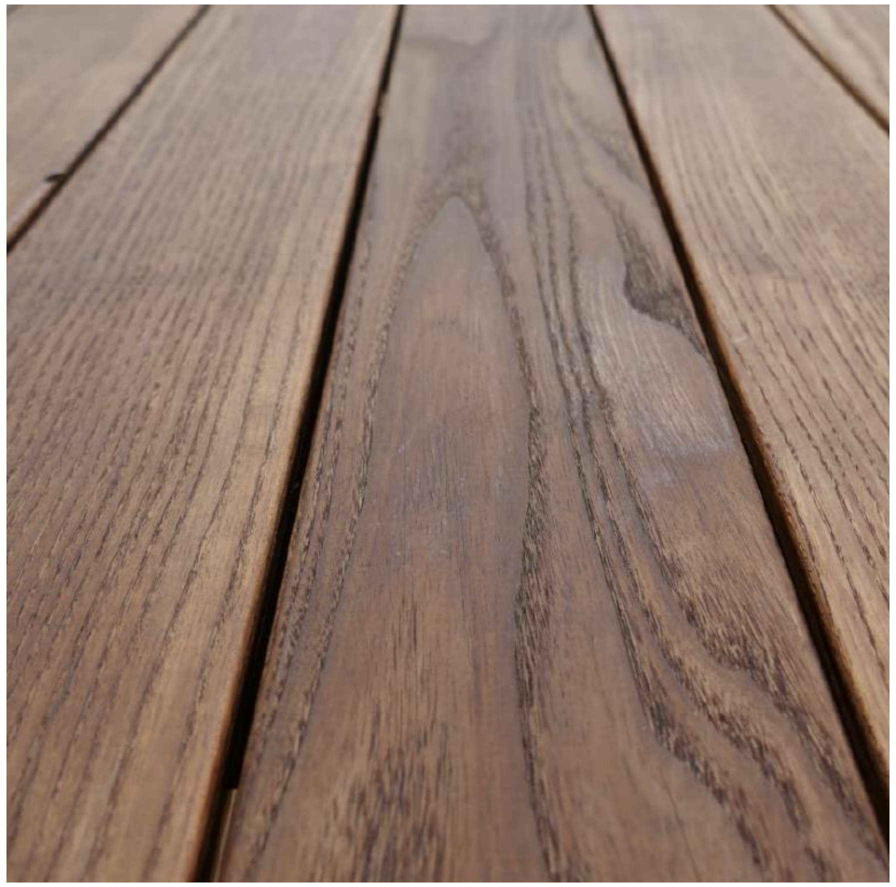


Figure 10. Thermowood texture. Source - Backegards

9. CASE STUDY

5 Zero-Energy Houses On Strijp-R – Eindhoven

An excellent example of a design featuring EcoCocon is the 5 Zero-Energy Houses on Strijp-R in Eindhoven, the Netherlands. Strijp-R is a revitalized industrial site that has transformed into a sustainable urban district focusing on innovative urban living and green spaces. Completed in 2016, these houses showcase sustainable living, innovative design, and the use of eco-friendly materials and technologies.

The development of these houses followed a Collective Private Development model, allowing future residents to collaborate and create their housing projects. This approach ensures personalized designs and resident involvement throughout the development process. The houses were designed in a modern "Bauhaus" style, emphasizing simplicity, functionality, and clean lines. The incorporation of historical building materials pays homage to the neighborhood's industrial past.

As zero-energy houses, these homes generate as much energy as they consume over a year. This is achieved through energy-efficient features and renewable energy generation. Heating and hot water are provided by electrical heat pumps, and each house is equipped with 25 solar panels to offset energy consumption and power the electrical systems and appliances.

To ensure energy efficiency, proper insulation is crucial. EcoCocon (formerly StroTec) prefabricated straw panels were utilized in these houses due to their high insulation value, structural integrity, and vapor permeability, creating a comfortable indoor climate.

The houses feature a split-level floor plan with rooms of various heights, adding spatial interest and creating a unique interior atmosphere. The living rooms are particularly spacious, measuring at least 30m² with a remarkable height of nearly 4.20m. The exterior design presents a sense of uniformity and cohesion with white plastered facades and black window frames, reminiscent of the famous Weißenhofsiedlung in Frankfurt, known for its modernist architecture. (World Architecture Community, 2017)

The 5 Zero-Energy Houses on Strijp-R exemplify sustainable and vibrant urban living, showcasing the successful integration of EcoCocon and other eco-friendly elements into a forward-thinking design.

Figure 7. Bas Gijselhart | BASE PHOTOGRAPHY

10.SUMMARY

This thesis explores the future of single-family houses in urban areas and concludes that a complete ban on such houses may not be the optimal solution for every city in terms of eliminating greenhouse gas (GHG) emissions from construction. However, it suggests that single-family houses can be modified to reduce their carbon footprint. Proposed modifications include reducing the plot area and the number of houses on a plot compared to similar houses in rural areas. The positioning of the houses on the plot could be closer to the road, and the floor area and the number of rooms could be smaller than typical new developments, excluding garages from the plot. These changes would make the houses more suitable for urban environments and distinguish them from rural and suburban houses.

The recommended optimal floor area for these houses is 100-120 m2, with a plot area of approximately 350 m2. Additionally, several principles are suggested to minimize the carbon footprint of these houses. These principles include avoiding underground floors to reduce excavation, reusing excavated earth for fences using a rammed earth technique, using lightweight constructions for walls and roofs, excluding heated garages to save energy during construction and heating, ensuring proper insulation for improved winter performance, installing solar panels on roofs to reduce reliance on electric stations, and using the minimum calculated adequate floor area.

Furthermore, optimal materials for load-bearing structures and facades are selected based on their sustainability and environmental impact.

PRACTICAL PART

1. INTRODUCTION

As a practical part of this thesis was decided to create a new urban single-family housing in Kopli. In this housing will be created several variants for detached houses with the implementations of previously described principals for urban houses. Overall, 6 variants of single-family houses will be shown, as well as their location at the site plan.

2. LOCATION

The location for the current project is the planned land area in the eastern part of Neeme settlement in North Tallinn, on the southern shore of Paljassaare Bay. Formerly the land was used for farming by the ETKV (Eesti Tarbijate Kooperatiivide Vabariiklik Liit). According to the "Neeme tn 30 tinnitus ja lähiala detailplaneering", made by Ruum ja maastik OÜ in 2022, the planned area consists of 95% production land and 5% residential land, which are located on Neeme tn 30 and Neeme tn 30a properties, Neeme tn 34a property on non-purpose land and Neeme tn 26 property on residential land. Formerly occupied with greenhouses, presently the surface is undeveloped. An existing detached house and auxiliary buildings are located on the property at Neeme St. 26. The properties of the planned area are privately owned. High greenery is growing on the property at 30 Neeme Street, and the plot of residential land at 26 Neeme Street has been landscaped. (RUUM JA MAASTIK OÜ, 2022)

The planned area is connected to the city through the existing Neeme Street. The house's height on that street is typically 1.5 - 2 story up. On the right side of the planning, the area is located existing garage campus, with the potential to create an innovative micro apartment neighborhood. On the southeast of the planned area is located the former garbage Kopli mountain, which was covered with earth and grass and now is used as a park by the residents of Neeme Street. The path from the mountain is going to the north and connects with the seashore. The seashore will be developed further by the city of Tallinn and the promenade will connect this side with the newly developed part of Kopli Liinid. Overall the neighborhood is starting a new development cycle and the attractivity of the please is shifting towards more positive results. This way the location is suitable for the implementation of a new, more progressive approach to housing. Such solutions can help to spark interest in the new generations and fill the area with young residents.

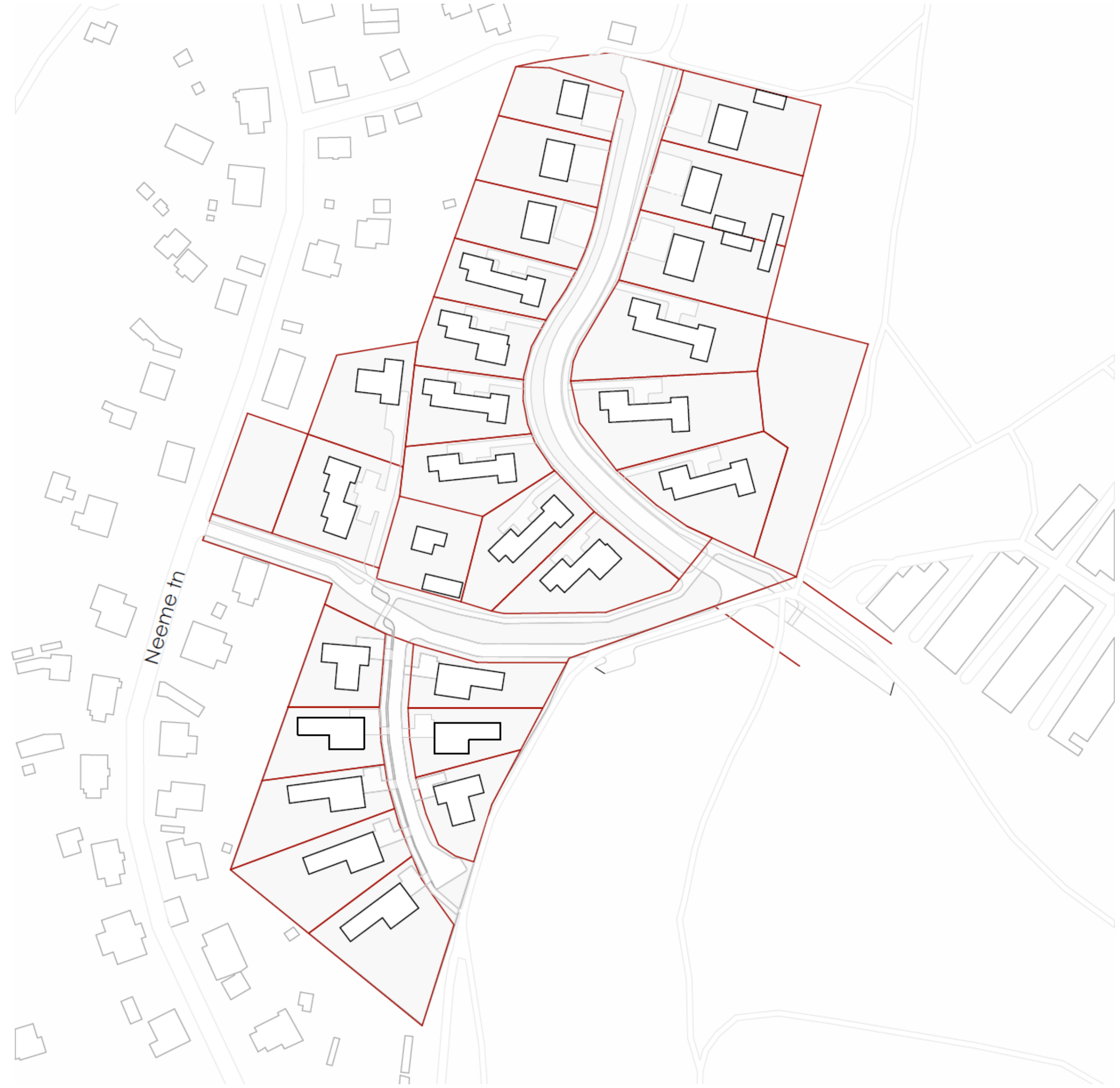
Existing site

Proposed design

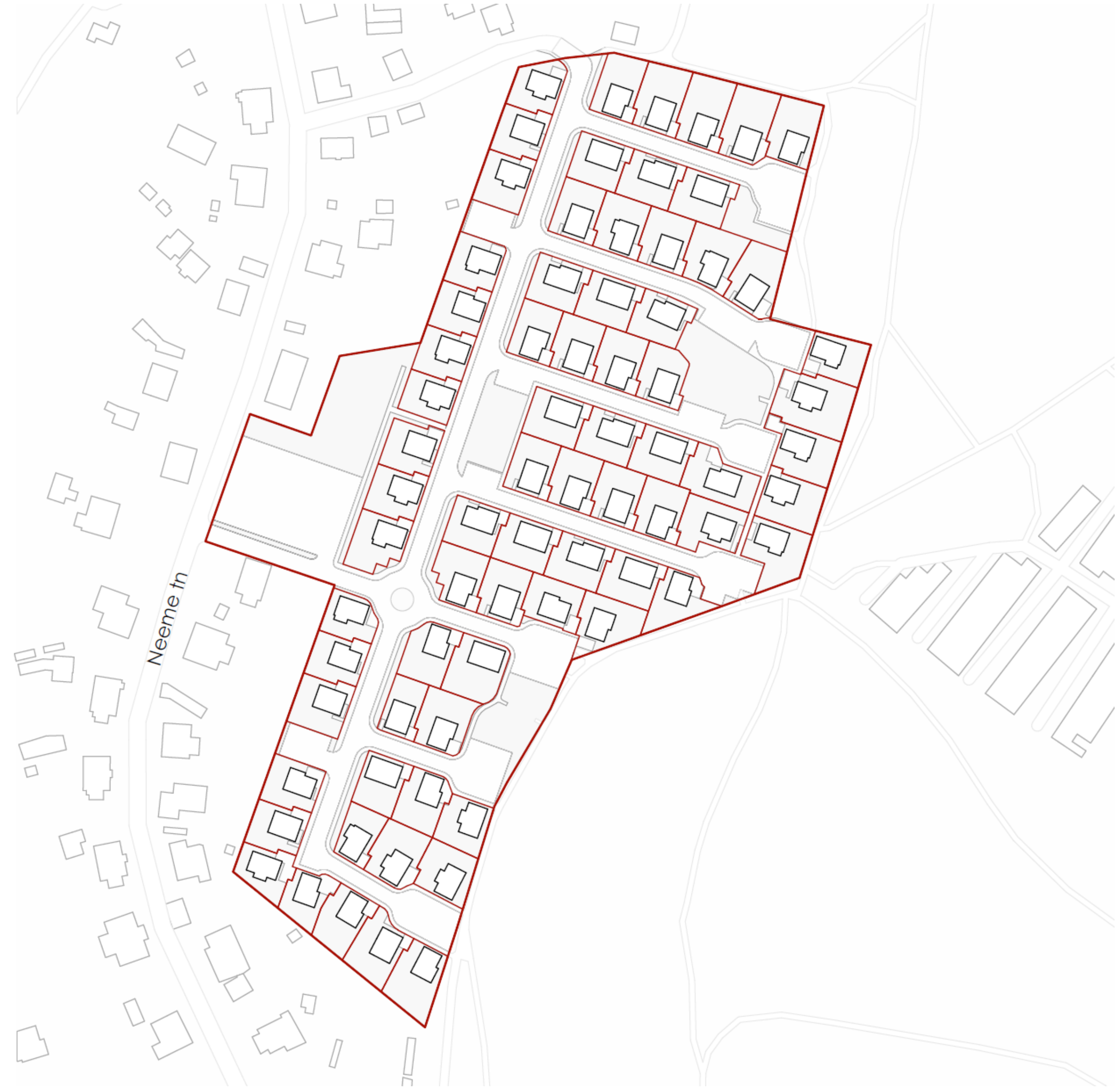
SITUATION PLANS, REDUCED SIZE. SCALE ON PANEL 1:5000

3. COMPARISON WITH THE EXISTING DETAILED PLANNING

The decision for plot division and housing position on the plots in this work was changed and is not following the existing detailed planning, introduced by Ruum ja Maastik OÜ in 2022. The main reason for that was the attempt to introduce a solution with denser development. In comparison with existing planning, which divides the area into 15 single-family houses and 10 duplexes, the proposed solution in this thesis creates 73 individual plots for single-family houses. Such division was possible through the reduction of the plot area. Formerly plot sizes varied between 800 and 1700 m2, but in this work was decided to create 300 – 400 m2 plots. The reason for such size is described in Chapter 4.



Stylized existing plot division plan by Ruum ja Maastik OÜ. Source: Tallinna planeeringute register



Proposed by author plot division plan

PLOT DIVISION SCHEME, REDUCED SIZE. SCALE ON PANEL 1:2000

4. SITE PLAN

The project part of this thesis proposes a single-family housing development. The project aims to be community and pedestrian-oriented, as is shown in the schemes. The roads are equipped with cul-de-sacs at the end to restrict the movement of cars, but pedestrian pavements are intersecting between each other as well as existing pavements on a hill, creating walkable space for the families.

Roads between houses are designed to be walkable and secure for pedestrians since cars will be using these roads only for parking. This way the space of the roads is not wasted during the day and creates a safe environment for kids to play, ride a bike or play. Similarly, cul-de-sacs can be used by residents as a place for gatherings and evening amusements.

Cars' movement paths

Pedestrians' movement paths

PEDESTRIANS' AND CARS' MOVEMENT PATHS REDUCED SIZE. SCALE ON PANEL 1:2000

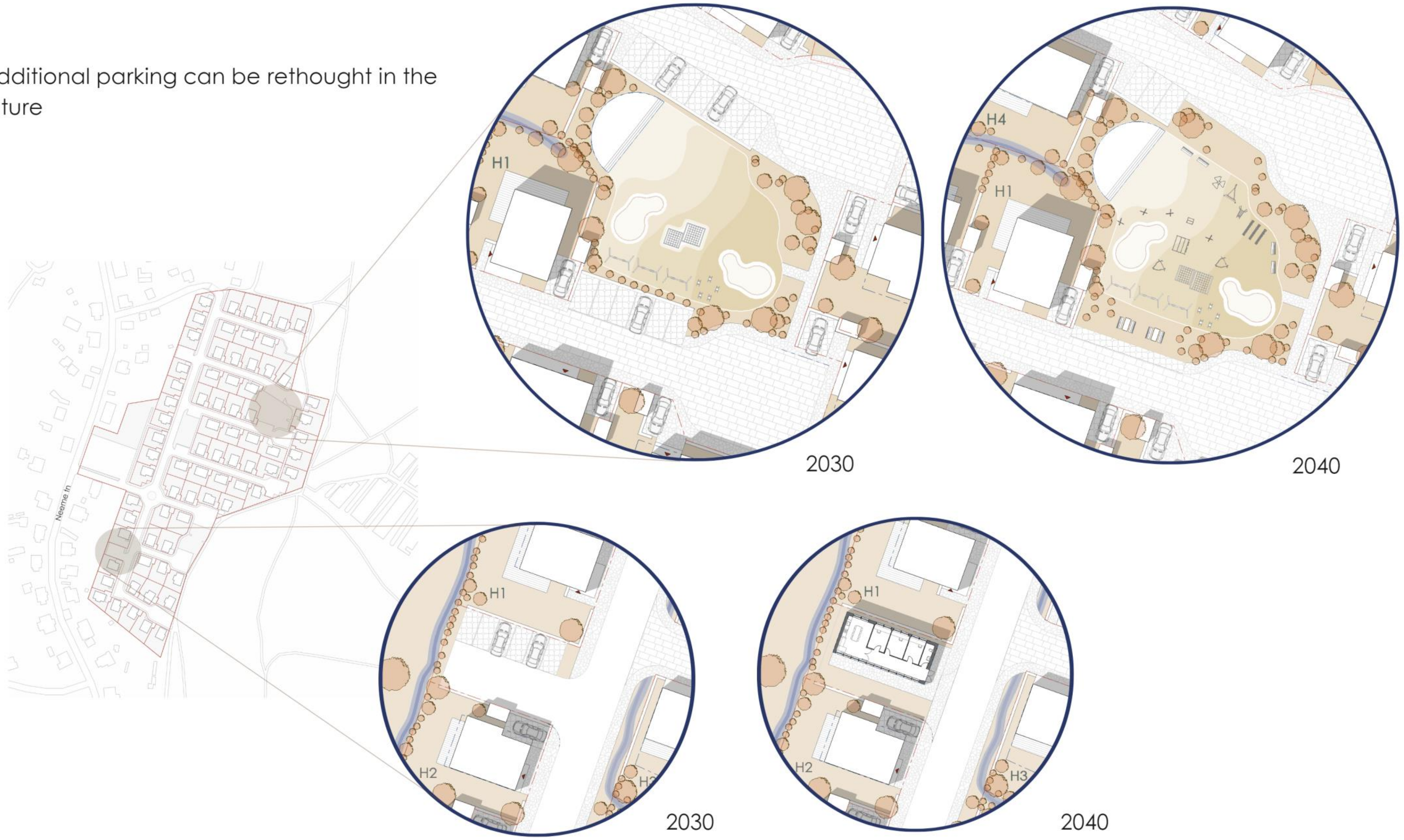
SITE PLAN, REDUCED SIZE. SCALE ON PANEL 1:500

Houses on the plots are located near the border, with their porches coming side by side with the sidewalks. Such a decision was made to create a more urban feeling for the street. To prioritize sunny parts of the plots, houses then were moved to the eastern part of the plots. With such solution the mid-day and evening sun will be seen from the gardens and living rooms. Near each house was designed a personal parking slot for cars as well as a storage space for bicycles and scooters, giving people an option for transport. To meet the need for additional parking, the entrance to the plot was designed the parking plot for guests and some additional parking was made alongside the roads. Houses and parking slots are surrounded by 1,2 m tall walls, with can be made from rammed earth, which will be generated during the construction of a road on fundaments. Beside them will be used trees and bushes for creating a greener environment. For the same reason, the plot's intersections will be separated with the use of a hedge. Another part of the plot's division will be an open drainage system, which will dry during sunny days and create a place for different vegetation which can temporarily be flooded during raining season. Between roads also can be found playgrounds for the kids and sports fields for adults.


Site plan
Border of the planning site
Border of the proposed plots
Border of the possible construction area
Tiled road surface
Tiles with grass for the paking slots
Tiled pedestrian pavement surfae
Playground
House variant
Vegetation
Hedge/ rammed earth fence
Open drainage system
10 m
N
Neeme tn

Even though currently private houses need two or even more cars, and, therefore, need more parking, it might not be the case in the future. Currently car sharing is rapidly developing, at the same time EU creates more and more restrictions for cars. At the same time after covid 19 can be seen a development in home office – a lot of people are choosing to work from home even now. With that in mind, current site plan can be changed in the future, if the number of cars will reduce and number of people at home during the day will increase. Additional parking can be shifted into small working units, where the residents of this neighbourhood could work during the day, if they need a working place that house cannot provide but don't want to go to the office. Or these units can be used as a place for school kids to do their homework. Some other parking plots can be shifted into additional room for playgrounds as well.

Additional parking can be rethought in the future




Site plan 1:500
Border of the planning site
Border of the proposed plots
Border of the possible construction area
Tiled road surface
Tiles with grass for the paking slots
Tiled pedestrian pavement surfae
Playground
House variant
H1
Vegetation
Hedge/ rammed earth fence
Open drainage system
10 m
N
Neeme tn

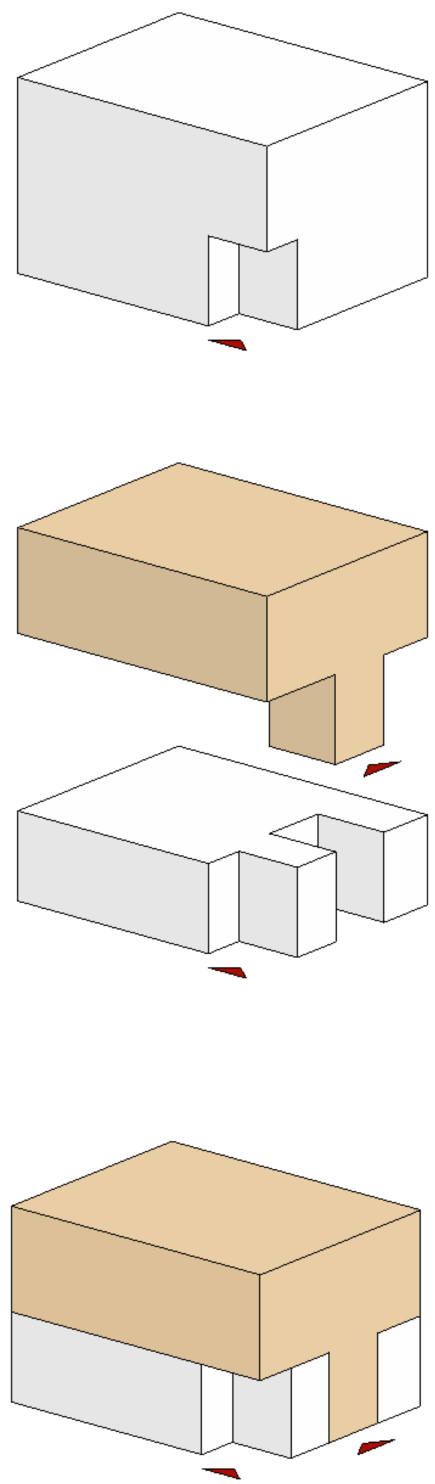
5. ROAD SECTION

ROAD SECTION, REDUCED SIZE. SCALE ON PANEL 1:100

6. PLANNING AND DESIGN APPROACH

One of the single-family housing problems that were targeted in this project is the problem of under-occupied homes, meaning that houses are too large for the needs of the household living in them. Such a problem typically happens when older couples remain in their home after their children have grown up and left. In this project, each variant of a house is planned with an option for division without a massive change in room positions. This way the older couple will have an option to divide their house into two apartments and rent or sell a part of a house, creating affordable additional living space for young people. Another option for the usage of such planning is creating temporary divisions in the same house for creating more privacy for adult children. This way families can stay in the same house with less influence on each other's lives and can be used by the same family for generations.

The design will be featuring window shutters for additional privacy inside and as an architectural element, which will allow reducing sunlight during hot summer days. The main material for them is thermowood. With the complimentary usage of fiber-cement boards, houses will have a modern yet close-to-nature look. Together with intense vegetation on the plots, such a design will give a pleasant feeling to the residents and create a good environment for raising children.



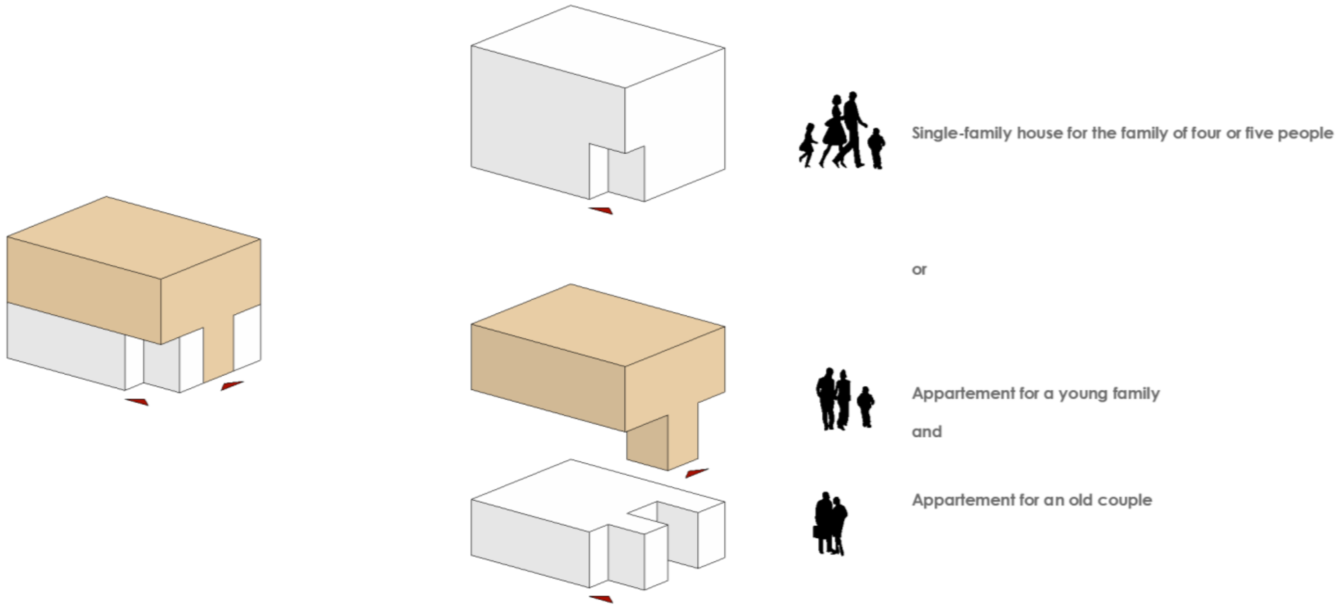
HOUSE 1 DIVISION SCHEME

HOUSE 3 WITH AND WITHOUT OPEN WINDOW SHUTTERS

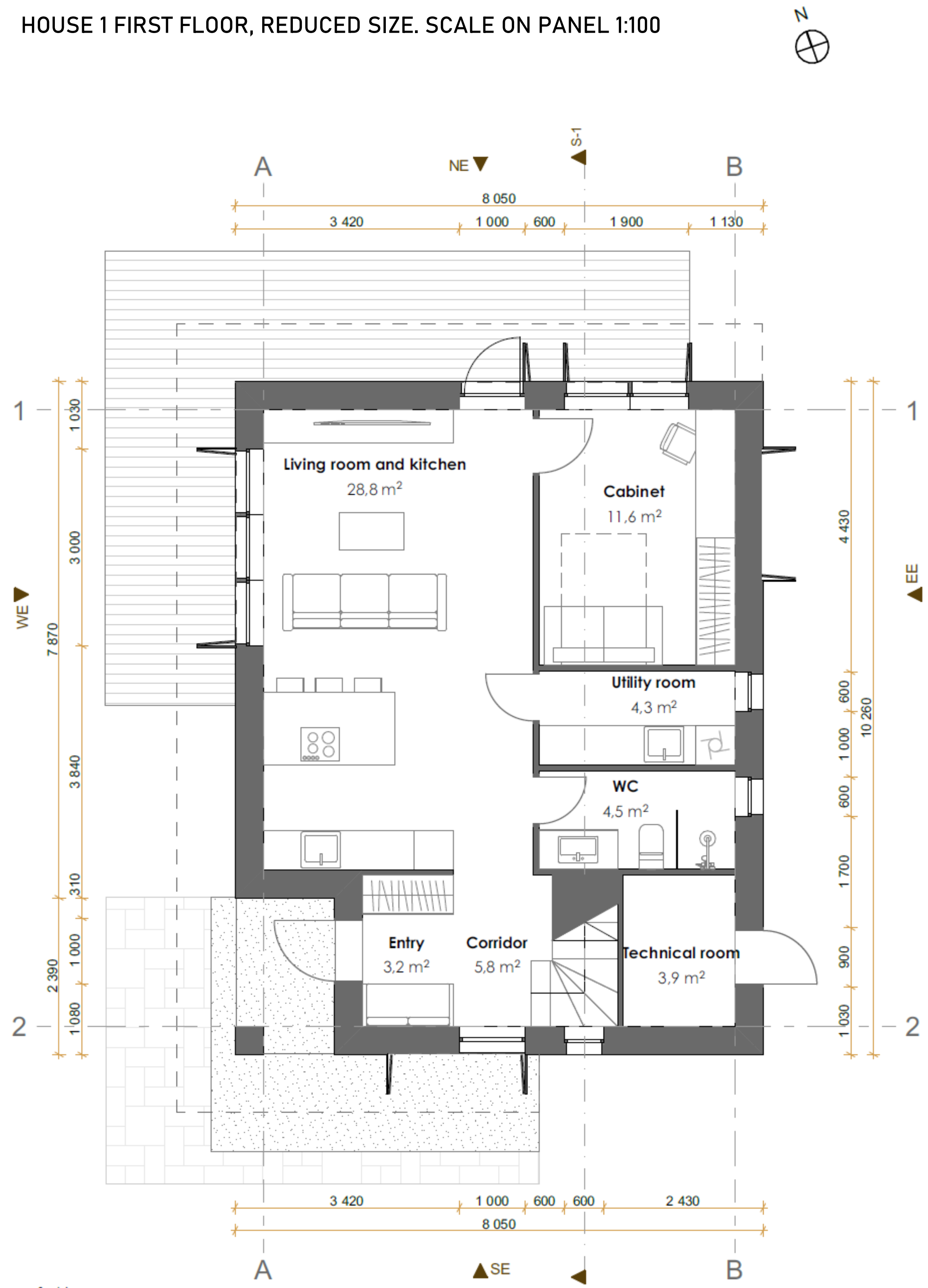
7. HOUSE VARIANT 1

The first house can be divided through the separation of the stairs and, therefore, the entire second floor. This way from one 5 room house can be generated two separate appartements. The additional entrance for the second apartment can be made from the existing window. All sizes for the planning were chosen accordingly to the optimal adequate room area, which was chosen in Chapter 5.

HOUSE 1 DIVISION SCHEME



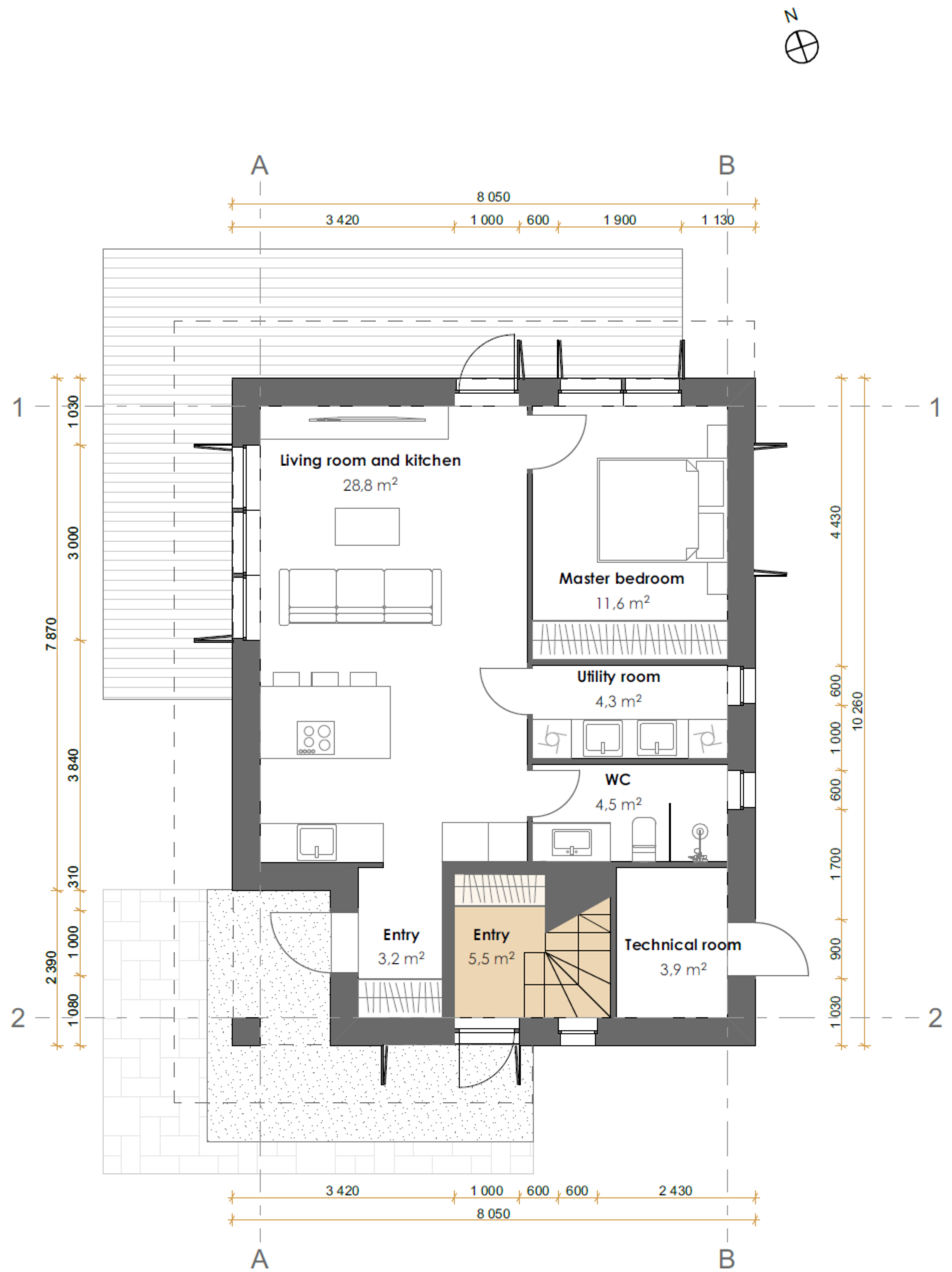
HOUSE 1 FIRST FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



1. House
1. Variant

Construction area 82,0 m²

1st floor net area 62,1 m²
net area total 127,0 m²



1. House
2. Variant

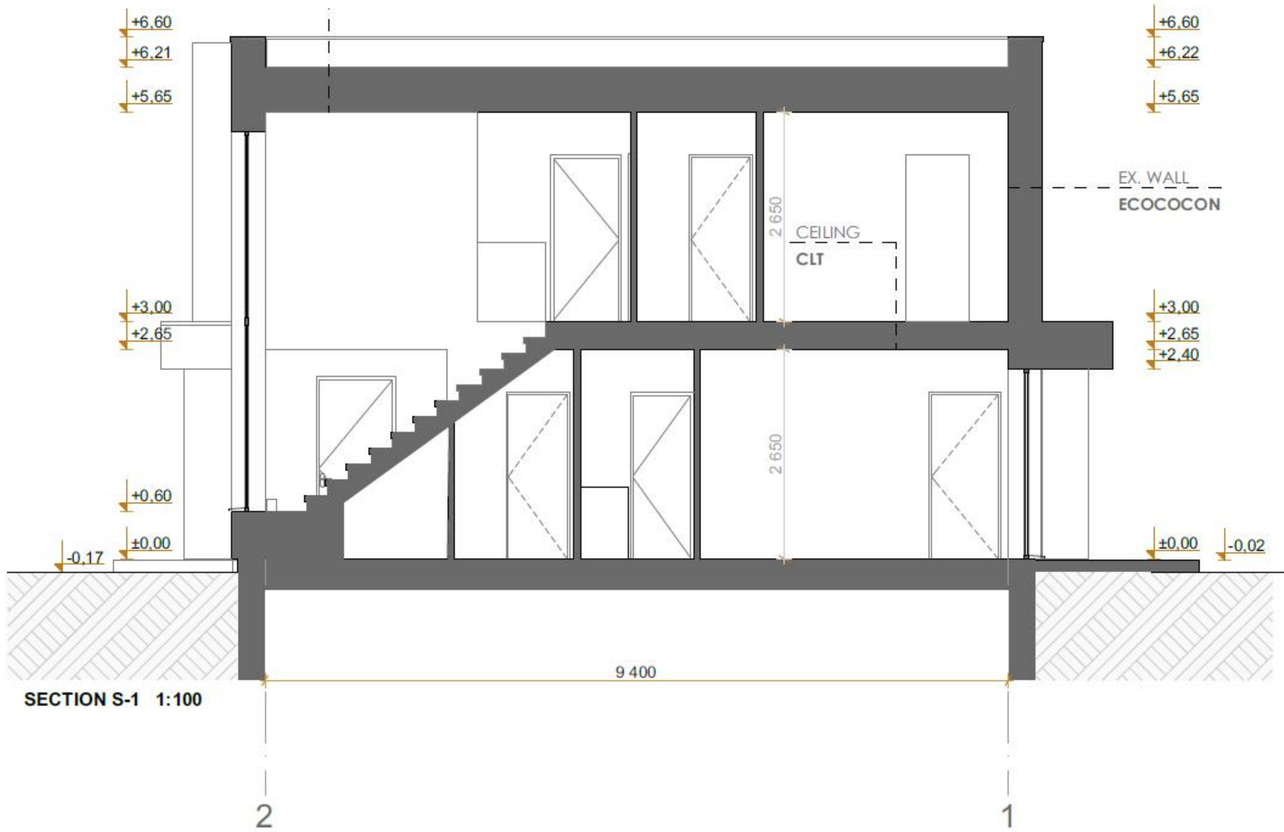
Detached area

Construction area 80,2 m²

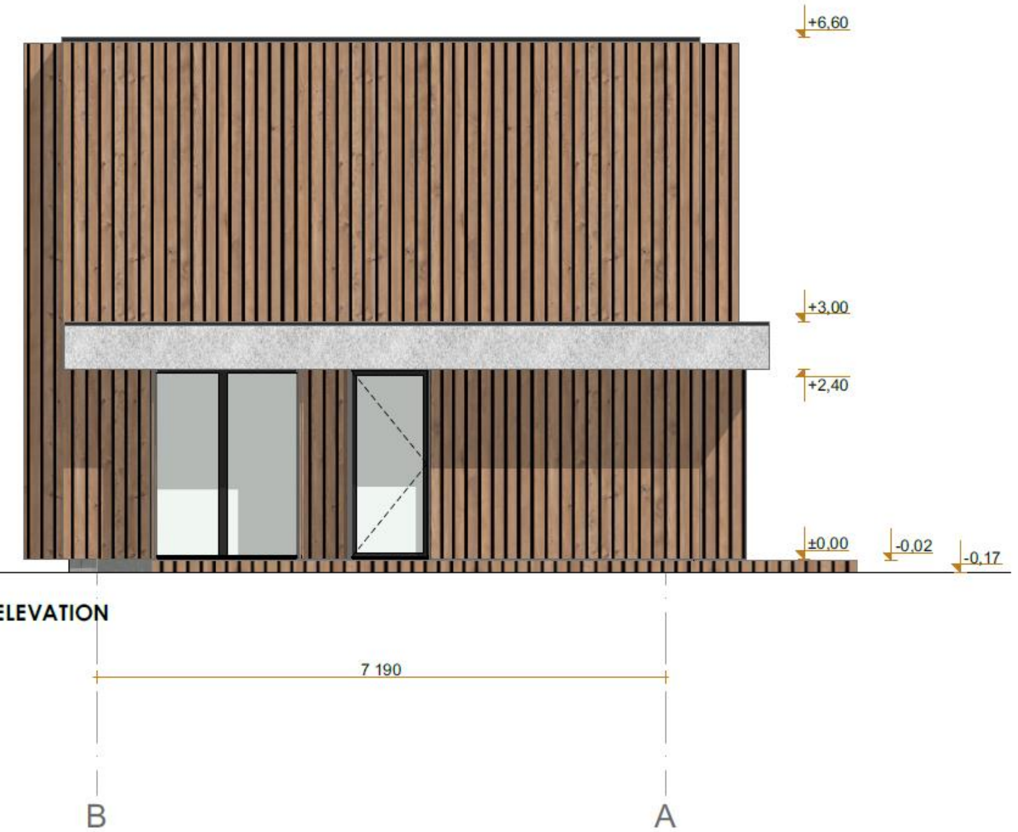
1st floor net area 56,3 m²
net area total 56,3 m²

1st floor net area 5,5 m²
2nd appartement net area 70,9 m²

ELEVATIONS AND SECTION, REDUCED SIZE. SCALE ON PANEL 1:100



SECTION S-1 1:100

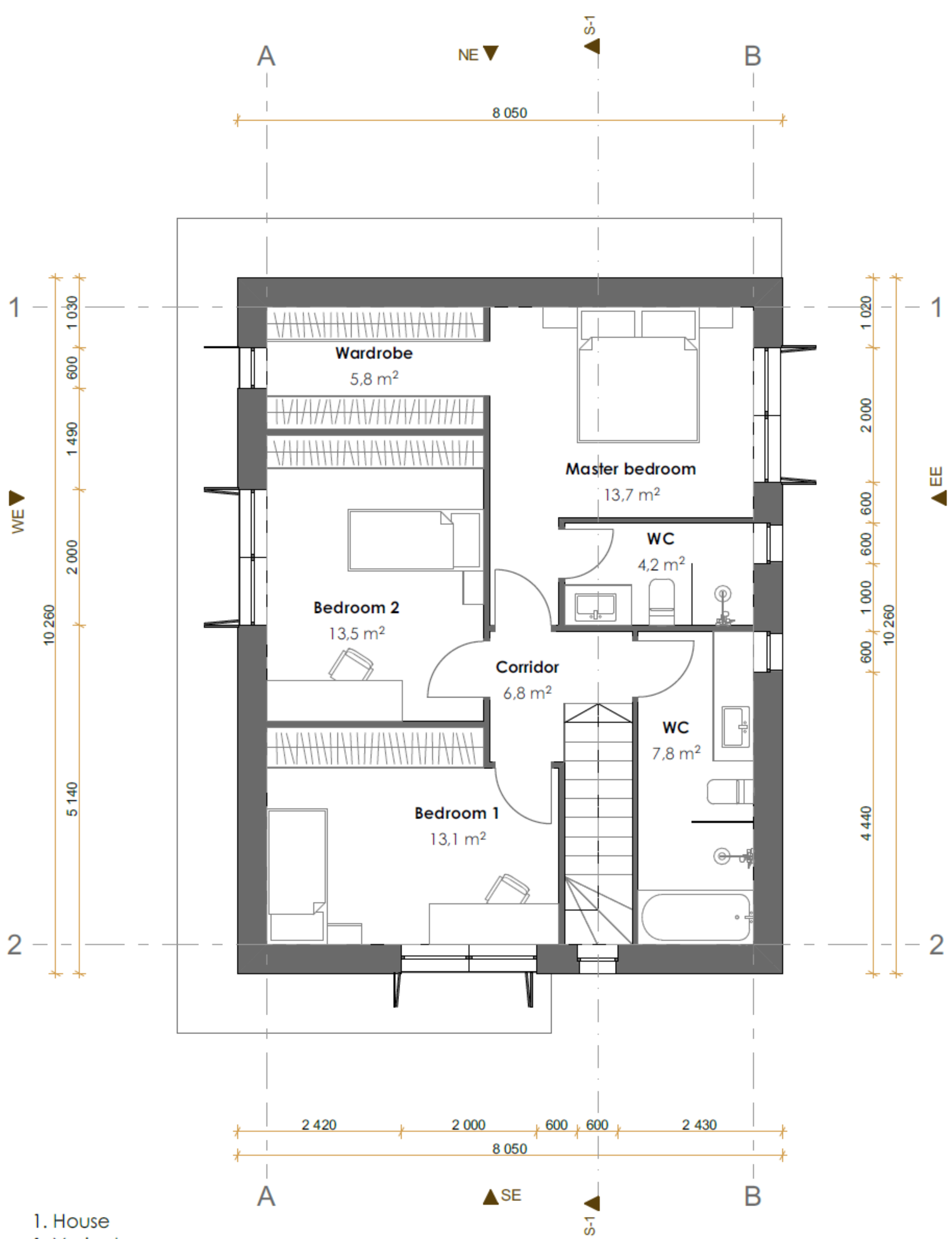


NORTH ELEVATION

SOUTH ELEVATION

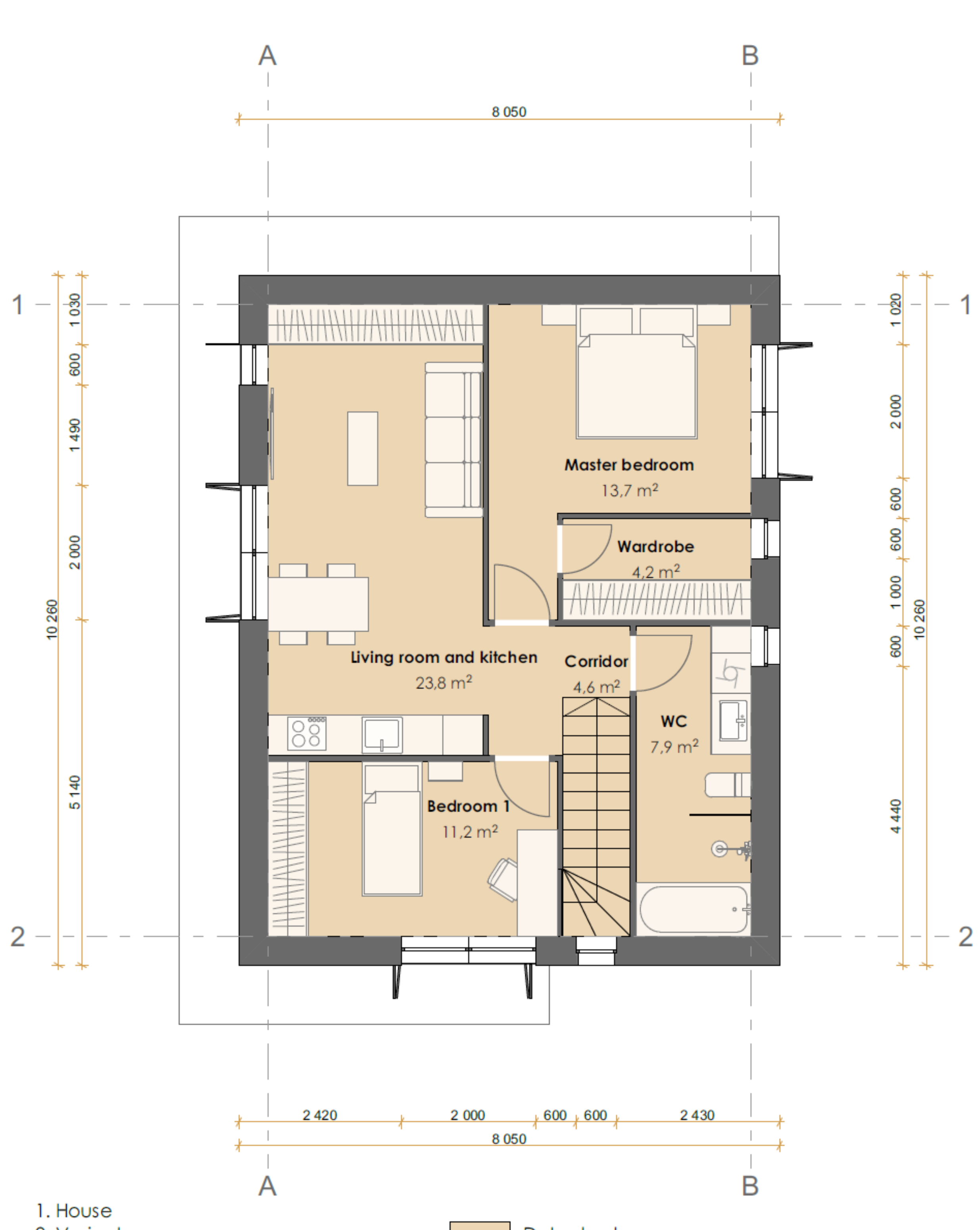
WEST ELEVATION

HOUSE 1 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



1. House
1. Variant

Construction area	82,0 m²
2nd floor net area	64,9 m²
net area total	112,2 m²



1. House
2. Variant

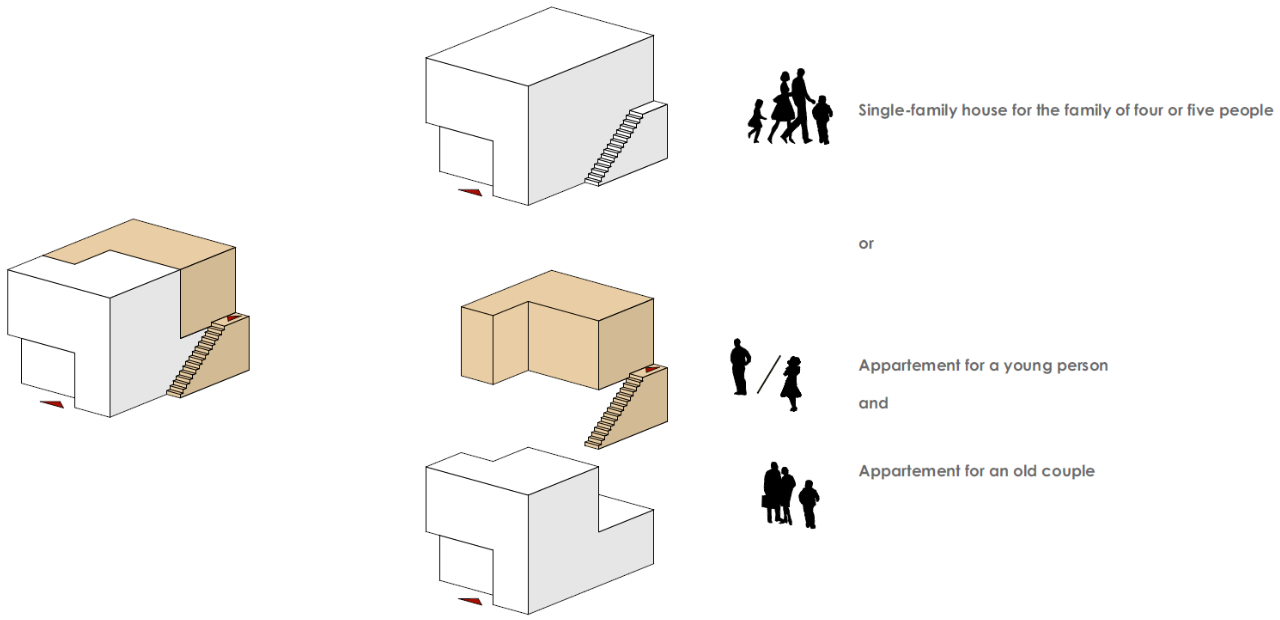
Detached area

Construction area	82,0 m²		
2nd floor net area	0 m²	2nd floor net area	65,4
net area total	56,3 m²	2nd appartement net area	70,9 m²

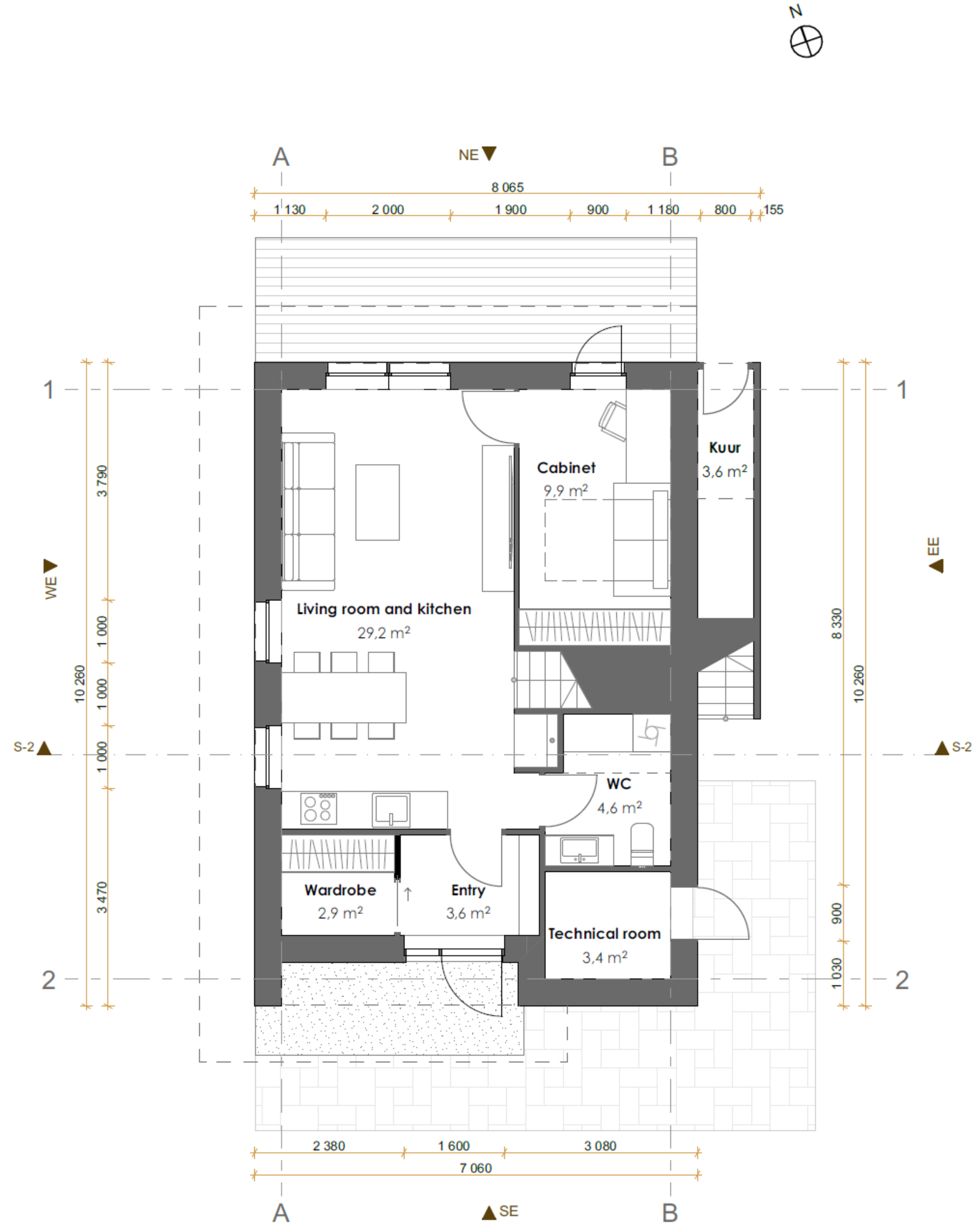
8. HOUSE VARIANT 2

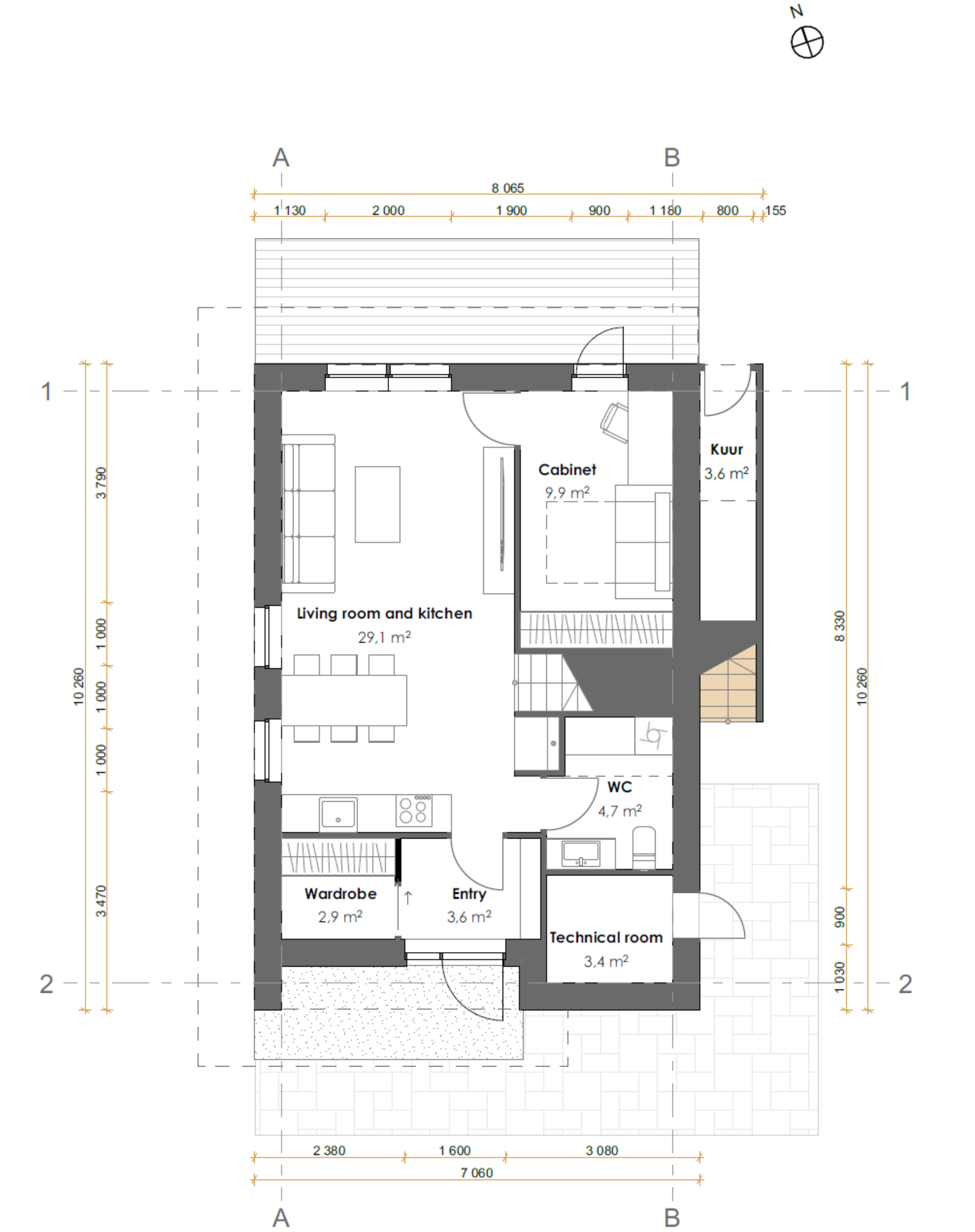
The second variant for a house has similar parts to the first variant in terms of internal planning, overall position on the plot, and therefore the position of the living room. But the main difference for this variant is the additional external stairs. That can be used as outdoor storage space and a balcony in the first implementation, but during the division same stairs will create access to the new one-bedroom apartment on the second floor. This way owners of the house can keep two rooms in their use.

HOUSE 2 DIVISION SCHEME



HOUSE 2 FIRST FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100





2. House
1. Variant

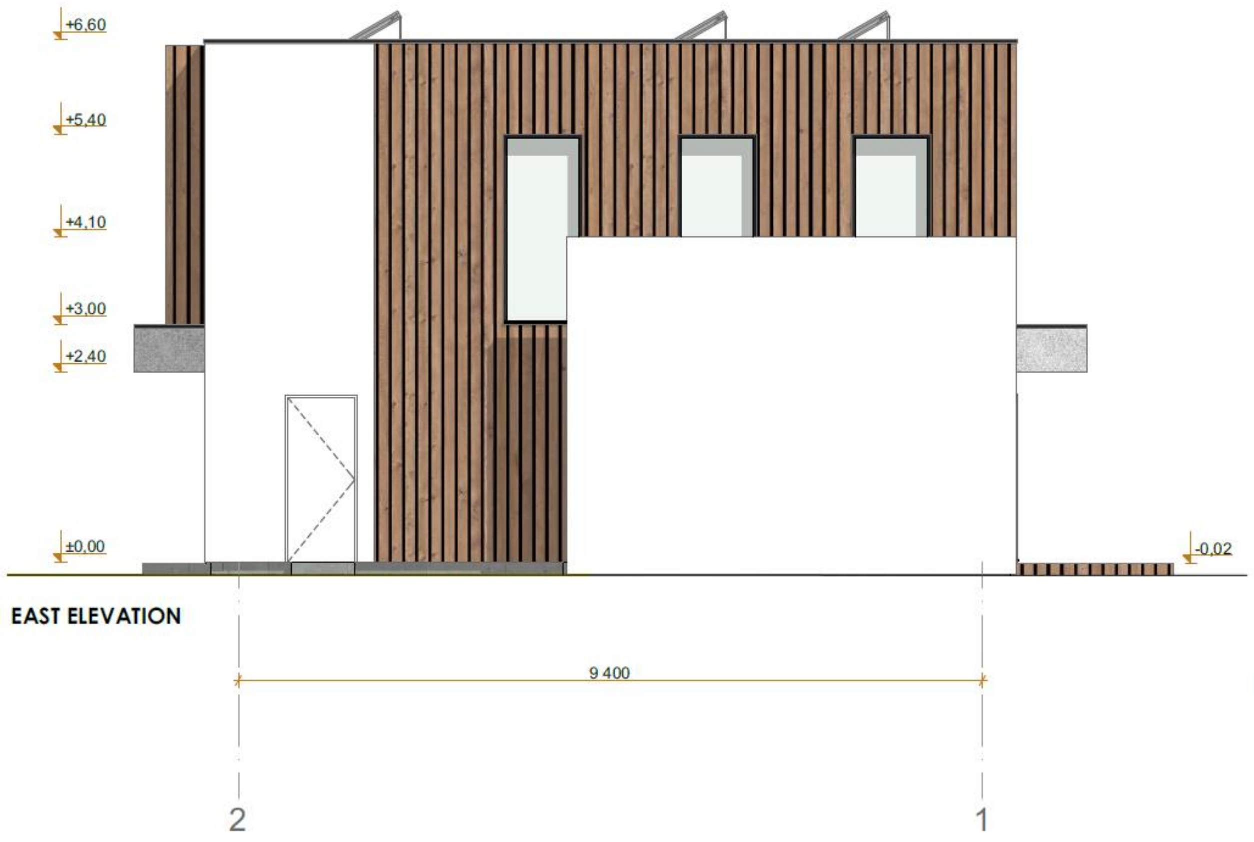
Construction area	77,9 m²
1st floor net area	56,0 m²
net area total	112,2 m²

2. House
2. Variant

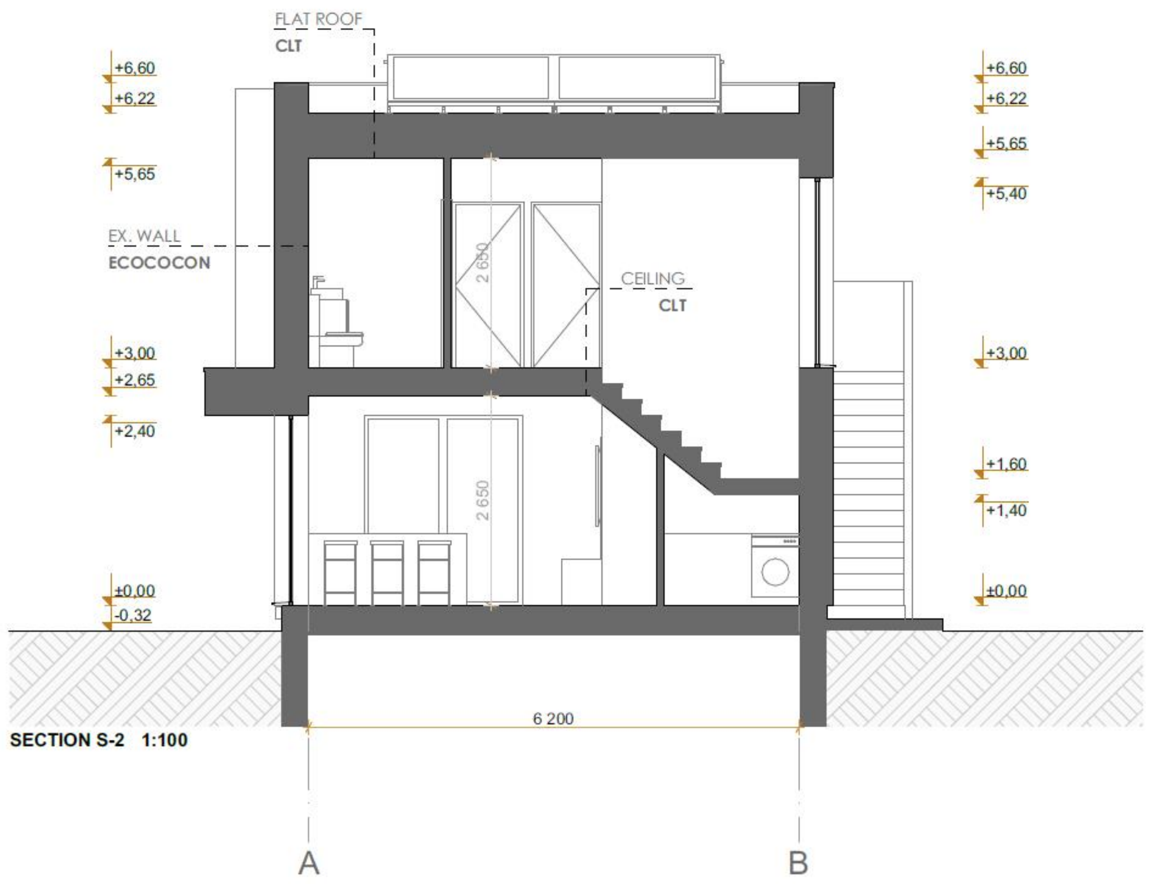
Detached area

Construction area	77,9 m²
1st floor net area	56,3 m²
net area total	80,8 m²
2nd appartement net area	31,5 m²

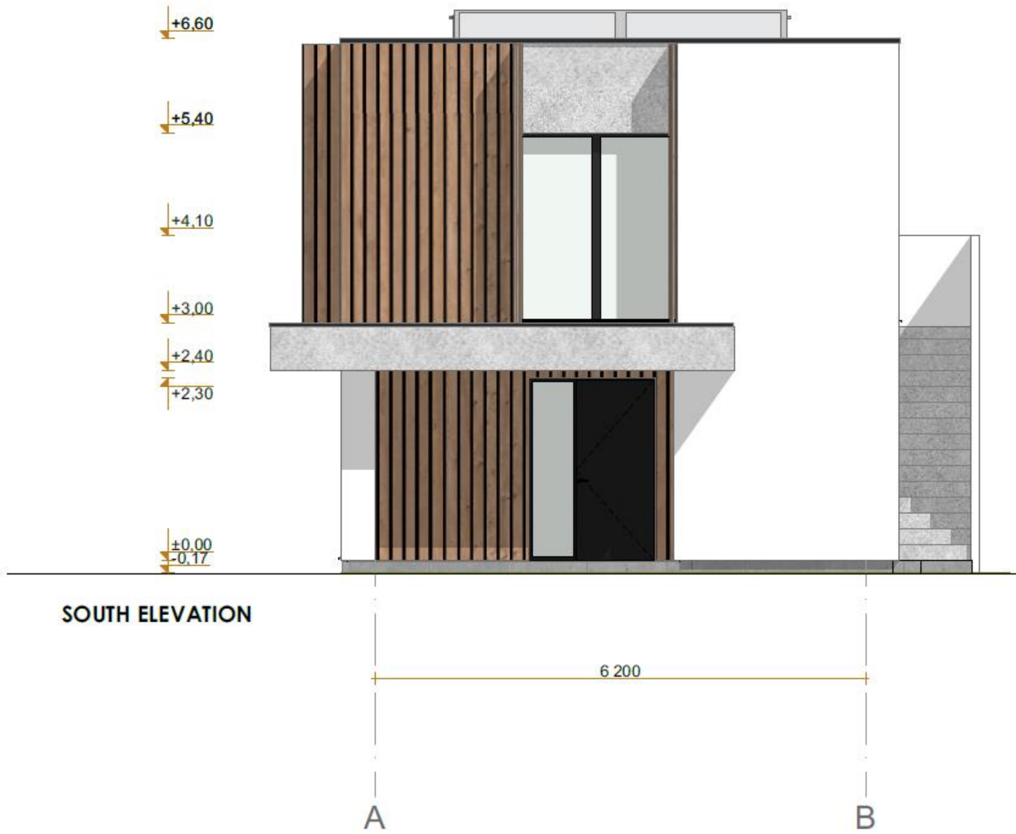
ELEVATIONS AND SECTION, REDUCED SIZE. SCALE ON PANEL 1:100



EAST ELEVATION



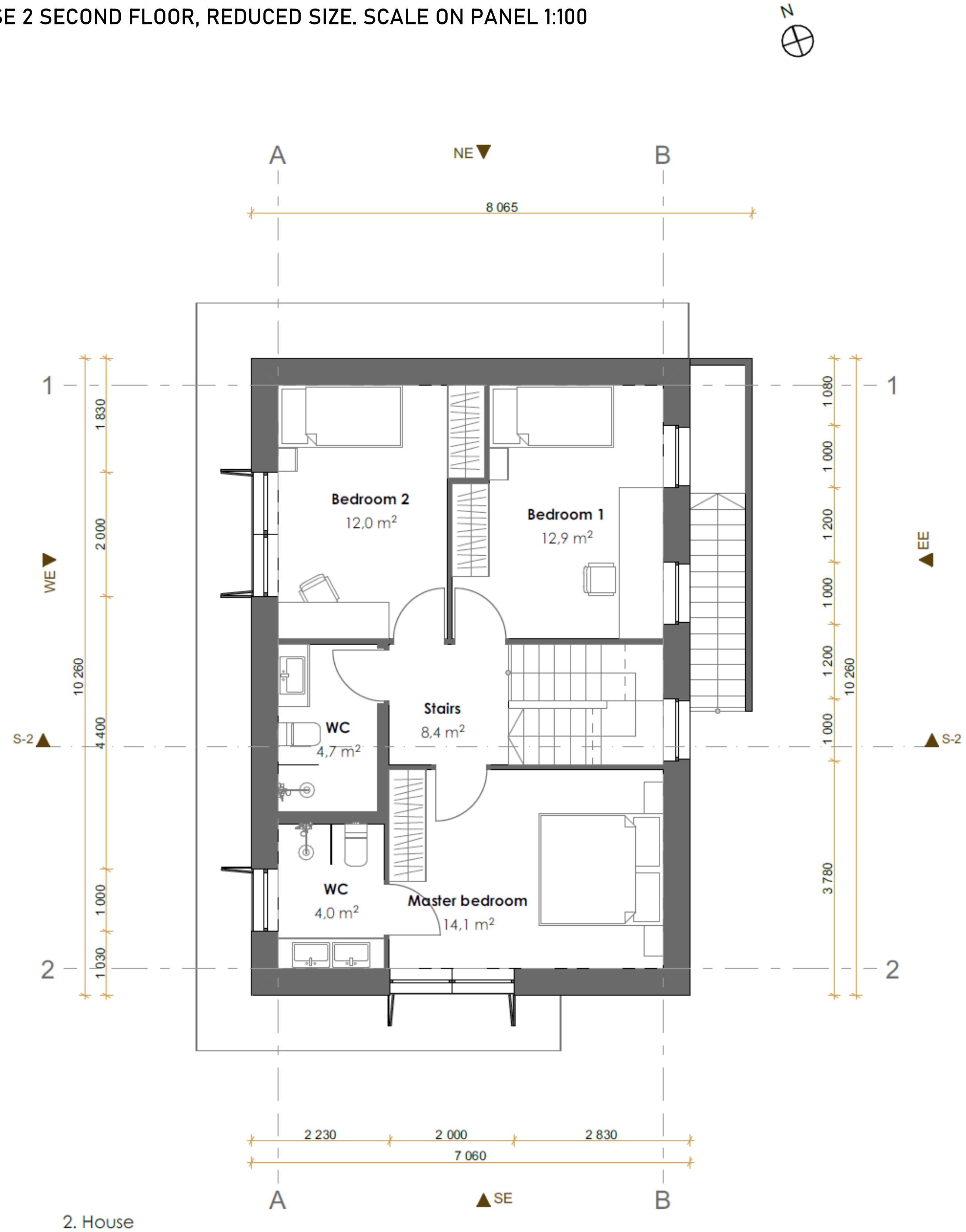
SECTION S-2 1:100



SOUTH ELEVATION

WEST ELEVATION

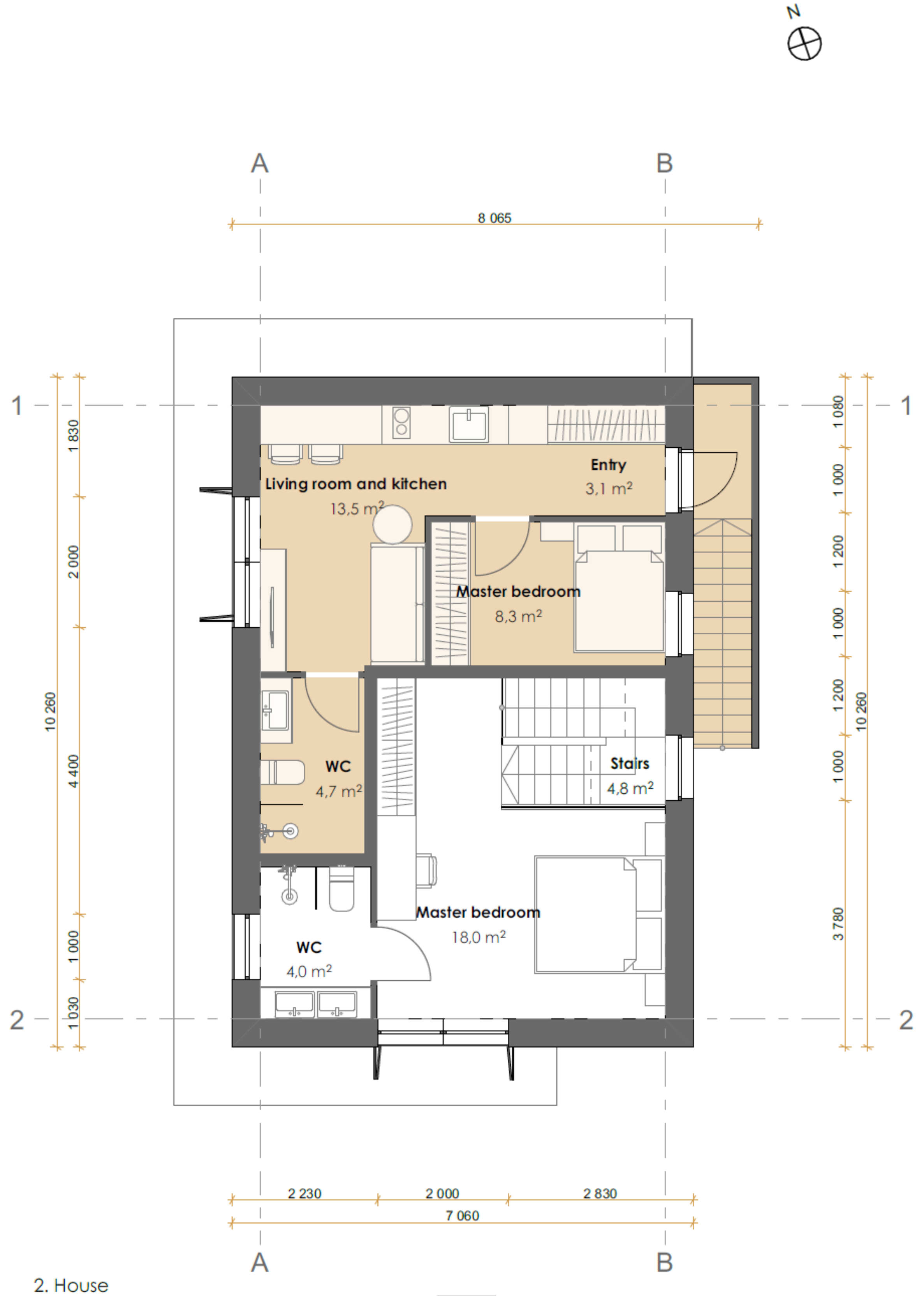
HOUSE 2 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



2. House
1. Variant

Construction area 77,9 m²

2nd floor net area 56,2 m²
net area total 112,2 m²



2. House
2. Variant

Detached area

Construction area 77,9 m²

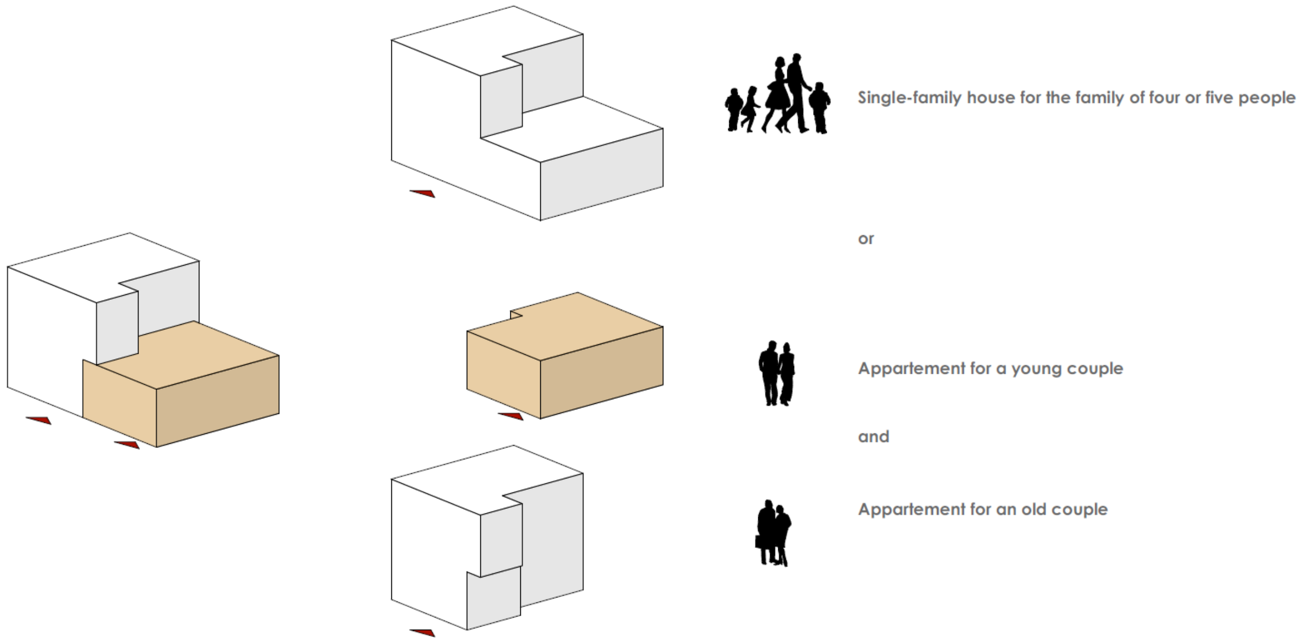
2nd floor net area 26,8 m²
net area total 82,6 m²

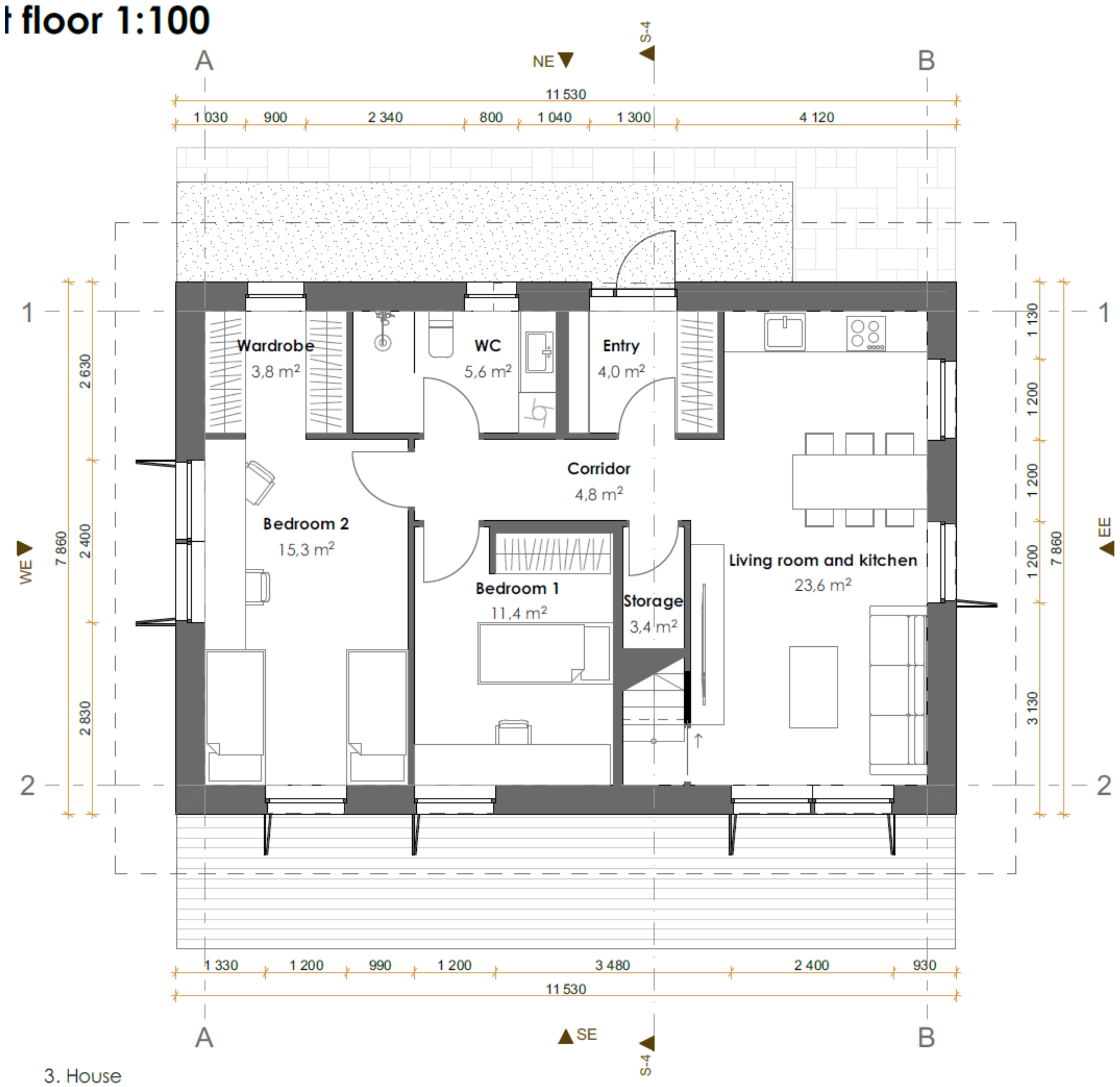
2nd appartement net area 29,6 m²

9. House variant 3

The third house was made with the possibility of separation on the first floor. This way second stairs are not needed, but the number of rooms on the first floor has to be increased. In terms of not generating unnecessary room area for a house, on the second floor, the floor area is smaller than on the first, and roof space is dedicated to the terrace and additional solar panels. Since such houses will be located in the northern part of the plot, the southern part of the house is equipped with a long terrace on the first floor as well. After division terrace can be accessed from each apartment.

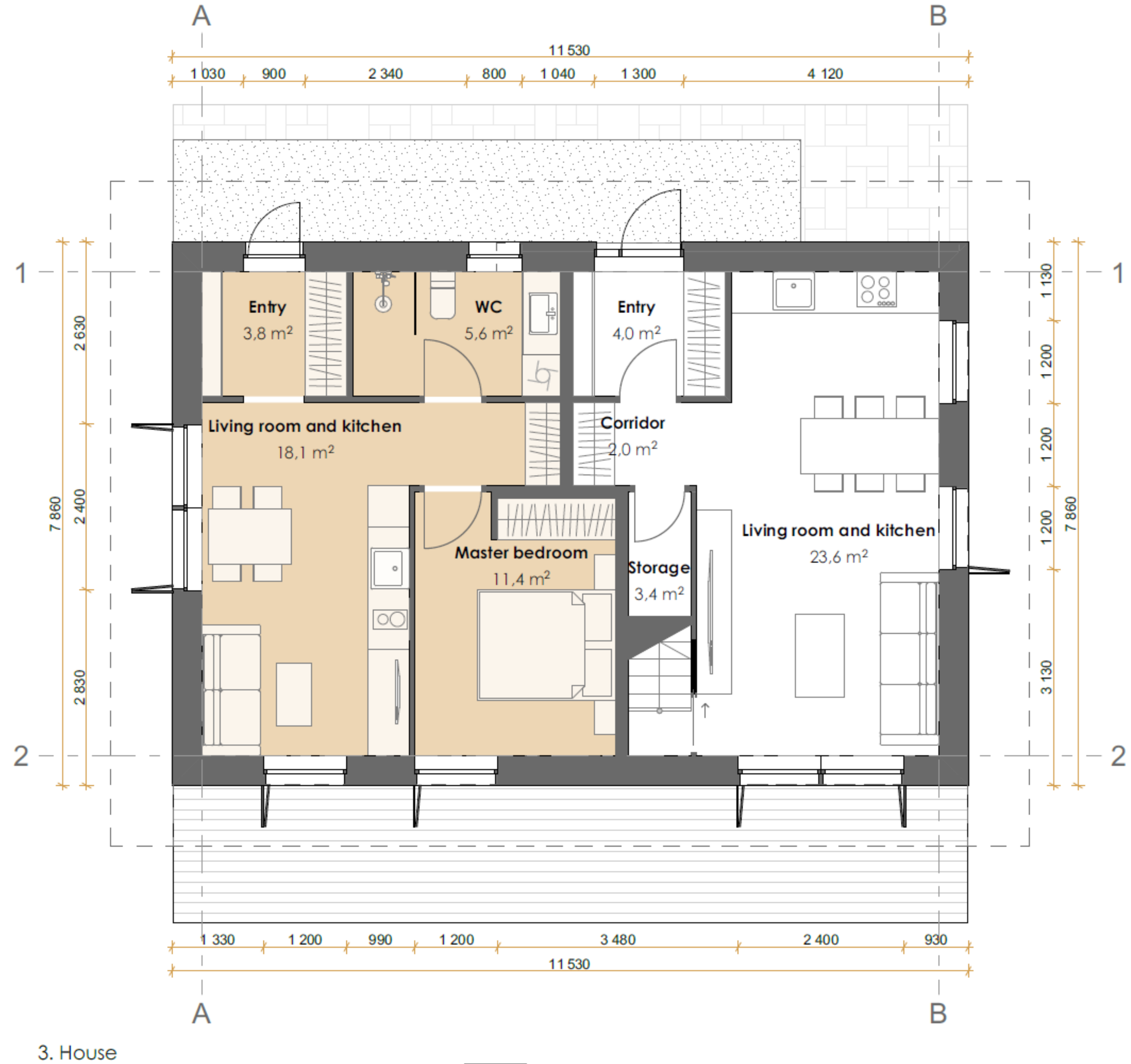
HOUSE 3 DIVISION SCHEME





3. House
1. Variant

Construction area	90,1 m²
1st floor net area	75,2 m²
net area total	107,0 m²

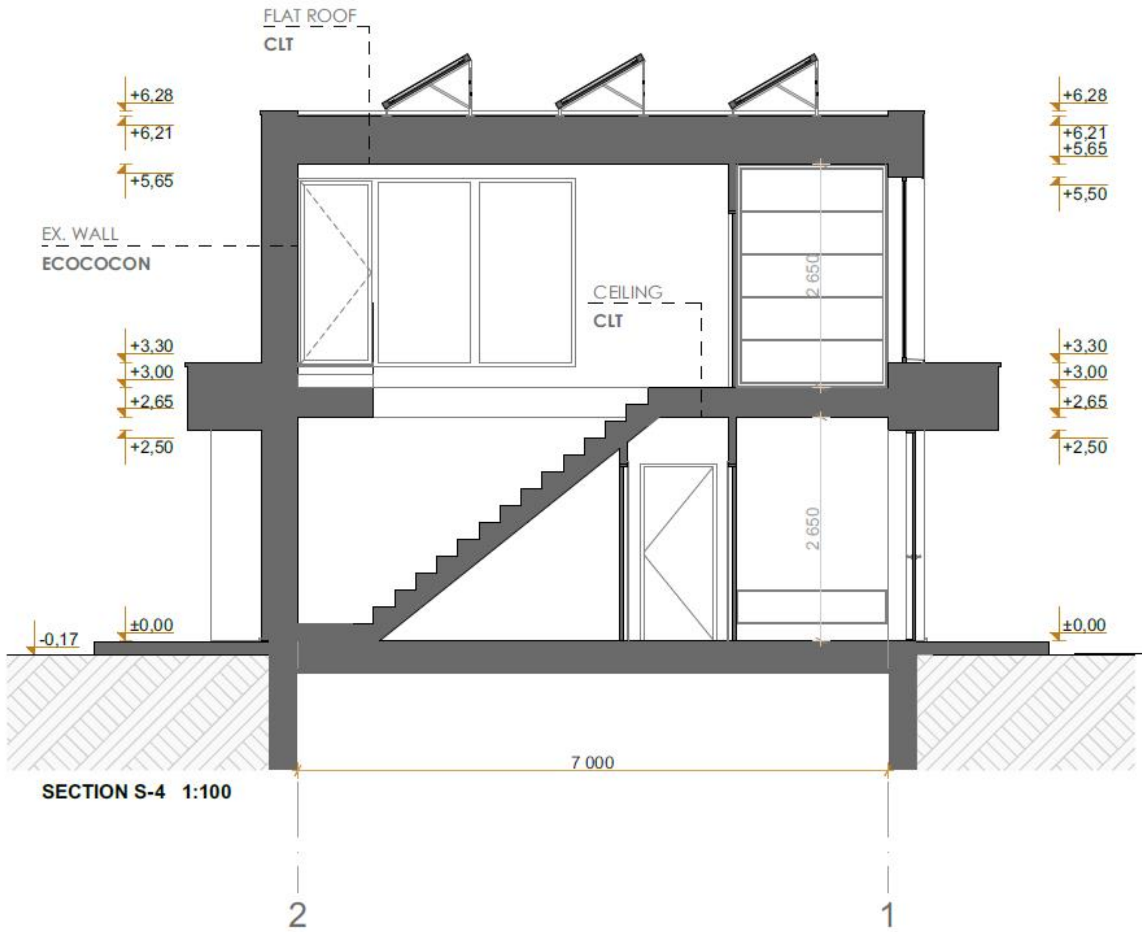


3. House
2. Variant

Detached area

Construction area	90,1 m²
1st floor net area	34,3 m²
net area total	66,1 m²
2nd appartement net area	40,8 m²

ELEVATIONS AND SECTION, REDUCED SIZE. SCALE ON PANEL



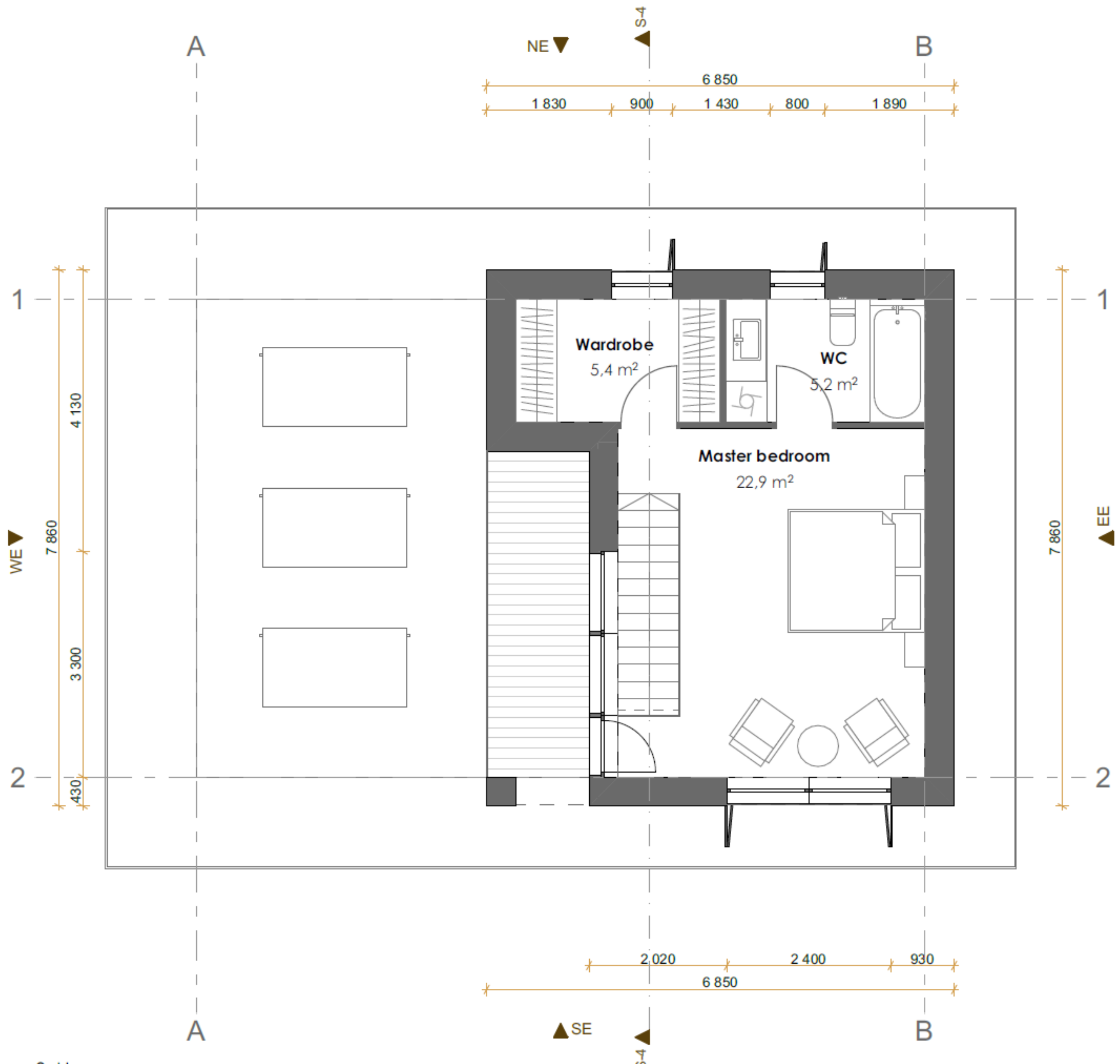
SECTION S-4 1:100

NORTH ELEVATION

SOUTH ELEVATION

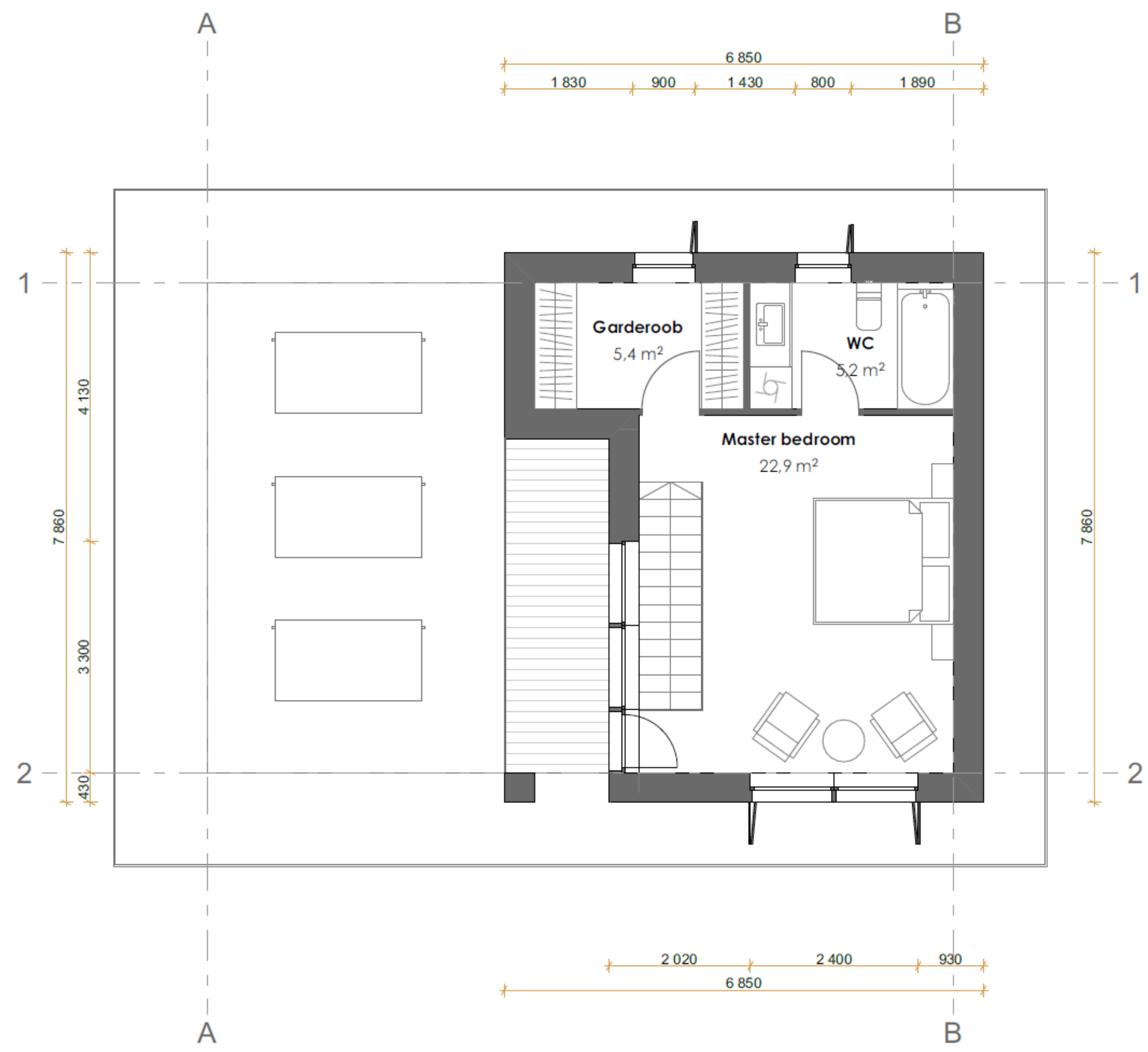
WEST ELEVATION

HOUSE 3 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



3. House
1. Variant

Construction area	90,1 m²
2nd floor net area	33,8 m²
net area total	107,0 m²



3. House
2. Variant

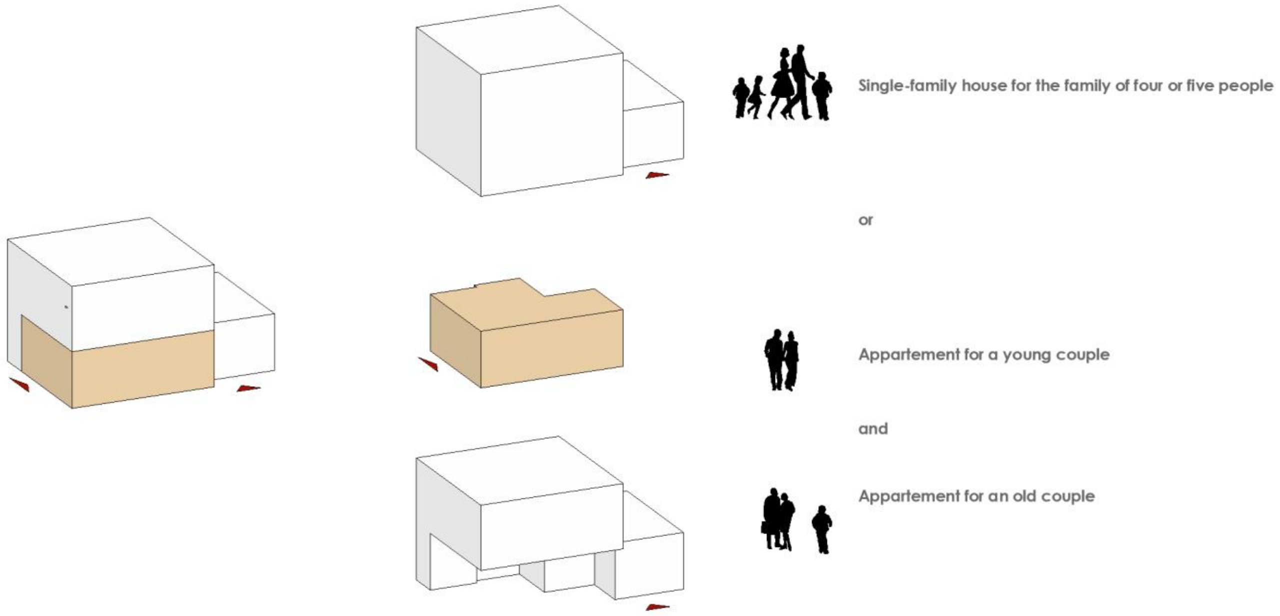
Detached area

Construction area	90,1 m²
2nd floor net area	33,8 m²
net area total	66,1 m²
2nd appartement net area	40,8 m²

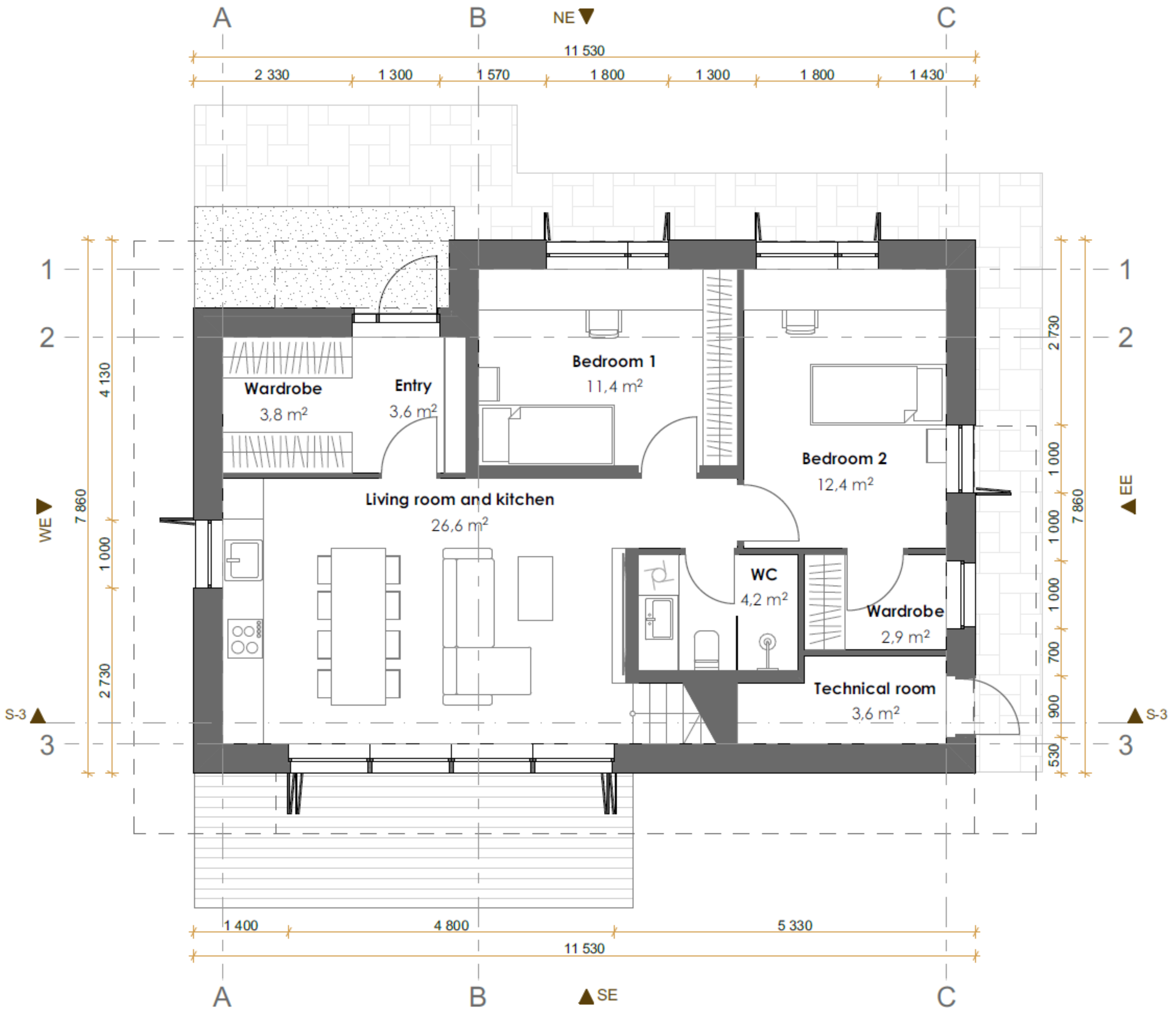
10.HOUSE VARIANT 4

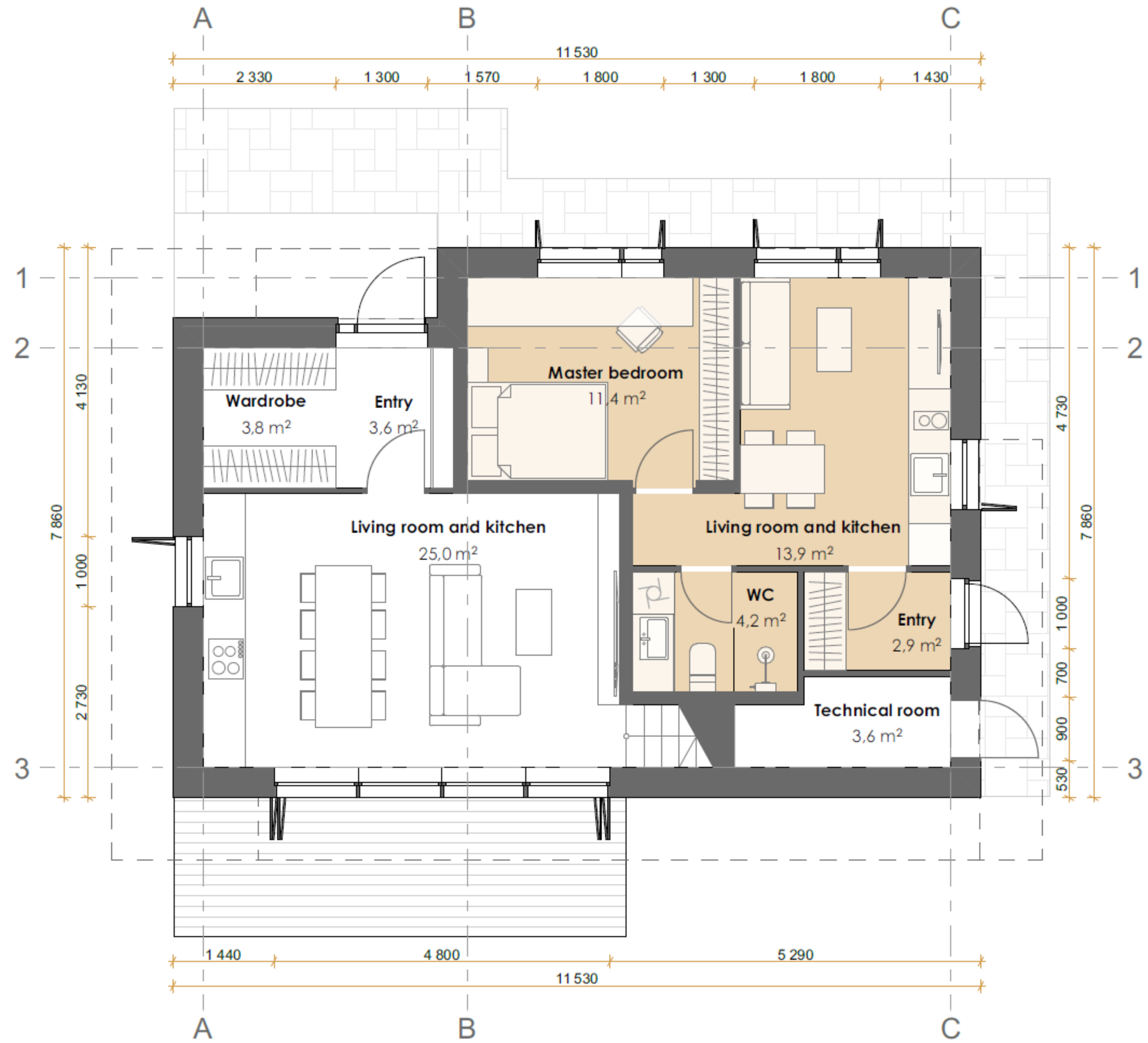
The fourth variant is taking a similar approach to the third, but with the additional room that can be left after separation for the original owners of the house. The second floor also has a roof terrace. To protect the bedrooms on the first floor from the pedestrian's views, this variant is the only one that is located closer to the middle of the plot than others, and a wall of rammed earth was also added between the pavement and the house, which can be seen both on the site plan as well as on the visualizations.

HOUSE 4 DIVISION SCHEME



HOUSE 4 FIRST FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100





4. House
1. Variant

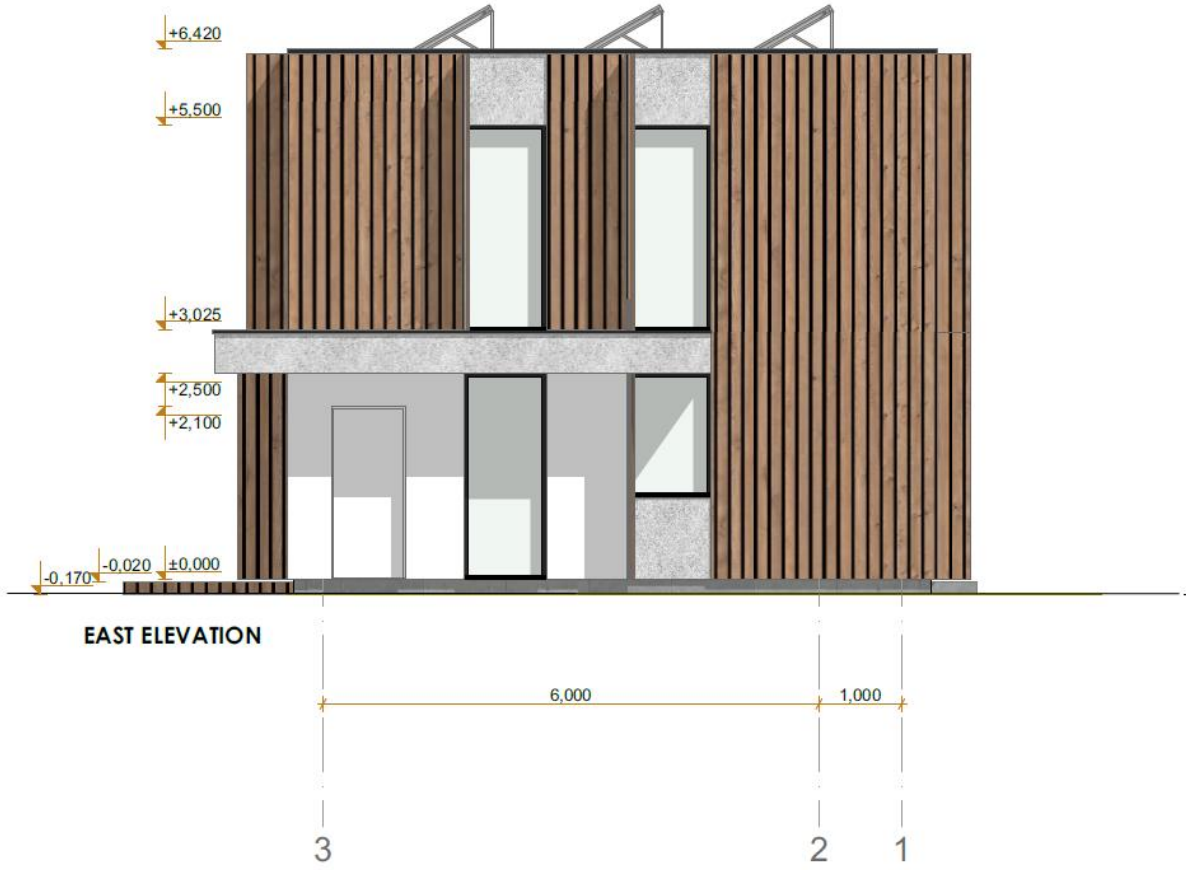
Construction area	86,3 m²
1st floor net area	70,7 m²
net area total	119,8 m²

4. House
2. Variant

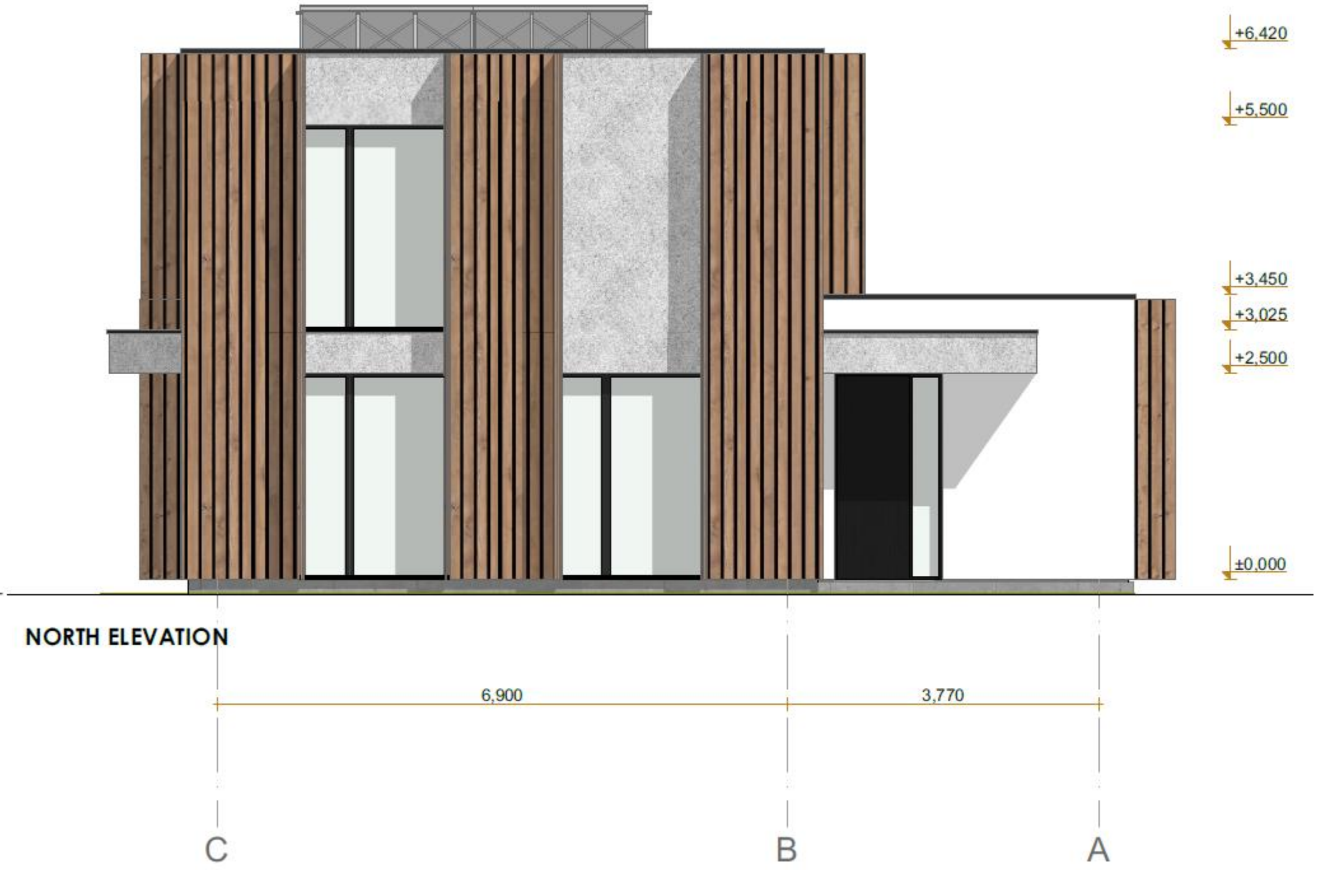
Detached area

Construction area	86,3 m²
1st floor net area	34,4 m²
net area total	83,5 m²
2nd appartement net area	36,2 m²

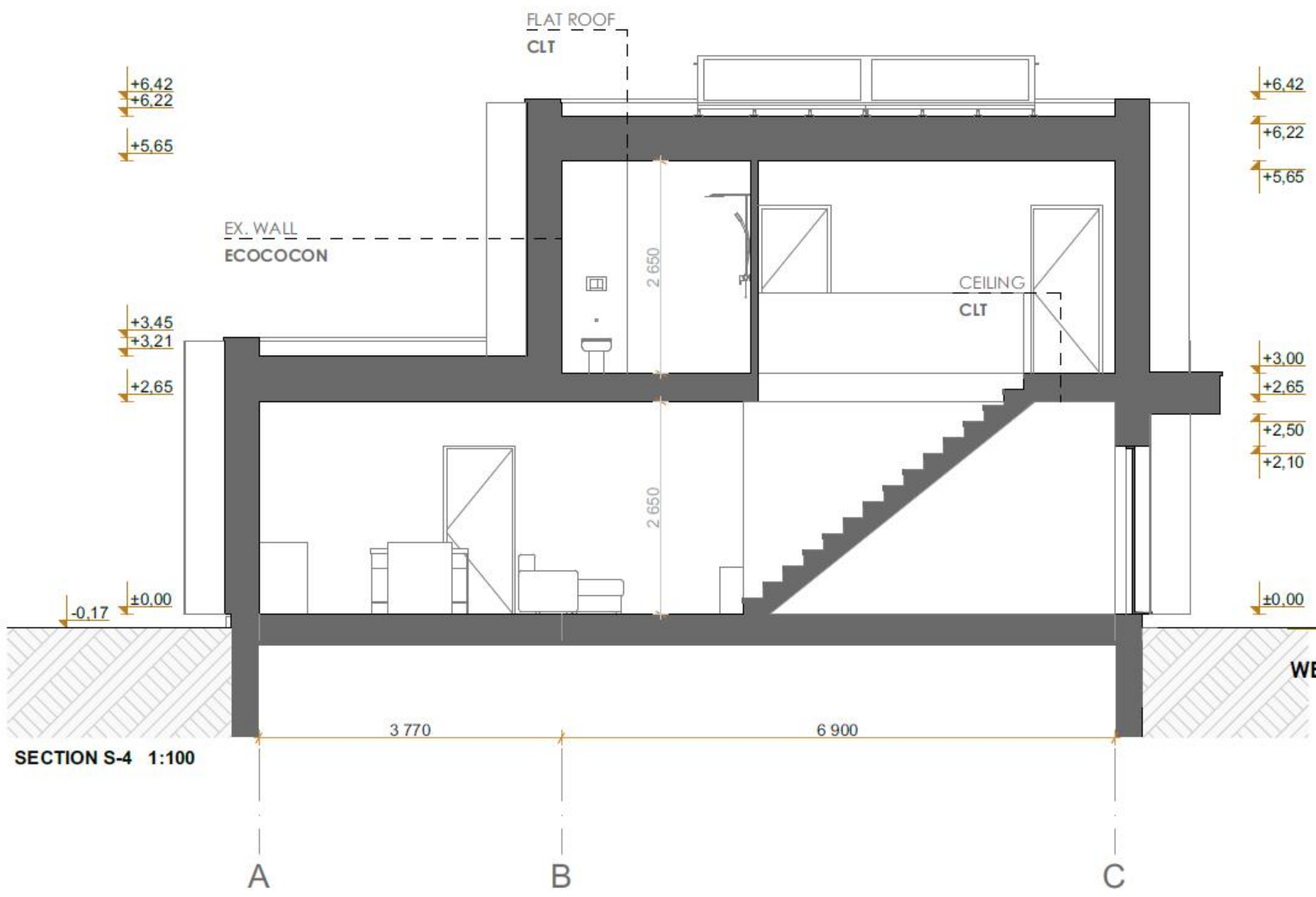
ELEVATIONS AND SECTION, REDUCED SIZE. SCALE ON PANEL



EAST ELEVATION



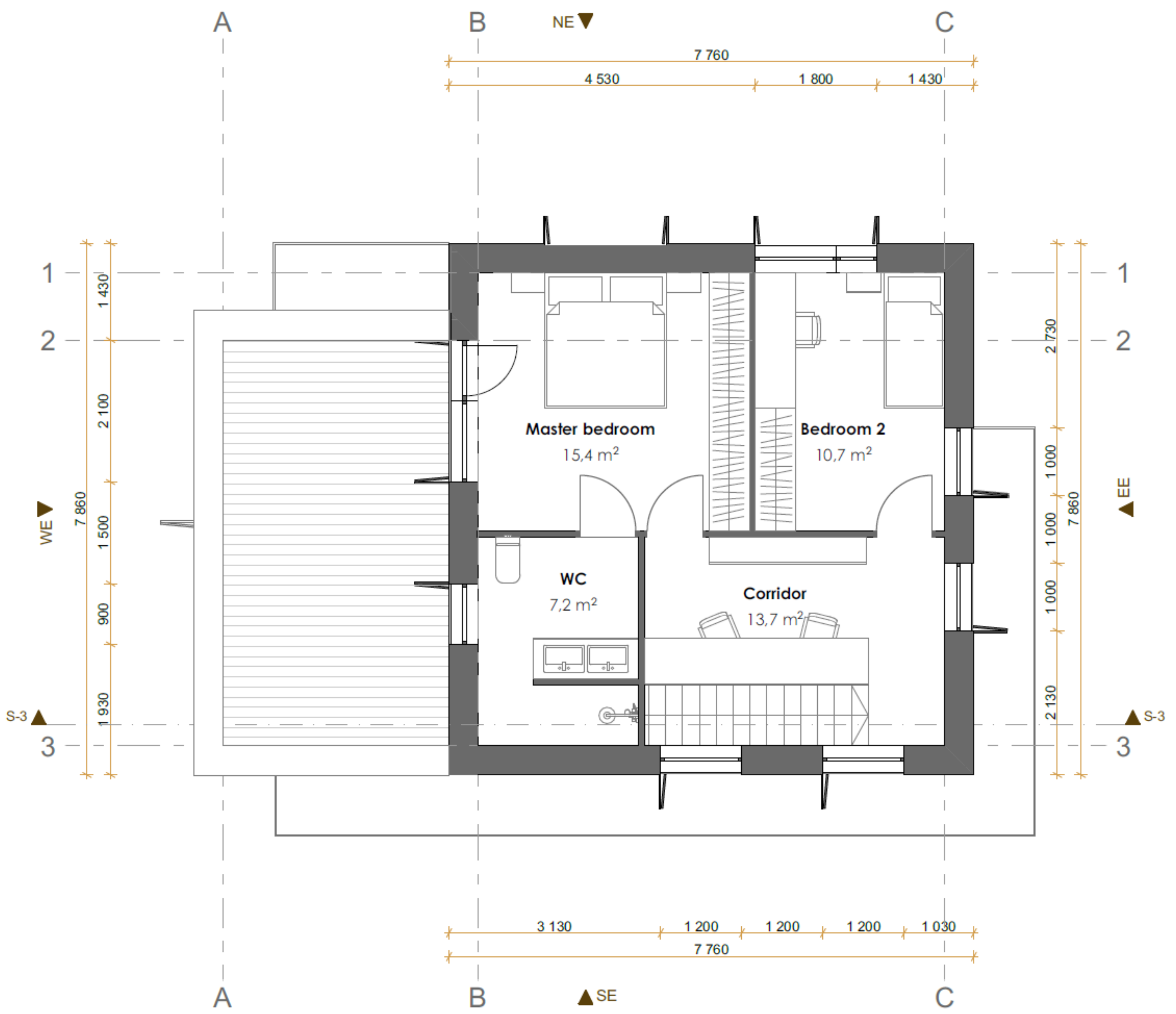
NORTH ELEVATION



SECTION S-4 1:100

WEST ELEVATION

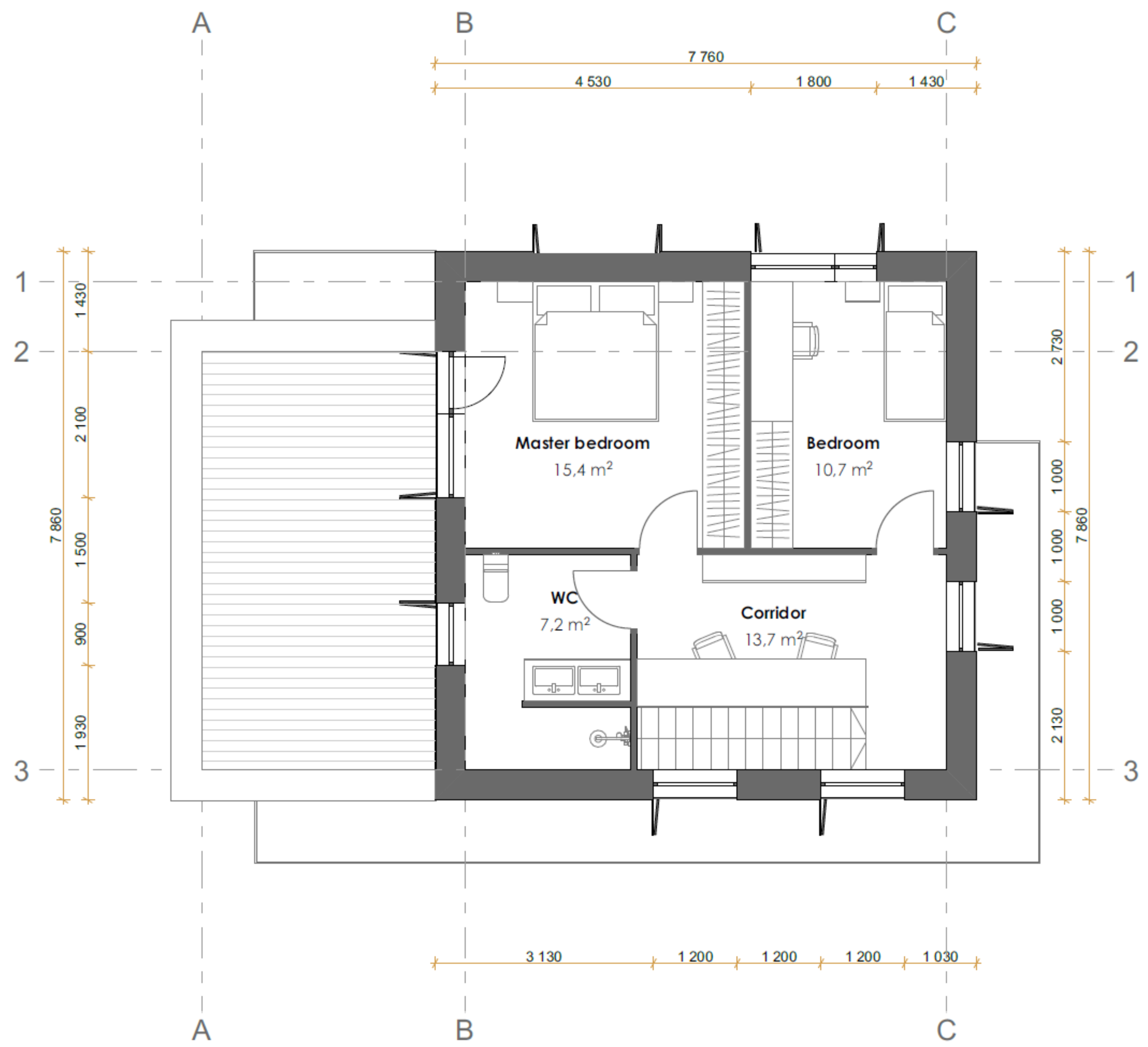
HOUSE 4 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



4. House
1. Variant

Construction area 86,3 m²

2nd floor net area 49,1 m²
net area total 119,8 m²



4. House
2. Variant

Detached area

2nd appartement net area 36,2 m²

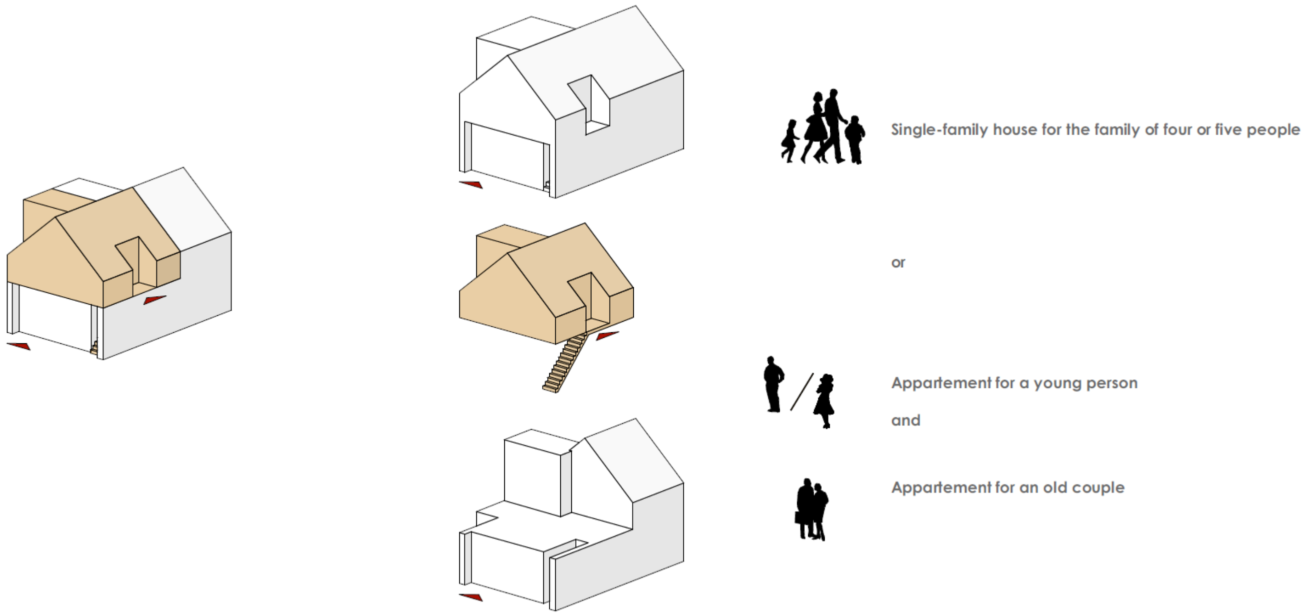
Construction area 86,3 m²

2nd floor net area 49,1 m²
net area total 83,5 m²

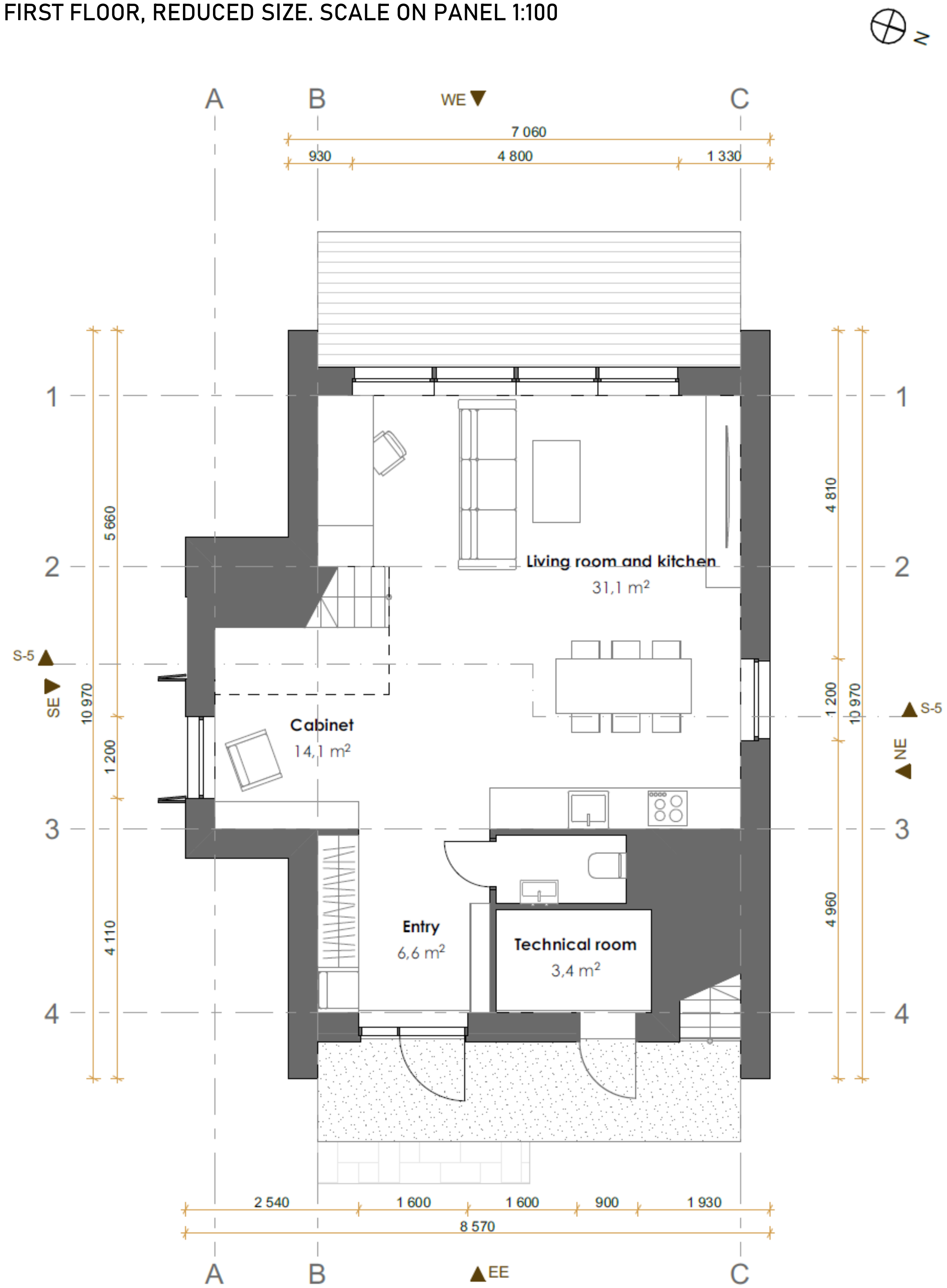
11. HOUSE VARIANT 5

To add diversity to the variants, the fifth and sixth of them are made with pitched roofs. This way the transition between old and new development will be smoother because the majority of these variants are located parallel to Neeme Street, where all houses are with pitched roofs. The fifth house variant, similar to the second variant, is using an external staircase.

HOUSE 5 DIVISION SCHEME

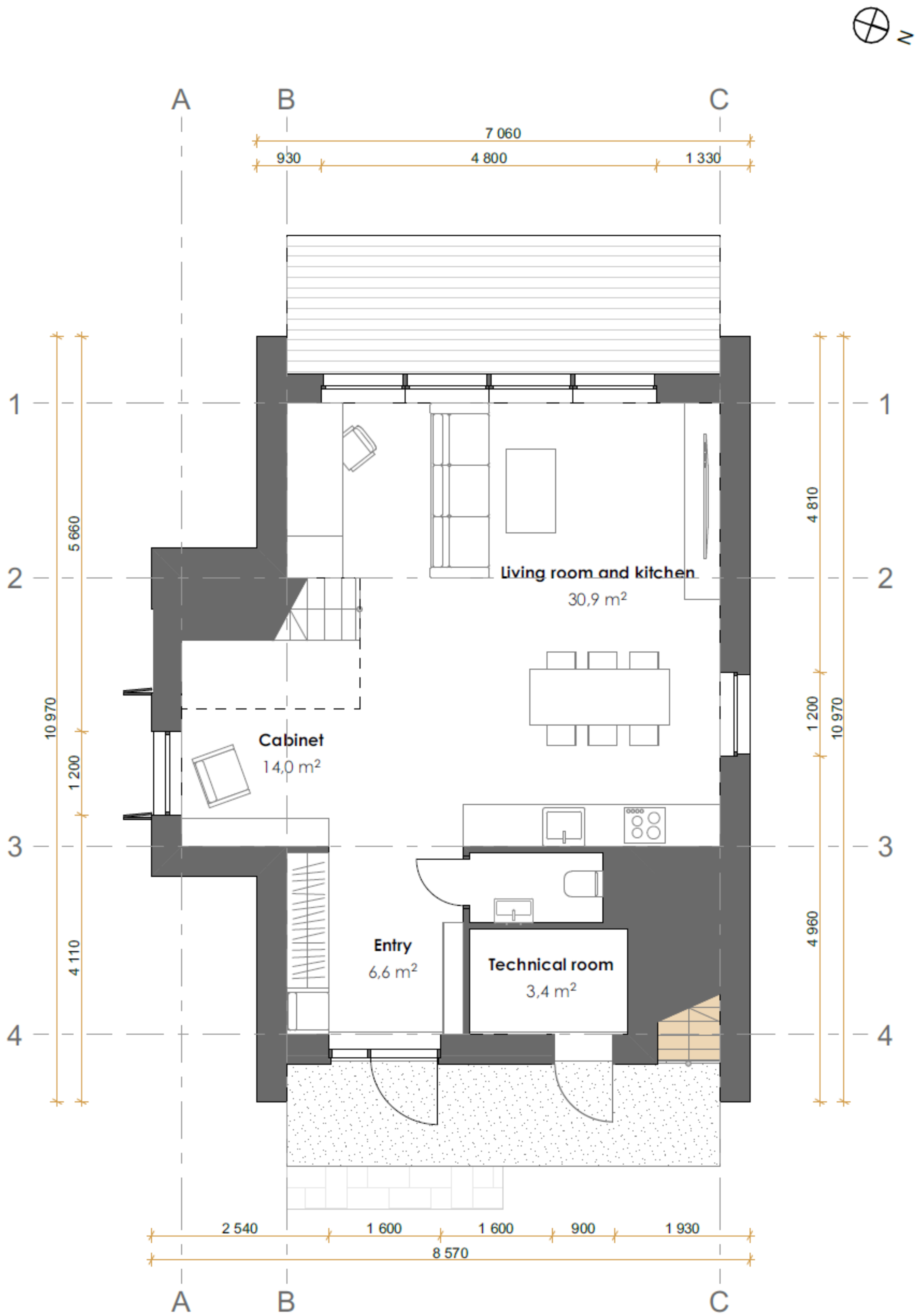


HOUSE 5 FIRST FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



5. House
1. Variant

Construction area	83,3 m²
1st floor net area	58,2 m²
net area total	118,1 m²



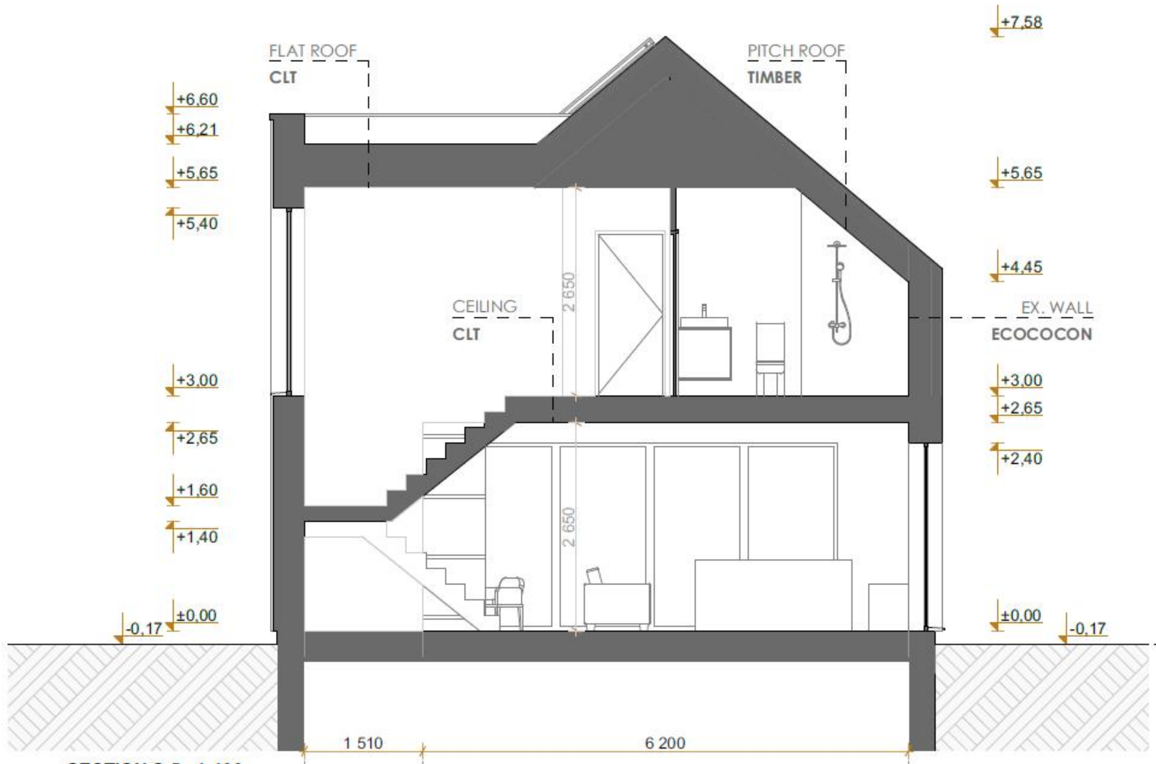
5. House
2. Variant

Detached area

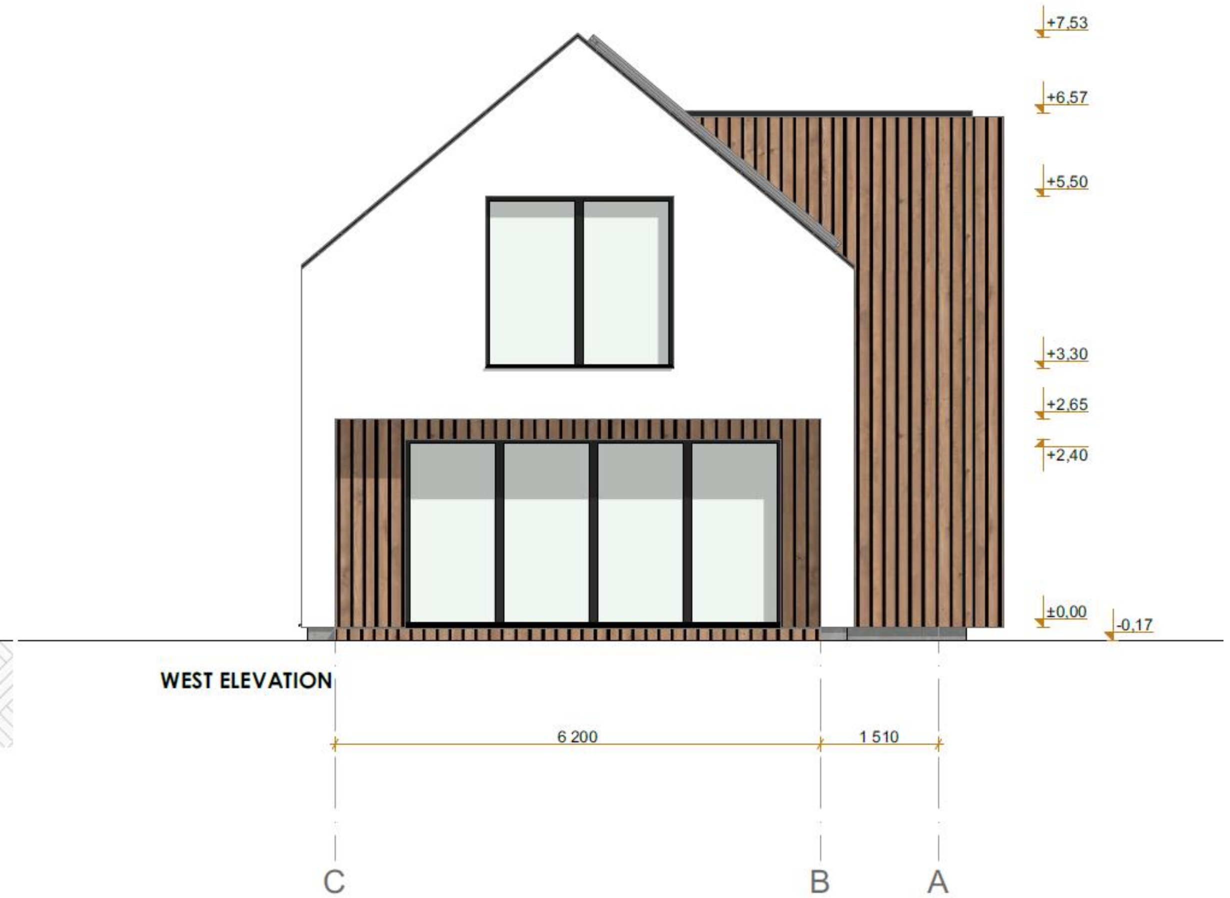
Construction area	83,3 m²
1st floor net area	58,2 m²
net area total	85,5 m²

2nd appartement net area 32,5 m²

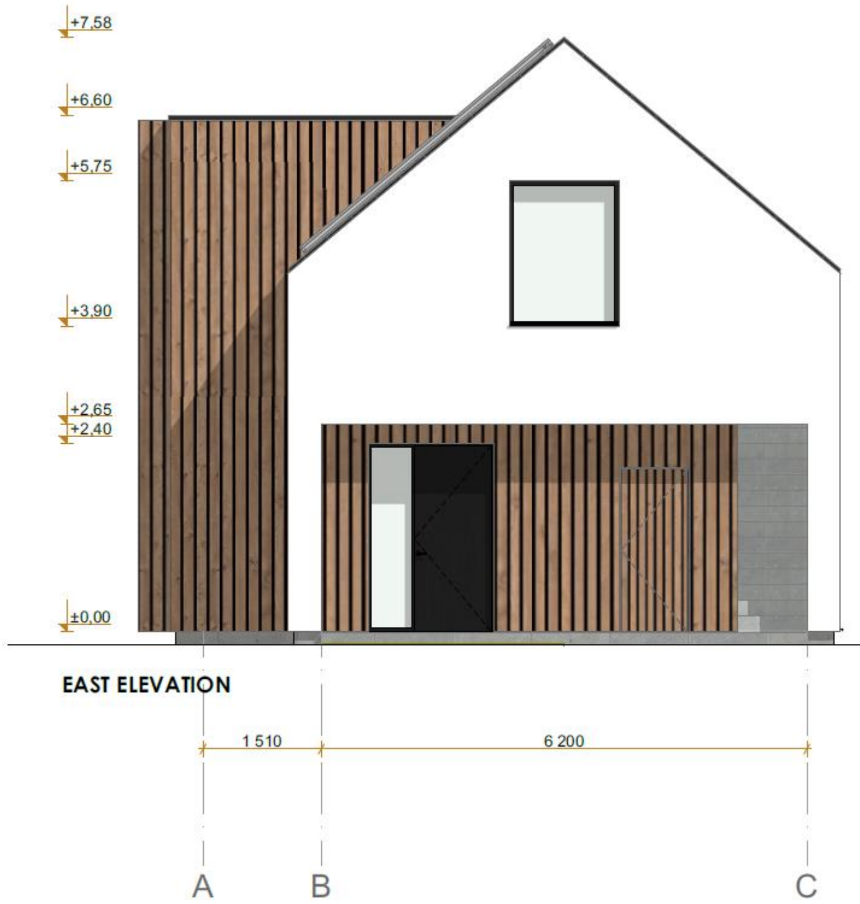
ELEVATIONS AND SECTION, REDUCED SIZE. SCALE ON PANEL 1:100



SECTION S-5 1:100



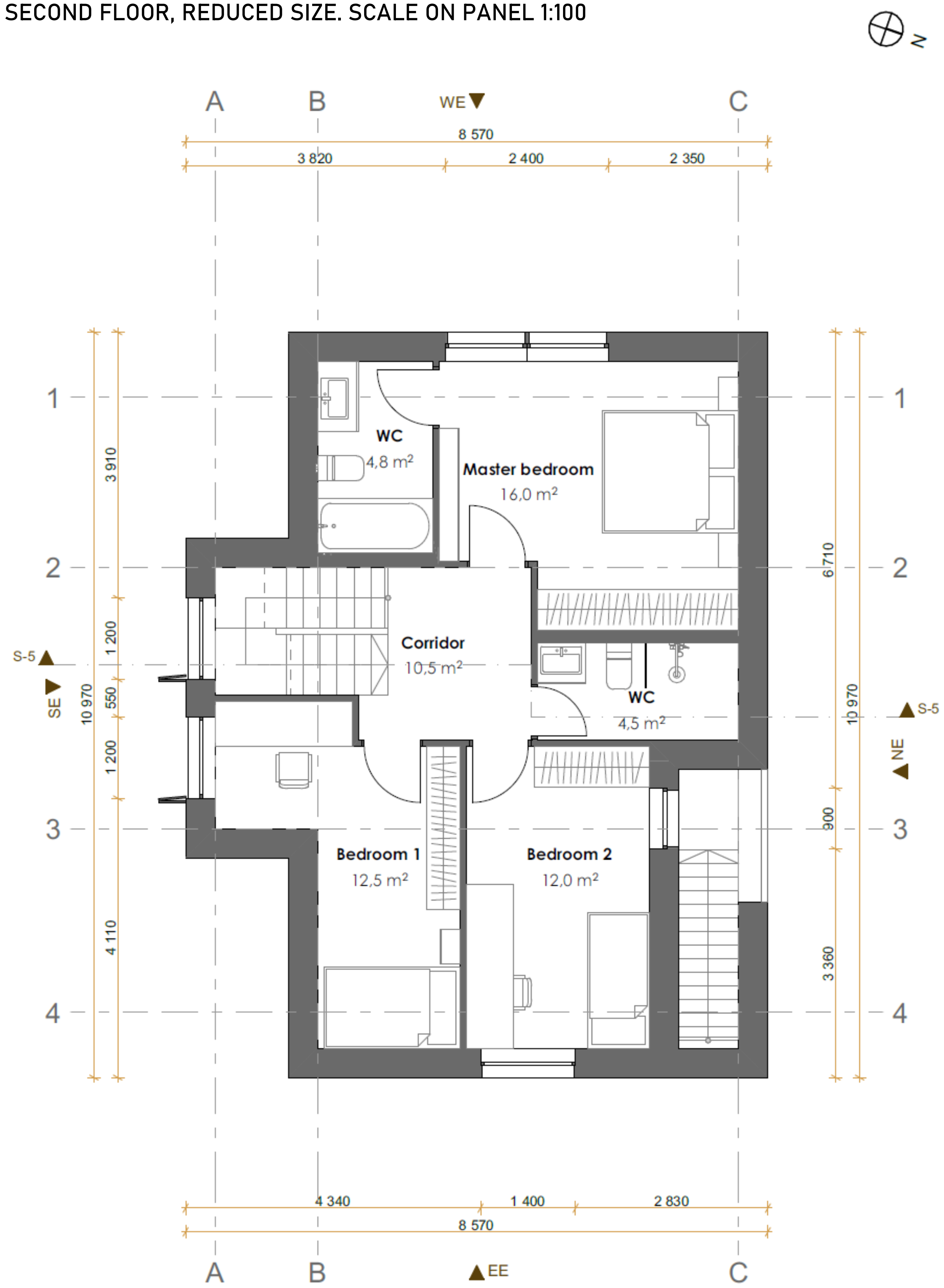
WEST ELEVATION



EAST ELEVATION

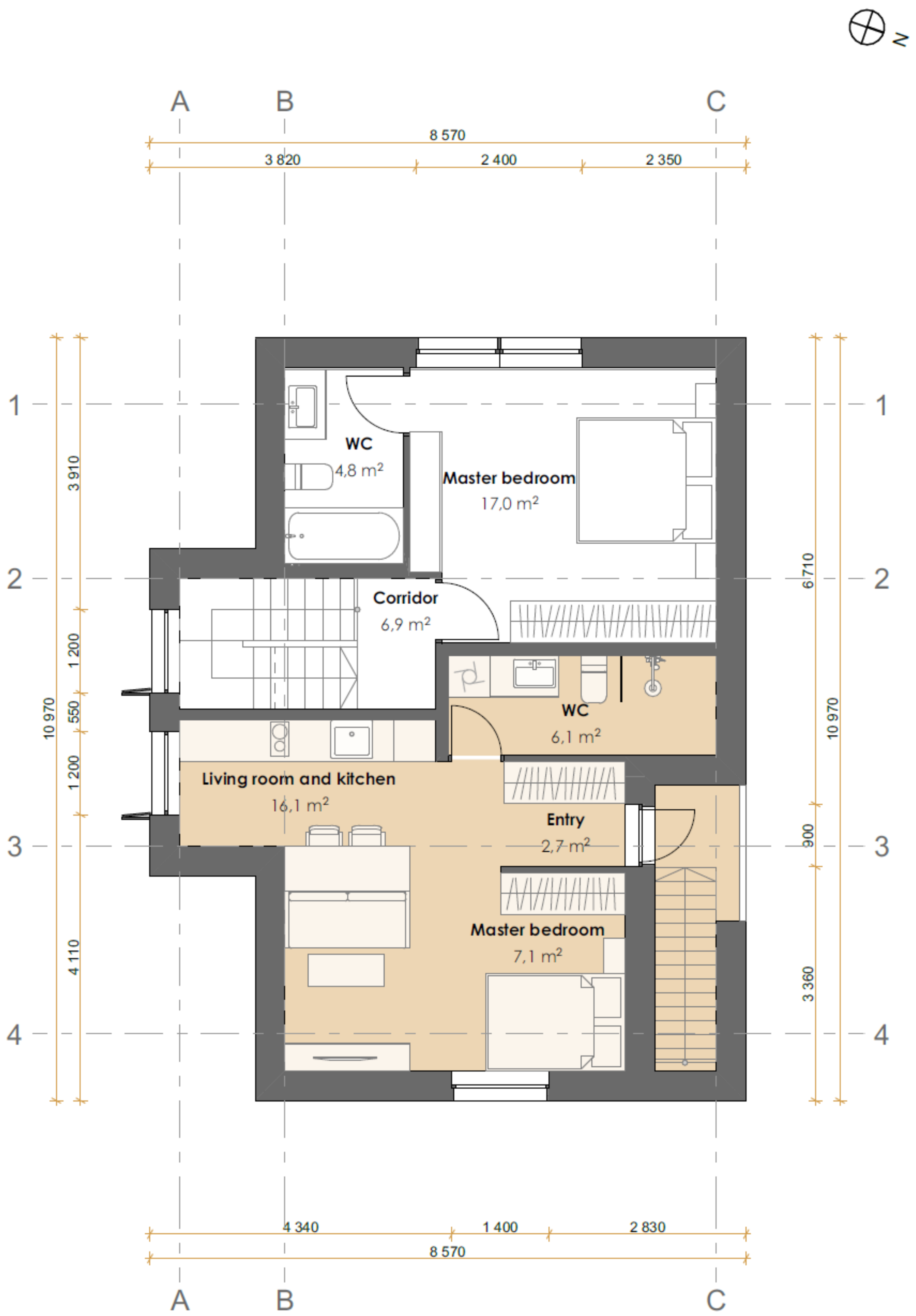
SOUTH ELEVATION

HOUSE 5 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



5. House
1. Variant

Construction area	83,3 m²
2nd floor net area	59,9 m²
net area total	118,1 m²



5. House
2. Variant

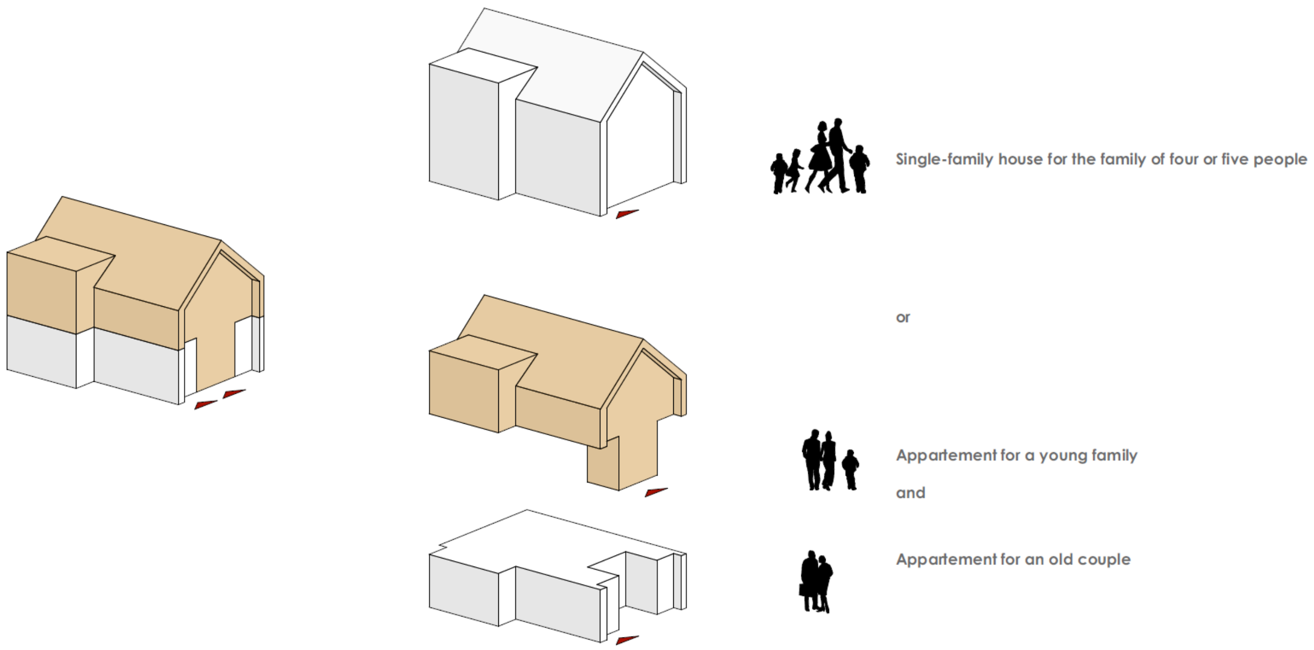
Detached area

Construction area	83,3 m²	2nd appartement net area	32,5 m²
2nd floor net area	27,3 m²		
net area total	85,5 m²		

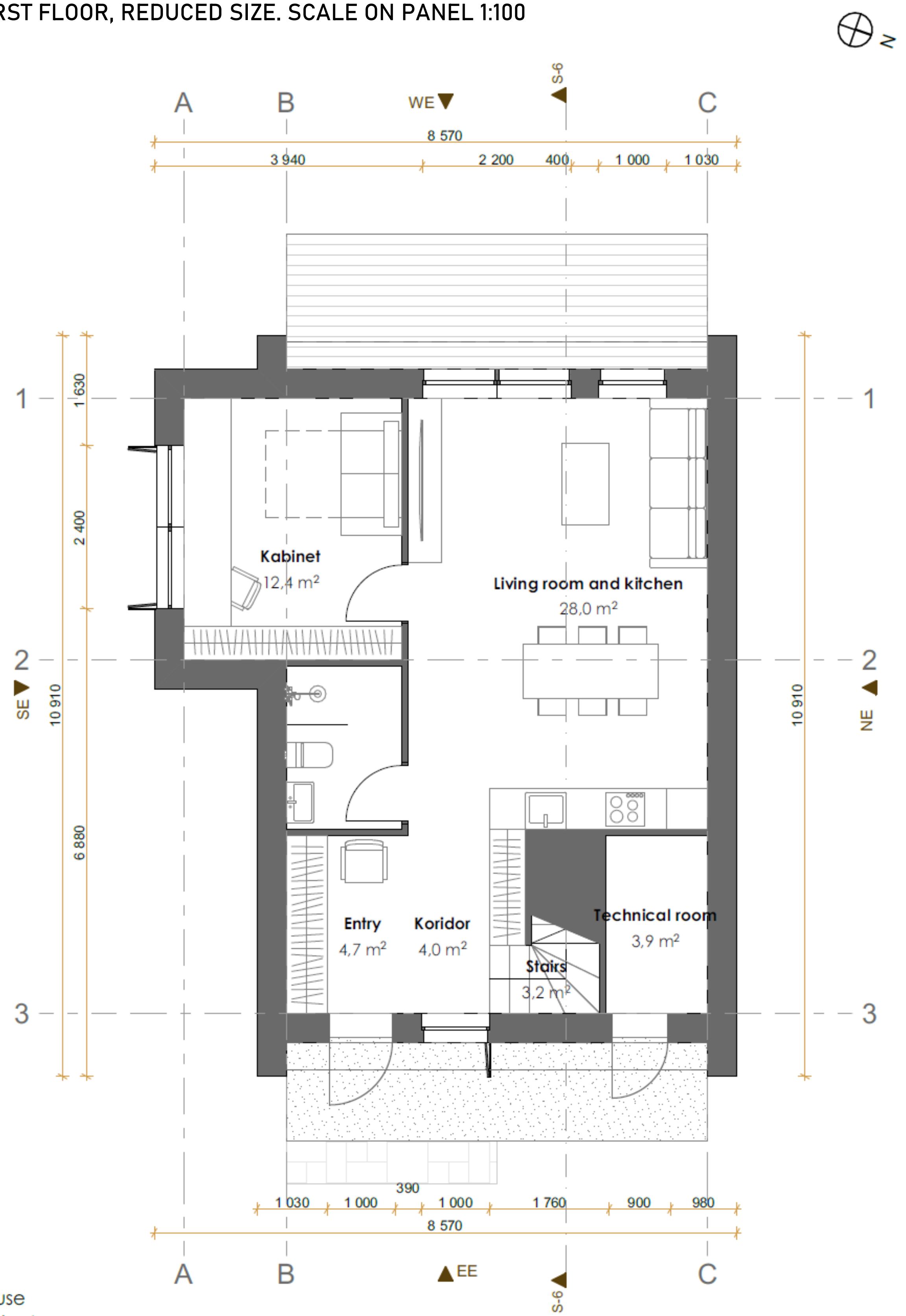
12. HOUSE VARIANT 6

The sixth and currently final variant is using the same approach as the first one – the stairs can be separated and equipped with additional entrances to separate the entire second floor. Such an approach showed the best results in terms of the space for additional apartments, as can be seen on the plans. Both the first and sixth are the only ones with a possibility for the two bedrooms and overall create a good opportunity for future division of the house.

HOUSE 6 DIVISION SCHEME

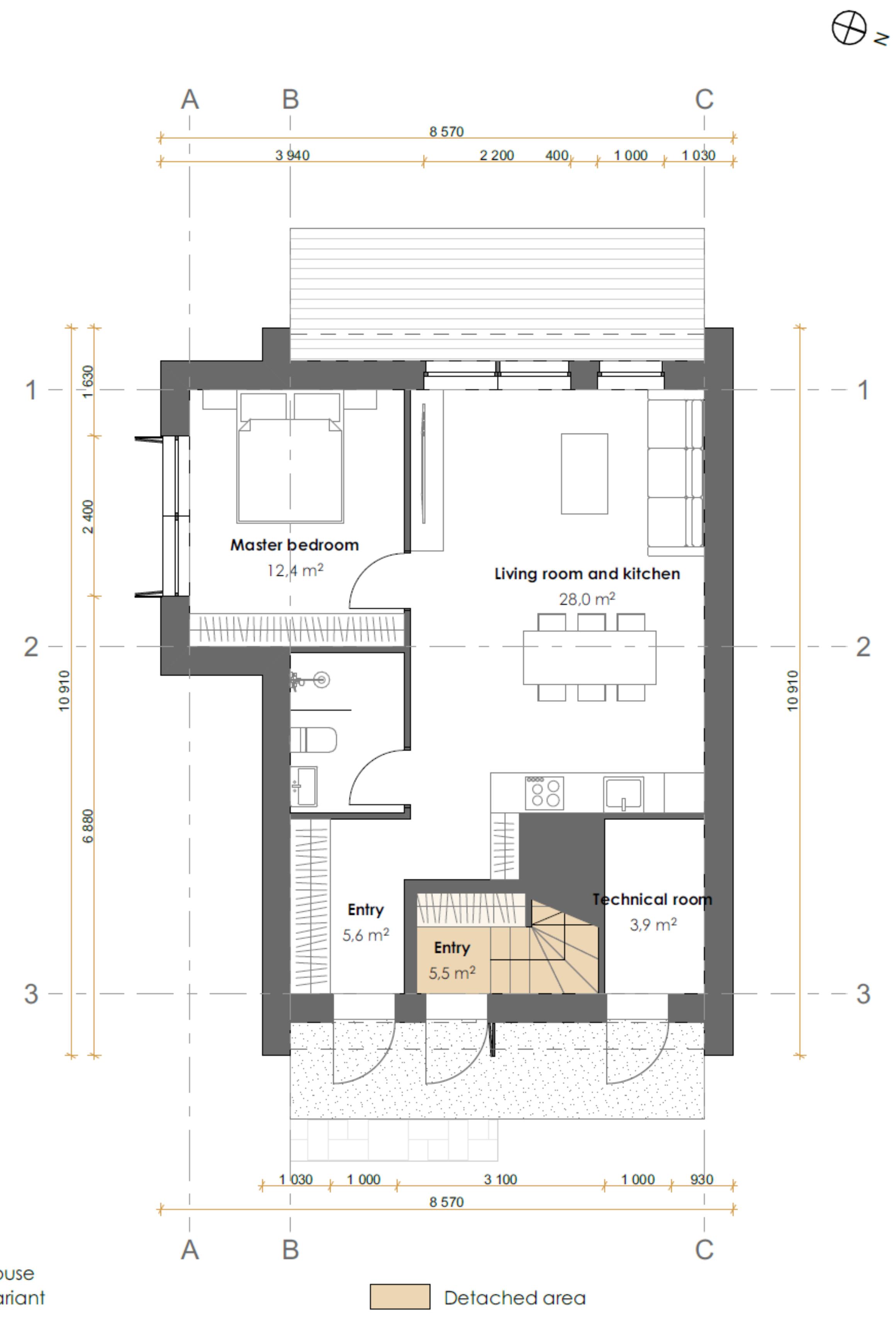


HOUSE 6 FIRST FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



6. House
1. Variant

Construction area	83,3 m²
1st floor net area	58,9 m²
net area total	112,8 m²

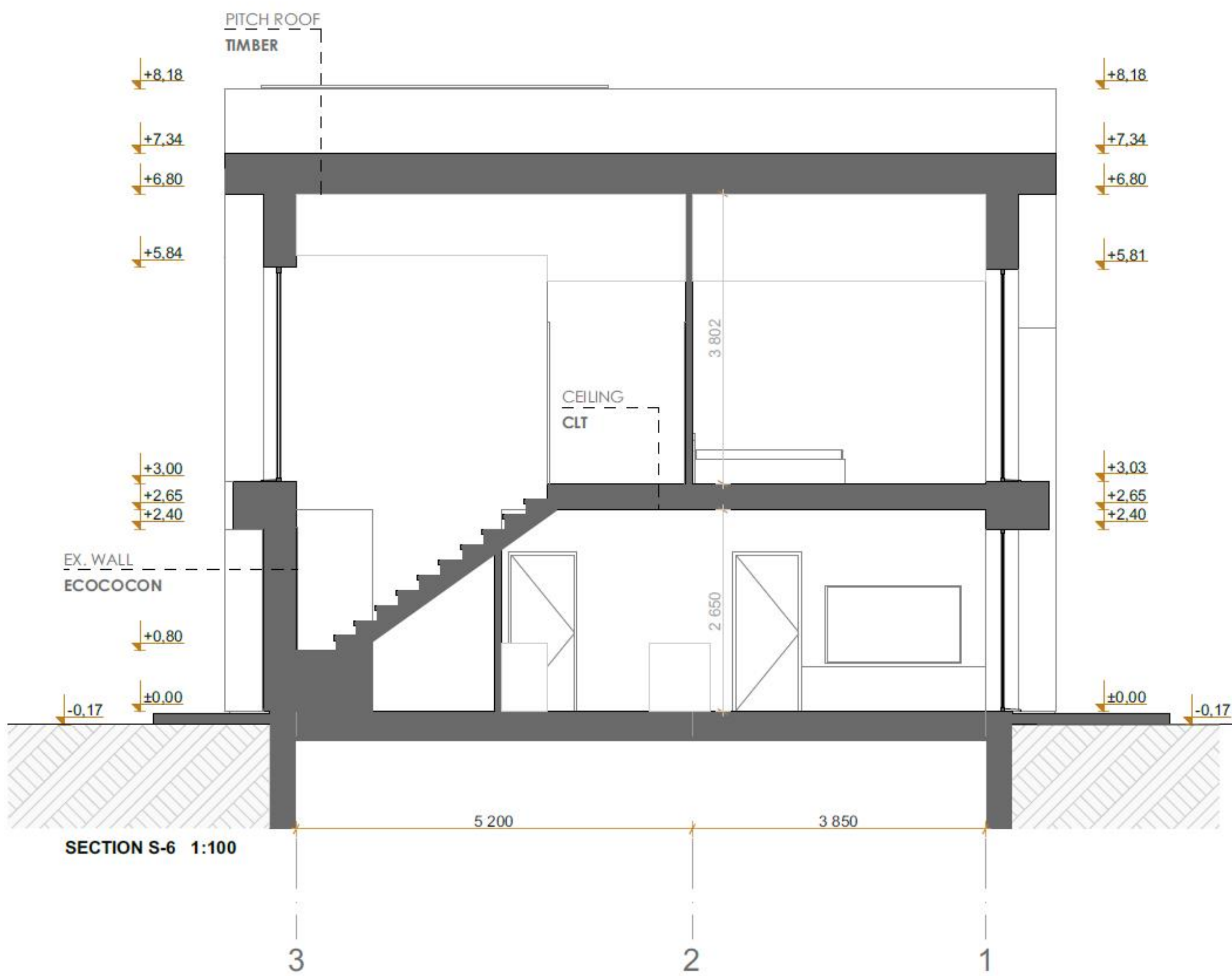


6. House
2. Variant

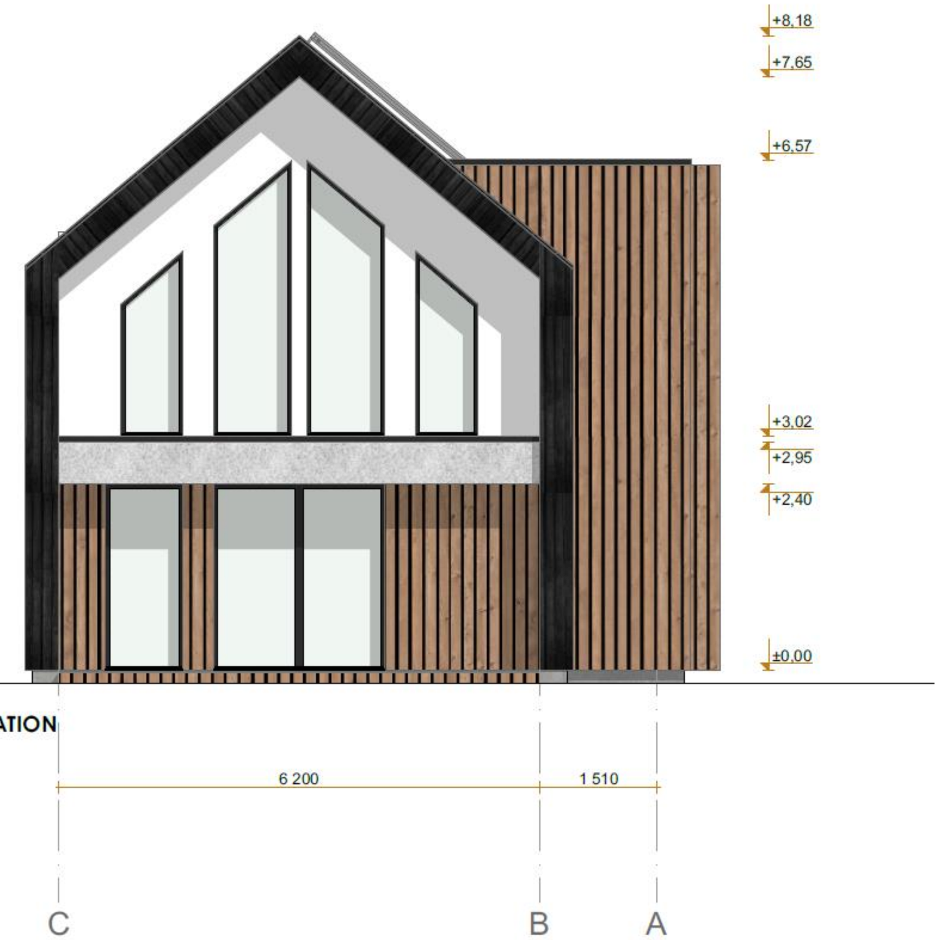
Detached area

Construction area	83,3 m²	2nd appartement net area	29,3 m²
1st floor net area	58,9 m²		
net area total	83,5 m²		

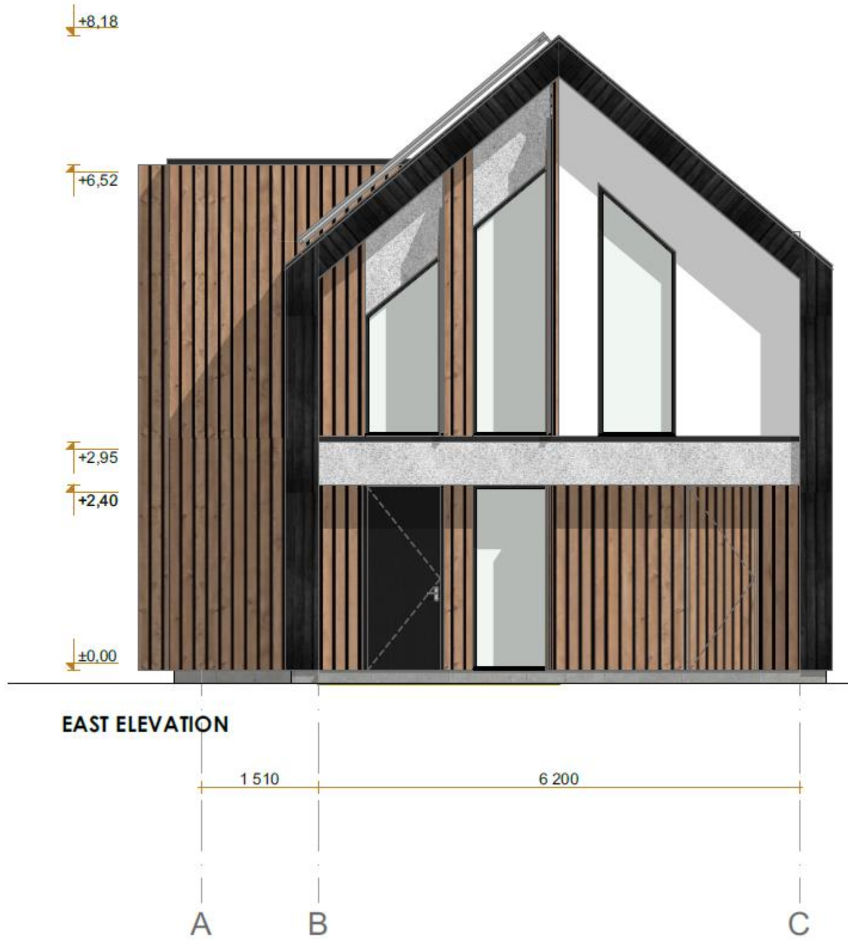
ELEVATIONS AND SECTION. REDUCED SIZE. SCALE ON PANEL 1:100



SECTION S-6 1:100



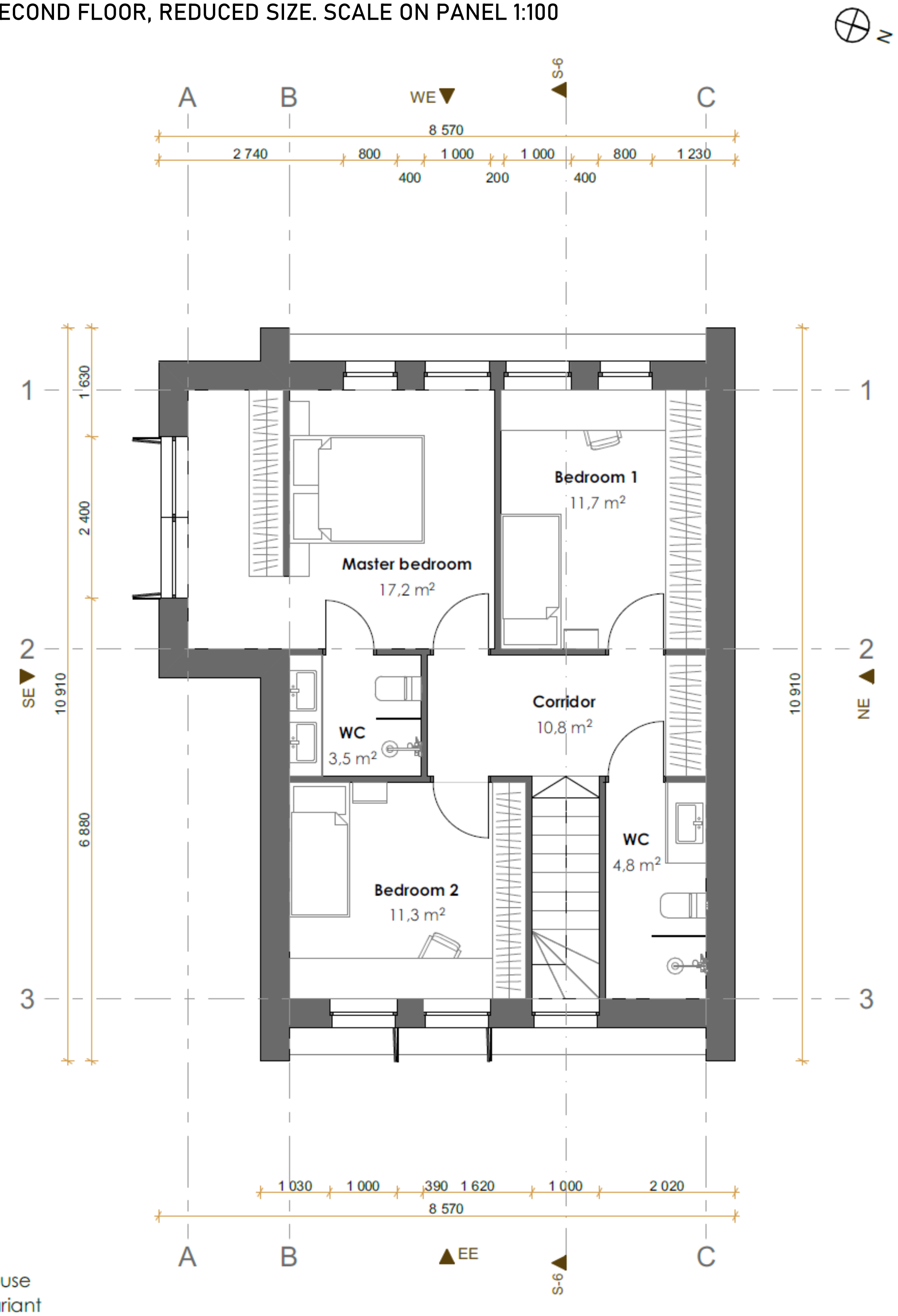
WEST ELEVATION



EAST ELEVATION

SOUTH ELEVATION

HOUSE 6 SECOND FLOOR, REDUCED SIZE. SCALE ON PANEL 1:100



6. House
1. Variant

Construction area	83,3 m²
2nd floor net area	53,9 m²
net area total	112,8 m²

6. House
2. Variant

Detached area

Construction area	83,3 m²
2nd floor net area	24,6 m²
net area total	83,5 m²
2nd appartement net area	29,3 m²

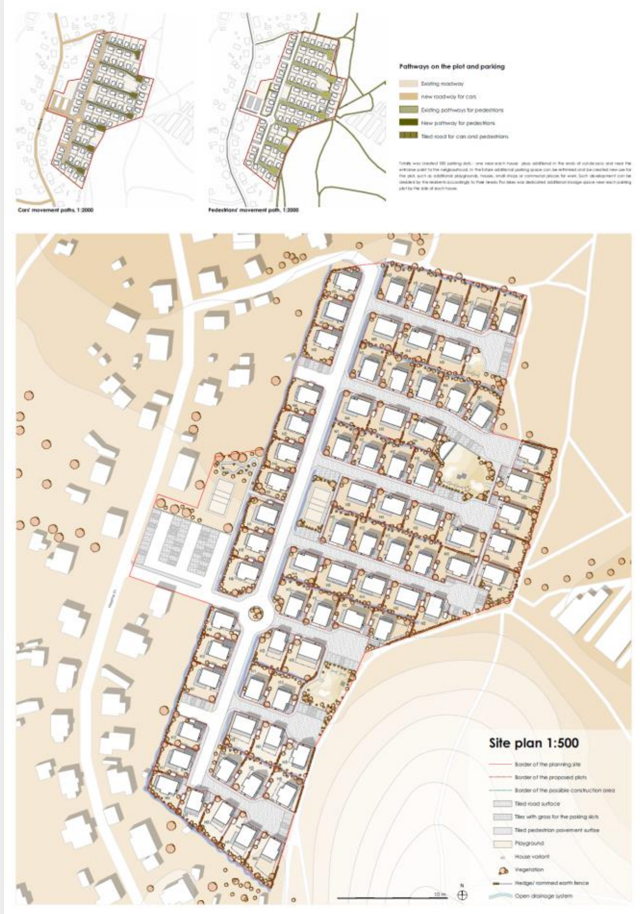
13.SUMMARY

The main goal of this project is to show that a shift towards more sustainable future is possible with single-family houses. Using principles, described in theoretical part, was possible to create a neighbourhood with 73 separate private houses instead of the 15 luxury private houses and 10 duplexes, that are originally proposed by the detail planning. With smart design, area is secure from under-occupation and can constantly give living space for 350 people, whereas the old division provide space only for 140 people. The results of this project are not determined by the location but more so by design choices, that we as architects are using. Thus, the project can be used as an example for future developments and can be shown to client as a possible way towards the more sustainable future. But this work is only focusing on the architectural aspects, so further development and analysis should be done. This work is not a ready strategy for the development of future single-family houses, but it is the first step. The design does not provide luxury that some can expect from private houses, instead it cherishes and promotes the idea of adequacy in space and manages to create comfortable and interesting space for living and rising a family. Similarly to how the Scandinavian concept in interior design is known worldwide for its minimalism and harmony, we can create a new concept for a detached house – adequate and comfortable, that can be our mark in this world, something that distinguish us from the rest and gives for everyone a solution that we needed, but were not searching for.

PANELS


FUTURE OF DETACHED HOUSE.
URBAN SINGLE-FAMILY HOUSING IN KOPLI
ÜKSITELAMU TULEVIK. LINNALIKUD ÜHEPEREMAJAD KOPLIS
Student: Georgy Karyagin
Supervisor: Emil Urbel


Location
Comparison with the existing DP
The site


Site plan 1:500


Design approach
Used materials


House 1
House 2


House 3
House 4


House 5
House 6


Road section 1:100

REFERENCES

archywordys. (2021, july 7). *Hamburg bans single-family houses – nationwide ban possible?* Retrieved from Archyworldys: https://www.archyworldys.com/hamburg-bans-single-family-houses-nationwide-ban-possible/

Bliss, L. (2019, July 2). *Oregon's Single-Family Zoning Ban Was a 'Long Time Coming'*. Retrieved from Bloomberg: https://www.bloomberg.com/news/articles/2019-07-02/upzoning-rising-oregon-bans-single-family-zoning

Boydell, R. (2020, June 22). *Why zero-carbon homes must lead the green recovery from COVID-19*. Retrieved from The Conversation: https://theconversation.com/why-zero-carbon-homes-must-lead-the-green-recovery-from-covid-19-141149

Cao, L. (2020, February 11). *How Rammed Earth Walls are Built*. Retrieved from Archdaily: https://www.archdaily.com/933353/how-rammed-earth-walls-are-built

CINARK. (2019). *The Construction Material Pyramid*. Retrieved from The Construction Material Pyramid: https://www.materialepyramiden.dk/#

Connolly, K. (2021, February 16). *German Green MP hints at ban on new urban single-family houses*. Retrieved from The Guardian: https://www.theguardian.com/world/2021/feb/16/german-green-mp-calls-for-ban-on-new-urban-single-family-houses

Darby, S., & Fawcett, T. (2018). *Energy sufficiency: an introduction.* Stockholm, Sweden: eceee.

Deschermeier, P., & Henger, R. (2015). *Die Bedeutung des zukünftigen Kohorteneffekts auf.* Cologne, Germany: Institut der deutschen Wirtschaft Köln.

EcoCocon. (2021). *EcoCocon in a Nutshell.* Retrieved from EcoCocon: https://ecococon.eu/assets/legal/ecococon_in_a_nutshell.pdf

Eesti Energia AS. (n.d.). *Solar panels*. Retrieved from Eesti Energia: https://www.energia.ee/en/era/taastuvenergia/paikesepaneelid?orderDetails=1&tabgroup_2=seadmed-paigaldus

Enerdata. (n.d.). *Average floor area per capita*. Retrieved from entranze.enerdata.net: https://entranze.enerdata.net/average-floor-area-per-capita.html

EQUITONE. (2022, march). *MATERIAL SUSTAINABILITY DATASHEET EQUITONE [natura].* Retrieved from EQUITONE: https://www.equitone.com/-/dam/equitone-msd-natura-en-epo/pd34389/original/equitone-msd-natura-en-epo.pdf?v=-2128011373

European comission. (2017). *People in the EU - statistics on housing conditions*. Retrieved from Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:People_in_the_EU_-_statistics_on_housing_conditions#General_overview

EVS843. (2016). *Urban streets.* EVS.

Heinonen, J. (2012, March 23). *The impacts of urban structure and the related consumption patterns on the carbon emissions of an average consumer.* Retrieved from Aaltodoc.aalto.fi: https://aaltodoc.aalto.fi/bitstream/handle/123456789/4948/isbn9789526045368.pdf?sequence=1&isAllowed=y

International Code Council. (2021). *2021 International Residential Code for one- and two-family dwellings.* ICC.

Junnila, J. H. (2011, march 28). *Implications of urban structure on carbon.* Retrieved from ioppscience: https://iopscience.iop.org/article/10.1088/1748-9326/6/1/014018/pdf

Kahlenberg, R. D. (2019, October 24). *How Minneapolis Ended Single-Family Zoning*. Retrieved from The Century Foundation: https://tcf.org/content/report/minneapolis-ended-single-family-zoning/?agreed=1

LETI. (2020). *Climate Emergency Design Guide.* London: LETI. Retrieved from LETI.

Majandus- ja taristuminister. (02.07.2015). *Eluruumile esitatavad nõuded.* Majandus- ja taristuminister.

Martin Röck, M. R. (2020). Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. *Applied Energy, Vol. 258*.

Neufert, E. a. (2012). *Architects' Data Fourth Edition.* Blackwell Publishing Ltd.

Passive House Institute. (2021, June 11). *Thermal insulation*. Retrieved from Passipedia the passive house resource: https://passipedia.org/planning/thermal_protection/integrated_thermal_protection

Pfäffli, K. (2012). *Grundlagen zu einem Suffizienzpfad Energie Das Beispiel Wohnen.* City of Zurich, Switzerland: sia.

Riigi Teataja. (2012). *Minimum requirements for energy performance.* Tallinn: Riigi Teataja.

RUUM JA MAASTIK OÜ. (2022). *Neeme tn 30 kinnistu ja lähiala detailplaneering.* Tallinn: RUUM JA MAASTIK OÜ.

Statistics Estonia. (2023, April 25). *Households and families*. Retrieved from Statistics Estonia: https://rahvaloendus.ee/en/results/households-and-families

Thomas, A. B. (2019). *Energy sufficiency in buildings.* eceee.

Thomas, S. B.-A. (2017). *Energy Sufficiency Policy: How to limit energy consumption and per capita dwelling size in a decent way.* Stockholm, Sweden: European Council for an Energy Efficient Economy.

UNEP. (2020). *2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector.* Nairobi, Programme, U. N. E.

UNFCCC. Secretariat. (2020). *Human settlements: sustainable low-emission housing and building solutions.* United Nation.

Wang, Q. L.-P. (2020, may 7). *Does urbanization lead to less residential energy consumption? A comparative study of 136 countries.* Retrieved from SccienceDirect: https://www.sciencedirect.com/science/article/abs/pii/S0360544220308720

World Architecture Community. (2017, November 14). *5 Zero-Energy Houses On Strijp-R - Eindhoven.* Retrieved from World Architecture Community: https://worldarchitecture.org/architecture-projects/hphhe/5-zero-energy-houses-on-strijp-r---eindhoven-project-pages.html