

Towards a Carbon-negative City

– Summary of an Expert Survey

Susa Eräranta



Helsinki

The logo for Helsinki, featuring the word "Helsinki" in a white, sans-serif font inside a white speech bubble shape with a drop shadow, set against a dark blue background.

Helsinki

**Towards a Carbon-negative City: Summary of an
Expert Survey**

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Contents

FOREWORD	4
1 INTRODUCTION	5
1.1 The aim of the survey.....	5
1.2 Responses	6
2 PRECONDITIONS FOR CARBON-NEGATIVE CITY PLANNING	7
3 PRECONDITIONS FOR ACHIEVING A CARBON-NEGATIVE CITY	10
3.1 Construction	10
3.2 Mobility.....	13
3.3 Natural environment.....	18
3.4 Summary of the three key themes.....	21
3.5 Other themes raised.....	22
4 LIVING IN A CARBON-NEGATIVE CITY	24
References	26
Appendix 1: Carbon Negative Helsinki Expert Survey (English)	27
List of Tables	31
List of Figures	32

Foreword

The City of Helsinki aims to be [1] carbon-neutral by 2030, zero-carbon by 2040, and thereafter carbon-negative. Taking into account that the carbon-neutrality target set in 2030 means the city must cut its CO₂ emissions by 80% compared to the 1990 level and the remaining 20% can be compensated outside the city limits, the transfer to zero-carbon already requires balancing the CO₂ emissions produced and sequestered by the city inside the city borders. Carbon-negativity, on the other hand, means that the emissions produced inside the city borders must be lower than its ability to sequester carbon within its geographical borders.

In order to concretise the target, a background information report has already been compiled based on a literature review and expert discussions on the key planetary boundary conditions that must be taken into account in the work [2]. As a follow-up to this, an expert survey was carried out in May 2023 to test the identified boundary conditions and to identify the necessary concrete actions and change needs. This report is based on the responses received through the survey and serves as background information for the next steps of the process.

We would like to thank all the respondents for their valuable contribution to clarifying the planetary boundary conditions and concretising the carbon-negativity target.

Helsinki 8 September 2023,
Susa Eräranta

1 Introduction

The City of Helsinki aims to be carbon-neutral by 2030, zero-carbon by 2040, and thereafter carbon-negative [1]. Taking into account that the carbon-neutrality target set in 2030 means the city must cut its CO₂ emissions by 80% compared to the 1990 level and the remaining 20% can be compensated outside the city limits, the transfer to zero-carbon already requires balancing the CO₂ emissions produced and sequestered by the city inside the city borders. Carbon-negativity, on the other hand, means that the emissions produced inside the city borders must be lower than its ability to sequester carbon within its geographical borders. Current emission reduction measures are not sufficient to reduce emissions to a level equivalent to carbon sinks [3].

As the set targets are new, not all solutions for achieving them are yet known. However, a carbon-negative city is already being planned for decades to come, so it is important to make sure that the solutions created today will also work in a carbon-negative city after 2040.

1.1 The aim of the survey

In order to identify concrete solutions that enable carbon-negativity, the City of Helsinki organised a Carbon-Negative Helsinki expert survey in May 2023. The aim of the survey was to support the concretisation of a carbon-negative future, in addition to which the responses can be used in the later stages of the process and for research

purposes that promote understanding of the topic.

The survey was organised in Finnish and English and sent out to targeted experts from Finnish and international research institutions, universities, think tanks and the City of Helsinki and some other cities (altogether 66 people), who have worked on themes closely related to the target. In addition, those invited to respond to the survey were given the opportunity to share the survey with a few experts they considered to be central to the topic. The aim was not to maximise the number of respondents, but for the responses to be justified and based on commonly used definitions as well as knowledge of the operating environment. All survey responses were anonymous. The aim of the targeted survey was to ensure that the respondents are familiar with the definitions related to the target, as well as the research literature and practices that are relevant to the topic. This was considered important in concretising the target and the measures, as significant challenges have been previously identified in the process due to the confusion of different climate targets and their definitions, target levels and boundaries.

The survey was divided into two sections: themes on the prerequisites for achieving a carbon-negative city, and envisioning life in a carbon-negative city. Respondents could choose which themes to respond to based on their own special expertise. The survey outline can be found in English in Appendix 1.

1.2 Responses

A total of 15 experts responded to the survey, ten of them in Finnish and five in English.

Responses in Finnish have been translated into English and responses in English are presented as such. However, the responses have been classified differently from the survey outline. Some of the responses have been divided into several parts during the classification of the material, so that their comparison and achieving an overall understanding is thematically possible. The thematic classification is based on previously identified [3] key themes from the perspective of the carbon-negativity target, which the city can influence through its own actions:

- **Construction;**
- **Mobility;** and
- **Natural environment** (e.g., carbon sinks).

It is important to note that not all of the measures suggested in the responses directly contribute to the carbon-negativity target or previously identified planetary boundary conditions. Therefore, the responses cannot be utilised directly as a planning guide for a carbon-negative city, but it rather requires further work and specifications.

2 Preconditions for carbon-negative city planning

When planning a carbon-negative city, it is also important to take into account other expected changes. The key planetary boundary conditions [2] for planning a carbon-negative city previously identified in the work are:

- **Emissions reduction need:** The emissions reduction need is critical, and emission-intensive solutions should be avoided.
- **Material limitations:** The solutions must also work in a resource-scarce world and rely on existing infrastructure. Therefore, the presented solutions cannot be based only on new technology.
- **Biodiversity loss:** The solutions cannot accelerate biodiversity loss. The preservation of vegetated areas and the replacement of lost vegetated areas must be ensured.
- **Warming:** The passive resilience of the living environment must be ensured. Solutions that accelerate the urban heat island phenomenon should be avoided.
- **High precipitation:** In critical infrastructure, the increased risk of storm water flooding should be prepared for. Increasing the amount of permeable soil must be ensured.
- **Windiness:** Preparation for increasing storm damage both in terms of infrastructure and nature must be ensured.
- **Rise in the sea level:** Preparations should be made for increased risks of seawater flooding.

One of the aims of the survey was to ensure that key boundary conditions for the target are not ignored. In addition to the above, respondents were able to name other themes if they thought that they should be featured more prominently.

In terms of boundary conditions, mainly clarification needs for already identified boundaries, such as material limitations and global warming, were raised. In terms of materials, it was considered important to emphasise more clearly that solutions cannot be based on scarce materials or materials that cause environmental burden. In terms of warming, the respondents recommended paying attention to passive solutions in addition to active cooling solutions and taking into account the effects of increasing drought. In addition to these, a new proposal for limiting the chemical load emerged from the planetary boundary conditions.

In addition to planetary boundary conditions, several respondents emphasised the need for stronger consideration of justice-related perspectives and impacts, as well as identifying the theme's key actors. Based on the observation, a background study based on a literature review and expert interviews [4] was carried out in the summer of 2023 from the perspective of justice in order to identify its key themes. In addition to these, the report discussed methods on how to take the theme more strongly into consideration in the process in the future.

Some respondents also noted that nothing essential is missing from the list of already identified boundary conditions.

The responses related to the specification of boundary conditions are presented in Table 1.

Table 1. The responses related to the specification of previously identified boundary conditions.

Specifications to previous boundary conditions	<p>Materials</p> <ul style="list-style-type: none"> • <i>“Critical materials (as a specification to section2?) - Solutions cannot be based on materials that are scarcely available and/or the procurement of which causes environmental issues elsewhere.”</i> • <i>“Somehow this is a bit covered by ‘Material limitation’ but not very explicit. Moreover, high precipitation, (warming) and windiness looks mostly at causing ‘damage to the city’: theoretically this could be merged as e.g. ‘damages through extreme events’ or alternatively as ‘structural adaptation (of the city structure) to extreme events’. While you looking at ‘emission reduction needed’ (which I found a bit generic) I am missing ‘potential for mitigation of emissions.’”</i>
	<p>Warming</p> <ul style="list-style-type: none"> • <i>“For (4 [warming]) I think passive needs to be encouraged as much as possible, but there may be a point when active measures become necessary.”</i>
	<p>Drought</p> <ul style="list-style-type: none"> • <i>“We wondered whether drought and fire hazard/wildfires could also be relevant for Helsinki.”</i>
Justice	<p>Social justice</p> <ul style="list-style-type: none"> • <i>“Social justice. Now the upper limits of the doughnut model are mentioned, but the lower limit is missing.”</i> • <i>“There is a floor as well as a ceiling. The planetary boundaries are best used in combination with minimum criteria (socioeconomic as well as ecological) that should be met. There’s plenty of social aspects missing from your list, things that should be considered as well. Also, just as climate change has been broken down into several challenges biodiversity loss could be unpacked and made more specific (invasive species, changed trophic interactions etc.). Guess climate is in focus here, but it should not be treated as separate from other sustainability issues.”</i>
	<p>Health, well-being and safety</p> <ul style="list-style-type: none"> • <i>“The solutions should increase the well-being, health and safety of the residents.”</i> • <i>“There are substantial health benefits in taking these mitigation actions.”</i>
	<p>Global justice</p> <ul style="list-style-type: none"> • <i>“You look very much at only local impacts and boundary conditions: doesn’t it make (more) sense to include also spill-over effects and try to reduce impacts there as else there is a high risk of while becoming locally green simply exporting impacts to elsewhere.”</i> • <i>“Sustainability-relevant dependencies of the construction and use of local built environments and infrastructure on resource inputs from other parts of the world, as well as sustainability-relevant consequences of local built environment and infrastructure development beyond the local community. A relevant empirical source for the former is a database offered by the European Union (Ciuta & Ciupagea, 2019).”</i>
New identified boundary conditions	<p>Chemicalisation</p> <ul style="list-style-type: none"> • <i>“The chemical load should not increase.”</i>

<p>Nothing is missing</p>	<p>Nothing is missing</p> <ul style="list-style-type: none"> • <i>“Fundamental planetary boundary conditions are probably there to some extent. The need to reduce emissions is most often considered separately from this context, but it can and perhaps should be seen on this list. The city’s other targets, in particular the target to grow, are a whole different thing. This is not a planetary boundary condition even though it is clearly the most important driver/boundary for urban planning. So there is nothing missing.”</i> • <i>“In my opinion, nothing essential is missing and the boundary conditions correspond to the list created in the workshops.”</i> • <i>“No”</i> • <i>“Not missing”</i>
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3 Preconditions for achieving a carbon-negative city

In the second section of the survey, the respondents were asked to describe by theme (urban structure, buildings and spaces, mobility, cityscape, green structure, other theme) what it would take to achieve the carbon-negativity target. As a result, the responses describe the future carbon-negative city and the actions required by it, not the city as it currently stands.

3.1 Construction

As the city grows [1], one of the most important emission themes in terms of the carbon-negativity target is construction, which, even if realised sustainably, is most often a source of emissions. The following construction-related themes were raised:

- Reducing unit emissions from construction;
- Expanding the use of existing infrastructure and highlighting the importance of renovation construction; and
- Increased need for cooling.

Reducing unit emissions and amount of emissions from construction

The most important factors raised from the perspective of unit emissions in construction was utilising low-emission building materials and steering towards low-emission construction solutions. The responses related to the topic are presented in Table 2.

Expanding the use of existing infrastructure and highlighting the importance of renovation construction

In addition to reducing unit emissions from construction, the responses highlighted the need to reduce the total amount of new construction. The essential measures for this were, for example, the utilisation of existing buildings and other infrastructure for transformative use, as well as increasing the flexible sharing of premises. In order to reduce the total amount of new construction, the responses emphasised the significance of renovation construction and building the city upwards, while taking into account the implementation of other planetary boundary conditions (e.g., through carbon sinks, soil permeability). The responses related to the topic are presented in Table 3.

Table 2. The responses related to the number of unit emissions in construction.

Low-emission construction materials	<p>Buildings</p> <ul style="list-style-type: none"> • <i>“Also increasing solar panels to buildings and as low-emission construction materials as possible, such as low-emission concrete, and different circular economy solutions, for example, in moving land masses or material recycling should be utilised in full.”</i> • <i>“As building material wood (as short term carbon sink) should be preferred.”</i>
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Table 3. The responses related to expanding the use of existing infrastructure and highlighting the importance of renovation construction.

<p>Utilising existing buildings for transformative use</p>	<p>Buildings</p> <ul style="list-style-type: none"> • “A new kind of thinking is required for adapting premises to new uses. Current standards must adapt, in exchange we will have buildings with interesting and creative solutions.” • “Flexible zoning is usually called for, but is it only flexible once (from business premises to residences), after which it is no longer possible to be flexible in the other direction due to ownership issues?” • “New buildings are designed to be flexible and local detailed planning ensures agile changes in premises’ purpose of use.” • “Nothing new is built until it has been determined whether the new function could fit in an already existing space.” • “Sufficiency - very limited new construction, but rather making use of existing spaces.” • “The city of Copenhagen are currently attempting something similar by trying to build a complete new city quarter as a carbon negative quarter together with Home.Earth (https://www.home.earth/). You may look into their approaches. I guess one of the general problems is that completely rebuilding of Helsinki is not planned so one has to build/re-shape existing.”
<p>Flexible sharing of premises</p>	<p>Buildings</p> <ul style="list-style-type: none"> • “Sharing spaces as efficiently as possible.” • “The shared use of spaces has been developed so that there are only a few empty spaces.”
<p>The growing role of infill renovation construction</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • “New construction as such becomes marginal, moving to different forms of infill construction.” • “Renovations and infill renovation construction are preferred instead of new construction.” • “New construction should be limited where possible, and more weight should be given to renovation, from a consumption-based emissions perspective.” <p>Buildings</p> <ul style="list-style-type: none"> • “In the future, construction must focus significantly on renovation/energy renovation construction.” • “The knowhow for renovation construction and the best solutions for the climate and nature will be absorbed by new experts already in educational institutions.” • “The relationship between renovation construction and new construction must be constantly examined to see which causes more emissions. It depends entirely on the development of building materials and, on the other hand, on the development of renovation construction techniques.” • “Energy efficient retrofit as well as increased use of e.g. solar and geothermal heating.”

Increased need for cooling (active/passive)

Regarding the planetary boundary condition of warming, the responses highlighted the increased need for cooling in construction. Based on the responses, it is important to take into account how to improve the passive resilience of buildings in addition to active cooling solutions. The responses related to the topic are presented in Table 4.

Impacts on the cityscape: The cityscape is diversifying and the role of carefully regulated aesthetics is changing

It was suggested that changes required in construction would lead to the diversification of the cityscape and a change in the role of carefully regulated aesthetics as the city is increasingly built on reused materials available at the time. The responses related to the topic are presented in Table 5.

Table 4. The responses related to the increased need for cooling (active/passive).

Improving passive resilience	<p>Blocks</p> <ul style="list-style-type: none"> • <i>“Planning and building permits have directed towards almost passive construction and created a city free of the heat island phenomenon with the help of urban green spaces.”</i> • <i>“Buildings are designed primarily with passive design strategies in mind (building orientation: enabling passive heat and passive ventilation; optimal solar energy collection and distribution networks; building massing: good natural light conditions; attention to green and social infrastructures that promote health and well-being; good connections to the green environment and neighborhood functions, lush plots, pleasant microclimate)”</i>
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Table 5. The responses related to the cityscape impacts of construction activities.

Diverse cityscape	<p>Cityscape</p> <ul style="list-style-type: none"> • <i>“A carbon-negative city looks like its users: in terms of cityscape, it is layered and rich. The cityscape is a patchwork of different eras that also shows the principles of the circular economy: since we can’t always know in advance what kinds of elements will be used in construction and what they will look like, the most important feature of the cityscape is that it is meaningful and cosy for people.”</i> • <i>“The cityscape can be more layered and ‘richer’. What has been recycled can be aesthetically high-quality and interesting.”</i> • <i>“The city is built from reused materials and shows more freely the user’s handprint: projects started by communities are given space and visibility.”</i>
	<p>Buildings</p> <ul style="list-style-type: none"> • <i>“The city looks largely the same as it does today. The use of circular economy materials is compulsory from the perspective of life cycle emissions, and this is visible in renovation and new construction. Aesthetic values have diversified in these respects.”</i> • <i>“Buildings are diverse as their design is guided by the availability of recycled materials and not the designer’s aesthetic vision.”</i>

3.2 Mobility

Mobility was identified as another key theme for a growing city’s carbon-negativity. Emissions from mobility are strongly linked to mobility needs, so the responses related to the actual urban structure are also discussed in connection with this theme. In terms of mobility, the themes highlighted were:

- Reducing unit emissions from transport by increasing the relative amount of active and sustainable mobility;
- Reducing mobility needs through means of urban structure; and
- Utilising existing transport infrastructure to increase the share of active and sustainable mobility.

Reducing unit emissions from transport by increasing the relative amount of active and sustainable mobility

The key themes for reducing unit emissions from transport were the means that increase the relative role of active and sustainable mobility, such as increasing the fluency of travel chains and increasing a network that supports active and sustainable mobility. The responses related to the topic are presented in Table 6.

Reducing mobility needs through means of urban structure

Reducing the need for mobility was highlighted as an essential theme from the perspective of reducing

emissions from mobility. In terms of everyday mobility, the need for mobility is strongly linked to the urban structure, and the means emphasised were densifying the areas with already good accessibility, increasing a mixed community structure and increasing local services to enable local life. The responses related to the topic are presented in Table 7.

Utilising existing transport infrastructure to increase the share of active and sustainable mobility

In a growing city, there may also be pressure for the transport infrastructure to grow. However, from the perspective of the emission reduction target, the responses emphasised the need to minimise the amount of new infrastructure and redistribute existing infrastructure to increase the relative amount of active and sustainable mobility in a situation where available space is limited. The responses related to the topic are presented in Table 8.

Impacts on the cityscape: The perspective of slow-moving people is highlighted

In terms of the cityscape, it was suggested that the need for change would lead to an emphasis on the perspective of slow-moving people, setting new requirements, for example, on the dimensioning, structure and rhythm of urban and street spaces. The responses related to the topic are presented in Table 9.

Table 6. The responses related to the reduction of transport unit emissions.

Increasing the fluency of travel chains	<p>Transport system</p> <ul style="list-style-type: none"> • <i>“Even in a carbon-negative city, we have to get to work, even practical work, using public transport and also outside of office hours. The chains for using different means of transport are in active use; for example, trains have more space and carriages for cyclists.”</i> • <i>“The urban structure has safe and clear routes between residential environments, services and green spaces so that people from as many starting points as possible can operate there.”</i> • <i>“Owning a car is rare, and the majority of people utilise a mobility-as-a-service solution when they need a car to go, for example, to their summerhouse or on a trip. Using cars as a service has been made more attractive than owning one with, for example, parking pricing, and the use/per-kilometre performance of the car is influenced through road tolls.”</i> • <i>“Public transport must be competitive in terms of time and costs when compared to one’s own car.”</i>
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<p>Increasing the network supporting active and sustainable mobility</p>	<p>Transport system</p> <ul style="list-style-type: none"> • <i>“The mobility environment is accessible and, above all, comfortable so that it encourages people to use it.”</i> • <i>“It is important to ensure that public transport and bicycle routes always form a more attractive and direct route than car routes. Therefore, the transport network must be designed so that so-called calm mobility cells/blocks are formed, where the local network is protected from car traffic, and car traffic circulates along the main network to the destination, when it can be reached directly with, for example, a bike. A high-quality walking environment, on the other hand, attracts people to use public transport and their own local surroundings so that they don’t feel a constant need to leave their neighbourhood to refresh themselves, but sometimes their own home street can also offer this opportunity.”</i> • <i>“Public transport and cycling infrastructure have been implemented with such high quality that their use is more attractive than driving a car.”</i> • <i>“The dimensions of the street space must correspond to the traffic prioritisation order decided in Helsinki: walking, cycling, public transport, distribution transport, passenger car traffic. A carbon-negative city has extensive walking areas and public transport streets, as well as comprehensive and unambiguous cycling main roads that also serve electric scooters. Driving private cars has been severely restricted, and there is no street-side parking in the city centre.”</i> • <i>“Public transport solutions based on rail traffic are comprehensive.”</i> • <i>“In a carbon-negative city, driving is secondary, maybe even unattractive.”</i> • <i>“Trips are made as far as possible by foot, bicycle or public transport. Electric micro-mobility devices also have a role to play.”</i> • <i>“Mobility is mainly carried out by public transport and muscle power. Electric vehicles have been abandoned as a solution due to the poor availability of battery materials.”</i> • <i>“Better biking conditions, in the form of separate bikepaths as well as bike lanes (including bike lanes in the opposite direction of streets with one-way car driving) should also be implemented.”</i> • <i>“Mobility through mainly muscle driven or alternative energy powered vehicles (material transport, people, services)”</i> • <i>“Road pricing should also be implemented - such solutions have been in place in several Norwegian cities (including Oslo) for many years.”</i> • <i>“Cycle paths, public transport. Services should be walkable.”</i> • <i>“There should be fewer private cars and heavy duty transport, sufficient public transportation and more designated cycling lanes than car lanes. Bicycles and walking should be the prime forms of transportation.”</i>
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Table 7. The responses related to reducing mobility needs.

<p>Reducing mobility needs</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“The need for mobility has to be reduced, but people probably change jobs more often than they change homes. Also for other reasons, it is too simplistic to assume that everyone could live close to their workplace.”</i> • <i>“The need for mobility in a carbon-neutral city is small. This is made possible by a dense urban structure.”</i> • <i>“In a carbon-negative city, we move in a smaller territory, but when moving further away, it usually happens on tracks.”</i> • <i>“In a carbon-negative city, we move within our own 15-minute city to things that matter to us (work, school, leisure, recreation) on foot, by bicycle or by public transport. Moving further away is possible, but not necessary in everyday life. Infrastructures are spread evenly and serve people regardless of their socio-economic status.”</i>
<p>Densifying the areas with already good accessibility</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“A carbon-negative city does not necessarily seek growth or expansion: it becomes denser wisely and takes care of those who already live there (zero growth).”</i> • <i>“Locating business premises, in particular, in the top public transport nodes is important, so that people can choose their jobs flexibly and without the need to consider getting a car. Land use is particularly intense at these public transport nodes. The urban structure does not sprawl out, and thus it is possible to rely on existing municipal engineering infrastructure and ensure short distances that people can cover with their own muscle power between as many activities as possible.”</i> • <i>“In addition, sufficient density in railway hubs, for example, is really important so that the green areas can be saved more extensively elsewhere.”</i> • <i>“A carbon-negative city is compact, with high densities especially in the central and inner parts. Office workplaces should be located to areas where accessibility by transit is high and accessibility by car is low. The same applies to other visitor-attractive functions that do not generate much freight transport. Such areas are first and foremost in the inner city, but maybe also in major second-order centers if car accessibility is suppressed.”</i> • <i>“The building stock size per capita and the mobility level in affluent European cities is arguably already higher than what could be realized globally without enormous negative environmental impacts. Given that planetary limits to growth in consumption exist, overconsumption in the global north could be seen as a hindrance for economic development in the global south. There is thus a need to combine resource-efficient urban development principles with a halt in, or even reversal of, the per capita growth in building stock, combined with radical redistribution of floor space and urban space. Today, radical policies and measures necessary for a transition to sustainable development are often deemed unrealistic and impossible. This situation calls for transformative societal change, where social structures, practices and cultures currently blocking sustainability transitions should be superseded with conditions enabling environmentally and socially sustainable pathways.”</i> • <i>“How to restructure a city by building on old infrastructure? Or can be build new from scratch.”</i>

<p>Increasing the mix of urban structures</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“The goal should be a mixed community structure, where a good everyday life is possible within a 15-minute walk.”</i> • <i>“Mixed urban structure.”</i> • <i>“In a carbon-negative city, the functions of buildings blend and overlap, supporting the principles of a 15-minute city.”</i> • <i>“Reduced need for cars, walkable.”</i> • <i>“Specialized functions should be located in the city center or in major second-order centers unless they need a large amount of area per employee or visitor, or generate much freight transport. Cf. the Dutch ABC model. Co-location of jobs and housing is climate-friendly if this takes place in the inner city, but co-location of housing and (specialized) jobs in the suburbs tends to generate a high share of car commuters, since most employees will normally be recruited from outside the local neighborhood, and because transit accessibility is normally poorer and car accessibility normally better in the suburbs than in the inner city.”</i> • <i>“Mixed use, so that services are nearby.”</i> • <i>“Consider the integration of utilities and similar functions in a multifunctional way in the city landscape.”</i>
<p>Increasing the number of local services</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“A carbon negative city is a 15-minute city in which services and green structure are part of the daily operating environment. In a carbon-negative city, people get around primarily by public transport, on foot or, for example, by bicycle, and all the services needed in everyday life can be reached using the aforementioned modes of transport.”</i> • <i>“However, people still go to their workplaces at least part-time. On the other hand, placing local services, especially daycare centres and schools, close to homes is essential. A sufficiently dense network, even if the units are smaller than what is the current trend!”</i> • <i>“A compact 15-minute city where there is also a lot of green.”</i> • <i>“Different daily functions, such as housing, services and workplaces, are located within short distances of each other.”</i> • <i>“In a carbon-negative city, there are a lot of vibrant, distinctive urban centres that have all the functions that local residents need, but there is also a vibrant, large city centre accessible by public transport.”</i> • <i>“In a carbon-negative city, people use emission-free modes of transport. In mobility, nearby destinations are emphasised, in general, the sphere of life is more physically compact.”</i> • <i>“Non-specialized services regularly visited by residents should be located interspersed with residential areas in local centers with good transit accessibility.”</i> • <i>“Shared services.”</i> • <i>“There should be a focus on leisure and liveability more than consumerism and shopping for city spaces.”</i>

Table 8. The responses related to the utilisation of existing transport infrastructure.

<p>Redistribution of existing transport infrastructure</p>	<p>Transport system</p> <ul style="list-style-type: none"> • <i>“The urban structure enables and actively guides towards zero-emission mobility. However, it must be understood that in order to achieve such an urban structure, no significant emissions can be produced, so the existing infrastructure must be used to the maximum, in practice this means the redistribution of space required by transport modes.”</i> • <i>“The capacity of car traffic has also been proportioned so that more and more space from the street area is reserved for sustainable modes of transport and only the absolutely necessary space for cars.”</i> • <i>“The street space for cars has been clearly narrowed, and the space is used by other modes of transport, companies and events.”</i> • <i>“The city is not planned for driving a private car, and the space taken up by driving has mainly been put to other uses.”</i> • <i>“Sufficient space for operations is ensured so that fewer parking spaces that take up a lot of space and cause construction emissions are built.”</i> • <i>“Road capacity increase should be avoided. Instead, existing lanes on multilane roads should be converted to dedicated transit lanes and/or bikepaths.”</i> • <i>“I have already answered much of this above. Road and parking capacity should not be increased. Instead, better transit provision should be prioritized. Converting car lanes on multi-lane roads into transit lanes (as was, among others, done with great success fifteen years ago in the Norwegian city of Trondheim) should be part of the mobility policy, along with reduction of parking space in the city center, sub-centers and major workplace areas.”</i> • <i>“There should be less room for cars and more room for green spaces integrated throughout the city.”</i> • <i>“Urban space should first and foremost give space for pedestrians, bicyclists and transit travelers. Car driving and parking should occupy much less space than currently in most cities. Necessary goods transport should not be hindered, but it could be regulated to take place in specific time-slots o the day.”</i>
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Table 9. The responses related to the cityscape impacts of mobility activities.

<p>The perspective of slow-moving people is highlighted</p>	<p>Cityscape</p> <ul style="list-style-type: none"> • <i>“The cityscape and the notion of aesthetics are primarily defined by the notion that humans are not above nature. This requires quite a lot of redefinition of what we consider to be good architecture. Street spaces have been planned so that a slow-moving person who observes the details of the environment is at the heart of the scale, material choices and the design of the street green spaces and furniture. The mobility function is larger on the main network’s streets than in the local network; however, all in all, street space is no longer perceived mainly through its traffic function, but social, ecological and comfort-related values are taken into consideration with equal weight.”</i>
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3.3 Natural environment

The third key theme raised in the responses to the carbon-negativity target and other planetary boundary conditions was the natural environment. In this regard, the following themes were highlighted:

- Preserving existing permeable soil and vegetation and increasing their amount; and
- Increasing the number of urban green spaces that provide shade and enable evaporation.

Preserving existing permeable soil and vegetation and increasing their amount

In terms of preserving and increasing soil and vegetation, the responses raised the issue of increasing carbon sequestration and adaptability. In order to meet these needs, in the future, construction should strive to avoid existing urban green spaces and permeable soil, in addition to which the number of urban green spaces and the amount of permeable surface should be increased, such as in connection with infrastructure renovation projects. The responses related to the topic are presented in Table 10.

Increasing the number of urban green spaces that provide shade and enable evaporation

Increasing the number of urban green spaces that provide shade and enable evaporation was linked to improving the adaptability to increased warming and high precipitation instead of actual carbon negativity. When the number of urban green spaces is increased, it is important that the increase simultaneously meets the needs of as many planetary boundary conditions as possible. The responses related to the topic are presented in Table 11.

Impacts on the cityscape: The cityscape grows more lush

It was suggested that development needs related to the natural environment would lead to an increase and diversification of the cityscape's greenery. The responses related to the topic are presented in Table 12.

Table 10. The responses related to preserving existing permeable soil and vegetation and increasing their amount.

<p>Increasing the amount of carbon sinks</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“Carbon sinks are actively created in existing field areas and perhaps at sea.”</i> • <i>“Regarding sequestering capacity, it is important to avoid sub-optimalization - it will not be helpful to avoid transforming villa areas into dense urban districts for the sake of protecting garden greenery if this pushes the construction of new buildings outward to forest areas or farmland, where the land consumption per dwelling or per workplace will normally be much higher.”</i>
<p>Increasing the number of urban green spaces</p>	<p>Urban structure</p> <ul style="list-style-type: none"> • <i>“In an urban structure, it is also important to have sufficiently extensive solid green areas where human activities are as minimal as possible and the species range is abundant and healthy. On the other hand, it is also important to look at the green of the urban space at the network level, so that there is green in every neighborhood in the immediate vicinity of the home, for example, to combat the heat island phenomenon.”</i> • <i>“The green structure is integrated as part of a densifying city through determined planning management: its creation is constantly supported and promoted, especially the enrichment of biodiversity is encouraged by all available means.”</i> • <i>“The importance and significance of the green structure has been emphasised very much. The development of the urban structure is not possible by reducing green values.”</i> • <i>“Nature is not a separate entity from the city, but ecological systems (green structure) and the man-made system are intertwined with each other.”</i> • <i>“Infill development is planned to preserve as much existing green areas as possible. New residential areas are not placed in existing green areas at all.”</i> <p>Blocks</p> <ul style="list-style-type: none"> • <i>“According to studies, the physical and visual accessibility of green environments increases the physical and mental well-being of residents (both human and non-human).”</i> • <i>“Green as part of the city: on rooftops, walls, traffic islands, plazas, parking lots.”</i> • <i>“Nature is integrated into the cityscape, and the overall look is green, even in a city made of stone. Green is integrated into roofs, wall elements, noise protection walls, etc. As aesthetic perceptions change, urban nature looks wilder than at present.”</i> • <i>“More green integrated infrastructure. Not just in parks, forests, but also on streets and rooftops.”</i>
<p>Increasing the amount of permeable surfaces</p>	<p>Blocks</p> <ul style="list-style-type: none"> • <i>“Increasing the amount of permeable soil in connection with all infrastructure renovation projects.”</i>

Table 11. The responses related to increasing the number of urban green spaces that provide shade and enable evaporation.

Increasing adaptability	<p>Blocks</p> <ul style="list-style-type: none"> • <i>“Green structures are the most important feature of a carbon-negative city. Green environments help adapt to the effects of the climate crisis, for example, by lowering the average temperature in cities and delaying stormwater.”</i> • <i>“Green areas in the spaces between everything else provide room for snow stacking and they absorb stormwater. Trees are primarily cooling and shade-producing structures rather than carbon sinks.”</i> • <i>“Green structures retain stormwater and produce a good microclimate. It is justified to have a lot green around.”</i> • <i>“The green structure is primarily important for public health and outdoor recreation and as an esthetic amenity, and as permeable surfaces in cases of hard rainfall. It can also counteract the urban heat island, but this is normally a very big problem in Nordic cities given the current and also the expected future summer temperatures at our latitudes. Moreover, it should be remembered that urban sprawl tends to increase the urban heat island if new suburbs are built on previous forest areas.”</i>
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Table 12: The responses related to the cityscape impacts of the natural environment activities.

The cityscape grows more lush	<p>Cityscape</p> <ul style="list-style-type: none"> • <i>“Above all, the cityscape is lush, downright wild. There is less and less stone and asphalt in the cityscape, and the most prominent plant in a park is not grass as they are instead biodiversity-rich and multi-species environments (which also require significantly less resources to maintain than grasslands with poor biodiversity).”</i> • <i>“Lush, cyclist-friendly, less asphalted. Green areas are more diverse, not just grassy patches.”</i> • <i>“There is more green on the street, rooftops and walls.”</i> • <i>“There is considerably more green on the street than there is now.”</i> • <i>“The city is significantly greener in its overall appearance, as green on the street and integrated green solutions have been brought to even the most urban environments.”</i>
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3.4 Summary of the three key themes

Based on the responses for the three key themes (construction, mobility + urban structure, natural environment), the following factors in particular are highlighted. They are further divided to match the planetary boundary conditions in Figure 1.

Construction

- Reducing unit emissions and amount of emissions from construction.
- Expanding the use of existing infrastructure, highlighting renovation construction.
- Increasing the amount of permeable soil.
- Increasing cooling
- > **The relative role of infill renovation construction increases as the city densifies upwards in existing high accessibility areas. Completely new construction areas are not reserved from areas that are significant for planetary boundary conditions.**

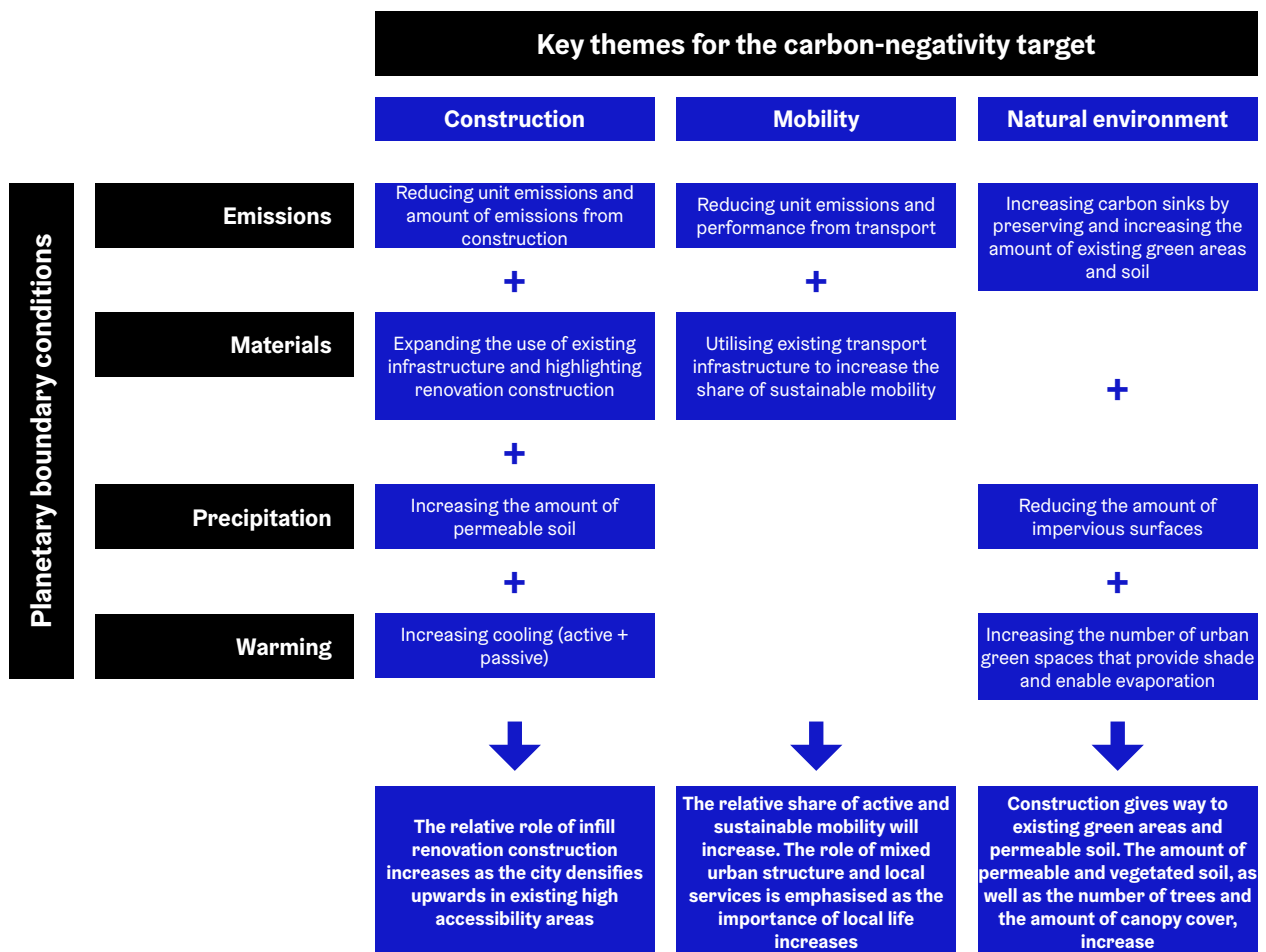
Mobility

- Reducing unit emissions and performance from transport.
- Existing transport infrastructure is utilised to increase the share of active and sustainable mobility.
- > **Increasing the relative share of active and sustainable mobility by supporting the role of a mixed urban structure, local services and local life.**

Natural environment

- Preserving and increasing carbon sinks by preserving and increasing the number of existing green areas and soil.
- Reducing the amount of impervious surfaces.
- Increasing the number of urban green spaces that provide shade and enable evaporation.
- > **Construction gives way to existing green areas. The amount of permeable and vegetated soil, as well as the number of trees and the amount of canopy cover, increase.**

Figure 1: Summary of the three key themes.



3.5 Other themes raised

In addition to the three main themes presented above, six other themes were raised. They are related to the target more loosely or their situation, according to studies [3], will be significantly improved by other actions already being carried out. However, these responses have also been reported for possible further use in Table 13. The other themes identified in the responses are:

- Energy;
- Food production;
- Compensation;
- Regional perspective;
- Holistic approach; and
- Inclusion.

Table 13: The responses related to the other themes raised.

Energy	<ul style="list-style-type: none"> • <i>“A carbon-negative city runs on renewable energy.”</i> • <i>“Local forms of energy production, such as geothermal heat or small nuclear power plants, should be taken into account as space reservations in local detailed plans.”</i> • <i>“Energy production may also be visible in the city in a different manner. Industrial-scale offshore wind power is likely to be examined as the overall electrification progresses and the need for electricity continues to grow.”</i> • <i>“Any fossil fuel driven car should be banned, el-vehicles fed from alternative energy sources from roof tops.”</i> • <i>“Green biotechnology needs to be fueled by green energy.”</i>
Food production	<ul style="list-style-type: none"> • <i>“Food provision through urban gardening (local) or commercially through vertical gardens (outside buildings) or UV-LED powered (inside) growing houses to keep transportation costs low. Buildings for Lab-grown meat (?), using Insects (crickets and other edible insects) and fungi (Quorn, yeasts).”</i>
Compensation	<ul style="list-style-type: none"> • <i>“Any emission (during the building process, while operating and later decommission of buildings/streets) needs to be compensated by a sink source. These can be natural vegetation or technical solutions (CCA-technology, that still needs to be developed). Using natural vegetation would need 1:2 or 1:3 (building to vegetation ratio) for compensation. As building material wood (=extracted and solidified CO2 from atmosphere) should be used.”</i> • <i>“Mainly need to (over-)compensate for all emissions? Across what timescales? Does this include the building-, using-, maintenance- and/or house demolishing phase as well?”</i> • <i>“Next to natural vegetation, what other technologies for CCA are available?”</i>

<p>Regional perspective</p>	<ul style="list-style-type: none"> • <i>“We also need to take into account the wider context of Helsinki and increase systemic understanding in carbon-negative land use planning. Also, the so-called trade offs should be taken into account between denser land use and preserving green areas. It is important that people are in general offered the opportunity to live in a dense urban structure, and Helsinki has many more opportunities for this than many other places on a national scale. If, for example, climate refugees increase the population of Finland in the future, it is much more profitable to direct the growth to the Helsinki region to a more sustainable urban structure than to a single-family area built in a forest. We must have a supply of sustainable housing also for internal migration, as Finland is still urbanising.”</i> • <i>“We don’t have room for everything. Not everything and everyone has to be inside the city borders.”</i> • <i>“The core issue is clarifying the role and appropriateness of carbon sinks. Is it possible and wise to increase the number of carbon sinks within the Helsinki borders or should the scale be, for example, the Helsinki region or the MAL region?”</i> • <i>“Try to define what you mean by ‘carbon negative’ city? Need to within urban boundaries negative or is larger region included? On what timescales (negative on lifetime of a building? of a quarter?).”</i>
<p>Holistic approach</p>	<ul style="list-style-type: none"> • <i>“When visioning the future, it feels extreme to plan on the basis of ‘just’ one theme, even a theme as good as carbon negativity. I would rather have a holistic vision of a city that enables a good life.”</i>
<p>Inclusion</p>	<ul style="list-style-type: none"> • <i>“The availability of democratic and inclusive public space also contributes to the realisation of democracy and civic participation: when a person experiences inclusion and a sense of belonging in their environment and can function actively there, they undertake to take care of their environment and feel seen and heard. The experience of being seen and heard in one’s own living environment is one of the most important factors promoting political and social agency that can be influenced in urban planning.”</i> • <i>“A carbon negative city is planned in cooperation with residents and local actors from the ‘bottom-up’. Urban space is developed either on the terms of the people who use it or by actively taking their wishes into account and respecting them.”</i> • <i>“Access to spaces that promote democracy: the ability to use urban space and operate in it without being dependent on consumption. A carbon-negative lifestyle requires a reduction in consumption and dependence on consumption. In practice, this means that there should be an increasing number of places in the city, such as libraries, parks, allotments or other activating urban spaces, where people can meet their friends and acquaintances and promote a lifestyle that supports health and well-being without having to consume something in return.”</i> • <i>“Use water to build floating houses and/or for alternative energy (floating solar panels, wind turbines), use water for growing food (aquaculture). To create incentives for emission reduction behavior and investments into low emission technologies, consider state supported citizen ownership of city quarters ? (people own also streets, traffic infrastructure, buildings, etc) that can be shaped by citizen communities rather than infrastructure ministries and municipal decision makers.”</i>

4 Living in a carbon-negative city

In addition to the actual thematic entities related to the concretisation of the carbon negativity target, the respondents had the opportunity to take a moment to imagine what it would be like to live in a carbon-negative city and describe snapshots of how the city has changed to enable carbon negativity. What does it look like? What does it sound like? What does it smell like? How does it feel? How do you live in a carbon-negative city? What are apartments like? What functions do they have? What facilities are shared? How do people take care of their well-being? How do they spend their free time? What is consumed and how? What kinds of new professions have emerged in the carbon-negative city? What kind of governance system does the carbon-negative city have? What kind of economic thinking is the carbon-negative city based on?

The responses related to these are presented in full in Table 14, and they are not specifically categorised so that readers can, if they wish, become immersed in the possible carbon-negative futures that lie ahead and begin their own reflection on the topic.

Table 14: The responses related to imagining living in a carbon-negative city.

<p>Living in a carbon-negative city</p>	<ul style="list-style-type: none"> • <i>“A carbon-negative city is lush, accessible, human-scale, and promotes the inclusion and agency of its residents. The resident feels seen and heard and works to develop their own living environment. In a carbon-negative city, everyday activities do not depend on consumption: you don’t have to spend time in shopping malls or in places of paid pastimes; the urban space offers the opportunity for a variety of activities alone or together with people who are important to you. A carbon-negative city is permissive and constantly evolving.”</i> • <i>“A carbon-negative city is based on the doughnut economy, and well-being consists of new kinds of things, such as community and care.”</i> • <i>“The importance of a high-quality and comfortable public space that is not based on consumption is emphasised, the role of cities as engines of consumption is changing? The governance system must be sufficiently long-term, but it must adapt to the times of ongoing crises, democracy must also be ensured in these circumstances, even if the objective requires unprecedentedly large political decisions. Personal carbon budgets as one way of controlling emissions. What is the attitude towards climate refugees? Is the target of carbon negativity greater than that of climate justice? Climate refugees are likely to require construction, especially in the northern hemisphere, as the southern states become unviable.”</i> • <i>“There is no traffic noise in a carbon-negative city. I cycle on tree-shaded paths that are full of life, not cars.”</i> • <i>“Multifunctional, accessible, modular (dense-open), non-material consumption and qualities, changeable over time, adaptable (e.g. easy to convert existing infrastructures), engaged and emphatic residents, rich in biodiversity...”</i> • <i>“Less stress, more liveability and less consumerism, cleaner air, safer and more quiet (less traffic).”</i>
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References

[1] City of Helsinki. (2021). *Sources*. Referenced: 6.9.2023. Available: <https://www.hel.fi/en/decision-making/decision-making/strategy-and-economy/strategy>.

[2] Eräranta, S. (2023). *The City in a Changing World: Boundary Conditions of a Finite Planet for Planning a Carbon-negative City. Summary of Expert Discussions*. City of Helsinki, Publications of the Central Administration 2023:5. Referenced: 6.9.2023. Available: <https://julkaisut.hel.fi/en/reports/city-changing-world-boundary-conditions-finite-planet-planning-carbon-negative-city>.

[3] Supponen, A.; Tikkanen-Lindström, T.; Metsäpuro, P.; Eräranta, S. & Koskinen, K.R. (2023). *Helsingin kaupungin päästöjen BAU-skenaario vuoteen 2050*. City of Helsinki, Publications of the Central Administration 2023:10. Referenced: 6.9.2023. Available: <https://julkaisut.hel.fi/fi/julkaisut/helsingin-kaupungin-paastojen-bau-skenaario-vuoteen-2050>.

[4] Will be published later in the same publication series.

APPENDIX 1: Carbon Negative Helsinki Expert Survey (English)



Aim of the Survey

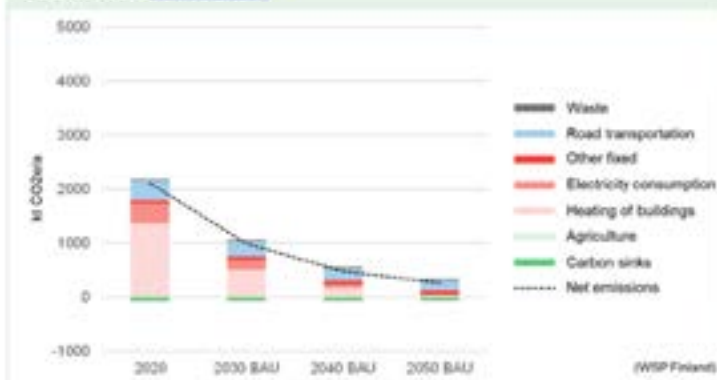
The City of Helsinki is aiming for carbon neutrality by 2030, carbon zero by 2040 and carbon negativity after that. Carbon negativity means that the emissions (carbon footprint) generated within the city borders should be smaller than the city's ability to sequester carbon (carbon sinks). If the City of Helsinki follows the BAU scenario depicted in the figure, the size of its carbon sinks will not be sufficient by 2040 to offset its emissions. A transformation is necessary.

As the set targets are new and ambitious, not all solutions are yet known. However, the carbon-negative city is already being planned for decades ahead, so it is important to ensure that the solutions implemented today will also work in a carbon-negative city.

The aim of this survey is to provide support for conceiving carbon-negative futures. Additionally, the responses may be published as part of other project materials and used for research purposes. The survey is anonymous.

The survey is divided into two parts: discussing the prerequisites for achieving a carbon-negative city and envisioning life in a carbon-negative city. You can choose which themes to respond to.

Further information: suutaranta@helsinki.fi



Background Information

1

I work at the city of Helsinki *

- Yes
- No

Boundary Conditions of Planning a Carbon-Negative City



When planning a carbon-negative city, it is essential to consider other expected changes as well. The key planetary boundary conditions to be considered are:

1. **Emissions reduction need.** The emissions reduction need is critical and emission-intensive solutions where the caused emissions exceed the reduction/sequestration potential must be avoided.
2. **Material limitations.** Solutions cannot be based only on material-intensity or new technology that has not yet been invented, but must instead work also in a world with scarce resources and rely strongly on existing infrastructure.
3. **Biodiversity loss.** Solutions must not accelerate biodiversity loss. The preservation of vegetative land area and renewal of lost vegetative land area must be preserved. From climate perspective, strengthening of the carbon sequestration potential and adaptation must be particularly emphasized.
4. **Warming.** Solutions that accelerate the urban heat island phenomenon must be avoided. The passive resilience of the habitat must be ensured with regard to aspects such as overheating.
5. **High precipitation.** The increase in permeable surfaces must be ensured. The city must prepare for an increasing stormwater flood risk especially with regard to critical infrastructure.
6. **Windiness.** Preparation for increasing storm damage with regard to infrastructure and nature alike must be ensured.
7. **Rise in the sea level.** Increasing sea water flood risks must be prepared for.

2

Do you think that any significant boundary conditions are missing from the list? If so, what are they? Please present a reasoning for your answer, so that it can be utilized in the process.

Kirjote vastaus

The survey is divided into two parts: discussing the prerequisites for achieving a carbon-negative city and envisioning life in a carbon-negative city. You can choose to respond to just one or both of these themes.

1

I would like to start by *

- Addressing the themes related to the prerequisites for achieving a carbon-negative city. Afterwards, if you'd like, I can also discuss envisioning life in a carbon-negative city.
- I will skip the prerequisites and move straight to envisioning life in a carbon-negative city.

Prerequisites for achieving a carbon-negative city

From your perspective and expertise, what would achieving carbon negativity in the City of Helsinki require and mean? Please provide also reasoning for your answers. If needed, you can also recommend relevant references.

Below, we present several perspectives on this broad topic, but you are free to choose which themes and/or their subquestions you would like to answer based on your expertise.

4

Urban structure

What does the structure of a carbon-negative city look like? How are different functions located in relation to each other? How is a carbon-negative city planned?

Kyötiä vastaus

5

Buildings and Spaces

How are functions that require space, such as housing and services, organized in a carbon-negative city? How do we ensure that there are enough carbon-negative spaces for all necessary functions (housing, services, etc.)? What is the relationship between new construction and renovation?

Kyötiä vastaus

6

Mobility

How, why, and where do people move in a carbon-negative city? What is the mobility environment like in a carbon-negative city? What kind of infrastructure is needed for mobility in a carbon-negative city? How do different modes of transportation relate to each other? What is the design of streetscapes in a carbon-negative city?

Kyötiä vastaus

7

Cityscape

What does a carbon-negative city look like? What is its cityscape like? How is urban space and streetscape divided among different uses and users? What materials are used to build a carbon-negative city? How does circular economy show up in the cityscape? How does the current understanding of aesthetics need to change in a carbon-negative city?

Kyötiä vastaus

8

Green Structure

What is the meaning of green structure in a carbon-negative city, for example in terms of carbon sinks or climate change adaptation? How does green infrastructure integrate into a densifying city? How does nature show up in a carbon-negative city?

Kyötiä vastaus

9

Other theme: What?

Is there a theme that you think should be considered as part of the concretization of a carbon-negative city, but was still missing from the list? Please provide more information about the theme here.

Kyönte vastaus

10

I would like to continue by envisioning life in a carbon-negative city. *

- Yes, I want to continue with the survey.
- No, thank you. This is enough. I want to move straight to the end of the survey.

Out 6

...

Life in a Carbon-negative City

Let's imagine for a moment that we are in a carbon-negative city. What does a carbon-negative city look like in your imagination? What do you see around you? What do you hear, smell, or feel? How does it make you feel?

How do humans and other species live in a carbon-negative city? What are (for example the apartments) like? What functions do they have? Which functions are shared? How do humans take care of their well-being? How do they spend their free time? What and how do they consume? What new professions have emerged in a carbon-negative city? What kind of governance system does a carbon-negative city have? What kind of economic thinking does a carbon-negative city rely on?

11

You can describe the carbon-negative city here in any way you like.

Kyönte vastaus

Out 7

...

Did we miss something important?

12

If we missed an important theme in the survey, you can mention it here. Please also explain why the theme is important to be considered as a part of the concretization of a carbon-negative city.

Kyönte vastaus

Out 8

...

Participation in the Future of the Process

Thank you for your responses!

If you are interested in participating in the future steps of the process, for example through expert interviews or workshops, you can provide your contact information to pasa.miettinen@hel.fi. Your contact information will only be used for process-related communication. Your contact information cannot be linked to the responses of this survey.

List of Tables

Table 1.	8
The responses related to the specification of previously identified boundary conditions.	
Table 2.	10
The responses related to the number of unit emissions in construction.	
Table 3.	11
The responses related to expanding the use of existing infrastructure and highlighting the importance of renovation construction.	
Table 4.	12
The responses related to the increased need for cooling (active/passive).	
Table 5.	12
The responses related to the cityscape impacts of construction activities.	
Table 6.	13
The responses related to the reduction of transport unit emissions.	
Table 7.	15
The responses related to reducing mobility needs.	
Table 8.	17
The responses related to the utilisation of existing transport infrastructure.	
Table 9.	17
The responses related to the cityscape impacts of mobility activities.	
Table 10.	19
The responses related to preserving existing permeable soil and vegetation and increasing their amount.	
Table 11.	20
The responses related to increasing the number of urban green spaces that provide shade and enable evaporation.	
Table 12.	20
The responses related to the cityscape impacts of the natural environment activities.	
Table 13.	22
The responses related to the other themes raised.	
Table 14.	25
The responses related to imagining living in a carbon-negative city.	

List of Figures

Figure 1.	21
Summary of the three key themes.	

Helsinki