TALLINNA TEHNIKAÜLIKOOL

ONE-TONNE-LIFE: A SUSTAINABLE COMMUNITY IN TORPPALA

ÜHE-TONNI-ELU: JÄTKUSUUTLIK ELUKESKKOND TORPPALAS

MASTER THESIS

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Tallinn 2019

AUTHOR’S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material.
All works, major viewpoints and data of the other authors used
in this thesis have been referenced.

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Acknowledgements

I would like to thank my supervisor, professor Kimmo Lylykangas for guiding me at times when I got lost in the vast environmental data and steered me in the right direction.

My research would have been impossible without the support of my co-supervisor, professor Targo Kalamees.

My sincere thanks go to the landowners and developers for giving me the opportunity to propose vision for the development.

And last, but not least, I am grateful for the moral support from my parents, my sister and friends.

List of Abbreviations

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent, unit
EPD	Environmental product declaration
GWP	Global warming potential
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LCA	Life-cycle assessment

The Abstract

Many species and enormous areas of natural environments have been damaged in recent decades. We are on the brink of a crisis of extinction of one million species. (LEAHY 2019) Mankind is exploiting nature faster than it can renew itself. Overconsumption of products, food and fossil-fuel based transport methods have led to a situation where more carbon dioxide is added to the world that it can absorb. The connection between climate change and mankind's activites can be explained by the correlation of Earth's average temperature and greenhouse gases emitted every year. For keeping the Earth livable for future generations, the society needs changes.

The Nordic countries are great examples of preserving natural values and aiming for a better natural environment. This thesis introduces the possible solutions or ways to live a sustainable life in the context of Finland. The measurement tool for sustainability in the thesis is one tonne of carbon dioxide emissions per person a year. That is the level of sustainability we need to reach to keep global warming below 1.5°C. Human carbon footprint is explained by measuring carbon dioxide emissions since it is the main greehouse gas, accounting for around 80% of all GHGs.

Low emission life is introduced through a planning proposal in the area near Kaarina, in Torppala. The landowners are interested in developing an ecological settlement. The question that people in the world and in the area are facing is the sustainability of a single-family-house concept. Is there a future for single-family housing?

In the first part of the thesis, the different development plans near Kaarina and Turku are introduced. The guide for connecting new developments to a working system is proposed by the author. The measurements and calculations of different parts of human carbon footprint are presented in the second part. The planning proposal follows in the project part. The main aim of the proposal is to test the viability of the development in the frame of one-tonne-life. The goal is to create a development supporting one-tonne lifestyle and answer the question about the sustainability of single-family housing.

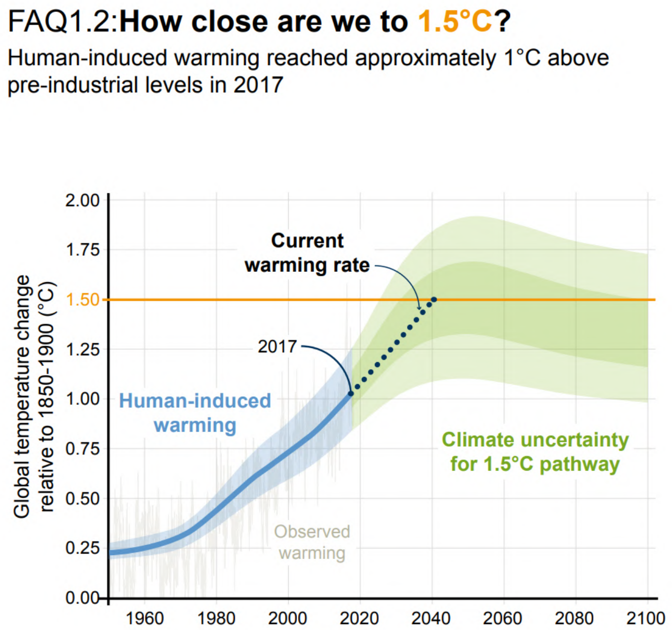
Annotatsioon

Mitmed liigid ja looduskeskkonnad on viimastel aastakümnetel kannatanud pöördumatute kahjustuste all. Üle miljoni loomaliigi on väljasuremisohus. (LEAHY 2019) Inimkond kasutab loodusressursse kiiremini, kui need uueneda jõuavad. Toodete, toidu ja fossiilkütuste ületarbimine on viinud olukorrani, kus süsinikdioksiidi paisatakse õhku rohkem, kui maailm suudab absorbeerida. Seos kliimamuutuse ja inimkonna tegevuste vahel on seletatav sellega, et Maa keskmine temperatuur on korrelatsioonis suurenevate kasvuhoonegaaside eritamisega. Elamiskõlbuliku Maa säilitamine järgnevatele põlvkondadele eeldab ühiskonnas suuri muutusi.

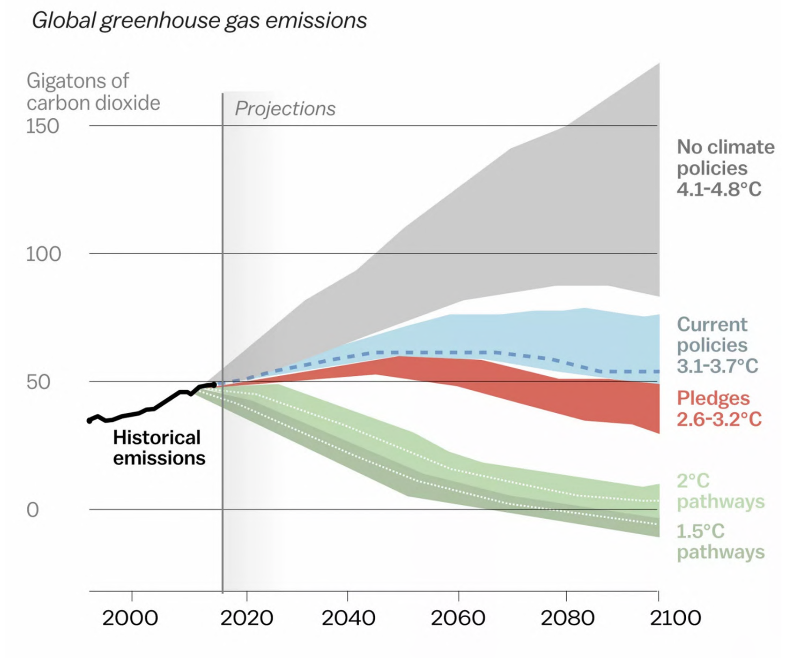
Põhjamaad on suurepärased näited riikidest, kes üritavad säilitada looduslikke väärtusi ja püüdlevad parema looduskeskkonna suunas. See lõputöö tutvustab võimalikke lahendusi ja jätkusuutlikke eluviise Soome näitel. Jätkusuutlikkuse mõõdupuuks on valitud üks tonn süsinikdioksiidi emissioone ühe inimese kohta aastas. See on jätkusuutlik saastepiir, mis võimaldab kõikide eelduste kohaselt säilitada maakera keskmise temperatuuritõusu alla 1.5°C . Töös mõõdetakse peamiselt süsinikdioksiidi jalajälge, sest süsinikdioksiid on enim levinud kasvuhoonegaas, moodustades kõikidest kasvuhoonegaasidest ligi 80%.

Madalsaastelise eluviisi võimalusi tutvustatakse planeeringu näitel Kaarina lähistel Torppalas. Maaomanikud on huvitatud jätkusuutliku ja ökoloogilise elamupiirkonna arendamisest. Töös tõstatakse küsimus ühepereelamu kui hoonetüübi jätkusuutlikkusest. Kas ühepereelamul on tulevikus kohta?

Töö esimeses osas tutvustatakse Turku ja Kaarina linna lähistel planeeritavaid arenguid. Autor pakub välja plaani uute arenduste tervikuks ühendamiseks. Inimese süsiniku jalajälje peamised osad koos statistika ja võimalike arvutuslahendustega on esitatud teises osas. Teoreetilisele osale järgneb projektlahenduse ettepanek. Planeeringu peamine eesmärk on katsetada linnaäärse elamupiirkonna otstarbekust ühe-tonni heitkoguste juures. Ettepaneku peamine eesmärk on luua ühe-tonni elustiili toetav elukeskkond ja vastata ühepereelamute jätkusuutlikkusele.



Human-induced warming reached approximately 1˚C above pre-industrial levels in 2017. At the present rate, global temperatures would reach 1.5˚C around 2040. Stylized 1.5˚C pathway shown here involves emission reductions beginning immediately, and CO_2 emissions reaching zero by 2055. (IPCC 2018)



Different pathways of CO_2 emissions and the possible warming rate of the earth. (Source: Climate Action Tracker)

The Background

Global warming and CO_2 emissions

In recent years, global warming or climate change is a topic frequently covered in the news. The concept of climate change is not new; Joseph Fourier suggested already in 1824 that gases in the atmosphere serve as barriers for solar radiation escaping from the Earth and thus influence temperatures at the surface of the Earth. (Vasseur 2004, 594)

Humans and ecosystems have always had to adapt to climate change as a natural phenomenon, but only in the recent thirty years has climate change been linked to human activities on the planet. Scientists from the Goddard Institute of Space Studies in the US managed to prove that the global mean temperature of the Earth was rising compared to 1890s. The concept of global warming does not imply that the temperature is getting warmer at the same rate all over the world; some areas can experience cooling while other areas experience warming. (Vasseur 2004, 594)

EU policies and the Paris Agreement

The European Union's policies on climate change have set a target to reduce greenhouse gas emissions by 80% to 95% by 2050, compared to levels of 1990. The first measures of the target were adopted in 2008, setting goals for 2020. The goals for 2020 were to cut greenhouse gas emissions, increase the usage of renewable energy sources and increase energy efficiency, all by 20%. The long-term goal for 2050 is supported and led with regulations on emissions trading system, renewable energy, reduction of energy use, reduction of CO_2 emissions in the transportation sector, etc. (European Commission 2019) The EU states that for achieving global warming below 2ºC, the world must stop the growth in greenhouse gas emissions by 2020.

In 2016, 195 countries signed the Paris Agreement with the central aim to strengthen the global response to the threat of climate change, by keeping a global temperature rise below 2 degrees compared to pre-industrial levels. The EU contributed to the world's greenhouse gas emissions with 8,97%, landing third in the world behind the United States (12,10%) and China (23,75%). With the policies described, the goal to make an impact needs support from all the countries. (Carbon Brief staff 2015)

IPCC reports

In 1988, Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Organization and the United Nations Environment Programme. The goal of the IPCC is to provide governments with scientific data and information for developing climate policies. The IPCC has 195 members including Finland and Estonia. The IPCC does not carry out its own research but publishes comprehensive summaries about drivers of climate change, its impacts, future risks and scenarios. (IPCC 2019)

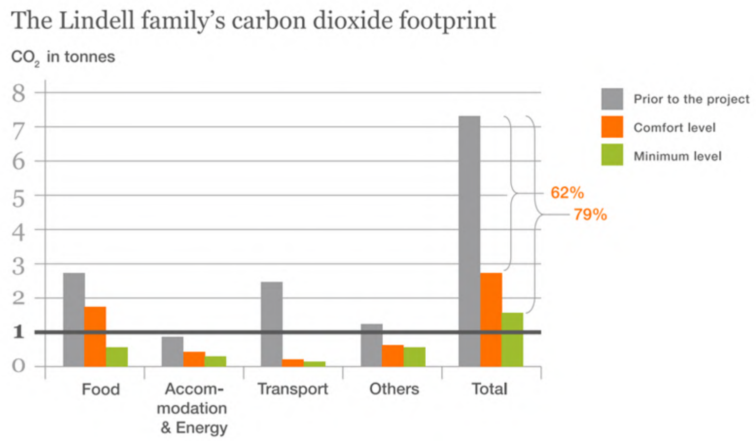
Since 1988 the IPCC has issued five assessment reports and additional supplementary reports. The last assessment report was published in 2014. The next major report is scheduled to be published in 2021.

The paper 'Global Warming of 1.5ºC' concentrates on the impacts of global warming of 1.5ºC above pre-industrial levels. The paper gives different scenarios for future paths on the emittance of global greenhouse gases. The report is in direct connection to the Paris Agreement of 2016. The IPCC report puts the Paris Agreement and EU policies in a bad light by claiming that there are not enough strict rules to fight climate change and suggest that the current goal of keeping the global warming below 2ºC is not enough to reduce the impact of climate change.

The IPCC report estimates that human activities have caused an approximately 1.0ºC rise of the Earth's average temperature compared to pre-industrial levels. It is estimated that global warming will reach 1.5ºC in between 2030 and 2052. The report states that warming from anthropogenic emissions (greenhouse gases, aerosols, and their precursors) since the pre-industrial period to the present will continue for decades and centuries. The impacts will continue to cause further long-lasting changes in the climate system. Reaching and sustaining net zero global CO_2 emissions would stop global warming on a decadal timescale. The forcing of the non- CO_2 radiative emissions may still be required to prevent further warming due to the Earth's system feedbacks. The report states that for the goal of keeping global warming under 1.5ºC, the Earth's global CO_2 emissions must reach net zero in 2040 to 2055. (Hoegh-Guldberg 2018) That means reducing CO_2 emissions by 50% every decade.

For global sea levels, the increase is projected to be around 0.1m less at 1.5ºC than at 2ºC at the end of the century. The report notes that it would mean up to 10.4 million fewer people would be exposed to the impacts of rising sea levels globally. However, sea levels will continue to rise beyond 2100. There is a risk that instabilities in the Greenland and Antarctic ice sheets triggered by 1.5-2ºC of warming will cause increases in the sea levels in the centuries to come. (Carbon Brief staff 2018)

One Tonne Life experiment family and the house (One Tonne life 2014)



Percentage reductions

	Food	Accommodation & Energy	Transport	Others	Total
Comfort level	44%	52%	91%	47%	**62%**
Minimum level	84%	58%	95%	51%	**79%**

Carbon footprint reductions of the Lindell family during the One tonne life experiment (One Tonne Life 2014)

The awareness of Climate change in Finland

In 2019, a survey was commissioned by the Steering Group for Central Government Climate Communications and carried out by Kantar TNS to find out what Finns think of climate change and policies. A total of 1013 people from ages 15 to 74 were questioned. 80% of them considered an immediate action necessary to soften the impact of climate change. 75% expect the EU to serve as a role model for fighting climate change. The poll already showed the results of people's awareness and behaviour towards climate change; more than half of Finns have reduced electricity consumption and are buying less. 43% of car users drive less and 40% of Finns have reduced flying. (VTT 2019)

A similar poll was carried out by Taloustutkimus on behalf of YLE, Finland's national public broadcasting company. The results showed that 60% of respondents find climate change a serious problem. In 2012, the same number was only 23%. That shows that Finns are educated and aware of the results and broader effects of climate change. (YLE 2018)

The uprising trend in the awareness of climate change in Finland is the result of the Finnish climate politics. Finland has an active role in climate policy on international and EU level. In addition to many agreements internationally, Finland has adopted and supplemented many climate strategies nationally over the years. (Ministry of the Environment, Ministry of Agriculture and Forestry, Ministry of Employment and the Economy 2015)

In March 2019, the minister of the Environment, Energy and Housing Kimmo Tiilikainen announced Finland's wish for the European Union to agree on the net-zero carbon emissions strategy in 2050. (Baczynska 2019)

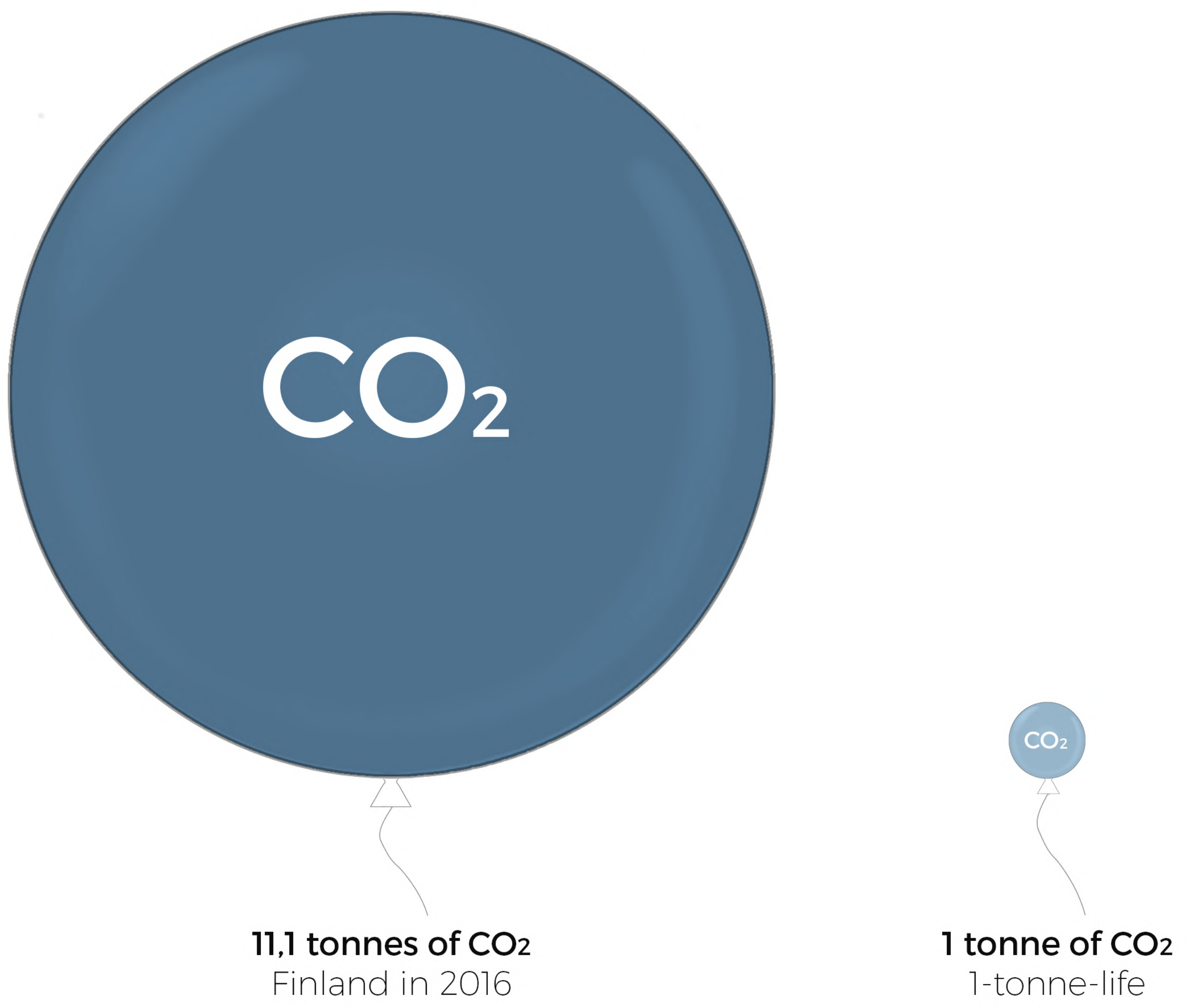
One tonne experiment

In 2011, an experiment on one-tonne-life took place in the suburb of Sweden's capital Stockholm. The Lindell's, a test family of four was accommodated to a test house built just for low CO_2 emission living. The family changed their normal lifestyle for the climate-smart lifestyle for six months. The family was guided and consulted by experts from the transportation, energy, and food sector.

The family started with 7.3 tonnes per person per year of carbon dioxide emissions. Within 3 months' time, the family managed to reduce the number down to 2.8 tonnes of CO_2 per person per year. The record low number was recorded during the 20th week into the experiment when the emissions from the family were recorded as low as 1.5 tonnes per person per year.

This was achieved with the energy-efficient house that used produced solar power and had a low maintenance cost, designed by distinguished Swedish architect Gert Windgård. The family used more public transportation and instead of two cars had one small electric car to use. They were also on a special food diet with less meat than the family had consumed before. The emissions from materials used for the construction of the house corresponded to about 400kg of CO_2 per person per year with the life expectancy of 50 years. All other emissions of the products the family used were distributed throughout each product's lifetime, such as a car with a life expectancy of 15 years and clothes of 2 years. The total 'rucksack' of the production of products and appliances for the family accounted for about 900kg of carbon dioxide emissions per person per year. That made it difficult to cut emissions down to just 1 tonne per person per year.

The results showed that emissions in transportation were cut down by 91%. The food emissions decreased between 44% to 84%, depending on the usage of meat products. The energy and accommodation had a reduction of about 55%. In total, the family reduced its emissions by 62% from 7.2 tonnes to 2.8 tonnes per person per year, as presented on the figure 1. With the change in lifestyle and comfort zone, the result was 1.5 tonnes per person a year. (One Tonne Life 2014)
In the conclusion of the project's final report, the idea of 'one tonne life' is described as a realistic endeavour with some clauses. The energy system must be modified, and the lifestyle change of eating habits play a major role in cutting emissions. Sustainable living expects major efforts from families, politicians and companies. After the end of the experiment, the house was occupied by the Jogensjö, a family of three who is living there daily. They continue to live a sustainable life with emissions as low as possible. (One Tonne Life 2014)



Personal Carbon footprints, Drawing of the author,
Source: EUROSTAT

Formulation of the topic

The world's population expectancy according to United Nations is 9.8 billion people in year 2050. With more people in need for food, shelter, fresh water and other qualities for life, the reduction of the emissions is demanding and long-term task. (United Nations 2017)

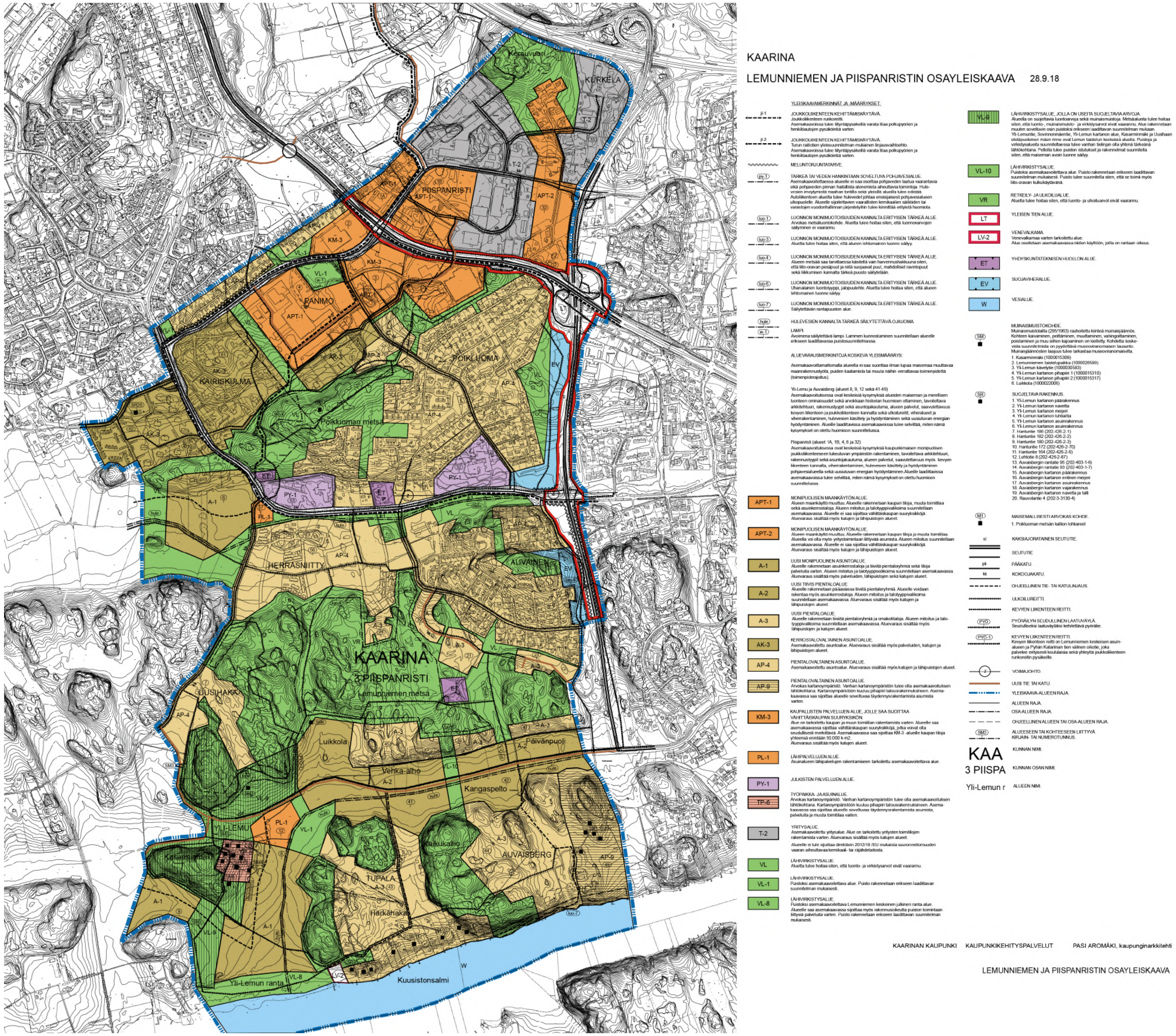
The coming decades may be the most crucial ones in the history of humankind. With the world population increasing rapidly, economic activities tripling, and with the desires of developing countries to adopt standards of living of the western world, slowing the climate warming might not be achievable for decades. (Vasseur 2004, 594)

The One Tonne experiment in Sweden proves that reduction of emissions down to 1 tonne of carbon dioxide is possible. The question that architects, engineers, urban planners – and first of all, people – have to answer in coming decades is whether our current ways of living are sustainable for the future generations; what we have to change in our values and living habits to minimize the contribution to emissions and follow the data set by scientific research. The uncertainty and long-term results of climate change make it hard to imagine, identify with and understand the possible consequences in the Earth's environment. The climate change is not only about warming and climate disasters. It will also bring migration and social problems, clashes between religions and different cultures. All that while all people are pursuing a higher standard of life.

Taking into consideration the previous introduction and facts listed, the aim of this Master's thesis is to investigate the possibility of living a low emission life in Finland in a chosen location in low-scale housing. The aim of the thesis is to propose an environmentally sustainable community in Torppala, Finland that supports One Tonne Life. One tonne life is used as a major tool to measure the contribution of emissions per person. One tonne measure should be the standard by continuous development of EU energy and emissions policies between 2040 to 2050. Since it is a collective battle, the support of the community is possibly one of the most important aspects for implementing 1-tonne-life.

One objective in the thesis is to examine, whether the one-tonne life, as described above, can be reached in a new suburban area with single-family houses, or is the single-family housing just urban sprawl, something that Finns cannot afford in the future for environmental reasons. Carbon footprint calculation in accordance with the standards EN15804 and EN15978 were carried out to examine if the one tonne CO_2 emission "budget" is a realistic target in this site and in this context.

One tonne of CO_2 illustrated in Copenhagen in 2007.
Foto Hasse Ferrold



Extract of Lemunniemen Masterplan, Source: Kaarina Municipality

The Introduction

Turku and Kaarina

Turku and Kaarina are two cities located on the south-western coast of Finland. Turku is historically significant due to its location as an important transportation hub of the region, especially with the direct link to Stockholm. The population of the Turku city was around 189,000 inhabitants in 2017. (Statistics Finland 2018)

The city of Turku has a strategic plan for reaching carbon neutrality by 2040. The city council promotes in its Climate and Environment Programme a reduction of greenhouse gases, generating no waste and no overconsumption. The biggest reduction in greenhouse gas emissions will be reached by increasing the share of renewable energy and promoting sustainable modes of transport and mobility. (Turku City Council 2009)

Kaarina is a neighbouring city in the southeast from Turku with a population of 32,000 inhabitants. Both cities have a growing population and expect growth in the living space area. Similarly to those of the state of Finland, the two cities' policies on the environment and lowering the emissions are very future-oriented. That in mind, the planning of the new areas are under profound development for a high-quality local environment for current and future residents. (Kaarina Municipality 2013)

The city of Kaarina has a masterplan that densifies the area between Turku and Kaarina. It stretches the city from Piisipanristi to the south towards the sea. The plans include building an area for more than 10,000 inhabitants. The city council expects the population of Kaarina to be risen by 14,200 inhabitants by 2035. The same number is expected to be 4,500 by the year 2025. The vast plan includes building new roads, light road traffic, residential areas with related services and public areas. The traffic routes and public transport connections are included to be looked over in the plan. Local natural and recreational areas are highly valued and are not to be harmed, green belt is respected. (City of Kaarina 2018)

Location of Turku, Kaarina and Torppala. Drawing of the author.

Location of Torppala, Drawing of the author

Torppala

West from the area described previously, the city of Kaarina together with private landowners has another area under development in Torppala. The main objective of the 12ha area is to intensify the urban structure and expand the existing borders. The land use program estimates 600 to 700 new inhabitants. The plan for the housing typologies is mostly described as private houses, terraced houses and other bigger groups of housing. The objective is to create a financially viable and long-lasting residential area that respects the nature.

The goal is to map out a new residential area that respects the principles of sustainable development. According to the City Council's evaluation plan of Torppala's eco-village, the principles include ground-source heating (land and sea), production of biogas from waste, intelligent power grid, treatment of rainwater and organic waste, natural building materials, and local food production. (City of Kaarina 2019)

Before the development of the area, there are about 30 households situated in Torppala. The area is quiet and lacks services, depending on Kaarina and Turku where people travel for every day life needs. With a few hundred new residents in the area in the future, the potential for an exemplary sustainable neighbourhood due to its location and proximity to nature is high.

The developers and landowners gave permission to the author to propose a solution for a sustainable development in Torppala. The question raised by the author is whether it is reasonable to build private housing in the context of emissions? In the perspective of an urban sprawl, it is vital to connect Torppala to Kaarina's new developments in the future. Providing small centres of service areas will reduce the dependency on Turku and Kaarina.

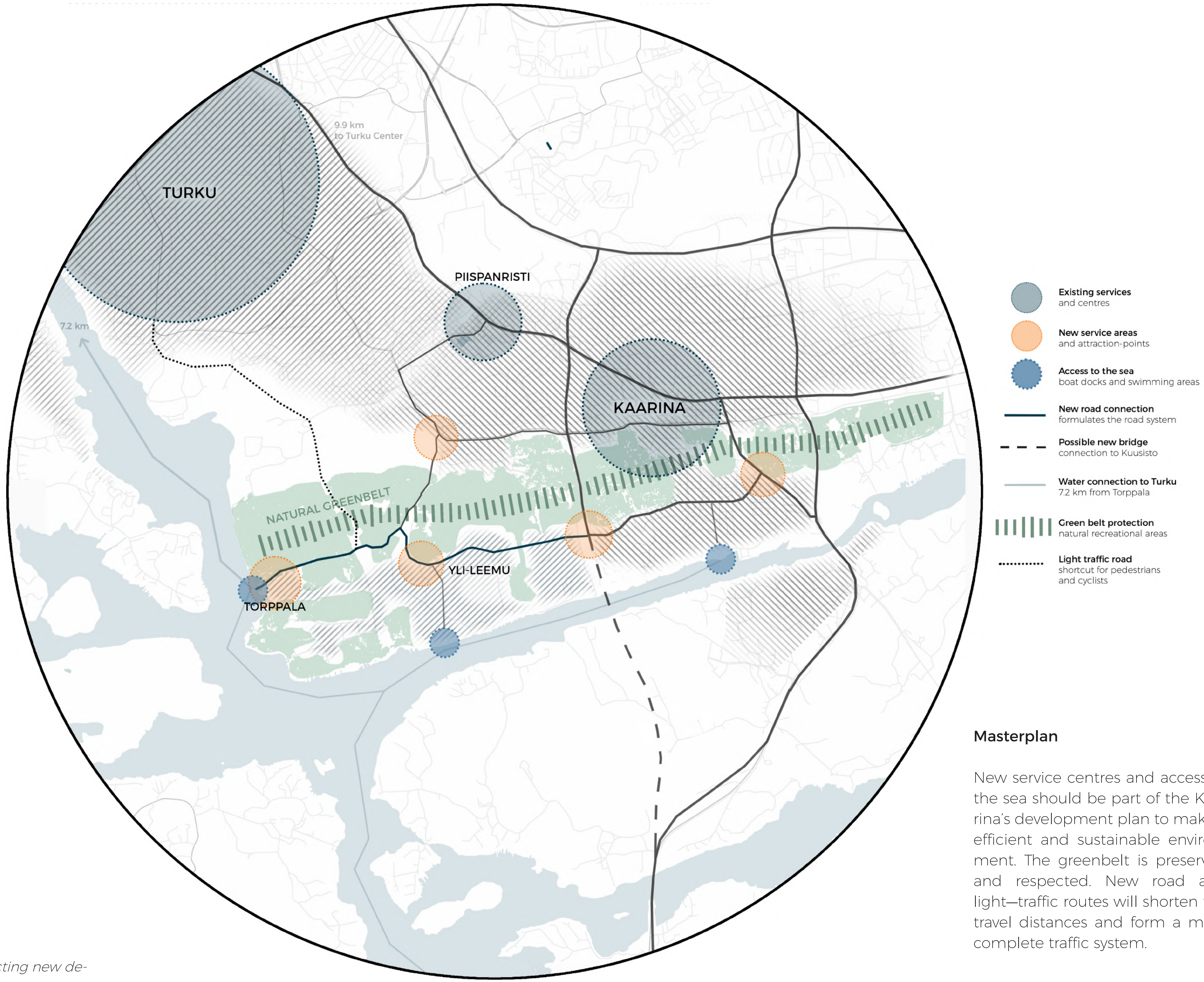
The graphical scheme of Kaarina's developments in the future gives a guide on how to connect new residential areas in the Kaarina region (see pages 20-21).

Pictures from the location, Torppala, Pictures of the author

Growth directions

Kaarin city has plans to grow towards the south by building new low-density living areas by the sea in the south. Directions to the sea and existing greenbelt directions are vital to preserving the natural values. The newly planned road will strengthen the infrastructure to Torppala.

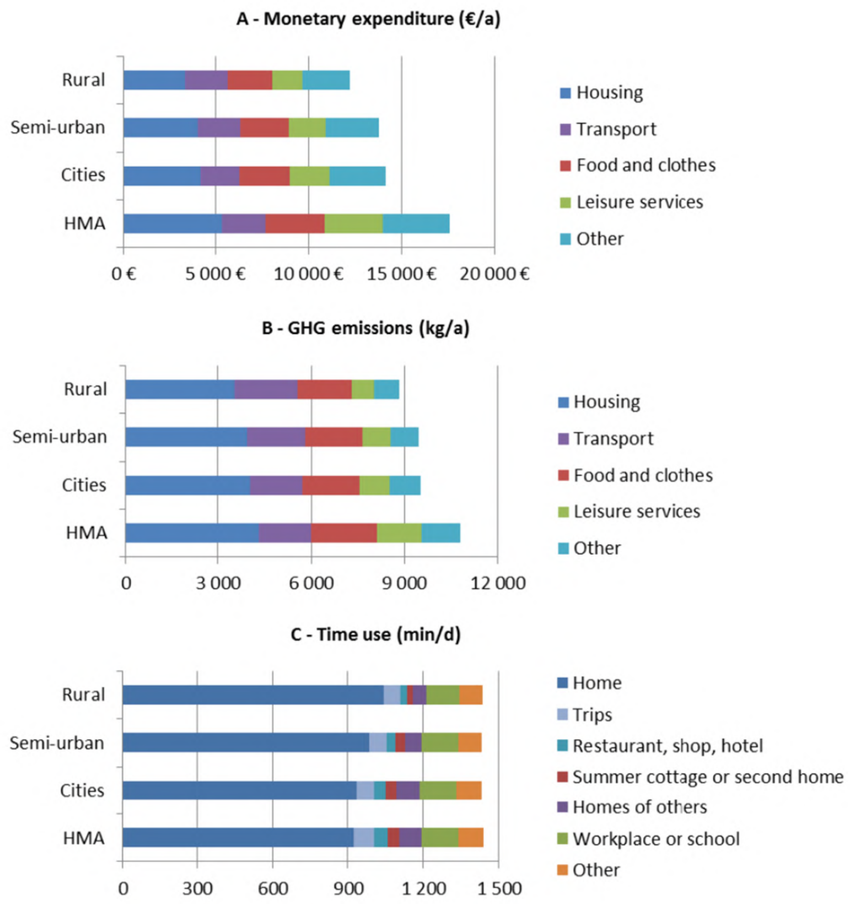
Graphical schemes showing the growth directions near Kaarina. Drawing of the author.



Masterplan

New service centres and access to the sea should be part of the Kaarina's development plan to make a efficient and sustainable environment. The greenbelt is preserved and respected. New road and light—traffic routes will shorten the travel distances and form a more complete traffic system.

The guide for connecting new developments to a working system. Drawing of the author



Differences in Monetary expenditure related to GHG emissions in Finland. (Heinonen, J., Jalas, M., Juntunen, J. K., Ala-Mantila, S., & Junnila, S. 2013)

Dense is better?

In the United States of America, cities like Minneapolis, Seattle, Portland and Los Angeles are reconsidering the rules and allowance of building single-family houses. Minneapolis is the first one who will ban the single-family zoning. The city planners have reached an understanding that single-family housing is not helping to make cities more easily commutable, walkable, bikeable and more transit friendly. The higher goal of creating such an uncommon rule is to fight segregation, create more affordable housing and reduce greenhouse gas emissions. (L.A. times 2018)

The idea behind living more densely in urban areas will cut down emissions related to commuting and transportation. However, the research done in Aalto University puts that goal for American cities under a question in the perspective of emissions. In a case study of Finland, the emissions per person were compared to family incomes and location. The results showed that in more urban areas the emissions on commuting reduced as expected. However, all expenses and emissions related to urban lifestyle rose significantly. Study showed that people in urban areas bought more clothes, spent more on food and restaurants and more on leisure activities. The difference in carbon footprint of a person living in the Helsinki metropolitan area (HMA) or a rural area differed by 18%, or 2 tonnes of CO_2e emissions, as seen on the Figure 9. (Heinonen, J., Jalas, M., Juntunen, J. K., Ala-Mantila, S., & Junnila, S. 2013) Professor Junnila's research applies so called tiered hybrid LCA method, where the data about the economic consumption is combined with the more accurate process LCA methods for higher accuracy in the most important emission sources.

That research gives a new perspective on suburban living in the context of Finland. It shows that through correct ways and methods, semi-urban living can contribute to sustainable life and help reach the low-emission life. It also shows that setting rules for suburban living must be country-specific. It can be said that urban lifestyles encourage consumption of products and services which does not support the one-tonne-life goal.

Single-family house areas near Kaarina Source: Google maps

Traditional single-family house areas

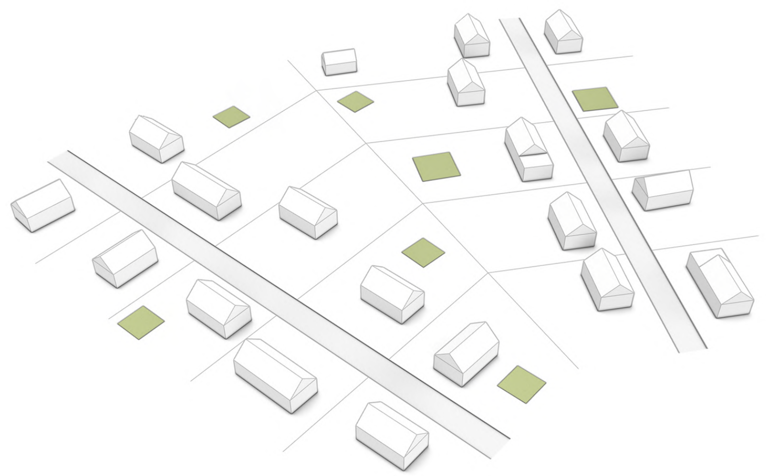
The popularity of flats is rising compared to previous years, since it is more affordable to many people, especially in urban areas where land prices are higher than in small cities. The share of families with children living in block of flats in Helsinki Metropolitan area was 57% in 2016. The same value for the rest of the country was only 20%. (Statistics Finland 2018) In 2017, according to Statistics Finland, 49,3 of the whole population lived in the detached houses (Statistics Finland 2018) and in 2005, 56% of Finns were interested living in a single-family detached house. (Juntto 2008) That shows that single-family housing is still popular and demand for it is probably not decreasing in the near future since the lifestyles of the people have not changed much.

Urban researchers Alexander Ståhle and Noah Raford launched a research project in 2015. During the research a poll was carried out between four thousand people. The poll asked people's preferences in the future development of Stockholm for 2050. Three types of photomontages were used to illustrate different scenarios: techno city, eco city and free city. They were put on a scale between low to high social control and low to high energy expenditure. The interviewees included Swedish urban developers, Norwegian architects, 300 Finnish urban developers among three and a half thousand people not related to city planning. The results showed that the most people preferred techno or eco city concepts. Only 12% of 3346 online readers of Dagens Nyheter newspaper preferred the free city. The free city marks the continuous increase of traffic and urban sprawl. (Ståhle 2016, 148)

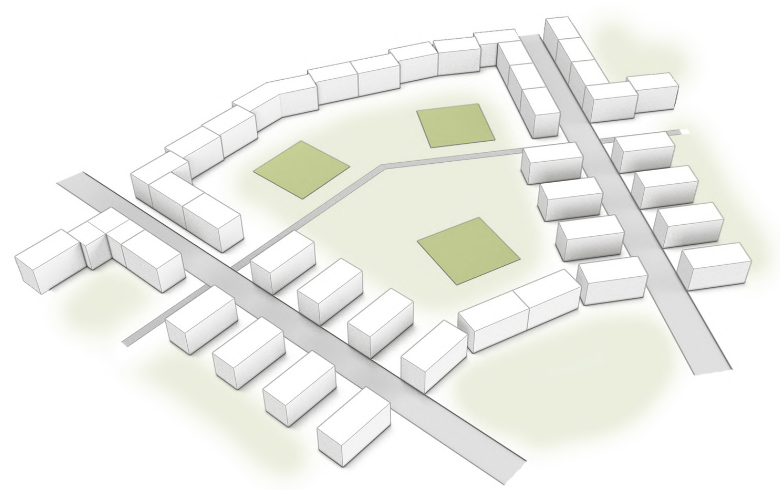
Single-family houses near Kaarina

Current single-family house areas near the Kaarina area have the traditional approach of the suburbs. The spatial concept is weak and greats a loose border between public and private space. Public space is formed usually by fenced or marked hedges to great a street space were cars, pedestrians and other transport must co-exist. Garden space that is defined as "private" is hidden behind the houses and is unseen from the street. The plots are divided equally around the street-grid. The houses themselves have pushed away from the street space towards the centre point of the plot and do not follow any specific building line. This kind of planning layout is very much car-oriented and does not great a space that supports a community that is aiming for better sustainable results. In the case of Torppala, the goal of a sustainable environment cannot be met with the traditional layout method.

Four basic planning elements can be used comparing the traditional single-family neighbourhood around Kaarina and a sustainable development: spatial concept, infrastructure, functionality and materials.



Traditional plot layout



Revised plan

Comparison of traditional and revised plan. Drawing of the author

Comparison

Spatial logic

Spatial logic is a fundamental aspect of a successful living environment. Traditional housing development starts with a street layout to make space for plots. Plots are then equipped with houses that are usually in the centre of the plot. Plots themselves are separated with fences or hedges, which marks a strong border between private and shared spaces. That kind of planning does not support a community aspect between inhabitants.

In the case of Torppala, the spatial concept makes more room for social and communal space between the buildings. The streets are narrower and shared between all means of transport. The border between public, semiprivate and private space is more defined that in a traditional area. Semi-private space forms between the buildings to support social life and safety. A space is formed where people can meet and interact and have a 'social vision' (see chapter 'Building a Community'). The open semi-private space and low-speed traffic creates a safe and vibrant environment for children to play in. No specific playground is marked like in the typical suburban living area, where kids must often play inside a fenced playground.

Semi-private courtyard in Torppala acts similarly to the semi-private front yards of denser and bigger cities. In the study of outdoor activities in Melbourne residential areas, the results showed that most activities were held in the semi-private front yards. (Gehl 2010, 83)

Infrastructure

The concept of the Garden City by Ebenezer Howard had a network of six towns around the central city linked by railways, canals and roads. It was a benevolent plan; however, the great plan has resulted in typical suburbs around the world, with the fate of overgrowth and displacement of public traffic systems by cars. (Abel 2017, 349) The infrastructure logic in a traditional housing development is city-like. In 1970s, a car invasion occurred more prominently, and people and cars were segregated into separate traffic systems. (Gehl 2010, 234) Cars, buses, light traffic and pedestrians follow the same system. Pedestrians might have their own walking trail to separate them from cars but still follow a strict (usually a grid) pattern to travel from one point to another.

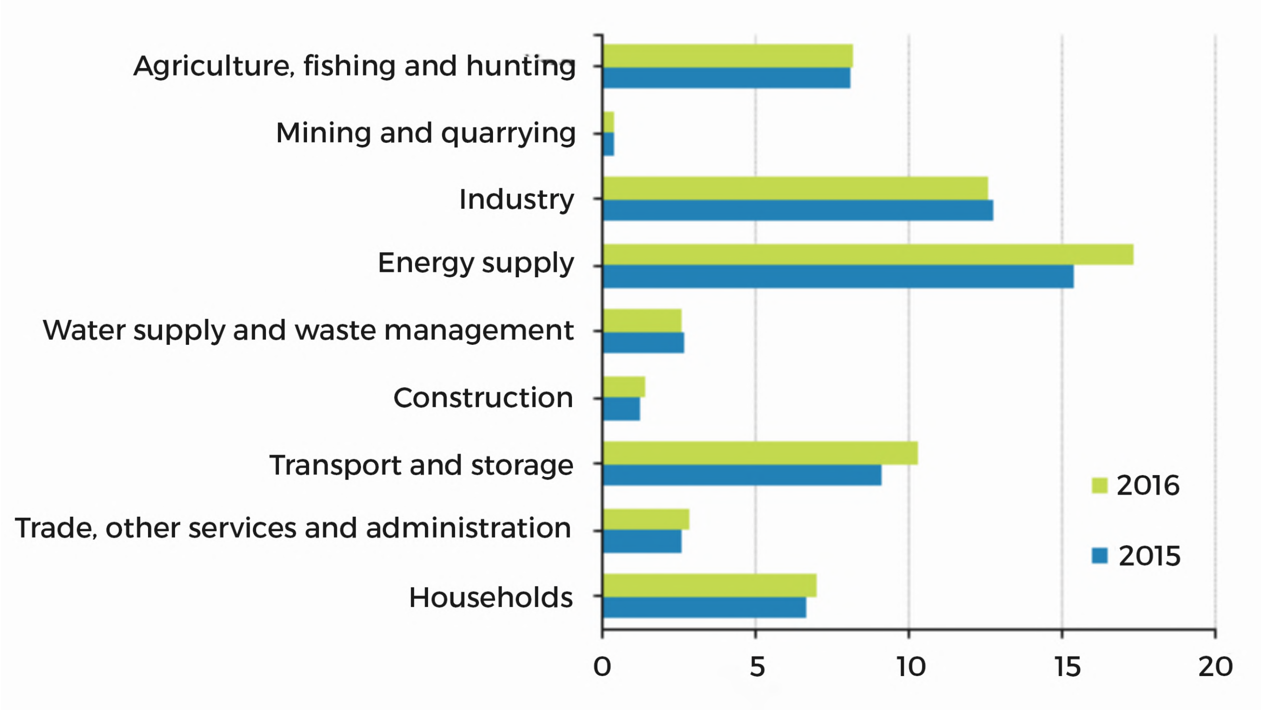
In Torppala's case, a more pedestrian friendly infrastructure is being implemented. According to Gehl, fast traffic creates lifeless environments. Traffic moves out of social vision fast and fewer people remain. Slow speed walking and biking creates more wealth of experience and interactions between people. (Gehl 2010, 71). The main access road in Torppala connects the area from the north were 4 shared low-speed streets are coming towards the centre of the development. Car traffic is solved in a way that circular traffic is not possible by motor-vehicles. The paths for pedestrians are dominant and connect more locations with shorter distances. The car parking is brought to a minimum and is planned on the northern edge of the development.

Functionality

Monofunctionality of traditional single-family housing creates more traffic and pendulum migration between services and homes. People often travel between schools, kindergartens, offices and shops by car. The possibility of having shared offices, kindergartens, services and a community centre in walking distance creates a more compact area. Sustainable urban planning suggests having main services nearby with functioning public transport. (Ministry of the Environment, Ministry of Agriculture and Forestry, Ministry of Employment and the Economy 2015, 29) Having main services nearby helps to create a more vibrant and active community.

Materials

Materials used to make a traditional development are often oil based, such as asphalt. Plots are covered with grass and lack a natural landscape environment. The impact on ground and landscape is immense during the construction phase of the area because of the positioning of the houses. The ground is damaged during the construction and later fixed with landscaping methods such as adding a new layer of soil for grass to grow.
In Torppala, the streets and paths are made with natural stone or gravel materials. The housing is closer to streets and built on pile foundations to minimize the impact on soil. The pile foundations will reduce the usage of concrete and leave a big part of the land under the house untouched.



Percentages of emissions by industries. Source: Statistics Finland 2018

Getting down to the One Tonne

According to Eurostat the average emissions caused by Finnish citizens were 11.1 tonnes of CO_2e per person a year in 2016. Compared to the record high of 15.7 tonnes of CO_2e in 2006 there has already been an improvement of 30%. Compared to its neighbouring states, Finland holds the 9th place in Europe ahead of Sweden (31st at 5.6 tonnes per capita) and behind Estonia (3rd at 15.0 tonnes per capita). The average CO_2 emissions equivalent per capita in the EU is 8.7 tonnes. (Eurostat 2018)

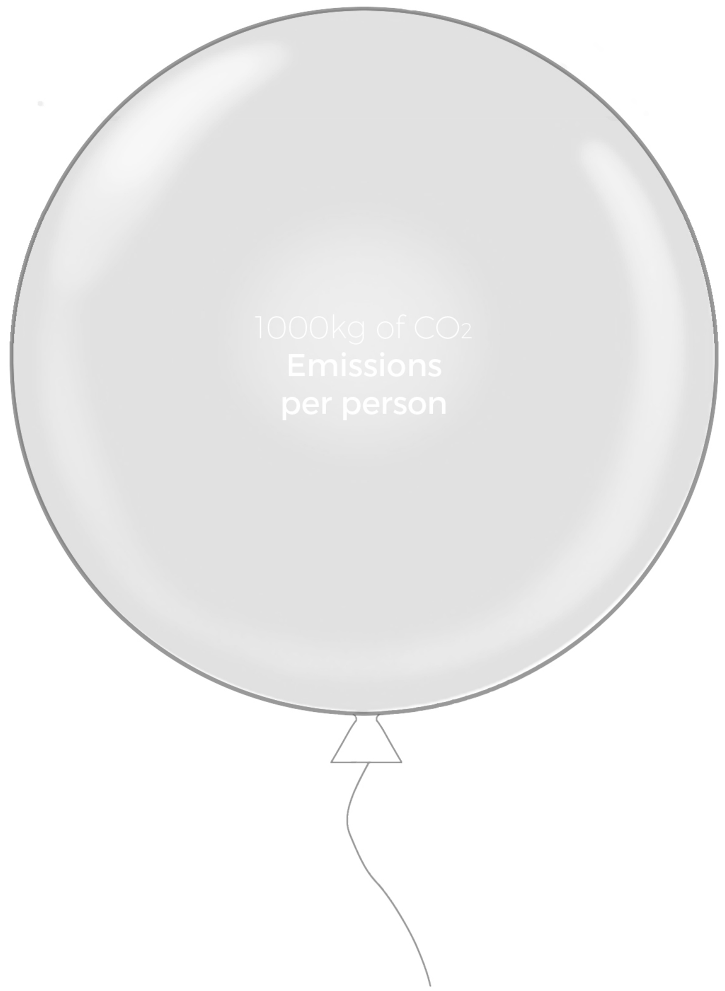
In 2016, the total emissions of CO_2e in the European Union were 4,440 million tonnes. If we compare the previous numbers by the share of total EU emissions, then Finland counts for 1.4%, Sweden 1.2%, and Estonia 0.4%. (Eurostat 2018) In the context of one-tonne-life, we must talk about CO_2e emissions per capita. For example, Germany is responsible for 21.1% of all EU emissions but the CO_2e figure per capita is almost the same as for Finland. (Eurostat 2018)

In 2016, according to Statistics Finland, the biggest contributors to greenhouse gas emissions were the energy supply chain and the industry. The next three major categories were households, transportation, and agriculture, accounting for 6-11% of the total of 62.7 million tonnes of GHG emissions. These categories have the biggest potential for cutting down CO_2 emissions. (Statistics Finland 2018)

Only through education and community actions can the greenhouse gas emissions be reduced. Although new technolgoies can help, without community acceptance most of these solutions will never be implemented. The future of humanity depends on the will of citizens to change their behaviours and to push others to do the same. In the long term, international policies might be useful, but might come too late. (Vasseur 2004, 594)

The lessons that can be learned from the Swedish experiment show that cutting emissions might have to result in having to reconsider the comfort zone people are used to today. Emissions cannot be reduced overnight in the whole society, but doing projects and setting goals like this could boost confidence in people that it is possible. Solely new technologies and methods will not result in a better number of emissions but raising awareness does.

Decades ago many regulations we have today were not affecting our lives yet. It might be that in future, we have to start setting rules and regulations on emissions per capita. The contribution to fight climate change must be a collective effort.



1 tonne of CO_2
1-tonne-life

Ballon of 1 tonne of CO_2 emissions. Drawing of the author

Building one tonne community

For a community that emits as little CO_2 as possible, the lifestyle changes it necessitates must be carefully investigated. The essential lesson from the one-tonne-life experiment in Sweden is to look over 'the rucksack' from building envelope, materials and energy consumption, as well as transport and diet to fit into a smaller emissions budget.

The one-tonne-life expects inhabitants of the community to be the role models. The one-tonne-life is voluntary and cannot be made mandatory to the residents. However, the goal of the project proposal is the create an environment where a person could live a sustainable life. One-tonne is an ultimate method to measure that a person does not contribute to climate change.

The main target for the one-tonne-life is to produce only 1 tonne of CO_2e emissions per person a year. Similarly to the One Tonne Life experiment carried out in Sweden, this thesis investigates four major categories of personal carbon footprint: housing, food, transportation and other. The categories are explained in more detail in the next chapters, in parallel to the calculations to achieve a one-tonne-life.

CO_2 budget and calculations

Due to the uncertainty and complexity of the processes behind global warming, it might be hard to understand it. To achieve a one-tonne-life, the inhabitants of the community must firstly understand the necessity of the budget set up for them and then carefully follow it. Compared to an average Finn, lifestyle must be drastically changed and the inhabitants are expected to adopt new travel, food and accommodation methods. The author uses one-tonne calculations as a tool to explore whether single-family housing and small apartment buildings are sustainable solutions for future developments.

The budget follows a principle of ecological simplicity. People pracitising ecological simplicity make as few demands for their environment as possible. Usually it means decreasing their consumption and making evironmentally responsible consumer choices. That does not mean living in a state of deprivation or technological simplicity, but more a voluntary rejection of the complexities of capitalist consumer-based lifestyle. (Shepard Krech III 2004, 378)

The budget is set to the residents in 4 major categories:

First, the main category is **housing** and related accommodation that includes energy usage for living, building materials, furniture and appliances.

The second category is related to **food** and diet.

The third category looks over emissions on **transport.**

The fourth category is **other**, that includes travelling, clothes, products.

The goals for the budget in each category are set by the author.

Housing

The rising population in Europe necessarily results in increasing demand for new living spaces. The number square meters of living space per person is rising. In 2017, the average dwelling size in Finland was 40.5 square meters per person. (Statistics Finland 2018) The number has grown from 31.4m^2 per person in 1990 and does not show any sign of decreasing soon. Meanwhile, the average household size has been decreasing. The EU's average is 2.3 people per household (Eurostat 2018) Similar to other Scandinavian and developed countries, Finland shows the trend of around 2 people per household; in 2017 the number was 2.01 for Finland. (Statistics Finland 2018)

People are expecting a higher quality of life and more space to live, at the time when emissions and consumption must be reduced. That makes the EU goal of reducing all emissions by more than 90% a challenging task for engineers, developers, urban planners and architects. The building sector is responsible for about 40% of environmental overload, mainly produced by developed countries in the European Union. (Nojana Petrovic 2019, 3548) The building sector needs to change its methods of traditional affordable housing in order to cope with climate change.

Key to sustainable and low-emission housing with today's technology is choosing the right building materials and building methods. Renewable materials will play significant role for reducing the emissions of a building. Concrete, steel and plastics have a big carbon footprint compared to timber. According to Norwegian EPD database, concrete cast on site and pre-fabricated concrete sandwich panels have correspondingly 3- and 2-times higher carbon footprints than CLT walls of 90kg of CO_2e emission per m3. A traditional timber-frame house could reduce that even by a half. (EPD Norge 2019) The same material from different manufacturers or locations could have a different EPD emission declaration.

Emissions from the entire life cycle of a building are not currently regulated in Finland. The Finnish Ministry of Environment has published a roadmap on how to implement the new regulation on the carbon footprint of buildings. The European Commission has launched a voluntary project on this subject. European Standard introduces calculation guidelines for energy use, EN 15978. The EU and country-specific rules on EPDs are not regulated, but the need for that exists and would result in better and more clear results on life cycle assessments of buildings. (Link 2015, 20) Compulsory regulation of the life cycle emissions of buildings or emissions of building materials has so far been introduced only in France, Belgium and the Netherlands. (BIONOVA 2017)

The Finnish Ministry of Environment has published a roadmap on how to implement the new regulations on the carbon footprint of buildings that will lead to mandatory regulation in the 2020s. Guidance would be piloted on a voluntary basis and in public sector projects before binding regulation come into force. Preparing the guidance system requires preparation and significant decisions in the coming years. (BIONOVA 2017)

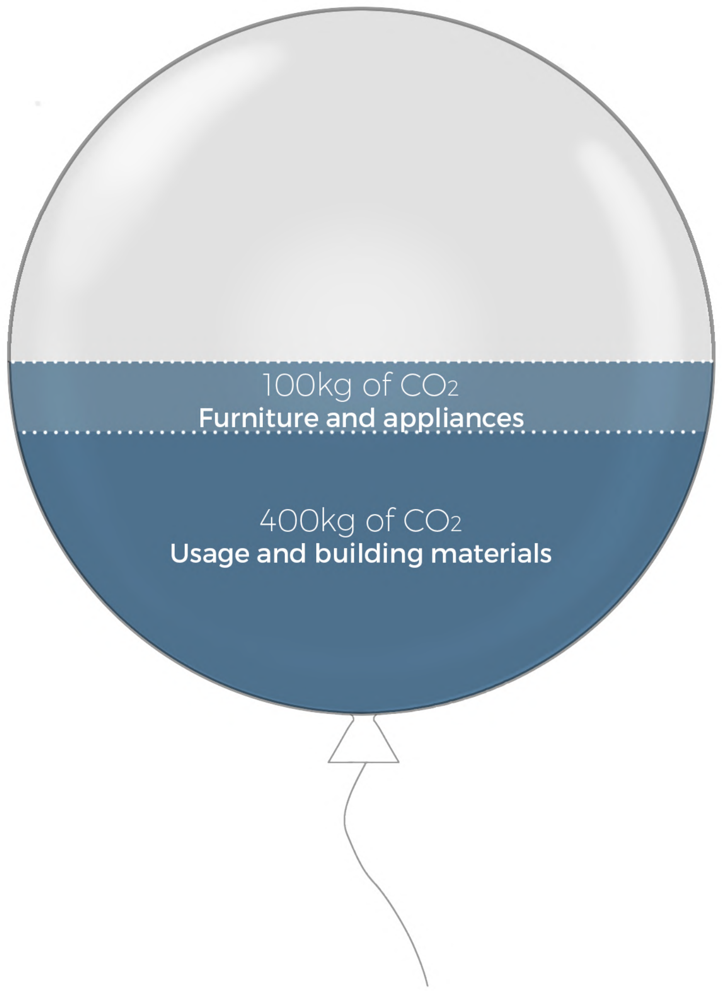
A seven-story apartment building built with CLT panels results in 30% less emissions than an equivalent building with concrete elements. (Link 2015, 82) On a smaller scale, a life cycle assessment for a typical 180m^2 single-family house in Sweden was done in 2019. (Nojana Petrovic 2019) The wooden frame building with traditional concrete foundation over the lifespan of 100 years resulted in about 39 tons of CO_2e. That makes it 2 kilograms of CO_2e per m^2/year. The biggest contributor in building elements was the concrete foundation, accounting for 34% of total emissions. The results also showed that a thermo-treated wood façade, gypsum, doors and windows had the highest rates of CO_2e per m2. Replacement of materials such as a wooden façade and windows over the total life span accounted for almost half of total emissions.

That shows that creating alternative foundation methods like building on piles, could decrease the amount of emissions. Also, the maintenance of a building has a significant impact on creating a low emission building. The study did not cover energy use and water consumption. Therefore, it is not relevant to compare it in the one-tonne life perspective, although it provides a guide to where the largest possibilities for reduction are.

The trend of evaluating the life-cycle of a building is getting more relevant in nordic countries with the EU regulations on energy performance of the buildings. (Nojana Petrovic 2019) The calculation of emissions from the building materials and the energy use gives us only a number. It can be reduced by changing main materials and the size of the building structure. That number does not give us any emissions per capita perspective, because the number usually is in thousands of kilograms. It does not show how much of the building's emissions contribute to the emission budget of a person. The carbon footprint of a building sould be divided between the number of users of the building. For example, building a public building for ten thousand users per year out of concrete and steel coul lead to the footprint of users to overshoot. If the number of users would be a hundred thousand then the impact would be 10 times smaller.

That same principle of calculation has to be implemented in single-family housing. The statistical trend of a smaller average household size shows that it is hard to fight emissions. The situation is going in the opposite direction compared to other industries in Finland. Emissions on housing are not being lowered due to more dwelling units and fewer people living together.

A family of four shares the emissions between inhabitants equally. Within years passed, the children will probably move out and will start living independently. That leads to the emissions on housing doubling for the parents. That results in the need of adaptable housing for converting areas, rooms or floors for a new purpose. The new or refurbished areas could be rented to other inhabitants. That helps to share the emissions load of the building between inhabitants equally.



Housing emissions
1-tonne-life

Budget on housing emissions. Drawing of the author

The Methodology

For an ecological and sustainable solution, the building techniques and solutions should be conservative and easily maintainable. (Ranta-Aho 2019) Carbon footprints of 3 different of construction types were calculated for a single-family building in Torppala.

The most relevant guidelines and principles for estimating the carbon footprint are the European standards EN15804 and EN15978. Standards on the sustainability of construction works describe the four stages the life cycle of a building and introduce calculation guidelines for energy use. The life cycle of a building consists of product stage, construction stage, use stage, end-of-life stage. (European Committee for Standardization 2013) (European Committee for Standardization 2011)

For the calculations for the emissions caused by building materials and housing, the author used an LCA tool created by Nicola Lolli. The LCA tool is based on the Norwegian database of EPDs. Since creating EPD for a building material is not mandatory, not all materials compared were in the Norwegian database. Therefore, the calculations of this paper do not only rely on the one resource; different resources are noted. The tool shows the results for GWP in phases A1-A3, material production, according to ISO EN 15804. The demolition phase is not included.

For load-bearing elements, 2 types of wall structures were selected. CLT panels and traditional wooden frame construction with insulation between elements. For a small single family house, 80mm CLT panels are enough to bare the load needed. Intermediate floors were chosen similarly to wall structures, CLT or a beam system.

Insulation wise, 3 different materials were selected: traditional mineral wool, low emission cellulose wool and polymer based polyisocyanurate (PIR). The targeted U-value for walls was 0,09 W/(m^2K). The U-values were selected to be more effiecient than the minimum requirements of Finnish building code.

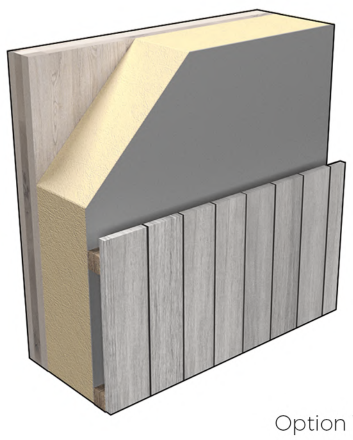
Facades, windows, doors and roof structure were not compared. For the facade a wooden cladding with a small carbon footprint was selected. Thermally processed wood lasts longer overtime and needs less maintenance but has a greater GWP compared to non-processed claddings. The facade's impact has been calculated with a factor of 3. That means over 50 years' time, the facade will be changed twice. Similarly to the facade material, the interior walls had a factor of 3 to be replaced or refurbished twice over 50 years time.

Pile foundation's quantities were used in the calculation of foundation emissions to reduce the share of it in the buildings total GWP. Traditional slab foundation can account for about 30% of total emissions of a single family house. (Nojana Petrovic 2019)

The results were retracted down to square meters per person to fit the budget set on housing emissions. Results show that on a small scale, the emissions on materials play an adequate role. The energy usage is vital since the electricity and heating carry a big load of emissions.

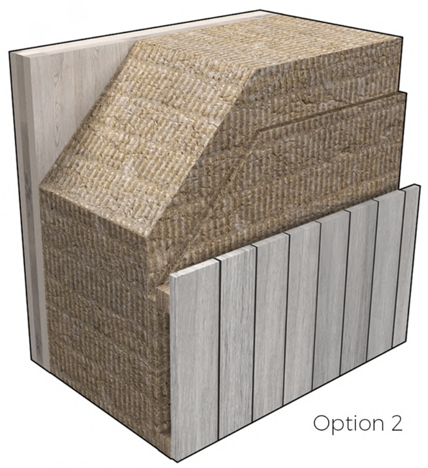
The results also show that the materials cannot be compared just by the building material environmental data (EPD), but the efficiency and the quantities of a building material must be compared. For example, the calculations done by comparing 3 different types of insulation materials show that traditional mineral will have a greater impact on the emissions of the building, compared to polyisocyanurate (PIR) insulation over the life span of the building, because of the almost double difference in quantity for achieving a similar thermal value for the exterior construction. The most effective insulation was the third option, cellulose wool.

The detailed results are presented in the appendicies at the end of the paper.



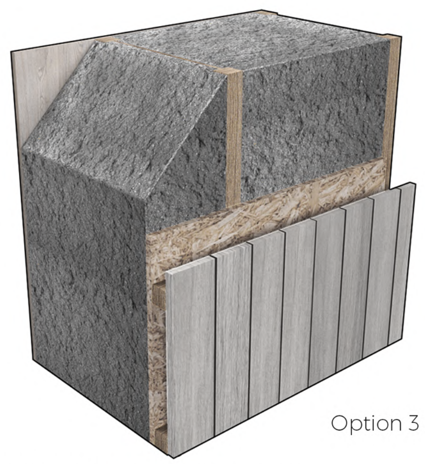
Option 1

CLT main structures
PIR insulation



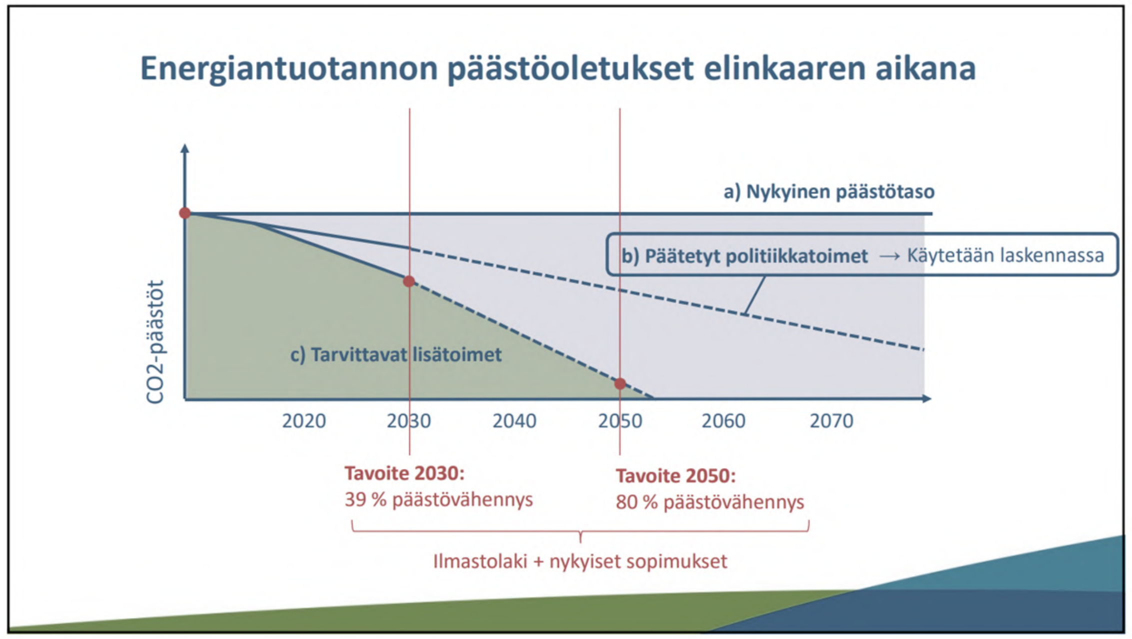
Option 2

CLT main structures
Mineral Wool insulation



Option 3

Wooden frame main structures
Cellulose Wool insulation



The expected decrease in grid electricity emissions (Kuittinen 2019)

LCA approach, $tCO_{2\text{-}eq}$/MWh – 2002 to 2013

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Austria	0.252	0.289	0.287	0.289	0.271	0.257	0.250	0.235	0.280	0.267	0.235	0.211
Belgium	0.315	0.327	0.321	0.338	0.310	0.313	0.300	0.299	0.298	0.263	0.265	0.239
Bulgaria	0.892	0.952	0.950	0.920	0.890	1.005	0.935	0.905	0.967	1.101	0.946	0.824
Croatia	0.419	0.455	0.340	0.318	0.310	0.376	0.314	0.270	0.238	0.257	0.240	0.228
Cyprus	0.981	1.075	1.004	1.011	0.982	0.981	0.966	0.952	0.886	0.891	0.906	0.817
Czech Republic	1.059	1.031	1.016	0.964	0.943	1.037	0.949	0.938	0.940	0.972	0.917	0.850
Denmark	0.588	0.753	0.562	0.457	0.693	0.562	0.497	0.523	0.549	0.405	0.301	0.380
Estonia	1.672	1.900	1.847	1.825	1.491	1.935	1.685	1.471	1.978	1.922	1.643	2.017
Finland	0.276	0.377	0.325	0.191	0.312	0.274	0.216	0.221	0.310	0.230	0.165	0.206
France	0.096	0.100	0.096	0.121	0.111	0.116	0.105	0.110	0.114	0.098	0.098	0.093
Germany	0.675	0.652	0.636	0.636	0.644	0.676	0.641	0.626	0.611	0.618	0.643	0.658
Greece	1.021	1.004	0.995	0.981	0.905	0.927	0.901	0.872	0.828	0.876	0.867	0.810
Hungary	0.554	0.593	0.529	0.481	0.455	0.506	0.487	0.411	0.431	0.389	0.388	0.297
Ireland	0.814	0.728	0.712	0.691	0.636	0.625	0.601	0.571	0.583	0.537	0.587	0.523
Italy	0.576	0.587	0.581	0.560	0.559	0.556	0.540	0.485	0.489	0.480	0.467	0.424
Latvia	0.120	0.116	0.100	0.090	0.107	0.093	0.109	0.107	0.194	0.160	0.115	0.183
Lithuania	0.208	0.197	0.196	0.214	0.170	0.161	0.149	0.178	0.276	0.166	0.172	0.128
Luxembourg	0.215	0.186	0.217	0.221	0.216	0.194	0.164	0.210	0.205	0.163	0.176	0.108
Malta	1.343	1.359	1.312	1.470	1.351	1.456	1.229	1.253	1.174	1.149	1.187	1.002
Netherlands	0.521	0.524	0.517	0.500	0.484	0.501	0.502	0.533	0.548	0.496	0.490	0.486
Poland	1.320	1.340	1.295	1.289	1.274	1.219	1.155	1.160	1.120	1.140	1.097	1.090
Portugal	0.652	0.512	0.527	0.589	0.495	0.434	0.427	0.452	0.333	0.388	0.423	0.368
Romania	0.834	0.937	0.812	0.796	0.846	0.864	0.839	0.762	0.652	0.760	0.702	0.532
Slovak Republic	0.310	0.373	0.319	0.327	0.308	0.273	0.266	0.266	0.270	0.269	0.279	0.241
Slovenia	0.505	0.461	0.449	0.441	0.443	0.453	0.461	0.499	0.476	0.462	0.444	0.424
Spain	0.567	0.503	0.517	0.535	0.500	0.524	0.456	0.416	0.336	0.403	0.429	0.343
Sweden	0.043	0.056	0.042	0.039	0.041	0.037	0.038	0.044	0.089	0.039	0.038	0.038
United-Kingdom	0.615	0.655	0.650	0.640	0.671	0.669	0.637	0.597	0.592	0.584	0.627	0.589
EU-28	0.527	0.532	0.517	0.513	0.514	0.523	0.494	0.475	0.467	0.469	0.468	0.444

Grid Electricity emissions in EU countries (Koffi, et al. 2017)

Other emissions related to housing

Other emissions related to housing include appliances and furniture used daily. The furniture and appliances have a lifespan similarly to the house itself. The greater the lifespan, the less emissions it accounts for in a yearly perspective. Energy emissions related to housing are mostly the emissions from electricity and energy use. The emissions for grid electricity in Finland were 164 grams of CO_2e per kWh. (Motiva 2018) That grid electricity factor was used in the calculations of a single-family house in Torppala. The Finnish Ministry of Environment proposes a calculation method which would apply a scenario considering the future emission factor of the grid electricity (Kuittinen 2019, 6) This means that the factor for grid electricity will be reducing every year from the level of 164 grams of CO_2e per kWh (see Figure 14)

The grid electricity emissions are expected to fall after new planned nuclear power plants will open. The grid electricity emissions in Sweden are approximately 5 times smaller and in Estonia approximately 10 times higher than in Finland, see Figure 15. (Koffi, et al. 2017) For this reason, it is much easier to reach the one-tonne goal in Sweden and nearly impossible in Estonia. Using photovoltaic panels in countries with high grid electricity emissions becomes obvious and necessary.

The photovoltaic panels have the life cycle emissions of 30-71 grams of CO_2e per Kwh depending on the type of panels used. (Ito 2011) In this thesis, the photovoltaic panels' emissions were not used to show the worst case scenario on electricity emissions. Also, not 100% of electricty produced with photovoltaics could be consumed without storing the energy. The possible emissions saving with the photovoltaic systems needs to be investageted more. The reduced emissions on housing by changing different components could result in having a bigger emission budget in other focused categories (food, transport, other). Also, good guality materials, high-quality construction, and examplary maintenance can boost the buildings' life time. For an age of 100 years, the emissions would be twice as low as for 50 years' life expectancy.

In the budget of housing, the impact of emissions of public buildings is included. The calculations are based on the example of a kindergarten built in Maardu, Estonia. The calculations follow the same principle mentioned before, sharing the emissions of a building between the users. 1112 m^2 kindergarten will occupy about 42 kg of CO_2e emissions of a 500 kg budget set for the housing. The emissions are calculated with effiecient lighting and with 30% of electricty produced with PV-panels. The detailed calculations are presented in the appendix.

Food emissions
1-tonne-life

Budget of Food emissions. Drawing of the author

Food

Our food choices have a great impact on our carbon footprint. 18% of all carbon emissions are caused by animal agriculture (Henning Steinfeld 2006). Research carried out by Worldwatch Institute calculates the same percentage as 50% of total emissions (Robert Goodland 2009). According to the research done in 2006 by the Food and Agriculture Organization of the United Nations (FAO), the global production of meat is projected to double from 229 million tonnes in 2000 to 465 million tonnes in 2050 due to growing population. The same figure for cow milk will grow from 580 to 1043 million tonnes. (FAO, 2006) Because of the fact that more and more people are born on our planet, the meat-dependent diet is not sustainable. (Henning Steinfeld 2006, 22) The water consumption for producing meat products is responsible for 30% of the world's water consumption (Andersen 2014).

Climate change is usually considered to be mostly related to fossil fuels, but that might be a misunderstanding. Animal agriculture is often overlooked and its impact is underestimated. The issue is not addressed enough by the major environmental groups in the world and the statistical data is not transparent enough. (Andersen 2014) That can be compared to problem with EPDs. The environmental data of a product, whether it is a building material or a burger, is neither mandatory nor regulated.

Data given on the Finnish eating habits by the Natural Resources Institute Finland (LUKE) shows that an average Finn consumed 160 kilograms of milk products, 81 kilograms of meat, 80 kilograms of grains, 65 kilograms of fruit and 64 kilograms of vegetables in 2017. (Natural Resources Institute Finland 2017)

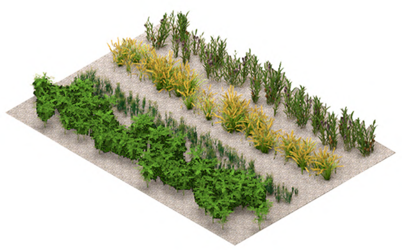
Using data given by the Finnish Environment Institute on the carbon footprint of food, the average carbon footprint calculated on Finnish food usage results in 1.2 tonnes of CO_2 emissions per person a year. (Marja Salo 2019) The data does not include eating in restaurants and bars, and beverages are left out as well.

Research made in Italy showed that the carbon footprint of vegetarian and vegan diets is 35-40% lower than that of omnivorous diet (Rosi, et al. 2017). Changing the diet and re-evaluating the proportions of different food types help to reduce the emissions from food. In addition to eating less meat and more vegetables, the Climate Guide Finland points out many other methods for reducing the carbon footprint of food. These include avoiding frozen food products, eating rationally and not more than needed, preferring locally grown produce to reduce transport load on food, buying seasonal vegetables at the appropriate time, planning trips to grocery stores mindfully, etc. (SYKE 2018)

For a one-tonne life, eating habits must be reconsidered but the change has to be even more drastic. The average consumption of vegetables is around 3 times higher for vegetarians and vegans than for omnivores (Rosi, et al. 2017).

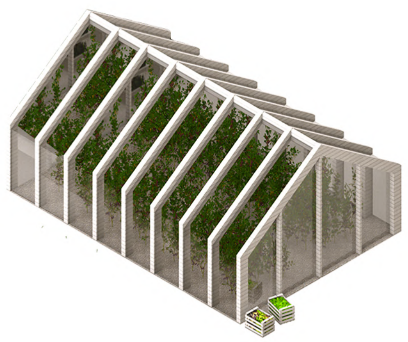
The estimated consumption of food in the one-tonne community are the author's assumptions. The results show that cutting meat and other animal-based foods to a minimum results in 77% to 83% difference in CO_2 emissions. These numbers take into account local food production with zero emissions.

Modern farming and greenhouse solutions help to grow more food more effiecntly in a smaller area of land. They help to reduce the water usage and bring down the travelling distance of food. Efficient greenhouse production can have a 10 times higher crop yield per square meter than a traditional open field production (Barbosa, et al. 2015). Vertical farming solutions can have a 20 times higher crop yield per square meter compared to conventional open field production (Luuk Graamans 2018). The aspects of energy use and emissions have to be carefully considered for finding a sustainable solution in Torppala.



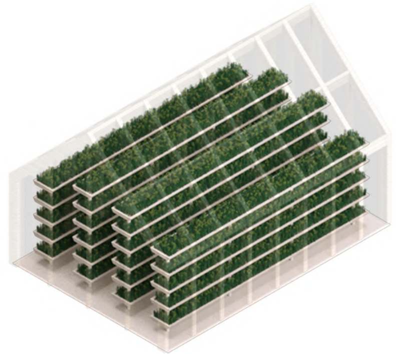
Open field

Crop yield 4kg per m²/year



Greenhouse

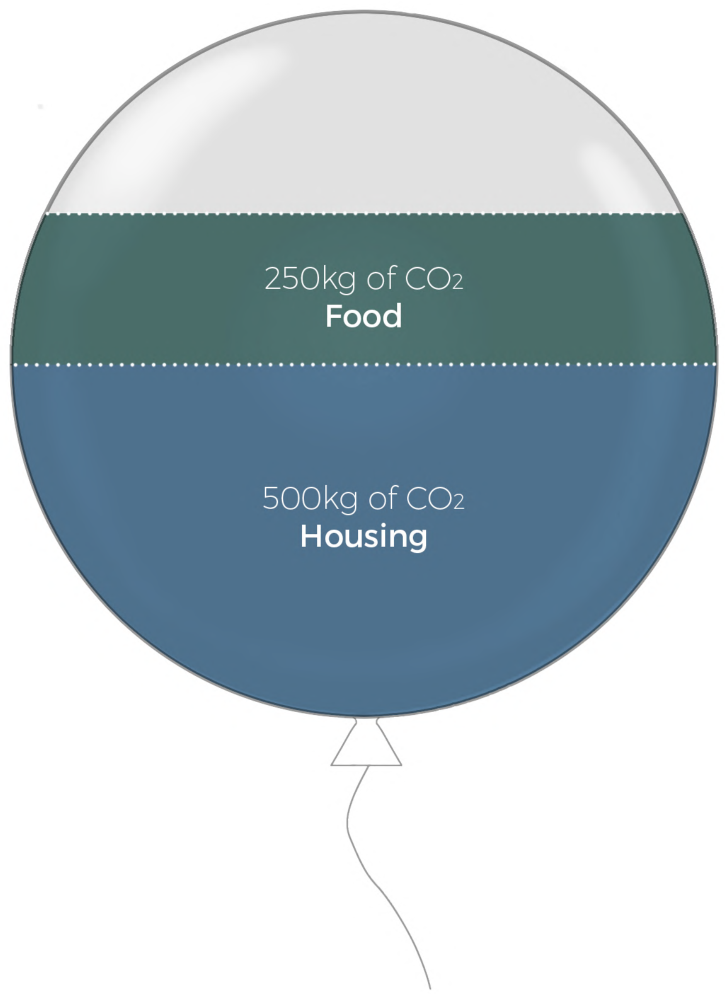
Crop yield 40kg per m²/year



Vertical farm

Crop yield 80kg per m²/year

Illustration of crop yield. Drawing of the author



Total of first two categories. Drawing of the author

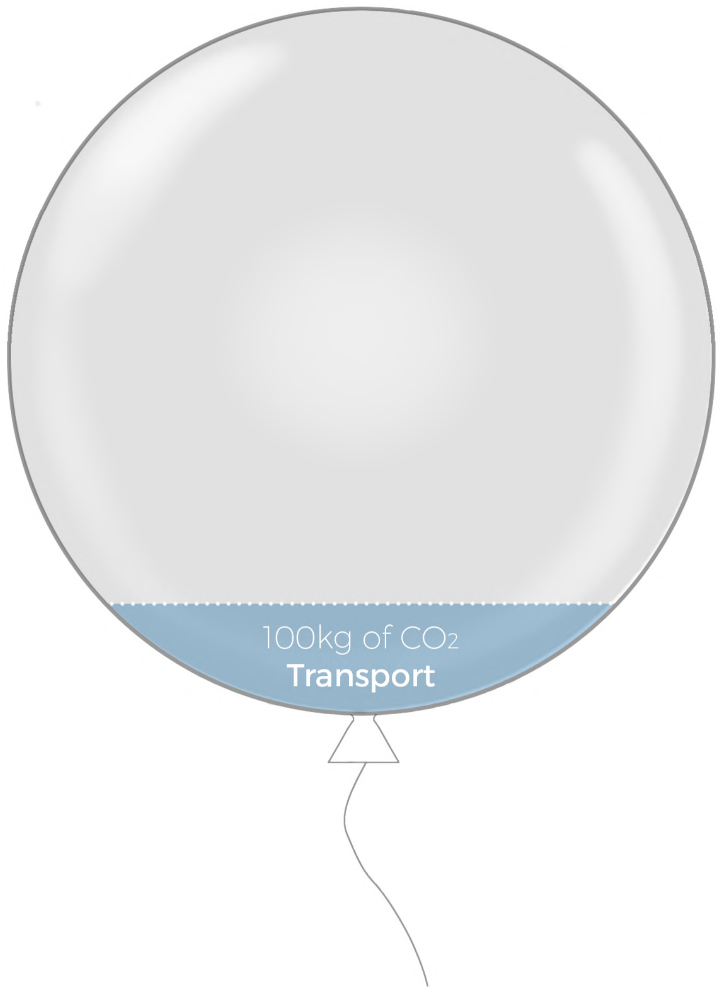
Finns in 2017				
	kgC02e/kg	Finns in 2017	Emissions	tCO2e/kg
Beef	15	19,40	291,00	0,291
Cheese	13	25,80	335,40	0,335
Pork	5	33,40	167,00	0,167
Tomato, cucumber (GH in winter)	5	11,60	58,00	0,058
Rice	5	6,00	30,00	0,030
Vegetable oil	3	5,20	15,60	0,016
Eggs	2,5	11,90	29,75	0,030
Fish	1,5	15,40	23,10	0,023
Rye bread	1,3	15,50	20,15	0,020
Sugar	1,1	30,60	33,66	0,034
Dried beans	0,7		0	0,000
Wheat	0,5	44,50	22,25	0,022
Milk	2,5	65,00	162,5	0,163
Berries, vegetables, potatoes	0,2	52,20	10,44	0,010
Total		**336,50**	**1198,85**	**1,199**

Ilmasto Dieeti, 2019
Luke, 2019

The two different one-tonne diets show that the emissions on food can be cut down drastically and could fit into 250kg of CO_2 emissions per person a year. However, further research and development on diets must be considered as the calculations do not consider different specifics of protein, fat, carbohydrates, vitamins and minerals. Educating people to make small changes in their dietary behaviour could be a key action towards this common goal.

Very low meat diet				
	kgC02e/kg	Finns in Torppala	Emissions	tCO2e/kg
Beef	15	2,00	30,00	0,03
Cheese	13	4,00	52,00	0,05
Pork	5	2,00	10,00	0,01
Tomato, cucumber (GH in winter)	5	0,00	0,00	0,00
Rice	5	6,00	30,00	0,03
Vegetable oil	3	5,20	15,60	0,02
Eggs	2,5	5,00	12,50	0,01
Fish	1,5	2,00	3,00	0,00
Rye bread	1,3	18,00	23,40	0,02
Sugar	1,1	5,00	5,50	0,01
Dried beans	0,7	10,00	7,00	0,01
Wheat	0,5	60,00	30	0,030
Milk	2,5	10,00	25	0,025
Berries, vegetables, potatoes	0,2	180,00	36,00	0,04
Total		**309,20**	**280**	**0,280**

Vegans				
	kgC02e/kg	Finns in Torppala	Emissions	tCO2e/kg
Beef	15	0,00	0,00	0,00
Cheese	13	0,00	0,00	0,00
Pork	5	0,00	0,00	0,00
Tomato, cucumber (GH in winter)	5	0,00	0,00	0,00
Rice	5	10,00	50,00	0,05
Vegetable oil	3	8,00	24,00	0,02
Eggs	2,5	0,00	0,00	0,00
Fish	1,5	0,00	0,00	0,00
Rye bread	1,3	18,00	23,40	0,02
Sugar	1,1	5,00	5,50	0,01
Dried beans	0,7	20,00	14,00	0,01
Wheat	0,5	60,00	30	0,030
Milk	2,5	0,00	0	0,000
Berries, vegetables, potatoes	0,2	240,00	48,00	0,05
Total		**361,00**	**194,90**	**0,195**



Transport emissons
1-tonne-life

Budget for transportation emissions. Drawing of the author

Transportation

As the transportation sector in Finland is one of the biggest contributors of CO_2 emissions, the sector is under many state developments and plans. In 2016, transportation was responsible for 10.3 million tonnes, or 16% of all CO_2 emissions in Finland. (Traficom 2017) There were about 4 million automobiles registered in Finland in 2018, with average emissions of 157 grams of CO_2 per kilometre. (Likkene fakta 2019) That makes car transportation one of the most popular methods of getting around in Finland.

One of the long-term objectives of the National Energy and Climate Strategy is to make Finland's entire transport system extremely low-emission. By 2030, the goal is to reduce traffic emissions by about 50% compared to levels in 2005. The reduction of emissions from road traffic will be particularly targeted, since it holds the greatest potential for reduction. (Finnish Transport Agency 2016, 40)

For the one-tonne community, needs and rules must set for achieving the minimum emissions from transport caused by a person. Relying on data from LIPASTO, the calculation system for traffic exhaust emissions and energy use in Finland developed by VTT, the best suitable transportation method connecting Torppala to Kaarina and Turku is under review. The budget for transportation of a one-tonne 'diet' is 100kg of CO_2e emissions per person. (Lipasto 2018)
In Copenhagen, cyclists save about 90,000 tonnes of CO_2 emissions a year. In the case of the one-tonne life it accounts for a population of 90,000 inhabitants, double the population of Kaarina after 2035. Cycling will take a person three times further than walking at the same rate of energy expenditure. A car consumes 60 times more energy than a bicycle and 20 times more than walking. (Gehl 2010, 104-105)

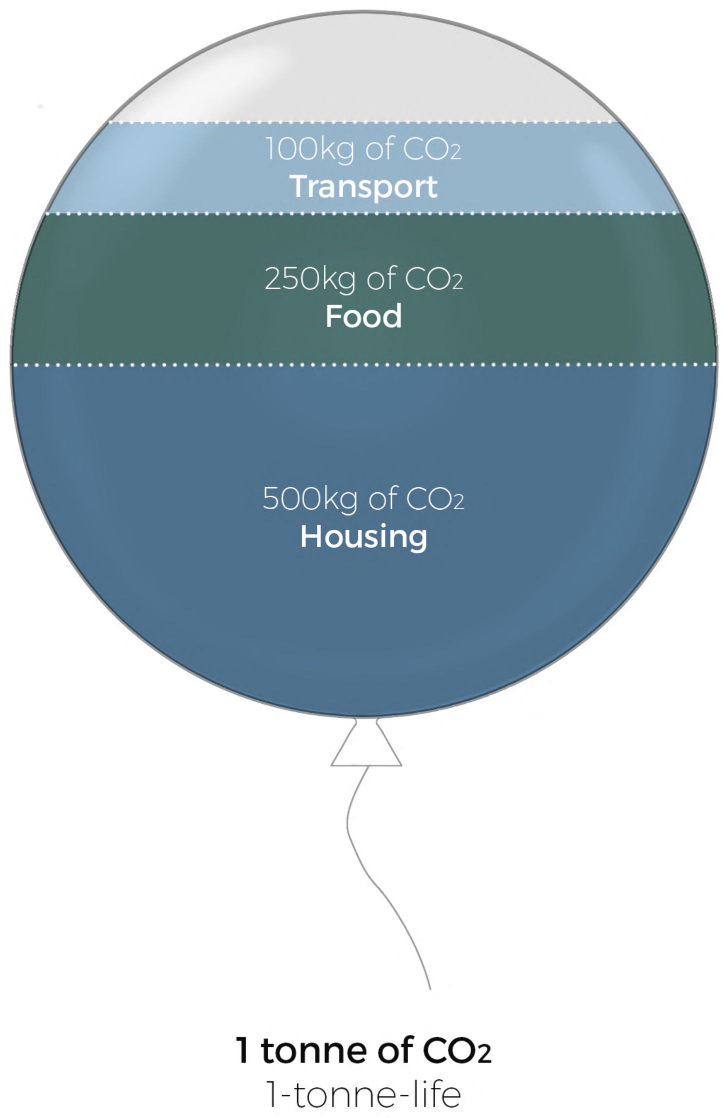
The main options for connecting Torppala are private cars and public transport by bus, and a great potential lies in connecting to Turku by sea. The table below illustrates the main methods along with their emissions caused and measured by the distance. LIPASTO calculation system claims zero carbon emissions by electric vehicles, but since there is a high probability that they will be charged from the public electric grid, the resulting value of $C0_2$ emissions comes from grid electricity on 1 kWh of energy. (Motiva 2018)

An electric bus with an average of 18 passengers has about 4 times less emissions per passenger per kilometre. The electric car emits 10 times less emissions than a typical petrol car. (Lipasto 2018) The electricity consumption of the electric boat in the calculation relies on the same value as the bus because of the lack of information on electric boats.

The one-tonne life sets a huge limitation on air transportation as it is the most unsustainable method of transport, with 45kg equalling to 110km of flight distance. A simple round trip to Rome results in around 1.3 tonnes of CO_2 emissions per passenger.

In Torppala the electric cars will be shared with an intelligent demand-based system. Private cars cannot be forbidden for the inhabitants, but they would not have a positive result for the one-tonne goal.

Example methods of transpor. Drawing of the author



Budget total of first three categories. Drawing of the author

The three most effective low-emission options were selected for connecting Torppala to Kaarina or to Turku. The calculations are based on travel distance to Turku. The calculations expected people to have 4 round trips to Turku per week in a year. Sharing the travel equally between bus, boat or a shared car system results in the average emissions for travel in Torppala to be below 100kg per person a year. 55kg of CO_2e emissions leave an additional 45kg of CO_2e emissions for longer travel. 45kg equals to about 700km on a long-haul bus or 400km train travel in Finland (Ilmasto Laskuri 2018).

The budget on transportation can be reduced and saved up further for long-distance traveling by bicycle use.

Transportation type	kWh/pkm**	gCO2e/pkm	Distance	Emissions	Trips*	Emissions tC02e per year
Electric Bus (18 passengers)	**0,078**	**12,8**	**9,9**	**126,6**	**416**	**0,05**
Bus Diesel (18 passengers)	-	55	9,9	544,5	416	0,23
Bus Gas (18 passengers)	-	43	9,9	425,7	416	0,18
Boat (gas)	-	99	7,2	712,8	416	0,30
Boat (electric)	**0,078**	**12,8**	**7,2**	**92,1**	**416**	**0,04**
Petrol car	-	183,0	9,9	1811,7	416	0,75
Electric car	**0,11**	**18,0**	**9,9**	**178,6**	**416**	**0,07**
Motorcycle	-	68	9,9	673,2	416	0,28
Bicycle	**-**	**-**	**8**	**0,0**	**416**	**0,00**

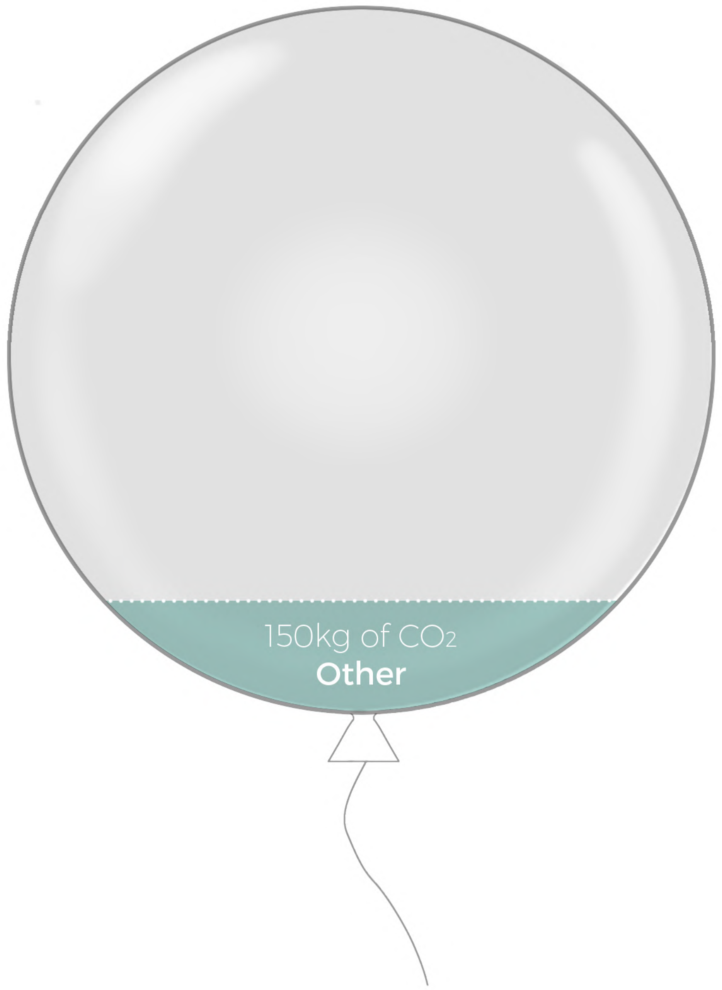
*Trips: Average 2 trips per day 4 times a week

**Electricty emissions 164 gCO2/kWh (Motiva, 2018)

Sources:

Lipasto 2018

Transportation type	kWh/pkm*	gCO2/pkm	Distance	Emissions	Trips*	Emissions tC02 per year
Electric Bus (18 passengers)	0,078	12,8	9,9	126,6	139	0,018
Boat (electric)	0,078	12,8	7,2	92,1	139	0,013
Electric car	0,11	18,0	9,9	178,6	139	0,025
Bicycle	0	0,0	8	0,0	57	0,000
Total:						**0,055**



Other emissions
1-tonne-life

Budget of the Other category. Drawing of the author

Other Emissions

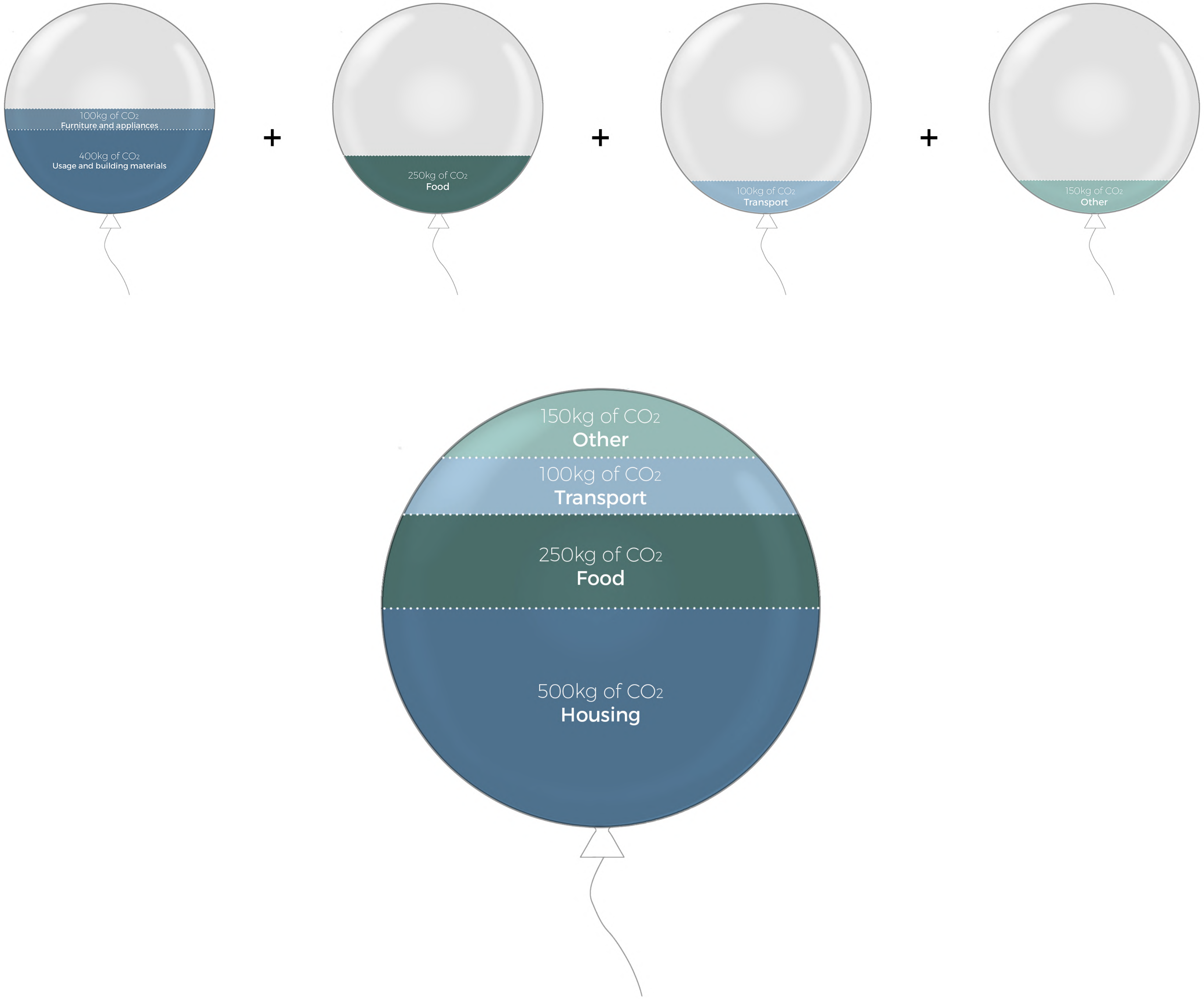
All our consumption decisions and habits have an impact on our carbon footprint. The clothes we wear, the computers and smartphones, services we use – all have an impact on our environment. Emissions of leisure activities and services must be reduced by 90% to follow the 1.5°C pathway (Lettenmeier, et al. 2019). This category of emissions is probably the most challenging to reduce, since it is related to leisure, shopping, consuming and consumption – the very basics of capitalism. Clothes, outdoor gear and miscellaneous products and services have around 240 kg of CO_2e emissions per person (Lettenmeier, et al. 2019). That could be reduced with recycling and the usage of second-hand clothes, as well as wearing clothes for more than 2 years, which is the average lifetime of clothing. Social and education services cannot be reduced without the state directed reduction of emissions. That is why the details of emissions on services will not be evaluated in this thesis.

The overall budget for "Other" category is 150 kg of CO_2e per person a year.

Other					
Category	**gCO2e/piece**	**Age**	**tCO2e/year**	**User factor**	**tCO2e/year**
Mobile phone	58500	5	0,012	1	0,0117
Laptop	155600	5	0,031	2	0,0156
LED TV	208000	10	0,021	4	0,0052
Total:					**0,0325**
Furniture					
Furniture	**gCO2e/piece**	**Age**	**tCO2e/year**	**User factor**	**tCO2e/year**
Wooden chair	3000	20	0,0002	6	0,0009
Table	34000	20	0,0017	1	0,0017
Bed	34000	15	0,0023	2	0,0045
Total:					**0,0071**

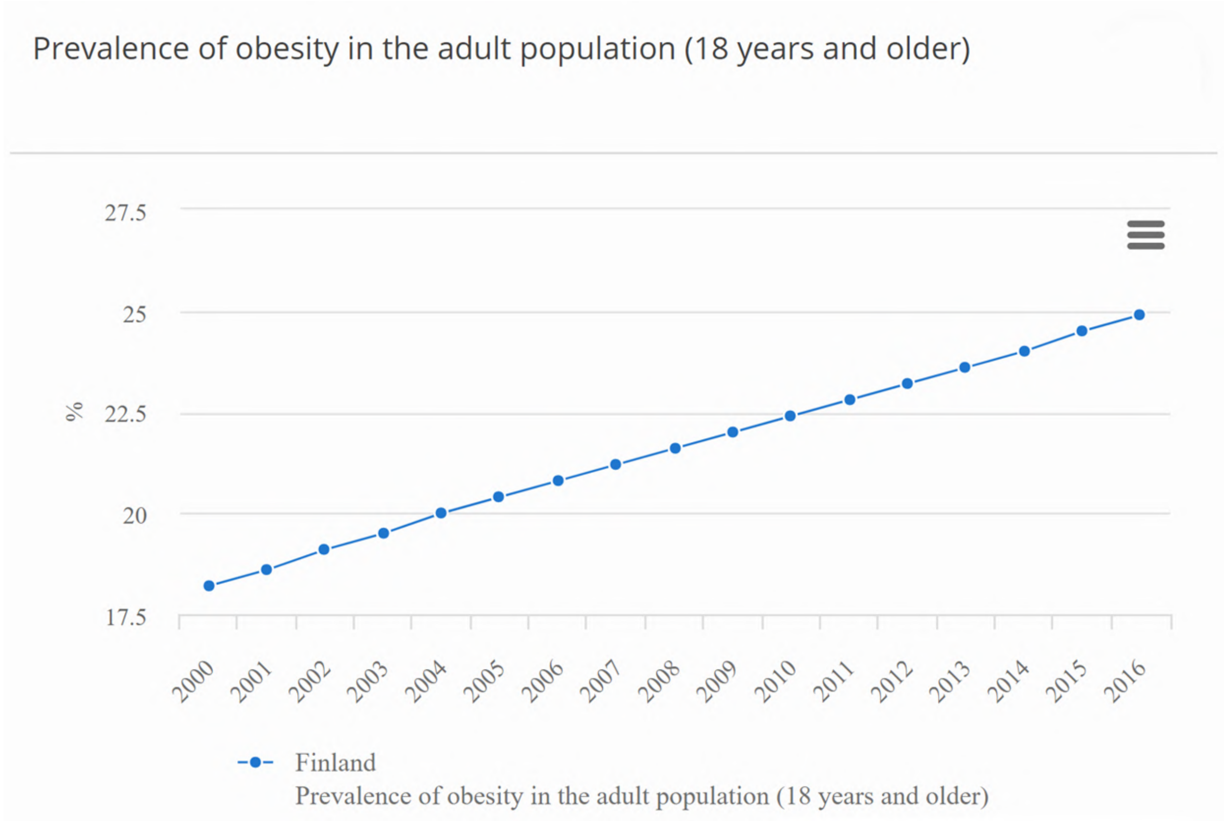
Ilmasto Laskuri, 2019

http://www.ilmastolaskuri.fi/en/calculation-basis?country=1320&year=10746



1 tonne of CO_2
1-tonne-life

The whole budget. Drawing of the author.



Prevalence of obesity in the adult population (18 years and older) Source: FAOSTAT, May 19, 2019

Building a Community

City planner Jan Gehl has investigated many cities in the context of human dimensions, scale, liveliness, people's behaviour, good cities for walking, etc. He has examined the morphology and use of public space very deeply.

An important aspect of a strong community is social connection between people. How much they could interact, meet and share conversations between themselves. A social field of vision could be one aspect of measuring a living environment's quality. A person can be recognized at the distance between 50 and 70 meters by body language and hair colour, for example. At the distance of 25 meters, people's facial expressions and emotions could be detected. For communication, around 60 meters is the limit when shouts for help can be heard. The distance of 35 meters is suitable for one-way communication and at around 25m short messages can be shared. For a regular conversation, a distance of 7 meters is required. (Gehl 2010, 35)

The inner courtyards in Torppala have the social field of vison taken into account. No distance between buildings inside the block easily reaches over 100 meters, which is considered the maximum of social vision. The 25 meter communication range reaches the shared gardening part of the inner-courtyard. That kind of dimension also encourages the safety of the area. According to studies on Danish housing areas, the developments with 2 story townhouses have more street life and socializing between households than taller buildings. (Gehl 2010, 68)

Healthy community

The past 20 years of technological evolution has had a significant lifestyle change in people's lives. More people are car-dependant, spend a lot of time behind screens and eating whenever and whatever. That has resulted in fewer physical activities and less time spent outdoors. Even just these two factors have an important role in the public health of society. Increased obesity rates are a problem in the whole world with an increasing trend. All That results in a decreasing quality of life, a rise in healthcare related costs and a shorter lifespan. (Gehl 2010, 111)

The obesity of adult population in Finland has risen from 18% in 2000 to 25% in 2016. Many people are spending money on memberships in fitness centres, looking for improvement in their quality of life. The reasonably short walking distances and a great light-traffic network encourage people to take the exercise as a natural part of their daily life. The perspective light-traffic routes to Turku and Kaarina would account for approximately 30 minutes of moderate intensity exercise.

Kokkuvõte

Teoreetilise osa peamine eesmärk oli testida ühe-tonni-elu elujõulisust Torppalas. Võib teha järelduse, et ühiskond peab ümber hindama oma prioriteedid ja väärtused. Ühel elamispinnal elavate inimeste arv on terves Euroopas vähenemas. Seda numbrit tuleb kergitada, et elada jätkusuutlikku elu. Tulevikus ehitatavad üheperеelamud peavad olema muudetavad vastavalt hoone eluea jooksul muutuvate elanike vajadustega. Olenevalt kasutatavatest materjalidest, arvutatud eluruumipind ühe inimese kohta jäi Torppalas 30 m^2 ligi. Arvestada tuleb võimalikke ebatäpsustega ühe tonni arvutustes, mis tulenevad elukaare jooksul vähenevatest elektrienergia emissionidest. Elektrienergia emissioonide vähenemine toob endaga kaasa ehitusmaterjalide ja kõigi muude toodete tootmisel tekkivate emissioonide vähenemise.

Taastuvate ehitusmaterjalide kasutamine elamu ehituses vähendab inimese personaalset süsiniku jalajälge. Siiski, ainuüksi lihtsate ja keskkonnasõbralike materjalide kasutamine ei taga jätkusuutlikku eluviisi. Tuleviku madal-tihedates asulates peab olema võimalus kohalikult toitu kasvatada, et vähendada toidu süsiniku jalajälge. Kliimamuutustega võitlemisel muutuvad inimeste igapäevased harjumused.

Torppala ühe-tonni-elu kontseptsioon on mõeldud vabatahtlikus vormis. Seal elamine ei sea elanikele mingisuguseid reegleid ega eeskirju, kuigi eeldab, et elanikud ei nõustu tarbismisühiskonna kommete ja ületarbimisega. Õigete meetodite, suhtumise ja teadmistega on ühe tonni emissioonide saavutamine võimalik ilma, et elukvaliteet langeks. Inimkonda ootab ees suur katsumus säilitamaks planeedi Maa elamiskõlbulikkus tulevasteks sajanditeks. Jätkusuutliku tuleviku probleemi keerukus ja suurus toovad endaga kaasa sotsiaalsed ja majanduslikud muutused.

Ainuüksi jätkusuutlike ehitusmeetodite kasutamine ei ole piisav meede kliimamuutustega võitlemiseks. Ühe tonni eluks peab kõik elustiili aspektid kriitilise pilguga üle vaatama ja neid drastiliselt muutma, alates rõivastest, mööblist ja kodutarvetest kuni toidu, toitumise ja transpordivahenditeni, alates materjalidest, mida esemete tootmiseks kasutatakse kuni kus neid toodetakse ja kui kaugele toode peab rändama, et oma tarbijani jõuda. Muutuste vältimine ja tahe jätkata vanaviisi on inimloomuses.

Võib tulla aeg, mil me ei saa enam eirata vajadust oma eluviise planeedi ja keskkonna nõudmistele adapteerida selleks, et ellu jääda. See aeg võib tulla varem, kui me tahaks leppida. Samal ajal, käesolevas töös välja pakutud kogukonna eesmärk on ühtlasi luua eluviisimuutusi, mis oleksid märgatavalt positiivsed. Üheks selle projekti eesmärgiks on õhutada kogukondlikkust, kus elanikud elavad ühises ruumis koos ja tajuvad oma võimet ning ühtekuuluvust. Tunne olla osa millestki kasulikust ning väärtuslikust sisendaks ka vastutustunnet ja suutelisust – kui iga inimene arvab, et ühe inimese teod ei saa midagi muuta, siis kokkuvõttes ei saagi midagi muutuda. Kaasav ja julgustav kogukond võib aidata jõuda järeldusele, et igaüks meist loeb.

Conclusion

The main aim of the theoretical part was to test one-tonne-life viability in Torppala. The conculsion for the question is that society needs to examine its priorities and values. The rising number of area occupied per person in a dwelling unit has been growing in all Europe. We must raise it to be able to live a sustainable life. The single-family-houses built in the future need to be more adaptable for different types of users over the building's lifetime. The calculated floorspace per person in Torppala was calculated to be around 30 m^2, depending on building materials chosen. The possible uncertainties in the calculations of LCA have to be considered which derive from the future reduction of electricity emissions. According to this, the emissions of building materials and all other products will see a reduction in carbon footprints.

The use of renewable building materias will lower the share of housing emissions in personal carbon footprint. Although, just using simple and ecological building materials would not result in sustainable lifestyle. The future low-density settlements must have local food production to reduce the food's emissions from air travel. The every day habits will change during the fight for better climate.

The one-tonne-life concept in Torppala is voluntary. It does not set any rules or regulations on the inhabitants, although it expects the inhabitants to disapprove consumerism and over-consumption. With right methods, attitude and knowledge, the one-tonne goal can be achieved without lowering the quality of life. The mankind is facing a great challenge to keep the Earth livable for coming centuries. The complexity and the size of the problem for sustainable future will bring social and economical changes.

Solely building a sustainable house and using sustainable building materials is not enough to combat climate change. For a One Tonne Life, every aspect of lifestyle must be put under scrutiny and undergo drastic changes, from clothes, furniture and household items to food and diets and methods of transportation, from the materials used to produce items to where they are produced and the distances they have to travel to reach their consumer. Dreading change and wanting to stick to what one is used to is inherent in human nature.

There might come a time when the urgency to adapt our ways of life to new demands of our planet and environment in order to survive can no longer be ignored, and that time might arrive sooner than we would like to accept. However, the community proposed in this work aims to bring about perceivably positive changes to our lifestyle. Another purpose of this project is to encourage a sense of community where residents coinhabit their space with a sense of agency and belonging. The feeling of being part of something beneficial and worthwhile would also instill a sense of responsibility and capability – when every person thinks that one person's actions do not make a difference, then altogether nothing could possibly change. A community of inclusion and encouragement could make people realise that each one of us counts.

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Project proposal

The site analysis

The site of 10 hectares is situated between the hilly forest site next to the Baltic Sea. The climate is humid continental climate with modest summers and cold winters. Average yearly precipitation is 720mm a year in Turku region. The climate in Torppala is rather soft compared to the average climate in Finland, because of the closeness of the sea.

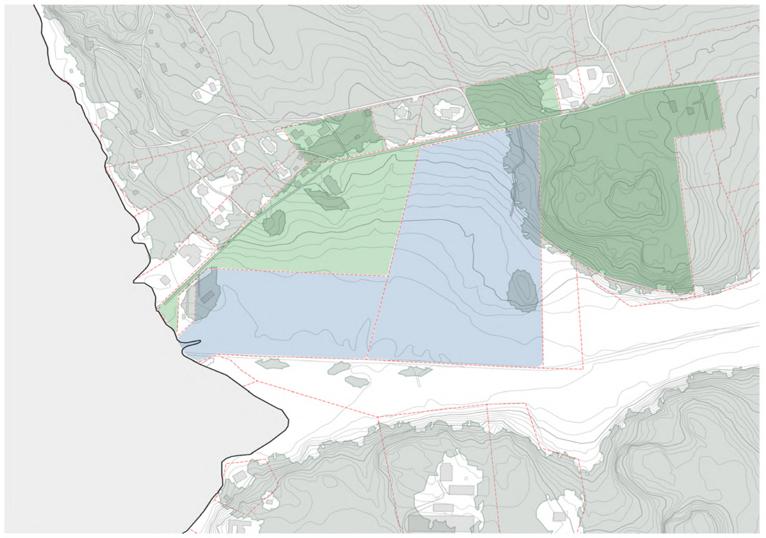
The planning site for the development is unused grass field sloping to the south. Currently, there are about 20 households in the area. The orientation of the hills and landscape creates great conditions for sunlight insolation. Also, good views towards the sea and to the surrounding forests are seen from all corners of the site. Forest works as natural protection from winds and plays a major role in preserving natural recreational areas. Accordingly, the plot covered with trees on the eastern side of the plot is not included in the planning area because of the forest's potential as a recreational space and as a carbon sink. The forest is part of the Green belt running in the south from Kaarina. From the south, the site is defined with the stream.

The location is currently fully car-dependent since there is no public transport connecting to Kaarina nor Turku. The roads are narrow and do not encourage to travel by bike or on foot. The coastline is opened to the public and accessible by the main road leading to the sea. The site has great potential for sustainable development due to great sunlight gain, arable land with a natural water system, and the closeness of two cities.

The location of Torppala has a greater potential than just a small neighbourhood on the outskirts of Kaarina. The area could work as an attraction and a connection point to Turku by the sea. Also, as a location where people bike to or walk for leisure activities. The peace and closeness to nature work as a strong recreational element.

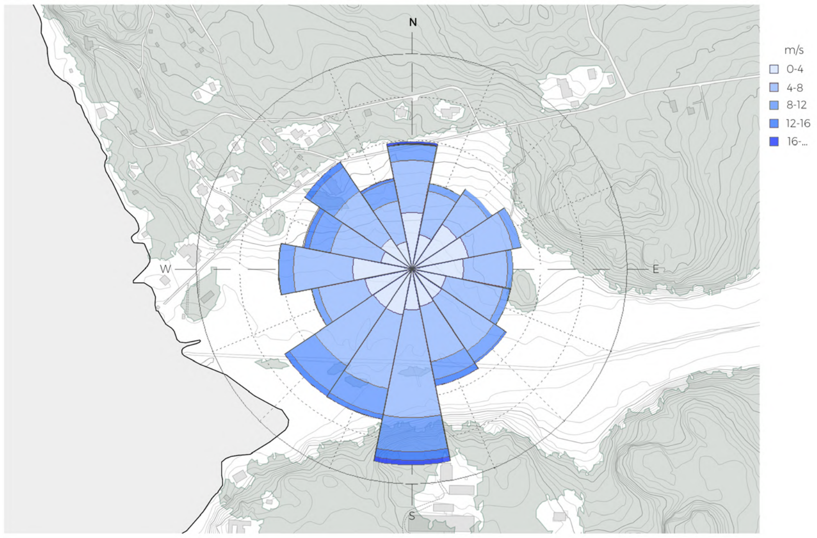
Housing

Current housing is located around the road passing the site in north. Approximately 20 households with supporting facilities are built. The connection to Turku and Kaarina happens through the main road.



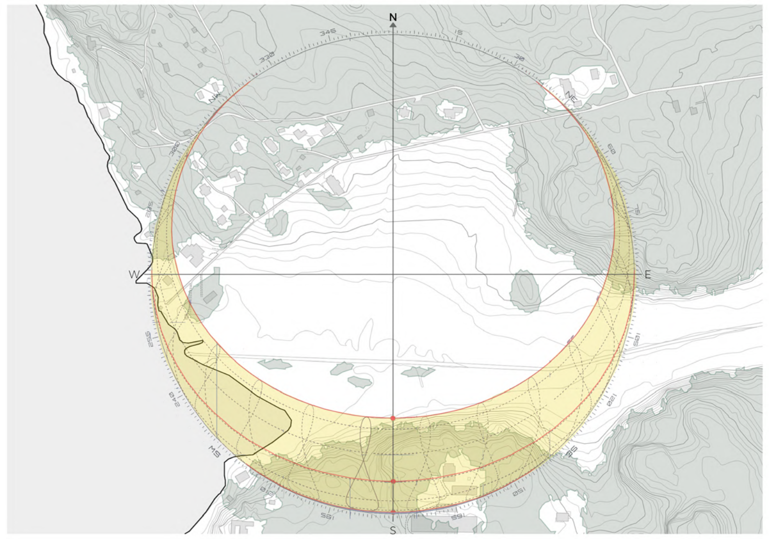
Land ownership

The site under investigation is owned by private owners(green) and the municipality of Kaarina(blue). The size of marked area is approximately 18 hectares.



Winds

Winds on the site are mostly dominated by the winds coming from the Turku Archipelago between south and west. Winds from other directions are protected by the forest barrier. Wind rose is created on data from Finnish Meteorological Institute.

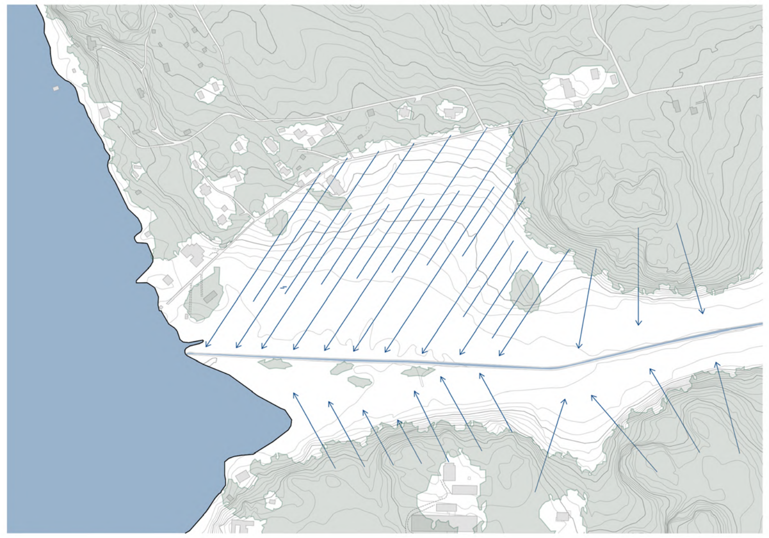


Sun

The site has a full specter of daylight during the most time of the year. Summer sun rises and sets behind the forest in the east and the west. The open plot towards south helps to gain maximum sunlight during winter time.

Terrain

The plot has natural slopes towards the middle of the site sitting between two hilly areas. The height difference on site is between 1m to 27m above the sea level.

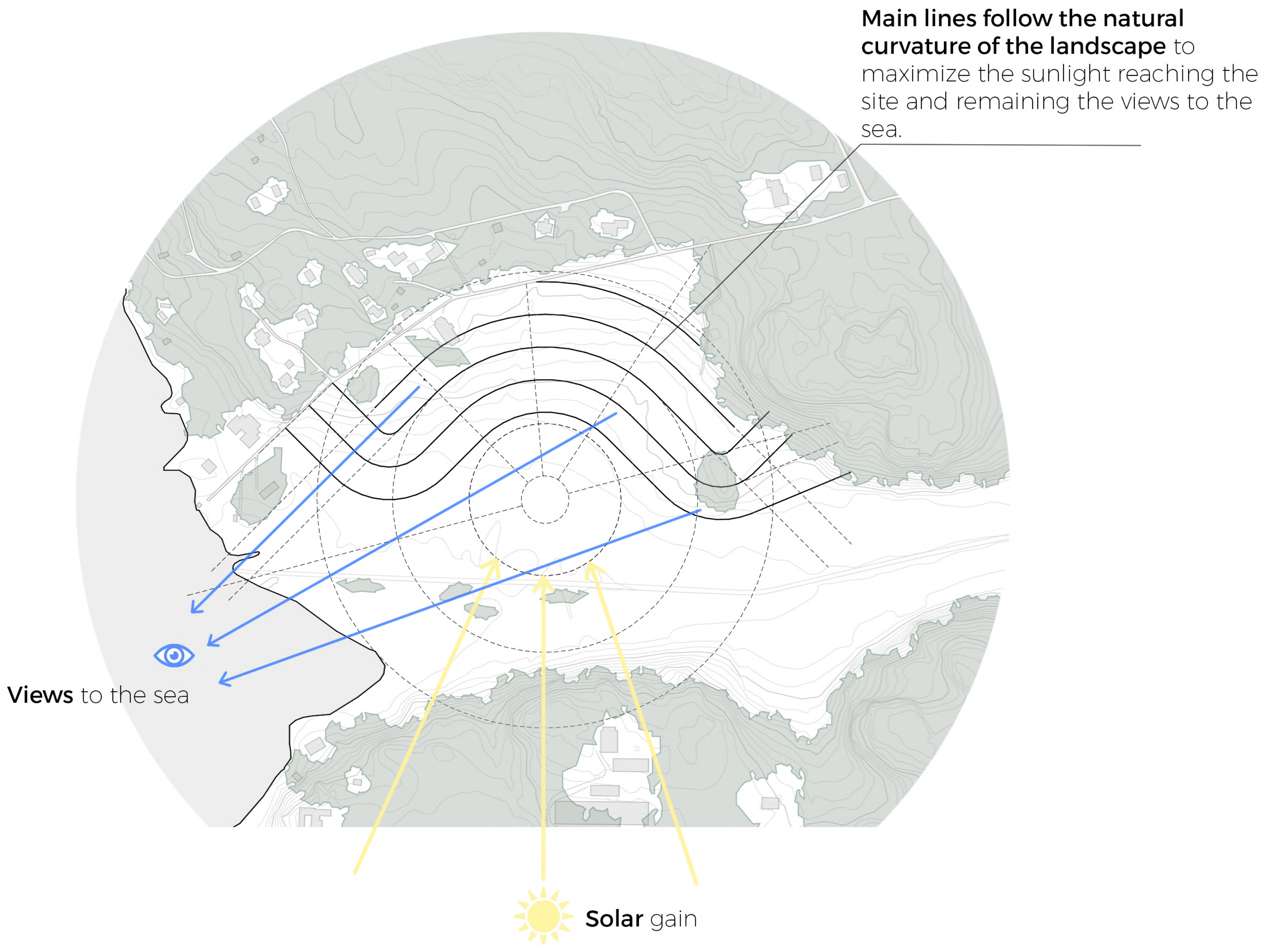


Water

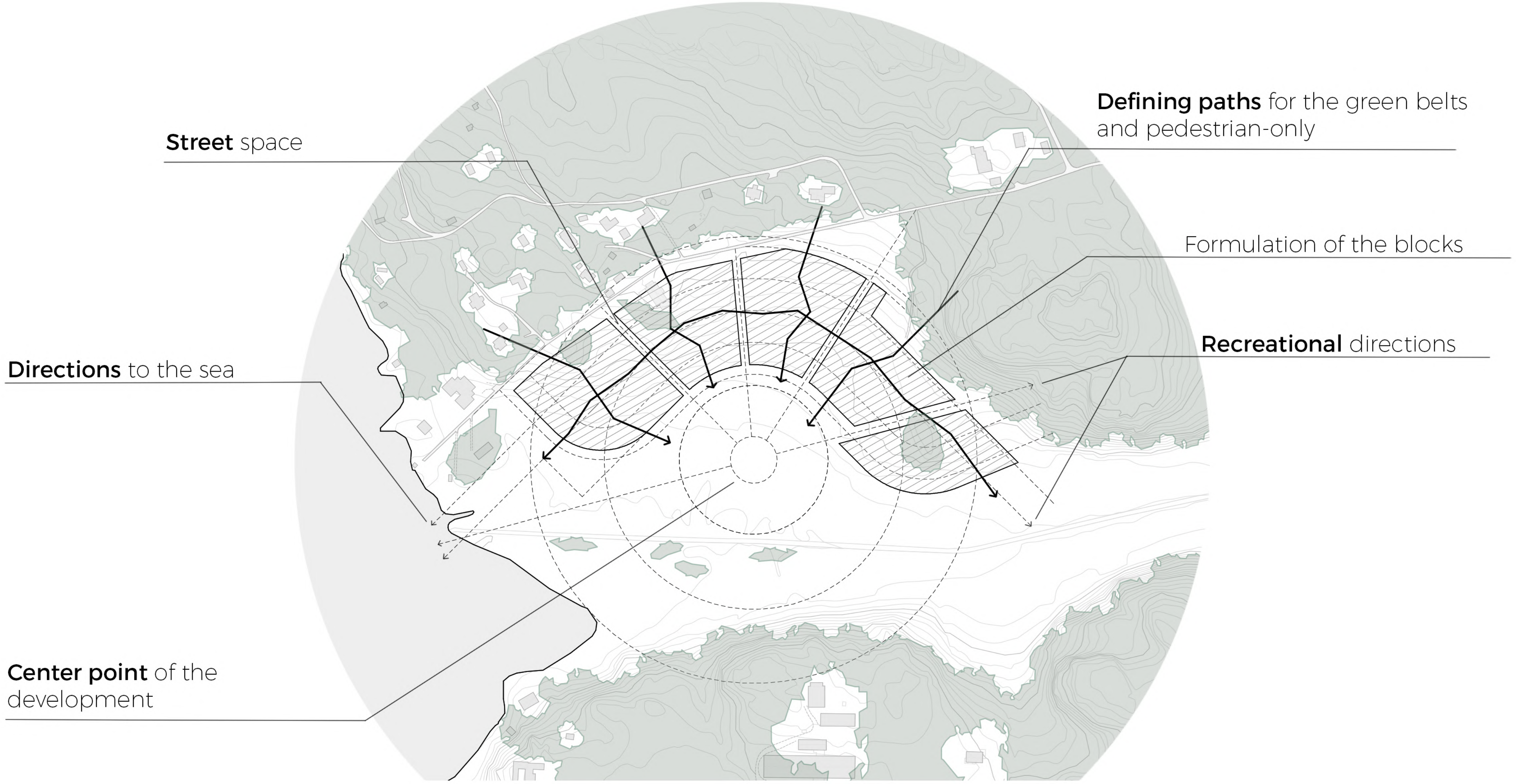
Thanks to the slope, the water is flowing naturally to the lower part of the site. The water is collected with a ditch passing the site in the south. The water runs into the sea near the seashore.

The Formation

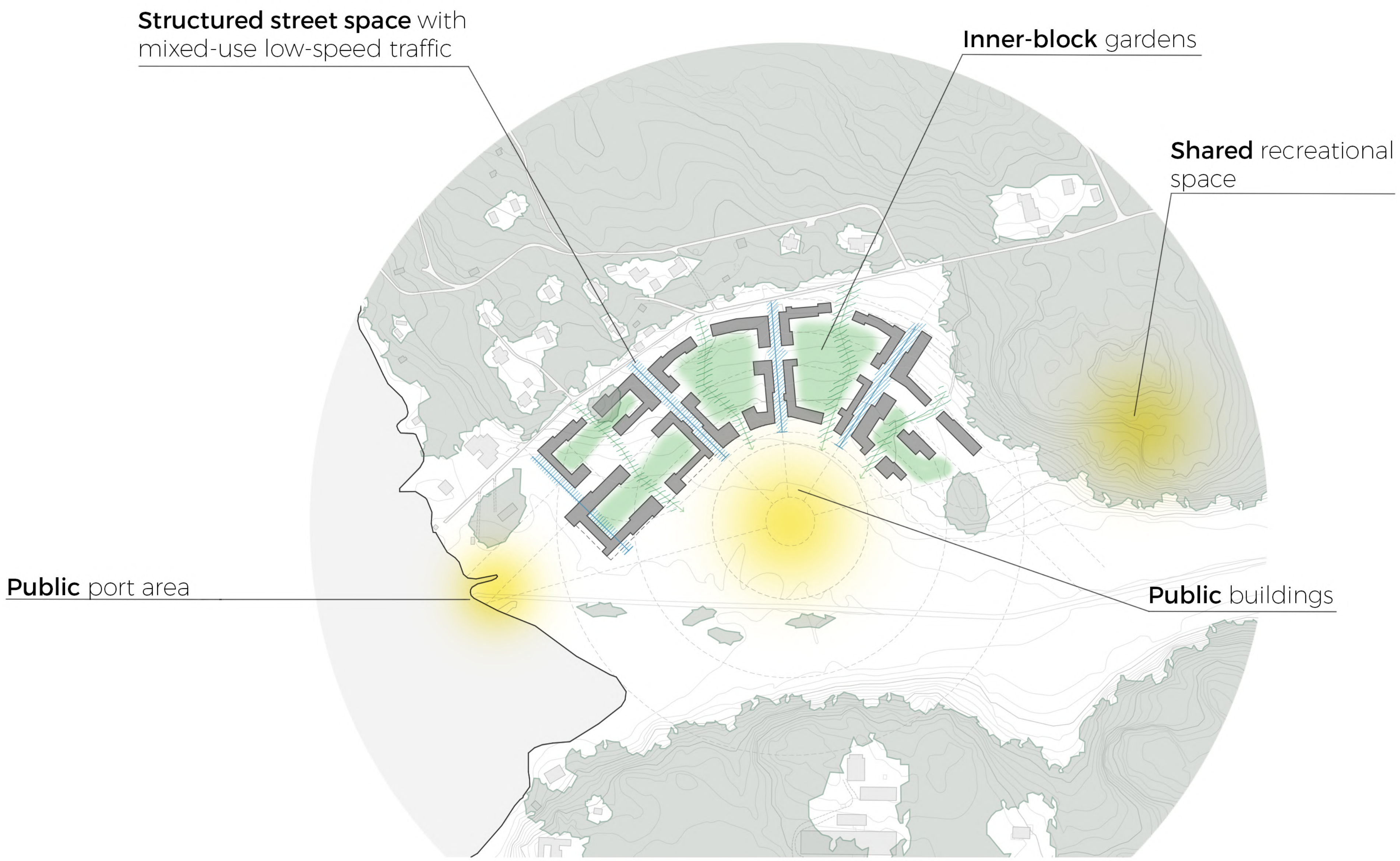
The goal for the land-owners is to build area for 600 to 800 inhabitants. The author saw the need to reduce the presumable population to 500 people to maintain a sufficient ratio between arable land and built land. The population could be increased with the potential expansion on the south-east part of the site. The planning logic of the site follows the planning principles described in the theoretical part of the thesis. The natural landscape of the site will be preserved as much as possible. The planning proposal ignores the only building on the site today to show the wholeness of the possible development.



The main guidelines follow the natural shape of the landscape. The buildings will be positioned on the slopes to guide the movement towards the middle of the plot. The views of the sea will be preserved as much as possible. Views towards the concentrated centres will create a visual connection for the inhabitants with the garden, to see the progress of the crop.



Street space is more defined compared to traditional developments. The closeness of the buildings will create a narrow feel of the space and reduces the speed of possible car traffic. The houses are close and create different private corners. The inner-block gardens are wide and open to maximize the sunlight.

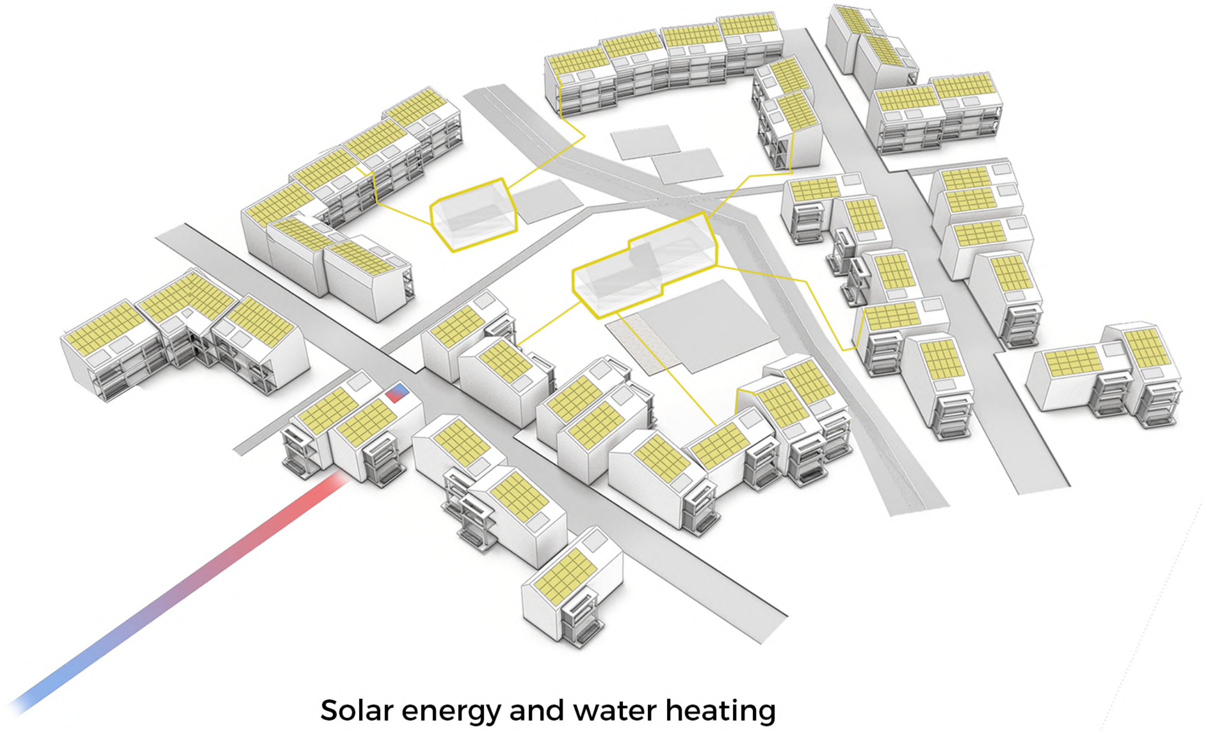


The public buildings will be positioned in the centre point of the development to encourage movement towards the centre as a meeting point. The main moving directions are oriented from the main road towards the middle to create a safer environment away from traffic. Additional pedestrian paths are connecting centres of marked blocks. Recreational directions towards the sea and the forest are marked as the middle ring of the development.

The planning of the blocks follow the principles and the logic presented in the theoretical part. The housing of the area is positioned on the outside perimeter of the block to create a more urban and compact street space, leave more space for the yards, and maximize the number of houses. The northern and higher part of the site is occupied by small two floor attached houses that work as a strong border to the site from the north. The arrangement works as a barrier from northern winds and the traffic in the north making the space inside the blocks quiet and safe.

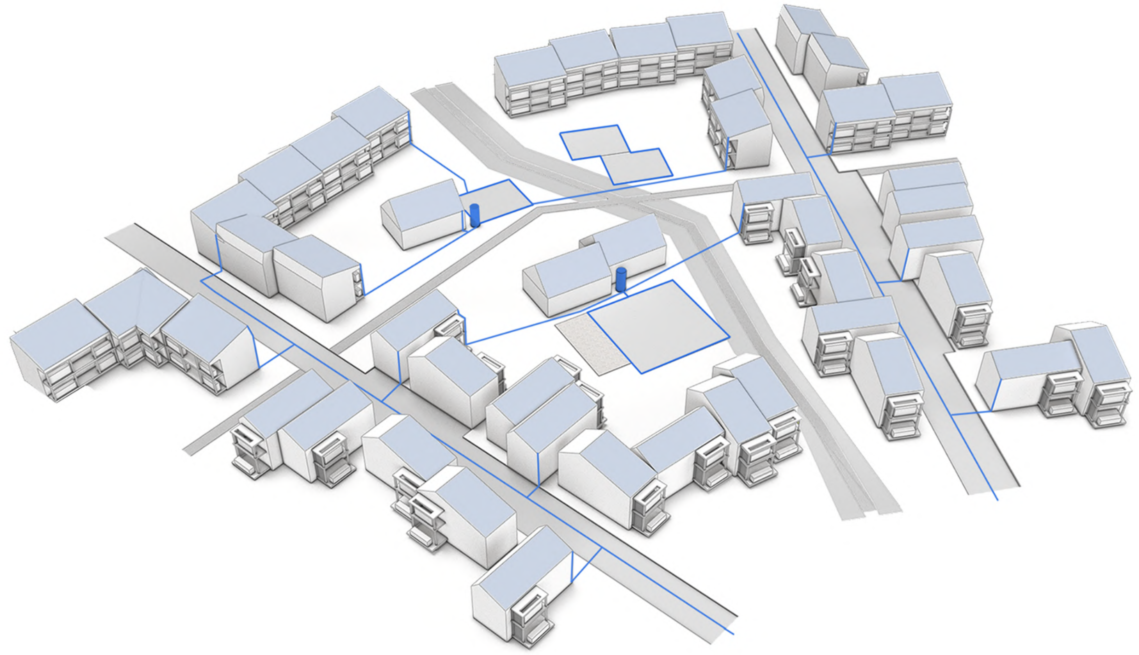
Lower part of the plot is occupied by single-family houses. They are positioned in perpendicular formation to create diverse and varied space. The area between the buildings is reserved for shared social space with the supporting facilities for local food productions. Pedestrian paths cross the area from 2 directions to form walkable and shorter distances between the different destinations.

The area depends mostly on the grid electricity and the main heating source for the houses are thermal heat pumps. The energy plan can take advantage of the plots shadowless location during most time of the year; and of the land's and the sea's geothermal energy potential. All the house are PV-panel ready and the roof pitch encourages the use of solar energy. Additional water heating collectors can warm the water used in the buildings during the suitable weather. All the excess rainwater will be collected for watering the gardens and for the use in the toilet's rinsing tanks.



Solar energy and water heating

All the houses have the readiness of PV panels for the production of clean electric energy. The energy is shared between community based on the demand at the specific time. The houses are heated with ground-heat-pumps fed with thermal energy from land and sea.

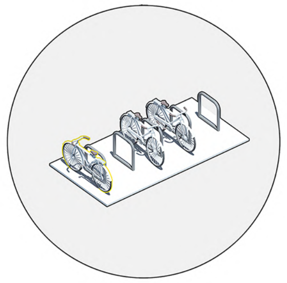


Rainwater collection

Rainwater from the roofs is collacted for the gardening and watering the plants purposes. The water will be collected naturally by the slope of the hill. The houses south from the greenhouses will collect water to the pond south from the public buildings and the appartment buildings in the north side of the plot will collect rainwater for the greenhouses.

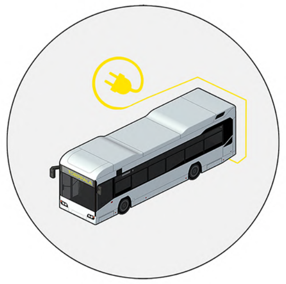
Added greenery and food production

All the balconies are the extentions of the gardens where plants like tomatoes and basilic can be grown. During the summertime plants give and extra shading from the south heating sun. Seasonal fruits or plants can be grown on these balconies. For more space demanding plants the greenhouses and the garden space can be used.



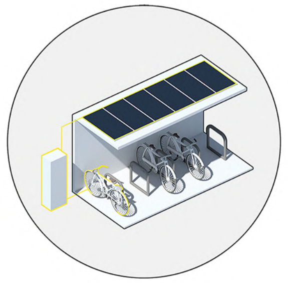
Bike racks

All the streets and main facilities are equipped with bike racks for a convenient and safe place to leave the bikes. Similarly to the cars, a small number of bicycles are in shared use.



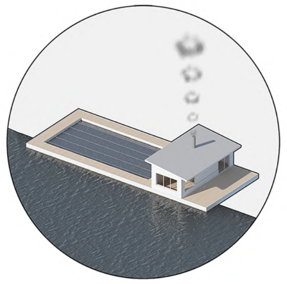
Bus connection

An electric bus connection will be established to Kaarina or to Turku. An electric bus is crucial for the carbon budget of transport of the inhabitants. The bus turns around at the end of the Torppala road.



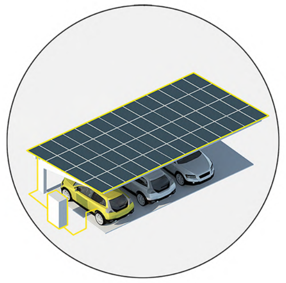
Electric bikes

The growing popularity of e-bikes will be addressed, and the site will be equipped with small charging stations. E-bikes are great for tackling the hilly areas in Torppala without a big effort.



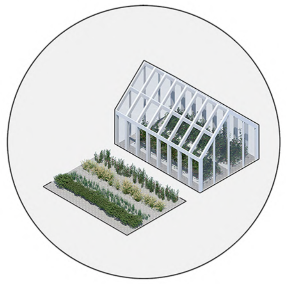
The sauna

The shared sauna together with an unheated sea pool is a part of a small port complex. The pool creates safer and cleaner swimming conditions, especially during ice hole dipping season.



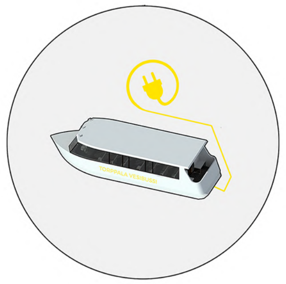
Car share

A solar panel covered structure will charge the cars from solar energy together with grid electricity. Cars will remain snow-free and clean. The use is demand-based and shared following the carpool logic.



Greenhouses

Greenhouses will boost the crop efficiency in the area, especially with mixed use of small vertical farms. The maintenance is organized in collaboration between inhabitants and hired staff.



Water bus

The boat that connects straight to Turku City center. A short distance can be covered with 10 minutes time. The boat is meant also for the people of surrounding neighbourhoods.

Recreational areas

Forest in the east and a path next to the stream in the south are part of the recreational directions that connect the site to Kaarina's greenbelt.

Carport
shared cars

Greenhouses
with gardens

Bus stop

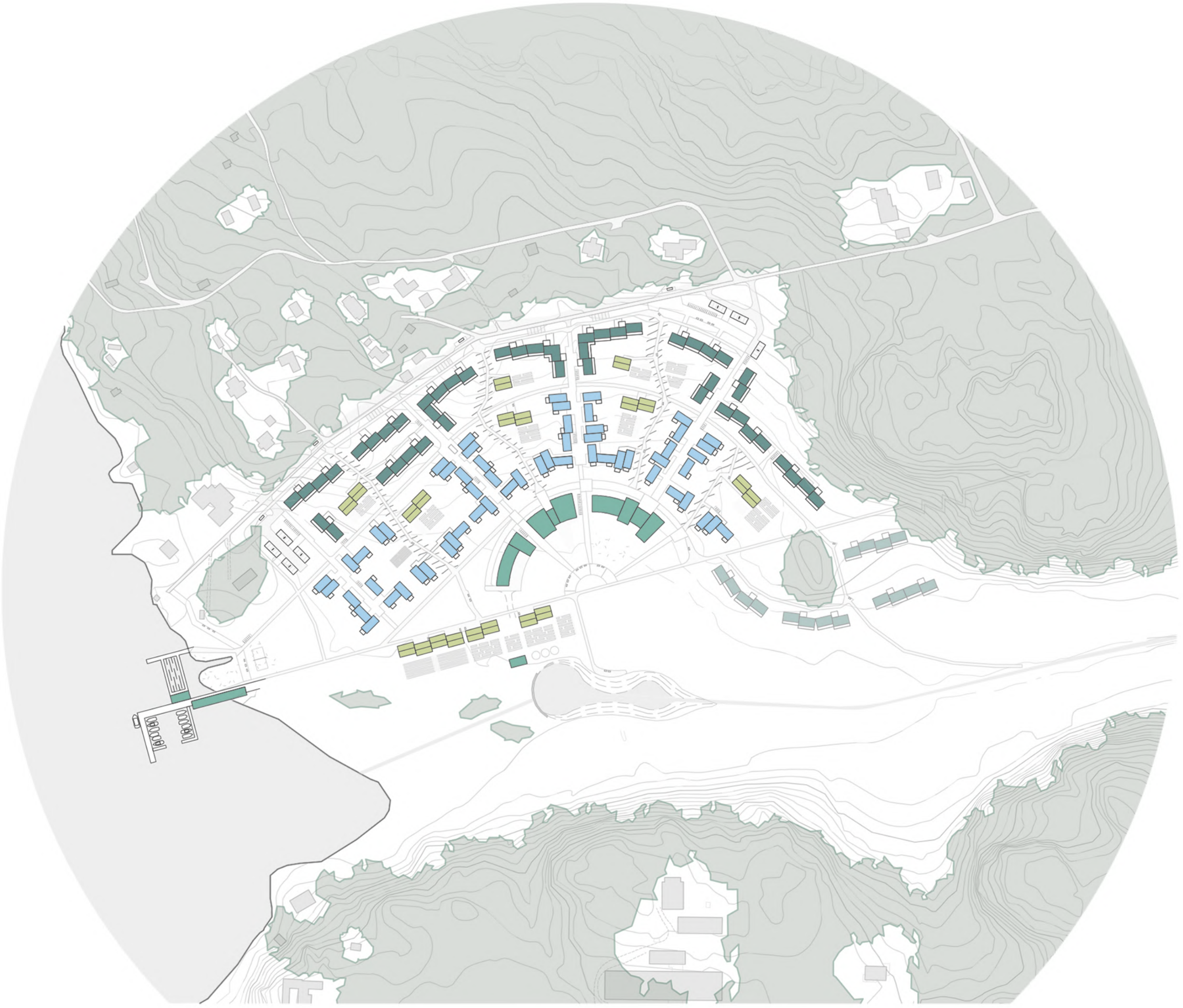
(1) **Kindergarten**
Korttelitalo

(2) **Open Office**
Shared workspace

(3) **Garden Administrative**
building

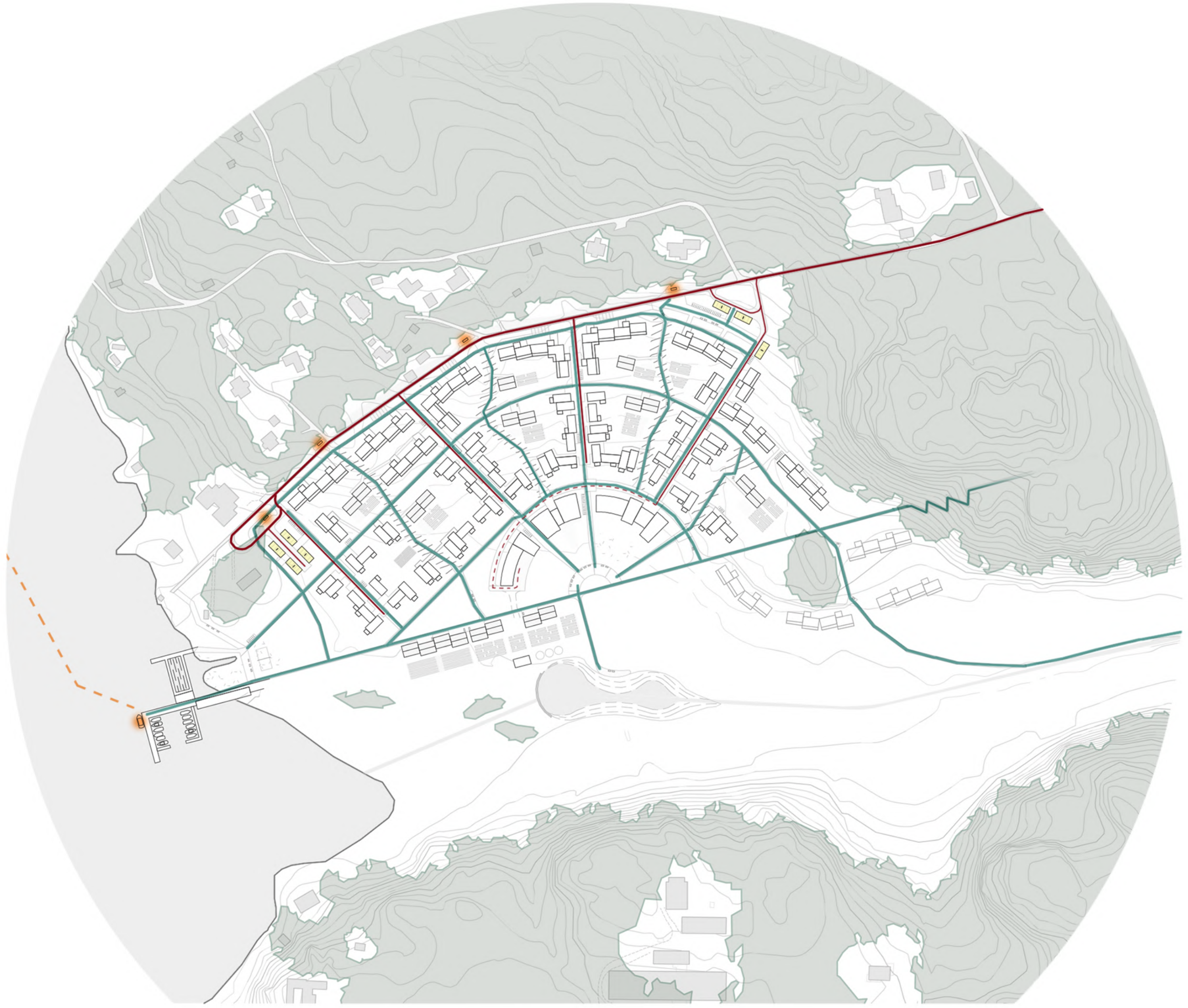
(4) **The port house**
with shared sauna


Possible extention direction
Fruit/Berry garden
Greenhouse garden
Expanded pond
1
2
3
4
M 1:2000



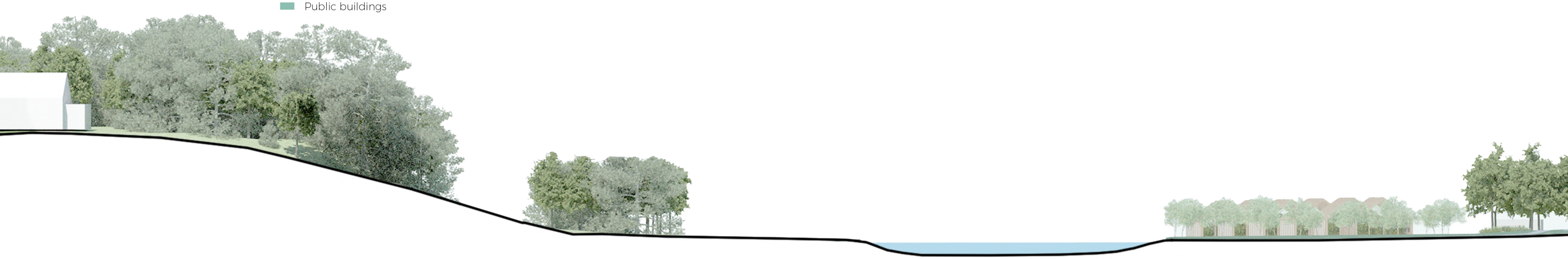
Buildings by function

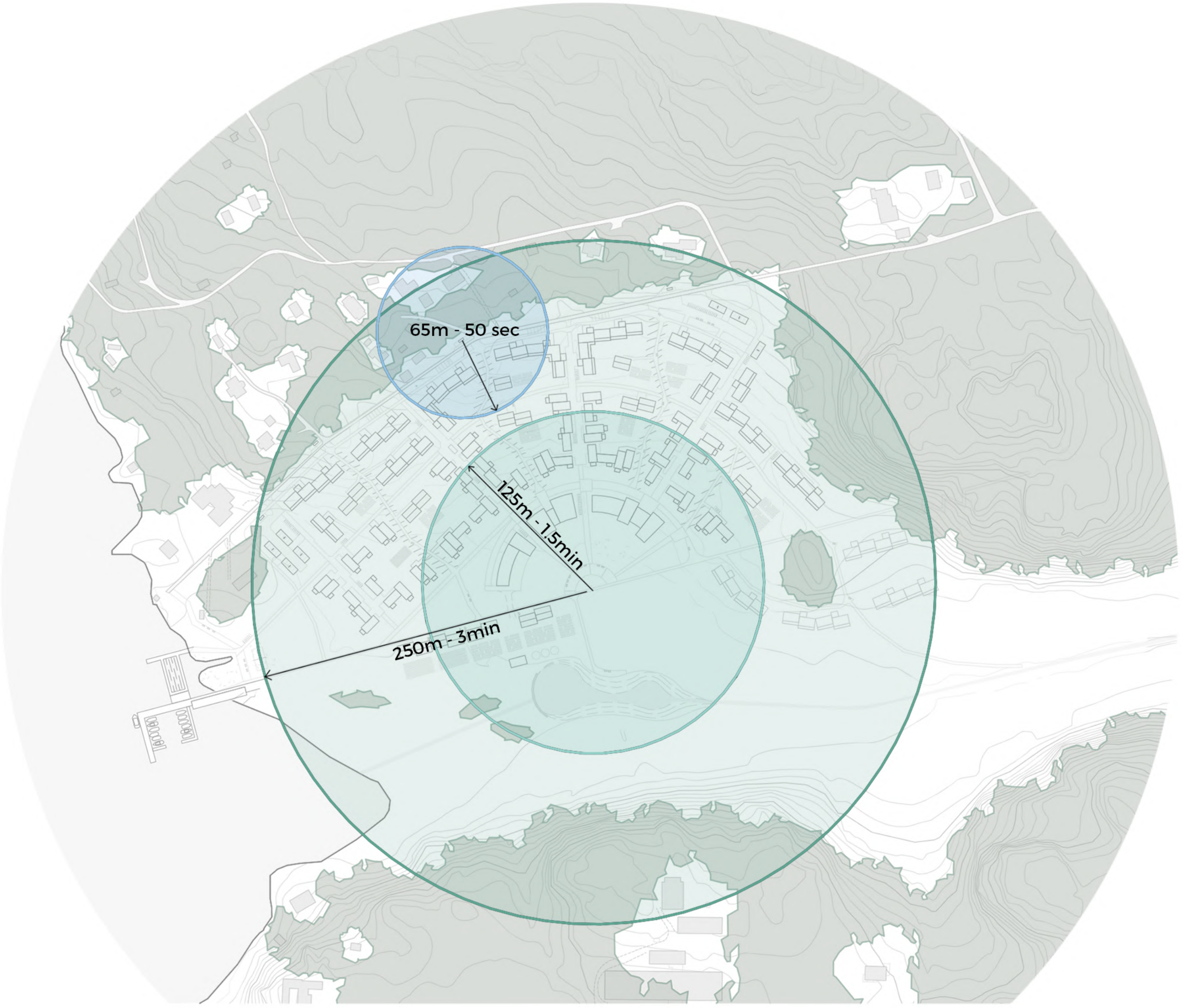
- Single-family houses
- Apartment buildings
- Greehouses and vertical farms
- Public buildings



Infrastructure and transportation

- Pedestrian / light traffic
- Bus / car traffic
- Boat connection





Distances and the walking time

Distances between places are maximum 500m which is a capable walking distance for people from all ages. That incourages more healthy community.

Gardening areas and water collection

The circular form of the site layout can be clearly seen. The housing is mostly formed around the central gathering point where most of the paths reach. The space in the central part imaginary circle of the plot is reserved for public buildings. The plan proposes the buildings to be kindergarten, open offices and gardening administrative building.

Kindergarten is planned for the kids living in Torppala and in the neighbouring areas. The exact number of children accommodated is not specified in the work and needs assessment of Kaarina city policies. The kindergarten's secondary function is to work as a culture house (Korttelitalo) outside its normal working hours. The rooms are shared for cultural and communal activities, such as dance classes or choir lessons. The use of the rooms is meant for all the inhabitants of the area.

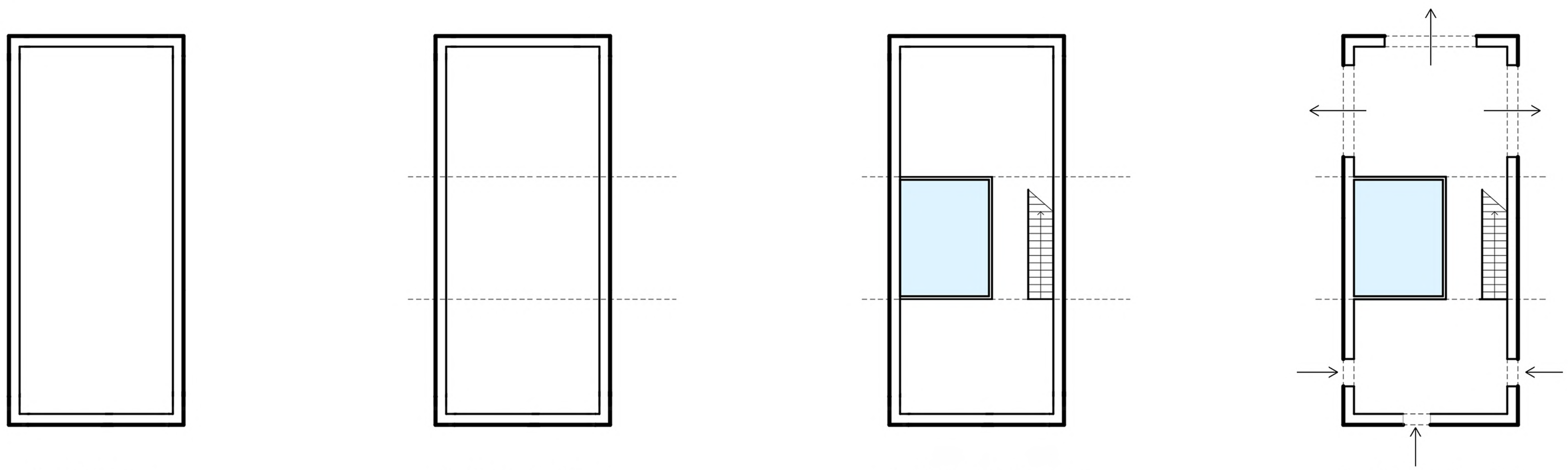
The shared offices' goal is to offer working space outside the home for the inhabitants. The method follows co-working space logic were people can book a table or a room for work. The fast internet connection and a good working environment can reduce the necessity to travel to the city. The building will accommodate the offices for running the village.

The gardening administrative building holds rooms for food preservation and distribution. The gear and supporting machinery that is used for the maintenance of the gardens are held in the building. The building supports the upkeep of greenhouses, a food garden and a fruit garden. It is run and led by a hired staff.

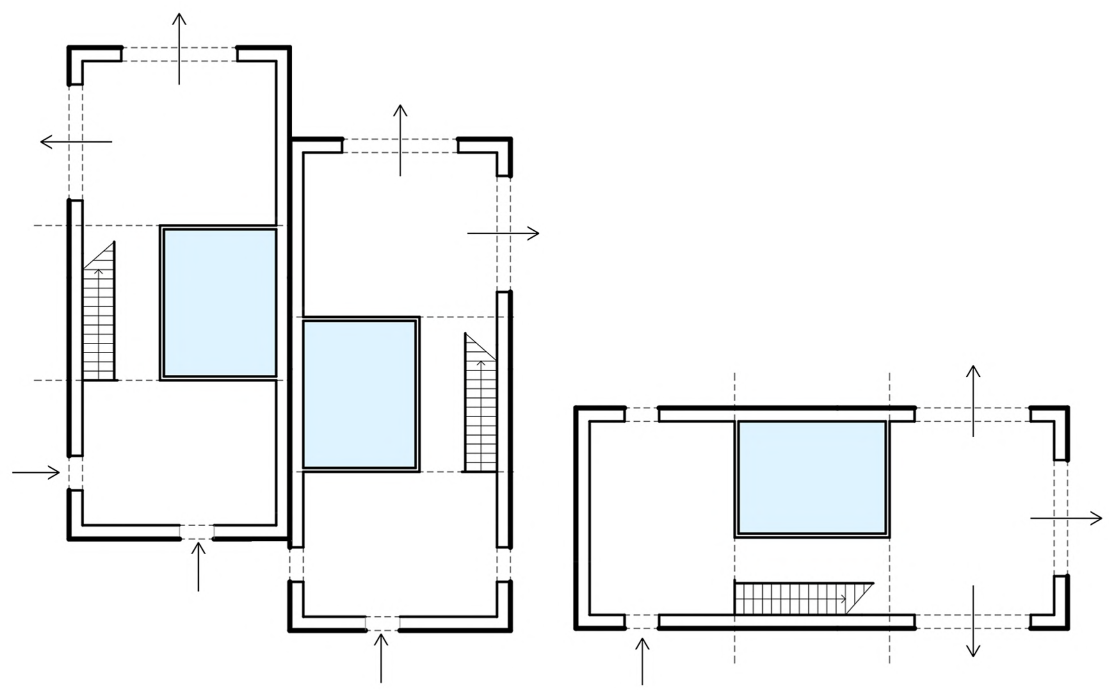
By the sea, there is a small complex including a public sauna and a port building. The public sauna has great views towards the islands and Turku city. The swimming platform creates an unheated swimming pool in front of the sauna. It is designed for a safer swimming experience, especially during winter time when Nordic people practice winter swimming or ice hole dipping. The port building contains rooms for boat maintenance and fishing gear. The inhabitants of the area can dry and clean the fishing nets after taking advantage of living by the sea. The pier is located on the south side of the port complex. Docking space can be rented for private boats and the profit can be earned for community needs.

The small stream is redirected and a small dam is built to form an artificial lake. The lake works as additional water storage for garden water needs.

Birds-eye-view to the site



Optimal shape Marking proportions Marking fixed elements Marking the directions



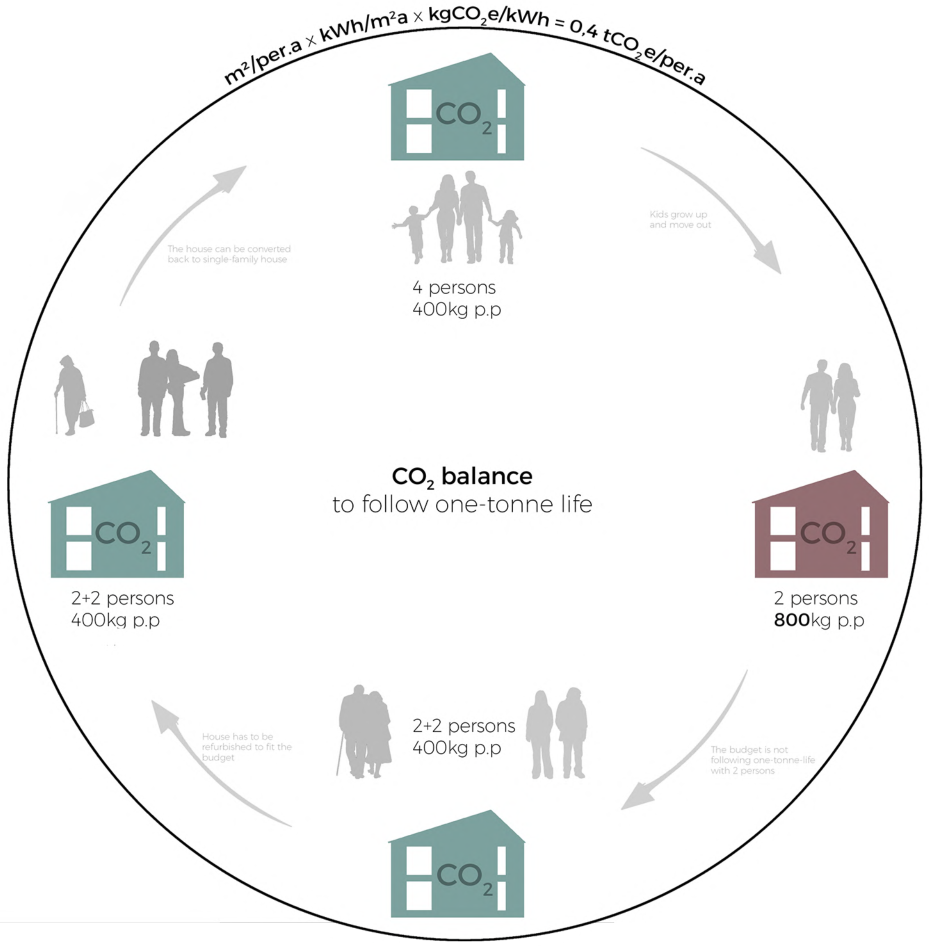
Detached house

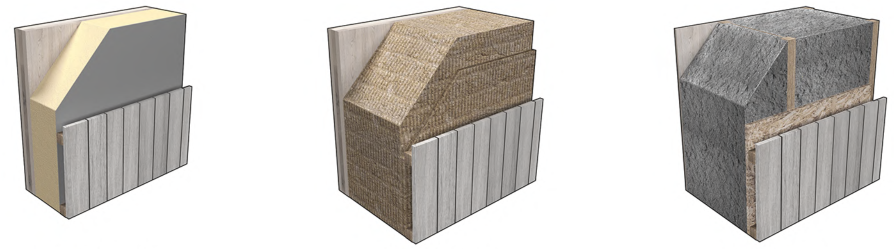
For one-tonne life, a detached house type was created that is adaptable over the life cycle of the building. To follow the conservative life of one tonne, the size and the floor area of the building was chosen optimally to fit the basic needs of the possible inhabitants.

The main scheme of the house follows the floor-plan principle where some elements are fixed no matter the orientation of the buildings. The location of wet rooms, the stairs, and the communications are brought to the centre of the building. This kind of plan layout creates an opportunity to form rooms and spaces independent of each other. The entrance of the house will be positioned next to the street side – 3 possible entries will not be dependant on the direction nor the angle of the house. The living area is orientated towards the garden and tries to take as much advantage of the south sun as possible. The balconies extend the living rooms to outside and protecting the rooms of overheating during summer months. Additionally, the purpose of the balconies is to create space for seasonal plants to grow. During winter times the containers are empty and let the sunlight pass compared to summertime when the plants throw an extra shade.

The house type is planned with a small environmental load considering materials, energy and land use. The floor area and the form are optimized for good thermal results. The size is compact and follows the principles of one-tonne-life. The interior layout can be refurbished and rebuilt according to the needs of the inhabitants. The wet rooms and location of the stairs are the only elements fixed. The views are oriented mostly towards the gardens in the middle of the blocks. The roof pitch is optimized for solar gain and the opposite pitch makes sure that the roofs of neighbouring buildings will not be in the shadow.

The material comparison options for the house were all selected keeping in mind the possibility of modular building. The houses are designed to be built with pre-fabricated elements no matter what material combination is chosen. The elements can be made in a way that they later refurbishment is easy and does not require massive efforts. For great thermal results and long lifespan, the high construction quality has to be achieved.





Option 1
CLT main structures
PIR insulation
30,24 m²/per person a year

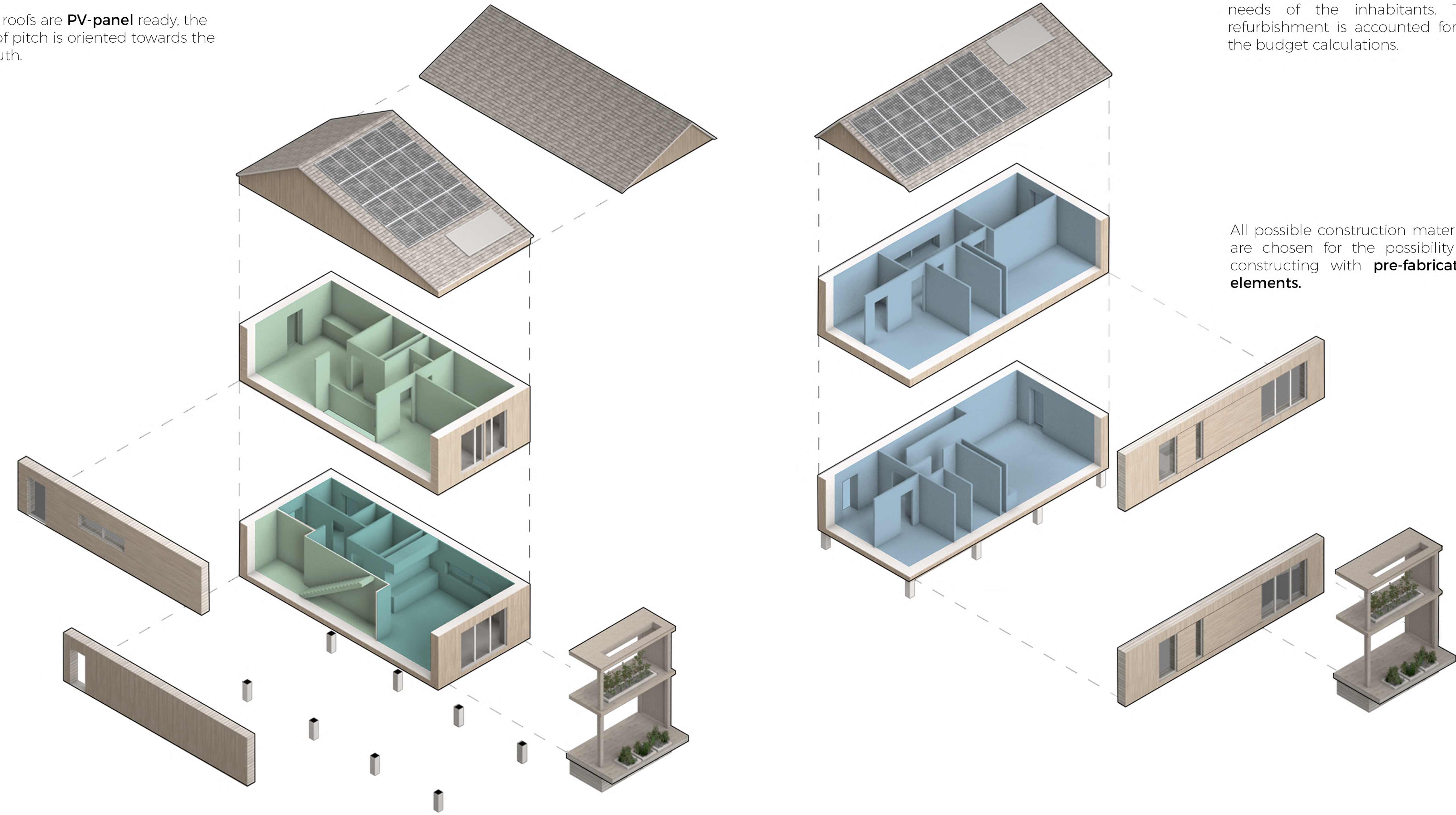
Option 2
CLT main structures
Mineral Wool insulation
28,75 m²/per person a year

Option 3
Wooden frame main structures
Cellulose Wool insulation
34,29 m²/per person a year

All roofs are **PV-panel** ready, the roof pitch is oriented towards the south.

Tine **interior partition walls** can be repositioned according to the needs of the inhabitants. The refurbishment is accounted for in the budget calculations.

All possible construction materials are chosen for the possibility of constructing with **pre-fabricated elements.**



Pile foundation reduces the impact on land and the carbon footprint of the building.

Balconies work as a buffer between the interior and exterior space, providing natural shading and the opportunity to grow plants.

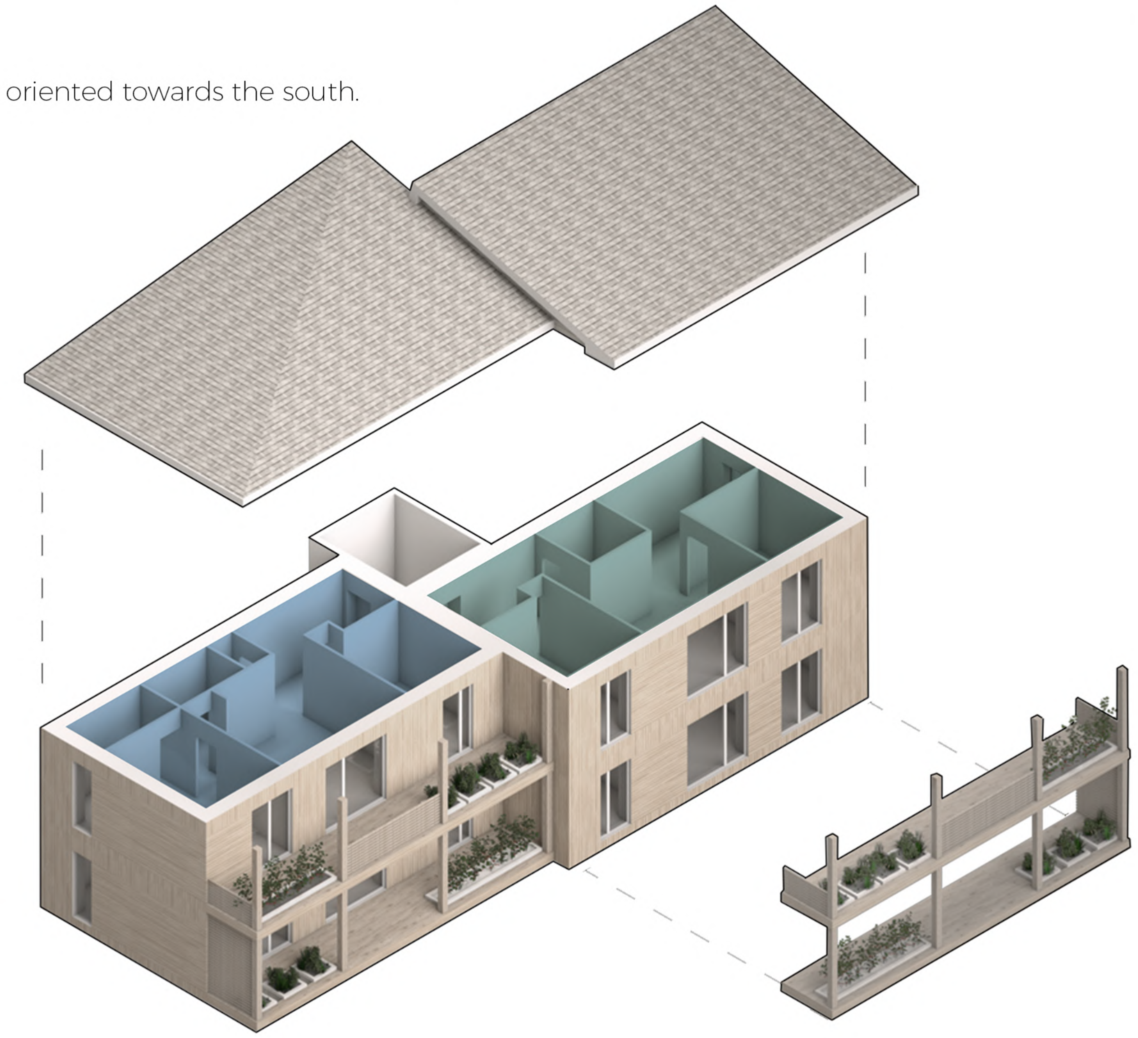
The adaptability of the interior layout is achieved with the fixed positioning wet rooms and communications inside of the houses. The communications are running in the shaft that connects water, sewage and ventilation between the 2 floors. The attic space is unheated.

The floor plans can be adapted for the needs of different inhabitants. The second-floor rooms can be granted separate access by changing the layout of the partition walls and the stairs. That creates two independent apartments that can suit the needs of many. A scheme below illustrates one possible course of change over the life-cycle.

Attached houses

Attached houses form the second typology in Torppala, following the same principles and methods used on the detached house type. The two-story buildings include 4 apartments that share a one access corridor. The apartments are 2 bedroom apartments but similarly to the single-family houses can have different layouts throughout the life cycle of the building. The smaller floor area and analogous materials used to ensure that one-tonne life is achieved. The exterior balconies have the same purpose as the ones used for the single-family houses.

Roofs are oriented towards the south.



Balconies provide shading and extra space.

Total: **55.5 m²**

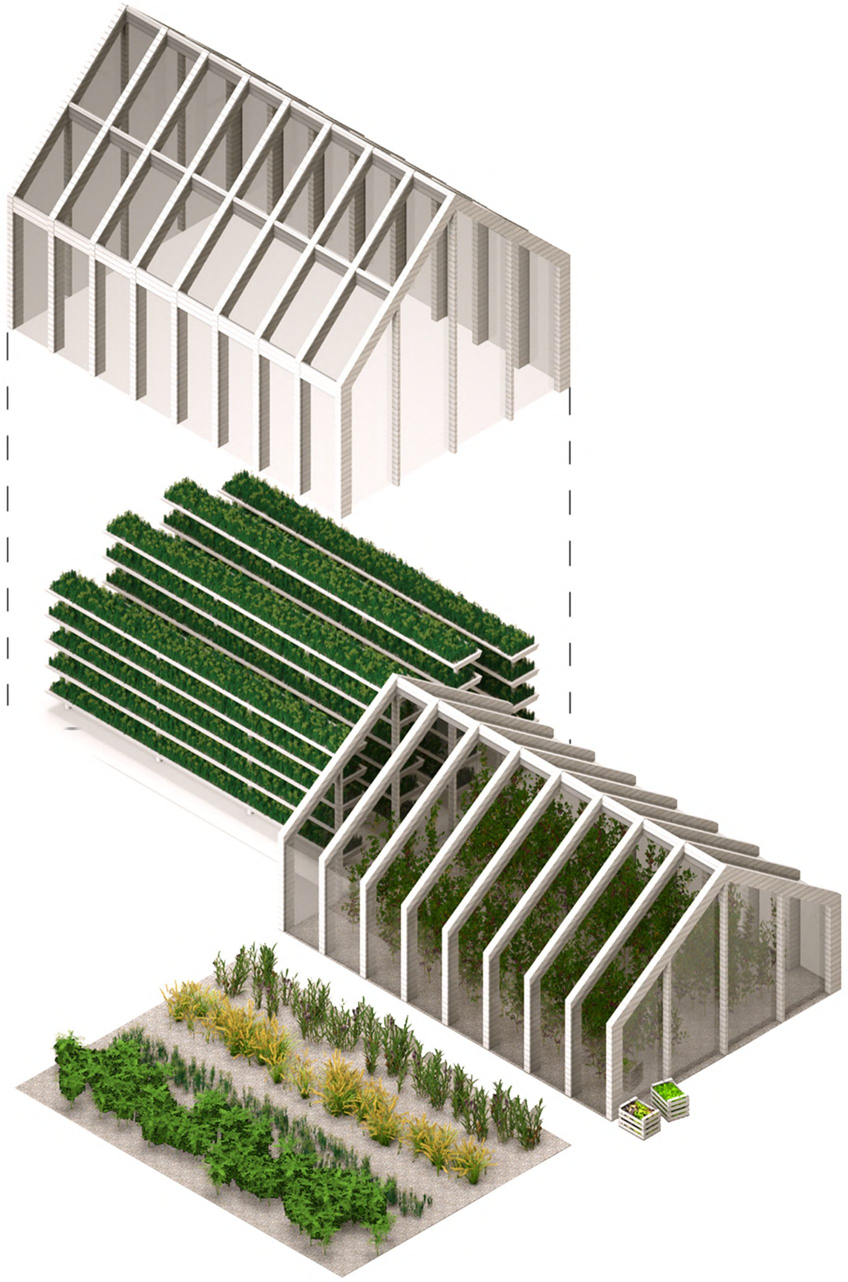
Total: **55.8 m²**

There are 20 greenhouse structures, mixed between vertical farm and traditional greenhouse techniques. The greenhouses are used mostly during summertime when the climate supports food production. The usage during winter time is brought to the minimum to reduce the energy demand for wintertime heating. The greenhouses and vertical farm systems are more efficient in the crop yield compared to traditional agriculture. The structures are maintained and lead by the inhabitants together with supporting staff. The staff can be chosen and hired among the locals.

Greenhouses are placed in the middle of the blocks to work as a social meeting place. Sharing gardening duties will boost communication between people. Next to the greenhouses, there are small fields for seasonal plants. Benches strengthen the shared space for people to meet and stay.

6 **Vertical Farms** can help to grow food on a smaller plot of land with less water and controlled climate.

14 **Greenhouses** have total arable land of 11200 m². Seasonal fruits and vegetables can grow in more stable environemnt.



Considering the crop yield factors of greenhouses, Torppala development has a total potential arable land of 27484 m².

The food production potential is shown on the example of lettuce.

	Count	Area m2	Crop Factor*	Total arable land
Garden plots	15	6684	1	6684
Greenhouses	14	1120	10	11200
Vertical farm	6	480	20	9600
Total:				**27484**

1 Crop Factor equals 4kg of lettuce		kg
Total food:		**109936**
109936 kg of food equals the need of 240kg of lettuce per year for 458 people		

View inside the garden

View inside the garden towards kindergarten

View to the street in front of the kindergarten

View to the street

Presentation posters in scale 1:10

Appendix A

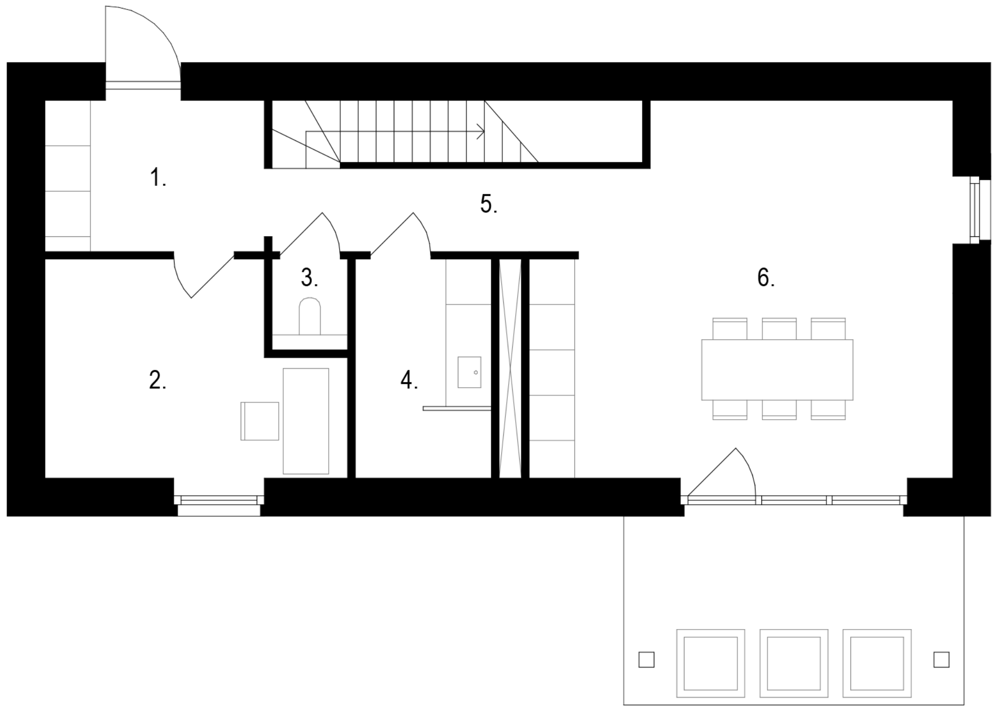
Base house

for the calculations

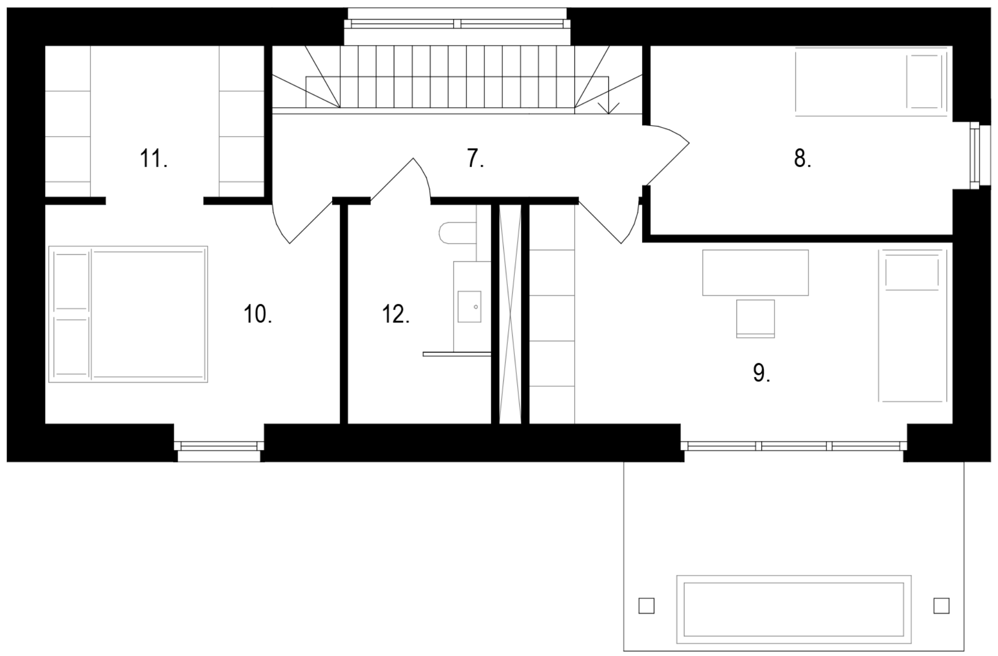
Heating sources		Ground-heat pump
Energy	Net.Energy Demand	Energy usage
	$kWh/(m^2 \cdot a)$	$kWh/(m^2 \cdot a)$
Room heating	32,0	8,7
Ventilation heating	4,1	4,1
Domestic Hot Water	30,0	6,0
Ventilation and pumps	8,8	8,8
Lightning	5,3	5,3
Appliances	24,2	24,2
TOTAL:		56,9

Source: MKM, Väikeelamu energiatõhususarvu kalkulaator

Different material quantities are seen in the **Appendices B-D**



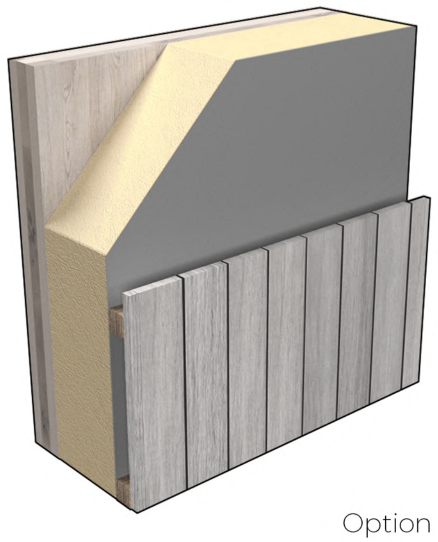
1. Entry 5.8 m^2
2. Room 10.1 m^2
3. WC 1.2 m^2
4. Bathr. 5.2 m^2
5. Hallway 4.4 m^2
6. Living 26 m^2



7. Hallway 5.4 m^2
8. Bedr. 10 m^2
9. Bedr. 14.2 m^2
10. Bedr. 11.3 m^2
11. Wardr. 5.4 m^2
12. Bathr. 5.5 m^2

Total: 104.5 m^2

Appendix B



Option 1

CLT main structures
PIR insulation

	FU	Quantity	
Foundation			**U=0,10**
1. Concrete	m3	7	
2. Insulation	m3	14	
3. Reinforcement	kg	450	
4. Flooring	m2	50	
Exterior wall			**U=0,09**
1. CLT	m3	19	
2. PIR 220mm	m3	40	
3. Cladding	m3	12	
Interior wall			
1.CLT	m3	10	
Intermediate floors			
1. CLT	m3	11	
2. Flooring	m2	56	
3. Sound insulation 50mm	m3	3	
Roof			**U=0,08**
1. Wood	m3	2	
2. PIR 250mm	m3	18	
Windows	m2	20	
Interior doors	m2	12	
Roof coverings			
1. Wood	m3	2	
2. Roof cover	m2	75	

Electricty heating:	18,7	kWh/(m²·a)
Electricty usage:	38,2	kWh/(m²·a)
Total:	56,9	kWh/(m²·a)
Total CO2:	9327,8	gCO2e/(m²·a)
Total CO2:	9,3	kgCO2e/(m²·a)

Materials:	GWP A1-A3	GWP/HFA	GWP/HFA-year
Building total	20369,99	194,93	3,90
Materials total:	3,90	kgCO2e/(m²·a)	
Budget:	400	kgCO2e/(m²·a)	
Usage:	Materials:		
9,3	3,90	**kgCO2e/(m²·a)**	
Total:	**13,2**		
Total:	**30,24**	**m²/p.p.a**	

m²/per.a x kWh/m²a x kgCO2/kWh = 0,4 tCO2/per.a

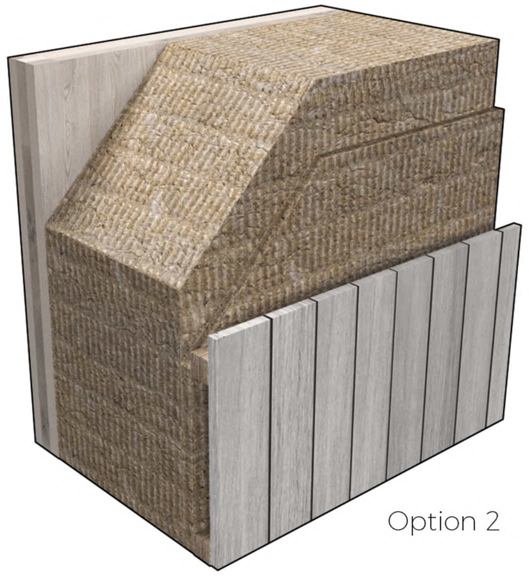
Electricty: 164 gCO2/kWh
Source: Motiva 2018

Building name		
Location	Torppala	
Building lifetime	50,0	years
Building heated floor area	104,5	m2

	GWP A1-A3	GWP/HFA	GWP/HFA-year	Carbon Credit	CC/HFA	CC/HFA-year	**GWP A1-A3**	**CC A1-A3**
Building total	**20 370,0**	**194,9**	**3,90**	**-45 639,9**	**-436,7**	**-8,7**	**100,0 %**	**100,0 %**
Bitumen	**331,7**	**3,2**	**0,06**	*0,0*	*0,0*	*0,0*	**1,6 %**	*0,0 %*
Cladding - wood	**900,0**	**8,6**	**0,17**	**-10 583,9**	**-101,3**	**-2,0**	**4,4 %**	**23,2 %**
Concrete	**1 793,1**	**17,2**	**0,34**	*0,0*	*0,0*	*0,0*	**8,8 %**	*0,0 %*
Coverings	*0,0*	*0,0*	*0,00*	*0,0*	*0,0*	*0,0*	*0,0 %*	*0,0 %*
Doors	**570,1**	**5,5**	**0,11**	**-852,1**	**-8,2**	**-0,2**	**2,8 %**	**1,9 %**
Flooring - wood	**954,0**	**9,1**	**0,18**	**-2 173,0**	**-20,8**	**-0,4**	**4,7 %**	**4,8 %**
Insulation	**9 834,3**	**94,1**	**1,88**	*0,0*	*0,0*	*0,0*	**48,3 %**	*0,0 %*
Metals	**233,1**	**2,2**	**0,04**	*0,0*	*0,0*	*0,0*	**1,1 %**	*0,0 %*
Plastics	**397,1**	**3,8**	**0,08**	*0,0*	*0,0*	*0,0*	**1,9 %**	*0,0 %*
Windows	**1 518,3**	**14,5**	**0,29**	**-311,3**	**-3,0**	**-0,1**	**7,5 %**	**0,7 %**
Wood	**3 838,3**	**36,7**	**0,73**	**-31 719,5**	**-303,5**	**-6,1**	**18,8 %**	**69,5 %**

*PIR EPD data is based on the average of 3 different manufacturers.
Finnfoam EPD „RTS EPD, No. 3"
Recticel EPD „Environmental product declaration for a PU insulation board with multilayer facer"
IKO „Product Data Sheet Composite Aluminium Foil Faced Rigid Polyisocyanurate Insulation"

Appendix C



Option 2

CLT main structures
Mineral Wool insulation

	FU	Quantity	
Foundation			**U=0,10**
1. Concrete	m3	7	
2. Insulation	m3	14	
3. Reinforcement	kg	450	
4. Flooring	m2	50	
Exterior wall			**U=0,09**
1. CLT	m3	19	
2. Mineral wool 480mm	m3	92	
3. Cladding	m3	12	
Interior wall			
1.CLT	m3	10	
Intermediate floors			
1. CLT	m3	11	
2. Flooring	m2	56	
3. Sound insulation 50mm	m3	3	
Roof			**U=0,08**
1. Wood	m3	2	
2. Mineral wool 560mm	m3	35	
Windows	m2	20	
Interior doors	m2	12	
Roof coverings			
1. Wood	m3	2	
2. Roof cover (metal)	m2	75	

Electricty heating:	18,7	kWh/(m²·a)
Electricty usage:	38,2	kWh/(m²·a)
Total:	56,9	kWh/(m²·a)
Total CO_2:	9327,8	$gCO_{2e}/(m^2 \cdot a)$
Total CO_2:	9,3	$kgCO_{2e}/(m^2 \cdot a)$

Materials:	GWP A1-A3	GWP/HFA	GWP/HFA-year
Building total	23970,60	229,38	4,59

Materials total:	4,59	$kgCO_{2e}/(m^2 \cdot a)$

Budget:	400	$kgCO_{2e}/(m^2 \cdot a)$

Usage:	Materials:	
9,3	4,59	**$kgCO_{2e}/(m^2 \cdot a)$**
Total:	**13,9**	

Total:	**28,75**	**m²/p.p.a***

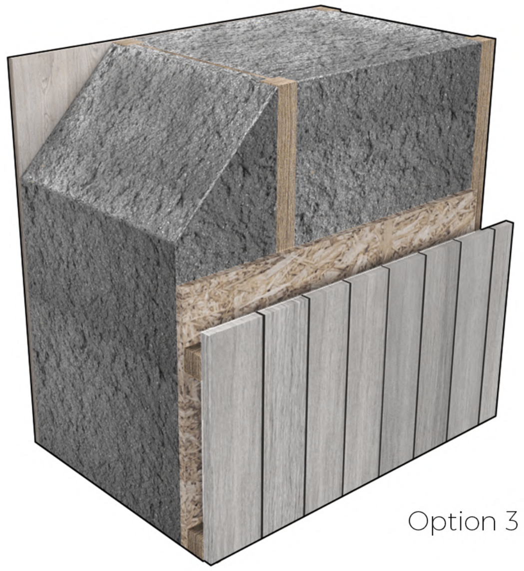
m²/per.a x kWh/m²a x $kgCO_2$/kWh = 0,4 tCO_2/per.a

Electricty: 164 gCO_2/kWh
Allikas: Motiva, Finland

Building name		
Location		
Building lifetime	50,0	years
Building heated floor area	104,5	m2

	GWP A1-A3	GWP/HFA	GWP/HFA-year	Carbon Credit	CC/HFA	CC/HFA-year	**GWP A1-A3**	**CC A1-A3**
Building total	**23 970,6**	**229,4**	**4,59**	**-45 639,9**	**-436,7**	**-8,7**	**100,0 %**	**100,0 %**
Bitumen	**331,7**	**3,2**	**0,06**	*0,0*	*0,0*	*0,0*	**1,4 %**	*0,0 %*
Cladding - wood	**900,0**	**8,6**	**0,17**	**-10 583,9**	**-101,3**	**-2,0**	**3,8 %**	**23,2 %**
Concrete	**1 793,1**	**17,2**	**0,34**	*0,0*	*0,0*	*0,0*	**7,5 %**	*0,0 %*
Coverings	*0,0*	*0,0*	*0,00*	*0,0*	*0,0*	*0,0*	*0,0 %*	*0,0 %*
Doors	**570,1**	**5,5**	**0,11**	**-852,1**	**-8,2**	**-0,2**	**2,4 %**	**1,9 %**
Flooring - wood	**954,0**	**9,1**	**0,18**	**-2 173,0**	**-20,8**	**-0,4**	**4,0 %**	**4,8 %**
Insulation	**12 839,2**	**122,9**	**2,46**	*0,0*	*0,0*	*0,0*	**53,6 %**	*0,0 %*
Metals	**233,1**	**2,2**	**0,04**	*0,0*	*0,0*	*0,0*	**1,0 %**	*0,0 %*
Plastics	**992,9**	**9,5**	**0,19**	*0,0*	*0,0*	*0,0*	**4,1 %**	*0,0 %*
Windows	**1 518,3**	**14,5**	**0,29**	**-311,3**	**-3,0**	**-0,1**	**6,3 %**	**0,7 %**
Wood	**3 838,3**	**36,7**	**0,73**	**-31 719,5**	**-303,5**	**-6,1**	**16,0 %**	**69,5 %**

Appendix D



Option 3

Wooden frame main structures
Cellulose Wool insulation

	FU	Quantity	
Foundation			U=0,10
1. Concrete	m3	7	
2. Insulation	m3	14	
3. Reinforcement	kg	450	
4. Flooring	m2	50	
Exterior wall			U=0,09
1. Wooden frame	m3	8	
2. Cellulose wool 520mm	m3	99	
3. Cladding	m3	12	
Interior wall			
1.Wooden frame	m3	4	
2. Sound insulation 60mm	m3	4	
3. Coverings wooden	m3	2	
Intermediate floors			
1. Wooden Frame	m3	4	
2. Flooring	m3	1	
3. Sound insulation 50mm	m3	3	
4. Other wood products	m3	1	
Roof			U=0,08
1. Wood	m3	2	
2. Cellulose wool 600mm	m3	38	
Windows	m2	20	
Interior doors	m2	12	
Roof coverings			
1. Wood	m3	2	
2. Roof cover (metal)	m2	75	

Electricty heating:	18,7	$kWh/(m^2 \cdot a)$
Electricty usage:	38,2	$kWh/(m^2 \cdot a)$
Total:	56,9	$kWh/(m^2 \cdot a)$
Total CO_2:	9327,8	$gCO_{2e}/(m^2 \cdot a)$
Total CO_2:	9,3	$kgCO_{2e}/(m^2 \cdot a)$

Materials:	GWP A1-A3	GWP/HFA	GWP/HFA-year
Building total	12216,85	116,91	2,34

Materials total:	2,34	$kgCO_{2e}/(m^2 \cdot a)$

Budget:	400	$kgCO_{2e}/a$

Usage:	Materials:	
9,3	2,34	**$kgCO_{2e}/(m^2 \cdot a)$**
Total:	**11,7**	

Total:	**34,29**	**$m^2/p.p.a^*$**

$m^2/per.a \times kWh/m^2a \times kgCO_2/kWh = 0,4\ tCO_2/per.a$

Electricty: 164 gCO_2/kWh
Allikas: Motiva, Finland

Building name		
Location	Torppala	
Building lifetime	50,0	years
Building heated floor area	104,5	m2

	GWP A1-A3	GWP/HFA	GWP/HFA-year	Carbon Credit	CC/HFA	CC/HFA-year	**GWP A1-A3**	**CC A1-A3**
Building total	**12 216,8**	**116,9**	**2,34**	**-28 837,7**	**-276,0**	**-5,5**	**100,0 %**	**100,0 %**
Bitumen	**331,7**	**3,2**	**0,06**	0,0	0,0	0,0	**2,7 %**	0,0 %
Cladding - wood	**1 050,0**	**10,0**	**0,20**	**-12 347,9**	**-118,2**	**-2,4**	**8,6 %**	**42,8 %**
Concrete	**1 793,1**	**17,2**	**0,34**	0,0	0,0	0,0	**14,7 %**	0,0 %
Coverings	0,0	0,0	0,00	0,0	0,0	0,0	0,0 %	0,0 %
Doors	**570,1**	**5,5**	**0,11**	**-852,1**	**-8,2**	**-0,2**	**4,7 %**	**3,0 %**
Flooring - wood	**459,0**	**4,4**	**0,09**	**-1 045,5**	**-10,0**	**-0,2**	**3,8 %**	**3,6 %**
Insulation	**3 789,1**	**36,3**	**0,73**	0,0	0,0	0,0	**31,0 %**	0,0 %
Metals	**233,1**	**2,2**	**0,04**	0,0	0,0	0,0	**1,9 %**	0,0 %
Plastics	**992,9**	**9,5**	**0,19**	0,0	0,0	0,0	**8,1 %**	0,0 %
Windows	**1 518,3**	**14,5**	**0,29**	**-311,3**	**-3,0**	**-0,1**	**12,4 %**	**1,1 %**
Wood	**1 479,6**	**14,2**	**0,28**	**-14 280,8**	**-136,7**	**-2,7**	**12,1 %**	**49,5 %**

*Celluloose wool EPD data is based on the „NEPD-427-301-EN ISOVER InsulSafe"

Appendix E

Elements	$kgCO_{2e}$
Basement, doors, load bearing elements	43252,0
External walls	15962,0
Roof	61550,0
Floor	94512,0
Windows	24476,0
Total	**239752,0**

Lifetime	50,0
$kgCO_{2e}$/ a	**4795,0**

Users	500,0
$kgCO_{2e}$/ p.p a	**9,6**

Heating sources	
Energy	Net.Energy Demand
	$kWh/(m^2 \cdot a)$
Room heating	39,9
Ventilation heating	6,6
Domestic Hot Water	9,8
Ventilation and pum	33,3
Lightning	15,0
Appliances	10,1
TOTAL:	**114,6**

	$kWh/(m^2 \cdot a)$	emissions gCO_{2e}/kwh	emissions $gCO_{2e}/(m^2 \cdot a)$	emissions $kgCO_{2e}/(m^2 \cdot a)$	emissions $kgCO_{2e}/a$	emissions $kgCO_{2e}$/p.p.a
PV panels	34,4	40	1375,3	1,38	1529,36	
Grid electricity	80,2	164	13157,2	13,16	14630,84	
Total:			14532,5	14,53	16160,19	**32,32**

Area: 1112 m²
Users: 500

Owner: Maardu municipality
Constructor: Matek. Ehitus5ECO
Desgin: Arhitektuuribüro PLUSS
Inseneribüroo PLUSS

Net area 1112 m2
Occupants: 80 children

Material quantitites and emissions:
Targo Kalames

Energy demand:
Endrik Arumägi

Emissions based on LCA tool created by Nicola Lolli

Materials:	GWP A1-A3	GWP/HF A	GWP/HF A-year
Building total	239752,00	215,60	4,31

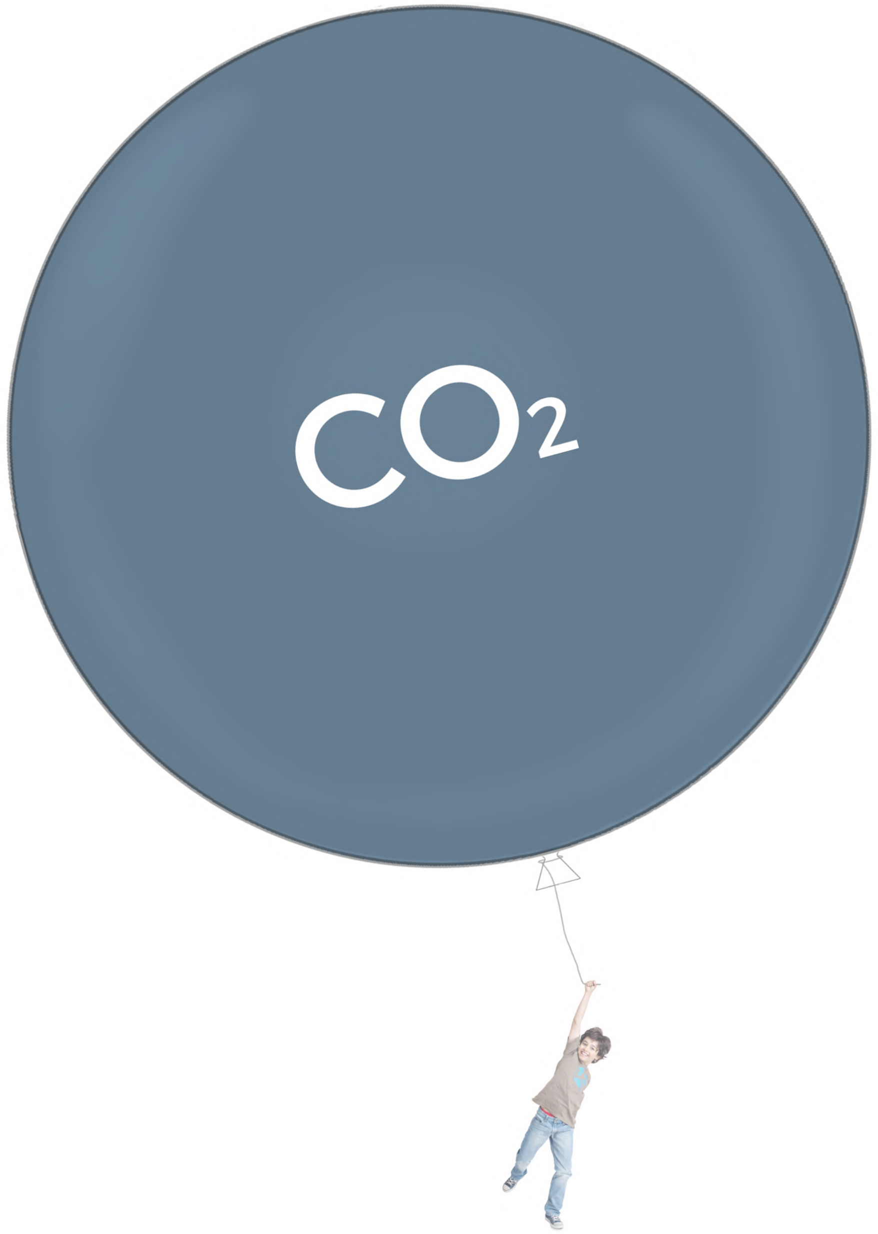
Materials total:	9,59	$kgCO_{2e}/(m^2 \cdot a)$
Budget:	50	$kgCO_{2e}/(m^2 \cdot a)$

Usage:	Materials:	
32,32	9,59	**$kgCO_{2e}/(m^2 \cdot a)$**
Total:	**41,9**	

Total:	**1,19**	**m²/p.p.a**

$m^2/per.a \times kWh/m^2a \times kgCO_2/kWh = 0{,}05\ tCO_2/per.a$

PV: 40 gCO_2/kWh
Electricty: 164 gCO_2/kWh
Source: Motiva 2018


CO2


CO2