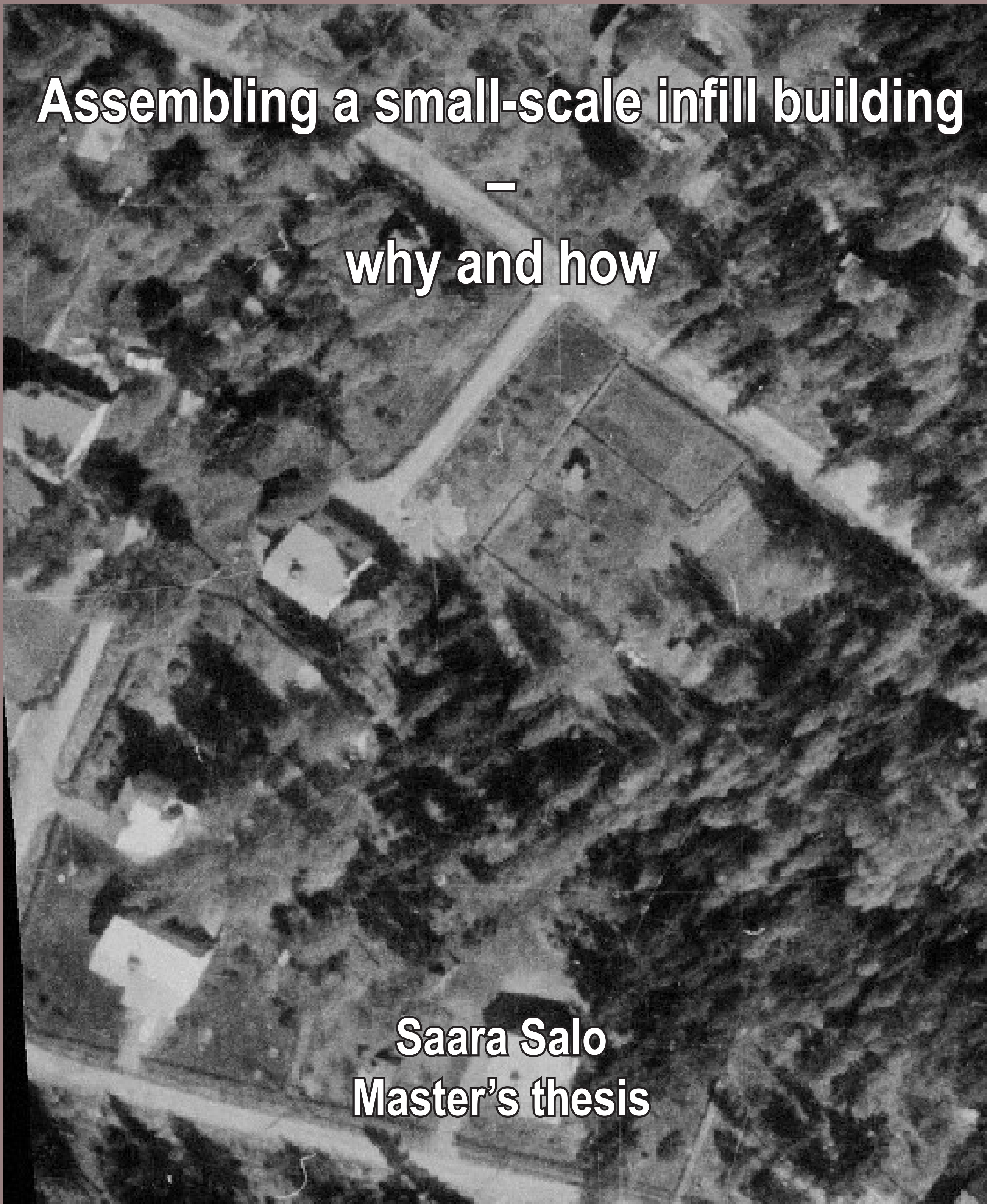
Assembling a small-scale infill building
–
why and how



Saara Salo

Master's thesis

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ABSTRACT

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Assembling a small-scale infill building – why and how

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Tenure Track Professor

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This thesis is a study of infill design in small-scale, both in the terms of the size of the construction and the amount of city planning required: the planning is for specific plots, not districts. The background research of what makes an infill viable is done on ecological grounds, economical grounds, and social aspects. At the same time, the practical questions of location and implementation are addressed. This is applied to a concept of a flexible and easy-to-implement building.

For the concept design, various neighbourhoods of Espoo were investigated through maps and pictures. Based on the them, the ones with plots suitable for infill construction were selected with the criteria formed for this thesis. Wood, more specifically, log was selected as the building material for the infill design due to ecological reasons, and because Finns prefer it as the material of their homes. After studying the process of log construction, a theory about how log building could be realized by modular construction was formed and used to design an infill block selection.

The criteria to plots to densify with infill construction was created to ease the selection of plots suitable for infill design or discard ones that are not. The criteria mainly address the locations of existing buildings on the plot, the plot ratio and the terrain on the plot.

The infill block selection is a concept where a flexible, modular-construction log house is formed by using a base block and as many add-on blocks as necessary. The construction is easy to implement to different locations. It is both expandable and shrinkable according to the needs of the household and, therefore, it allows for changes and creates a house for life. The concept fits any need, and when the needs change, the number of blocks changes by adding new blocks or taking old ones away, to be reused in somebody else's construction, made possible by the construction method and the possibilities of log as a construction material.

TIIVISTELMÄ

Saara Salo

Assembling a small-scale infill building – why and how

Diplomityö
Tampereen Yliopisto
Rakennetun ympäritön tiedekunta
Arkkitehtuurin yksikkö
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Tarkastaja: Sofie Pelsmakers
Tenure Track Professor

Avainsanat: täydennysrakentaminen, pienimittakaavaisuus, hirsirakentaminen, pientalorakentaminen, muuntojoustavuus, Espoo

Diplomityön tarkoitus on tarkastella täydennysrakentamista pienessä mittakaavassa sekä täydennysrakennuksen koossa että sen vaatiman kaavoituksen suhteen. Mittakaavana on yksittäisten tonttien, ei kaupunginosien täydennysrakentaminen. Mahdollisten täydennysrakentamisprojektien kannattavuutta on tarkasteltu ekologisesta, ekonomisesta ja sosiaalisesta näkökulmasta samalla, kun on tutkittu käytännön ongelmia sijainnin ja toteutuksen kannalta. Kaikkea tätä on sovellettu mahdollisimman helpon ja joustavan rakennuksen toteuttamiseksi.

Diplomityötä varten Espoon eri alueita tutkittiin karttojen ja kuvien kautta ja alueista rajattiin diplomityön aikana muodostettujen kriteerien avulla ne, joilta löytyy tontteja, joihin diplomityössä suunniteltu konseptirakennus sopisi täydennysrakennukseksi. Konseptirakennuksen materiaaliksi valikoitui ekologisten syiden ja suomalaisten yleisten preferenssien perusteella puu ja tarkemmin hirsi. Hirsirakentamisen prosessin tutkimuksen jälkeen kehittyi mahdollinen hirsitalon esivalmistuksen teoria ja tällä pohjalla suunniteltiin esimerkkitontille täydennysrakennusmoduulivalikoima.

Täydennysrakentamiseen sopivien tonttien valintaan kehitettiin ohjeelliset kriteerit, jotka auttavat valitsemaan ja rajaamaan pois täydennysrakentamiseen sopivia tai sopimattomia tontteja helposti. Nämä kriteerit liittyvät lähinnä olemassa olevan rakennuksen sijaintiin tontilla, tontin rakennustehokkuuteen ja maastoon.

Täydennysrakennusmoduulivalikoima on konsepti, jossa perusmoduulista ja useista mahdollisista lisämoduuleista kootaan joustava esirakennettava hirsitalo, jonka voi tuoda helposti monille tonteille. Konsepti on paitsi laajennettavissa, myös kutistettavissa asujan tilatarpeiden mukaan. Näin se antaa pohjan koko elämän kaaren mittaiseen asumiseen. Konsepti on sovellettavissa lähes jokaiseen tarpeeseen, ja kun tarpeet muuttuvat, voi moduuleiden määrää kasvattaa tai pienentää paitsi uusilla myös kierrätetyillä moduuleilla, minkä konseptin rakennustapa ja hirren helppo korjattavuus mahdollistavat.

CONTENTS

1. INTRODUC-TION

This thesis started when an acquaintance asked if I could make an infill plan for their plot in Espoo. They have more room that they need, and their frontman's house (see chapter 2) needs some repairs. They would like to renovate the house and then sell or rent it, and move into something smaller, but they like the area and would like to stay there. We talked about how the possible infill would fit and how to make it in the fastest way with the least problems to the neighbours and with ecological solutions. That was the start.

Goal

The goal of this thesis is to delve into infill planning in a small scale. This is not meant to be an urban planning work where large areas would be systematically densified with the help of plan regulation changes. This thesis is a study in possibilities of infill in the scale of a private citizen. The point of view is a positive one discussing the benefits of infill planning and densifying detached house areas on a conceptual level that might encourage people to built an infill house on their plot. The thesis is not a by step guide to what one needs to do to make it possible. The thesis includes a design solution for the plot that I was asked to make an infill plan for. The design solution of the house is done without input from the owner of the plot with a design that I think is the best solution from my research and preferences.

Definition

This is specifically small-scale infill thesis. There are no references to apartment building plots, semidetached house plots or rowhouses plots that could have an infill plan. The focus is solely on detached house areas and plots. The area studied is the city of Espoo, and I only used the building codes and regulations of Espoo in the thesis. Although the thesis references other places, all the theoretical study is implemented in Espoo.

This thesis does not look into the bureaucratic process of building a house. Outside of the information that was necessary for the design part of this thesis, there is no guide on how the process would actually go from a building permission to the completed house.

Structure

The thesis is divided into following parts: the first part is a context study where infill planning is outlined and explained from the historical standpoint that the plot inspiring this work is tied to. The second part is a theoretical study into the possible positive impacts of infill design, one of which is the future possibilities of telecommuting. With the theoretical base, the concentration to certain areas of Espoo is established.

After the theory, the thesis delves into the physical choices of infill design from a low carbon dioxide point of view, looking, for example, into materials and opening directions while also studying the necessary regulations for this kind of a project. The final part is the concept design project itself.

2. INFILL AND FRONTMAN'S HOUSE

Infill is a construction that is built as a part of an existing urban area or right next to one (Espoon kaupunki/ täydennysrakentaminen, 2021). Especially in a housing area the new buildings need to take the existing structures and the spaces between them into account in order to build something that fits the environment and does not destroy the important shared spaces like groves and parks, as they make areas more distinct and inviting. Furthermore, the construction should be done without devaluing the existing structures and their needs, such as views, sunlight and privacy, by the infill itself or the with the necessary infrastructure, parking and access roads for example. (Espoon kaupunki/täydennysrakentaminen 2021.)

When referring to detached houses and infill planning in detached housing areas, the first image to most Finns is a type of houses that are known as rintamamiestalo; a frontman's house. A frontman's house is used as an umbrella term to describe any 1½ -tory wooden, gable roofed detached house built after or during the Second World War, before the nineteen seventies (Niukko 2009). Not many regulations today limit the height of a building to 1½ stories, but those that do define the 1½ stories as a percentage of the main floor for the ½ story, usually 2/3 of the square footage of the main floor. The Finnish building regulations specify that spaces under the height of 1600 mm are not included in the square metres of a house. (RT 12-11055.) Officially, a frontman's house is a specific type of house built on a plot that was formed by the govern-

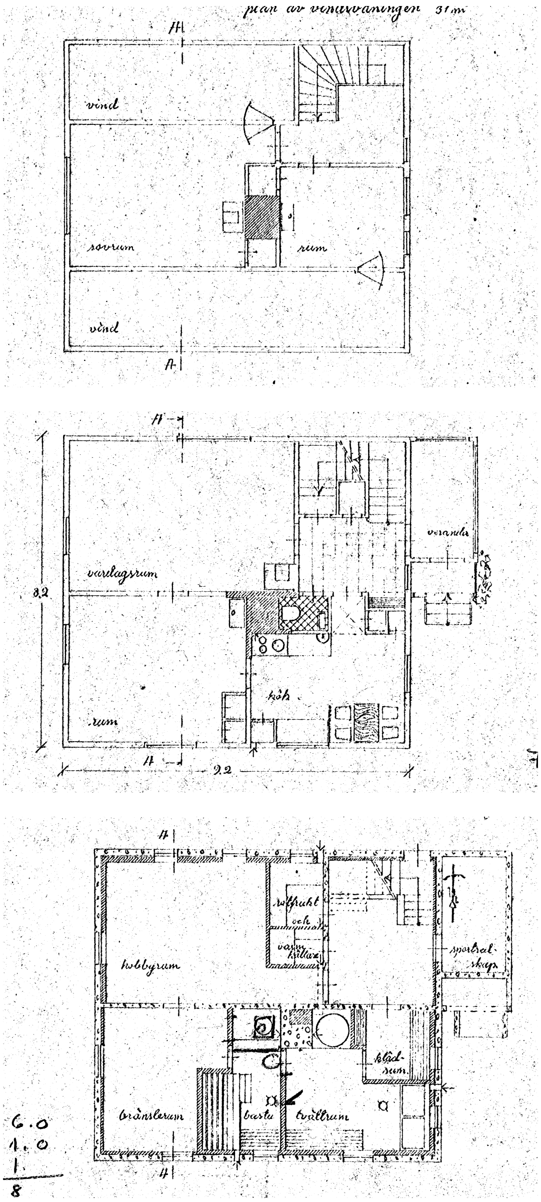


Figure 1 Typical floor plan of a frontman's house

ment to be donated to the people that had either served in the military during the WWII or who were affected by the war, like the widows of fighting men or migrants from the Karjala area (Niukko 2009; Tuuri 1998). The frontman's house is a wooden building, of either log or timber with a gable roof. The houses often have a cellar and 1½ stories above the ground. The plan of the house is, on the first floor, divided in four spaces with a fireplace and a chimney in the middle serving all the rooms. The four spaces are an entrance with the stairs to the upper floor, a kitchen and two rooms. There is almost always an enclosed porch, acting as an arctic entry, outside of the basic mass of the house. The second floor has two rooms at the ends of the house and storage space on the edges under the low roof sections. A typical plan, section and façades of a frontman's house can be seen in figures 1, 2 and 3.

Before and after the Second World War, several concepts for these types of houses were put forward by the best Finnish architects, including legends like Alvar Aalto and Kaj Engelund. Since the designs were driven by economic reasons and an urgent need for housing, the plans inspired a simple collection of plans that were wildly distriputed and used to make basic type house RT-cards (information files published by Building Information Ltd, used widely as guidelines in construction in Finland). However, the houses executed with these plans lacked a clear identity with little to no room of variation in the plans. (Tuuri 1998.) Nowadays most of the houses that fit under the basic characteristics of a frontman's house are called that even if they are not, for example many similar looking houses built in the 1970's and 1980's are still called, incorrectly, Rintamamiestalo.

For infill development, the frontman's house is relevant because the frontman's house plots were, in a way, the first detached house plots to be more systematically either divided into more plots or to be infill planned with more houses on the same plot with the frontman's house. This is because the original plots donated by the government were big enough to have space for allotment gardens, so the plots were commonly larger than 1500 m². The need for growing food for the family diminished greatly after the seventies, and it became common to build more densely. (Tuuri 1998.; Hedman 2016.) The common way to divide the frontman's house plots was the so called 'axe shaft plot'. The main building on the plot was often built near the access road close to the middle of the plot boundary, leaving space for anew plot on the back yard. To have a connection from the road to the new plot, the new plot was given a narrow strip on the side of the plot to the road to create an access point (figure 4). (Hedman 2016.)
The frontman's house plots were big enough to allow more buildings without the need to apply for any changes in the planning regulations since the permitted square metres for buildings were either regulated by a percentage of the total area of the plot, or the regulations had stipulations that allowed certain parts of the built square metres to be exclu-

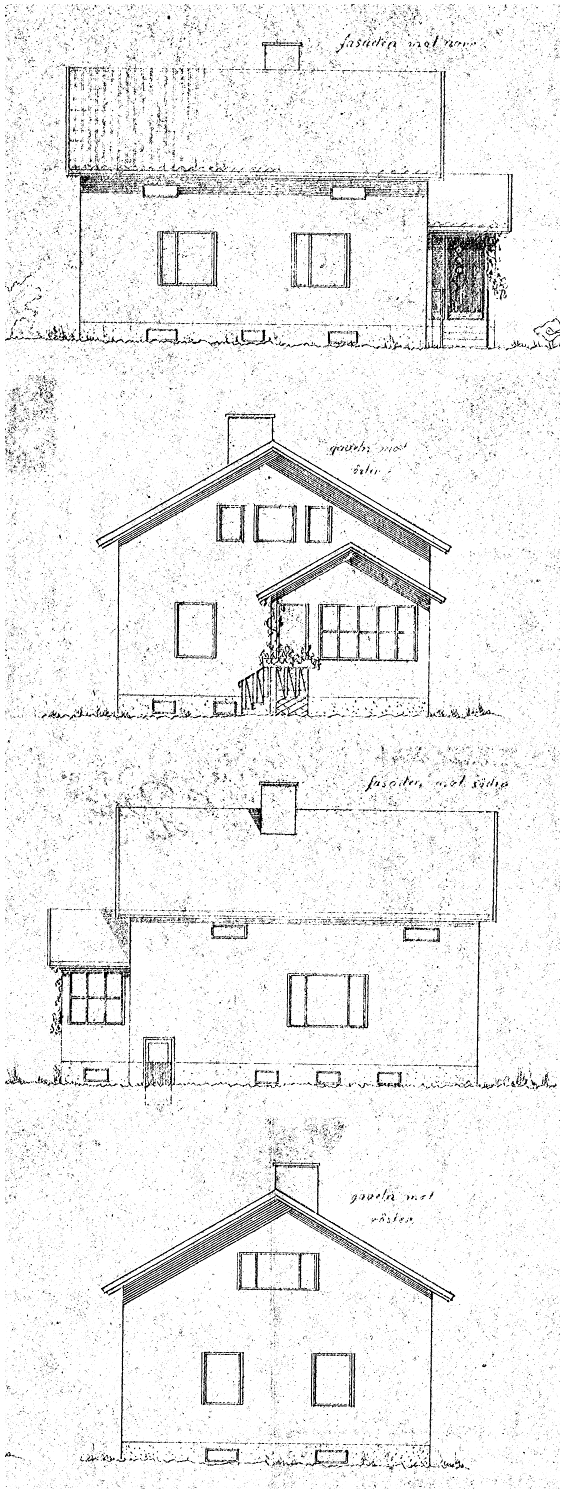


Figure 2 Typical facades of a frontman's house

ded from the official calculation, or both. This often leaves a lot of square metres for an additional house or two on the same plot (Hedman 2016). Many of the neighbourhoods I look into in this thesis have their origins as areas for frontman's houses. These origins are still visible in the original and divided plots of the areas. It is a history and tradition that I am building on with this thesis.

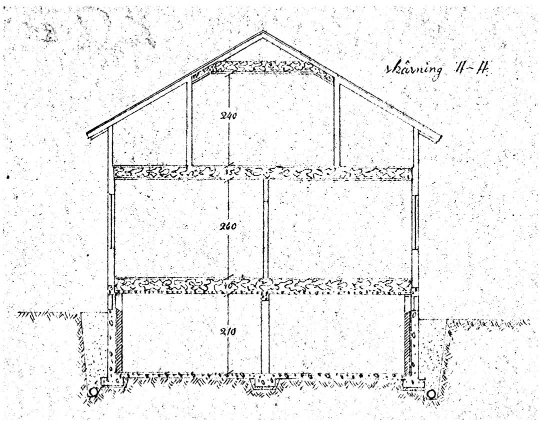


Figure 3 Typical section of a frontman's house

A detached house is still a preferred form of living among Finns (Kunnallisalan kehittämissäätiö 2017), but creating totally new detached house areas is often not sustainable; for example, the new residents would have houses before any municipal engineering or services are built to the area (Espoon kaupunki/täydennysrakentaminen 2021). Furthermore, it would be beneficial if the transportation network were to be built before building the new area to make sure that when people move to their new homes, they have the possibility to come and go without a private car. Unfortunately, it is usually not economical to have, for example, a new railway connection before there are customers to use it. Since economical reasons often prevail and new infrastructure is only built after the houses, there is time between creating a new housing area and having a public transportation network reach that area, which almost forces the new habitants to have a private car. In addition, it would be preferable to avoid ending up with an American style suburban sprawl where detached house areas stretch out far and wide, making it virtually impossible to organize a fast, efficient and usable public transportation network when either the distances to stops grow or the connections are too slow. (Wahlgren et al. 2011.) This is further emphasized by the fact that not only do Finns want to live in a detached house, they want to live in a detached house close to a city centre. (Kunnallisalan kehittämissäätiö 2017).

Finns have slightly negative attitudes towards densely built areas, but they are slowly turning into more positive about more urban and more tightly built areas, especially among younger generations (Kunnallisalan kehittämissäätiö 2017). However, most Finns would still like to live in an area where one can live on one's own without anyone bothering them (Kunnallisalan kehittämissäätiö 2017).

Olli Lehtovuori, a professor of architecture, is a strong supporter of small scale infill planning and densifying of detached house areas. He believes that both will be more necessary in the future than ever before. According to Lehtovuori, there can be both privately owned and rental houses on one plot since small rental homes are needed. More and more people live either alone or in a two-person household and do not necessarily have the money to buy a one or two room apartment. (Salmela 2016.)
Lehtovuori sees that infill building best suits older detached house areas where a generational change is ongoing. Infill construction is also a way to advance urban small scale living while making sure that the services stay in the area (Salmela 2016).

Figure 4 Current axe shaft plots on 1976 air view highlighted in duple colour purple and pink

3. WHY INFILL IS A GOOD OPTION

3.1 Existing transportation network

A universally accepted part of infill development is that a good transportation network, specifically a public one, is the most important requirement of a sustainable infill project, meaning railways, metros and busses (Pajamo 2018).

In Espoo the situation with railways is developing. Two new railway tracks are to be built through all train stations in Espoo as a part of the future quick railway connection, City Rail Link, from Helsinki to Turku (figure 5). This enables more trains per hour, which allows more users and stimulates the densification of the areas around train stations. The railway takes almost ten years to be completed, but the extended metro system comes into use in 2023 (Espoon kaupunki/kaupunkirata, 2021) The areas around the stations of the first part of West Metro are quite developed already, but the railway and the second part of the West Metro have a lot of older, low-rise detached house areas close to the stations. As these areas are not yet densified or developed, they are well qualified to be used as case plots for my thesis.

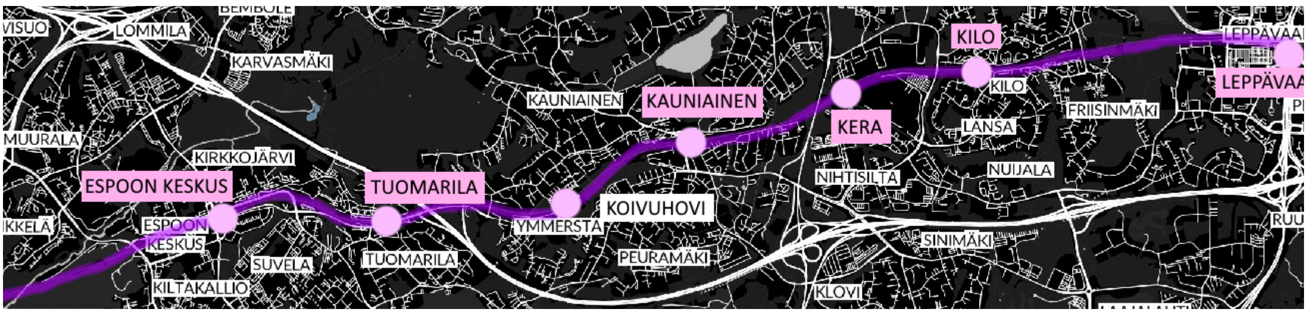


Figure 5 Espoo’s railway stations allong the Helsinki - Turku railway

3.2 Economic reasons for infill development

The City of Espoo claims that the biggest economic benefit for infill planning comes from being able to utilise existing infrastructure networks; not only transportation like railways, but also new roads, and widening the electrical, plumbing and heating networks. Building these pieces of infrastructure costs a lot, especially in a detached housing area, where the costs that the city transfers to owners in the form of taxes and plot prices are not divided between as many users as, for example, is the case in apartment building areas. (Espoon kaupunki täydennysrakentaminen 2021.) Building on an area with existing networks diminishes these expenses.

Infill construction can have a positive impact on house prices although the price rise seems to be more due to the benefits that a larger scale infill development brings. Both an article by Ahvenniemi et al. (2018), referring to multiple studies, and a 2013 study by Nykänen et al. (2013) indicate that the infill development would need to be 20 % of an existing housing stock to have even a 5-9 % increasing effect on the house prices, and even with a 50 % growth the rise in prices does not exceed with 17 %. A well-made infill development seems to have the biggest effect on property values in areas that have the lowest housing prices, given the slight improvement in the prices, whereas in areas where the housing prices are already high, the slight rise in values is not that noticeable. Most studies that Ahvenniemi et al. reference, like Laakso's Helsinki city study 2012, have shown that infill development increases the property value of the original housing stock or the plots mainly indirectly. If the infill is well developed and planned, it can raise the value of the area through amenity effects where new development in housing brings along more services in all possible areas: more stationary services such as day-care, shops, and health services, or improved public transportation like more trains in an hour or additional bus routes. These raise the desirability of the area and, thus, the prices of the houses. Ahvenniemi et al. also summarize studies about the downside of infill development, like Seppälä's study for Aalto university 2013, which seems to indicate that, if executed badly, infill development can decrease the value of properties. For example, a too eager building on, and therefore loss of, green areas, deteriorating the landscape and decreasing the natural areas, can plummet the prices since the area is no longer perceived as desirable as earlier. (Ahvenniemi et al. 2018.)

Infill development can be a circle of co-benefits: more residents bring new services to the area and keep the existing ones in place, which possibly leads to an improvement in the neighbourhood attractiveness, which in turn leads to the rising of property values in the larger neighbourhood scale, again increasing the vitality of the area. More work possibilities and services closer by create a more competitive and attractive area that also benefits the surrounding neighbourhoods. (Espoon kaupunki/ täydennysrakentaminen 2021.)

Even though on larger scale infill projects are not necessarily economical, the economic benefits might still be there for private residents (Espoon kaupunki/ täydennysrakentaminen 2021). If an infill house is well planned and can be accomplished without the need for an alteration in the regulation of the plot, it can be quite beneficial to the builder and owner of the plot. The plot owners can rent or sell the economically built new infill houses, thus earning some money for themselves even if the second building would not raise the value of their own plot very much, if at all. The profit from selling or renting a second house on the plot also has useful benefits of helping to pay for possible renovations of the first house on the plot. As a lot of the buildings on larger plots date from the 1960's, 70's or 80's, the need for major renovations of these detached houses is imminent right now. (Ahvenniemi et al. 2018.) It is also possible for the owner to sell the first house on the plot and move to the second one if, for example, the first house has become needlessly large for the family. This would possibly offer even more profit and transfer the renovation expenses to the new owner.

The prices of housing especially in the Finnish capital area are very high since the demand is high. The capital area is one of the growing centres in Finland, and Espoo's population is expected to grow with around 1.5 % every year, which equals close to 5000 people. (Espoon väestöennuste 2019-2028, 2019.) There is a high demand for more affordable housing options not only on an individual level but on the society level as well. While zoning new areas is slow, using existing areas with existing planning regulations that allow infill planning is easy and quick and, therefore, saves time and money. Moreover, the space exists: in 2011 there was enough unused building volume for 97 000 new residents to move into already built areas of the capital area, a third of it in Espoo. Of course, not every single plot with unused building volume is suitable for infill development, the plot may be, for example, of a wrong shape or on a too steep slope, but even by careful estimate the already built areas in Espoo could house 35 000 people more. (Kytö et al. 2014.)

3.3 Ecological benefits

“The biggest negative impact on eco-efficiency per resident is, however, the anticipated growth in living space per person” (Karjalainen & Patokoski 2007). With good or fully used plot ratios, the building density is high and the effect this has on the environment is positive. Furthermore, densely built areas save larger, connected nature areas in the city. In Karjalainen and Patokoski’s book Wooden urban villages, Pekka Lahti has calculated that if 90% of new small-scale houses can be located in and around densely populated areas, the eco-efficiency, in this case smaller CO_2 emissions, smaller material, energy and fuel consumption and smaller waste amounts, would improve with this one change up to 7 % in thirty years. (Karjalainen & Patokoski 2007.)

According to the Paris Agreement, Finland has promised to keep the rise of global average temperature at 1.5 degrees Celsius above the pre-industrial levels. To achieve this, the CO_2 emissions need to be lowered in the long term. (Lappalainen 2010.) Most of Finland’s CO_2 emissions are made in the energy-sector, which includes built environment and traffic. Of all transportation emissions, more than 80 % are from cars, and of those, almost 60 % come from private driving. (Wahlgren et al 2011.) In Finnish low-rise areas, the population density is much lower than in similar areas in other Nordic countries, leading to higher costs of construction and maintenance of infrastructure, longer distances to travel to services and the movement of local services further away to centres. All this can be mitigated by densifying and integrating the areas. According to a study made for the Ministry of the Environment by VTT, the integration of the low-rise areas results in significantly lower CO_2 emissions. On the other hand, if the low-rise areas keep expanding, the CO_2 emissions inside an area can grow 25 % in a decade. (Wahlgren et al 2011.)

Densifying housing areas is a method of lowering CO_2 emissions that is implementable on all levels of society. To have an effect on a large scale, it has to start from administration and city planning. (Wahlgren et al 2011.)
Detached house plots have surprisingly diversified nature, more so than the public nature in the same areas. Therefore, saving them is important for both insect and bird populations. (Pajamo 2018.) Finns often feel that closeness to nature is an important factor in a living area and often like to use native flora which is easy to maintain, survives winters and naturally maintains a good bio-diversity in their gardens (Tanner 2021). The possible flooding that densifying and, therefore, new hard surfaces create is preferable to be addressed on the plot without putting an extra strain to the city’s water lines. An infill construction could be a good time to think about the green areas of the plot as a whole. By using built solutions, like permeable or semipermeable surfaces on access roads instead of stone roads and areas, or green roofs or underground rainwater tanks, the ru-

noff water is minimized. There are also garden solutions, like rain gardens, that allow the water to pond before dissolving slowly. (Tanner 2021.)

On some plots it is necessary to consider the condition of the original structure and decide whether it is ecologically more beneficial to save the building and possibly repair it, or if it has gotten into such a bad shape that saving it would take more time and resources than demolishing it and maybe reusing the materials for an infill building. If repair is the better option, the old building can be made more ecological with, for example, the green roofs mentioned above, better insulation or new energy solutions, like sun panels.
Another important point is that despite the growing of energy efficiency in technology, the ecological efficiency of housing areas is diminishing, probably because of the older housing stock in need of renovation. Infill development can also diminish the effects of CO_2 emissions as the big united green areas of Espoo can be saved. (Espoon kaupunki/täydennysrakentaminen 2021.)

Densifying areas is an ecological solution since that affects the services offered, decreases the need to use a private car, and prevents the extension of urban sprawl and excess use of land area (Karjalainen & Patokoski 2007). The positive effect of densification on CO_2 emissions from all possible sources like traffic is significant (Peltonen et al 2002). Furthermore, the CO_2 emissions from constructing a building are relatively low compared to the emissions associated with using a building and living in it. That is why it is important that the planning of heating, lighting, and other systems is as close as possible to carbon neutral. (Lahti et al. 2010; Peltonen et al. 2002.)

Denser areas with a lot of infill development have slightly, or about 10 %, smaller carbon footprints and CO_2 emissions from transportation than other areas, due to, especially, less use of private cars. The heating of houses in areas that are densely built cause up to 20% smaller CO_2 emissions than the heating of houses in an area that has loose building density. (Harmaajärvi VTT.)

A house with a yard can also be smaller than an apartment in a multiple story building since the yard is a part of the living space. This minimizes the square metres that need to be heated, as Olli Lehtovuori brought up in an article in Helsingin Sanomat. (Salmela 2016.) This is an important point since 22% of all the energy used in Finland is used to heat buildings (Lappalainen 2010).

3.4 Growth of diversity

Infill development reinforces social stability in an area by creating more permanent bonds and bringing people closer together through their shared gardens (Ahvenniemi et al. 2018). Despite the population growth, the population is shrinking in most of the housing areas built in the 1960's and 1970's in Espoo (Espoon kaupunki/väestö 2021). The reasons are probably quite obvious, more people than ever live in one and two people households and have neither the money or the need for a large detached house. The existing population grows older and their grown-up children have moved out of the areas while the parents stay behind.

Espoo has set as its goal the prevention of the continuation of segregation. Segregation is the separation of people of different socio-economic, cultural, or ethnic backgrounds to different areas, which causes the growth of social and cultural differences between these groups (Kytö et al. 2014). The problem has not been considered a major one in Finland in the past, compared to for example slums in many other countries, the worst end result of segregation, since urban planning has been done intentionally so that different income groups are mixed in the same areas to offer the same level of healthcare and education to everyone. However, after the economic problems of the 1990's, the segregation started to take roots even in Finland, growing rapidly in the capital area. (Kytö et al 2014.) Different areas have different core reasons why this is happening. In detached house areas, one of the reasons is the lack of affordable houses. The housing prices are quite high, and low-income groups cannot afford to buy a house and renting options are very limited (Kytö et al 2014).

Infill houses might offer a good solution. With a good concept, the construction and planning should not be expensive, so buying or renting an infill home should not be as expensive as buying or renting a more traditional house, as an infill house is also likely to be smaller. In addition, infill building would be optimal for renting, allowing, again, a lower income family to move into the area. The availability of rented houses raises the possibility to benefit of living in a small house area and enjoy its benefits, such as their own yards for people who could not afford to buy a house. This also widens the social structure of the area.

Moreover, infill houses offer people the opportunity to stay in the area longer, ensuring more stable social structures. In interviews about possible infill areas, a big positive point for infill seemed to be the possibility of keeping the family close for a longer time, and creating an area with three generations living together. (Espoo 2016.) It can be assumed that people who have moved into a detached house when they have started a family would often like to stay in the area even after the children move out and they grow older and do not need or want as much space. If they can stay in the area in a smaller house with, perhaps, a shared or smaller yard, their life quality might stay better than if they were to move to a new area. Furthermore, this would create a more natural age distribution in the area and allow families to stay close together for a longer time, in their familiar environment.

A major part of preventing segregation is also the community and cooperation between the residents. When some people are not excluded from the community, the area does not start to fraction and feel unwelcoming to people of different backgrounds. The community strengthens the area, making it safer and more welcoming, which enhances the quality of life. This is easiest when the residents do not change too quickly. Having multiple people living on the same plot should strengthen these connections as they take care of the same yard. (Ala-Mantila 2018.; Pajamo 2018.)

Few older people really want to move into an apartment building where they are, at worst, stuck in their small apartments with strangers around them. Even a small yard can give so much more quality of life than one can get in an apartment as the small piece of nature brings joy. (Salmela 2020.)

A major point is also the change in social structures. The sizes of households get smaller if an ageing population is left to live alone when their children move out and if more and more people of the younger generations live alone or in households of two people (Espoon kaupunki/Väestö 2021). These changes would mean an increase in the need for smaller houses. With this change, it would seem that, there are enough existing houses for big families, but not that many practical choices for singles and couples other than in apartment buildings.

3.5 Growth in telecommuting

Telecommuting or remote work means working from home or another private location outside of an official workplace, like an office building. During the COVID19 pandemic of 2020-2021 more people than ever have been doing work from home. There are not yet that many studies of telecommuting on this scale, but I wanted to take this into account, because infill buildings could be used as telecommuting spaces. This is just a small view of what possibilities telecommuting could find in infill planning and not a full analysis of all the advantages and disadvantages that a wider scale of telecommuting causes since a lot of these are linked to the decisions of the companies and not the private owners of possible infill offices. Furthermore, for the purposes of this thesis, I assume that the residents do not move to another house to have more space to work from home and, thus, the travel distance to the office or other services is not affected.

A major benefit offered by full telecommuting to private residents are the savings on transportation. If the transportation is a private car, the savings are not as big as one could hope for, since other necessary commutes can no longer be integrated with the daily commute. Another benefit is saved time. On the other hand, the biggest disadvantage of telecommuting is the growing energy consumption at home due to work necessities like an extra computer, but also due to heating, cooling, lighting, not to mention the social aspects. Any other aspects greatly depend on the individual: whether they work better in a space away from their house, if they live with other people that should not have access to their work and so on. In addition, building a separate office space as an infill house creates costs in build and in use. (O'brien et al. 2020.)

This type of telecommuting does not offer a lot of benefits to using infill development as telecommuting workspaces since my case study is focused on areas where public transportation is in great use. This means that only if the infill building is used by multiple people would the benefits outweigh the costs of its construction. Unless the infill building would be built in any case in the near future, the benefits to the people and environment prevail.

Full telecommuting, meaning working only from home five days a week, is not necessarily the future. A questionnaire by Eurofound to Finnish workers showed that only one fifth of the respondents would prefer working from home five days a week. However, almost a half would like a hybrid working model where they work from home a part of the week, and the rest of the week they go to the office. (Raita-Aho 2021.) Studies have shown that workers are more efficient in repetitive tasks at home and more creative at the office (Bloom 2021).

This type of future working model could profit from separated telecommuting workspaces used by not only the owner but also used as rented telecommuting spaces for people in the neighbourhood. Renting an office space from a walking distance from home one or two days a week could be a desirable solution for many, especially those with many other people in the same house, especially children. The infill office could be rented to different people on different weekdays or be used by several people working there at the same time, adding to the ties of the community.

From this point of view, the benefits of an infill telecommuting workspace would balance the possible negatives, especially if the users commute to work by car. Detached house areas are also the ones that would have the most users for infill telecommuting workspaces, since the workers who can telecommute are usually university educated people who work in management, business services or intelligent services (Bloom, 2021.) - including, in my opinion, architects. Furthermore, these people often live in detached houses and may have the means to develop an infill construction (Vantaa 2018).

4. EXISTING CASES

I looked and collected examples of existing small-scale infill projects that have some similarities to my project. They are all single-family houses, one or two floors, in low-rise residential areas. The cases I chose are located in cities with planning regulations and tighter spaces. I found out that there are not that many examples of this type of construction outside of basic prefabricated houses that are quite popular in Finland: over 70% of new detached houses are some type of prefabricated houses (Dekotalo 2021) and there are more than a dozen popular companies in Finland that offer these kinds of houses. However, I aimed at something more unique.

One room house in a garden

Yksiö puutarhassa, Master's thesis by Olli Enne, Aalto University

A single-room house in a garden is a designed in the master's thesis by Olli Enne and constructed in Vantaa. They are two 50 m² houses at the back of a plot, carefully executed to be as efficient as possible. He built one of them as a home for himself and his partner and has made the concept commercially accessible (figure 6). (Enne, 2017.)

The plot is one kilometre from the nearest train station. The design was created as a solution to the housing shortage in the capital area. It is supposed to be an activating and desirable solution to plot owners, and it is designed to be as affordable as possible. (Enne 2017.) In many ways this is very close to what I am aiming to execute.

Figure 6 One room house in a garden

To me this was the most interesting example. On the basic level, the concept is very close to mine, but without a growth aspect. In fact, on the sketch level it is so close that I had to try to be careful not to copy it. On the theoretical level, the cases are very different. I have adopted a more theoretical view, whereas Olli Enne did a very practical project from an idea all the way to construction. The project looks at the same type of limitations as mine, but from a very personal point of view.

Home and houses in a garden

Home and houses in a garden by Olli Lehtovuori

What professor Olli Lehtovuori has done on his plot in Helsinki is also a close example of what I want to do. On his almost 1100 m² plot there is the original house of 132 m² built in 1970 and two smaller buildings of 46 m² and 39 m² built 1980 and 1990, respectively (figure 7). Lehtovuori sees that the small buildings can be smaller than apartments since the yard works as an extension of the rooms. Originally Lehtovuori's adult daughters lived in the houses, nowadays they are rented out. The rent is cheaper than in many apartment buildings and the perks are better. (Salmela 2016.)

Figure 7 arial view of the buildings

The only disadvantage with the Lehtovuori case from the perspective of my parameters is that although the plot is right next to a bus stop, it is more than three kilometres from the nearest train station. The distance is perfectly cyclable, but not within the ideal one-kilometre distance. The design is also more a one-of-a-kind design, made by an architect for his own plot. The solution, even though beautiful, is not easily repeatable. without major alterations. It is, in a way, similar to old farming communities where houses were built around a yard and everyone who lived in the house complex worked together (Vuolle-Apiala 2012). This solution brings the newer houses close to the main building, and as the main direction of the houses is towards each other, it is very much like a community on a single plot. Although an idea that I would like to cultivate, the Lehtovuori solution brings all the houses a bit too close in my taste. There is not much garden left, and since all the houses look into the same direction, they do not really have their own gardens, which in my opinion is important.

ADU, Vancouver
ADU, Additional dwelling Units Vancouver Canada

ADU, short for Additional Dwelling Unit, also known as Laneway House, is a well-developed concept of infill construction on a detached house plot especially in Vancouver, Canada. In Vancouver, there are more than 3000 ADU units. The demand for these houses is high since Vancouver is an expensive city to live in, and affordable housing is hard to find. According to the regulations, ADU's need to be stylishly similar as the main building but clearly submissive to it, no more than either 50% of the size of the main building or 800 square feet (75 m²), and there can be just one per plot. The AUD can be built even if the main building has used all the square metres allowed by the regulations, and when building one, the amount of parking spots is not increased. To build an AUD, the plot owner needs to apply for a construction permit, but it has been made as easy as possible. (Pajamo 2018.)

ADU's are a good example for city wide cooperation. It is an admirable example about how a city can encourage infill planning and achieve good solutions to housing shortage problems. Since the ADU's are widely distributed in the city, they have become a part of the infrastructure. They are part of a quite dense housing stock that is built much closer to each other than would be advisable in Finland, which has also leaves the garden spaces small.

5. BASIS OF DESIGN

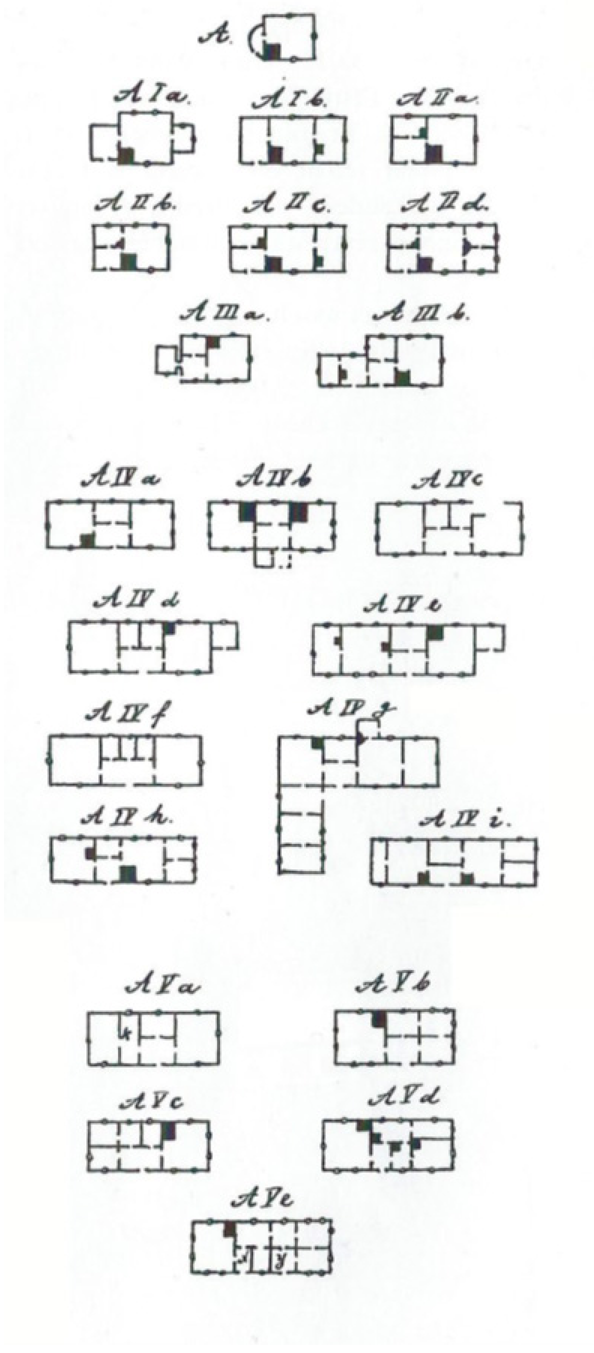


Figure 8 Traditional log buildings expansions

The basic idea for the design created in this thesis is inspired partly by IKEA: it is a basic concept with some variations that is easy to put together and take apart, and it is easy to add more parts into the design. Another inspiration comes from a traditional Finnish lumber house: they usually began with just one room with a fireplace, but when needs and means grew, new spaces would be added and expanded (figure 8) (Vuolle-Apiala 2012). Finally, I was also inspired by Alvar Aalto's ideal of type houses as he described them after the war: the goal is to define the prime unit and the base elements and use them to create a house that can grow and change. To Aalto, it was always necessary to have a possibility to additional development, the prime principle of Finnish peasant construction. (Tuuri 1998.) The goal in the thesis is to create a flexible and protean design that can change throughout its live according to the needs of the residences.

5.1 Starting point for the design

A questionnaire concluded by Lauri Metsäranta for his master's theses revealed some preferences of Finns: they prefer to live in a residential area where buildings are situated sparsely (Metsäranta 2020). This is, of course, not ideal for infill prospects, but space can be imitated with the placement of houses on plots in a detached house area. To most people, the most favourable placement for a building on the plot is towards the middle of the plot (Metsäranta 2020). This probably means that people would also prefer having a green belt between the road and the house. Furthermore, wood is the most popular façade material although the architecture and colour of the façades seem more important than the material (Metsäranta 2020).

Another questionnaire done by the city of Espoo in a detached house area that the city planned to densify showed that the population felt that they could support a larger infill development if it was done in a way that preserved the spirit of the detached house area. At the same time, they loved the possibility of multiple generations living in the same area, and the possibilities to save or create communal and shared places in the area. (Espoo 2015.)

Since 22 % of all the energy consumed in Finland is used to heat buildings, and another 8 % as electricity, sunlight has a major impact on the energy efficiency of houses, and it should be maximized when possible. More important than the number of sun hours is the height of the sun in the sky. For example, in southern Finland the solar altitude is so low for the whole December and most of January that there is not really enough sunlight for it to have an effect. (Lappalainen 2010.) As important as maximizing the energy gain from the sun is to lower the temperature difference between the outside and inside of a house as much as possible in order to minimize the heat loss through the building's envelope. This can be achieved by building solutions like placing spaces that need less heating and windows on the north side of the house and situating unheated spaces that can benefit from excess heat from the house and from sunlight, such as terasses, on the south side of the house. This way the spaces the need most heating are situated between these, so they do not lose heat directly to the outdoors but to the edge spaces. It is also good to have an arctic entry to the house so the whole building does not lose heat when opening the outdoor. (Peltonen et al. 2002.)

With an infill design, it is important to consider the possibility that the old house on the plot is not as fire resistant as the newer houses are. That is why it is important that the infill design follows the fire regulations, especially about the direction that the windows can face regarding the older house. (Ympäristöministeriö 2003.)

According to the fire regulations for buildings on the same plot:

1. If the buildings are joint. The wall between the apartments needs to be of class EI30.
2. If the distance between the buildings is 0-4 m. A building's outer wall needs to be of class EI30. The second building's outer wall is not regulated if the other building's outer wall is of class MEI30. The windows can not be regular windows, they must be either wire glass windows or clear fire glass.
3. If the distance between the buildings is 4-8 m. A building's outer wall needs to be of class EI30. There can be at maximum five 0.2 m² regular opening win-

dows.

4. If the distance between the buildings is over 8 m: no fire regulations.

Fire regulations for buildings on neighbouring plots:

1. If the buildings are joint. There needs to be a fire wall of class EIM 60 between them.
2. If the distance between the buildings is 0-4 m: There needs to be a fire wall of class EIM 60 on one of the buildings.
3. If the distance between the buildings is 4-8 m: The outer walls of both buildings need to be of class EI30.
4. If the distance between the buildings is over 8 m: no fire regulations.

The letters in the fire standards stand for

- R Load capacity
- E Consistency
- I Isolation
- M Impact resistance in fire.

The figure stands for fire resistance time in minutes, for example in a house with a wall of the class EIM60 the wall and its parts can stand for 60 minutes before collapsing, letting the fire through or being destroyed by a fire. (Ympäristöministeriö 2003.)

5.2 Modular construction

The idea of modular construction is to create a house as completely as possible in an industrial setting, i.e. in a factory. Once constructed, the modules are transported to the plot and attached to other modules and the utilities, like water and electronic networks. (Kotilainen 2013.) Up to 85 % of the construction process can be executed indoors (Kotilainen 2013). The benefits of this are significant. Not only is a factory a clean and dry space where the building materials are protected from the weather, the house is also handled by a smaller amount of workers than in a traditional building project, which results in better quality quicker. The construction process can be 50% quicker, and the time needed on a construction site is minimal. (Kotilainen 2013.)

A disadvantage of premade house modules is that the transportation of the modules can be challenging and cause high traffic emissions (Kotilainen 2013). If a factory is located close to the site, or the transportation can be done by other means than trucks, the emissions can be brought to an acceptable level.

The part of construction that cannot be made in a factory are the foundations. Foundation construction can take time depending on the plot type, soil type, and height differences, as well as how close the bed rock is to the surface on the plot. Although there is no universally suitable foundation solutions, a traditional ventilated base floor with a crawl space underneath is often a good solution. It can be built quite quickly with cinder blocks, and it does not need to be high, 40 centimetres is enough. The important thing is to have enough, but not too much, ventilation to the crawl space, and to have the main ventilation holes on the side of the house where it is not possible to add extension pieces. (Siikanen 2016.)

5.3 Material choice

For my infill design, I naturally leaned towards using wood as a material. It is the traditional material of Finnish houses and all frontman's houses have wood façades. Therefore, later infills in these areas are guided towards similar choices by Maankäyttö- ja rakennuslaki [Land Use and Building Act] § 117 that states that a new building needs to suit its surroundings, both buildings and nature. Moreover, many plan regulations have rules about what is an acceptable façade material or colour. However, having a wood façade does not mean that the buildings could not be made from other materials. Therefore, I considered other options from an ecological standpoint, looking at the whole lifespan of the building.

The most ecological construction material depends slightly on the criteria one uses. Most main construction materials, steel, concreate and wood, are recyclable although not necessarily in new buildings.The differences in the materials come out in their manufacture, and when looking at the production, wood is the only one that actually decreases the CO2 emissions. Furthermore, it is a 100% renewable natural resource unlike the materials needed to make steel or concrete. Moreover, the CO2 emissions as well as the emissions of other harmful substances released into the atmosphere and nature by steal and concrete are significant, not to mention the fact that producing the finished materials from the raw product takes a lot of energy (figures 9 and 10). (Pirilä 2017.) Unlike other materials that need massive amounts of energy to make, the manufacturing of modern log buildings actually produces more energy than it uses, in the form of wood waste that can be used as energy or fuel (Hirsikoti 2011).

After the initial evaluation, I decided that log was the material I wanted to use in the infill design in this thesis, and looking into it more closely and having studied the legislation, and characteristics of modern log material, my decision grew stronger.

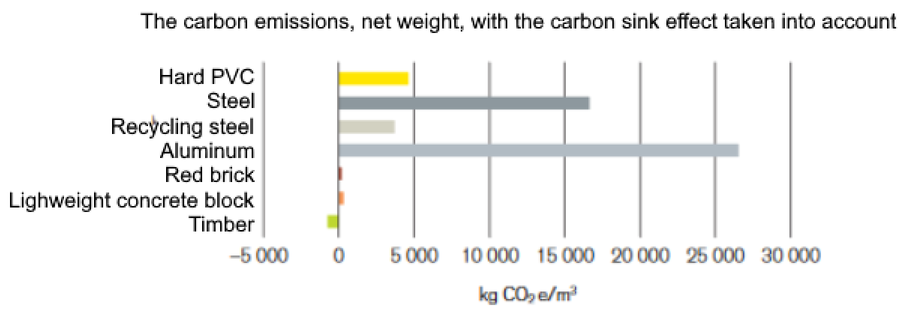


Figure 9 The carbon emissions, net weight, with the carbon sink effect taken into account

Finnish law for detached log houses changed in the year 2012, allowing less strict demands to be applied to log houses than to houses built from other materials in order to promote log as a building material. The U-value of a log house can be 0.40 W/(m2K), whereas the U-value of other materials needs to be 0.17 W/(m2K). These limits apply to houses that are 50 m2 in size at minimum. (Siikanen 2016; Hirsikoti 2011.) The basic building piece I am proposing in this thesis is smaller, but as the design aims at expendable houses, this must be taken into account. The outside walls of a log house need to be at least 180 mm thick which is not quite enough to fulfil the U-value demand, but the U-value of a bit thicker logs meets the regulations, and with a little bit of added insulation, log walls can even reach the U-value of 0.17 W/(m2K) (Siikanen 2016). A log structure is healthier and less likely to form problems if there is no other insulation (Pirilä 2017), and especially adding insulation on the inside of the wall is not recommendable; however, insulation on the outside does not usually cause a problem, as long as an air gap is left under the façade (Siikanen 2016).

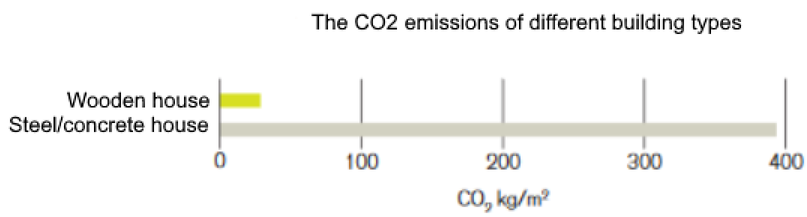


Figure 10 The CO2 emissions of different building types

The modern way of building log houses with non-settling industrially created logs with a square cross-section, instead of the natural round logs, is energy efficient in smaller thicknesses and more airtight since the log does not shrink or expand as much as a natural one and leave any joints (especially in the corners) open. In addition, factory installed seals between every log enhance the energy efficiency. (Honkarakenne 2021.) Therefore, log walls have an excellent airtightness when built correctly (Siikanen 2016). Even more important than the airtightness is the wood’s natural quality to maintain excellent air quality inside the building. Wood has a natural capacity to absorb humidity from the air when there is too much of it, and release it when the air is dry (Siikanen 2016). This keeps the air inside the house at an optimal level, preventing the growth of harmful bacteria, mold and so on (Honkarakenne 2021). This is excellent since it also prevents breathing problems like asthma. Living in a house that cleans the air naturally is a major advantage for anyone, unlike for example concrete houses with the many added substances and chemicals used to make concrete that are often unknown, and many can be harmful (Pirilä 2017).

Log is, in a way, a surprisingly fire-resistant material. It does not flare up, instead it becomes charred which leaves the wood underneath unharmed and unaffected. Furthermore, the charring of log in a fire is easily predicted: it burns 1 mm in 1 minute. Thus, a 92 mm thick square log has an EIM value of 60. (Siikanen 2016.)

A log house is an ecological choice. Trees use carbon dioxide to produce oxygen, and they also bind carbon dioxide when used to build a house. A medium sized log house binds over 30 thousand kilograms of carbon dioxide, more than is produced by driving a car every day for over a decade. (Krogerus 2019.) Moreover, log is a material with a long life: a log house will stay in a good shape for over 100 years and, if necessary, it is easy to repair or recycle (Siikanen 2016).

For the insulation that the floors and roofs need, wood fibre based insulations are the most environmentally friendly option for the same reasons as wooden buildings, but both polyurethane and polystyrene insulations are perfectly acceptable. The amount of energy their making uses is compensated by their long lifespan, light weight and excellent insulation properties. They are also recyclable. (Pirilä 2017.)

5.4 Construction methods

The goal of the design I am making is to have a new building to the plot as quickly and as undisturbed to owners, to neighbours and to nature as possible. The foundation work cannot be avoided, but if the rest of the house can be brought in place as whole or in quick-to-assemble pieces that will be ideal. The modular construction is not as often used in log houses, since they have to be put together log by log to get the connections and corners right, and most often modular constructions are transported wall by wall, since they fit into a smaller space tight together. Still, there should not be a problem why log house could not be put together in a factory setting.

5.5 Criteria for infill plots

When planning an infill design, the plot needs to fill some requirements for it to be possible. These are the rules that I set to be considered for both the plot and the possible infill building as a requirement for a successful infill.

There should be enough space left for the garden even after infill construction. In detached house areas, gardens, especially their diversity, are an important part of nature (Pajamo 2018). In my opinion, at least the same amount of plot should be kept as a garden as is allowed for buildings in the plan regulations. To make a harsh guideline of the necessary square metres of a garden can turn into a problem since regulations often allow some extra buildings in addition to the regulated houses, like a space for a car, a driveway, a shed or two, or a patio. Therefore, to reserve at least the same amount of square metres for nature as the regulation allows for houses is a good basis, in my opinion.

The possible distance between an original building and a possible infill construction should be carefully considered. There needs to be at least enough space between the buildings to abide by regulations; many regulations in detached housing areas do not allow attached houses. In addition, care should be taken to assure that the routes and accessibility to the plot work after the infill.

Apart from what was discussed in the previous point, the distances must also be considered to fulfil, especially, the fire regulations by the Ministry of the Environment (see chapter 5.1). The original house on a plot is not necessarily fire resistant for even 30 minutes. If the distance between the old building and an infill construction is short, the infill can most likely not have windows towards the old building.

The sun rotation should be considered carefully to leave enough space between buildings for sunlight.

Additionally, paying attention to the plot's surface and its possible height differences is necessary. Not only is building on a steep slope possibly not worth the effort in small scale infill, but the terrain can also form shadow places to the plot.

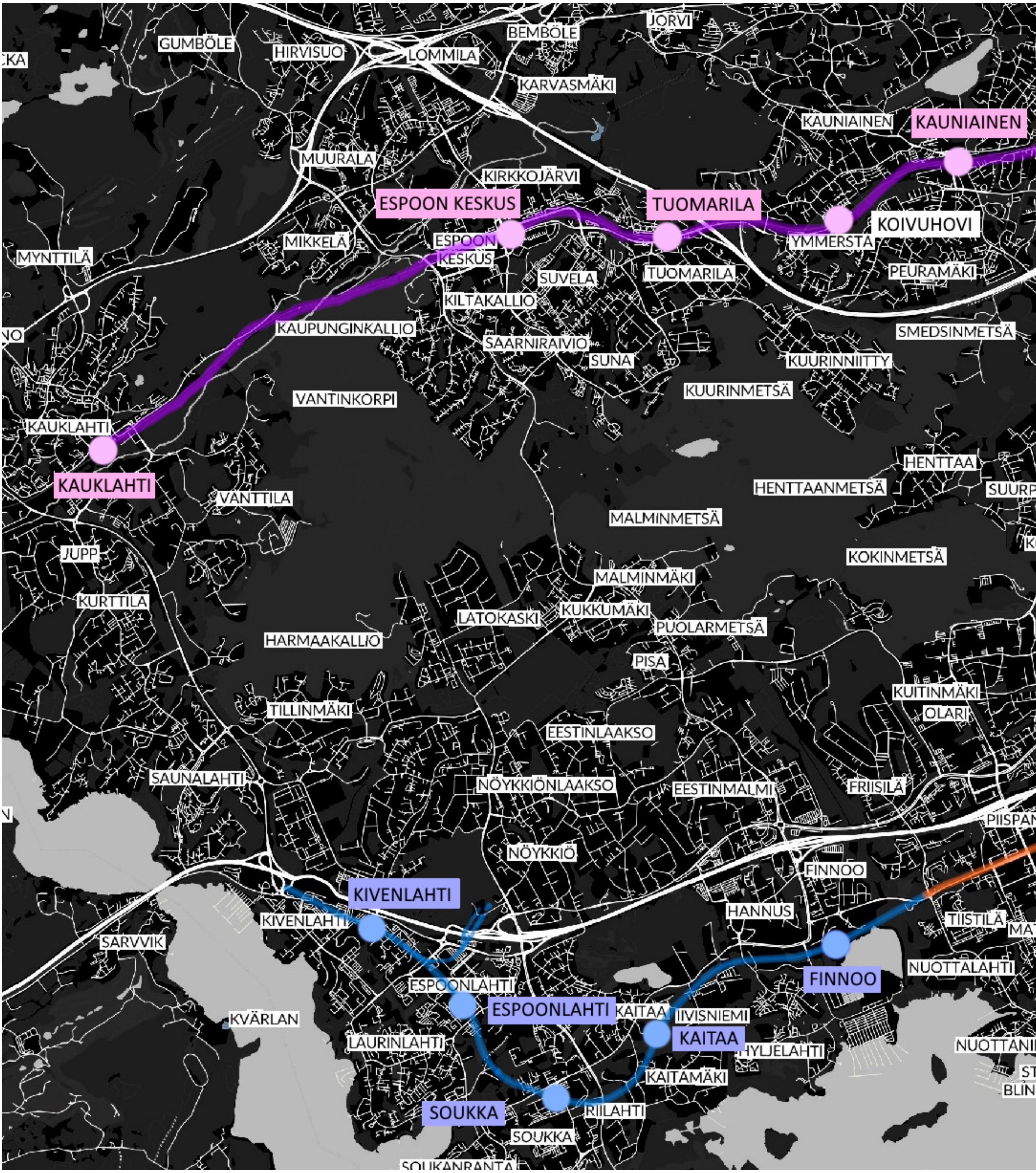
Finally, it is also important to take the neighbouring plots and houses into account when designing an infill. If the new building is closer to the plot border than half of it is height, or four metres, the building needs a permission from the neighbour, and it is much easier to get a permission if the new building does not block the view from the neighbour's house.

6. AREA STUDY

What are the best areas for infill planning? Firstly, the area needs to be easily accessible, not only by public transportation but also by foot and by bike. That is why the areas for wider infill planning should be close to railways, the metro, or other public transportation routes, and infill construction should start near stations. On a larger scale, systematic infill design in areas without much permitted building volume left would indicate that an area-wide alteration of a plan would be more profitable (Pajamo 2018), however, on my scale of infill design, the opposite holds more value. For a small-scale infill plan, it would be ideal to have enough building volume left for construction, since it would mean there is no need to apply for alterations in the plan regulations. This is the case especially if the building stock is inefficient or if the area is going through a generational change since new generations have different needs and wishes about their housing areas. Furthermore, one needs to consider if infill planning will make the area better, suit the existing structures, and raise the profile of the area.

6.1 Possible infill areas

The thesis concentrates on the detached house areas around Espoo's West Metro stations, and local railway stations with existing houses from primarily the 1980's or earlier, with a plot ratio greater than 0.2, which means they have a substantial amount of building volume left. Furthermore, having an at least somewhat flat space for the building is necessary, since the construction of


GUMBÖLE
HIRVISUO
LOMMILA
BEMBÖLE
JORVI
KARVASMÄKI
KAUNIAINEN
KAUNIAINEN
MUURALA
KIRKKOJÄRVI
ESPOON KESKUS
TUOMARILA
KOIVUHOVI
MIKKELÄ
ESPOON KESKUS
YMMERSTA
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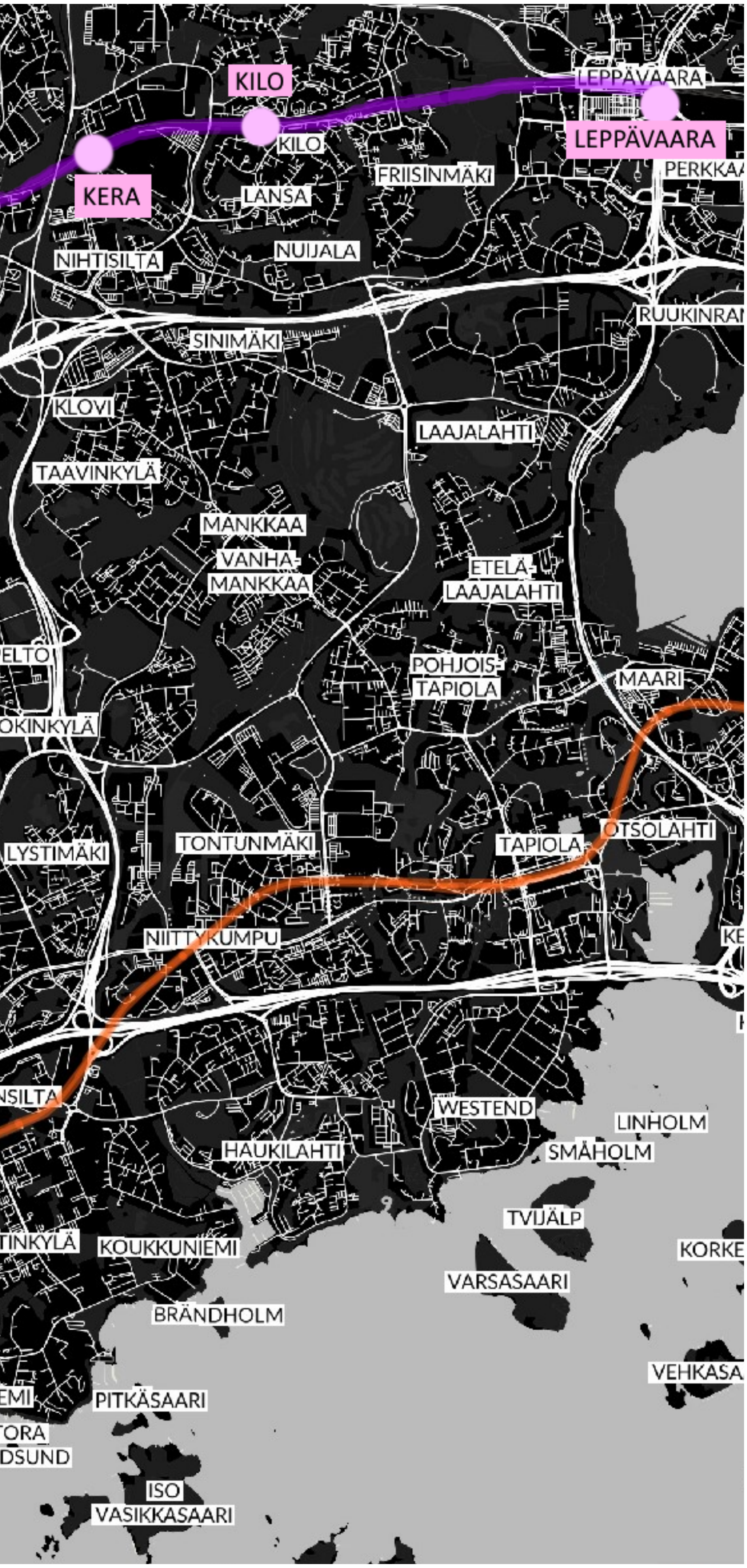


Figure 11 Map of Espoo railway line purple,
West Metro extencion blue,
West Metro first part orange

the foundation for a project of this size will not be worth the trouble on a slope plot. The new western metro route and the addition of two tracks in the Espoo local railway line are the ideal examples of good transportation networks; hence, a great starting place to find infill areas (figure 9). I used Espoo's map services in kartat.espoo.fi and Google maps to find information of these plots and their existing buildings.

The stations on the railway route are from west to east Kauklahti, Espoon Keskus [Espoo's Centre], Tuomarila, Koivuhovi, Kauniainen, Kera, Kilo and Leppävaara. Of the eight Espoo stations along the railway, I first excluded the ones without suitable areas with detached houses within a two-kilometre radius from the station. I also left out Kauniainen since it is actually its own city and so the regulations are slightly different from Those of Espoo. This left four stations that I concentrated on. Of the four remaining possibilities, Tuomarila proved to be unsuitable. It is the closest station to Espoo Centre, a bigger central with blocks of flats. Therefore, Tuomarila has a higher plot ratio, and most plots have either attached houses or at least two detached houses, or a steep slope., making building new houses there too big of a challenge.

The surroundings of the next station, Koivuhovi, are a better option although the north side of the station is outside of the area of this thesis, in Kauniainen. On the south side of the railway, there is a promising detached house area behind some apartment buildings with, on average, quite flat plots, 0.2 plot ratio and, at least on the surface, there are some plots that seem to have space for an infill house. On the other hand, the area has seen a lot of construction in the 21st century that has demolished some of the older buildings and filled the gaps with new ones. Based on this, I estimate that the area would not necessarily get as much of a boost as the next ones.

The following eligible station, the Kera station, has industrial and storage buildings closest to it, but on the south side behind them there is a very promising detached house area. The area has a high plot ratio for a detached house area, either 0.3 or 0.25 . The houses are mainly from the 1980's, and although there has been some development in the last 20 years, there are still plots with only one house and plenty of room for more. Some of the plots even seem to be original frontman's house plots that have never been divided.

The detached house areas close to the Kera station continue to the areas close to the next station, Kilo. The area around Kilo has mostly the same plot ratios as Kera, apart from some areas with a 0.2 plot ratio. There is less new construction in the Kilo area than in the Kera area although most of the buildings have been built in the 1980's in both areas. The ground also starts to rise from Kera to Kilo. The Kera station has mostly flat areas, but the plots towards Kilo include some plots where infill planning would be difficult to execute because of the heigh differences. Despite this, Kera and Kilo are both excellent areas for infill planning with mostly flat surface and slightly aging house stock, high plot ratio, and they are close to railway stations.

The stations on West Metro from west to east are Kivenlahti, Espoonlahti, Soukka, Kaitaa and Finnoo. Of these I immediately left out Espoonlahti since it is mainly surrounded by apartment buildings.

The final station on the West Metro line, Kivenlahti, is not a clear case. Although the station is surrounded by blocks of flats, there are detached house areas a little farther away from the station. However, they are mostly built during the last two decades and the plan regulations may be undergoing some changes since they at the moment (02/2021) seem a little unclear with barely any area boundaries or many regulations.

The Soukka station, east from Espoonlahti, is mostly surrounded by apartment buildings, but there are promising detached house areas for infills behind the high rises, blending into the areas close to the next station, Kaitaa. The plot ratio in the detached house areas in Soukka is slightly lower than that of the plots around the railway lines. The ratio is mostly 0.2, but there are also some plots with a plot ratio of 0.15, and they are not profitable as infill plots. The houses in Soukka are mostly from the 1980's and although there are quite a few plots with multiple houses, there are also those with only one and room for more. I even found one plot that already has an infill building on the plot, marked as an atelier. The surface in the area is a little bit uneven, some plots are mostly flat and some even have a quite steep slope.

As mentioned above, the detached house areas in Kaitaa blend into those closer to Soukka, and they also blend into those closer to Finnoo furhter to the east. Towards Finnoo, the houses are, on average, a little newer and the plot ratios range from 0.20 to as high as 0.25 per plot. The terrain is a combination of slopes and planes, sometimes right next to each other. The buildings are on average slightly newer than those closer to Soukka.

The change from Soukka to Kaitaa continues to the next station, Finnoo. Finnoo is slightly more tense with plot ratios around 0.25 and the housing stock is a little newer with more houses from the 2010's than Kaitaa. The area transforms quickly from a detached house area to an attached house area when moving deepr into Finnoo since Finnoo is close to Matinkylä, another big central in Espoo. Therefore, the area around the Finnoo station does not fit my criteria although there are some plots between Finnoo and Kaitaa that do.

Having studied the areas around the railway lines and West Metro, I decided to primarily concentrate on Kera and Kilo by the railway line. Furthermore, I chose Soukka and Kaitaa by the West Metro line as the secondary areas to concentrate on.

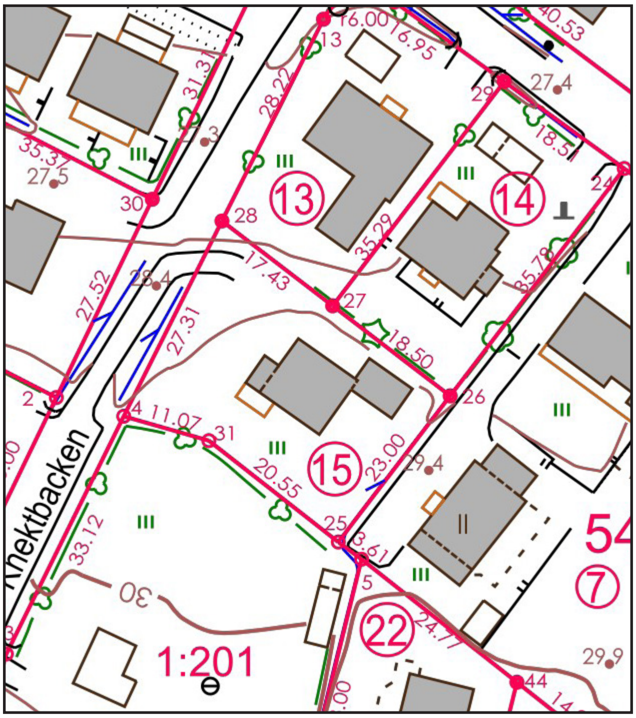


Figure 12 The example plot is the one with number 15

Figure 13 The frontman's house on the plot, picture taken from the road

6.2 Possible infill plots

Studying the areas, I found out that around 60% of the plots already have multiple buildings. Infill development on these plots is not recommendable, mainly because of the regulations about parking that most plots have. The most common stipulation is that a plot needs to have two parking spaces per house, and this takes space and can get difficult with plots with multiple houses. Most of the plots in the Kera and Kilo areas have been divided in the past but still have space for infill building. Therefore, I have not excluded them. Furthermore, I noticed that around the railway line the houses have some preference towards wood façades whereas the building material around the metro line varies much more, although concrete seems to be the most common choice. This is probably due to the fact that the traditional wooden frontman's houses were few and far between in the south of Espoo, along the metro line, because the area was not easily accessible in the early part of the 20th century whereas the railway line and all its current stations were built during the first decade of the 20th century (Iltanen 2010). Therefore, there were naturally more people living around the railway line in the era of wooden buildings, so they are more common in the area.

6.3 Example plot

I was asked to plan for infill options on the plot in Espoo that I am using as my sample plot. Figures 12 - 20 show the façades of the house, its layout and its location on the plot at various times.

The plot is 794 m² in area, about 500 metres from the Kera train station and with a frontman's house close to the middle of the plot. The 117.5 m² house was built in 1954 and it is a very traditional example of a frontman's house. There is a 28 m² garage, built in 1996, and a couple of light weight structures like a shed and a playhouse in addition to the frontman's house on the plot. The plot has about 120.5 m² of permitted building volume left. Furthermore, the plot is relatively flat, the biggest height difference is less than three meters from the south-east corner to the north-west corner of the plot.

The plot is quite challenging and interesting in many ways. The house is one of the original ones in the area, and the original plot has been divided at least once if not more, leaving the house that once was at the back corner of the original plot close to the centre of its new, much smaller plot. This makes the placement of an infill challenging.

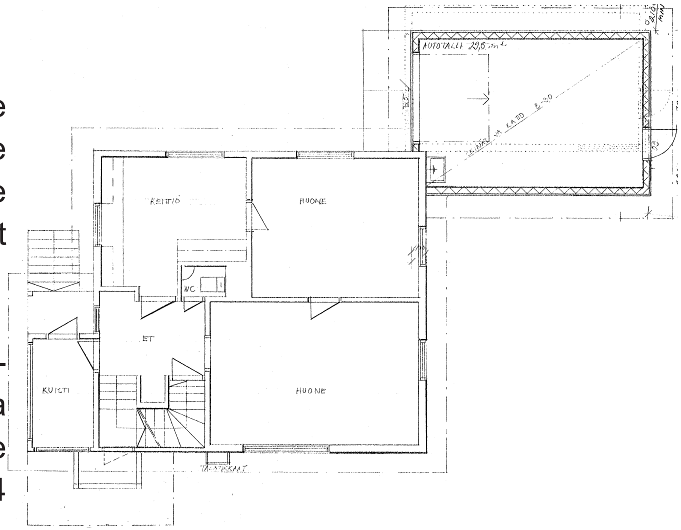


Figure 14 the floor plan of first floor 1:200

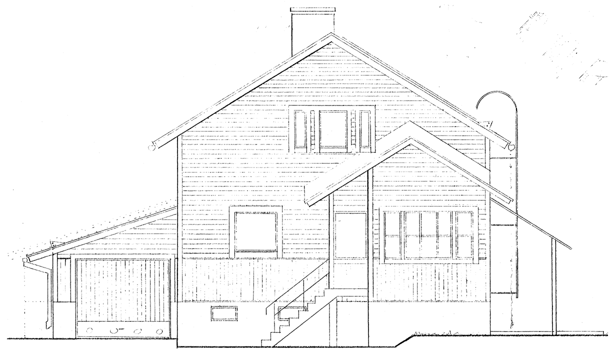


Figure 15 The façade from West 1:200

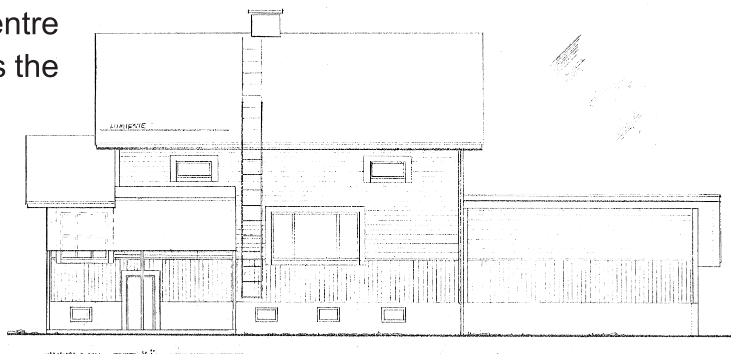


Figure 16 The façade from South 1:200

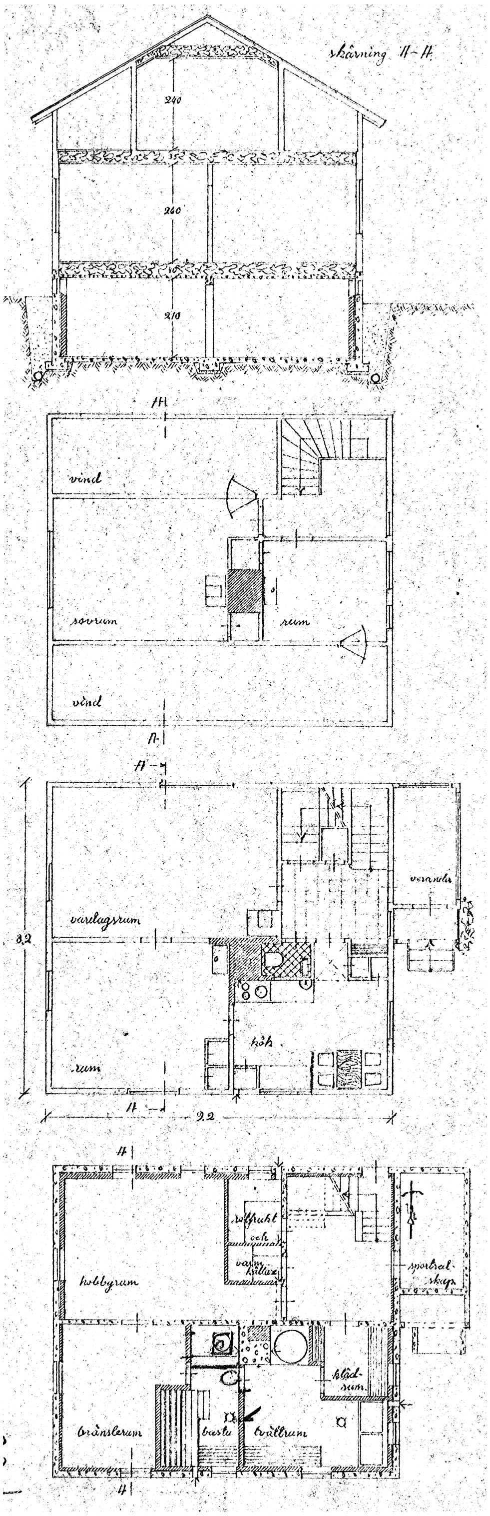


Figure 17 The original floor plans of the front-man’s house and section 1:200

On the north side of the house, there is the garage and a driveway to it in almost a straight line, with another branch of driveway turning to the front of the house. Thus, a new building cannot be situated on the north side of the existing building, not that it would be a smart placement anyway because of the lack of sunshine. On the south side of the plot, there is about eight metres of space, and on the east side almost ten. In front of the house, it is more than 12 metres to the road, but the building regulations limit construction close to a road.

The lower edges of the first-floor windows of the house are at 1.9 to 2.3 metres from the ground, which allows privacy even if the infill house is situated close to the oroginal building since the lines of sight would not meet. The house has two entrances, one to the first floor at about 1.5 metres above the ground and another to the basement, at about half a metre below the ground.

The written plan regulation for the plot states the following (figure 21):

Ao
Area of separate detached houses with no more than two apartments also rules §1+§2+§3 apply

II
Permitted number of storeys, with maximum floor-to-floor height 340 cm

e=0.30
Plot ratio, the building square metres can

be at maximun 0.30 times the square metres of the plot, in this case 794 m² * 0.3 = 238.2 m²

§1
Cellars that are mostly above the ground level cannot be built in two story buildings.
§2
On an Ao area, two parking spots need to be built for every apartment
§3
In addition to the permitted building volume determined by the plot ratio, 30 square metres of parking space and storage space in separate, one-storey buildings or building wings can be built on the plot for each apartment. (Espoon kaupunki 1976.)

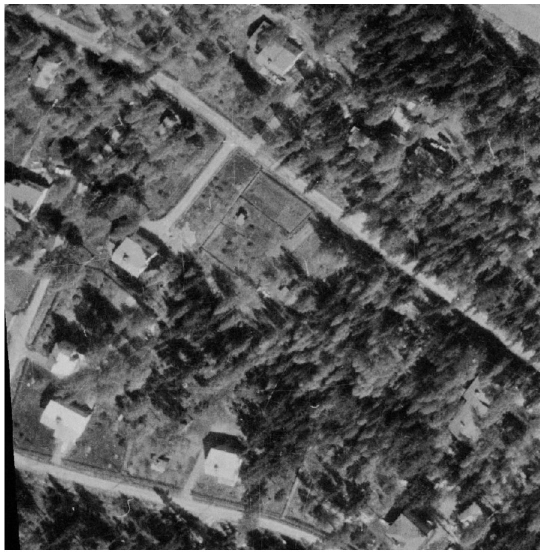


Figure 18 The plot 1969 arial view, the house still had access road from north-east. The south-west border of the plot is most likely the still existing border and at least the two current plots on north-east side of my plot were originally part of it.

The regulations include a plan of the plot with a dotted line marking the instructed building zone to be 5 metres from the road. This is a less strict line. The building code of Espoo, § 11 states that the entrases, terraces, roofs, stairs and other such structures of buildings can go over this line with 1.2 metres. Based on informal discussions with the city planers, it is possible that the building zone line five meters from a road can be crossed even more when discussing the plot in question, as long as about three metres of green space is left between the road and the house. Although this is a case-by-case decision, there is a precedence on the other side of the street from the sample plot where buildings are built over the building zone line on two different plots.


Figure 19 The plot 1976 arial view

Figure 20 The plot 2015 arial view

A shadow study done for the sample plot, including the house on the plot east of the sample plot, shows that there is a clear light area on the plot on the south-east side of the existing house, so that is the area where I planned the first option for the infill construction. For this placement, I got the plans of the house on the east plot since it looked like the infill would come really close to it (figure 23 and 24).

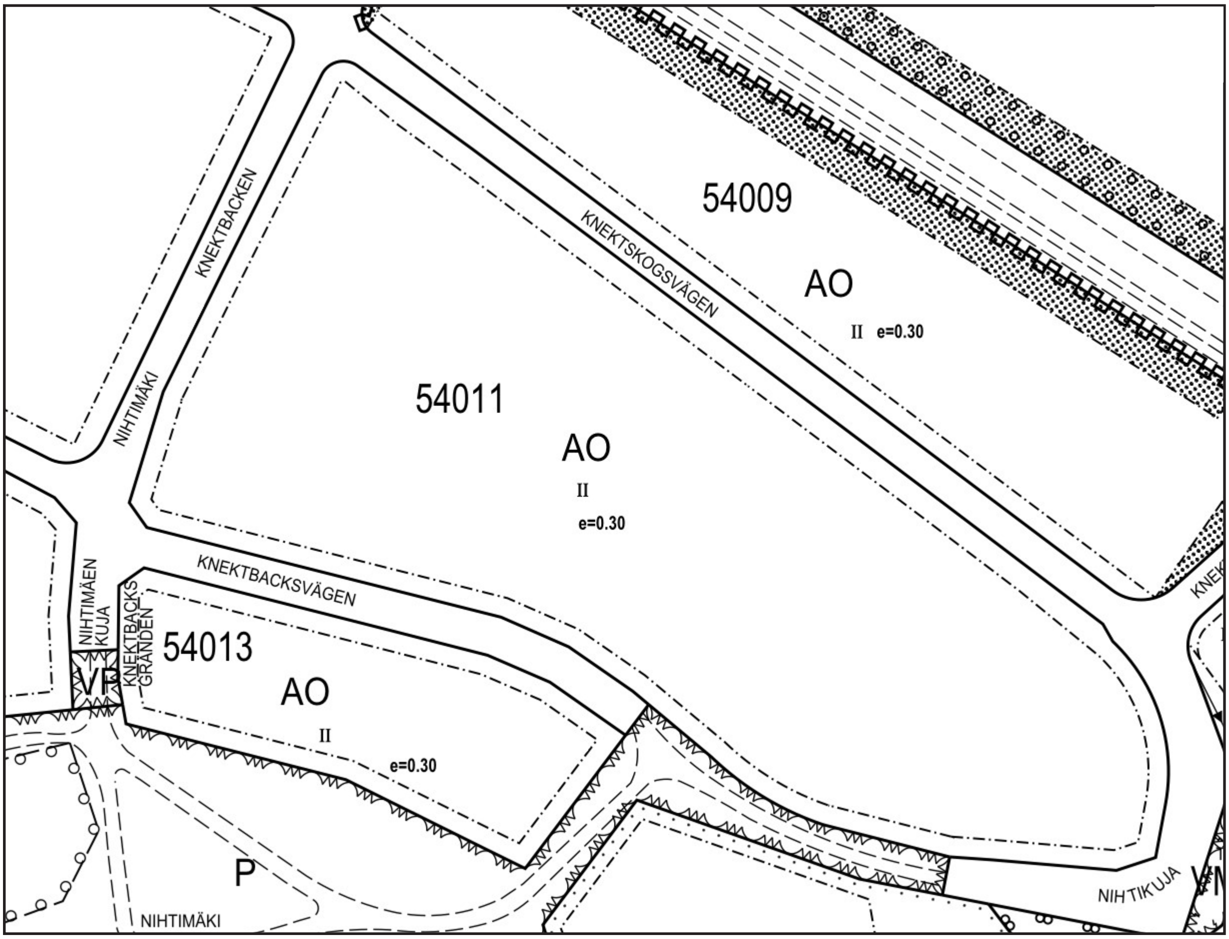


Figure 21 The plan regulations

The floor plans of the neighbouring house suggested that as long as the infill building would not come to the north side of the entrance of the neighbouring house, it should not bother the views of the neighbour. The window on the south side of the entrance is to a storage room, and although the neighbouring house has a terrace as the ending of the building, the main viewing direction from it is, logically, not towards the neighbour. The infill might add some shade to the terrace, but on summer evenings the existing building does too, and if the infill is a low building and positioned correctly, the shadows should not be too bad.

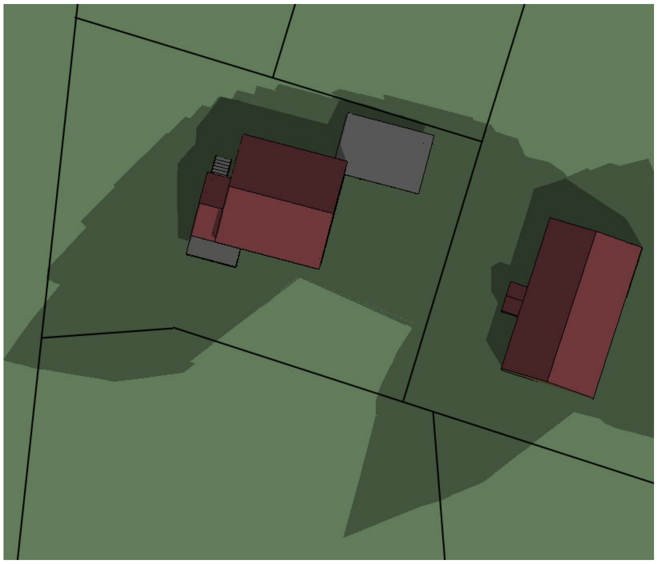


Figure 22 Shadow study at midsummer with the midday sun as darker shadow.

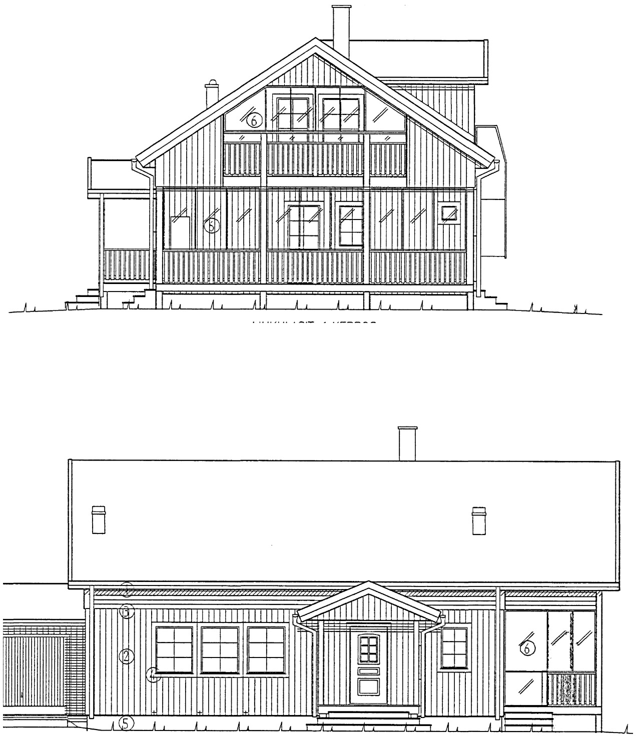


Figure 23 The facades of the neighbour house 1:200

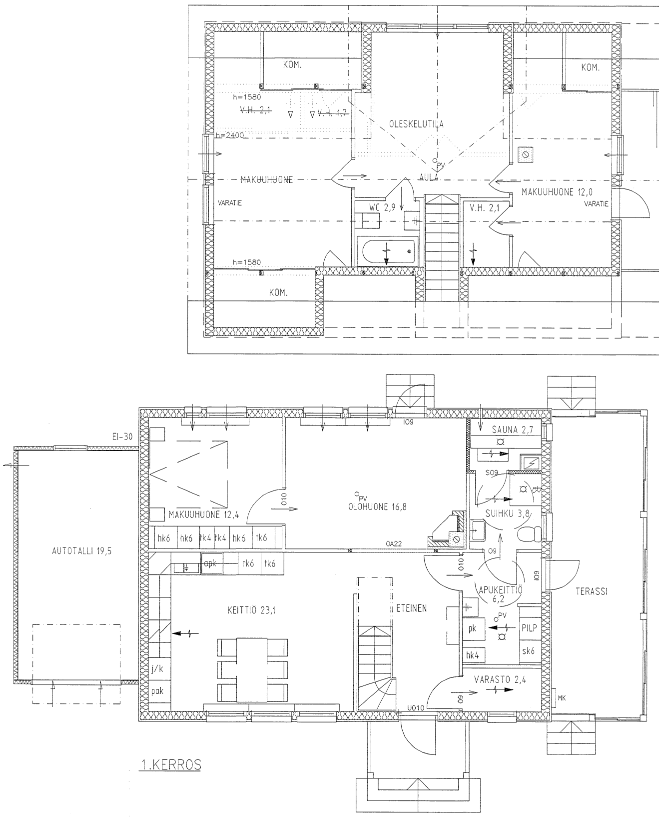


Figure 24 The floor plans of the neighbour house 1:200

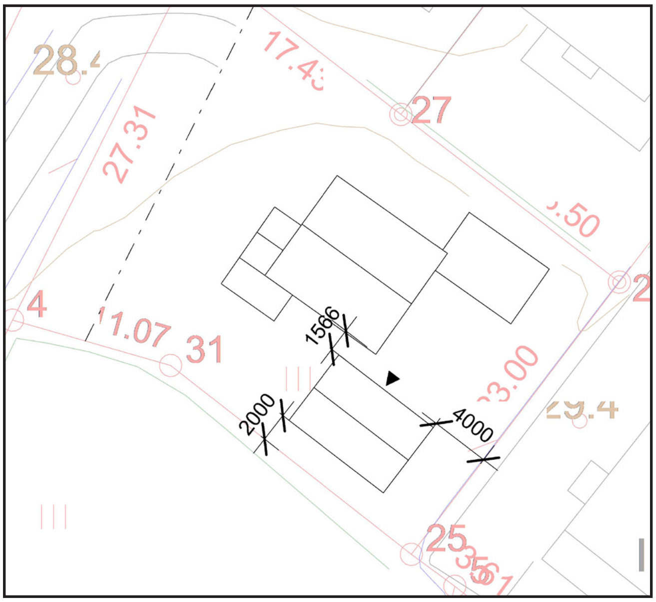
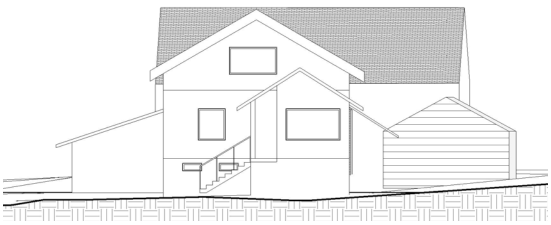


Figure 25 The first placement option 1:500

I did the test fittings to the plot with a 4 meters high block with 5,5x8 metres floor area.

The first placement option south-east from the existing building is not a bad alternative (figure 25). The light directions for the infill design are good because the window directions would be to the south-east and south-west, and the closed fire-resistant walls would be to the north-west and north-east, in other words, close to ideal directions. The building would be four metres from the border of only one other plot. Therefore, only one plot owner would need to be asked for permission for the infill building. Furthermore, the infill would not be seen from any of the windows of the existing building, which is perfect (figure 26). Placing the new infill to the back of the plot creates a pretty clear divide of two gardens although the need to extend an access road to the back of the plot would take out some of the greenery.

However, his solution has problems too. The biggest of them is the entrance to the new building: it would be very close to the corner of the existing building. Anyone coming to the front door would have to walk between the buildings in a gap less than two metres wide.



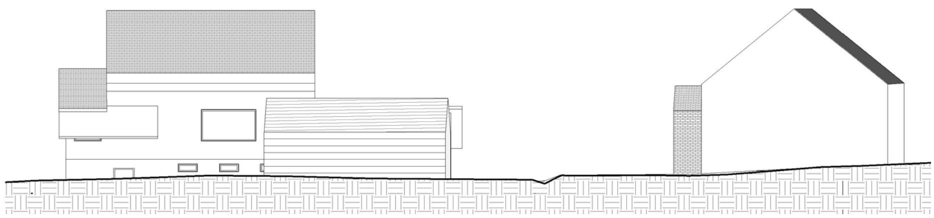


Figure 26 The first placement option facades west and south 1:400

The second placement option (figure 27) is also situated in the back of the plot but it does not have all the same problems as the first one. One problem that it does have though is that in this position the infill is closer to the border of the south-east plot. The only way to get the house four metres from that border would bring it half a metre away from the existing building which is not a solution.

The advantages of the second placement option are the same as the ones of the first option: the windows are in an ideal direction and the infill does not block the windows of the existing building (figure 28). The distance from the infill to the building on the next plot is eight meters, in other words, a safe fire distance (see chapter 5.1). This leaves a gap of 2.25 metres to the original building, which is enough to have a sufficient travel space between them. This position also places the entrance of the infill in a much better direction. A long access road is still necessary, but placing the infill building this way solves most of the problems of the first placement option.

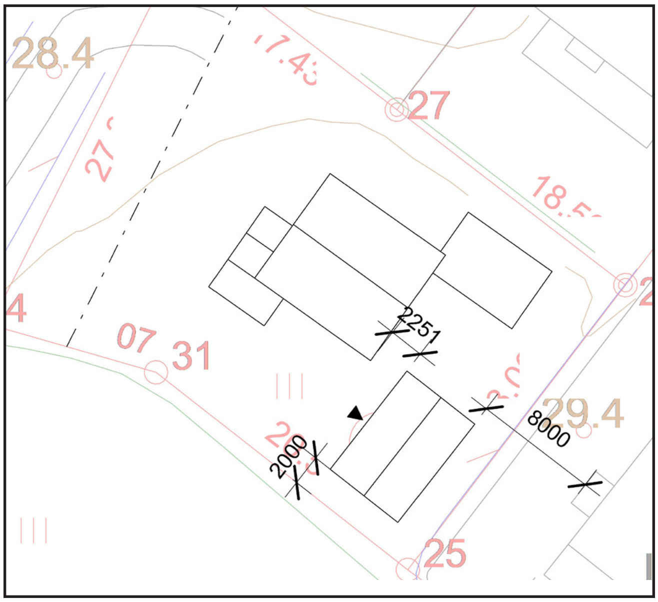


Figure 27 The second placement option 1:500

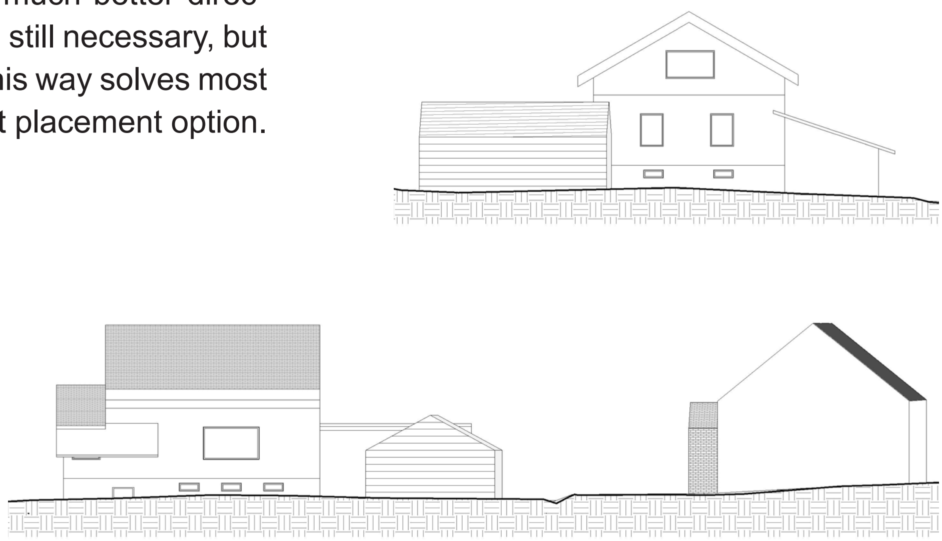


Figure 28 The first placement option facades east and south 1:400

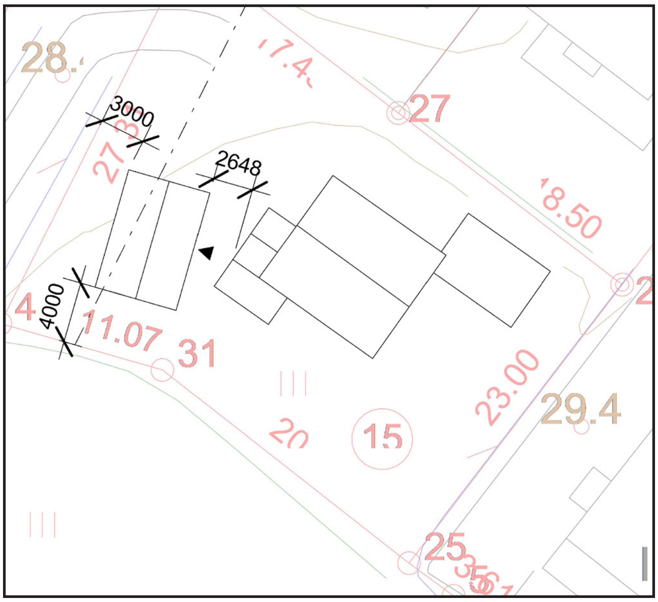


Figure 29 The third placement option 1:500

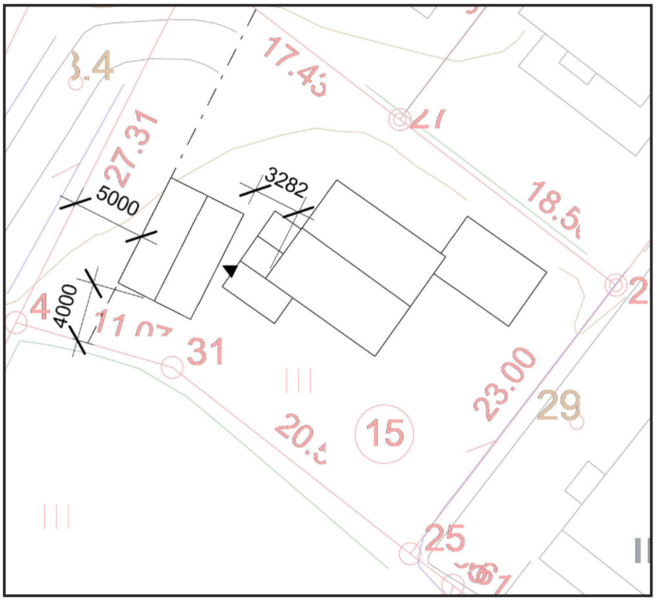


Figure 30 The fourth placement option 1:500

The third placement option is to bring the infill house close to the road (figure 29). To place the infill inside the building area marked in the plan regulation (see chapter 6.3) would mean demolishing the arctic entry of the existing house, which would not be a major problem since the house has a second entrance. However, this would not be the best solution.

A good option when placing the infill between the road and the existing house would be to take advantage of the city's somewhat relaxed stance with the building area and place the infill closer to the road. This is the fourth placement. This would leave enough space between the existing building and the infill and allow a comfortable passage. Although it might be necessary to remove the additional cover over the basement entrance of the existing hous, the whole arctic entry would not need to be demolished.

At this place, the infill house would be far enough from any neighbouring plots so that there is no need to ask for a permission from them (figure 30).

For sunlight, the fourth position on the plot is not as good as the first and second ones at the back of the plot. The fire-resistant wall of the infill would need to be towards the existing building, and the other closed wall should face north which leaves the window sides towards south-west and north-east. The directions are passable (see chapter 5.1) but not the greatest, especially when the longer side of the building faces the north-east. The infill building in this location would block the windows of the arctic entry of the original house but it would not be in front of the second-floor window even if the infill building was to two storeys high (figure 31), which is a plus for this placement compared to the placement at the back of the plot where the building is so close to the plot border(s) that making it a two-story building is not recommendable. Since in the placements 1 and 2 the distance of the infill from one or two borders is two metres, which is half the height of the house, it fulfils one rule on how close to the border between plots the construction can come, but if the height of the infill would rise this stipulation would be broken. Which is why the building cannot be a two-story one in the back of the plot (see chapter 5.5).

The infill placement option four is the easiest to build. There is no need for an extended access road, and the construction materials can easily be lifted to a correct place from the road with no need to drive on the plot. This saves most of the nature of the plot undisturbed.

The fourth placement seems the best possible option, although in my opinion, the first option looks the best, and, personally, I prefer the second option. The façades seem the best in the first placement since the infill is parallel to the existing house, showing that the infill is close to the same size as the arctic entry of the existing building and since both buildings face the same direction they

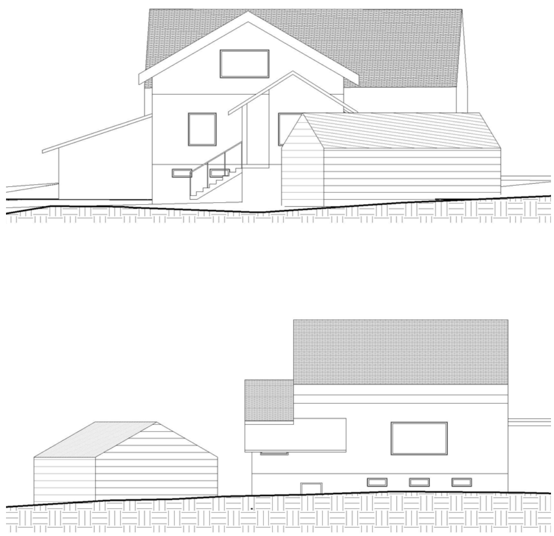


Figure 31 The third and fourth placement options facades west and south 1:400

seem like a good pair, especially so since the infill is about the same height as the garage on the other side of the existing building creating a symmetrical view. But since the first placement option is, without a doubt, the worst due to the reasons listed above, so it cannot be recommended.

7. FINAL DESIGN

My design process for the building started with sketches that resemble the final product, but between the first and the final design I explored several design alternatives. I wanted to use wood as the main construction material from the start, although I did entertain an idea of a steel structure at some point.

My first designs were narrow and long with many of them having the possibility of an L-shaped form. I liked the idea of two main wings, one of which could be tilted in different angles with a joint piece between them. In the joint piece there would be an arctic entry and HVAC space and depending on the angle between the wings the joint piece would be different (figure 32). A slight problem with this was that to get from one wing to another one would have to go always through the entrance space which I did not see as the most logical solution. However, the idea of two pieces that were, in a way, possible to be used as separate buildings gave me an idea for the final design.

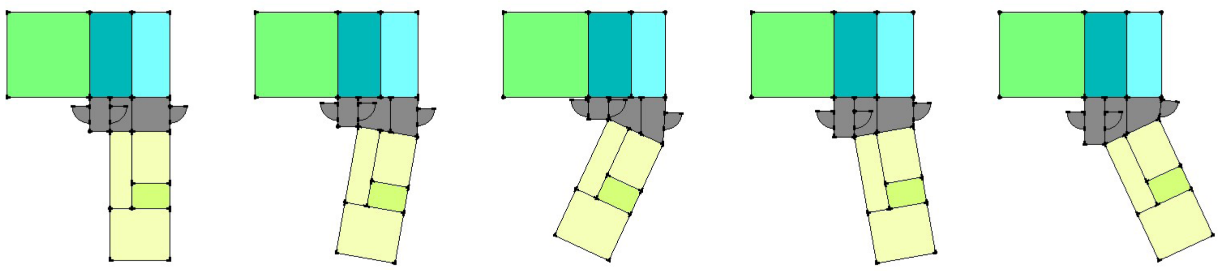


Figure 32 The idea of two wings of a building possible to be placed differently with the entrance-package.

The solution to the problem above was an arctic entry-package with the necessary HVAC spaces and one living space as the base of a house where more pieces could be added as needed. The additional living spaces or living cubes would come in different sizes and have different functions, and they could, theoretically, be both added on and removed from the building as needed. I designed four basic pieces, shown in figure 33, to be used especially in infill construction.

These designs formed the base idea of my final design for the infill building on my sample plot.

Naturally I needed to acknowledge the limitations of designing a building that is supposed to be an infill design. First, the space is always limited, and the building is probably located quite close to an existing building. Thus, tighter than usual fire regulations govern at least one side of the building. This meant no windows or only very small ones on at least one side of the house, most likely on two.

Secondly, the size of the building should be on the small side, preferably narrower in one direction and longer into another since there is more likely a free space on one edge of the plot than a wider space that would fit a more even sided structure. In addition, my decision to use log for the structure means that the distance between perpendicular walls could be at most 8 metres to stabilise the structure (Siikanen 2016).

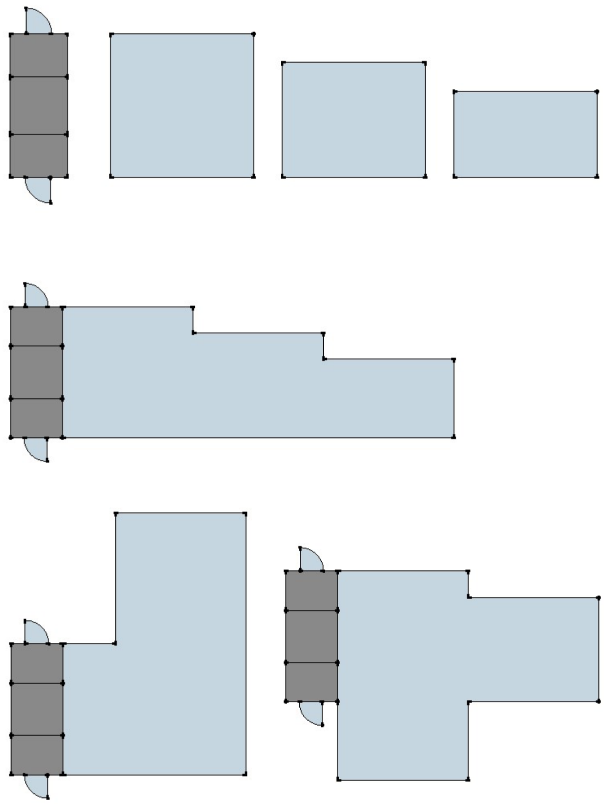


Figure 33 The basis of the concept, four basic blocks and their combinations

I started my design with the main block. I listed the necessary and desirable spaces with an idea that the first block would be enough for many needs. The spaces I listed for the main block were

- an arctic entry,
- a HVAC space,
- a wheelchair-accessible bathroom,
- a kitchen
- enough living area to function as a studio apartment or an office.

Although the first block is not large enough to require a bathroom designed with a wheelchair turning circle (Ympäristöministeriö 2018), the possibility to add pieces to enlarge the building could make such a bathroom necessary, so I saw it as necessary. Furthermore, I deemed an arctic entry as a must since in the Finnish weather conditions, the whole block space would be flooded with cold air without an arctic entry when the outdoor is opened in the winter.

I had to abandon my first idea of a separate arctic entry-package because it was too complicated and unnecessarily hard to connect to a working space arrangement.

The visual look of the outside of the infill design needed to fit the traditional Finnish urban area in order to be a possible option to be implemented in different areas of the country. A wood façade is the best for that since it is the traditional Finnish look and can be easily painted to fit the surrounding buildings. Furthermore, I saw that a gable roof was the best fit for blending the infill buildings into urban areas. Although I did consider a pent roof for a long time and even a flat roof for a moment, I changed my mind since although in different decades housing areas had many different roof shapes the gable roof is a good traditional option that is also weather safe, with much less possibilities to damage from the elements than some other options.

The next question to answer is the size of the building. It should be small enough to fit everywhere but big enough to be functional. I started at around 5x7 metres and stayed approximately in that. The height of the building was decided less on the basis of functionality and more on the basis of the regulations. The city building code of Espoo §9 stipulates that the distance from the plot border to a building should be at least four metres, or half the height of the building. But with a good reason, or an agreement with the owner of the neighbouring plot, the distance could be less. I have used two metres in some of my plot studies (chapter 6.3) with the assumption that the infill construction would be four metres high at the most.

When I started doing more detailed sketches with these ideas, I constantly ran into problems with my dimensions, as they seemed somewhat off. One by one I realised that the spaces were more or less of wrong sizes: initially I had, for example, twice as much space as necessary for the technical space, not enough room for the kitchen or a good space for a possible staircase. I only realised these problems out one after another, sometimes weeks apart and they often meant a completely new design for the house. I wanted a space where a staircase could be placed without a problem and that could, perhaps, be used as a bedroom alcove that I had hard time to place, and the kitchen seemed to be too small all the time.

While I was looking for a good floorplan, I also planned how my idea of a growing building could be realised. I decided that the best solution on how to add blocks to the main block on the same floor could be most efficiently done by having filled cut outs in the walls of the main block. The filled cut outs could be opened when adding a new block. The holes in their original state would be used as window or door spaces and they would either be left empty or be replaced with a door when adding a new block.

I designed two basic options for windows and two basic options for doors that would fill the cut outs in the walls (figure 34). The cut outs for windows have an insulated wood structure underneath the window. The window options are of the same width and have the same size ventilation window, but they are of different heights. The windows in traditional frontman's houses are located slightly higher than has become popular in more modern houses. The difference is really only about 10-15 centimetres, but as the that frontman's houses were usually built on a raised concrete foundation, the first floor is at least 40 centimetres above ground; thus, the visual

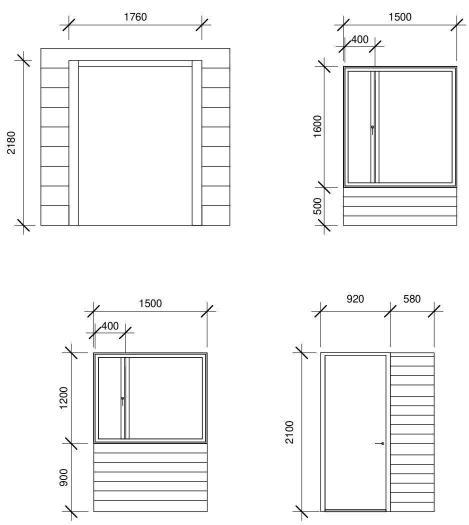


Figure 34 The cut out options: a opening, 1500x1600 mm window, 1500x1200 mm window and a door, 1:100

impact is greater. That is why I made one of the window options 90 centimetres from the floor level; it could fit in an area with several older houses around. The other option at 50 centimetres from the floor has a more modern look. Both windows as well as all doors have the same top height to have a synchronised look.

The add-on blocks only need three walls since the fourth wall is one of the original block's walls. This raised a question about how an outside wall would act when turned into an inside wall. Even though the outside log structure would not be problematic as an inside structure, the wall on the outside would still have collected some damage and dirt from the outdoor environment. Therefore, I decided that the blocks needed an exterior cladding, naturally a wooden one to fit the environment, and one that could easily be taken off if an add-on block is added, leaving just the weather protected log wall between the spaces.

I designed all the corners of the blocks to have a traditional looking protruding log corners although it is not necessary anymore, log house corners can be made snug. However, the extended corners allow an easier attachment for the add-on blocks. Furthermore, there are protruding log corners next to the wall openings to allow the addition of a shorter add-on piece. The basic principle is that at the end of a log there is at least a 50 mm deep groove and on the other there is a cleat (figure 35). In industrial logs these can

Figure 35 The continuation joint between logs

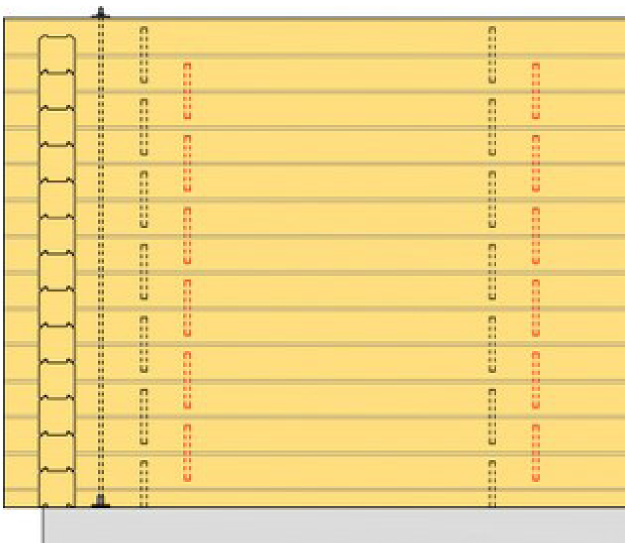


Figure 36 The basic principle of how spindles are placed between the logs

be on point by the millimetre. The logs are pushed together, and no other attachment is necessary on each single log. Of course, some fasteners should be added on the exterior of the wall, under the façade, to make sure the connection stays stable. (Pro Puu, 2021.)

Not only the building blocks but also the roofs needed to be their own pieces to make extension upwards an option. I designed a roof block that is attached to the top two logs so that it can be lifted up in one piece as long as there is no installations attached to it. The wall is braced with spindles that are placed between the logs at about every two metres (figure 36). The spindles are often fortified in place with screws between the logs. (Puu Info 2021.) However, with the roof I suggest that the spindles are screwed in the traditional way between the logs into the top logs that hold the roof, but fortified to the actual wall logs on the outside with fasteners. By removing them, the roof and top logs are easily lifted up and then placed on top of the second floor when this is done.

The roof needed to be the same size as the building blocks so that the roof of the possible add-on block will fit next to it. The roofs have chutes inlaid into the long edges of the roof with drainpipes at one end of the building where it is not possible to add another add-on. The other end of the chute is closed so that water cannot drain down the wall. Add-on blocks need to have their roof ridge going the same direction as the main block. This means that if the add-on block is added to the long edge of the main block there will be a valley between the roofs, but it is better for the rain to rebound from roof to roof instead of from roof to gable that can be water damaged after some time. When an add-on block is added to the short end of the main block, the roof is situated so that the drainpipes of the add-on roof are at the far end of the building from the main block. The closed ends of the chutes are opened and joint together with a joint piece when an add-on block is added.

7.1 Transportation and building and dismanling

The transportation of a whole building is probably not smart, it would need an abnormal transportation permit for roads. The width limit of a transportation that does not need a permit is four metres (Ely-keskus 2021). This caused a problem for my design work. Often if buildings can't be transported whole, they are transported as wall elements, but since I have opted for the long log corners to be the best solution for add-on blocks, the corners have to be transported joined. Otherwise, the building would need to be transported log by log and built on the plot. This is not that fast and goes against one of the principal ideas, prefabrication, of the project. So, since the whole block is too large to transport without a permit, it needs to be divided. One reason for assembling a building in a factory is that things like plumbing and electrical fixtures can be installed there. Therefore, the dividing line needed for transportation cannot be drawn

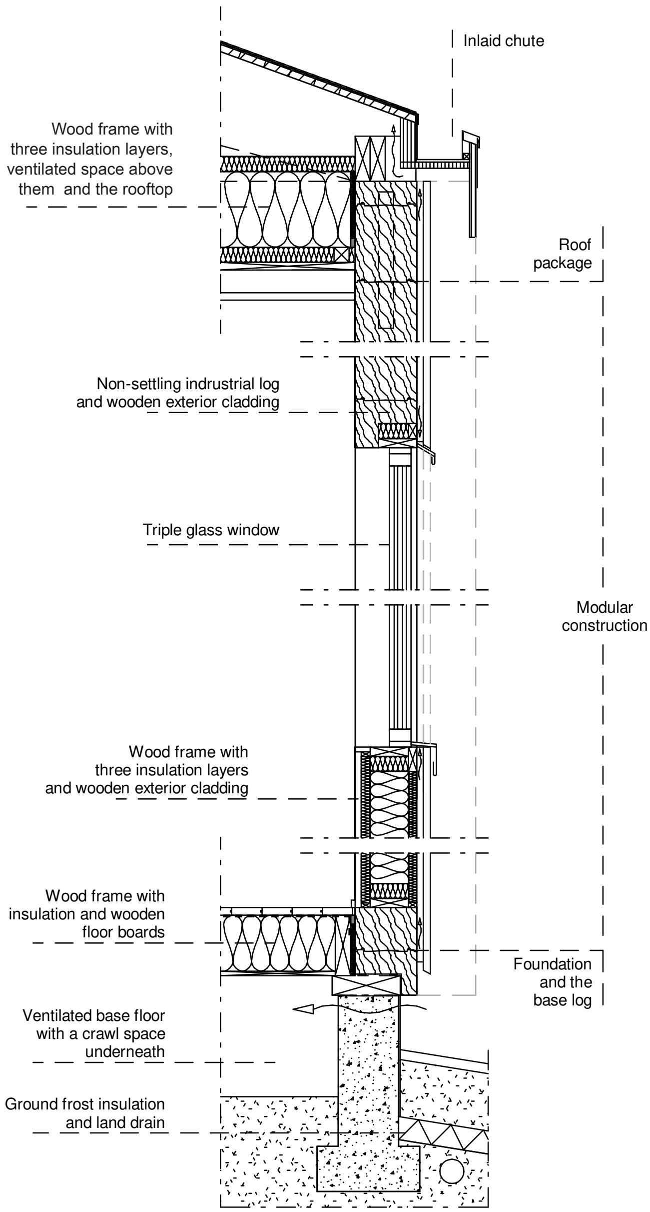


Figure 37 The structure system 1:25

across the bathroom or the kitchen. In the beginning of the design process, the building was a little bit too big to fit into the 4 metres whichever way it was divided, and it looked like I would have to divide the blocks in three pieces. At the end, I managed to tighten the design up just enough so that it can be divided into two equal size pieces. The division goes through the opening needed by the outdoor on one side. On the other side I decided to add a second window so that the wall on that side would also be divided through an opening. This way, only two logs on both sides of the building need to be attached to each other on the plot, and the window and the door need to be installed. The cut goes between the floor supports, which means that only one segment between floor supports need to be insulate and floored on the plot. The same is true for the roof.

Before the pieces are brought to the plot, the bottom logs need to be attached to the foundations separately before placing the rest of the walls on top of them. The walls need to be carefully guided to place so that the attachment spindles line with the holes they are meant to. When the walls are in place, they need to be fortified with similar fasteners under the façades as are used to attach the roof (figure 37).

Since the roof is detachable, I designed the whole space with a celling. Most of the HVAC equipment are installed above the ceiling. Above the ceiling in the arctic entry the water and electricity lines that are separated for transportation are joined together. Cables and pipes are drawn to the openings where the possible add-on blocks will be attached to allow for easy connections.

There may be a time when the block collective gets too big. For example, the building may have been expanded to fit in a nursery, but those rooms may become unnecessary once the children the nursery was for move out. At that time the extra room can be removed in the reverse order that it was built. First, the fasteners that hold the roof are removed, thus allowing removal of the roof. Then The fasteners that keep the now excessive block attached to the rest of the building and the foundation logs are removed, and, finally, if the add-on was transported in two parts, the fasteners that hold the pieces together are removed. When the fasteners have been removed, the add-on block can be carefully lifted off the remaining building. After that the access hole to the removed add-on is blocked with the existing options, the chutes of the end are closed, if necessary, and finally the foundations are either demolished or reused as foundations of a smaller add-on or for a terrace. The removed add-on block is taken back to the factory and, after its condition is inspected, it can most likely be resold after minimal alterations. Most likely the block would need a new cladding and a new paint layer on the inside before it could be sent out to the world again. This makes the house truly sustainable, it can be built, demolished and rebuilt multiple times before it has to be recycled as energy.

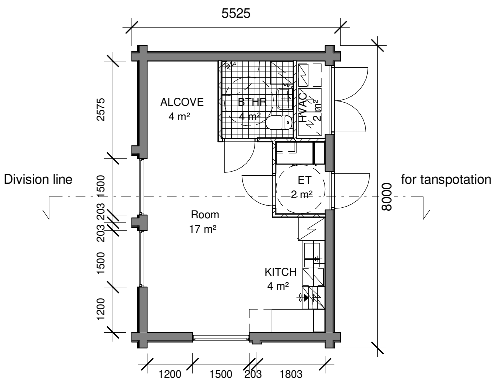


Figure 38 Floor plan of the main block 1:200

7.2 Floor plans

The main block is 8000 x 5525 mm from outside. Its interior measurements are 7180 x 4705 mm, 34 m² and 76,5 m³. The total area that is stated when applying a building premit is 40 m², by RT-kortisto rules.

When coming into the main block (figere 38), the first space is an arctic entry with enough room for a 1300 mm turning circle (Ympäristöministeriö 2018) and storage spaces. Inside one of the cabinets there is a space reservation for drainpipes to allow for another bathroom to be added on the second floor.

On the immediate right after the arctic entry there is a bathroom with the same size of turning circle as the arctic entry, a toilet bowl, a sink, a washing machine reservation, and a shower. The floors and walls are tiled.

After the bathroom on the right there is an alcove that is big enough for a double bed - if the sleeper does not mind crawling to bed from the end, or wide enough for a single bed and some cabinets. The size of the alcove is planed specifically to fit a U-shaped staircase if or when a second story is added. This aspect made the planning hard as it was difficult to place a space that is usable in a one-room house that can accommodate stairs if necessary. The solution is one that I am really happy about. It is easy to attach the stair to the outside walls if they rise counter clockwise on the plan, but there is no structural problem if the owner wishes the stairs to rise clockwise either.

The kitchen is on the wall to the left in an L-shape. Against the wall there is a fridge-freezer, a 1200 mm wide sink with room for a 450 mm wide dishwasher underneath, and a stove. Above them there are cabinets and a hood above the stove. The other side of the L is a 1400 mm long countertop with a flip-down part at the end that can be raised to stretch the countertop to 2000 mm. The whole length of the countertop has cabinets underneath.

In the middle there is 16.7 m² of free space, big enough for many purposes such as an office space, a living room, a dining room, or an atelier (figure 39). The floors are parquet. The walls are painted with a breathable paint.

On the other side of the arctic entry there is the utilities room with a boiler, a ventilation machine and a switchboard under which there is a hatch leading to the crawl space. The space has a double door to outside so that any maintenance can be done from outside.

The second floor could have different combinations, such as the example here in (figure 40) that I like. First there is an open living space and at the back there is a bedroom.

The add-on blocks have no fixed partition walls, but many possible combinations of partitions can be placed inside. The add-on blocks are 9, 15 and 24 m2 with outside measurements of 3615 x 3615 mm, 3615 x 5525 mm and 5525 x 5525 mm, respectively.

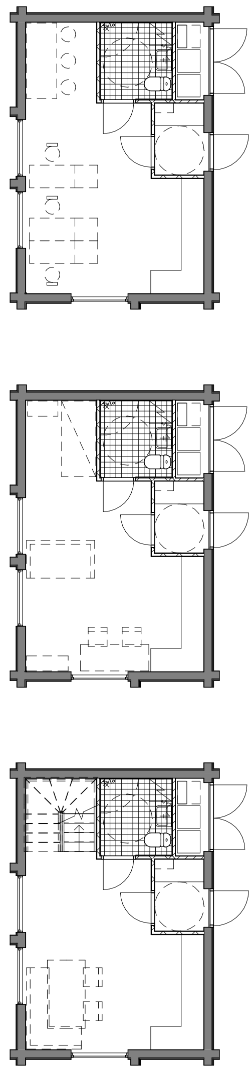


Figure 39 Multipurpose space 1:200

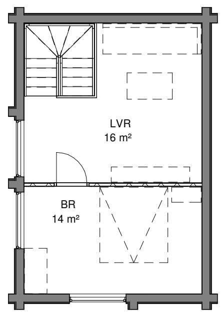


Figure 40 Second floor space 1:200

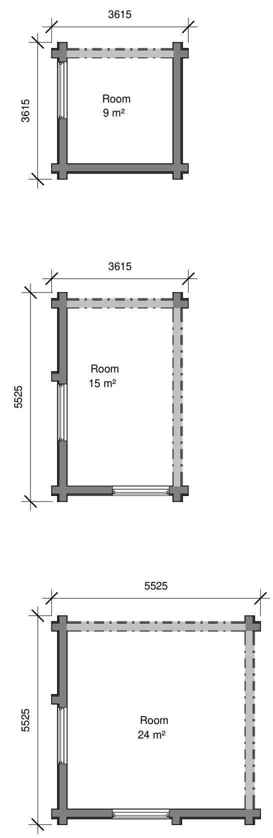


Figure 41 The add-on blocks 1:200

Their measurements measured from inside walls are 2795 x 2795 mm, 2795 x 4705 mm and 4705 x 4705 mm. The smallest block, for example, is a good size for a sauna and washroom. The medium block is a nice size for one big bedroom or two small ones, whereas the biggest one could fit all of the above. The partition walls are light wood structures so that they can be altered when necessary (figure 41).

The 9 and 15 m2 block can be transported in one piece to the plot, but the 24 m2 block needs to be divided in two. Depending on what side of the block is to be attached to the base cube, it can be divided either way so that only one wall is cut at the opening on the wall. The non-existing wall where the add-on is joined to the existing block is the second wall that would be divided if it existed. For this division, extra support must be added to the floor since the floor does not have two supporting walls to hold it in place before the halves are joined together. The extra floor supports have to be joined together between the block haves after the add-on block has been attached to the existing block so that the floor can be easily attached to the old exterior wall of the existing block.

7.3 Implementation

The plot where the existing house is in the middle of the plot is actually the hardest plot to infill since it does not leave a clear space for a infill construction.

Espoo prefers that the plots have only one access road from the main road no matter how many houses there are (Espoon kaupunki 2015).

Here are my infill blocks implemented on different plots in the areas that were pointed out in the chapter 6.1.

First implementation is also in Kera area like the example plot and have same plan regulations. The first is a 974 m² plot with a 1½ story house close to the road. The house was built 1956, it is 96 m². Despite the floors the building has been dug into a slight slope making it quite low. Best place for the infill development seems to be at the back of the plot, the existing building only has one window towards there, and it is on the southern corner of the wall. With the plot ratio 0.30 that means that the plot has 196 m² permitted building volume left. The access road is on the north side of the building.

I placed the base block with the 15 m² add-on block to the north corner of the block four metres from the plot borders, entrance on the north side, windows mainly to south and west. The total building volume is 59 m² in one floor and since the existing building is quite low, I would not build two floors. Figure 42.

Second implementation is in Kaitaa. The plot has similar plan regulations as previous plot, but it only has 0.20 plot ratio. In this case it is not a problem since the plot is 2117 m² and

Figure 42 The infill plan1:500

has only one house of 111 m². This means that the plot has 312 m² permitted building volume left. The house is a one floor building with a basement built in 1962 close to the road. It is on the highest point of the plot and although the rest seems quite even it slopes slightly to the back of the plot. The plot also already has two access roads which makes placing a building on the plot even easier.

The plot has the room for multiple small infill buildings but since it is one of the few plots where one could place a large building, I combined one from the blocks. (Figure 43). The building has all the blocks attached, in one floor it would be a 99 m² building and if all but the smallest block are in two floors the building would be 187 m². The two floors would not be too high since the existing building is higher and the distance between that and the infill is over eight metres, so they would not be as clearly related. This massive infill building could for example have a sauna in the far end in the small block, a cooling of room or smaller living room between it and the main block with a door to outside and a dining room and living room in the biggest add-on block. On the second floor there would probably be a toilet, at least two bedrooms, and a living room area. Main views would be towards west and south with entrance on the east side.

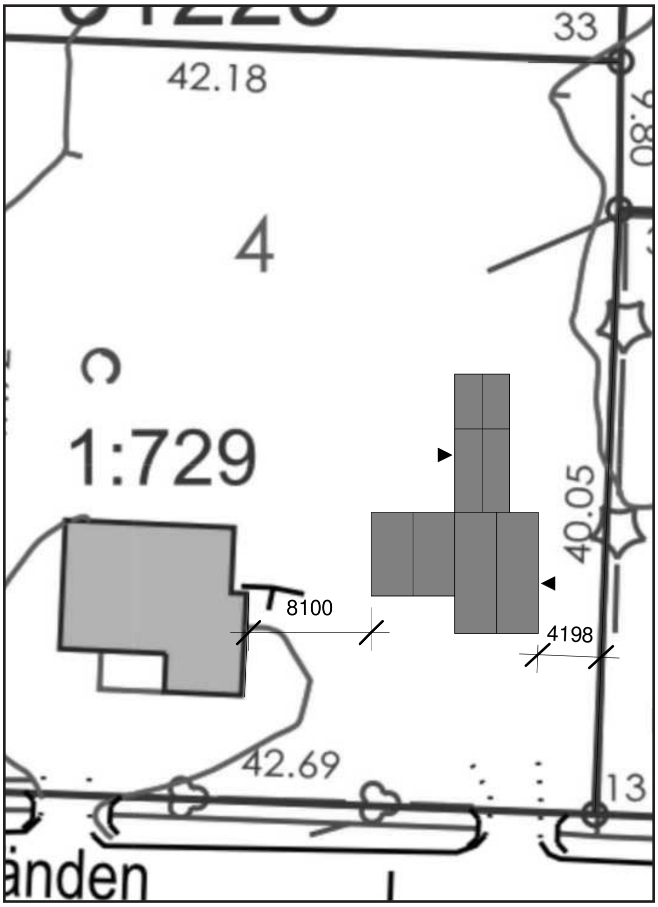


Figure 43 The infill plan 1:500

The final implementation is in Kilo. The plot is a 1132 m² and the plot ratio is 0.25. This means permitted building volume of 283 m². The existing house is from 1952 very traditional frontman's house: 96 m², 1½ floors with basement and high foundations. Slightly different is that the plan specifies a large part of the plot to be left green and that nothing can be build there. The sector is eight metres from the road and whole south-west of the plot between the existing building and a road. The building volume left is 187 m².

The basic block fits nicely into the corner of the plot. It does not have the best light, but it is out of the way of the existing buildings line of sights and the access road comes straight to it, so there is no need to bulldoze wide turns to the road to have enough room to turn a car. In two floors and extra block at the end the building volume is 91 m² (Figure 44).

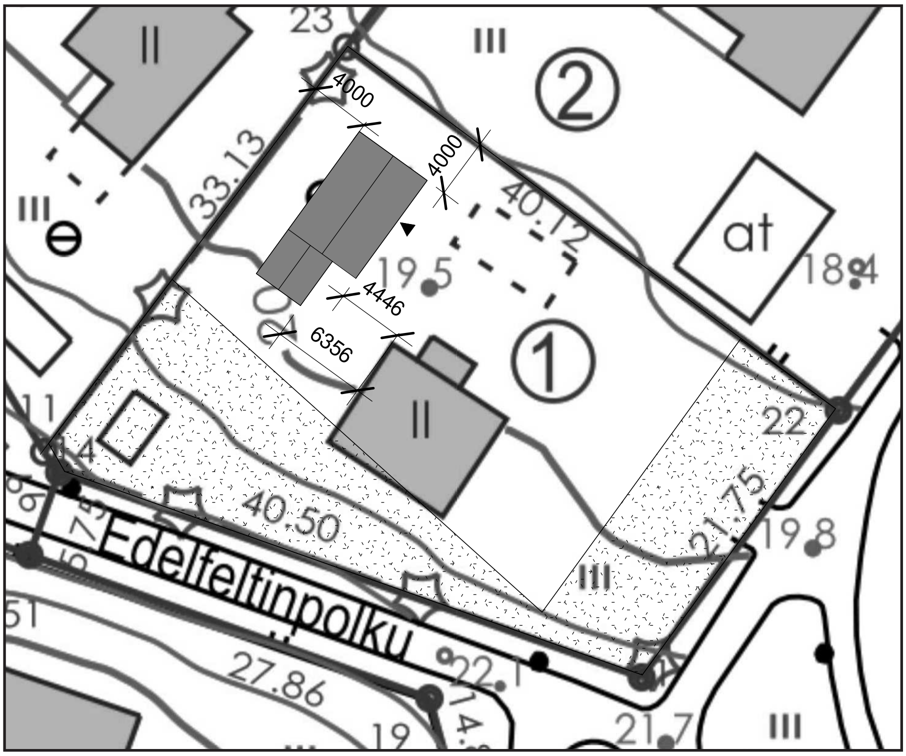


Figure 44 The infill plan1:500

CONCLUSIONS

Infill construction is a type of construction that is built as a part of an existing urban area or right next to one. Infills have probably been a part of Finnish housing construction for ever, but more systematically since the division and filling of frontman's house plots got more common. In growing cities, infill construction is now more important than ever before. Finns most often want to live in detached houses but building new detached house areas is problematic in many ways. The services and the public transportation often reach these new areas only long after the houses are ready and new residents have moved in. Finns also prefer to live close to a city centre with services close by, and new farther and further reaching detached house areas do not offer that. Small scale infill planning and densifying detached house areas is a solution to these and multiple other problems.

The densifying of detached house areas cannot and should not be done with big new detached houses. Instead, mainly smaller houses for smaller households should be built. More and more people live either alone or in a household of two and they do not need, want or cannot afford a large house. This is true not only for the younger generation but also for the older one. The average age of Finns is growing, and ageing people and couples that do not want to move away from an area they like are left living in the houses they shared with their children with too much room. This is partly why infill construction suits best the older detached house areas where a generational change is ongoing. Furthermore, despite the fact that the population is expected to grow at around 1.5 % a year in Espoo (see chapter 3.2), in most of the housing areas built in the1960's and 1970's, the population is shrinking. Infill construction in these areas could amend that by freeing the big houses to new families while allowing the old residents to stay in the area in smaller houses.

A big positive impact of infill is that it allows multiple generations to stay in the same area. The longer people stay in the area, the stronger the community in the area and, therefore, the safer it is.

Espoo has set a goal to prevent the continuation of segregation. In detached house areas one reason for segregation has been the lack of affordable houses. The prices of housing in Espoo are very high since the demand is high and there are often very limited rental options in detached house areas. This means that the areas have mainly middle and upper class residents who can afford to buy a house. Densifying the areas with smaller houses means affordable options in a good area that are more rentable and cheaper to buy. This widens the population structure, leading to many positive social changes when no so-called bad neighbourhoods are formed.

Smaller houses and infills are also more ecological than new neighbourhoods and bigger houses. Denser areas have significantly lower CO_2 emissions through smaller material, energy and fuel consumption. In Finland, the population density in low rise areas is lower than in the other Nordic countries, leading to higher costs of building and maintenance of infrastructure, longer distances to travel to services, and the movement of local services further away to centres. Densifying also saves the larger green areas in the city, while bringing more people to the areas to take care of the small-scale nature, yards and gardens. Even a small yard can give so much more quality of life than one can get in an apartment; that small piece of nature brings joy, and a house with a yard can be smaller than an apartment in a multiple-story building since the yard is a part of the living space, not to mention the importance of gardens for the diversity of the nature in cities.

Infill development is a circle of good: more residents bring new services to the area and keep the existing ones in place. This possibly leads to an improvement of the neighbourhood attractiveness, which in turn leads to the rising of property values in the larger neighbourhood scale, again increasing the vitality of the area. This again brings more work possibilities and services closer by.

All of this is an endorsement of the possible benefits of infill planning in detached house areas that will not only benefit the people living there, but the whole area and possibly the society at large.

When planning an infill design, the importance of the existing environment is highlighted. Building a new house should disturb the area as little as possible from construction to demolishment. If the house can be built in a factory and just brought to the plot with the construction taking as little time as under a week, the area's population would definitely approve. The new building needs to fit both the surrounding houses and nature. It is important to save the gardens for the diversity of nature. The existing buildings should not suffer from the lack of sunlight after the construction.

I developed an infill house concept that has a basic block with all the basic requirements for a house to be used either as is or expanded with one or several of three different sized add-on blocks. The basic block has a kitchen, bathroom, closed wind entrance, living area, and a HVAC space. The interiors of the add-on blocks can be organized with light-structure division walls to fit most needs. A second story can also be added to all the blocks. All blocks have set locations for wall openings that are either left open to allow access to another block or closed with a window or a door. This concept can both grow when needed but it can also be sized down. The joining of the blocks is designed so that it can be separated if needed. To be environmentally friendly, the building material needs to be recyclable or reusable. Luckily there is a material that is both. The concept blocks made with log walls can be recycled or the removed blocks can be used again since logs are not only durable, but parts of a log construction can be replaced without compromising the whole.

Wood is the most environmentally friendly building material, the manufacturing of modern logs actually produces more energy than it uses (see chapter 5.3), and since it is also the preferred building material for Finns, choosing log as the main material for the concept infill design was clear. Furthermore, the Finnish government encourages the use of the most traditional Finnish construction material, log, by allowing lower thermal transmittance values for log buildings. With modern non-settling industrial logs as building material, the building has naturally excellent attributes. Industrial logs do not shrink or expand as much as a natural one, and with factory installed seals between every log, the walls are airtight and energy efficient. Combining this with the natural quality of wood to maintain excellent air quality inside, and the natural capacity of wood to absorb humidity from the air, the air inside the house is naturally kept at an optimal level, preventing the growth of harmful bacteria and mold. Logs are also local, fire resistant and they bind over 30 thousand kilograms of carbon dioxide during their lifetime.

All of the above made log an obvious choice, except that it is not really a material that can be used to build houses or separate walls in a factory setting: a whole building is hard to transport, and separate walls cannot be joint together properly when they are stacked. Log building is still very much a carpentry skill even with industrial logs. Furthermore, my concept design needs traditional protruding log corners to make an extensible design and those cannot be built from fully stacked walls. So, I needed to develop a concept for modular construction, a log building that is still transportable, preferably without abnormal transportation permissions, meaning at most four metres in width.

The solution that I found was to divide the blocks that were too wide into two. In the basic block, the division goes through the opening needed for the outdoor on one side and through the opening for a window on the other. This way, only two logs that are on top of the door and window need to be cut and then attached to each other on the plot. The joining of the separated halves is done with a traditional log continuation method that is also used when the add-on bocks are joined with the basic block or each other. The method consists of carving a 50 mm deep groove to one log end and providing the other log end with a cleat that is pushed into the groove. Similarly, traditional support of spindles are used to attach the logs on top of each other. In the traditional method of construction, these alone or with attachments like screws that are hidden between the logs are enough, but in my concept thisis not possible, so the seams of different blocks and block parts are fortified with attachments on the outside that can be taken off if the blocks are separated. The attachments are hidden under the facade planks that protect the logs from weather damage. After all, an outside wall can become a partition wall if the building is later extended.

This concept created from the basis of the research is implementable on different shapes of plots and suits multiple, changing needs. It is a new point of view into the process of traditional log building with a modern twist. And I am very pleased with the end result.

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FIGURE 6 Enne, Olli, Yksiö puutarhassa, 2017, Master's Thesis Aalto University

FIGURE 7 Helsingin kaupunki, karttapalvelu, https://kartta.hel.fi/, last visited 05/2021

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FIGURE 8 Vuolle-Apiala, Risto, Hirsitalo ennen ja nyt, 2012, Kustannusosakeyhtiö Moreeni

FIGURE 35 Pro Puu, Puupfoffa, Hirren jatkaminen https://puuproffa.fi/liitosten-arkki/hirsiliitokset/hirren-jatkaminen/ , last visited 09/2021

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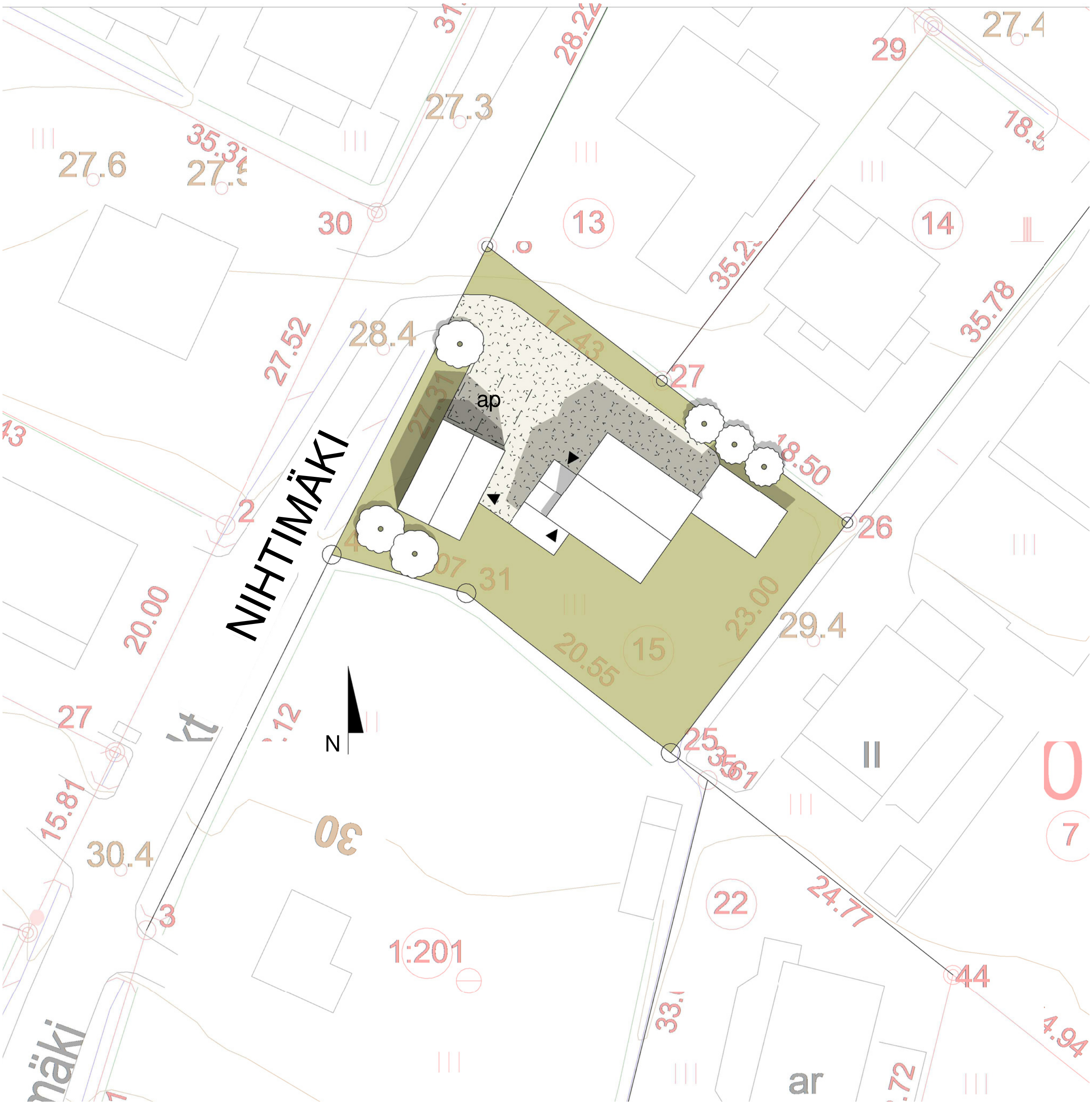
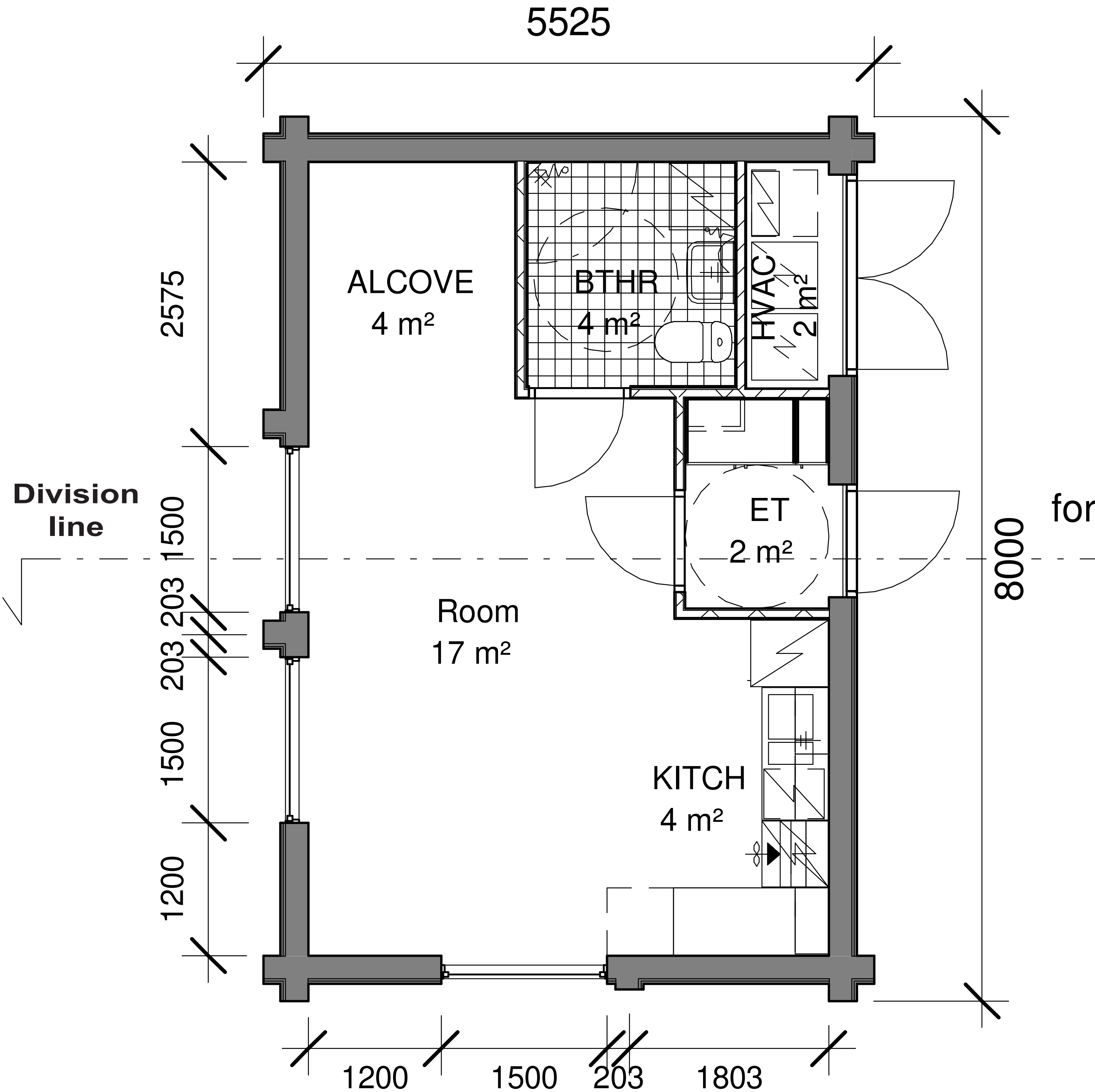
Other figures done by the author 2021

ATTACHMENT:

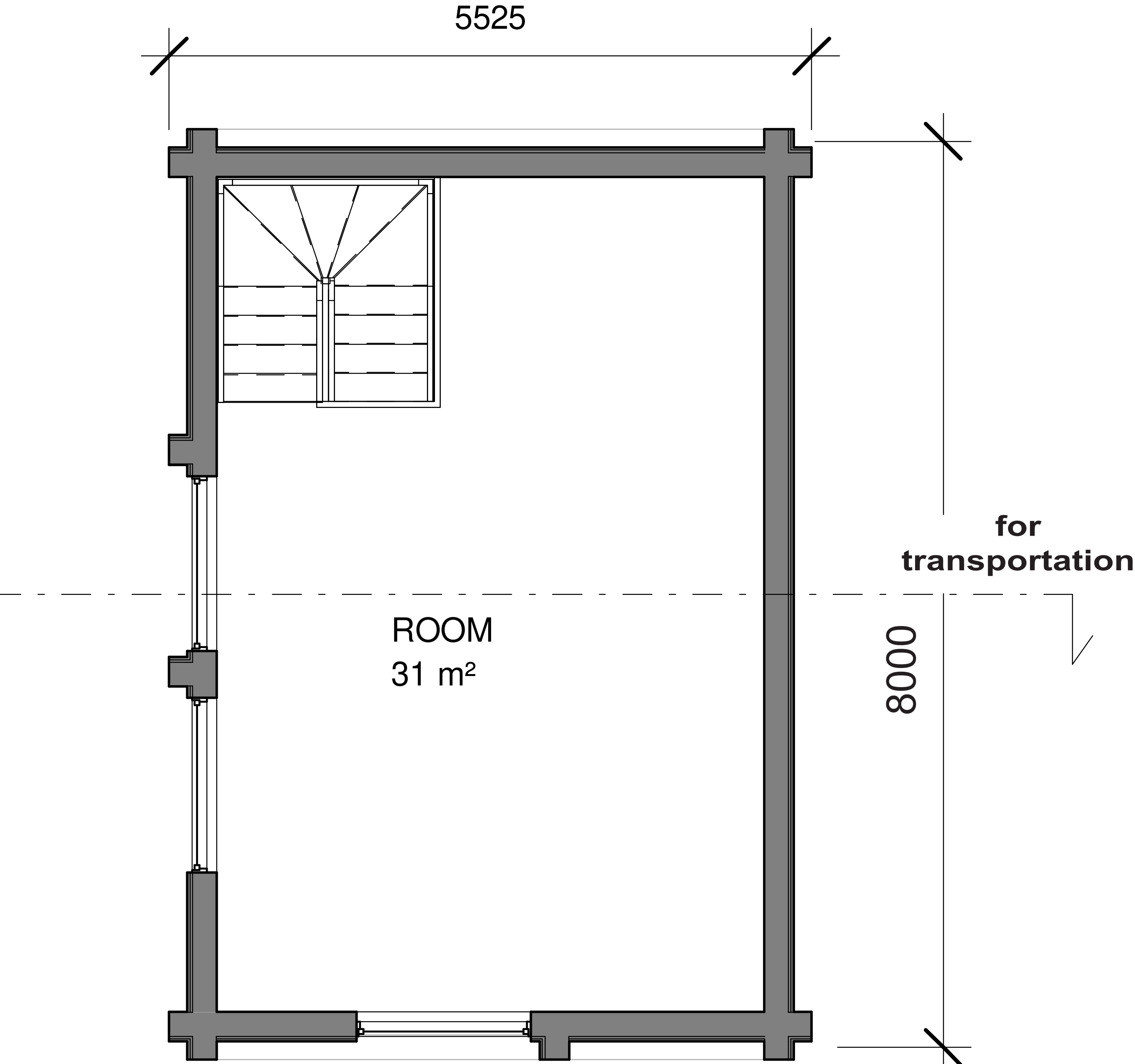
DESIGN DRAWINGS



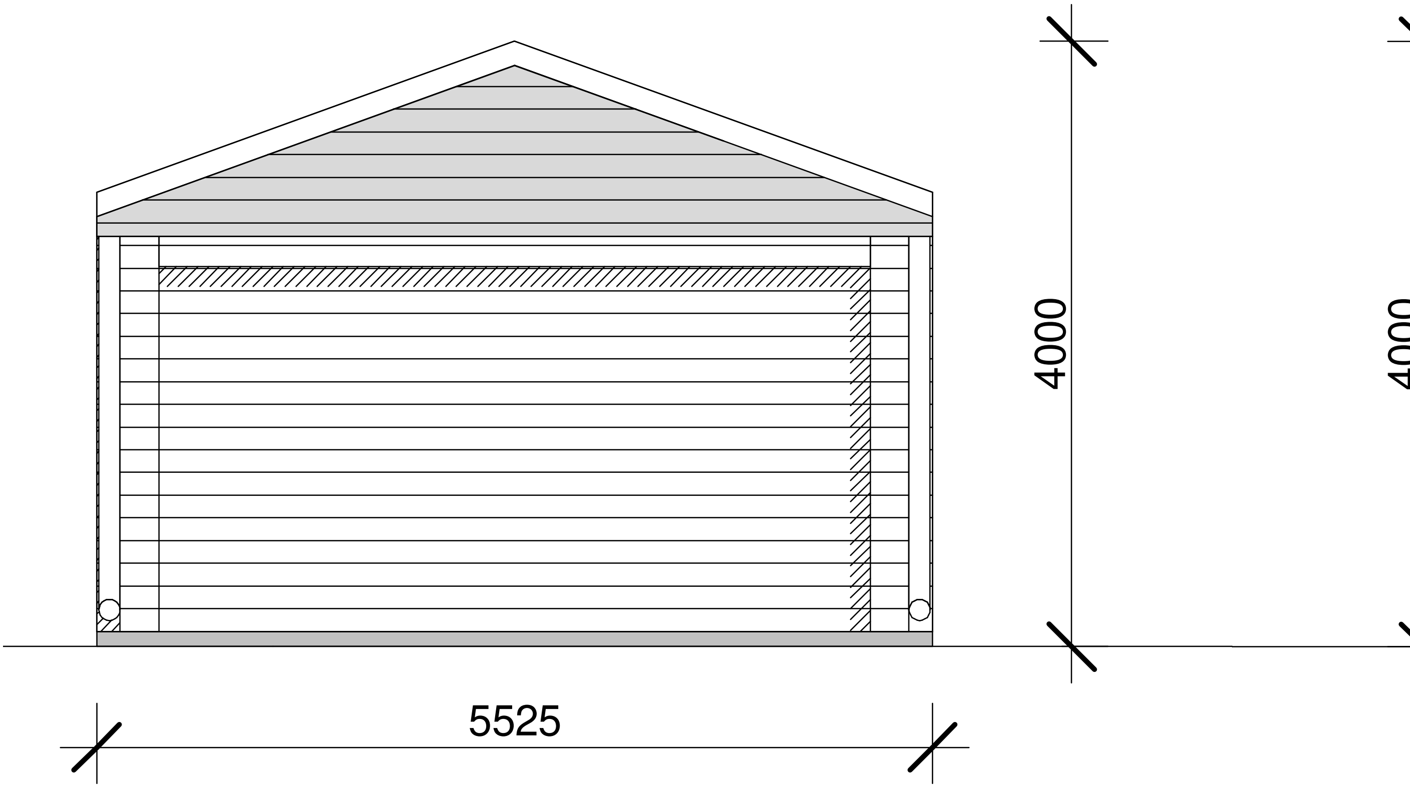
The site layout 1:500 Infill building's darker shadow is from one floor building and lighter shadow is from two floor building. One floor is 40 m² and two floors 80 m². The plot has 120 m² permited building volume left.



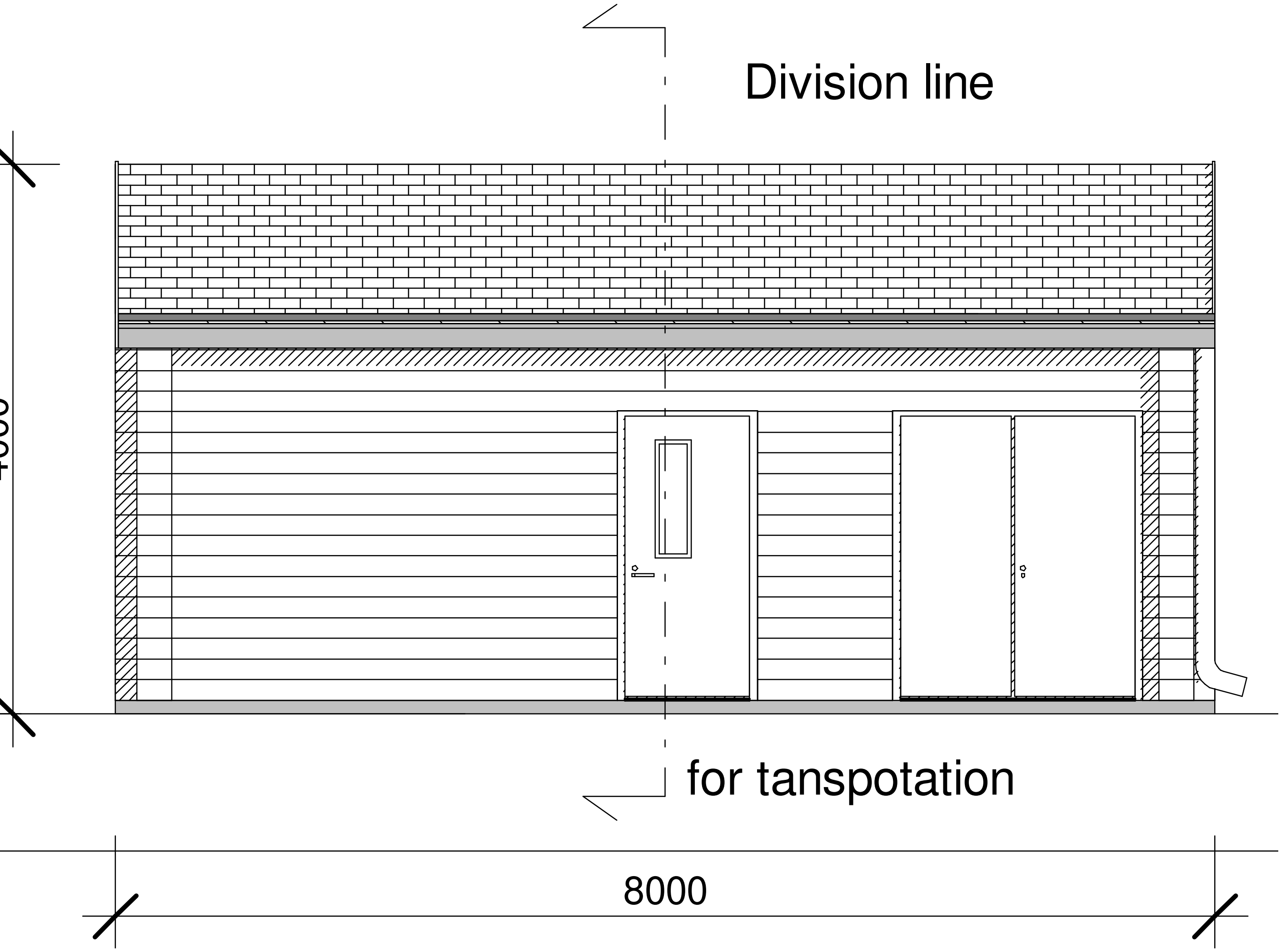
The floor plan of the basic block 1:50



The floor plan of the basic block second floor 1:50



The facade of the basic block 1:50



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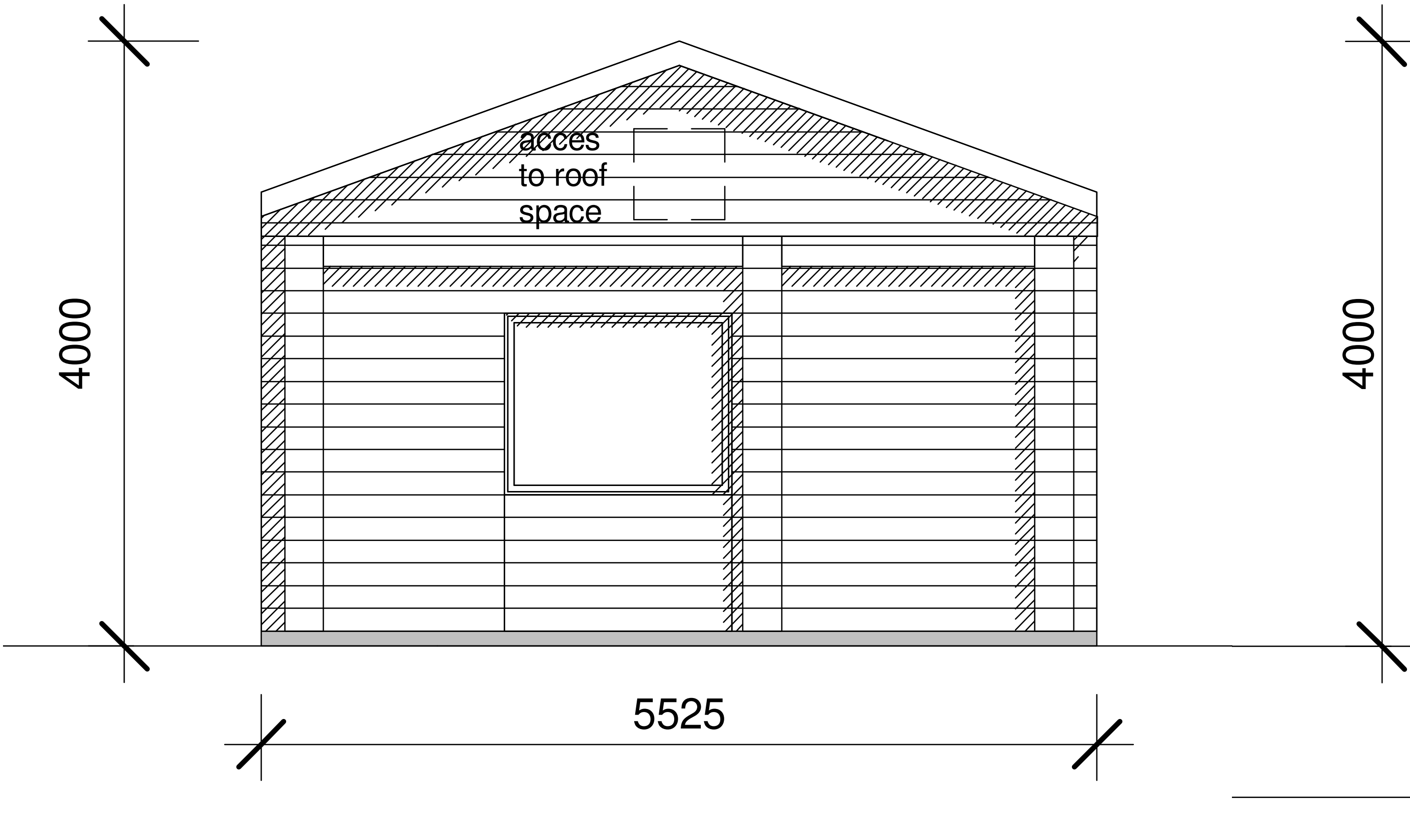

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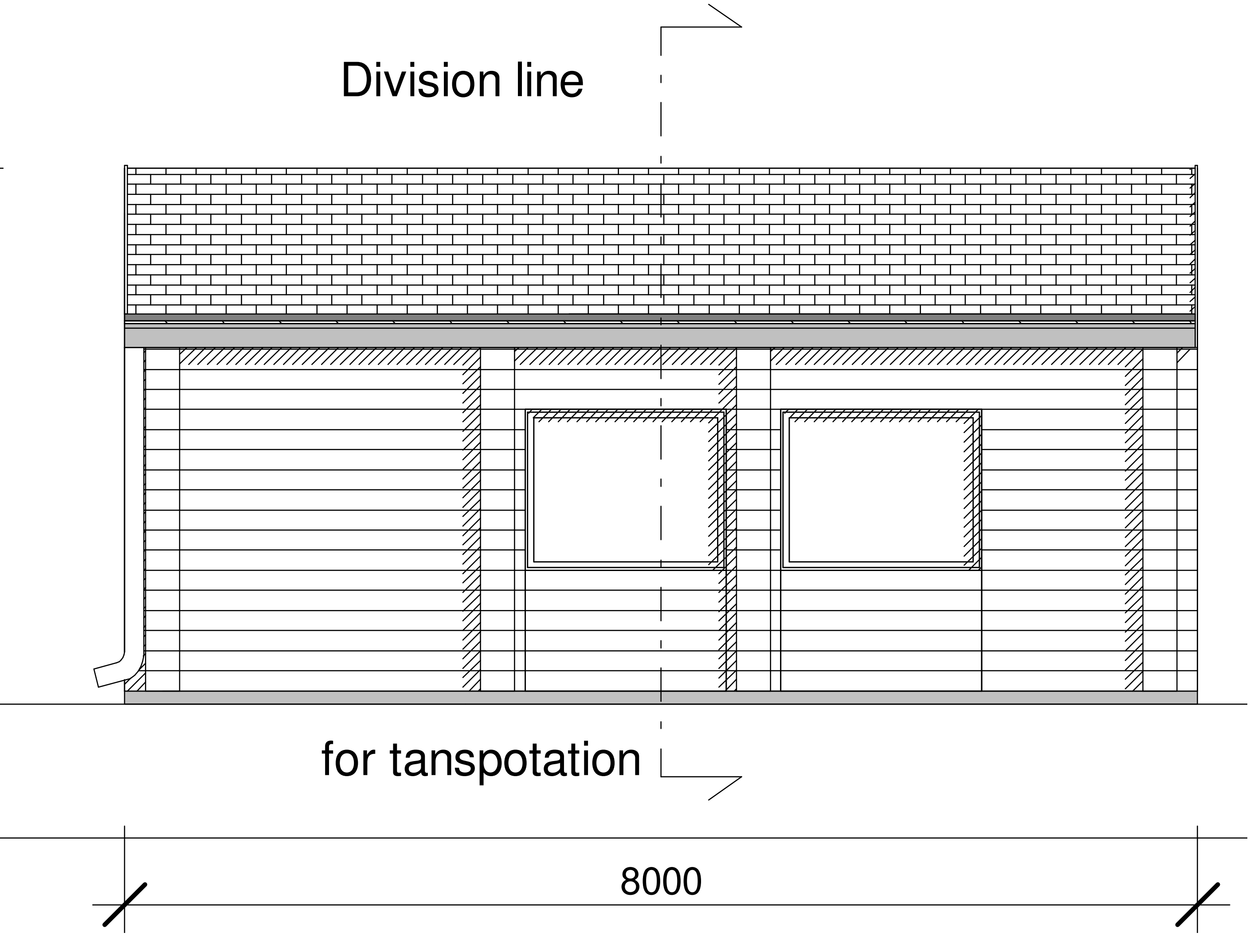
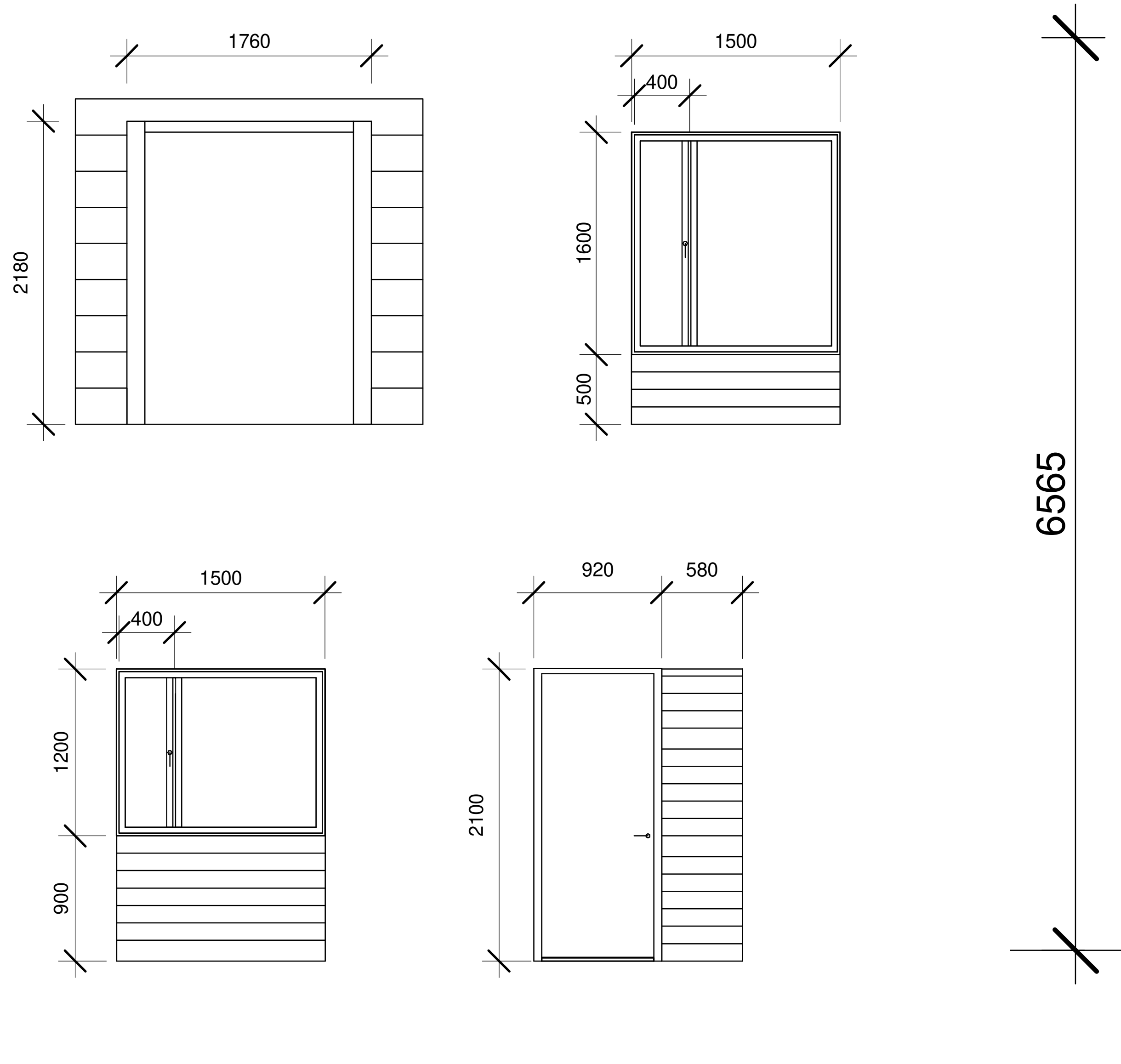
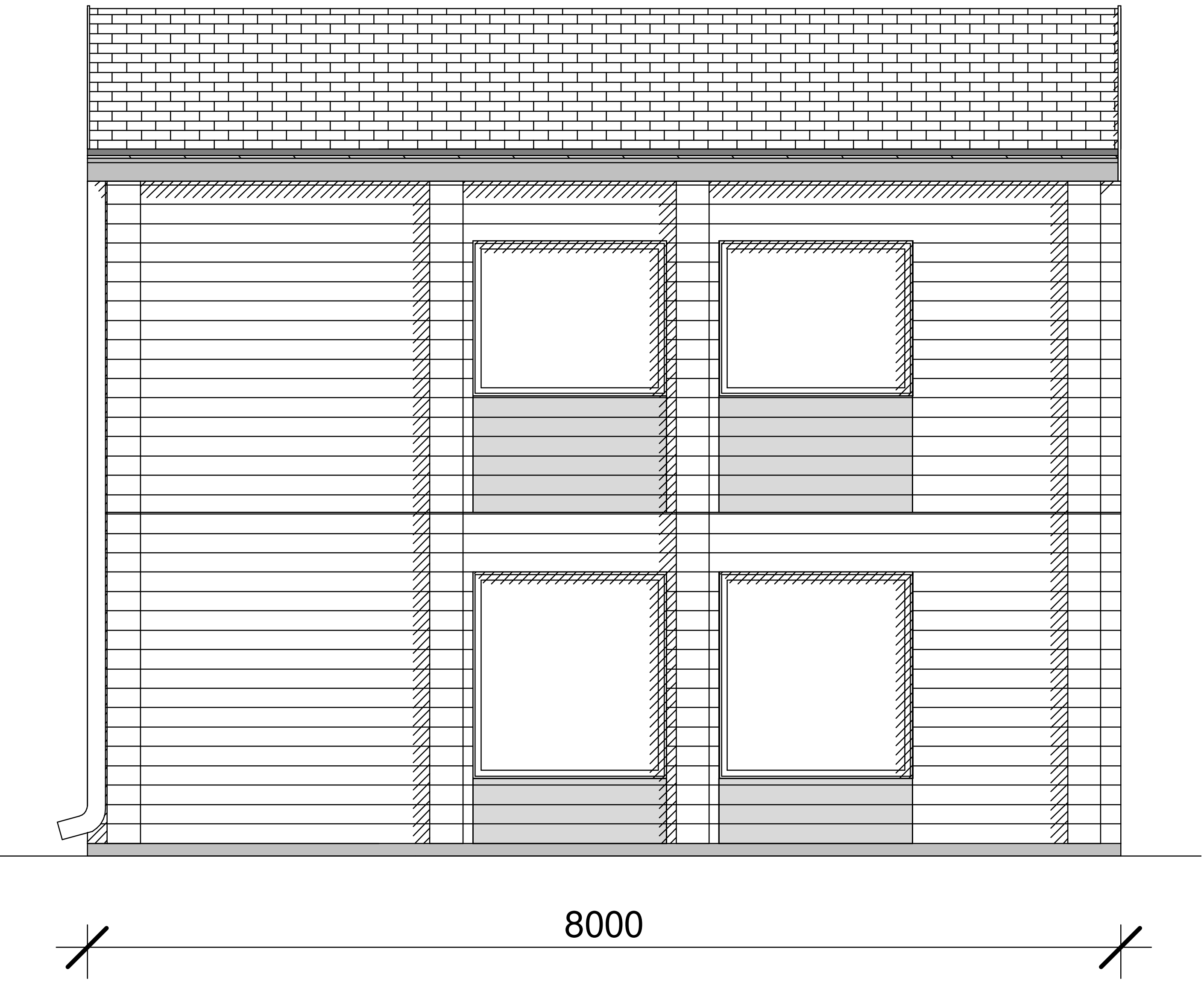


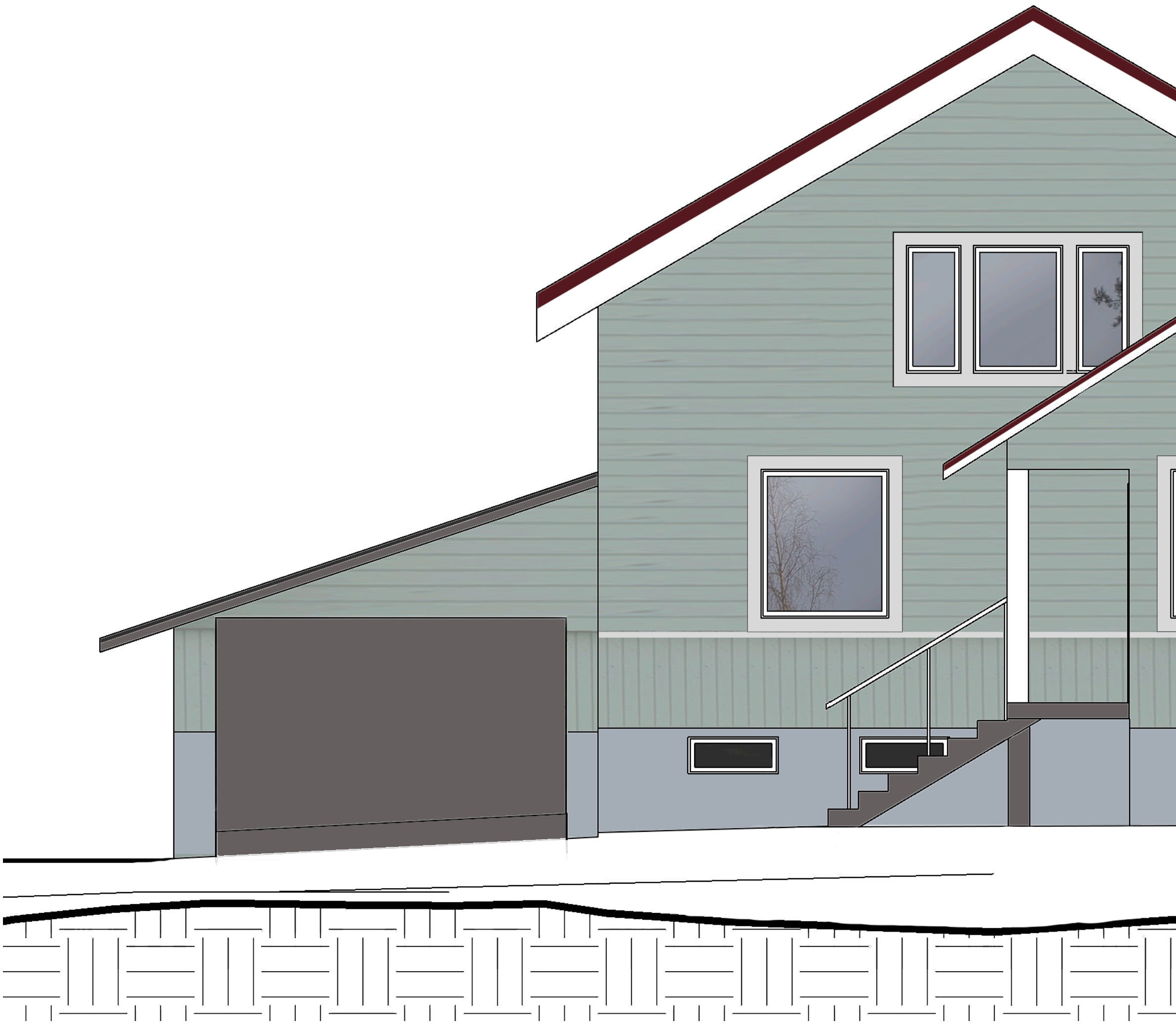
The facade of the basic block 1:50



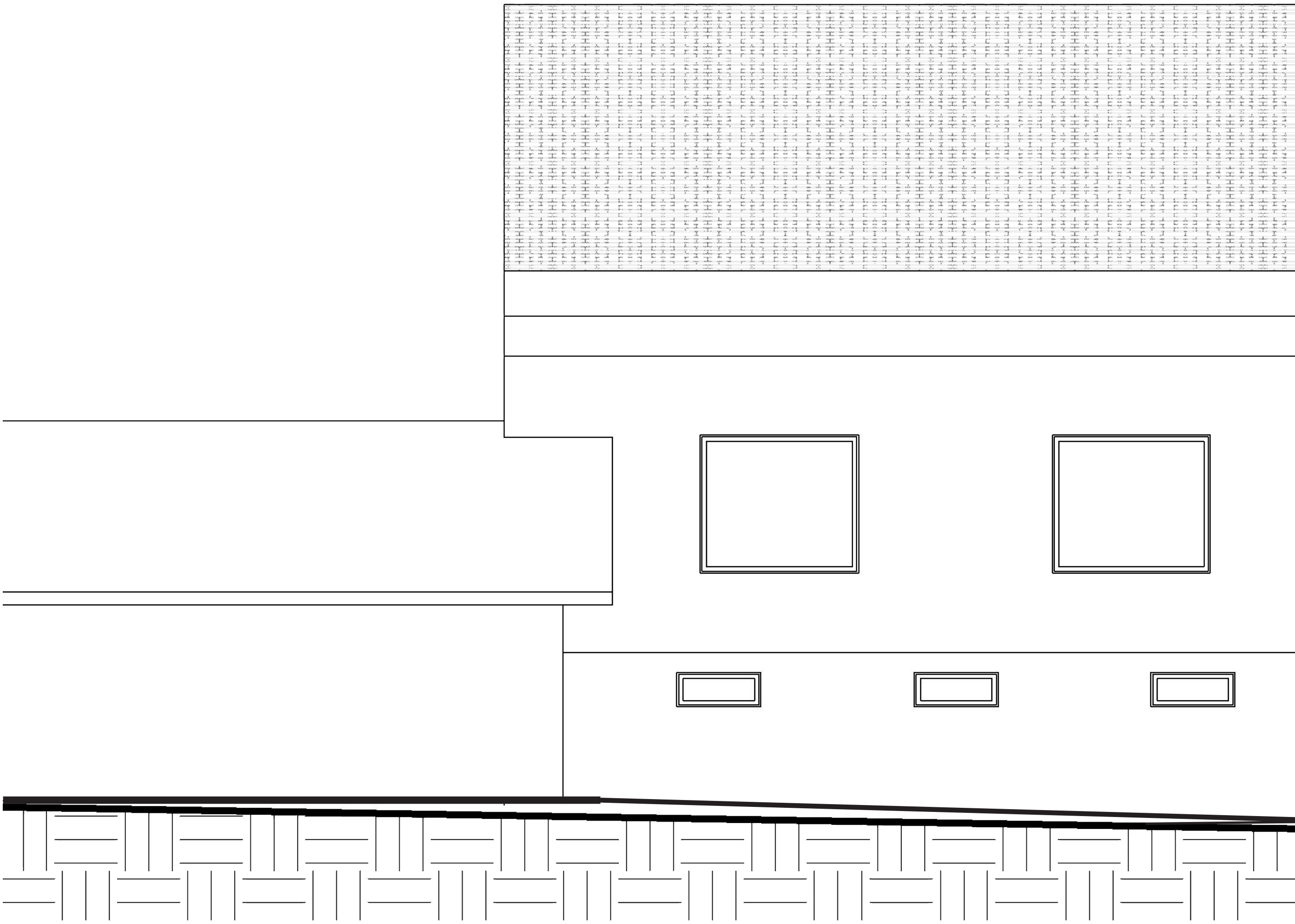
The cut through options: hole, 1600 mm height window, 900 mm height window or a door 1:50

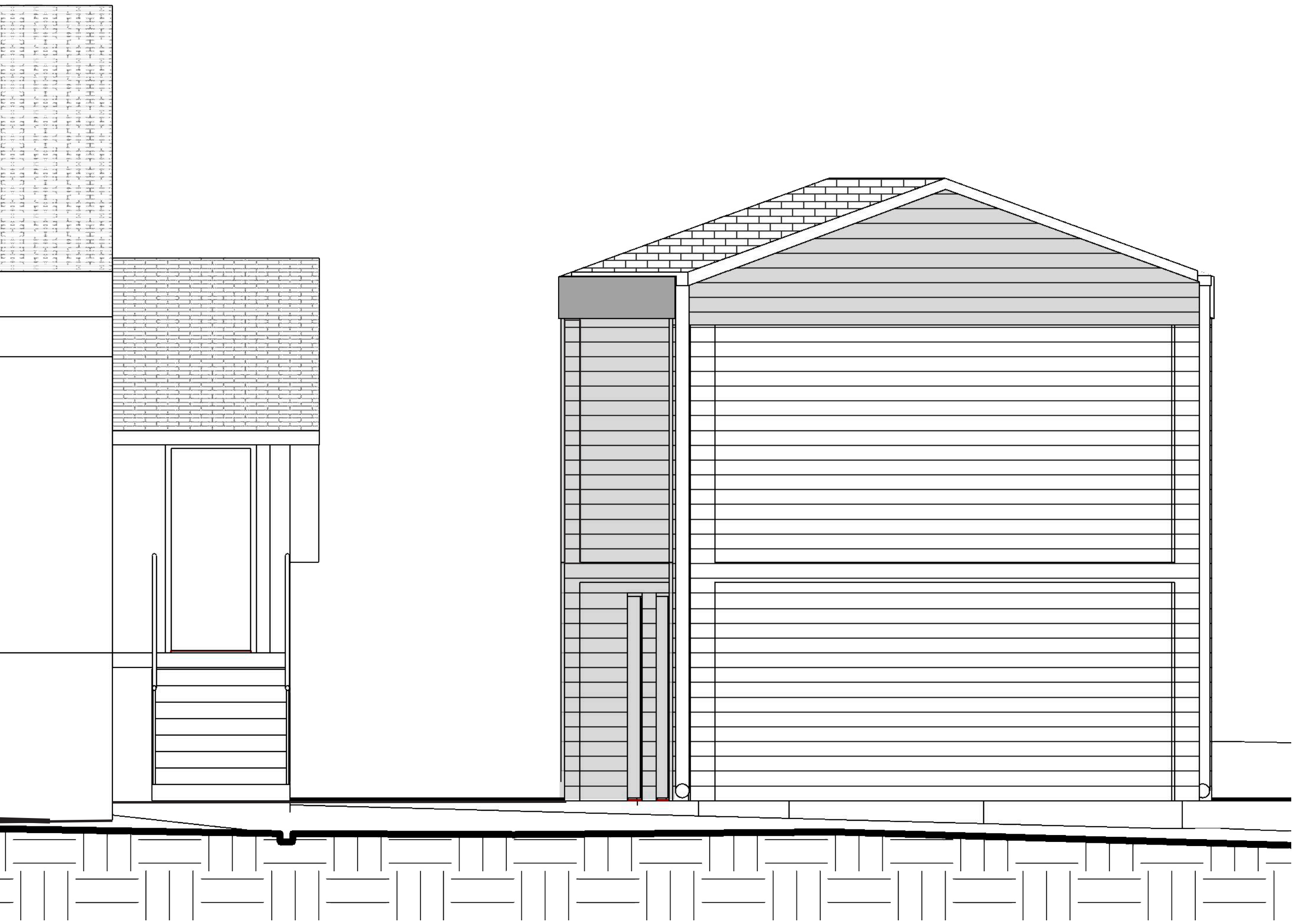


The facade of the basic block with second floor 1:50

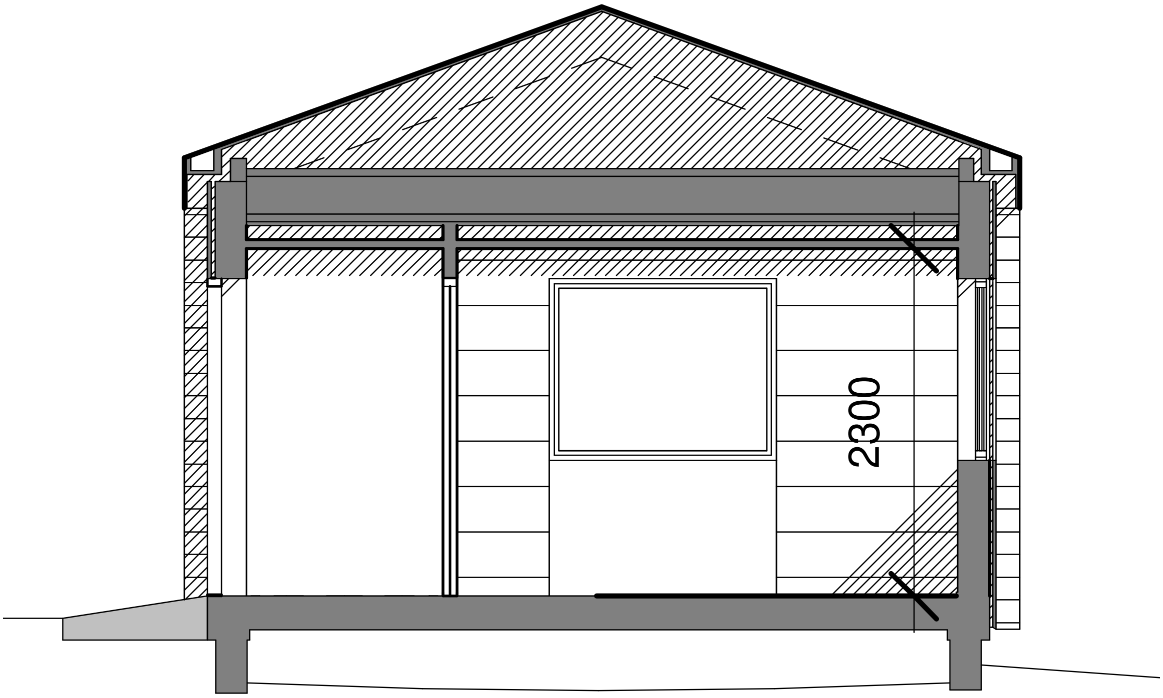


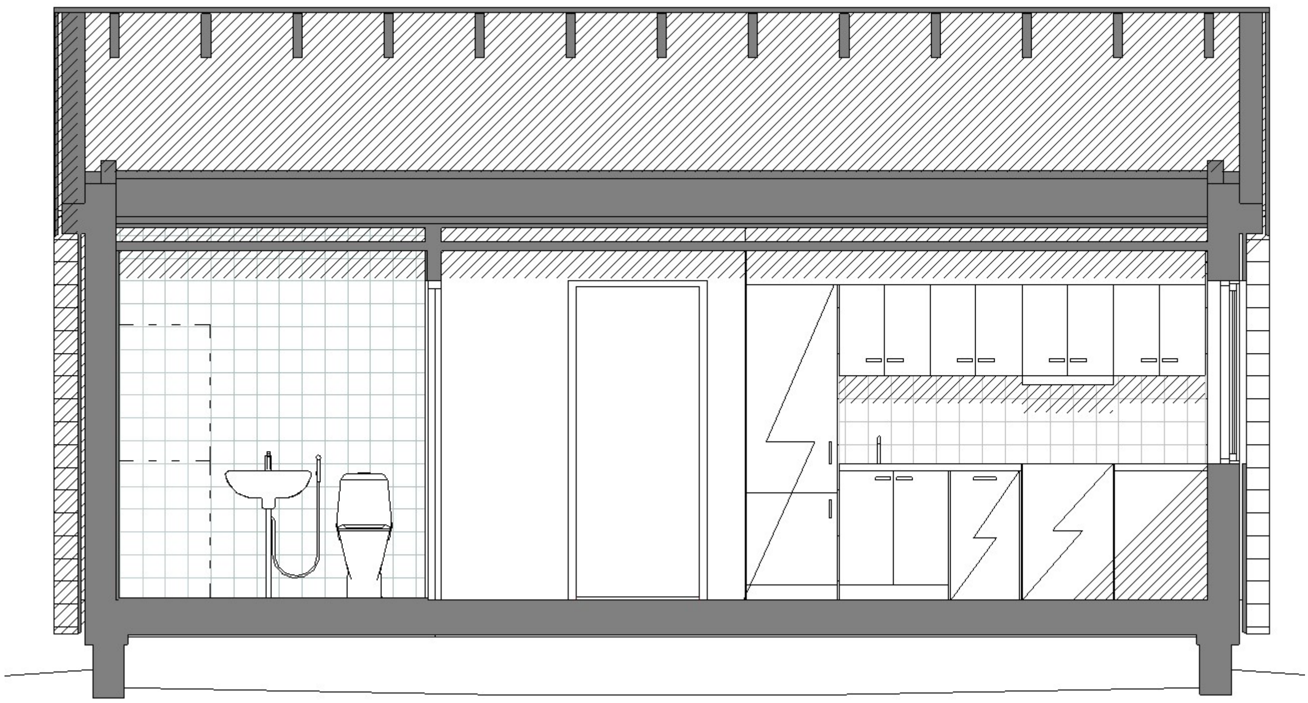
The facade of a two floor basic block situated on the example plot 1:100. The facades are towards west, this is the view from the street. Colours are an example possibility.



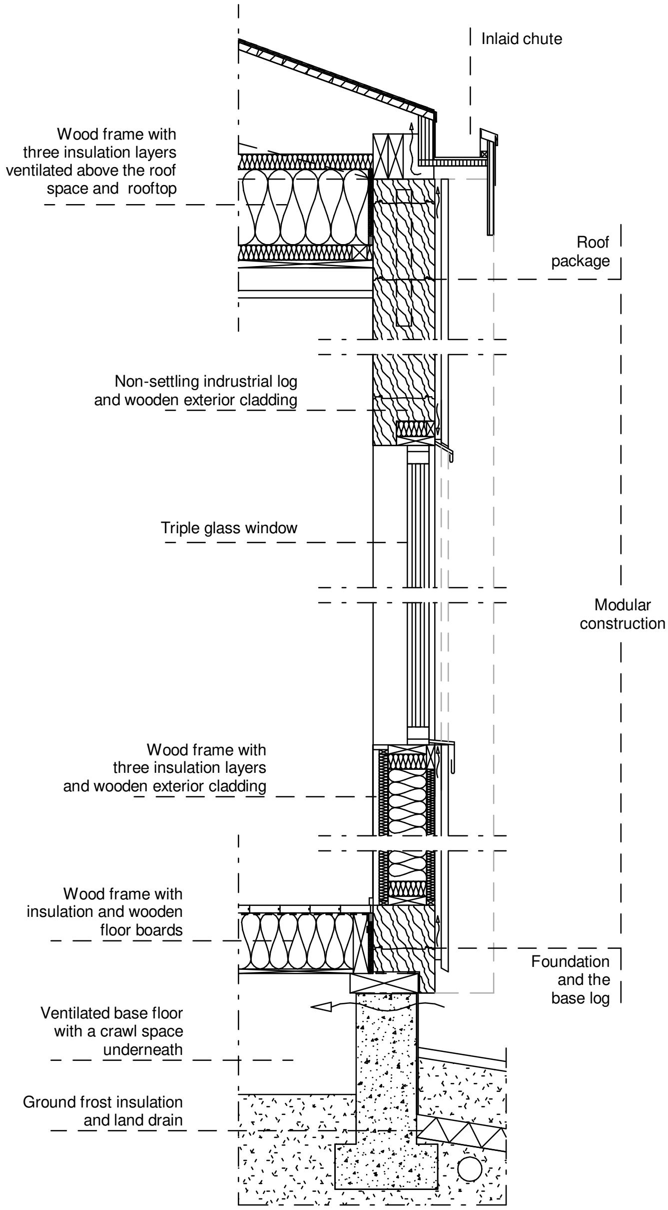


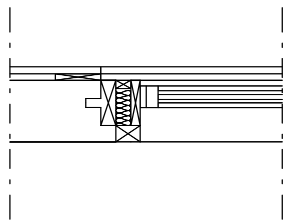
The facade of a two floor basic block situated on the example plot 1:100. The facades are towards north, this is the view from the acces road on the plot.



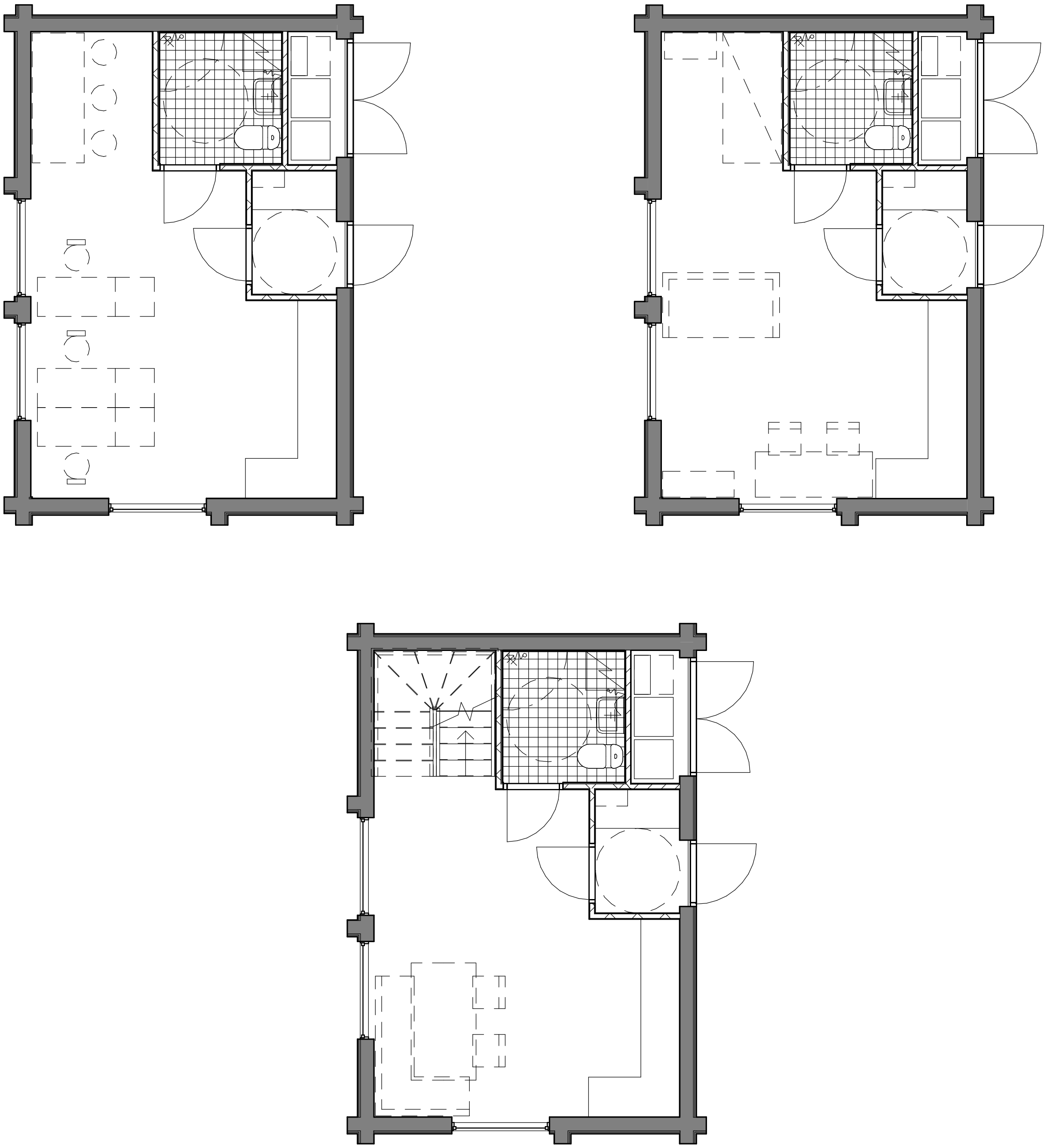


The sections of the main block 1:50

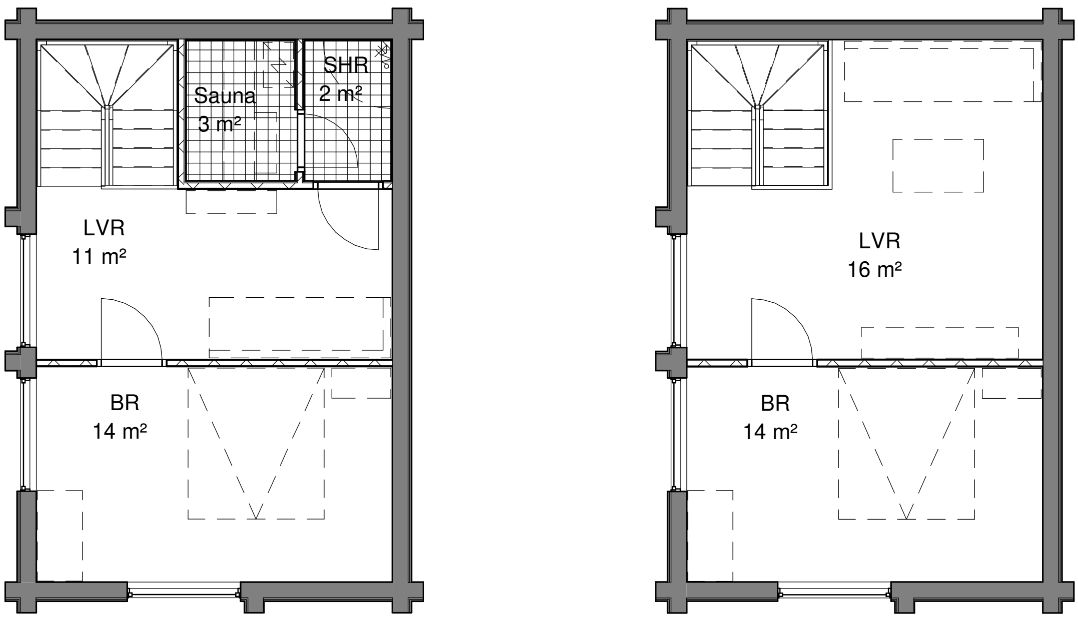




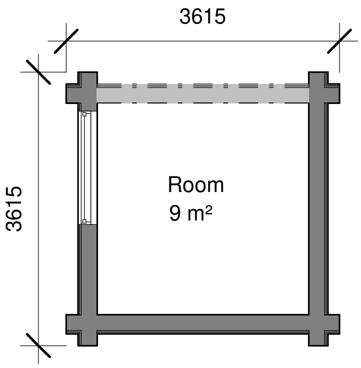
The detail sections of the main block by a window 1:25



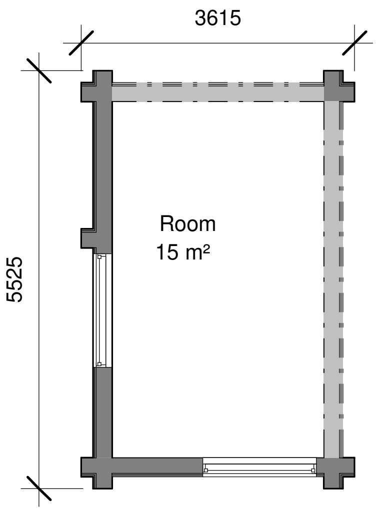
The possible floor plans first floor 1:100
Top left a office set-up for telecummuting,
top right a studio appartment and under them first floor of two floor house



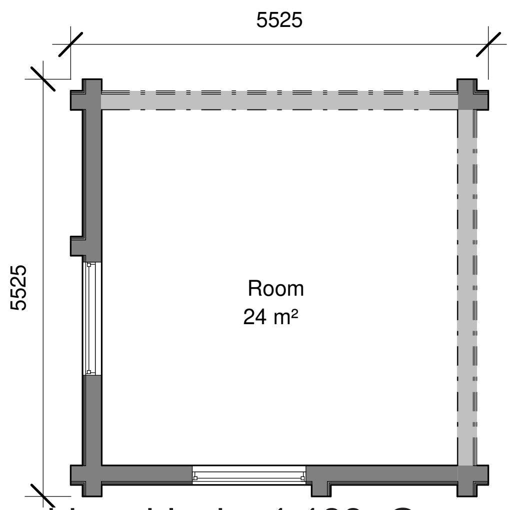
The possible floor plans second floor 1:100
The left a plan a second floor with a sauna, bedroom and livingroom space. The right a big livingroom with a bedroom.



The 9 m^2 add-on block, with inside measurements of 22795 x 2795 mm



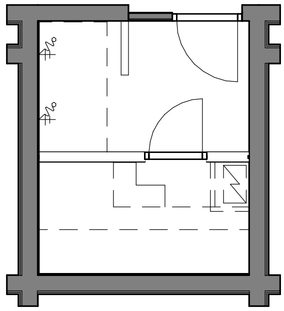
The 15 m^2 add-on block, with inside measurements of 22795 x 4705 mm



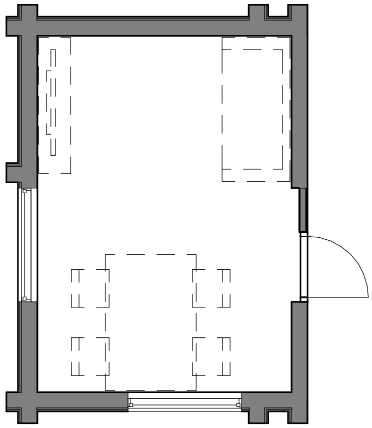
The 24 m^2 add-on block, with inside measurements of 4705 x 4705 mm

The add-on blocks 1:100. One wall is in lightgray dash dot line to symbolize that one wall will be left out from these.

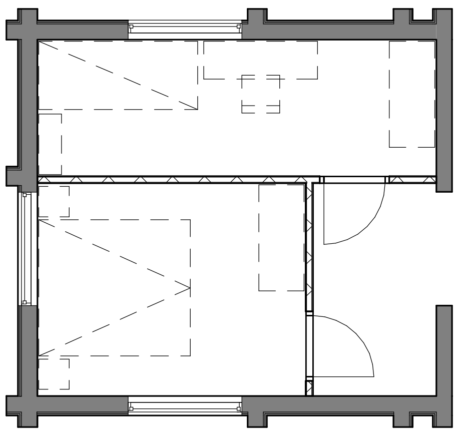
A sauna and a shower room with little bit of space separated for dry clothes



A living and dinign room.



Two bedtooms, one with a single bed and desk and the other with a dubble bed.



A one possible floor plan for each add-on block 1:100.