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Deliverable due date: M12 – November 2017

D4.1 Baseline report of Helsinki demonstration area

WP4, Task 4.1

Transition of EU cities towards a new concept of Smart Life and Economy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731297.

Project Acronym	mySMARTLife
Project Title	**Transition of EU cities towards a new concept of Smart Life and Economy**
Project Duration	1st December 2016 – 30th November 2021 (60 Months)
Deliverable	D4.1 Baseline report of Helsinki demonstration area
Diss. Level	PU
Status	☐ Working ☐ Verified by other WPs ■ Final version
Due date	30/11/2017
Work Package	WP4
Lead beneficiary	VTT
Contributing beneficiary(ies)	HEL, FVH, HEN, CAR, TEC
Task description	Task 4.1: Baseline Assessment [VTT] (HEL, FVH, HEN, CAR, TEC) This task will set and assess baseline for Helsinki demonstration, including calculated and measured values from one year period. An integrated protocol for monitoring the progress of the demonstration will be followed according to WP5. The following subtasks are encompassed in this task: - Subtask 4.1.1: Buildings and district baseline: VTT will coordinate partners in the definition and assessment of the baseline and protocol for building and district energy consumption, share of renewables, CO2 emissions and use of waste energy sources. In addition the base line sets the baseline for control and management systems. - Subtask 4.1.2: Energy supply diagnosis – local resources: The definition and assessment of the energy supply systems and use of local and renewable resources will be led by VTT and HEN. The assessment includes the primary energy use, utilisation of hybrid and smart (two way) energy networks and waste energy resources. - Subtask 4.1.3: City transportation current status: The assessment of city transport system including share of public transport, access to public transport, access to low carbon transport, share of e-cars in public transport and in private cars, number of e-cars charging points will be carried out, with the collaboration of HEL, VTT, FVH and HEN. - Subtask 4.1.4: Suitable urban infrastructures for integration: All partners will assess urban infrastructure suitable for integration, e.g. lighting combined to data, energy infrastructures gaining from integration e.g. tri-generation of heating, cooling and power. The focus is in integrating central and de-central (e.g. building integrated) energy supply and storages. - Subtask 4.1.5: Existing urban plans for promoting low energy districts and sustainable mobility: HEL and FVH will define and assess the current status of existing urban platforms, their interfaces and data availability as well as data quality. In addition the current amount of APIs based on existing urban platforms will be identified. - Subtask 4.1.6: Public procurement procedures, regulations and normative: HEL to lead the

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	assessment of current public procurement procedures especially focusing on low carbon and smart city solutions focusing on energy savings and reduction of CO2 emissions. In addition the municipal norms and regulations compared to national and European levels will be assessed. - Subtask 4.1.7: Identification of existing actions for citizen engagement: Identification and assessment of existing actions for citizen engagement and their success rates. All partners involved.

Date	Version	Author	Comment
09/03/2017	0.1	Aapo Huovila (VTT)	Table of contents and distribution of responsibilities
25/04/2017	0.2	Aapo Huovila (VTT)	First draft with inputs from partners
29/05/2017	0.3	Aapo Huovila (VTT)	Second draft with updated contributions from partners
15/06/2017	0.4	Aapo Huovila (VTT)	Interim version for comments to the consortium. Includes complete Part I on Helsinki City Audit and a ToC and draft content on Part II on actions baseline
30/062017	0.5	Aapo Huovila (VTT)	Finalised interim version based on internal review by Cartif.
12/07/2017	0.6	Estefanía Vallejo (CAR)	Overall review. Section 11.
16/10/2017	0.7	Aapo Huovila (VTT)	Complete report covering also Part II for comments to Finnish partners
03/11/2017	0.8	Aapo Huovila (VTT)	Final for review
28/11/2017	0.9	Aapo Huovila (VTT)	Final updated based on review comments from Cartif.
30/11/2017	1.0	Estefanía Vallejo (CAR)	Final formatreview

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Abbreviations and Acronyms

Acronym	Description
BEST table	Building Energy Specification Tables used in lighthouse project proposals
EV	Electric vehicle
HVAC	Heating, Ventilation, and Air Conditioning
IoT	Internet of Things
KPI	Key Performance Indicator
mySMARTLife	Transition of EU cities towards a new concept of Smart Life and Economy -project
HTM	Human Thermal Model
nZEB	nearly zero energy building
sqm	square meters (m^2)
HSL	Helsinki Regional Transport Authority
HKL	Helsinki City Transport
CHP	Combined Heat and Power production

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1. Executive Summary

This report consists of two parts: Part I Helsinki city audit & Part II Action specific KPIs and baselines values.

The Part I Helsinki City Audit provides a comprehensive overview of Helsinki on various aspects that are useful for other activities in mySMARTLife project. The aspects covered include the following: Chapter 4 overall city characterization (socioeconomic, climatic, urban morphology, environmental), Chapter 5 urban plans promoting low energy districts and sustainable mobility, Chapter 6 public procurement and regulations, Chapter 7 existing actions for citizen engagement, Chapter 8 transport status, Chapter 9 Energy supply and resources, Chapter 10 Integrated infrastructures. The characteristics and performance of Helsinki are described by calculating 132 City Level indicators. This wide spectrum of the city's characteristics are also analysed by summarising existing good practices and potential for improvement. The summary and conclusions from the city audit are presented in the form of a SWOT analysis in Chapter 11.

The Part II of the report, in contrast, focuses on project level and more specifically on the actions that will be implemented in Helsinki during mySMARTLife project. The baseline of the actions is described with help of Project level indicators that are defined and calculated within the specific scope of each action in order to be able to later monitor the impacts of the actions within their scope. The main aim is to precisely describe (in the context and boundaries of each action) its state or performance before the action starts so that the impacts or achievements of the actions can be assessed after implementation by following similar measurement procedure. Those action specific KPIs have been developed with the partners involved in the actions to best capture the aims and scope of the actions. Those action KPIs will be used later to monitor the impact achieved by the actions within WP5 of the project (together with some KPIs common with other cities). Baseline values are calculated for the action level KPIs based on measured data over one year, whenever applicable. The Part II of the report is structured to action KPIs and baselines related to 12. Buildings and districts, 13. Energy infrastructures, 14. Mobility, 15. Non-technical (Citizen engagement, Business models, Urban planning), and, 16. ICT. The results are concluded in Chapter 17 in form of a table that summarises all the 48 actions, the KPIs specifically designed for their assessment as well as the baseline of each action.

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2. Introduction

2.1 mySMARTLife project

The main objective of mySMARTLife project is the definition of an Innovative Urban Transformation Strategy in which the main lines of the project are depicted; highlighting that all interventions in the city must answer to real city challenges, identified following a city led approach and counting on with the active participation of the citizens through citizens' engagement strategies.

Figure 1. mySMARTLife Project concept

There are four different frameworks in which this Innovative Urban Transformation Strategy is deployed:

- **Technological framework,** in which all the actions foreseen will be delivered in three sectors: Energy, Mobility and ICT.
- **Non-technical framework,** covering the urban plans and business models.
- Innovation framework, that are focused in the three pillars of the project, smart people, smart economy and ecosystem.
- **Temporary framework,** that represents the evolution of the project from the city challenges and audits until the evaluation of the performance of the actions, passing through the design and implementation of the solutions.

This Urban Transformation Strategy aims at giving response, in a holistic and integrated manner, to the transformation process, following its main phases (City Audit, Design of the Solutions, Demonstration and Evaluation or final assessment), for these priority sectors (Energy, Mobility and ICT) and for the key frameworks of this process, the non-technological framework through the integration in Urban Plans of existing and innovative City Business Models overcoming the financial barriers, and the innovation frameworks, which aim is twofold: technical support to the phases in the sense of existing methods and tools supporting these phases and technologies innovation and integration in each of the priority sectors.

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This Urban Transformation Strategy, as well as its implementation, demonstration and replication stages, will be depicted and fully described within WP1, while the Part I of this document aims at covering the implementation of its first phase (City Audit) within the Helsinki lighthouse city.

In this framework, the D4.1 Part I aims to collect all data and information for the first step of the process: the City Audits and diagnosis. This is a key phase for the process because by an accurate diagnosis it can be identified the priority action lines. It includes the assessment of the current state of each of the fields of study and the identification of the main opportunities and capabilities of the city to meet several strategies that may arise.

After the City Audit (Part I of this deliverable), the baseline values for the demonstration actions are defined in Part II of this report. Both the results of the Part I on City Audit and Part II on the action specific baselines use indicators (City and Project level indicators) defined in close collaboration with WP5 to summarise the current state in Helsinki in the beginning of the project. The action specific KPIs are specified together with the partners involved in the actions. With help of the baseline values, the impacts of Helsinki demonstration actions will be monitored in WP5 (during and) at the end of mySMARTLife project.

2.2 Purpose and target group

This report presents the current state of the Helsinki lighthouse city in the beginning of the mySMARTLife project with regard to the demonstration actions that will take place during the project. The report is divided into two parts: Part I Helsinki City Audit and Part II Action specific KPIs baseline values. The first part aims at giving an overview of the city of Helsinki in the beginning of the project and with regard to the main topics addressed in mySMARTLife project. The key characteristics are summarised with help of City level indicators. The second part of the deliverable focuses on the actions that will take place in Helsinki demonstration and set the baseline values for those with help of Project level indicators restricted to the scope of the actions (buildings, districts, local energy supply units etc.).

More specifically the City Audit (Part I) collects information from the Helsinki lighthouse city and carries out an accurate diagnosis of its current status within the framework of the Urban Transformation Strategy. The data to be collected will cover the three main sectors where Urban Transformation Strategy is focused on: building, mobility, and urban infrastructures including ICT. In addition, it covers the analysis of other non-technical aspects that may affect the project goals implementation. Thus, it covers the diagnosis for seven fields: buildings and district, energy supply, city transportation, suitable urban infrastructures for integration, existing urban plans for promoting low energy districts and sustainable mobility, public procurement procedures, regulations and normative; and existing actions for citizens' engagement. The City Audit (Part I) provides the context within which the demonstration actions take place and for which the baseline values and KPIs are set in the Part II of the deliverable. This diagnosis, as well as those

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developed in D2.1 and D3.1, will also serve as a starting point for the replication plan for the three follower cities, which will be also developed within task 6.1. However, the City Audit (Part I) can be of interest for any reader interested in Helsinki city's current state and readiness with regard to different smart city topics.

This deliverable was originally due by month 12. However, at month 12 the deliverable cannot take into consideration the final detail of the interventions, crucial inputs to build a complete reference baseline. Moreover, these final details are especially necessary to be considered to build the energy part of this reference baseline, following de facto standard protocols like IPMVP.

Considering that an Amendment was requested in September (month 10) and that the process of negotiation and approval can still take several months, it was agreed with the Project Officer to submit an interim report at the original due date, that will include Helsinki City Audit and a first version of Helsinki Baseline report. The final version, including the final version of Helsinki Baseline will be submitted in m42.

The related Milestone MS4, which is also in line with this final baseline of Helsinki demonstrator area is also requested to be updated, considering on one hand the City Audit reports ready, justified with the interim versions in month 12 and the Final baseline (new Milestone MS13) with the final version of Nantes, Hamburg and Helsinki baseline reports to be delivered in month 42.

The present deliverable is structured as follows:

PART I: Helsinki City Audit

Chapter 3: shows the overview and scope of the City Audits to be implemented in the three lighthouse cities. This includes the description of the Urban Regeneration model focusing on the City Audits, the city characterization scope and the predefinition of the evaluation framework through the indicators.

Chapter 4: shows the characterization of Helsinki lighthouse city, collecting information about the following aspects: socioeconomic structure, climatic conditions, urban morphology, land use and environmental issues.

Chapter 5: shows the analysis of the existing urban plans for promoting low energy districts and sustainable mobility.

Chapter 6: shows the analysis of public procurement procedures, regulations and normative that may affect the project implementation. Moreover, it is identified the potential for improvement on them.

Chapter 7: shows the existing actions for citizen engagement, focused on the current practices and other initiatives for empowering citizens to be part of the city life, as well as the potentiality for creating an innovative, replicable and effective citizen engagement strategy.

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Chapter 8: shows the city transportation current status, focused on the mobility city profile and the statistics of internal movements, typology of the public transport, rate of sustainable vehicles, existence and main characteristics of the charging infrastructure for EV, etc.

Chapter 9: shows the diagnosis of the energy supply network. This information is essential in order to estimate the foreseen contribution of the proposed solutions for improving energy supply facilities. As the main project target is to supply energy by means of centralized systems based on renewables, it is necessary to collect information about the barriers, needs and potential to substitute the existing systems.

Chapter 10: shows the diagnosis of suitable urban infrastructures for achieving benefits in a possible integration such as potential local energy resources suitable for integration. Although several specific actions have been planned in the demo sites for the pillar of integrated infrastructures, it has been collected information about the potential that some relevant city infrastructures have to be integrated in order to take advantages about a jointly operation. Information about electrical grids, broadband infrastructure, traffic management systems, and so on, has been analysed.

Chapter 11: summarises the results of the city audit in form of a SWOT analysis structured under mySMARTLife framework and with related project actions for Helsinki identified.

PART II: Action specific KPIs and baseline values

Chapter 12: introduces the demonstration actions related to buildings and districts. Demo zones and their energy characteristics are presented. Action specific KPIs and baseline values defined by the people involved in the actions are presented.

Chapter 13: introduces the demonstration actions related to energy infrastructures, and presents action specific KPIs defined by the action groups and sets related baseline values.

Chapter 14: introduces the demonstration actions related to mobility, and presents action specific KPIs defined by the action groups and sets related baseline values.

Chapter 15: introduces the non-technical actions and presents their KPIs.

Chapter 16: introduces the ICT actions and presents their KPIs.

Chapter 17: summarises the results of Part II with action specific KPIs and baselines.

Chapter 18: draws conclusions from the whole report.

Chapter 19: references and bibliography.

Chapter 20: annex in which all Helsinki city level indicators are reported.

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2.3 Contributions of partners

The following Table 1 depicts the main contributions from participant partners in the development of this deliverable. All the Finnish project partners and CAR have commented on the various version of the report. The city KPIs (Part I) have been calculated by VTT, HEL and FVH. All Finnish partners have participated in the design and definition of action specific KPIs and collection of baseline data for Part II, led by VTT.

Table 1: Contribution of partners

Participant short name	Contributions
VTT	Task leader, editor of the whole deliverable. Chapters 1-2; 4.2; 8-11 (Part I), whole Part II
HEL	Chapters 4-6; 11 (Part I), 12; 15 (Part II)
FVH	Chapters 7; 10 (Part I), 16 (Part II)
HEN	Contributions to chapters 9 (Part I), and 12-13 (Part II)
CAR	Chapters 2-3 (Part I), whole report review
TEC	Simulation models for the baseline calculation. (Task 1.4)
FOU, SAL, HMU	Contributions to parts relating to actions that they are in charge of in the project (including action description and KPI and baseline definition); review and commenting on the report

2.4 Relation to other activities in the project

The following Table 2 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the mySMARTLife project.

Table 2: **Relation to other activities in the project**

Deliverable Number	Contributions
D5.1	This deliverable provides the overall description of the evaluation framework, including city indicators calculated in this report.
D5.5	D5.5 carries out impact assessment of Helsinki lighthouse demonstration comparing the achieved impacts against the baseline defined in this report.
D1.12	This deliverable provides the overall description of the 3D models for each pilot.
D1.13	This deliverable provides a compilation of energy system scenarios for each lighthouse city. Analysis of the energy demand for each lighthouse city

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PART I: Helsinki City Audit

3. City audit overview

3.1 City characterization

The characterization of Helsinki lighthouse city, and its supporting data collection, provides the citywide integrated documentation and analysis of the current conditions required to identify the priority action lines as well as their management needs. Through a range of city descriptions and indicators, information about the existing conditions including some of the key aspects for the sustainable development are collected and shown in a standardised manner: social, economic and environmental aspects. This information is essential to promote actions and management plans for implementing the sustainable urban regeneration model aiming in mySMARTLife project. The characterization model will provide through the presented KPIs a starting point and later the entry point to extensive available data sets, to be regularly updated with numerous sources, which will enable to detail the lighthouse and followers cities analysis. Moreover, it will facilitate the replicability assessment and adaptation of the Innovative Urban Transformation Strategy. The characterization will follow the approach developed for the evaluation framework developed in WP5. While the overall framework and the full set of indicators will be depicted in WP5 related documents, the City Audit includes a selected list of indicators aiming at covering the city characterisation.

3.2 Predefinition of the evaluation framework

A specific evaluation framework is being defined in task 5.1, and developed in mySMARTLife to assess the project activities from a holistic point of view and to replicate the project in other cities. This framework will be based on indexes, which can be built by integration of an objective set of key indicators, grouped and classified by categories that represent the main aspects of cities processes. The evaluation framework of mySMARTLIfe is currently under definition but in this first stage of city diagnosis, a preliminary set of indicators at city level can be considered to obtain some information about the starting point of every city.

This pre-selection of indicators at city level is mainly connected with parameters or information related with the main aspects considered in the City Audit, which are the following:

- City characterization.
- Existing urban plans for promoting low energy districts and sustainable mobility.
- Public procurement procedures, regulations and normative.
- Identification of existing actions for Citizen Engagement.

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- City transportation current status.
- Energy supply and resources diagnosis.
- Suitable urban infrastructures for integration.

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4. City Characterization

Helsinki is the capital of Finland and by far the biggest city in the country. It is located in the southern Finland on the coast of the Baltic Sea. The port of Helsinki is important for trade and tourism and boat connections to important nearby coastal cities in neighbouring countries - Tallinn in Estonia, Stockholm in Sweden and St. Petersburg in Russia - are excellent. The population of Finland is concentrated in the southern part and one fifth of the population lives in Helsinki metropolitan area that includes among others the second biggest city of Finland Espoo and fourth biggest city Vantaa.

Figure 2. Helsinki on map (Google Maps, Wikipedia[1])

4.1 Socioeconomic characterisation

Population

At the end of 2016, Helsinki had 635,000 inhabitants. The population has been growing rapidly, by 8,000 annually on average in 2013–2016. This pace is exceptional in Finland, and over 40 per cent of Finnish population growth occurred in Helsinki. Growth in Helsinki is mainly due to three factors: net migration gains from the rest of Finland, net migration gains from abroad and natural population growth. Growing migration loss influences, in particular, the number of children, since out-migration from Helsinki mainly consists of families with children. Population structure of Helsinki in 2016 is illustrated in Figure 3.

[1] https://commons.wikimedia.org/wiki/File:Helsingin_seutu.png

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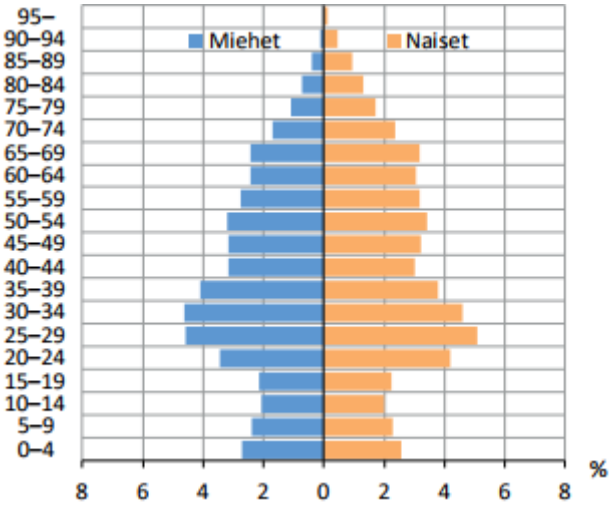

Figure 3. Population by age groups in Helsinki (blue: male, yellow: female) (Statistics Finalnd; Mäki & Vuori, 2016)

The population structure of Helsinki shows a predominance of young adults and younger middle-age inhabitants with 53 per cent female citizens. Increasing immigration increases the share of young adults and families. There are areas in the city where there can be seen an effect of population concentration by for example a particular age groups or immigration.

Economy

The Helsinki Region produces almost one-third of Finland's gross national product. In late 2015, investments started to increase in the private sector, and 2016 saw a new upswing through construction and production investments. Yet, neither trade nor manufacturing have recovered to the same extent as, for example, construction and business services. Economic development is divided. Exports have lagged, and growth has been based on domestic demand only. Sales have declined somewhat in daily consumer goods trade, but for the rest, private consumption has started growing. The consumption of durable goods, in particular, has grown strongly. At the same time, the indebtedness of households has increased.

During recession between 2012 and March 2016, the number of unemployed people grew by almost 60 per cent in Helsinki; however in 2016, the increase in the number of unemployed slowed down, and in early 2017, unemployment is likely to have decreased. At the end of 2016, there were around 40,000 unemployed searching for work in Helsinki, the unemployment rate being 11.9 per cent. Extended unemployment concerns especially older age groups, but it has become more common also among young people and the recently graduated. This has been generally due to the recent poor development of global economy. Furthermore there can be seen a new trend in work positions concentrating more and more on services and short-term contracts rather than conventional job structures and business sectors. At the same time there is a considerable amount of jobs in the city for commuters (self-sufficiency of over 130 per cent). Figure 4 illustrates the employment structure and development in Helsinki between 1997-2017.

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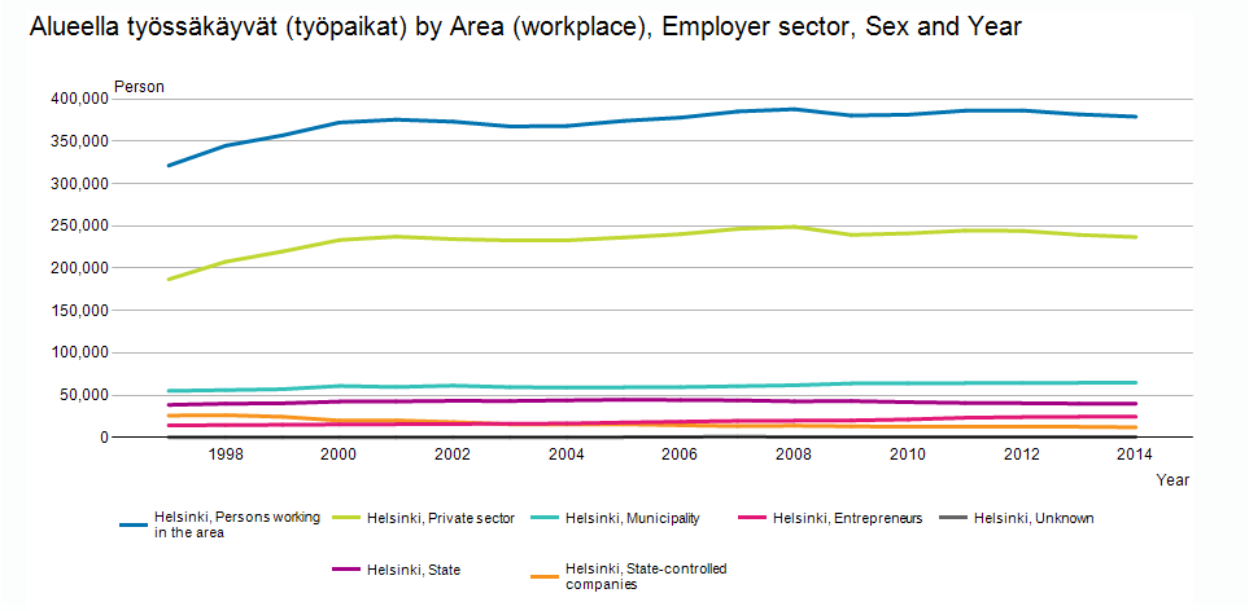

Source: Statistics Finland

Figure 4. Employed workforce in Helsinki by sector (Statistics Finland, 2017)

Construction

Towards the end of 2016, construction increased in Helsinki. The aggregate floor space in building permits and building starts for new housing, in particular, grew significantly. Construction of business premises increased, too. As a whole, however, construction was more geared towards housing than it had been earlier.

Between 2013 and 2016, around 15,500 dwellings were completed in Helsinki, either as new dwellings or extensions, and an additional 1,300 dwellings through change of intended use. The annual number of dwellings completed has varied between around 4,000 and 4,500. Of all new dwellings completed, 61 per cent were non-subsidised owner-occupied or rented dwellings. The “in between” tenure statuses, such as the price-level-adjusted owner-occupied and the tenant-owned flats, accounted for 23 per cent and the state-subsidised (ARA) rented flats for 15 per cent of new dwellings completed.

Housing

At year-end of 2015, the floor space per person in household-dwelling units in Helsinki was 33.8 square metres on average. In Helsinki, housing space per person has stabilised at the level reached in 2007 and has not grown in recent years – unlike in Finland on average. In recent years, housing has become considerably more expensive and the pricing varies a lot between neighbourhoods and locations within the city. In Helsinki there are distinctively bigger share of people living in apartment buildings (almost 90%) and rental homes (almost 50%) than in the neighbouring municipalities (Parviainen, 2017). Additionally, as explained above in ‘Économy’, there are numerous people that commute to Helsinki from the surrounding

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areas, also long distance (100+ kilometres). There is also a major share of buildings that date from earlier than 1951, which is challenging for retrofitting. (Parviainen, 2017)

Income and social assistance benefit dependence

In Helsinki, the proportion of residents who have a good income is larger than in the rest of Finland. Reflecting the general economic situation, the overall development of incomes has been weak. Differences in income between population groups are very clear. Women's income still comes out at only three quarters of men's income. The average income also varies by age group. Low income levels are also more common among families with a foreign background, particularly in first-generation immigrant families.

Low incomes often lead to the need of social assistance benefit. The numbers of people needing social assistance benefit have been growing steadily. In 2015, almost 76,000 people in Helsinki received the benefit, equalling 12.1 per cent of the population. There are great differences between districts in the proportion of children living in recipient families. Although a great majority of families with children are doing well, many have to rely on the support of the society. Thus the proportion of pupils receiving special support at school is larger in Helsinki than in Finland as a whole. The total number of homeless people is estimated to have decreased, as well as long-term homelessness. In return, the proportion of homeless people with an immigrant background has grown in recent years.

Work and education

Some young people are still excluded from both work and education. In Helsinki, almost 9,000 young people who have completed basic education are neither at work nor on the school bench. Overall, the proportion of youth outside work and education has remained at the same level during the last few years. However, a certain positive trend can be observed for those under 20. More and more young Helsinki residents find a place to study at secondary level, and this positive trend applies especially to young people with an immigrant background.

Although various support measures have enabled many young people to find a place to study or work, the position of young people on the labour market is challenging in many ways. Unemployment and the lack of money have a variety of effects on young people's lives. It can prevent them from taking up a hobby (and force them to give it up), or not seeing their friends because it costs too much. Furthermore, 10% of young people had left their bills unpaid or used consumer credit. Young people's transition to independence in Helsinki is affected by challenges of employment and income and – particularly – high housing costs.

People with foreign background

Helsinki has over 90,000 residents with a foreign background – 15 per cent of the city's population. Both their number and proportion of the population are growing. Around 74,300 have been born abroad and around 15,600 in Finland. For the most part, immigrants are in working age. Yet their unemployment rate

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is considerably higher and their employment rate clearly lower than in the native population. Of those born in Finland, almost 90 per cent are still less than 20 years old. There are some suburbs with more concentration on immigrant population however the differences are levelling out. For some cases there are related recognised challenges in segregation visible for example in primary education. (Mäki & Vuori, 2016)

Business location

Helsinki's industrial structure is service-dominated, and yet very diversified. No single industry overshadows the others, which gives Helsinki better opportunities to overcome problems pertaining to single industries. Strong industries in Helsinki are still trade, information and communication, administrative and support service activities, and professional, scientific and technical activities. Well over half of all jobs in Helsinki are in these industries. Among industries, trade especially is undergoing a period of change caused by digitalisation and globalisation, among other things. Many smaller local shopping centres are struggling as consumers head for the large shopping malls. Competition with foreign actors has toughened, too. The proportions of small, medium-sized or large enterprises have remained unchanged in Helsinki. Almost all (98%) companies in Helsinki fall in the category of small enterprises, with less than 50 people on the payroll. Of total company staff in Helsinki, however, around 40 per cent work in large companies, whose importance for economy and employment is considerable.

Business activities in Helsinki are concentrated close to the city centre. Studies have shown that clustering into certain areas improves the conditions for knowledge-intensive businesses. According to a survey published in autumn 2016 (City of Helsinki, 2016), companies value the location of Helsinki. The main factors influencing their location decisions include proximity to where staff, owners and executives live, the provision of adequate labour in the commuting area and the proximity to present and potential customers. Helsinki's accessibility, too, played a certain role, and respondents were very glad there were enough alternative locations in Helsinki – albeit some respondents found Helsinki's price level high and the provision of business properties a challenge. Respondents were pleased with the public transport, but at the same time they also called for more investments in other traffic connections in the city and improved parking. Mostly, they felt that the city's attitude towards entrepreneurship and business enterprise was positive.

4.2 Climatic characterisation

Helsinki has a humid continental climate, less than 2°C above the threshold for subarctic classification. Winters in Helsinki are notably warmer than in the north, and the snow season is much shorter. However, because of the latitude, days last 5 hours and 48 minutes around the winter solstice with very low sun, and the cloudy weather at this time of the year accentuates the darkness. Conversely, Helsinki enjoys long daylight in summer, during the summer solstice days last 18 hours and 57 minutes. The average outside

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temperature is -3.97°C in January and 16.05°C in August. Average global horizontal radiation is 975 kWh/m2/a. The average annual temperature in Kaisaniemi weather station has risen more than 2 °C since 1900's (see).

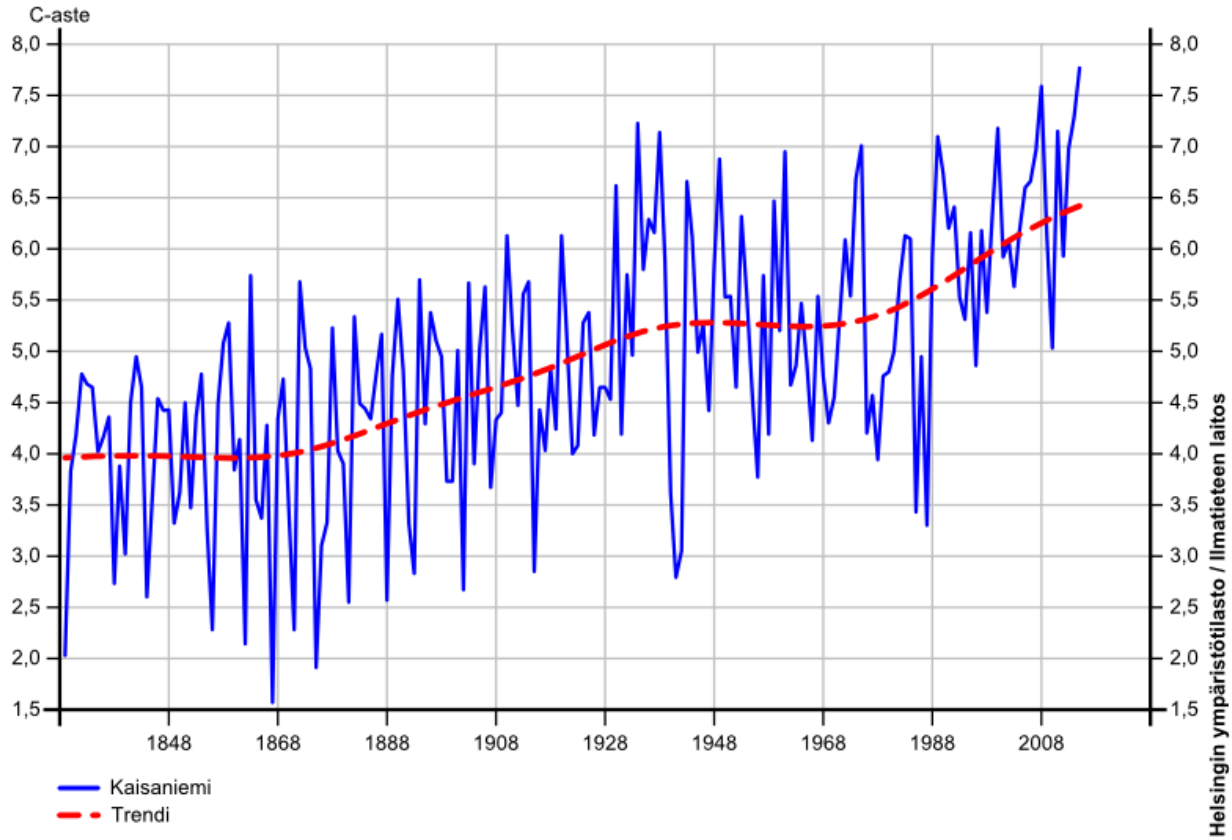

Figure 5: Annual average temperature from 1829 - 2016 from Kaisaniemi weather station in city of Helsinki (Blue: temperature; Red: trend) [Helsingin ympäristötilasto, 2017]

4.3 Urban morphology and land use characterisation

Helsinki has a surface area of 686.2 km2, of which 186.7 km2 is land area. Nature is present even in the city centre, with parks constituting 36% of the land area. Residents place high value on these areas and are passionate about protecting them. Altogether, there are 40 nature reserves in Helsinki, making up a total of 890 hectares. Three of them form part of the European Natura 2000 network. Around one fifth of the land surface area is used for residential buildings, other buildings account for 13%, and around one fifth is for traffic.

Bordered by the Baltic Sea in the south and neighbouring cities of Espoo (west) and Vantaa (north) as well as Sipoo (east) the city has numerous small parks, vast forests areas and green fields and conservation areas. In the field of urban planning and land use, Helsinki aims at eco-efficiency by making

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the urban structure denser, and by developing the public transport system. Figure 6 illustrates the land use of the City of Helsinki in 2015 (HSY, 2015).

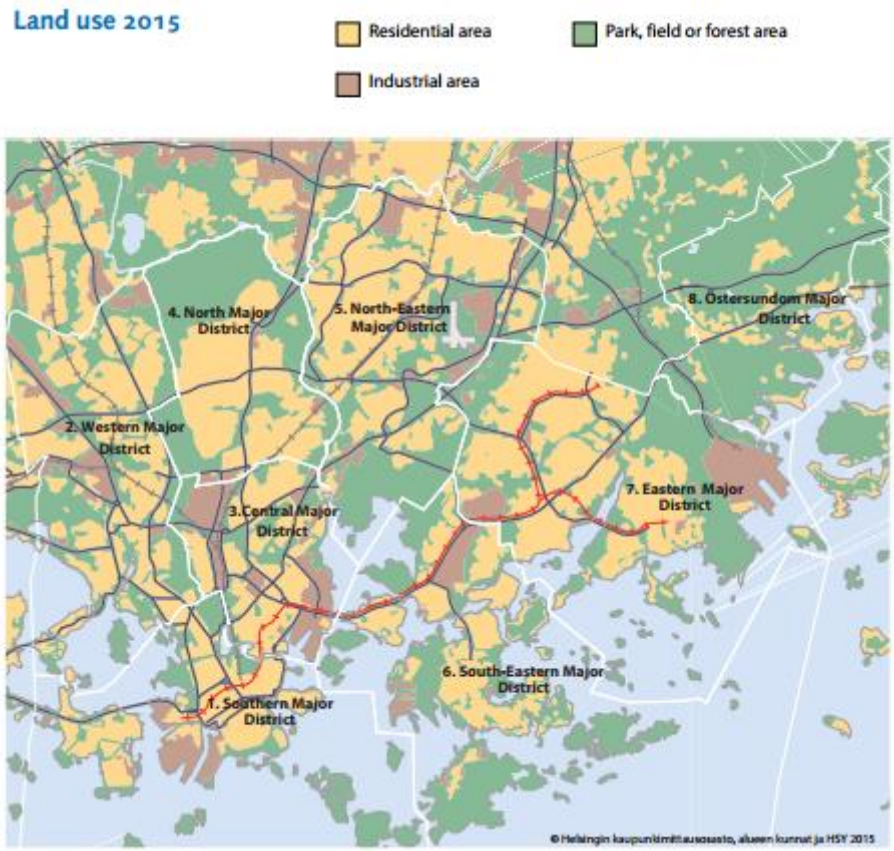

Figure 6. Land use by sector in the City of Helsinki, 2015.

The solutions adopted for land use and urban structure influence both directly and indirectly the community's functionality, health, enjoyment, and the different factors for ecological sustainability such as the consumption of energy and natural resources, the amount of greenhouse gas emission, and biodiversity. As far as eco-efficiency and energy savings are concerned, a compact urban physical structure and efficient public transport are regarded as being advantageous. Current situation of the urban infrastructure in building stock is presented in Table 3 (Statistics Finland, 2016).

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Table 3. Helsinki building stock in 2015 by heating and building type.

Heating type Floor area (m^2)	District heating	Oil or gas heating	Electrical heating	Coal	Wood or peat	Geothermal	Other
2015							
Total	40 832 126	2 550 888	2 657 858	91 907	94 606	224 054	1 065 619
Detached houses	869 277	813 500	1 639 385	52 221	40 612	172 780	45 380
Terrace houses	1 403 598	304 219	447 141	3 204	5 292	6 897	7 112
Residential apartment blocks	22 057 315	560 965	119 510	7 951	26 202	15 796	72 344
Commercial buildings	1 811 535	79 722	30 016	371	6 515	6 134	25 827
Office buildings	5 716 403	82 168	16 216	6 599	389	2 319	41 023
Transportation buildings	978 304	77 792	147 142	515	2 991	1 230	539 065
Healthcare buildings	1 302 494	23 247	24 002	1 990	2 493	192	14 161
Convention buildings	1 140 545	42 753	42 104	2 734	1 106	0	18 626
Educational buildings	1 841 926	96 385	28 718	10 649	794	643	7 621
Industrial buildings	2 706 011	340 863	93 307	4 530	151	7 984	80 729
Storage buildings	829 842	119 987	60 343	1 143	2 951	9 773	115 961
Other	174 876	9 287	9 974	0	5 110	306	97 770

People commute to Helsinki from ever increasing distances from the surrounding municipalities, and the amount of car traffic at the city borders is increasing. With urban sprawl and the concentration of services, the dependence on cars in the region will probably increase even more. The modes of transportation within Helsinki break down into three almost equal proportions: cars, public transport, and walking or cycling. Traffic causes a fifth of Helsinki's greenhouse gas emissions. While emissions that are detrimental to health have decreased as a result of technical advances, the air quality along busy thoroughfares is still often poor.

City of Helsinki experienced a historical turnaround in 2016 when the increase of the amount of cars stopped. In 2006–2010 the annual growth was still considerable and in 2010-2015 moderate. Actions and

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policies for new infrastructure as facilitative measures for this positive change include strong promotion of complementary construction and the good public transport network. Additional investments in walk ways, bicycle routes and public transport have accelerated the change. Furthermore, the increasing number of citizens has subsequently led to taking traffic planning into close consideration. The possibilities to apply congestion charges in the city centre are also explored.

4.4 Environmental characterisation

Environmental progress

Emissions of greenhouse gases and energy consumption per capita have both decreased significantly in the recent years. Yet, in both respects, there is work to be done to reach the goals set for 2020. Emissions in Helsinki have been reduced through cuts to national emissions from energy production, as well as reduced emissions from the city-owned Helen Ltd's own energy production and by upgraded energy efficiency in the urban area. Important reasons for reduced energy consumption include improved energy efficiency in buildings and electric appliances such as street lights, as well as improved energy efficiency of motor vehicles.

Air quality has improved somewhat during the Council term in terms of hydrogen dioxide contents, but nonetheless, the EU's Air Quality Directive's annual limit value for hydrogen dioxide emissions in the air is still occasionally exceeded due to exhaust gas in the busy street canyons in central Helsinki.

The amount of disposed waste in the Helsinki Metropolitan Area was significantly reduced when the Waste-to-Energy power station in Vantaa started operation. Meanwhile, however, surveys conducted by the Helsinki Region Environmental Service Authority HSY suggest rubbish sorting in households has slackened somewhat.

Air quality

Compared to large European cities, the air quality in Helsinki is rather good due to the favourable location by the Baltic Sea. Air quality problems are caused by traffic emissions and street dust from traffic, as well as long-range transported fine particles and ozone. The burning of wood in one-family house areas causes local hazards.

The street dust contents in Helsinki have decreased, which proves that the investments in controlling street dust over the past years have been successful. The daily limit value for particulate matter, introduced in 2005, was last exceeded in the centre of Helsinki in 2006. Street dust is a problem mainly in springtime, when the roads have just dried but the street sand has not yet been cleaned.

The Nitrogen dioxide concentrations in busy street routes, especially downtown street corridors continue to exceed the EU annual limit value, due to emissions from car traffic. The development of vehicle

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technology is expected to decrease the emissions of nitrogen oxides in the near future, but they did not have a sufficient effect by 2015 and Helsinki has prepared a new air quality action plan.

Also the Helsinki Metropolitan Area cities have a common air protection programme aimed at improving air quality. If air quality suddenly deteriorates, the metropolitan area cities take action as defined in an air-quality preparedness plan to protect residents. Air quality is monitored and communicated by municipalities in Finland. Air quality in the Helsinki Metropolitan Area is monitored by the municipal alliance Helsinki Region Environmental Services Authority (HSY).

Noise

About one-third of the Helsinki land area is high-noise exposure area. Nearly 40 percent of Helsinki residents live in areas where traffic noise exceeds the recommended highest daytime value of 55 dB. Road and street traffic is by far the greatest source of noise. Many residents of the inner city are also exposed to noise from trams.

Efforts are made to prevent noise problems by reducing noise emission, preventing the spread of noise, and by protecting noise sensitive areas. It is estimated that the number of residents exposed to road traffic noise will increase unless new noise barriers or other noise prevention projects are implemented. The main reasons for this growth are the increasing amount of traffic, the expansion of noise areas, and construction within noise areas.

The 2013 revision of the City of Helsinki noise control action plan presents 26 measures for carrying out noise control and reducing the noise levels caused by traffic. These concern land use planning and traffic planning, anti noise coatings for roads, the promotion of quieter modes of transport, the construction of noise barriers, improving the sound insulation of buildings and the development of quiet areas.

Soil remediation

Harmful substances have accumulated in the soil as a result of many kinds of industrial and other activities. The land is often cleaned in when new dwellings are built on former industrial, storage and harbour areas. The state of the soil is constantly improving with remediation of soil.

The significance of the land mass economy in the operations of the city has been emphasised in recent years with the launch of large area building projects. Several projects that aim to utilise surplus landmasses were initiated in 2013 with landfill shaping and noise barriers. The mass saving resulting from more efficient utilization of surplus landmasses have totalled approximately 7 million euro in 2012–2013.

Nature

The land surface area of Helsinki includes a total of 36% of various types of green area, 22% of which is forest. The forests are maintained as recreational areas. The flora of Helsinki includes over 1,100 species, of which 40% are native. Their proportion is highest in the archipelago. Plant species have disappeared as

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a result of construction, forestation of meadows and fields, and change of use of forests. 3.2% of the city's land area and 1.2% of the water areas are protected under the Nature Conservation Act or designated as Natura areas. There are a total of 52 nature conservation areas in Helsinki.

Waste

Waste management in the metropolitan region has been based on source separation of waste, and on landfilling the non-recyclable waste. From year 2014, mixed waste that cannot be recycled has been used for energy production. This resulted a significant improvement in the degree of waste utilization in the metropolitan area. As the number of residents in the metropolitan area increases, the overall amount of waste will also probably continue to increase. Over six million tons of waste is created every year within the Helsinki metropolitan region. Of this, some 350,000 tons come from private households. The total amount of municipal solid waste from private households in the region has been increasing since 2004, but per capita it has been quite stable.

Waters

Nutrient loading of the sea in Helsinki has decreased significantly since the 1970s due to improved wastewater treatment. The Vantaanjoki River currently brings around 60% of the nutrient loading to the waters in Helsinki. However, the phosphorous loading during winter in the waters in Helsinki has risen since the beginning of the 1990s due to general increase in phosphorous concentrations and the internal loading from the seabed. The total amounts of bluegreen algae and phytoplankton in the summer have increased due to the rise in phosphorous concentrations and the warming of the surface waters.

The state of the Helsinki bay areas has improved significantly from the 1970s and 1980s, when wastewater was discharged into the bay areas. However, there is still over-eutrophication. The quality of the water at the swimming beaches has been mainly good.

4.5 Calculation of indicators for city characterization

The indicators selected for City Characterization are being calculated and they are showing in the following table.

Table 4: Indicators for city characterization

Indicator	Units	Value
Size	km^2	216,5
Population	Inh	628208
Population density	Inh./km^2	2902
People > 75 years	%	6,9%
Average population age	#	42,5

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Indicator	Units	Value
Type of city		metropolitan
Land consumption (Nº Buildings/Total city surface)	nº build/Km^2	195
Land consumption (Total built surface/Total city surface)	Km^2/Km^2	0,31
Balance between residential and no-residential building use	%	39,70 %
Overall CO_2 emission reduction target	%	30 %
Tourism intensity	nights/100000	550 782
Climate koppen geiger classification		Dfb
Smart energy meters	% of buildings	100%
Refurbished buildings improving energy performance	% of refurbished buildings	N/A
Number of connections to a district heating network	% of buildings	approx. 90%
Greenhouse gas emissions per capita	tonnes CO2/capita	4,2
Greenhouse gas emissions (tertiary)	Mtonnes CO2/year	0,956
Greenhouse gas emissions (transport)	Mtonnes CO2/year	0,600
Greenhouse gas emissions (Residential)	Mtonnes CO2/year	1,474
Greenhouse gas emissions in buildings, equipment/facilities and Industries	Mtonnes CO2/year	2,051
Greenhouse gas emissions (Public lighting)	Mtonnes CO2/year	0,0061
Greenhouse gas emissions (Municipal)	Mtonnes CO2/year	2,651
Greenhouse gas emissions (Industry)	Mtonnes CO2/year	0,22
Transport greenhouse gas emissions per capita	t /(pers.·a)	0,9
Percentage of renewable energy use in public transport	%	28
Water consumption	m3/cap/day	0,181
Water re-used (rain/grey water)	% of houses	0
NOx emissions	g/cap	10493
PM2,5 emissions	g/cap	304
Air quality index	index	0,27
Recycling rate	% tonnes	48%
Exposure to noise pollution	% of people	40%
Amount of solid waste collected	tonnes/capita/year	0,312
Brownfield use	% of km2	N/A
Urban Heat Island	°C UHImax	5-10 °C depending on the measurement

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Indicator	Units	Value
		point
Local food production	% of tonnes	N/A
Availability of government data	Qualitative Likert scale	4
Quantity of open data	# / 100.000 inhabitant	96,1
Cross-departmental integration	Qualitative Likert scale	4
Smart city policy	Qualitative Likert scale	4
Voter participation	%	61,8
Multilevel government	Qualitative Likert scale	5
Costs of housing	% in € 	28,3% of income €
Green public procurement	%	75%
GDP	€/cap	50 741€ (2014)
Median disposable income	€/household	25 000€
New businesses registered	#/100.000	N/A
New startups	#	N/A
Research intensity	% in euros	N/A
Population Dependency Ratio	#/100	45,7
Unemployment rate	%	12,6
Youth unemployment rate	%	9,6
Fuel poverty	%-points in €	N/A

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5. Existing urban plans for promoting low energy districts and sustainable mobility

5.1 Current status

The integration of environmental and climate wise solutions for planning have been in place since 2016 in all projects. In addition, Helsinki will have planning areas, which have higher standards for carbon emission savings, energy efficiency and adaptation to climate change. The City Council's strategy and other strategic documents with good environmental targets are recognized and put into practice and their realization is actively monitored. (City of Helsinki, 2015) In the forthcoming decades, Helsinki will expand faster than ever before, with the construction of a variety of apartments, offices, kindergartens, schools, parks, streets and recreation areas. The City of Helsinki aims to build quality neighbourhoods where people can enjoy both work and leisure. To name a few examples, recent construction of a new cargo harbour (Vuosaari) in a different location some distance away from the city centre has provided the opportunity to develop the site of the former old ports (Jätkäsaari and Kalasatama) and railway yard area for other uses, radically altering the appearance of Finland's capital.[2] In public transport, the regional transport office HSL uses environmental criteria for public transport procurement. HSL's strategic goal is to reduce local emissions and carbon emissions by over 90 per cent by 2025 from the 2010 level. In addition by 2020 10 % and by 2025 30 % of buses will be electric. HSL has already started using a couple of electric buses[3] and in addition have awarded environmental bonuses[4] for bus operators suggesting measures to reduce carbon emissions and local emissions. City of Helsinki has a goal that by 2020 all public procurement has environmental criteria, as now more than half have those have.

Strategy programme

The city strategy programme 2013-2016[5] has many goals that are related to sustainable city planning, reduction of greenhouse gases, increase in energy efficiency and increase in the share of sustainable transport modes. Some of the goals were that Helsinki is a known environmentally wise city of green economy. Helsinki also aims to increase partnerships to improve competitiveness and environmental responsibility. Smart technology and carbon neutral products are created in co-operation with different stakeholders. Also the amount of environmental criteria and resource efficiency was aimed to be increased. New environmental and energy technologies were aimed to be implemented in new construction development projects. The share of public transport modes was aimed to be increased by 3 %. In addition, the city's climate goal was raised from 20 % to 30 % in 2013. As a few examples from

[2] Helsinki New Horizons. http://en.uuttahelsinkia.fi/
[3] https://www.hsl.fi/en/news/2015/first-fast-charging-electric-buses-developed-linkker-enter-service-soon-7692
[4] https://www.hsl.fi/en/news/2016/environmental-bonuses-four-bus-companies-2017-9480
[5] https://www.hel.fi/static/taske/julkaisut/2013/Strategy_Programme_2013-2016.pdf

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various topics the measures promoted include strong collaboration and support for innovative business that has created a launching pad and living lab platforms as well as a good market for small and medium sized enterprises for example in climate smart solutions. One-stop-shop methodology for citizen services has been improved considerably and engagement work remains in an important role where feedback channels and discussion forums are numerous and active for wellbeing and functioning city for its residents.

The new city strategy was launched in the summer 2017 (City of Helsinki, 2017) and new climate goals were set. Underlining ecological values is in the core of the strategic work and Helsinki strives to join the C40 climate network of the leading cities of the world and profiles itself as an internationally networked pioneering local implementer of global responsibilities. The new climate goals include reducing emissions by 60 per cent by 2030 and bringing forward the target of carbon neutrality to 2035 instead of 2050, as earlier. Helsinki is preparing for a possible decision by the State to forbid the use of coal in energy production. Here, consistent State support is needed to develop solutions to compensate for this and the carbon neutrality goal is set in a way that corresponds to general practice in Finland.

The actions foreseen in mySMARTLife project are connected with two key initiatives of Helsinki transformation strategy for the new term from July 2017:

- Helsinki's climate roadmap (see below in Climate Roadmap 2050); New climate targets have been set which were unanimously approved by a decision of the City Council on 27th September 2017. The climate roadmap sets out how Helsinki will become a carbon neutral and climate resilient city by 2050->2035.
- "Smart and clean" initiative: Helsinki Metropolitan Area aims to be the best test bed in the world for smart and clean solutions. New technologies and services are tested in different parts of the city. The best ones will be exported and create thriving businesses. New services in mobility and living will increase quality of life and mitigate climate change. This will boost the circular economy and smart solutions where small and large actions build permanent changes.

Environmental policy

Many of the other climate-related goals come from city's Environmental policy (2012[6]), which has the goals for the long term (2050) and for the medium term (2015/2020). Climate related present goals are, that Helsinki will be climate neutral by 2050 and reduce emission by 30 % by 2020. The city's climate steering group has estimated that the city can set a greenhouse gas goal of -60 % for 2030 and a carbon neutrality goal for 2040. In environmental policy there is an aim for energy consumption reduction by 20 %

[6] https://www.hel.fi/helsinki/en/housing/environmental/policy/policy

In Finnish https://www.hel.fi/static/ymk/esitteet/ymparistopolitiikka.pdf

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/capita between 2005-2020. The goal for public procurement, waste and materials efficiency is that 100% of public procurement will have environmental criteria by 2020. The goal for environmental awareness and responsibility is that all city administrations have environmental management system by 2020. Some examples of good practices becoming more common as promoted environmental policy measures include the city climate roadmap and major improvements in sustainable procurements, waste and materials efficiency.

Energy saving in city organization

Helsinki has signed a voluntary energy saving agreement with the state of Finland among most Finnish large cities[7]. Helsinki reached its earlier goal for 9 % in 2008-2016 (129 GWh) energy saving in earlier agreement (KETS), which included city-owned public buildings and apartment buildings. Helsinki has signed a new agreement which has a goal for 7,5 % of energy saving between 2017-2025 (from 2015 level). The energy conservation board of Helsinki has also set a goal for city administrations to reduce the energy consumption by 2 % annually. Examples of policy measures include, among others, energy advising, instructions and supportive guidance for energy efficient lighting and installing of solar electricity.

Energy production

City-owned energy company Helen has set a roadmap to carbon neutrality by 2050[8]. The company has also goals to increase the share of renewable energy in energy production to 20 % by 2020 and reduce the energy productions emissions by 20 % by 2020. City council decided in 2016, that Helsinki will shut down its biggest coal-based CHP plant in Hanasaari by 2024.

City planning

Helsinki's new masterplan[9] was accepted in 2016 and one of the key visions is to prioritise the sustainable transport modes, especially rail transport. The Plan allows for the growth of Helsinki from the current city of 625,000 inhabitants to one with some 860,000 inhabitants by 2050. The key strategy is to urbanise the city, which includes extending the inner city northwards, densifying new developments to emphasise a more urban structure, creating a 'network city' of public rail transport and the gradual transformation of motorway-like entry routes in the outer suburbs into 'city boulevards', thereby reducing traffic on the main streets.

Transport policy

[7] In Finnish https://www.hel.fi/blogit/fi/kirjoitukset/tuuma-ja-toimi/helsinki-solmi-uuden-energiatehokkuussopimuksen

[8] https://www.helen.fi/en/helen-oy/responsibility/carbon-neutral-future/varmaa-tuotantoa/

[9] http://www.yleiskaava.fi/en/

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In Helsinki's city planning walking and biking are prioritized, then public transport, finally cars (Helsinki's transport development plan[10]). Also, investments are prioritized accordingly on sustainable transport, especially rail transport, biking and walking. The largest transport investments in coming years are aimed for fast tram (Joker) and for tram route to new neighbourhood Kruunuvuorenranta from city centre with large bridges, and the route is to be used only by trams, pedestrians and cyclists. Helsinki is improving the cycle network with large investments on fast bicycle roads called "baana". Helsinki's aim is to double the share of biking to 15 % by 2020. New pedestrian streets are planned for the city centre and older are renovated. The regional public transport office HSL has a strategy that 100 % of buses and rail transport are fuelled with renewable energy by 2020 and 30 % of buses are all-electric by 2025.

Helsinki's Climate Roadmap 2050->2035

Helsinki's Climate Roadmap[11] sets out how Helsinki will become a carbon neutral and climate resilient capital by 2050->2035. Climate Roadmap is a visually enticing tool for communicating about the City's climate objectives with different stakeholders. The targets are being pushed further with more ambitious plans. The City Council set new climate targets prepared by the City of Helsinki climate working group for a checkpoint in 2030 and carbon neutrality by 2035.

The ambitious climate targets[12] cannot be reached by the city organization alone: good collaboration among the residents and different organizations is vital. City-owned properties and transport account for only 10 per cent of the emissions from Helsinki area. Households and different services and workplaces account for the vast majority of the emissions. The Climate Roadmap initiated a process of improving the collaboration between the City and different stakeholders and finding ways for the City to enable a more climate friendly lifestyle of the Helsinki residents.

Helsinki's Climate Roadmap is available online and in print. It is updated regularly and the next edition will feature Helsinki's adaptation strategy and new climate targets for 2030 that will be set by the newly elected city council. The Climate Roadmap has been presented in many interviews and events including the COP21 conference in Paris.

5.2 Improvement potential identification

In recent years, Helsinki has made many studies of the potential of various measures to affect the carbon emissions and energy aspects. These are PEK-study[13] (Best energy practises), 30 % emission reduction study[14], Renewable energy and De-centralized energy production study[15] and Siemens CyPT-study[16]. The

[10] In Finnish http://www.hel.fi/hel2/ksv/julkaisut/esitteet/esite_2016-1.pdf

[11] Available online: http://www.stadinilmasto.fi/en/climate-roadmap/

[12] The targets are under revision in 2017 and are discussed in detail in section 5.2.

[13] PEK-study (2013), in Finnish http://www.stadinilmasto.fi/files/2013/04/PEK-raportti.pdf

[14] 30 % Study (2014), Abstract in English https://www.hel.fi/static/ymk/julkaisut/julkaisu-07-14.pdf

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results of these studies were used in scenario workshops to set a proposal for City Council in Strategy Programme 2017-2021 for new climate targets for 2030 and carbon neutrality. That proposal prepared by the climate working group set by the Mayor is presented in this section based on the report by Huuska et al., 2017. The new city strategy was launched in summer 2017 as presented in relation to the climate targets in Chapter 5.1.

The climate working group's proposal for the new climate objectives for 2030 and the update of the City's carbon neutrality objective is based on alternative scenarios for Helsinki's emissions development, climate objectives and key measures. The alternative scenarios include in addition to the Business-as-Usual scenario six additional scenarios. These scenarios evaluate additional measures for reducing emissions, particularly as regards the consumption of electricity and heating, as well as traffic. The report (Huuska et al., 2017) also presents how the emissions development of Helsinki would be affected by lower than anticipated development of occupancy and employment rates or if the use of coal is stopped in accordance with the government's Energy and Climate Strategy (Ministry of Economic Affairs and Employment 2016). (Huuska et al., 2017)

Based on the scenarios and the sensitivity analyses conducted on them, the report proposes that Helsinki could set a greenhouse gas emissions reduction target of reducing total emissions by 60 per cent by 2030 compared to the 1990 level. This would mean a reduction of 73 per cent per capita. The report also proposes that Helsinki set the objective of becoming carbon neutral by 2040, by which point any remaining emissions would be compensated for locally or internationally. (Huuska et al., 2017)

The precondition for setting these objectives is that the city is able to reduce its emissions through the implementation of additional measures by another 10 percentage points in addition to the 50 per cent reduction of emissions of the BaU scenario. These additional measures concern the reduction of energy and heating consumption, the increase of local electricity production, the reduction of oil consumption and the reduction of traffic emissions. The objective for 2030 as regards energy production is based on Helen Oy's current development programme option as decided by the City Council in 2015 and an assessment based on market prospects of the distribution of fuels used in district heating (coal 30%, natural gas 30%, biofuels 30% and air source heat pumps 10%). At the same time, Helsinki will define the realisation of carbon neutrality in a way that corresponds to common practices. This way emission will be reduced by at least 80 per cent. The objective of achieving carbon neutrality by 2040 is in line with Helen's objective of achieving carbon neutrality by 2050, which will require significant measures for reducing the use of fossil fuels in district heating production. (Huuska et al., 2017)

[15] Renewable and De-centralized energy study (2015), in Finnish https://dev.hel.fi/paatokset/media/att/9d/9d03ce885409c36fff4f836ff30314d0f95bcb72.pdf

[16] Siemens CyPT (2016), in English https://issuu.com/helsinginymparistokeskus/docs/helsinki_cypt_report_-_2016

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If the Finnish Government implements its decision to prohibit the use of coal by 2030, Helsinki could advance its objective of achieving carbon neutrality to some point between 2030 and 2040. The exact time frame would depend on how extensively coal will be replaced with emission-free energy sources. (Huuska et al., 2017)

The climate working group proposes that in order to implement the proposed measures, the policies regarding Helsinki's climate measure for 2030 should be drawn up in autumn 2017. The policies for the climate measures will be drawn up once the new City Council has decided the climate objectives of the council strategy. At the same time the range of means by which the emissions target is to be achieved should be clarified, in addition to which schedules, responsibilities, needs for further reviews and cost estimates should be presented for the proposed measures. (Huuska et al., 2017)

5.3 Calculation of diagnosis indicators for existing urban plans

The indicators selected related to existing urban plans for promoting low energy districts and sustainability mobility are being calculated and they are showing in the following table.

Table 5: Indicators related to existing urban plans for promoting low energy districts and sustainability mobility

Indicator	Units	Value
Existence of plans/programs to promote energy efficient buildings	Number of plans	Over five: e.g. energy saving agreements in municipality organisations, city strategy programme, environmental policy of Helsinki (energy saving goal), energy efficient plot stipulation assignments, low energy renovation instructions for public buildings
Existence of plans/programs to promote sustainable mobility	Number of plans	Over five: e.g. Air quality plan 2017-2022, HRT strategy CO2-free public transport by 2020, SUMP in preparation, City Strategy programme: sustainable modes prioritised in city planning and masterplan
Existence of local sustainability action plans	YES/NO	YES. Called such until 2010, after that sustainability has been included in strategy programme, environmental policy and sectoral programmes like global responsibility strategy and city food culture strategy
Climate resilience strategy	Likert scale 1-7	6
Existence of local sustainability plans	YES/NO	YES
Existence of Smart Cities strategies	YES/NO	YES
Existence of an Agenda 21	YES/NO	YES (First European capital who finished the process in 2002)
Signature and compliance of the Covenant of Mayors	YES/NO	YES

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6. Public procurement procedures, regulations and normative

6.1 Current status

6.1.1 Public Procurement Procedures

The City of Helsinki strives to be a smart procurer and urges businesses that provide novel solutions to approach the city. In 2016, 75 per cent of all centralised acquisitions included environmental criteria. By establishing environmental criteria for procurement, the City has managed to affect the environmental impact of the producers of services and supplies, materials efficiency, product development and other aspects considerably. Following environmental criteria in recent years has resulted in considerable financial savings along with the gained environmental benefits. According to the city environmental policy the share of environmental criteria in the centralized acquisitions will be 100 percent by 2020. (City of Helsinki, 2016b)

The City's environmental network for procurements has reinforced the cooperation between departments and information exchange between the parties in charge of the procurements. The Sustainable Procurements Guide was published in autumn 2015. Helsinki partook in the Hankintamappi project managed by the Finnish Environment Institute, which involved creating a database for public procurement cleantech procurements. Two of Helen Ltd's investments were added to the database: one of them being a school centre's renewable energy pilot and smart street lighting control solution. Additionally, the project involved calculation of the carbon footprint for the paving stones for the renovation of an inner city street for different procurement options. The City of Helsinki is a member of ICLEI's sustainable procurements Procura+ campaign, and a founding member of the Global Lead Cities on Sustainable Procurement working group, founded in April 2015. The City is also involved in the EU funded INNOCAT project, the aim of which is to develop methods and activities to promote sustainable and innovative food service procurements.

Regulation and normative for public procurements in Helsinki follows the national regulations laid by the Ministry of Economic Affairs and Employment. Public contracts must comply with rules that guide the stages of the procurement procedure, the drafting of documents, and the advertising and conclusion of contracts. The fundamental principles of public procurement provisions include transparent and efficient tendering as well as equality and non-discriminatory treatment of tenderers. Contracts shall be awarded

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based on either lowest price or the most economically advantageous tender in which case the measuring is done against previously indicated comparison criteria. Threshold values of public procurements are[17]:

- 0 to 15,000€ - Individual direct purchase is allowed where the planning takes into account both economic and practical efficiency and the purchase is well documented. Previous tendering for framework agreements is also possible. Departments can also have stricter normative for procurement process.
- 15,000€ to 60,000€ - Tendering procedure is necessary unless direct purchase is argumented as above mentioned and
    - set criteria are met or
    - in the case of force majeure timeframe or
    - in the case of having a single known service provider or
    - with known service providers and prices or
    - when the benefit from tendering is lower than the cost of the tendering procedure
- 60,000€ or over – Public tendering procedure with published criteria, pre-announcing, tendering notices and decisions is always required. The tendering is made public in the national tender notice database service HILMA.

6.1.2 Regulations and normative

Normative: Call
Scope: Local - National
Summary: Open call in compliance with the categories divided by the threshold values

Normative: Selection of candidates
Scope: Local - National
Summary: Principles of equality and non-discriminative selection. Techno-economic evaluation

Normative: Tendering process
Scope: Local - National
Summary: Careful preparation to minimise need to clarify, alter contracts or make additional procurements. Minimum three to five candidates recommended to be included. Clear criteria must be presented.

Normative: Handling of acquisition offers and selection

[17] Public Procurement, Purchasing Centre of the City of Helsinki
https://www.hel.fi/helsinki/en/administration/enterprises/procurement

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Normative: Handling of acquisition offers and selection
Scope: Local - National
Summary: Offers to be kept unopened until the selection process (meeting). Notes, minutes and tables with selection data must be prepared for records and main points and results must be presented to candidates. Appeal periods and possible procedures must follow the national legislation. Public Procurement, Ministry of Economic Affairs and Employment. http://tem.fi/en/public-procurement

Normative: Contract
Scope: Local – National
Summary: Written contract is prepared except in the case of very minor or urgent procurements for which written contracts, when necessary, must be prepared afterwards as soon as possible. Contract includes all agreed measures, timetables and instalments.

Normative: Control
Scope: Local – National
Summary: The responsible department or body must manage and control the acquisition and its payments and assurances.

6.2 Calculation of diagnosis indicators for public procurement procedures, regulations and normative

The indicators selected for public procurement procedures, regulations and normative are being calculated and they are showing in the following table.

Table 6: Indicators for public procurement procedures, regulations and normative

Indicator	Units	Value
Existence of regulations for development of energy efficient districts	Number of regulations	9 national regulations, locally required in plot assignment stipulations of certain areas.
Existence of regulations for development of sustainable mobility	Number of regulations	1
Existence of local/national Energy Performance Certificate (EPC)	YES/NO	YES
Share of Green Public Procurement	%	75%
Level of correspondence between local energy codes	YES/NO (discrepancy)	NO (Generally national requirements are followed, except city-owned plots, with little higher requirements and some areas (e.g. Honkasuo) with more ambitious targets.)

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Indicator	Units	Value
Level of correspondence with national regulation	YES/NO (discrepancy)	NO
Level of correspondence with European legislation	YES/NO (discrepancy)	NO
Level of correspondence with international construction standards	YES/NO (discrepancy)	NO

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7. Identification of existing actions for citizen engagement and their success rates

7.1 Current practices

There is a major, ongoing organisational reform underway in the city of Helsinki. The reform challenges the offices and departments of the city to view the participation and interaction of residents in a new way. In order to strengthen the resident initiatives, the City is developing a new model for participation and interaction. The reform shall also respond to the latest developments in the forms of civic participation, defined as city activism or urban activism.

The City of Helsinki Urban Facts Library released in late 2016 a study report made by Anna Idström on the practises of civic participation. The study report focuses on the topics of municipal voting, citizen participation of various groups, Internet and media, urban activism and the networks of citizens.

7.1.1 Case: Helsinki City Planning Department

The Helsinki City Planning Department was the first municipal office in Finland to open a permanent position for an Interaction Designer about 15 years ago. The motivation for this was the new Land Use and Building Act that introduced citizen interaction requirements in a legislation level. Due to their long experience, their services are used here as an example of civic participation activities at a municipal office.

Several new practises have been introduced as part of the civic participation initiative. Planning engineers together with the interaction designer have had open meetups at libraries and performance venues in order to let the citizens discuss about their concerns “by the maps”. Open discussions have been arranged close to the citizens. Planning workshops have been held together with city activists. Plans concerning land use have been explained during walking tours. After tours, discussions have been continued inside. Sometimes the walking tours have involved social media and photos, such walks being called “Instagram-walks”. The photos taken have been shared to Instagram, thus allowing other people to join to comment and continue the discussion offline.

An important function in civic participation development has been a centrally located showroom “Laituri”, where current plans are open to the public. Recently there have been about 50.000 annual visitors at Laituri. As addition to being a showroom, the space has also acted as a meeting room and a place for workshops and joint planning sessions.

Attending social media is a mandatory function of any municipal office. The City Planning Department has organized training sessions of communications for the staff. The office encourages online discussions and

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commenting on both official forums and social media. The office is active on Facebook and twitter but also on YouTube and Periscope.

7.1.2 Case: Helsinki's Climate Roadmap 2050

The Helsinki Climate Roadmap - discussed in section 5.1 - sets out a target for the city to become a carbon neutral and climate resilient city by 2050. The implementation of the measures of the roadmap will support the city's strategy and help to make the city an even better place to live, work, conduct business and visit. The roadmap details what is needed from both the people and the city to adapt to carbon neutrality and climate change. It will encourage climate work, open up conversation and aid planning, while developing Helsinki's climate work to make it even better and more interactive.

Helsinki's Climate Roadmap was developed in a collaboration of many experts of the City of Helsinki and different stakeholders in workshops and using real-time collaborative writing. It was launched at the international Earth Hour in 2015. Helsinki's Climate Roadmap was designed to make Helsinki's climate policy and climate actions more easily understandable and approachable. It encourages practical climate work, opens up conversation and aids in planning. It inspires citizens and organizations of Helsinki to make a positive change in their everyday by showing how they can influence.

7.1.3 Tools or channels used for citizen engagement

The City of Helsinki has encouraged its departments to have an active, online presence in the social media. Some units have had a very personal and light touch on their message, as an example the public works department became very popular with their twitter account after they started to involve humour in their message – even though the actual content was mostly official and provided background information on current matters. It is also worth noticing, that their activities on twitter were not only dissemination: they actively participated on discussions as well. Currently their handle @HelsinkiKymp has about 20.000 followers and since joining twitter in December 2011, they have sent over 12.700 tweets.

While twitter is a key tool to get the message through, Facebook and Instagram are also actively used. Recently the online presence was branded under the new #myhelsinki –handle that is used for marketing purposes. A related website http://beta.myhelsinki.fi was just recently launched as a beta version.

Table 7. Outreach of Helsinki's social media channels

Communication tools/channels	Link	Outreach	Scope
Social media / Twitter	@helviestinta	13.784	Official city handle
Social media / Twitter	@helsinkikymp	19.965	City Environment Sector
Social media / Twitter	@helymparisto	4.058	City Environment Center

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Communication tools/channels	Link	Outreach	Scope
Social media / Facebook	helsinkikaupunki	6.328 followers	Official city page
Social media / Facebook	Helsingin Kaupunkiympäristö	8.056 followers	City Environment Sector (formerly public works and planning)
Social media / Facebook	Helsinki Loves Developers	281 members	Open data and open source developers

7.1.4 Living Labs

The Kalasatama Living Lab was set up to support citizen engagement in a new district that by the year 2035 will house over 25.000 people and have more than 8.000 jobs. The development is based on experimenting, IoT –technologies and the use of data. By the end of year 2016 over 20 projects had started in the district. The living lab has housed an Innovator's Club that is based on a quadruple helix model: the innovation clubs will have participants from industry, city, citizens and academia.

7.1.5 Health-care

At the city level, Helsinki supports its offices by providing cross-functional services that help the citizens to locate a specific service suitable for their needs. As an example, there is "Seniori-info" that provides a single point of contact for elderly people and "Ohjaamo" which does the same for younger people. For elderly people a form of trade show has been organized that collected together various city services related to housing, participation and regional services. While there is a little statistical information available on the successes, some specific service developments have already resulted with significant improvements: as an example, a "Digital Health Check" targeted to the male of the age of 40+ increased the number of completed health checks by 50%.

7.2 Success rates of current practises

According to Idström (2016), the following practises have been found important for successful civic participation:

- upbringing at home when it encourages on active participation
- education: the higher the educational level, the more interested the person is about politics
- media: according to the studies, most important source of information affecting election decisions has been news and current affairs programs on TV, newspapers and election programmes on TV
- voting advice applications (VAA) have increased people's political activity and have become popular source of information

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- social media and open data have been the platform to build new block and zone-specific events that later on have been expanded throughout the city and other cities as well (i.e. Restaurant Day)
- campaigns, democracy pilots: e.g. joint effort on the preparation of budget
- third sector organisations
- gamification, where participation on an activity has been turned on a game or competition
- adequate resources, especially time, funding, activists and positive attitude from city authorities
- reacting on the actual needs
- expert involvement in discussions and meetups
- open discussion
- productive answers on negative decisions
- single point service desk, especially in issues requiring complicated licensing process or other type of regulation

As a potential for improvement it can be identified that KPIs to monitor the success or impact of citizen involvement actions are not yet in use at least as a common practice. Possibilities for such and their potential usefulness will be further analysed within related mySMARTLife actions.

7.3 Calculation of diagnosis indicators for citizen engagement

The indicators related to existing actions for citizen engagement are being calculated and they are showing in the following table.

Table 8: Indicators related to existing actions for citizen engagement

Indicator	Units	Value
Number of local associations per capita	Number of consultations / inhab.	over 200
Number of information contact points for citizens	Number of information points	10 online systems, about 10 physical meeting places for events and information
Number of municipal websites for citizens	Number of municipal websites	Numerous (depending on the definition)
Number of interactive social media initiatives	Number of social media links	Numerous (depending on the definition)
Number of discussion forums	Number of forums	Numerous. Depending on what is calculated. For example, a comment option to multiple web services. In addition, discussion opportunities are organized on a project-specific basis, for example in the planning and other urban planning projects. If these are calculated, there are dozens of forums. Info for some are gathered e.g. Tell it on the Map direct feedback tool.

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Indicator	Units	Value
Access to public amenities	%	N/A
Access to commercial amenities	%	N/A
Diversity of housing	%	19,92%
Preservation of cultural heritage	Qualitative Likert scale	4
Number of high edu degrees per 100,000 population	n/100,000h	34 181

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8. City transportation current status

Almost half of the daily trips made in Helsinki are performed by walking or bicycling. Roughly, one third of the trips are done using the public transportation, and one fifth of the trips with passenger cars. Passenger car density in Helsinki is currently 328 cars per 1000 persons, including the vehicles in active road use. The density of passenger cars when counting all registered vehicles is 404 cars per 1000 persons [LOS 2016:7]. In total, transportation is a cause for 23% of Helsinki CO2 emissions, which of approximately half is caused by passenger cars [HSY 2017].

The public transportation system consists of a bus system and multiple rail transit systems, including tram, commuter train and a metro line. In addition, there are four ferries operating between the city and Suomenlinna Island. Helsinki Region Transport Authority (HSL) is responsible of the organization of the public transport in the region. HSL is also responsible for coordination of the planning of the Helsinki Region Transport System Plan (HLJ), which is setting the guidelines for the transportation development. HSL is a joint local authority whose member municipalities are Helsinki, Espoo, Vantaa, Kauniainen, Kerava, Kirkkonummi and Sipoo. HSL has begun its operations in 2010.

8.1 Modal split of the transportation in Helsinki

On average the citizens of Helsinki perform 3.1 trips daily per inhabitant [LOS 2016:7]. The average travel time in Helsinki region is 1 hour 13 minutes, including the total travel using all modes during the day. The average time spent on a single trip by walking is 17 minutes, by bicycle 4 minutes, by public transport 27 minutes and by passenger car 22 minutes [HSL LIIK 2012]. In the central district, walking is the most popular mode of transportation, and number of daily trips is slightly higher than in the suburban areas. The share of private vehicles is larger in the suburban area. The presented figures represent the average values inside the whole city of Helsinki, including the suburban areas [LOS 2016:7].

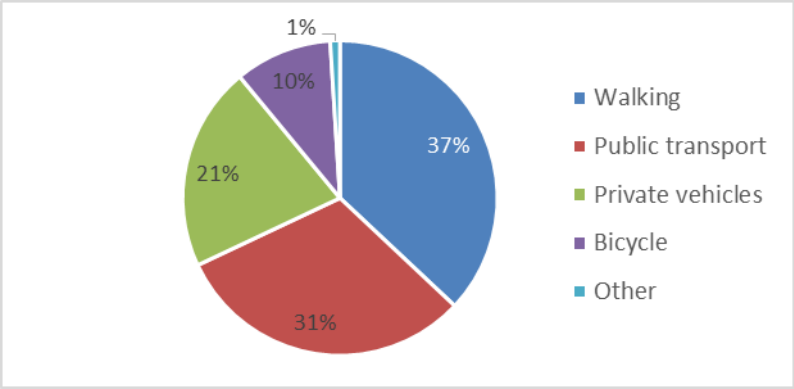

Figure 7. Modal split of transportation in Helsinki [LOS 2016:7]

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Table 9. Detailed modal split in Helsinki with daily trips

Mode	Daily travels	Percentage
Walking	635,000	37 %
Private vehicle, driver	292,000	17 %
Bus	241,000	14 %
Bicycle	179,000	10 %
Metro	125,000	7 %
Tram	101,000	6 %
Private vehicle, passenger	77,000	4 %
Commuter train	62,000	4 %
Taxi	12,000	<1 %
Other	11,000	<1 %
Total	**1 734 218**	**100%**

City of Helsinki has 1,190 km of bicycle route network [HYT 2011]. Three out of four residents have a bicycle available at least occasionally, and two thirds have constant availability to a bicycle [LOS 2016:7], which means that approximately 420,000 inhabitants have constant daily access to a bicycle. Bicycles are available more in the suburban areas than in the central district.

8.2 Transport emissions and energy usage

VTT Technical Research Centre of Finland is maintaining a calculation system for traffic exhausts emissions and energy use in Finland, called LIPASTO, where data is available also on community level [VTT LIP 2015].

Table 10. Transport energy and emissions for different vehicle classes

Vehicle class	NOx [t]	PM [t]	CO2 [t]	CO2 eq. [t]	Fuel cons. [t]	Energy [TJ]	Dist. driven [Mkm]
Passenger car	541	18	326 296	329 056	116 738	4 900	2 015
Van	227	17	38 778	39 124	14 917	638	223
Bus	379	5	44 087	44 507	17 020	729	56
Truck	446	8	71 006	71 576	27 333	1 169	96
Motorcycle	25	4	13 930	14 631	4 757	198	129
Moped	5	2	2 056	2 245	702	29	33
L6e (mopoauto)	6	1	1 293	1 331	442	19	9
Total	**1 630**	**55**	**497 446**	**502 469**	**181 910**	**7 681**	**2 561**

Vehicle fuel efficiency

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Total annual energy consumption by vehicles in Helsinki is 7681 TJ, which equals to 2,13 TWh/a. The average vehicle fuel efficiency is 83 kWh/100 km for all vehicles. Passenger cars have an average fuel efficiency of 67 kWh/100 km. Total greenhouse gas emissions from transport in Helsinki are 0,502 Mtn/a, and per capita the annual emissions are 0,799 tn/person [VTT LIP 2015]. Number of vehicles for the calculations is obtained from Trafi open data [TRAFI OD 4.8].

8.3 Traffic accidents

The Helsinki City Planning Department is maintaining statistics of the traffic accidents in Helsinki, which is published as open data under Creative Commons 4.0 license terms. The last published data, dated 14 November 2016 is from 2015. According to the data, 12 fatalities were observed during 2015, which is a slight increase to the average during last 5 years [KSV 2016].

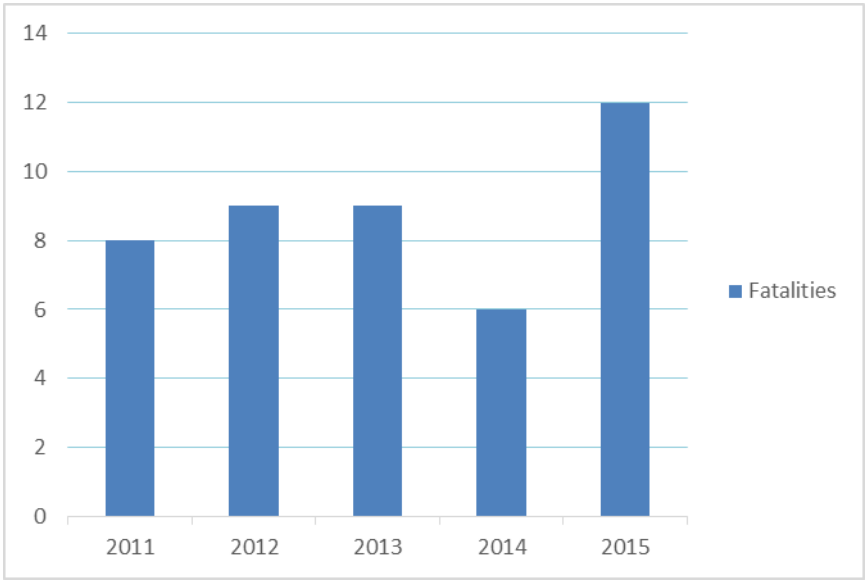

Figure 8. Fatalities in traffic accidents in the City of Helsinki

8.4 Congestion

Congestion data is based on TomTom Traffic Index from year 2016 [TOMTOM 2016]. The TomTom data has been found to be suitable for analysing the congestion and travel time according to a study performed on the different traffic data sources [KYTÖ 2016]. The data is based on actual driving data from a large set of drivers and vehicles.

The average congestion ratio in Helsinki in 2016 was 26%[18], which sets Helsinki in 62nd position among small cities in the city ranking. The congestion ratio increased 3% from the previous year. The highest peak is achieved in the afternoon, with 48% congestion ratio. The morning peak is 40%. Extra travel time per day due to congestion is on average 27 minutes [TOMTOM 2015].

[18] Increase in percent of overall travel times compared to free flow (uncongested) situation

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The average vehicle speed during congestion is 18 km/h during the morning peak at 8:30 - 9:00. The speed decreases a bit during the afternoon peak at 16:00 - 16:30, and the average speed goes down to 15 km/h. During the working day, between the morning and afternoon peak, the average speed is 24 km/h [HSL AJO 2015].

Average occupancy

Average occupancy in vehicles entering the central district during the morning peak is 1.22 persons per vehicle and the average occupancy per day is 1.29 persons per vehicle [KSV 2013].

8.5 Public transport

Helsinki invests strongly in extensive, reliable and fast public transport. The needs of a variety of user groups are taken into consideration in planning. According to a recent study (Van Auderhove et al. 2014) by the automobile associations of 15 countries, these goals have been met very well. The public transport system of Helsinki has been ranked second in a comparison to 23 European cities. Over the years, the public transport system of Helsinki has performed well in many international comparisons. Helsinki has always been among the top cities in the annual BEST study.

The public transport system of the Helsinki metropolitan area consists of metro and commuter trains that form the basis and complemented by buses and, in the central city area, trams. Helsinki also favours the use of environmentally friendly trams and metro. In the near future, the amount of people using rail traffic will increase, due to the construction of new housing near train and metro stations. The first light rail line planning has also been started for the Helsinki metropolitan area to improve the horizontal public transportation network.

In its calls for tender, the Helsinki Regional Transport Authority (HSL) favours vehicles with low emissions. In addition, HSL studies and tests the suitability of alternative fuels for public transport. Most buses run on diesel, but there are also a certain number of vehicles fuelled by natural gas. Use of electronic and autonomous vehicles for public transport are being piloted.

A total of 239,4 million trips were made using public transport including all modes of transportation in 2015, which means a yearly average of 381 trips per resident [HSL trips 2015]. The public transportation is used daily by 35% of residents, and only 2% of the residents never use public transport. The most active user group in public transport are 18 - 29 year old residents. Residents in the central district and female residents are utilizing public transport services above the average [LOS 2016:7]. Bus is the most used public transport mode with 40% share of the trips performed. Tram and metro have closely the same share, about a quarter of the trips performed [HSL YKK 2011].

The average trip length in public transport varies according to the vehicle type. The shortest trips are performed using trams, on average 2.19 km, and longest on commuter trains, 11 km. Bus and metro trips

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are on average quite similar in length, bus trips being on average 6.79 km and metro trips 6.45 km [HSL YKK 2011].

Access to public transport in Helsinki is excellent. Almost every inhabitant (99.81%) has less than 700 m to their closest public transport stop, and 95.96% of the inhabitants have less than 300 m distance to their closest stop [HYT 2015].

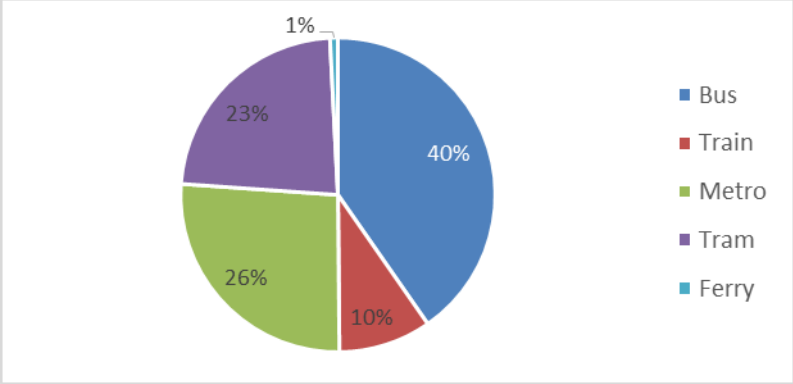

Figure 9. Modal split of public transport

Renewable energy use in public transport vehicles

Rail-based public transport (trams, commuter trains) of the city is fully electric, and since 2012 all rail transport electricity has been produced with low-carbon hydropower. Since 2014, the electricity for the rail transport has been sourced from the Nordic energy market as renewable energy, either hydro or wind power [HSL YMP 2013].

The bus fleet has been mostly based on diesel fuel until 2016, with a minor number of natural gas buses. In 2016, the use of biogas in place of natural gas was begun in the first 22 gas buses (1.5% of the bus fleet) by operator HelB[19]. An environmental bonus is paid for usage of biodiesel, bioethanol and biogas to four operators in the HSL region in 2017[20].

Biofuel content in diesel is being increased rapidly in the HSL region bus transport, as well as in the Stara municipal vehicles in a currently running BioSata project. The biofuel content was 25% in 2016, and a target is that in 2017 it will be raised to 50% and eventually to 100% in 2020 [MÄK 2016].

Table 11. Renewable energy in public transport

Vehicle type	Vehicles	Electric	RES-%
Bus	1406	2	28%[1]

[19] https://vihreakaista.fi/fi-fi/article/kaasu/paakaupunkiseudun-kaasubussit-kulkevat-biokaasulla/221/
[20] https://www.hsl.fi/uutiset/2016/hsln-hallituksen-paatokset-13122016-9466

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Commuter train	97	97	100%
Metro car	54	54	100%
Tram car	124	124	100%
Total	**1681**	**277**	**40%[2]**
Total renewable energy % based on consumed energy			**28%**

Notes:

1. Biodiesel content currently in the HSL fleet + bioethanol buses + biogas buses in 2017
2. Percentage of all public transport vehicles running on renewable energy sources

Electric buses

Helsinki Region Transport Authority (HSL) is starting to utilize electric buses to fulfil its strategy on sustainable public transport and cutting emissions (CO2, NOx, PM) by more than 90% by 2025 (compared to the level in 2010). According to the fleet strategy by HSL, the share of fully electric or hybrid buses would be more than 30% of the total fleet by 2025. To reach this, HSL started a pre-commercial procurement where 12 fully electric city buses are lent to 4-5 different bus operators and serving commercial traffic during 2016 – 2019.

Charging infrastructure for these buses is being built by cities of Helsinki and Espoo and will be placed at the end stops of central city lines and central terminal areas. The infrastructure within Helsinki is owned by Helsinki City Transport (HKL), and operated by Virta Ltd. The operation is based on small sized vehicle batteries and opportunity charging, which has been found to have the lowest total cost of ownership in Helsinki's case [PIHLATIE 2014].

Alongside with the procurement, HSL is preparing for public tendering of electric bus systems to start commercial roll-out in accordance with the strategic plans. The procurement and the commencing roll-out give an increasing geographic coverage of high power automatic charging infrastructure within the city.

Table 12. Electric bus charging points

Electric bus charging point	Nodes	Notes
Ruskeasuo	1	In operation
Koskela	1	Awaiting repair to start operation
Rautatientori	2 (+2 in reserve)	Will be finished by summer 2017
Hakaniemi	1	Building in 2017
Malminkartano	1	Building in 2017
Total	**6**	

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8.6 Cycling

Helsinki region has good facilities for cycling. There are some 3,000 km of cycle paths in the metropolitan area and about 12,000 Park & Ride spaces for bicycles across the region. The metropolitan area cities are constructing more high-quality cycle routes every year and expanding the maintenance to cover further areas. Helsinki launched its first set of 400 city bikes in 2000 but they were not successful due to vandalism and poor deposit system. A completely new line of better bikes and a flexible, user-friendly registration system was launched in 2016 with 500 bikes and the system was received extremely well. The network will be extended to cover larger areas and complimented by 1000 more bikes starting from spring 2017.

HSL and the Cities of Helsinki, Espoo and Vantaa have developed a marketing strategy for cycling aimed to encourage more and more people to cycle. The goal of the strategy is to change the attitudes of the residents to be more cycle-friendly and develop mutual understanding among all road users. The aim is to normalize cycling: it is one mode of transport among others.

8.7 Vehicles in Helsinki

Vehicles in traffic use in the city of Helsinki listed according to the vehicle type are obtained from the Trafi Open Vehicle Data [TRAFI OD 4.8]. There is not yet published municipal level statistics on electric vehicles. Plug-in hybrid vehicles were counted to the total number of electric vehicles, but the table shows also the share between battery electric vehicles and plug-in hybrids. Plug-in hybrids were only queried for the M1/M1G type vehicles, as they are still very rare among other vehicle groups. The data shows only two of the electric buses taken in use by HSL, as majority of them are being delivered during 2017. The listing was done by counting the vehicles by the postal code. The data would allow also counting by the most probable municipality, where the vehicle is going to be used. The difference between these two counting methods is relatively small. For example in passenger cars, the total number of cars which are marked as being most probably used in Helsinki city is 198 875.

Table 13. Vehicle types

Vehicle type	Total vehicles	Total number			Percentage Electric + Hybrid
		Electric[1] vehicles	Hybrid[2] vehicles	Electric + Hybrid vehicles	
Passenger car, M1/M1G	204,471	139	552	691	0.34%
Van, N1	21,653	36	-	36	0.17%
Truck, N2/N3	5,510	0	-	0	0%
Bus, M2/M3	1,122	2[3]	-	2	0.18%

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Vehicle type	Total vehicles	Total number Electric[1] vehicles	Hybrid[2] vehicles	Electric + Hybrid vehicles	Percentage Electric + Hybrid
Motorcycle, L3/L3e	10,167	1	-	1	0.01%
Moped, L1/L2/L1e/L2e	6,867	78	-	78	1.14%
Light duty L6e	188	17	-	17	9.04%
Light duty L7e	405	30	-	30	7.41%
Tractors, T/T1-5	1,755	11	-	11	0.63%
Municipal vehicles, MTK	2,622	20	-	20	0.76%
Total	**254,760**	332	552	**884**	**0.35%**

Source: Trafi vehicle open data 4.8, dated 1.1.2017

Notes:

1. Battery electric vehicles.
2. Including only plug-in hybrids for M1 vehicles
   Two of the HSL pre-commercial pilot fleet buses, registered in Vantaa

At the time of the reporting, there were a total of 884 electric or plug-in hybrid vehicles in Helsinki, which make up 0.35% of the total number of vehicles in use in Helsinki.

The total number of fossil fuelled four wheel vehicles is 237,120. Population of Helsinki at the beginning of 2016 was 628,208 [HEL 2016]. The amount of private fossil fuelled four wheel vehicles per capita is 0.38 vehicles/capita, including all vehicles. The number of public fossil fuelled four wheel vehicles per capita is only including non-electric buses, which means that the number of vehicles is only 1,406 vehicles. Per capita, the ratio is 0.0022 vehicles per capita. However, it is noteworthy that the share of renewable energy content in the fuel for the petrol and diesel vehicles is high in Finland.

Fuel mix

The fuel mix data is based on the registered vehicle data [TRAFI OD 4.8]. This gives an accurate indication of the fuel types that are being used, and on the market share. The actual fuel mix by fuel market share will be slightly different, but that data is not available on city scale in Finland.

The passenger cars in Helsinki are mostly running on petrol, with a 75% share of all class M1/M1G vehicles. Diesel has 25% share, and the rest of the fuels have less than 1% market share combined.

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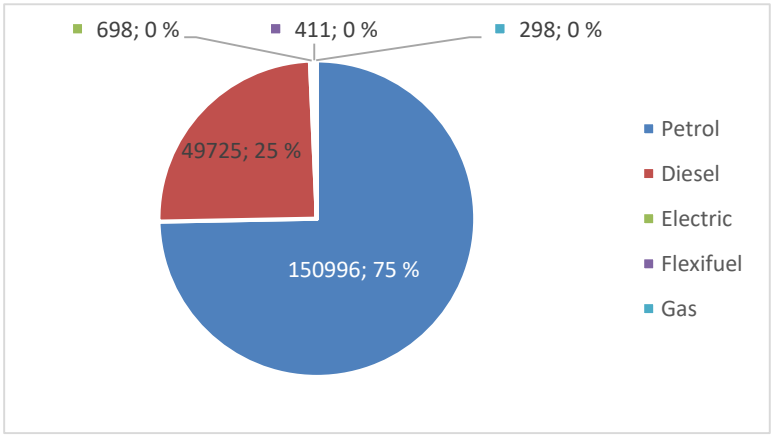

Figure 10. Fuel mix in passenger cars

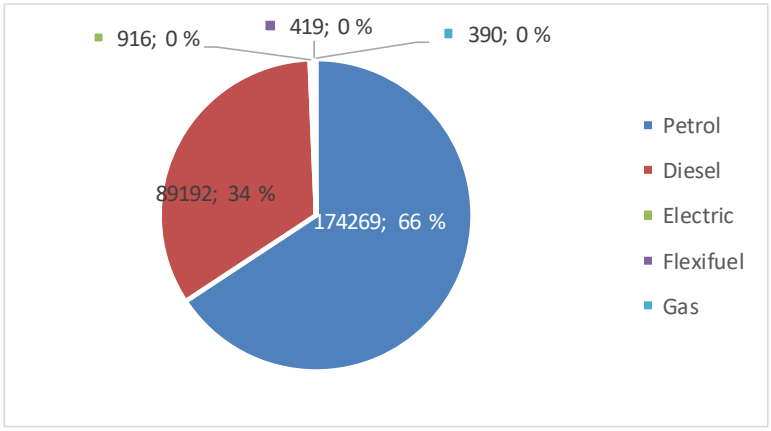

Figure 11. Fuel mix in all vehicles

Renewable energy use in private vehicles

Finland has set its own distribution obligation of biofuels, which requires that the share of renewable energy in transportation sector will increase to 20% by 2020. In 2016, the required amount of biofuel content was 10%. However, the actual situation is that in 2015, the share of renewable content in the Finnish transport sector fuel was already 22% [EUROSTAT 2017]. According to Statistics Finland, the share is larger in the diesel fuel (17.4%) than in petrol (4.9%). Biogas content in the total amount of fuel use is minimal, 61 TJ [STAT 2016].

In BioSata project, the Helsinki City construction service Stara is increasing its biofuel usage in its municipality vehicles, with the same goals as HSL. The target is to have 100% biofuel usage by 2020.

8.8 Car sharing services

Helsinki has several car sharing services, which each have their own specialities.

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City Car Club is the oldest still operating car sharing service in Helsinki, started in 2001. Currently it has widespread availability of cars around the city. The service requires membership, which has a monthly payment ranging from 0 to 50 €/month. Usage of the car is paid by the hour, and the pricing is tied to the type of the membership. For an additional fee, the service allows to compensate for the CO_2 emissions caused by the use of the car.

Ekorent is a 2014 opened car sharing service, offering only battery electric vehicles. The service is currently operating only in Helsinki. The fleet is consisting of Nissan Leaf's, with one Tesla Model 3 in order. The service is offered in 3 levels, with a monthly fee ranging from 0 to 12 €. The car usage is paid by the hour, with a rate ranging from 8 to 12 € per hour. Daily pricing is 55 € per day.

24Rent is a service that is between a car sharing service and a car rental. The service has spread the vehicles around the city, and the rental process can be performed completely online. The vehicle pick-up is performed using a smartphone app or SMS. The service does not require membership, and there is no monthly fee, but the car usage is slightly more expensive than with the previously mentioned services. Minimum rental time is two hours. There have been two plug-in hybrids and one battery electric vehicle in the fleet since 2015. The vehicles need to be refuelled before returning them to the location where it was rented. 24Rent is expanding its fleet, and by summer 2017 the fleet will grow to include 70 passenger cars and 55 vans in Helsinki[21].

Go now is a floating car sharing service owned by 24Rent, which is sharing part of the fleet with 24Rent. The service operates completely by smartphone, and offers Toyota Yaris/Auris Hybrids in Helsinki with a minute-based charge. The charge is 0.58€/min when the vehicle is moving and 0.058€/min when it is parked during the rental period. The rental charge includes also fuel and parking fees. After the rental, the car can be left anywhere within the service area, which is marked in the smartphone app map. The service requires only phone number and payment details to get started, which sets the threshold to test the service very low.

Shareitbloxcar is a peer-to-peer car sharing service that allows car owners to rent their own vehicles when they don't need them. At the time of writing the report, the service offered 35 cars in the City of Helsinki, including one battery electric vehicle[22].

Finnish financial group Osuuspankki (OP) is starting the BMW and Sixt owned car sharing service DriveNow in Helsinki[23]. The service has opened in May 2017, and will be in full use by June. The service consists initially of 150 vehicles, which of 10 are full electric. The charge for renting the vehicle is 0,57€/min, which includes parking and fuel charges.

21 E-mail from Matti Hänninen / 24Rent on 11.4.2017

22 https://www.shareitbloxcar.fi/available-vehicles?city=Helsinki [retrieved 11.4.2017]

23 http://www.hs.fi/talous/art-2000005205832.html

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Table 14. Car sharing providers and numbers of cars

Service name	Pass. cars	Vans	Electric
Ekorent	15[1]		15
City Car Club	61		18[2]
24 Rent	40	45	1+2[3]
shareitbloxcar	34	1	1
Go Now	30[4]		
DriveNow	150		10
Total	**310**	**46**	**47**

Notes:

1. Not confirmed, based on the location map in www.ekorent.fi
2. Plug-in hybrids
3. One battery electric vehicle and two plug-in hybrids.
4. Shared with the 24Rent vehicle fleet, not counted in the total

In total, City of Helsinki includes 310 car sharing vehicles, which of 15% are electric. On average, 49 vehicles per 100,000 inhabitants are available for car sharing.

8.9 Taxi

Finland has on average one taxi per 530 inhabitants. Taxi service is regulated by the Centre for Economic Development, Transport and the Environment (ELY-keskus), who is setting the maximum number for taxi permits per municipality. Also, the fare pricing is being regulated. According to the last ruling by ELY-keskus Region 15 (Uusimaa), the maximum number of taxi permits in the City of Helsinki is 1,300, including 1,205 passenger car permits and 95 accessible vehicle permits [ELY 2016]. The Helsinki taxi dispatch service (Taksi Helsinki) is reporting to have 1335 taxis in their current database[24]. At the moment, there is one battery electric taxi in operation in Helsinki[25].

A preparation for a new law for regulation of transportation market (Liikennekaari) is on-going, and is being processed by the parliament. The new law would free the taxi market from regulation, both on the number of taxi permits and fare pricing. It is expected that the number of taxis in Helsinki will grow if the law is passed.

Uber has been available in Helsinki since 2014. The service has been ruled as illegal in the Helsinki Court of Appeal in September 2016 [HOVI 2016], and the initial cases are now under process in the Supreme

24 https://taksihelsinki.fi/tilaa-taksi/taksikalusto/ [retrieved 10.4.2017]

25 https://www.teslaclub.fi/Koe+Tesla/

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Court. Commercial taxi service requires a taxi permit in Finland. The requirement for the taxi permit also for low income from taxi service is planned to remain in the new transportation regulation law.

8.10 Electric vehicle charging

There are three operators providing passenger EV charging service in Helsinki area. The payment methods between different charging networks are not compatible with each other.

Fortum Charge & Drive is a large Nordic charging service operator with over 1200 charging points in Norway, Sweden and Finland, and a few also in Lithuania and Poland. Fortum C&D has one normal charging point in Helsinki at the parking facility P-Eliel. Payment is possible by using SMS, RFID card ordered from Fortum or with a mobile app.

Virta Ltd. is a start-up company, established by multiple utility companies, aiming at creating a nationwide network of charging points within Finland. Virta is also expanding their network via roaming contracts within Europe. Payment at Virta charging points is possible with SMS, RFID card or tag and with a mobile app. Virta has now 64 charging points in Helsinki. The infrastructure belonging to the Virta network is not owned by Virta, but its partners, and thus there is more variety in the charging equipment. Virta also allows the individual clients to set the pricing for the charging service, so the pricing varies from charging point to another, being usually either time-based or electricity-based, or both. Virta is currently handling also the e-bus charging service in Helsinki and Turku by managing the installed fast charging stations.

Parkkisähkö Oy (Parking Energy Ltd) is a start-up company, who has just launched their service for EV charging. The service is based on NFC tag attached to the vehicle Schuko charging cable, which will enable the vehicle owners to charge from any of Parkkisähkö's charge points with a very simple user authorization (plug in the cable), and get invoiced from only the used energy for charging. The charging points are leased to the parking facilities or building owners. Since the service is based on low power charging with Schuko plugs, the devices are easily deployable in large numbers, and Parkkisähkö's first announced contract with EuroPark parking facilities increased the number of charging points within the Helsinki central district by 50%. Parkkisähkö just recently announced their latest expansion to a parking facility in Salmisaari[26], where they will be equipping 250 parking spots with slow charging capability. The new installation includes also smart load control to maintain the peak power consumption under the facility's maximum limit. The installation has started in April 2017 and will be finished by June. The parking facility is being used by four large companies having offices in that area.

There does not exist public e-bike charging stations in Helsinki at the time of the reporting. The first charging station is planned to be opened during the mySMARTlife project in Korkeasaari.

[26] http://www.parkkisahko.fi/salmisaaren-pysakointihallissa-250-ruutuun-tulee-latausmahdollisuus/

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8.10.1 Available charging points

The situation of the charging network in Helsinki requires combining information from multiple sources, as there does not exist a single database containing reliable information of all available charging points. To compile the information of available charging points, information from Virta Ltd[27], Parkkisähkö[28], Fortum Charge & Drive[29], Open Charge Map[30] and PlugShare[31] was used to get the overall situation.

Table 15. Available charging points

Operator	# of points	Notes
Virta	64	Mostly Type 2 or Type 2 / Schuko. 3 fast chargers.
Parkkisähkö	18	Expanding to 28 during spring. All Schuko connectors.
Fortum	2	Type 2
Total	**84**	

Helsinki has 691 electric or plug-in hybrid passenger cars, and 84 charging points. On average, there are 0.12 charging points per electric vehicle in the city.

8.10.2 Charging statistics

Parkkisähkö has just started it's operations, so statistics don't really exist yet on their charging point usage. Fortum has only two charging points in their network, that are located in the City of Helsinki. Virta has currently the largest charging point network within Helsinki, that is centrally managed, so the statistics was obtained from the Virta network usage.

In 2016, there were 6487 charging events in the Virta network within the City of Helsinki. There were a total of 64 individual charging points in the network, which yields an average use of 101 charges per charging point. The total charging energy charged through the Virta network in 2016 was 59 045 kWh.

27 E-mail from Jaakko Liesmäki / Virta Ltd. 11.4.2017.
28 E-mail from Jiri Räsänen / Parkkisähkö 23.3.2017
29 http://map.chargedrive.com
30 http://OpenChargeMap.org
31 http://PlugShare.com

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8.11 Calculation of diagnosis indicators for city transportation current status

The indicators selected for city transportation current status are being calculated and they are showing in the following table.

Table 16: Indicators for city transportation current status

Indicator	Units	Value
Total number of public transport vehicles	Number of vehicles	3,016
Number of Electric Vehicles (EV) in the city	n / 100.000 people	141
Number of fossil fuelled four wheels vehicles per capita	n/ cao	0,38
Traffic accidents	#/100 000 people	1,9
Public transport use	#/cap/year	381
Access to public transport	%of people	95,96 %
Access to vehicle sharing solutions	#/100 000 people	49
length of bike route network	% in km	191
Congestion	% in hours	26 %
Vehicle fuel efficiency	kWh/100km	83
Fuel mix	%	Petrol 65.7% Diesel 33.6% Electric 0.34% Flexifuel 0.16% Gas 0.11%
Average occupancy	number of passengers per vehicle	1.29
Average vehicle speed		Peak: 18 km/h Off-peak: 24 km/h
Total energy of charging points	kWh	59,045
Charging points per eVehicle	%	0.12
Total charging points	#	84
Recharges per year	#/year	6487
infrastructure growth e-car	[number of e-car charging]	84
infrastructure growth e-bike	[number of e-bike charging]	26

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9. Energy supply and resources

9.1 Energy supply diagnosis

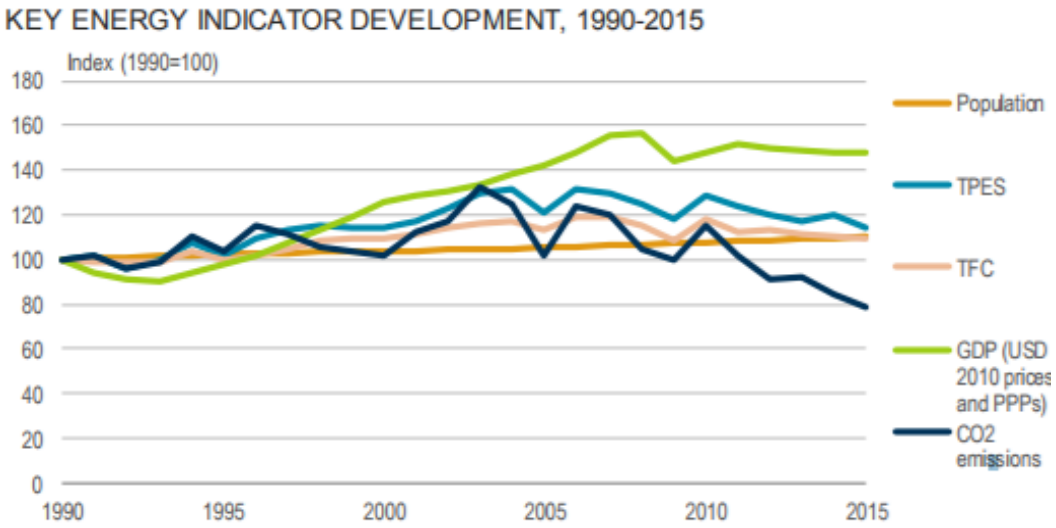
The Finnish energy fuel mix is detailed in the following table.

Table 17: Energy consumption in Finland as shares by sources in percentages [%] (Source: Statistics Finland, 2017[32])

	Share of total energy consumption, %			
	2013	2014	2015	2016*
Year Total				
Oil	23.1	23.0	23.7	23.0
Coal	11.0	9.4	7.9	9.4
Natural Gas	7.8	7.1	6.3	5.6
Nuclear Energy	18.0	18.3	18.6	18.0
Hydropower	3.3	3.5	4.6	4.2
Wind Power	0.2	0.3	0.6	0.8
Peat	4.2	4.5	4.4	4.1
Wood fuels total	24.6	25.2	25.3	25.8
Small-scale combustion of wood	4.5	4.6	4.5	4.6
Others	3.6	4.0	4.0	4.1

The evolution of key energy parameters in Finland is shown in next Figure.

Figure 12. Evolution of key energy parameters in Finland (Source: IEA, 2017[33])



[32] http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehk/010_ehk_tau_101_en.px/?rxid=5e3a8ad4-e4a4-4c6b-aa95-acc43605d168

[33] https://www.iea.org/media/countries/Finland.pdf

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9.1.1 Electricity

9.1.1.1 Energy supply

Helsinki is naturally connected to the national grid, but the local utility Helen does have a number of power plants within the city as well. The most relevant plants are the CHP plants also providing heating for the city wide district heating system. The power plants within the city are listed in Table 18.

Table 18. Electricity production plants in Helsinki[34].

Power plant	Capacity	Description
Vuosaari A and B	630 MW (and 580 MW_{th})	Two natural gas fired CHP units. Efficiencies up to 93 %.
Hanasaari B	220 MW (and 420 MW_{th})	A coal fired CHP plant, to be closed by the end of 2024.
Salmisaari	160 MW (and 300 MW_{th})	A coal and wood pellet fired CHP plant.
Vanhakaupunki	0.20 MW	Hydropower plant museum, oldest power plant in Helsinki.
Kellosaari	120 MW	Reserve power plant run on light fuel oil.
Suvilahti	0.34 MW	Solar panels.
Kivikko	0.85 MW	Solar panels.
Total	**1,131 MW**	**Total electricity production capacity in Helsinki.**

Electric energy production statistics for 2016 state a total of 4663 GWh produced and following amounts for big power plants based on different primary resources:

- Vuosaari 3450 GWh (natural gas, CHP)
- Hanasaari 643 GWh (coal/wood, CHP)
- Salmisaari 570 GWh (coal/wood, CHP)
- Suvilahti 0,275 GWh (Solar PV)
- Kivikko 0,7 GWh (Solar PV)

Electricity production of individual plants depends heavily on the year. In 2015, the Helsinki CHP plants produced 4.6 TWh of electricity. This makes Helsinki area producing slightly more than consuming. 1001 GWh of this production was exported outside the area whereas 785 GWh was imported during certain periods. The overall energy balance was thus 216 GWh positive. Majority of energy production takes place in big power plants located in the city area. Small-scale distributed generation is still minor but is currently rising; the amount of small-scale generation units are roughly doubling each year. The amount of small-scale generation is also difficult to assess as it is continuously growing and not always showing properly in statistics. However, by the end of 2016 the number of small-scale energy producers was estimated to be almost 100.

[34] Helen Ltd power plants; https://www.helen.fi/en/helen-oy/about-us/energy-production/power-plants/

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9.1.1.2 Distribution system

Electricity networks on Helsinki area are mainly built as underground cables. Especially distribution voltages (medium and low voltages) are practically fully cabled at the moment. This makes the network very robust against external disturbances. At the same time, fault location and repairing can be very time consuming when it is needed. As normally, electricity network structures on city area integrate strongly to other built environment like streets and buildings.

The overall length of electricity network on Helsinki area is 6286 km. Out of this, low voltage (400 V) lines cover 4468 km whereas medium voltage (10-20 kV) lines 1615 km and high voltage lines (>110 kV) 203 km. Cabling rate for low voltage network is 97,7%, for medium voltage 99,7% and for high voltage 34,5%.

Helsinki area has 23 bigger HV/MV substations. There are 1826 secondary MV/LV substations, meaning distribution transformers. These are mainly built as ground cabinets following the high cabling rates.

The network on city area has been built using meshed structure where ring connections can be used flexibly for network topology changes. Normally the network is operated in radial mode. Reliability indices for Helsinki area are on a very high level and average interruption times are very small in national-level comparison. This is due to high cabling rate.

9.1.1.3 Energy demand

The electricity network on Helsinki area serves around 375,000 customer points. Vast majority of these are normal consumers connected to low voltage (400 V) electricity network. Less than 1000 customers are located on higher network levels, which means they are practically bigger customers like industries, services or other non-residential use.

In 2015 Helsinki city area consumed a total of 4317 GWh of electric energy. Out of this, small customers connected to low voltage networks used 2375 GWh (55 % of total share) whereas bigger customers on higher network levels consumed 1941 GWh (45 %).

Figure 13 presents the progress of electricity consumption during 2007-2016.

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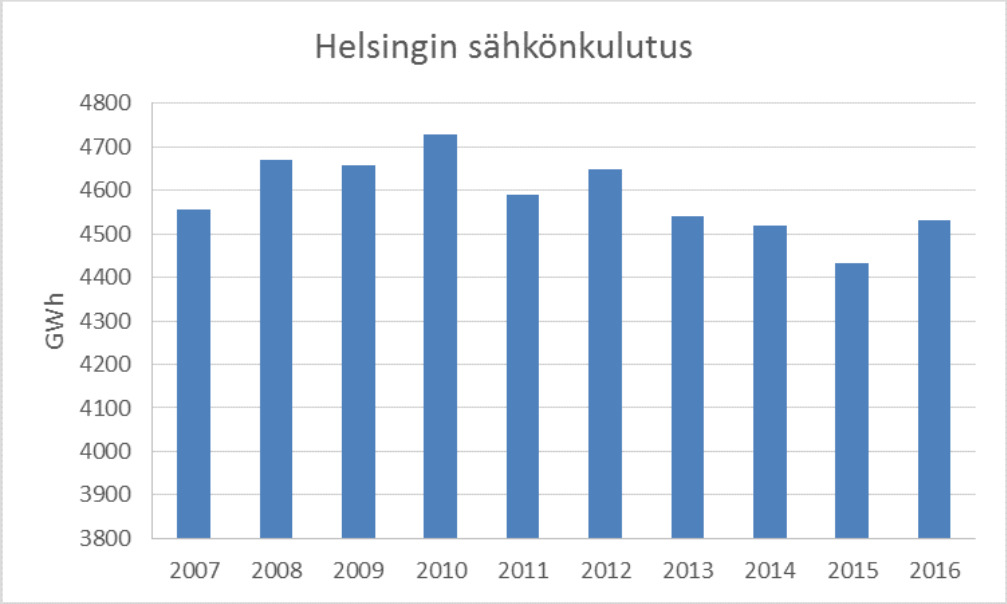

Figure 13: Development of electricity use in Helsinki 2007-2016. Picture by Helen.

The use of electric energy is dominated by service sector, which covers 52% of electricity consumption in Helsinki area. Private living sums up to 33% of overall consumption. Other sectors show only minor usage in comparison to these sectors. The full statistics for use of electric energy according to sectors:

- Private living in apartments 1,051 GWh / 24.2 %
- Private living in houses 384 GWh / 8.9 %
- Industry 255 GWh / 5.9 %
- Constructions 48 GWh / 1.1 %
- Services 2,241 GWh / 51.7 %
- Public traffic and lighting 250 GWh / 5.8 %
- Public services 109 GWh / 2.5 %

Figure 14 illustrates these shares across sectors.

9.1.2 Heating and cooling

Arguably, the most defining feature of Helsinki in terms of energy is the existing city wide district heating system and the currently expanding district cooling system. 92 % of the population within the city lives in buildings supplied with district heating with total sales being 6 TWh (2015). Most significant potential for integration within the energy system is enabled by further improving and extending these. Already implemented concept of integrated heat pump based heating and cooling production is an excellent demonstration of this.

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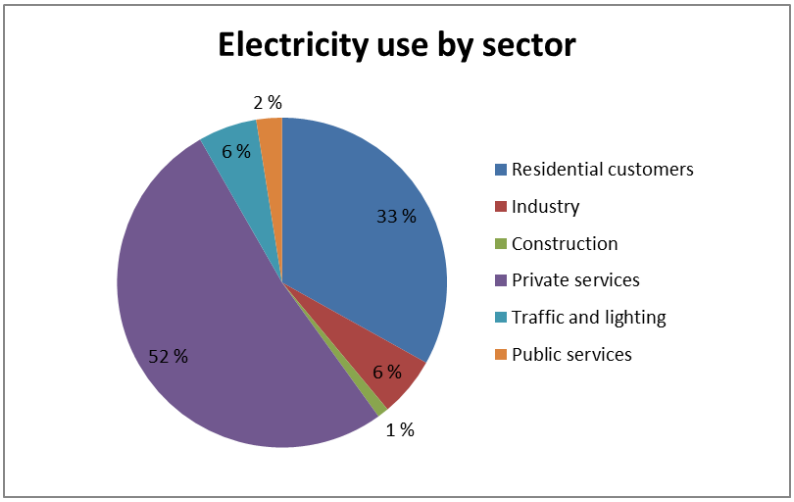

Figure 14. Electricity consumption shares by sector.

9.1.2.1 Energy supply

District heating is supplied by four efficient co-generation plants, a number of smaller heat only boiler units and a large-scale heat pump facility. The total heat production capacities for each of these sources are 1300 MW, 2195 MW and 90 MW, respectively. In addition, the co-generation plants have a total electricity production capacity of 1008 MW, resulting in a system with noticeably high power to heat ratio. The share of co-generation in the total heat supply is approximately 90 % (87.8 % in 2015). Figure 15 presents the sold district heating in 2016 as monthly values.

In terms of energy, heat supply is very much based on CHP based production. In 2015, 88 % (5.659 GWh) of the heat supply was covered by heat from CHP plants. The remaining heat was supplied from Kari Vala heat pump plant (440 GWh), heat only boilers (286 GWh) and heat trade from neighbouring cities (37 GWh).

District cooling is produced by absorption heat pumps in Salmisaari (35 MW), Katri Vala heat pump plant (60 MW) and individual cooling containers (2 MW in total). In 2015, total district cooling production was 125 GWh.

The district heating supply also utilises heat storages with total heat output of 200 MW. This storage option adds flexibility to the operation of the CHP plants and avoids starting up heat only boilers e.g. during winter morning peaks.

Apart from the large-scale heat pump facility, the heat production is mostly based on fossil fuels; coal and natural gas. Heat only boilers burn mainly heavy fuel oil and natural gas. Co-firing of pellets has been tested and is in operation in one of the CHP plants, but its share of the total fuel consumption is very

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small. A new, 200 MW pellet fired heat only boiler is currently under construction and will be in operation 2018. This project is part of process of increasing the share of renewable energy sources in heat supply.

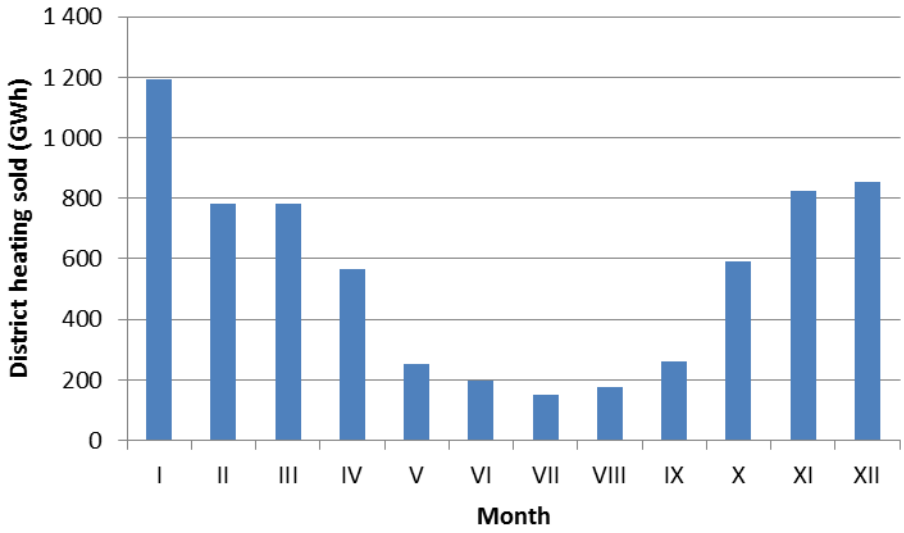

Figure 15. District heating sales monthly, 2016.

Figure 16 presents the monthly specific emissions of district heating production calculation with energy based allocation method showing a variation of the emissions due changes in heat supply.

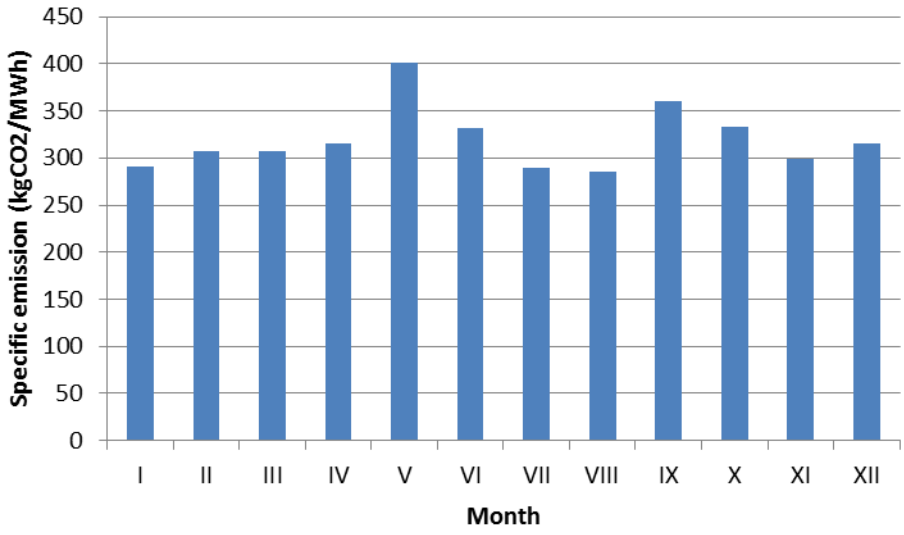

Figure 16. Specific emission factor of district heating.

District cooling system is growing also in Helsinki although compared in numbers to district heating the size of the system is still small. The contracted cooling demand was 177 MW and total sold cooling 125

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GWh in 2015. Although small, district cooling enables efficient integration possibilities with district heating. A good example of this is the previously mentioned large-scale heat pump facility Katri Vala, with capacities of 90 MW and 60 MW for district heating and cooling, respectively,.that can be operated to produce both district heating and cooling at the same time with very high efficiency. The cooling supply in the current district cooling system of Helsinki consists of absorption chillers using heat from a CHP plant as the main energy input, the aforementioned heat pump facility and free cooling using sea water when available in low enough temperatures.

9.1.2.2 Distribution

As indicated earlier, thermal networks within the city are extensive. The network consists of 1350 km of district heating and 65 km of district cooling pipe lines (2015). The relatively densely populated city area enables a very efficient distribution system. The relative heat losses (heat losses compared to total heat produced) were 6.5 % in 2015. As the district heating system is city wide and uniform in design, there are no significant district related characteristics or other differences. However, the heat demand densities are a subject to a given area.

Compared to other Finnish district heating systems, Helsinki district system ranks high both in terms of relative heat losses and heat demand density (ratio of consumption of heat to total network length) as seen in Figure 17.

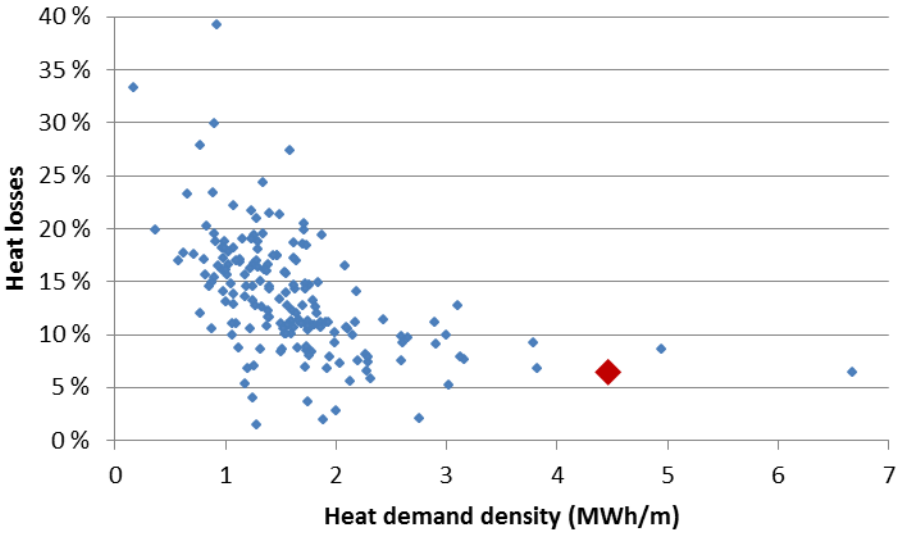

Figure 17. Heat demand densities and losses for Finnish DH systems with Helsinki marked in red.

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9.2 Calculation of diagnosis indicators for energy

Table 19: Indicators for energy supply network

Indicator	Units	Value
Final energy consumption per capita	MWh/capita	22,842
Final energy consumption (Transport)	TWh/year	2,587
Final energy consumption (Buildings, equipments/facilities and Industries)	TWh/year	11,809
Final energy consumption (Municipal)	TWh/year	1,57
Final energy consumption (Tertiary)	TWh/year	4,01
Final energy consumption (Residential)	TWh/year	5,751
Final energy consumption (Public lighting)	TWh/year	0,05
Final energy consumption (Industry)	TWh/year	0,711
Final energy consumption (electricity)	TWh/year	4,424
Final energy consumption (Heat/Cold)	TWh/year	6,633 DH (92% of inhabitants); 0,141 district cooling
Final energy consumption (Fossil fuels)	TWh/year	11,94*
Final energy consumption (Renewables)	TWh/year	2,47*
Share of local energy production to overall final energy consumption	%	103
Renewable electricity generated within the city	%	13%
Non-RES Heat/ Cold production	TWh/year	6,43
RES Heat/Cold production	TWh/year	0,636
Total buildings energy consumption per year	GWh/inhab.year	18,5
Renewable energy per carrier	GWh/RES_supplier	Local utility's heat pump plant: 440DH, 125 district cooling; Solar PV pants 0,975; small-scale (solar) production unknown, estimated around 100 producers; Imported electricity 13% renewable, mainly hydro; Some wood and waste used in CHP plants.
Percentage of renewable energy	%	13%*
Primary energy consumption in the city per year	GWh of PE/year	8TWh DH, 7,5TWh electricity*
Primary energy consumption per capita	MWh/capita	24,7*
Primary energy consumption (Transport)	TWh/year	N/A
Primary energy consumption (Buildings, equipments/facilities and Industries)	TWh/year	N/A
Primary energy consumption (Municipal)	TWh/year	N/A

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Indicator	Units	Value
Primary energy consumption (Tertiary)	TWh/year	N/A
Primary energy consumption (Residential)	TWh/year	N/A
Primary energy consumption (Public lighting)	TWh/year	0,08*
Primary energy consumption (Industry)	TWh/year	N/A
Primary energy consumption (electricity)	TWh/year	7,5*
Maximum Hourly Deficit (MHDx)	kWh	N/A
Green electricity purchased	%	N/A

* DH calculated based on local production; electricity based on national values (electricity can be purchased from whichever Finnish provider and private contracts are unknown)

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10. Suitable urban infrastructures for integration

10.1 Examples of infrastructures integrated to data

10.1.1 Helsinki Public Wi-Fi

Infrastructure summary

The city of Helsinki maintains a network of free, public WiFi hotspots in the downtown area. Currently there are 19 hotspots installed outside in parks and street areas. The network has about 300.000 daily users.

ICT Communication capacity

The Public Wi-Fi network operates in the network of the city of Helsinki that can provide reasonable data rates for all the users. It should be however noted, that the network speed in busy Wi-Fi networks is not typically the main bottleneck but the number of users and the limited, available radio channels. There is no studies or statistics available on what practical data transfer rates are available.

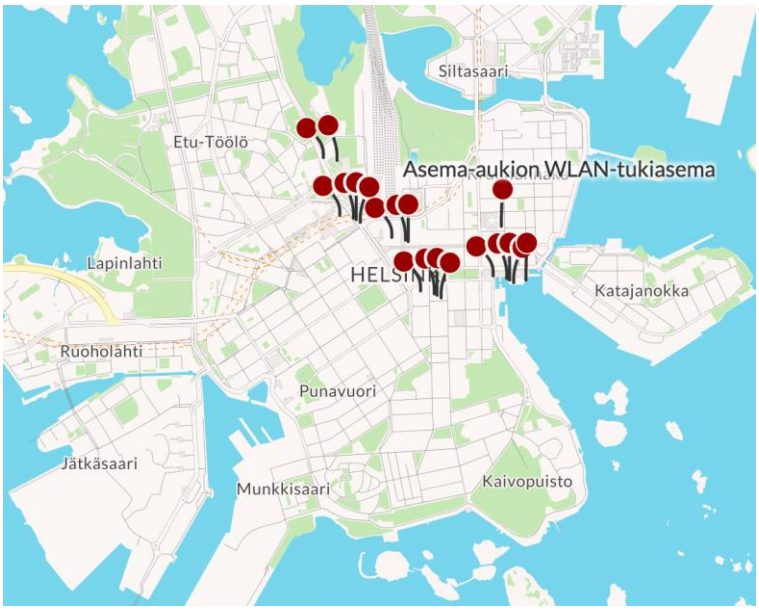

Figure 18. Helsinki Public Wi-Fi network

10.1.2 Mobile Networks

The city area is well covered with 3G and 4G mobile networks by several operators. Since the services are reasonably low priced, the mobile services can rely on data transfer. It is a common practise that IoT – devices such as air quality measurement stations use 3G mobile networks to transfer data.

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Several pilots and projects have already been completed using mobile phone networks, especially 4G networks. This approach is recommended whenever the solution requires more bandwidth than available at low-capacity IoT -networks. Typically, such solutions would require two-way communications or larger amount of data to be transmitted, i.e. camera image to be analyzed in the backend service. The coverage of 4G is complete within the area of City of Helsinki and several major buildings have been equipped with local substations and internal antenna networks.

In 2016 the first pilots using the new LTE-NB (Narrow Band) -network were starting. The first pilots of 5G networks have already started, supporting data rates of up to 20 Gbps with a latency of less than 3 milliseconds.

10.1.3 LoRa Networks

LoRa networks refer to networks using long range, low power wireless technology that are a key enabler for IoT networks. In Finland, the network operator Digita has started to install LoRa -networks in 2016. Currently the networks covers the city of Helsinki quite well and the company is planning to install yet more stations in order to improve the coverage inside the buildings. The LoRa -network also has a good coverage beyond the southern shore: applications where sensors are located in the Gulf of Finland can be accomplished with the LoRa -technology. The following map illustrates the current coverage: the deeper the blue, the better the network can reach inside buildings.

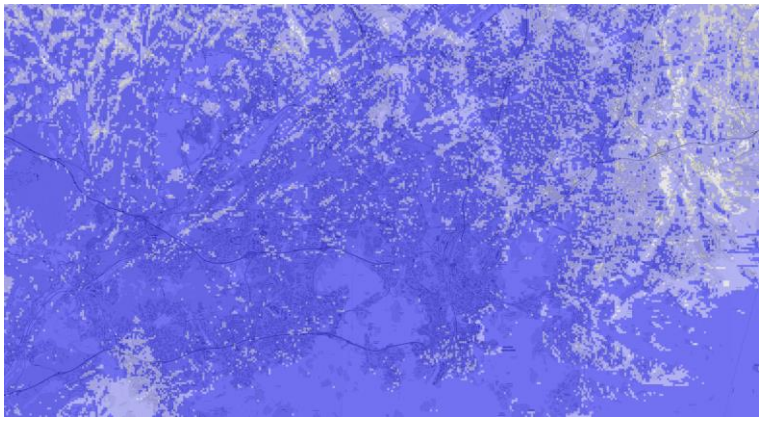

Figure 19. Coverage of LoRa network

10.1.4 Air Quality Monitoring

The City of Helsinki Environment Center together with the Helsinki Region Environmental Services Authority HSY operate a network of fixed and mobile air quality monitoring stations. There is currently no real-time data available for the public of the measurements, but the results are aggregated and made available using their websites and the Helsinki Region Infoshare urban data platform.

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10.1.5 Transport Infrastructures

EV Charging Facilities

As mentioned earlier in chapter 8.9.1, there are currently about 80 EV charging facilities in the city. The charging stations are operated by companies that by now have not shared much of the data related to stations (e.g. whether the station is available or not), but as part of the mySMARTLife –project, this data is about to be opened.

Public Transport

The public transport system has been opening its operational data as an API for developers. As a result, several journey guide apps have been released. Currently some buses are being equipped with sensor kit that would provide more real-time information about the vehicles and their environment.

Bicycles services

The city of Helsinki is operating together with a partner company a city bike service, that currently has over 1.400 bikes and 140 bike stations. The service is supported by a mobile app that can tell the availability of bikes on any given station. The stations operate with solar power that has made it easier to place the stations on streets without requiring a local power supply.

10.1.6 Traffic Counting Systems

For traffic management purposes, the City Planning Department maintains a network of induction loop based traffic counters that located in about 100 different positions around the city. Most of the locations are not supplied with power, so the traffic counters are battery-operated and require maintenance. This network provides data for mostly statistical and research purposes. Only a few of the counting stations are connected online, most of them operating offline data retrieved manually on monthly basis.

10.1.7 Energy, sewage, water Counting Systems

Most of the energy and water metering systems are based on traditional technology. Electrical meter reading is mostly done remotely using AMR –meters. In some specific projects, as an example in Kalasatama, there has been a more specific energy management solution as part of the local building automation. The HIMA –service, developed by Helen, provides detailed information on water, energy and electricity usage in a user-friendly format. The HIMA –service has only been operating in a two apartment buildings with a total of 100 apartments. Since it relies on modern building automation system (KNX), it does not provide same level of information in older retrofit developments. There are currently several ongoing projects where these limitations are being tackled.

In two new districts, Kalasatama and Jätkäsaari, the waste management is based on a vacuum collection system. A similar system will also be installed on third new major development area, central Pasila. The vacuum collection system has several inlets that identify the user with a personal tag. The information of created waste is then displayed to the users as part of the Hima –service.

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The following visualization is an example of all the data that in the two, most advanced buildings are available:

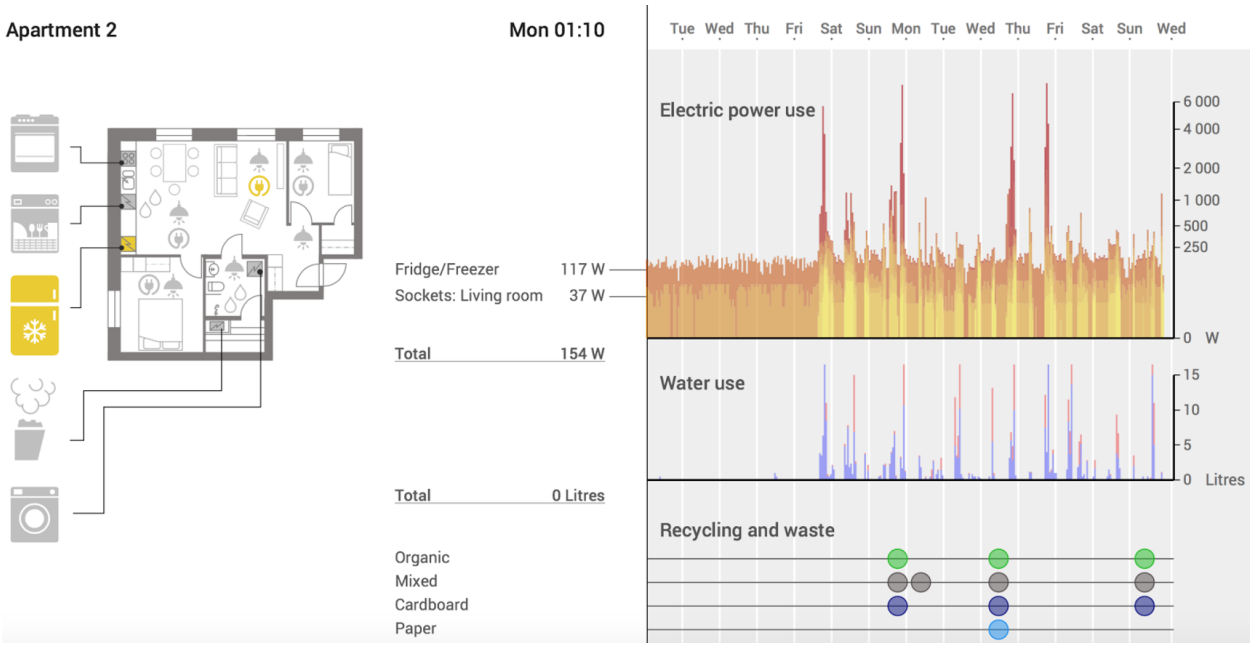

Figure 20. Example of advanced electricity, wáter and waste visualisations in a building in Kalasatama

10.1.8 Public services (e.q. Public lighting)

The city of Helsinki is operating a public street lighting system that currently has about 86.000 lamp posts. In year 2014 the city set a budget for a project called “Helsinki LED”, that aims to convert all the lamp posts to LED technology. The project will continue in steps. Currently there is an open request for tender of 5.700 new lamps to be installed during the next 18 months. As part of the project, the control system of public lighting was also renewed and the current system is purchased as a service.

10.2 Identification of potential Integrated Infrastructures Implementation

10.2.1 Energy infrastructures for integration of tri-generation

Continuing the integration of district heating and cooling systems by use of heat pump technology has great potential in further improving the efficiency of the energy system in Helsinki already utilising tri-generation, i.e. production of heating, cooling and electricity. The concept can also represent an alternative or at least a supportive action for the current decarbonisation plan based mostly on biomass combustion. The potential of the concept is greatly influenced by the expansion of the current district cooling system.

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The Helsinki district heating supply is already now closely linked to power system due Nordic electricity market and the role of co-generation in the heat supply. Price of electricity is a major factor in scheduling the operation of CHP plants, heat pumps and boilers. However, as capacity and significance of variable renewable energy (VRE) grows, the existing district heating systems can provide a solution for flexibility; both through operation of heat sources and by using heat storage for coping with possible excess electricity production. Heat storage is and will remain a financial attractive technology for large-scale energy storage compared to battery based electricity storages.

The operation of both the current and additional heat storage capacity will be studied in order to quantify the impact and benefit on system level. The heat storages can help in avoiding start-ups of peak heat only boilers and extend the rate of utilisation of CHP plants. The aim is to study the threshold where additional investment in heat storages would not improve the performance of the system.

The benefits of system with tri-generation will be studied by comparing a solar collector plant with buildings cooled by district cooling. As the returning flow is used as a heat source for heat pump based heat production, the buildings themselves are utilised as de-facto solar collectors.

10.2.2 Integrating centralised and decentralised energy supply and storages

Integration of distributed heat supply into the district heating system is one of the foreseen changes in the future. In the core of this concept are the low distribution temperatures in the district heating network that enable utilisation of new heat sources based on renewable energy or other excess heat available within the city.

The existing system is already efficient, but reliant on fossil fuels. Integration of these new heat sources can prove important in increasing the share of renewable energy. The evaluation of new heat sources should, however, include the impact analysis for the existing system in order to identify the best possible path way to a future district heating system.

The topic is studied by evaluation of measures enabling increase in renewable heat sources, distributed or centralised. Area of Tali in Helsinki is used as a case example where potential of both low temperature distribution and distributed production of heat by using exhaust air heat pumps is studied. The area is located in a suitable branch of the district heating system that could enable an actual implementation of a low temperature distribution network if the concept is found to be feasible.

As a system level analysis, the impact of additional solar or heat pump based heat production is studied. The investigation is carried out for a period of 20 years taking into account the current plans for developing the Helsinki district heating system. The objective is to compare the cost and energy efficiency of a defined investment in renewable energy.

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10.3 Calculation of diagnosis indicators for suitable urban infrastructures for integration

The indicators selected for suitable urban infrastructures for integration are being calculated and they are showing in the following table.

Table 20: Indicators for suitable urban infrastructures for integration

Indicator	Units	Value
Lighting system connected	YES/NO	YES
Waste management system	YES/NO	YES
Traffic management system	YES/NO	YES
Parking management system	YES/NO	YES
Public bicycles management system	YES/NO	YES
Public transport management system	YES/NO	YES
Number of public transport stops with real time info	%	8,94 %
Compactness	inhabitants or workplaces / m2	0,0029
Use of groundfloors	m2	N/A
Green and blue space	m2	10,34 %
Access to public free WiFi	%	0,19 %
Access to high speed internet	%	26,876
Number of phone connections per 100,000 inh	Connections/100.000 hab.	127,930
Number of Internet connections per 100,000 inh	Connections/100.000 hab.	N/A
Cybersecurity	Qualitative Likert scale	Not assessed
Data privacy	Qualitative Likert scale	Not assessed
Number of data publishers	#	50
Number of sensors/devices connected**	#	100
Number of services deployed	#	174
Number of available APIs in the current urban platform (e.g. website)	#	27
Number of available Open Data sources in the current urban platform (e.g. website).	#	480
Number of accesses to the urban platform APIs	#	21,620,218

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11. City audit conclusions

The Part I of the report on Helsinki City Audit provides a comprehensive description of the city's characteristics on various aspects. Good practices and improvement potential are identified. The current performance is presented with a help of 132 smart city performance KPIs. As such the city's smart city status summary description is extensive in scope and can be useful for various purposes to understand Helsinki city's readiness as a smart city in 2017. For the purposes of mySMARTLife project, the Part I is structured into chapters that are relevant for different activities that will take place later in the project and provides basic information and input values as a starting point for those.

After the deep City Audit and data analysis carried out in the previous sections of Part I, they are summarized in the following table in strengths, weaknesses, opportunities and threats identified, in both technical and nontechnical frameworks defined within mySMARTLife project. In addition, are presented the actions that are going to support the improvement of the issues identified in the city audit (threats and weaknesses) taking into account the opportunities and strengths of city of Helsinki.

Table 21. SWOT analysis of Helsinki in mySMARTLife framework with identified actions

		City Audit diagnosis (SWOT analysis)	**Actions defined**
Technical framework	**Building and district energy**	***Strengths:*** Very well insulated buildings, energy efficient even in cold climate. Efficient city-wide district heating, increasingly integrated with district cooling. ***Weaknesses:*** Large amount of old buildings in need of energy retrofitting. Cheap energy hinders profitable investments. ***Opportunities:*** Helsinki's Climate Roadmap 2050 / Carbon neutral Helsinki by 2035. Smart and clean initiative with aim to provide world's best test-bed for new technologies and services. Open data, new technical solutions and investment models create new opportunities for building owners in energy renaissance.	***Action 1:*** Merihaka and Vilhonvuori: retrofitting of the residential construction ***Action 2:*** Kalasatama High-Performance residential buildings (4355 flats) ***Action 3:*** Viikki Environm. House ***Action 4:*** Demonstration of heat demand response at apartment level at Merihaka/Vilhonvuori (167 flats) ***Action 5:*** Smart home solutions in Kalasatama high-perf. area (4355 flats) ***Action 6:*** Smart demand response system at the Viikki. Smart lights control

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	City Audit diagnosis (SWOT analysis)	Actions defined
	Threats: Need to speed up the cultural change for further climate smartness and using best potential and expertise of specialists in the public and private sector that already have well developed services e.g. for retrofit actions and funding.	***Action 7:*** Smart controls to automate and optimize electricity and heat demand in "Flexispaces" ***Action 8:*** Viikki Environment House RES production (60 kW). ***Action 9:*** Viikki Environment House Electricity Storage (45kWh capacity, peak 90kW)
Energy infrastructures	***Strengths:*** Efficient CHP plants for combined heat and power production. District system ranking high in relative heat losses and heat demand density. Reliable electricity distribution system. ***Weaknesses:*** Mostly fossil fuel based heat and power production, need for finding solutions for their replacement urgently to achieve the ambitious climate targets. ***Opportunities:*** Continuing the integration of district heating and cooling systems by use of heat pump technology has great potential in further improving the efficiency of the energy system in Helsinki already utilising tri-generation, i.e. production of heating, cooling and electricity. The district heating system through CHP and heat storage capacity provide a very promising future solution for the flexibility of the energy system. Use of existing excess heat as “renewable” in district heating, which is supported by the suggested new directive for two-way district heating network. Waste water and heat from ventilation air provides new opportunities for new business models. Need to change the way of thinking from traditional production towards services and new business models and towards supporting new technologies like waste water heat recovery.	***Action 10:*** Data and demand response ***Action 11:*** Technical integration of the EV charging point, energy storage and Solar plant ***Action 12:*** Compensation of reactive power - with solar power Zone 4 ***Action 13:*** Estimation of demand response cost value; integration models to energy market, analysis of impact at city level ***Action 14:*** Optimise the amount of renewables in the district heating ***Action 15:*** Smart dynamic public lighting up-take ***Action 16:*** Integration of Renewables and waste heat sources in the network. ***Action 17:*** Solar Power Plant (50-200 kW) implementation for Korkeasaari Zoo. ***Action 18:*** Solar power plants (Suvilahti

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	City Audit diagnosis (SWOT analysis)	Actions defined
	Threats: Solutions for replacing fossil fuels; climate is not the most favourable for solar energy. The increasing use of electricity (e.g. heat pumps) with reduced consumption of district heating (e.g. heat recovery of buildings) reduces the profitability of CHP-especially at summertime.	and Kivikko) to compensate reactive power ***Action 19:*** Optimise the storage system in the district heating and cooling (10% heating energy savings, 12% cooling and 15% peak demands) ***Action 20:*** Integration of existing district-level electrical storage (600 kWh)
Mobility	***Strengths:*** Extensive, reliable and fast public transport, bike route network and city bikes. Top positions in European BEST studies and public transport rankings. Rail-based public transport (metro, trams, commuter trains) based on renewable electricity. ***Weaknesses:*** Small share of EVs for a Nordic country, though quickly increasing. 62nd position in small cities congestion ratio ranking. Most bus fleet based on diesel fuel. ***Opportunities:*** Ambitious environmental targets of the regional transport office HSL to reduce emissions (CO_2, NO_x, PM) by more than 90% by 2025 (compared to the level in 2010) and have 30% electric buses by 2025. Target to increase Helsinki's diesel bus fleets bio fuel content from 25% in 2016 to 50% in 2017 and 100% in 2020. ***Threats:*** How to change the culture of owning a car (still dominant in Finland due to low level of population and long distances to remote locations).	***Action 21:*** 140 Electric Buses Up-take ***Action 22:*** Electrification of the City Maintenance fleet and logistics ***Action 23:*** 2 Autonomous Electric buses pilot to address Urban last mile mobility issues. ***Action 24:*** Up-take of (20) electric bus charging stations ***Action 25:*** Up-take of 2 wind-powered e-bike charging stations ***Action 26:*** One Commercial vehicle electromobility charging node ***Action 27:*** Demand management (EV charg. points, Solar plant and storage) ***Action 28:*** Smart personal EV charging (dynamic load balancing to low-cost electricity hours) ***Action 29:*** Implementation of universal pop-up storage places for parcel and local supply services

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		City Audit diagnosis (SWOT analysis)	Actions defined
			Action 30: Integration of "all electric" and "fresh air route" in multi-modal public transport and pedestrian navigator
	ICT	***Strengths:*** Good infrastructure supporting IoT; for example the city already well covered with LoRa networks. Excellent coverage of useful open data provided. Two types of advanced city 3D models in use. ***Weaknesses:*** Practical usability and permissions of open data and functional connection systems. ***Opportunities:*** 5G piloting taking place. Targeting and providing services, New apps for the citizens that helps to plan the energy efficiency renovations or solar panels. New business models for energy efficient renovations. ***Threats:*** Low interest of citizens and other stakeholders to utilize open data if practical interest not clearly visible. Availability of suitable services and usability for all age and social groups.	***Action 44:*** Helsinki Urban platform improvements with building-level open energy data on energy savings potentials ***Action 45:*** Implementation of "mySMARTLife features" into the Public Transport Navigator App. ***Action 46:*** Implementation of "Carbon-Neutral Me" App ***Action 47:*** Lighthouse IoT repository up-take and integration of sensor sources to the repository ***Action 48:*** Up-take of new sensoring infrastructure in the smart districts to support actions
Nontechnical framework	**Urban planning**	***Strengths:*** Masterplan prioritises sustainable transport modes. Engagement of business and citizens in planning new areas and in Helsinki's Climate Roadmap 2035 and recent strategy work. ***Weaknesses:*** Integration of all aspects including commitment to city strategy level environmental interests starting from early planning. ***Opportunities:***	***Action 31:*** RES strategy to contribute to Hanasaari B Coal Plant Decommissioning ***Action 32:*** Smart District-Level Energy RENEISSANCE Strategy ***Action 35:*** Advanced Urban Planning. ***Action 36:*** SECAP ***Action 37:*** SUMP ***Action 38:*** Replication Plan

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	City Audit diagnosis (SWOT analysis)	Actions defined
	Advanced comprehensive planning for an eco-system. From pilots of sustainable new areas into city-wide practises. Tying complementary construction together with financing the energy renovation of old buildings stock and modifying the parking norm to support energy efficient new construction and renovation. ***Threats:*** Commitment and common vision of the strategic plans.	
Business models	***Strengths:*** Business environment supportive for innovations, entrepreneurship and start-ups. ***Weaknesses:*** Challenge of replication and scaling-up. Matching of communication activities to specific target groups to enable further service development. ***Opportunities:*** Upscaling on positive early experiences of crowd-funded RES. ***Threats:*** Engagement of essential stakeholders.	***Action 33:*** RES-AS-A-SERVICE Business Model development ***Action 34:*** Engagement of external developers to mySMARTLife Open Urban Platform
Citizen engagement	***Strengths:*** Transparency and open data provision by the city. ***Weaknesses:*** The effectiveness of citizen engagement activities is not monitored in systematic way. ***Opportunities:*** Engagement of citizens to participate in various ways, Helsinki is well-known for its bottom-up initiatives such as Restaurant day. ***Threats:*** Getting citizens to commit to developments - scaling and replication of results after the project. Energy renovation may need financial support to succeed.	***Action 39:*** Smart Kalasatama Living Lab ***Action 40:*** Implementing Energy Advisor ***Action 41:*** Real-time Large scale visualizations

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PART II: Action specific KPIs and baseline values

The Part II moves from the city level analyses of Part I to present and analyse the specific 48 actions that will be implemented in Helsinki within mySMARTLife project. In order to be able to assess the achievements of the actions in the monitoring WP5 of the project, the partners involved in Helsinki actions have together designed KPIs for each action. This is important since in many cases the existing KPIs are at too high level to correctly capture the aim, scope and impact of a specific action. Those action specific KPIs and their baseline values whenever applicable and available are presented in this Part II of the report.

It should be noted that KPIs are only a simple way to monitor the impacts or benefits achieved through the actions. KPIs are easy to communicate and monitor but cannot cover all aspects of the often multi-faceted issues. The results of the actions are analysed in a more comprehensive way in related WP4 deliverables.

The remaining of the report is structured into the following main chapters according to type of actions: 12) Buildings and districts, 13) Energy infrastructures, 14) Mobility, 15) Non-technical (urban planning, business models, citizen engagement) and 16) ICT. Chapter 17 summarises the action specific KPIs and their baseline values with conclusions.

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12. Buildings and districts action KPIs and baseline (Actions 1-9)

12.1 Overview of the energy performance of buildings and districts in Helsinki

In Helsinki, there are more than 42,100 buildings, of which 35,280 are residential, 4,737 tertiary buildings, 1,167 public service buildings, and 962 industrial buildings (in 2015). The construction year of dwellings in Helsinki is shown in Figure 21. Most of the residential buildings are apartment buildings, and they are typically quite small: an average apartment is 63.3 m^2 with 2 rooms. The living space in Helsinki is approximately 33.8 m^2 per resident. [City of Helsinki: Living and construction, 2017]

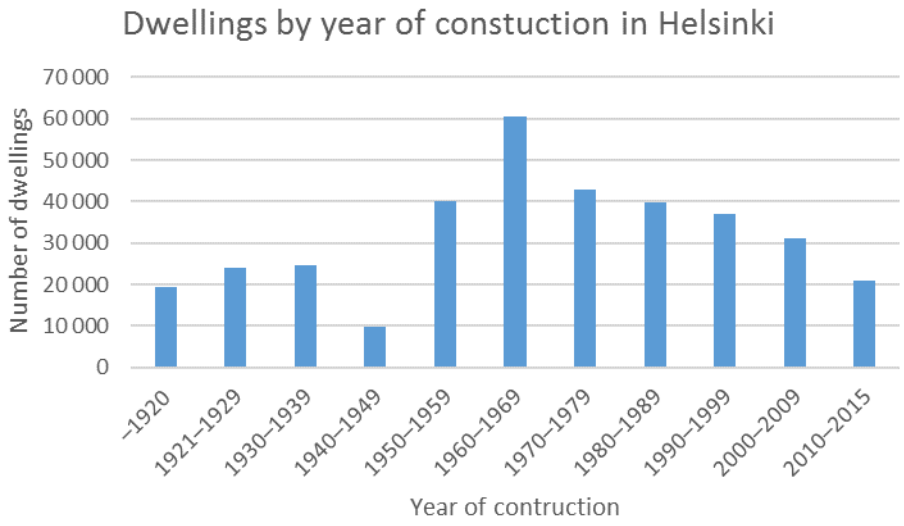

Figure 21. Dwellings by year of construction in Helsinki [modified from: Helsinki statistical yearbook 2016]

The building control office of the City of Helsinki granted building permits for renovation and changes in the use of spaces (permit D) for 942 projects in 2015 and 753 projects in 2016, and permits for measures (permit C) for 385 projects in 2015 and 435 projects in 2016 [Building control office, City of Helsinki, 2017]. Specific heat consumption of apartment building blocks by construction year in 2014 are showed in Figure 22.

High-Performance district area studied in mySMARTLife project is the Helsinki Vanhankaupunginlahti (Old Town Bay) area of the City of Helsinki (see Figure 23). The oldest hydroelectric plant (historic) in Finland is still producing energy on the site, and there is a waste heat capture plant from a large-scale ICT server farm, a crowd-funded solar power plant, a gas power plant for electricity peak demand management, the world´s largest heat pump plant, and one of the world's most eco-efficient coal-based electricity and heat

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co-generation plants. The CHP coal power plant has been decided by the city council to be shut down by 2024.

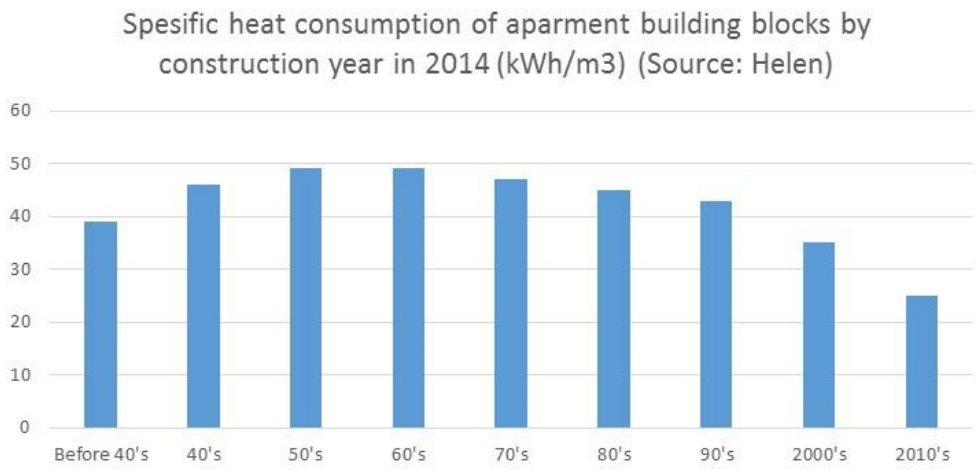

Figure 22. Specific heat consumption of apartment building blocks by construction year in 2014 [Figure from HELEN]

Vanhankaupunginlahti area has four intervention zones, which together represent perfectly the typologies of buildings across the whole city of Helsinki. Zone 1 comprises Merihaka and Vilhonvuori residential retrofitting zones (light brown zone in Figure 23) with a target of retrofitting 12 buildings. Zone 2 (yellow in the map) is a reference district for smart urban construction in the Kalasatama area with 67 buildings. Zone 3 (purple on the map) focuses on a high-performance tertiary building compromising the Viikki Environment office Building, where RES contribution will be maximised through better control and power management strategies. The baseline and planned interventions to each zone are described in the following sections.

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Figure 23. High performance district area of Vanhankaupunginlahti in Helsinki with the intervention zones

12.2 Zone 1: Merihaka and Vilhonvuori residential retrofitting districts (Action 1)

Zone 1 is Merihaka and Vilhonvuori residential retrofitting zone (light brown zone in Figure 23). Building blocks in Merihaka and Vilhonvuori are constructed in the 1970s and 1980s, and as such they represent a vast amount of building stock waiting for energy refurbishment in Helsinki (10,262 residential high-rise buildings with 22.28 M m2, of which 4,427 buildings with 9M m2 have been built in 1960s-1980s - see also Figure 21). The area borders the district towards the old city centre and Kallio, which are built in 1800s and early 1900s. A 3D model of Merihaka district is shown in Figure 24.

Figure 24. Merihaka district [figure from Helsinki city 3D model]

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The total target area consists of 34 buildings, with each building having a residential area between 2,876 m2 and 9,834m2. A model, how municipality can support and promote energy efficient building retrofitting and improving the energy performance of the residential construction will be developed. This model will be tested in the Action 40 implementing Energy Advisor Activity for the residential building owners (co-operatives) and small businesses in the Zones 1 and 2. The goal is to demonstrate, how municipality could boost interventions for improving the energy performance of the residential construction. The residents will be involved to the model development and Energy Advisor Activities by making an interview and/or questionnaire study about the current needs and requirements of the residents, and based on the feedback, the potential energy performance improvements will be promoted in the area, targeting to boost energy efficient retrofitting activities in at least 12 buildings which means on average 35% of residents living in the target district.

In general, the effectiveness of the building insulation materials (U-values) of this residential building stock are already relatively good compared to average European buildings. For example, more than two-layer windows have been a standard since 1970s in Finland. A substantial amount of the residential buildings from the suburban growth era have recently been through either façade and/or pipeline renovations in Helsinki. Hence, to produce replicability and impact, the interventions of the action 1 are focused more on improving the overall energy performance of the buildings than renovating the building structures (e.g. insulation of the envelope or glazing). Installation of smart controls for managing the heating and electricity demand at the apartment level is one of the key retrofitting interventions. For the retrofitting and domotics up-take, the project executes pilot-in-a-pilot approach with first planning the action and demonstrating the smart home management solution at a pilot building located in Haapaniemenkatu 12 (in total 167 flats) in Action 4 (section 12.2.1), and then further uptaking the solution to rest of the district with a commercially viable business model. This uptaking includes retrofitting potential analyses, thermographic camera shootings, guidance and other collaboration, which all aim for encouraging private housing associations to increase the overall energy efficiency of their apartments and buildings. In addition, energy advisor supports this action and the uptake of such renovation actions.

The energy performance related buildings' retrofitting goals in Merihaka and Vilhonvuori are listed in

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Table 22 according to the BEST table. Typically, the buildings have mechanical air conditioning with heat recovery, which have the 1970s normal practice level. Among other activities, these target values will be discussed with the private housing associations, and support will be offered for them in their retrofitting plans.

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Table 22. The energy performance related retrofitting targets for the buildings from the 1970s in Merihaka and Vilhonvuori according to the BEST table

Building parameter	Value	Unit	Existing buildings	National regulation for new built	National regulation for refurbishment or normal practise	Suggested specification	Reduction %
Façade/Wall	U	W/m^{2}K	0.4	0.17	0.4	0.24	40%
Roof	U	W/m^{2}K	0.35	0.09	0.35	0.35	-
Ground floor	U	W/m^{2}K	0.4	0.16	0.4	0.4	-
Glazing	U_g	W/m^{2}K	2.1	1	2.1	1	52%
Glazing	A	W/m^{2}K	64	35	64	64	-
Shading	Fs	total solar energy transmittance of glazing	0	0	0	0	-
Ventilation rate		air changes/h	0.45	0.55	0.45	0.45	-

All the buildings in Merihaka and Vilhonvuori are served by the district heating both currently and after the interventions. The average energy demands of the buildings in the area are presented in Table 23, according to the BEST table. Additionally, energy advisor can support and encourage housing associations to increase their energy efficiency and add the share of using RES. The interventions include smart controls connected to the Urban Platform through IoT, smart meters in all flats and ex-ante and further performance evaluation with heat leakage images. Management and optimisation of the district heating and cooling will be applied as well.

Table 23. The building energy demands and retrofitting goals per total used floor area [kWh/m2a, incl. system losses] in Merihaka and Vilhonvuori according to the BEST table

Energy demand [kWh/m^2,a]	Energy source	Existing buildings	National regulation for new built	National regulation for refurbishment or normal practise	Suggested specification	Reduction %
Heating and ventilation	District heating	128	38	102	89	13%
Domestic hot water	District heating	39	39	39	27	30%
Lighting	Electricity	9	9	9	6.3	30%
Electricity	Electricity	20	23	23	14	39%

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Energy demand [kWh/m^2,a]	Energy source	Existing buildings	National regulation for new built	National regulation for refurbishment or normal practise	Suggested specification	Reduction %
Subtotal sum of energy demand		**196**	**109**	**173**	**137**	**21%**

As a baseline for Action 1, the energy consumption data for the demo building Haapaniemenkatu 12 (167 flats) is presented. The following building energy performance data is available:

- District heating related data of the entire building from 2012-2016 for each hour, including: time stamp, separate and cumulative network water volume flow [m^3] per hour, separate and cumulative thermal energy demand [MWh] for each hour (see Figure 25), supply and return water temperatures for each hour, outdoor temperature for each hour (from Kaisaniemi weather station), and utilization rate [data provided by HELEN]
- Water usage in the whole building monthly from 2011 - 2016 [m^3 and average l/person/day], and the number of residents for each year [data provided by the housing co-operative of Haapaniemenkatu 12A].
- Hourly electricity demand for the facility electricity (hourly kWh) and for the total apartments electricity from 2014 - 2016 [data provided by HELEN].

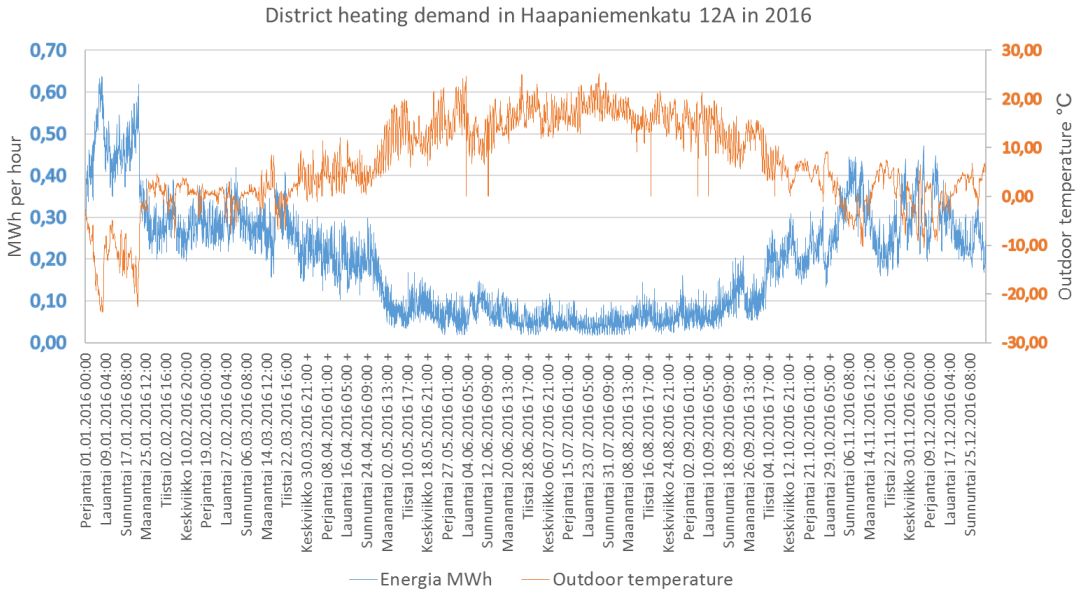

Figure 25. District heating energy demand hourly in Haapaniemenkatu 12A in 2016 [based on data from HELEN]

In order to have a reliable baseline for district heating demand, the consumption needs to be normalised with local degree days (the normalisation is done for heating of spaces without DHW). The degree day

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method allows the comparison of consumption in the same building during different years (as done here) or between buildings from different regions. The concept is based on the fact that heat consumption is proportional to the temperature difference between indoor and outdoor air. Degree days are defined as a sum of temperature different between outdoor temperature and an assumed indoor temperature of 17 °C as is the normal practice in Finland. Degree days are published by the Finnish Meteorological Institute (http://en.ilmatieteenlaitos.fi/).

An average value of degree days per month from past five years 2012-2016 is used in the calculation. The resulting values are presented in the following tables.

Table 24. Local monthly and annual degree days

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Annual**
Ref.	**647**	**612**	**566**	**383**	**153**	**11**	**1**	**12**	**125**	**316**	**464**	**588**	**3878**
2012	633	692	502	387	120	8	0	0	75	302	386	692	**3797**
2013	678	527	690	417	73	0	0	0	91	291	370	455	**3592**
2014	709	472	461	317	183	24	0	0	44	316	415	523	**3464**
2015	555	451	454	350	190	0	0	0	30	321	343	424	**3118**
2016	800	483	501	365	0	0	0	0	59	350	510	521	**3589**

Table 25. Coefficients corresponding to local degree days

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**Annual**
2012	1,022	0,884	1,127	0,990	1,275	1,375	1,000	1,000	1,667	1,046	1,202	0,850	**1,021**
2013	0,954	1,161	0,820	0,918	2,096	1,000	1,000	1,000	1,374	1,086	1,254	1,292	**1,080**
2014	0,913	1,297	1,228	1,208	0,836	0,458	1,000	1,000	2,841	1,000	1,118	1,124	**1,120**
2015	1,166	1,357	1,247	1,094	0,805	1,000	1,000	1,000	4,167	0,984	1,353	1,387	**1,244**
2016	0,809	1,267	1,130	1,049	1,000	1,000	1,000	1,000	2,119	0,903	0,910	1,129	**1,081**

To calculate a normalised district heating consumption using the measured consumption and information on monthly degree days for each year, the following equation is used.

$$Q_{normalised} = \frac{S_{reference}}{S_{realised}} Q_{measured} + Q_{DHW}$$

Where S are the reference and realised degree days (the fractions found in Table 25), Q the normalised total consumption, measured space heating consumption or domestic hot water consumption (DHW). The consumption of DHW does not have the same dependency on the outdoor temperature and thus is not multiplied by the coefficient.
(https://www.motiva.fi/julkinen_sektori/kiinteiston_energiankaytto/kulutuksen_normitus)

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Table 26. Measured and normalised district heating consumption in MWh in Haapaniemenkatu 12A

	Measured					Normalised				
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
I	252,5	261,5	265,1	214,7	308,9	257,3	251,1	244,8	244,8	256,2
II	253,9	203,3	183,3	174,8	194,9	228,4	230,6	227,7	225,3	238,0
III	187,2	246,4	175,7	171,8	201,2	206,8	208,1	208,1	205,8	223,0
IV	146,9	156,7	125,3	132,9	140,5	145,7	146,6	144,5	142,2	145,8
V	77,7	69,1	91,0	95,0	57,0	89,8	108,2	81,6	83,0	57,0
VI	41,5	33,4	57,5	56,7	48,8	41,5	33,5	57,5	56,7	48,8
VII	36,6	30,1	33,7	32,4	34,9	36,6	33,5	33,7	33,5	34,9
VIII	39,0	32,1	37,4	32,0	41,9	39,0	33,5	37,4	33,5	41,9
IX	71,1	67,6	56,4	50,1	60,0	96,1	80,4	98,5	102,7	89,5
X	126,2	117,9	127,1	119,5	150,6	130,4	125,1	127,1	118,2	139,2
XI	156,8	144,2	160,9	138,7	211,3	181,6	172,3	175,9	175,8	195,2
XII	267,9	177,8	199,3	174,2	207,4	232,7	220,0	219,9	228,6	229,8
Total	**1657,1**	**1540,1**	**1512,6**	**1392,8**	**1657,4**	**1686,0**	**1643,0**	**1656,6**	**1650,1**	**1699,4**

Thus the 2012-2016 average district heating consumption (normalised with degree days) is 1667 MWh. Since the total floor area is 10 113 m2, the baseline district heating consumption is 165 kWh/m2,a (without normalisation 153 kWh/ m2,a). The normalisation with degree days is done for heating only (excluding DHW of on average around 40 kWh/m2,a), but the baseline district heating demand (165 kWh/m2,a) includes both heating of spaces and DHW.

For electricity, the average metered consumption between 2014-2016 is taken. The total is 43,5 kWh/m2,a, consisting of both facility electricity (21,6 kWh/m2,a) and occupants' apartment electricity (21,9 kWh/m2,a).

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The water consumption in 2016 was on average 158,2 l/pers/day.

Table 27. Action 1 / Zone 1 baseline from Haapaniemenkatu demo 12 building (167 flats)

KPIs	Baseline	Year
District heating energy consumption	165 kWh/m2,a Five-year average district heating consumption normalised with local degree days	2012-2016
Facility electricity consumption	21,6 kWh/m^2,a (3-year average)	2014-2016
Apartment electricity consumption	21,9 kWh/m^2,a (3-year average)	2014-2016
Water consumption	158,2 l/pers/day	2016

12.2.1 Heat demand response in an apartment building at Haapaniemenkatu 12 (Action 4)

Action 4 “Demonstration of smart home management (heat demand response) at apartment level” will also be realised in Merihaka. In total, 167 flats will be equipped with a heat demand response system that includes smart thermostats and part of the flats are connected to the district heating through IoT and cloud-based intelligence to balance thermal loads. Data will be used to study how to share the heating cost in a more transparent and usage dependent manner. Currently, the heating costs are invoiced at the housing co-operative (building) level and are split equally among the dwellings. This means that neither the residents nor the dwelling owners have economic incentives to lower the heating costs. A technical and business model related to this action will be demonstrated, where the residents will be made aware of their relative share of the heating of his dwelling as part of the heating of the whole building. This demonstration implementation includes also designing a concept for smart home/away functionality and smart management of heating energy consumption with the residents. These dwelling implementations together are expected to lower the total energy consumption by 10-15%. Also, the smart homes will be connected to the IoT platform (Actions 47, 48).

The thermal demand response system provided by Salusfin controls heating at the apartment level according to the energy price (see an example figure of targeted performance in Figure 26). It will collect and use information automatically about:

- Dynamic heating control (=User’s setpoint for room temperature)
- Energy prices from the energy company to set the DR SetPoint (1° decrease from the User set point in the example shown in Figure 26)
- Sensors measuring the Radiator temperature (temperature of heat distribution water in radiator), and room temperature (=Ambient temperature).
- High / Low temperature limits for allowed variation in the room temperature.

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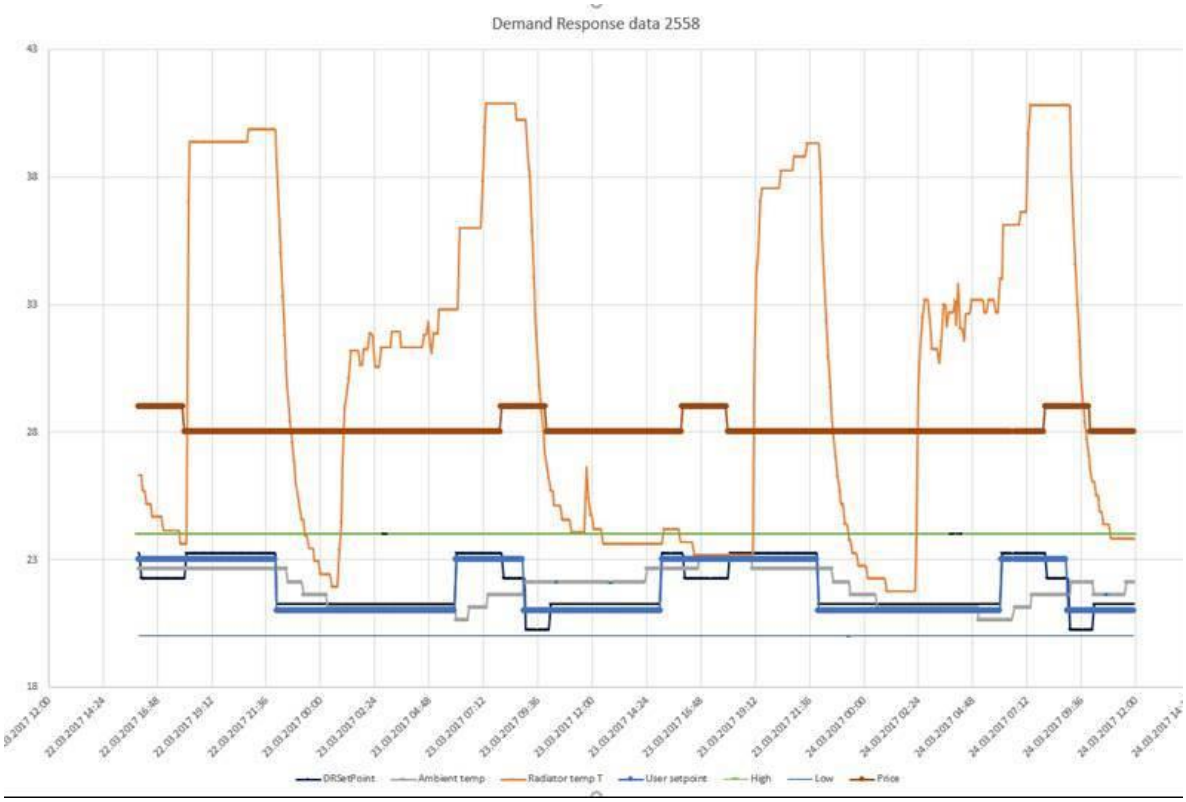

Figure 26. Targeted energy performance of a heat demand response at the apartment level (Figure from Tapio Toivanen / Salusfin)

The target of the Salusfin's system is that user can set the desired room temperature, and after that let the solution work in the background. During travelling on weekends and holidays, user can set a "vacation" mode on.

Part of the residents will be interviewed by the energy advisor of City of Helsinki. On top of automatic data collection, we collect feedback of the user experience and the usability of the solution. The feedback is used to prove that the demonstrated solution is an easy and effective way to influence on residents' own consumption habits, and also to improve the offered solution and service. The residents of the dwellings will also be invited to events where energy related tips are given and questions can be freely asked. When the pilot is on-going, the dwellers are also invited to co-develop the application for heat control and to brainstorm additional functionalities to improve for example the safety of homes. A questionnaire will be sent to the dwellers to map the living comfort aspect as well as the usability and utilization of the solution.

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Table 28. KPIs and baselines for action 4

Action KPIs	Unit	Baseline
Reduction in heating energy consumption	% (kWh/m2,a)	165 kWh/m2,a Average district heating demand between 2012-2016 normalised with local degree days.
CO_2 reduction	% (tons CO2)	No baseline. The CO_2 savings will be calculated as a comparative analysis when the system is in use
Reduction in heating costs	% (EUR/MWh)	Total heating costs in 2016 were 80 000 EUR (48,3 EUR/MWh). Potential 10-20% savings expected and will be monitored annually.
Payback period for heat demand response	years	Total investment costs are 87000 EUR (519 EUR/flat), after EU funding the costs for inhabitants are 26 000 EUR (155 EUR/flat). Potential 8 000-16 000 EUR annual savings in heating costs are expected.

12.3 Zone 2: New construction area in Kalasatama (Action 2)

Kalasatama area (see yellow zone in Figure 23) consists of a former fish harbor, and now it is developed as a reference district for smart urban construction (see an illustration of the urban plan in Figure 27). When the high-performance area of Kalasatama will be ready in 2032, it will consist of 67 buildings with nearly 4,500 flats and 1 million square meters of residential buildings for 20.000 residents (see an urban plan with the planned construction schedule in Figure 28). These buildings include Smart Home solutions, smart meters in all flats, integration of RES and waste heat in the buildings, demand response actions considering the waste heat and the co-creation area called Kalasatama living lab. Many on-going investments are included in this area, such as world's largest cool reserve (38 million litre cold water storage), crowd-funded solar power plant (0.34MW in Suvilahti) and world's largest heat, the first grid-scale battery energy storage at Nordics (600 kWh/1.2 MW) and cool pump (Katri Vala 90MW). The coal plant is included also in Zone 2, and its replacement with RES is one of the project challenges.

Currently, the Kalasatama area consists of 16 completed residential buildings with 992 flats (in total 115,409 m2, including a living area of 65,859 m2), all completed between 2012 and 2015, and several buildings are under construction. In Action 2, the high-performance buildings will be completed during 2017-2021, including in total 67 new residential buildings with total of 4,355 flats. In more detail, the completion schedule will be as follows: in 2017: 986 flats, 2018: 574 flats, 2019: 1071 flats, 2020: 702 flats, and 2021: 1022 flats. The average size will be 65 flats per building. 1,478 of these flats will be in the high-rise tower buildings. The level of targeted energy performance for the new buildings in Kalasatama area is presented in Table 29. The targeted average energy demands of the buildings in the area are presented in Table 30. The target energy demands will be compared to the estimated average energy

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demands for new buildings following the current national building regulations (according to the BEST table).

Figure 27. An illustration of the Kalasatama urban plan [City of Helsinki / urban planning, 2017]

Table 29. The energy performance requirements for the new buildings in Kalasatama according to the BEST table

Building parameter	Value	Unit	National regulation for new built
Façade/Wall	U	W/m^{2}K	0.17
Roof	U	W/m^{2}K	0.09
Ground floor	U	W/m^{2}K	0.16
Glazing	U_g	W/m^{2}K	1
Glazing	A	W/m^{2}K	35
Shading	Fs	total solar energy transmittance of glazing	0
Ventilation rate		air changes/h	0.55

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Table 30. The building energy demand per total used floor area [kWh/m2a, incl. system losses] in Kalasatama according to the BEST table

Energy demand [kWh/m^2,a]	Energy source	National regulation for new built	Suggested specification	Reduction %
Heating and ventilation	District heating	38	28.8	25%
Domestic hot water	District heating	39	31.2	30%
Lighting	Electricity	9	7.2	20%
Electricity	Electricity	23	16	30%
Subtotal sum of energy demand		**109**	**83**	**24%**

Figure 28. The construction schedule of Kalasatama district [City of Helsinki, 2016]

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Kalasatama area is heated with bio-energy: heat is produced at Hanasaari power plant with pellets and at Katri Vala heat pump, which recovers heat from waste heat sources to district heating. Currently, several buildings at Kalasatama have solar photovoltaic panels at their roofs (see Table 31). Kalasatama day care centre produces solar electricity for its own need, and also some town houses and high-rise buildings at the district have installed PV panels on the top of their roofs. In addition, Lemminkäinen, a construction company, has invested in a PV plant, which is physically remote to Kalasatama and produces electricity to couple of its properties at the Kalasatama district and hence increases the share of the renewable energy. New substation under construction at Suvilahti will also have few kilowatt peaks of solar electricity production capacity on its roof. The building and block level RES supply in Kalasatama area is described in Table 31 and total building energy use and supply in

Table 32.

Table 31. The RES contribution per m2 of total used area [kWh/m2,a] in Kalasatama according to the BEST table

RES measure[kWh/m^2,a]	National regulation for new built	Suggested specification
PV panels supplying the buildings, 10m^2 per apartment	0	5
Recycled excess heat from buildings in district heating	0	5.7
Biobased renewables and waste heat in district heating	3.9	11.94
Subtotal sum of RES contribution	**3.9**	**22.64**

Table 32. Building energy demand and supply in Kalasatama according to the BEST table

Energy demand and supply per m^2 of total heated floor area [kWh/m^2,a]	Existing buildings	National regulation for new built	Suggested specification	Improvement from regulation
Subtotal sum of energy demand	109	109	83	26
Subtotal sum of RES contribution	0	3.9	23	19
Total Building Net Energy Use	**109**	**105**	**60**	**45**

Apartment buildings in Kalasatama apply latest technologies for energy efficiency and user interfacing. These solutions enable for instance demand response and customer energy data based services. Energy data will be utilized and compared during this project as it is available. Figure 29 presents an example of energy use data for a typical 50-apartment storey house at Kalasatama. The data has been measured on an hourly basis over a period of two years.

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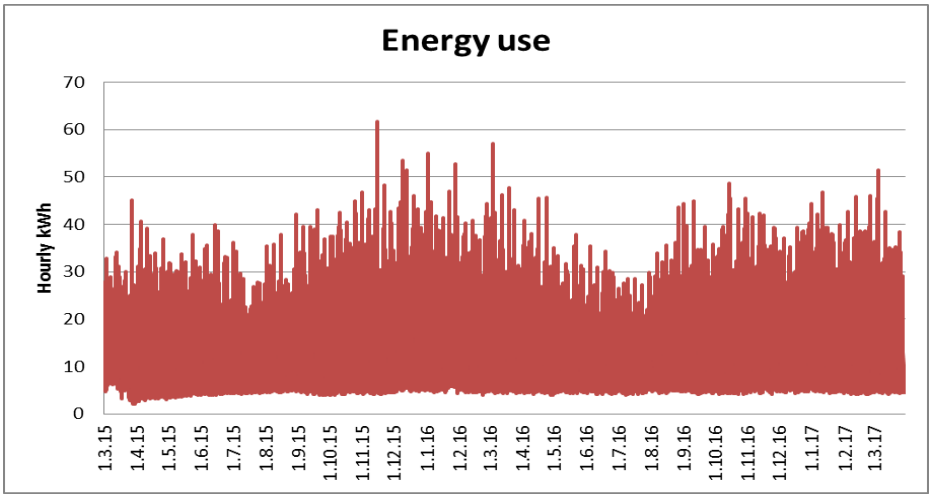

Figure 29. Example energy use profile for 50-apartment building.

Other building energy performance related smart city intervention implemented in the Kalasatama area is described in the following sub-section.

12.3.1 Kalasatama smart home regulation revisit (Action 5)

Some buildings in Zone 2, Kalasatama area, will include apartment-level smart controls for electricity with smart controls for heat. For the Kalasatama buildings included in mySMARTLife (Action 2), the use of open and standard-based interfaces and ability for remote control of the demand response are required.

The construction requirements for new residential buildings in this zone are regulated heavily by the city and they will add new requirements to the already strict national building regulations, including obligations to:

- connect to the underground waste collection system for collecting the key components of household waste,
- connect and integrate to smart energy systems (smart grid),
- have electric car charging for 1/3 of the residential parking spaces (with hour-based measurements),
- include open, standard-based APIs to all building technologies,
- be connectable via open internet,
- have systems to produce open data compatible with the Helsinki Region Infoshare open data platform (technical and license compatibility),
- prepare the building to be connectable to the district cooling network,
- have apartment-level smart controls for electricity and heat (heat optional in 2015),

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- have technical remote control ability for demand response at least on: heating, heat storage, car heating and charging systems and reserve space at building technical room for RES integration.

This action consists of revising the terms for the plot assignments in Kalasatama so that they would enable easier and more economically efficient integration of smart building to the grid and city infrastructures. The possibilities to implement the revised plot assignments in other areas in Helsinki will also be evaluated.

Table 33. Action 5 KPI

Action KPIs	Unit	Baseline
Changes in plot assignments enabling easier integration of smart building to the grid	Descriptive	No baseline

12.4 Zone 3: Viikki Environmental House (Action 3)

Viikki Environmental house (see violet zone in Figure 23), an energy efficient office building, was constructed in 2011 and is owned and used by the Environment Centre of the City of Helsinki, and the University of Helsinki (locates in Zone 3 in Figure 23). The building gross floor area is 6,791 m^2, of which 6,390 m^2 is heated (net floor area), and gross volume is 23,480 m^3. It has 5 floors. Mean occupant density is 25 m^2/person on average, and its occupied hours are 2600 h.

Figure 30. Viikki Environmental House [Figure from City of Helsinki]

The building design process of the Viikki Environmental House targeted to low energy building with holistic approach. The efficiency of the Environment House is achieved by combining several different energy saving solutions. Low energy consumption is implemented mainly by means of commonly-used technical solutions, including:

- energy-efficient building structures (insulation and air tightness, see Table 34),

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- bedrock-based cooling of the premises (25 boreholes),
- the south façade designed for the efficient utilisation of solar panels, which also shade the façade to prevent an excessive heat load in the summer, and
- natural daylight is utilised e.g. by means of light shafts.

Table 34. The energy performance requirements for the Viikki Environment building according to the BEST table

Building parameter	Value	Unit	National regulation for new built	Viikki Env. House	Reduction %
Façade/Wall	U	W/m^{2}K	0.17	0.17	-
Roof	U	W/m^{2}K	0.09	0.09	-
Ground floor	U	W/m^{2}K	0.16	0.16	-
Glazing	U_g	W/m^{2}K	1	0.8	20%
Glazing	G	W/m^{2}K	35	30	14%
Shading	Fs	total solar energy transmittance of glazing	0	0.2	-
Ventilation rate		air changes/h	0.6	0.56	-

Viikki Environmental House is currently the most energy efficient office building in Finland, with an average energy demand of 125 kWh/m^2 per year, and it demands annually 118 kWh/m^2, an energy from external grids. Typically, office building's energy efficiency rate is approximately 150 kWh/m^2. The average energy demands and RES supply of the building are presented in Table 35, according to the BEST table. The heating energy is bought from the district heating, and rest of the electricity demand from the electricity grid. The PV panel installation on the double façade to south serves as an effective solar shading (Figure 31).

Figure 31. PVs as solar shading on the Southern facade on the left; and large air handling units and ductworks on the right.

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Table 35. The building energy performance per gross area in Viikki Environmental house

Energy demand and RES supply [kWh/m^2,a]		Energy efficiency measures	National regulation for new built	Viikki in 2016
Demand	Heating and domestic hot water	Heating: Smart control, better ventilation heat recovery DHW: Energy saving equipment and smart control	95	64.4
	Cooling (measured in 2014)	Shadings	11.5	12
	Electricity	Low energy lighting, LEDs, energy saving appliances and smart control	76	46,7
	Subtotal sum of energy demand		**182**	**123**
RES supply	PV panels (60 kW, 570 m^2 on vertical and roof) (measured 04/2016-03/2017)		0	4.6
	Small wind turbines		0	minor
	Cooling from boreholes		0	12
	Subtotal sum of RES contribution		**0**	**16.6**

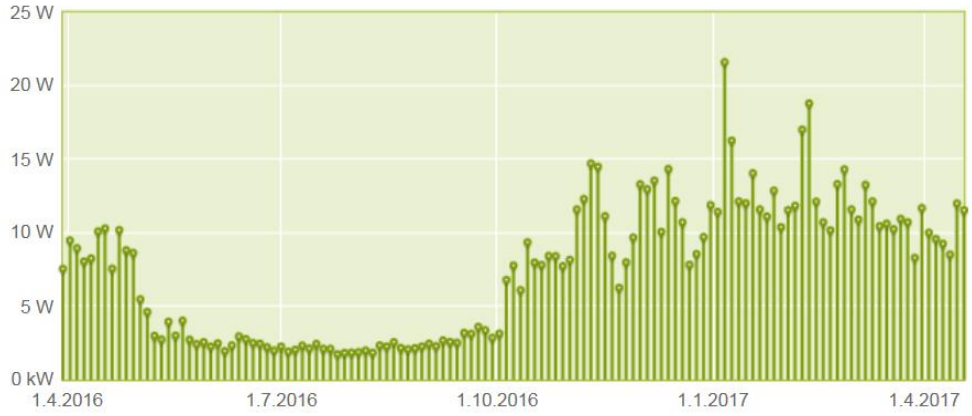

Figure 32. Annual district heating demand of Viikki Environmental Home (There system in Viikki, 2017)

The main objective of the Environmental House building demonstration in Action 3 is to find out the cost efficient solutions for the new building's energy production system, define the right technical dimension as well ensure the system integration of the technical administration and maintenance. The automation can use both temperature and human comfort set point values based on VTT's Human Thermal Model (HTM). The advantage in human comfort set point values is that it takes into account adaptive comfort aspect to increase users' wellbeing and enabling to save energy. Together with HTM, predictive algorithms are also used for optimised energy use and peak power control.

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Environmental House will be a regional "showcase", complementing existing solutions with the mySMARTLife Actions, and the gained experiences will be exploited in the planning of new buildings in Helsinki. The first of these newly planned buildings will be the City's Technical Department's new headquarters building at Zone 2 that will be completed in 2020. Also, the Environmental House already serves annually about one thousand people with professional excursions. The main outcome of the demonstrations will be technical solutions with verified performance and cost data for all important nearly zero energy building (nZEB) technology areas, such as HVAC, passive solutions and renewable energy production, as well as methods and tools needed in the decision making, design and performance verification of nZEB buildings.

Additional energy performance related actions will also be implemented in Zone 3, as described in the following sub-sections.

12.4.1 Smart demand response system at the Viikki Environment House (Action 6)

Building automation system will couple the need of energy and the heat and electricity production in the Viikki Environment House office building. The aim is to provide good lighting, temperature and air condition for building users when using smart demand response systems, both electricity and heat demand response. Building automation system is used to audit energy consumption and indoor air quality and comfort in Environment House, and to understand how the buildings with hybrid RES, integrated electricity storage and smart demand response systems are operated in heating/cooling/intermediate seasons. It will also contribute to reduced maintenance need due to automated maintenance.

The heat demand response system provided by Fourdeg communicates together with the Helen's district heating grid, to optimize the energy use of the building regarding real-time energy prices. Fourdeg's cloud-based service utilizes predictive algorithms to control wireless radiator thermostats. The system considers the capacity rate of the rooms, including measuring people's presences, enabling employees to adjust their individual temperature and save energy. The target is to minimize energy costs and emissions while maximizing user comfort.

Furthermore, an operating model will be developed with new data collection system. As a part of the heat demand response system, a detailed level user's comfort based indoor environment control will be studied with VTT's Human Thermal Model. Action 7 requires detailed information about the energy performance of the building, user's comfort and external data, such as weather forecasts, the state of the energy system load and energy prices.

Table 36. KPIs and baselines for action 6

Action KPIs	Unit	Baseline
Thermal sensation (taking into account measurements, surveys	Individual thermal sensation from -3 (cold) to +3 (hot)	Not available yet. Thermal sensation will be assessed before and after the implementation of the demand response

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and users' personal parameters)	(assessed based on measurements, surveys and users' personal parameters using VTT's HTM model. The used measurements consist of indoor air temperature, surface temperatures, and indoor air humidity)	system. The assessment consists of measurements, surveys and analysis on Human Thermal Model combining those with users' individual parameters. Detailed measurements including air and surface temperatures and relative humidity will be implemented in at least three rooms.
Maximum hourly deficit (MHDe for electricity and MHDh for heat)	%	Not available yet. The indicator measures the maximum value of how much bigger the hourly local demand is compared to the local renewable supply during that hour (per year) [Ala-Juusela, Crosbie, Hukkalainen, 2016].
Monthly ratio of peak hourly demand to lowest hourly demand (RPLe for electricity and RPLh for heat)	%	Not available yet. The indicator measures how big is the peak power demand [Ala-Juusela, Crosbie, Hukkalainen, 2016].

12.4.2 "Flexispaces" space reservation system (Action 7)

This action consists of the remote control of heat, lights and ICT/audio-visual electrical equipment, which is automated into the new concept of "Flexispaces system", an open reservation system for spaces. The smart control allows to automatically lower the heating and close electricity lines when the spaces are not used. This solution is expected to lead to a more efficient use of the existing spaces in the area, such as school spaces at evenings, organisations' meeting rooms and residential buildings' multi-use spaces.

Table 37. KPIs for action 7

Action KPIs	Unit	Baseline
User satisfaction	not yet defined	No baseline Will be assessed with survey after the solution is installed
Room booking rate	%	No baseline Will be monitored after installation

12.4.3 Viikki Environment House RES production (Action 8)

The aim of the Environment House is to develop an office building as near as possible to zero energy level as in Finland. In Viikki building, part of the energy needed is produced on-site: the solar panels placed on the façade and roof have a combined area of 572 m² and produce 60 kWh, which accounts for 20% of the building's energy needs. This makes the Viikki Environment House one of Finland's biggest solar power

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plants. The building also has four silent Windside wind turbines that produce a small amount of additional energy. The energy needed for heating water and interior spaces is supplied by the district heating network in Helsinki.

The cooling system does not require outside energy, because the building has 25 drilled wells, each one being 250 meters deep. The water retrieved from the wells is used for cooling and the only appliance using electricity in the cooling system is the water pump. The energy need for the cooling system is at a maximum of 40 W/m², which is guaranteed by cooling also during night time and the overall design of the building.

In mySMARTLife, complementing Action 6 (Domotics/Smart Controls), increasing of renewable energy and energy efficiency will be demonstrated. The main objective is to find out the cost efficient solutions for the New building's energy production system, define the right technical dimension as well ensure the system integration of the technical administration and maintenance. Existing cooling wells will be applied to also heat the building, with the aim to find out the best solution or hybrid solutions how to e.g. use heat pumps or preheating in winter air coming to building.

Table 38. KPI for action 8

Action KPIs	Unit	Baseline
Potential for additional RES	kWh	No baseline. Currently around 20% of the buildings energy demand is covered by solar panels. The potential for additional RES by using the cooling wells for heating will be evaluated.

12.4.4 Viikki Environment House Electricity Storage (45kWh capacity, peak 90kW) (Action 9)

Finland's first RES integrated building level electricity storage was installed in 2015 in Viikki Environment House to store solar power generated in the building, balance demand peaks and enable smart charging of the EVs. The electrical energy storage has rated power of 90 kW and 45 kWh of energy capacity.

In Environment House, the storage is connected to all other building energy loads to enable better optimization. During office hours, the Environment house normally consumes all of the produced solar electricity, but on sunny weekends there is excess production, which is stored in the battery. When the PV panels are not producing electricity, the battery can be utilized to other functions such as peak shaving of electric car charging. Further, for example due to seasonal changes, the battery still has non-utilizable hours available for building optimization.

In mySMARTLife, the operating system of the electricity storage will be optimized to the demand (Action 6). However, as a part of the cost optimization, electricity market based storage control will also be tested. Market driven usage will provide compensation for allowing to use the capacity for grid stabilization, and

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hence, increase the profitability of such system. The reserve capacity will be offered to the market place at otherwise non-utilizable hours.

Table 39. KPIs and baselines for action 9

Action KPIs	Calculation	Unit	Baseline
Peak load reduction (SCIS)	$(1 - \frac{P_{average}}{P_{peak}})*100$	%	No baseline yet. The indicators are comparative and the numerical baseline values do not describe the situation in any way. Also, the measurement data currently available does not have adequate temporal resolution and, therefore, e.g. the peak load value is not yet available. A real-time measurement system is under construction and will provide accurate enough measurement data to calculate the indicators at a later stage of the project.
Degree of energetic self-supply by RES (SCIS)	Ratio of locally produced energy from RES and the energy consumption	%	
Reduction of energy cost (SCIS)	$COST_{REDUCTION} = \frac{COST_{R\&I} - COST_{BAU}}{COST_{BAU}}$	%	
Battery capacity factor	hours when power activated over a period of time / hours in the period of time	%	
Functional capacity factor	allocated and available power capacity for certain function over a period of time / maximum possible power activation over a period of time	%	
Capacity allocated	hours when capacity allocated and available over a period of time / hours in the period of time	%	
Benefit from a functionality	monetary savings from the functionality over a period of time / hours in the period of time	EUR / h	

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13. Energy infrastructures action KPIs and baseline (Actions 10-20)

The actions presented in this chapter are related to the Helsinki energy system. Some of those analyse the whole electricity or heat grids and their optimisation while other focus on addition and integration of renewable energy sources. Overall description of Helsinki's energy systems and resources are presented in Part I Chapter 9.

13.1 Data and demand response (grid) (Action 10)

Considering the Smart Meters deployed in all the district dwellings and the latest distribution automation technologies including real time consumption patterns, a data and demand response strategy will be developed. Data available will be analysed and refined towards improved monitoring of system performance and decision making support. The practical results can be on improved customer profiling, improved fault detection, improved service reliability etc. Big data type approaches.

Table 40. KPIs and baselines for action 10

Action KPIs	Calculation	Unit	Baseline
Increased system flexibility for energy players (SCIS)	$\Delta SF = \frac{SF_{R\&I} - SF_{BAU}}{Ppeak}$ where SF is the amount of load capacity participating in demand side management [W]	%	No baseline. The potential for system flexibility will evaluated through data analysis and simulations. Currently there is no system flexibility.
Peak load reduction (SCIS)	$(1 - \frac{P_{average}}{P_{peak}})*100$	%	No baseline available.

13.2 Technical integration of EV charging, energy storage and solar plant (Actions 11, 20, 27)

In August 2016, Helen Ltd built a large-scale energy storage into Suvilahti in Zone 2. It was the largest energy storage in the Nordic countries. The output power of the energy storage is 1.2 MW and its capacity is 600 kWh. Size of the energy storage container 12 x 2 x 2 m. Helen Ltd together with Fingrid the national Transmission System Operator (TSO), and Helen Electricity Network the Distribution System Operator (DSO) of Helsinki use it as a research platform for different studies. The main objectives of the research at the moment are to:

- test the electric storage as a resource for power system frequency control (Fingrid)

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- usage of the energy storage for the control of reactive power and voltage, the peak shaving, and the demand response (Helen Electricity Network)
- support the generation of Suvilahti and Kivikko solar power plants (Helen Ltd, Helen Electricity Network)

Energy storage in Suvilahti is shown in Figure 33.

Figure 33. Helen Ltd's energy storage in Suvilahti (Helen 2016)

In April 2015, Helen Ltd built a solar power plant in Suvilahti in the roof of a substation owned by Helen Sähköverkko Oy. Both the Suvilahti energy storage and the solar power plant share the same connection point to the local DSO's 10 kV medium voltage network. The maximum output power of the power plant is 340 kWp, and the annual output will be around 275 MWh. Solar power plant in Suvilahti has almost 1200 solar panels, which are owned by their own customers. The amount of the electricity produced by each customers' solar panel is deducted from their own electricity bill. This is a new concept in that has not been used in Finland before.

Helen Ltd is also planning to build smart EV charging stations into Suvilahti and it is going to be used for EV charging studies. The energy storage, solar power plant, and EV charging station are all part of smart electricity system in Kalasatama.

The activities consist of analyzing the integration of EV charging, energy storage and solar plant and their best control strategies.

Table 41. KPIs and baselines for actions 11, 20 and 27

Action KPIs	Calculation	Unit	Baseline
Peak load reduction (SCIS)	$(1 - \frac{P_{average}}{P_{peak}})*100$	%	The EV charging station is not yet in use. However, based on two-months simulations on EV charging and BESS storage the peak load is 265 kW.
Degree of energetic self-supply by RES (SCIS)	(locally produced energy from RES / energy consumption)	%	The EV charging station is not yet in use. However, based on two-months simulations on EV charging and BESS storage the degree of self-supply by RES would be 25%.

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13.3 Compensation of reactive power with solar power in Zone 4 / Kivikko (Actions 12&18)

Helen Ltd has built a new solar power plant in the Helsinki district of Kivikko in April 2016. Almost 3000 panels covers an area of about one hectare on the roof of the Kivikko Arctic Sport Center which is own by the city of Helsinki. Nominal power of the solar power plant is 850 kW and the size of the inverter is 1 MW (2 x 500 kW). Inverter is manufactured by ABB and the model is PVS800-MWS, which is called the megawatt station. It is connected to the substation transformer with 20 kV cable. Kivikko's solar power plant is shown in Figure 34.

Figure 34. Solar power plant in the Helsinki district of Kivikko (PRESSER 2016).

Hourly production data from the solar power plant is available at the Helen Ltd website (HELEN 2017). The output of the power plant will exceed 800 kW and the annual output will be around 700 MWh. Kivikko solar power plant annual production (11.4.2016-31.12.2016) is shown in Figure 35.

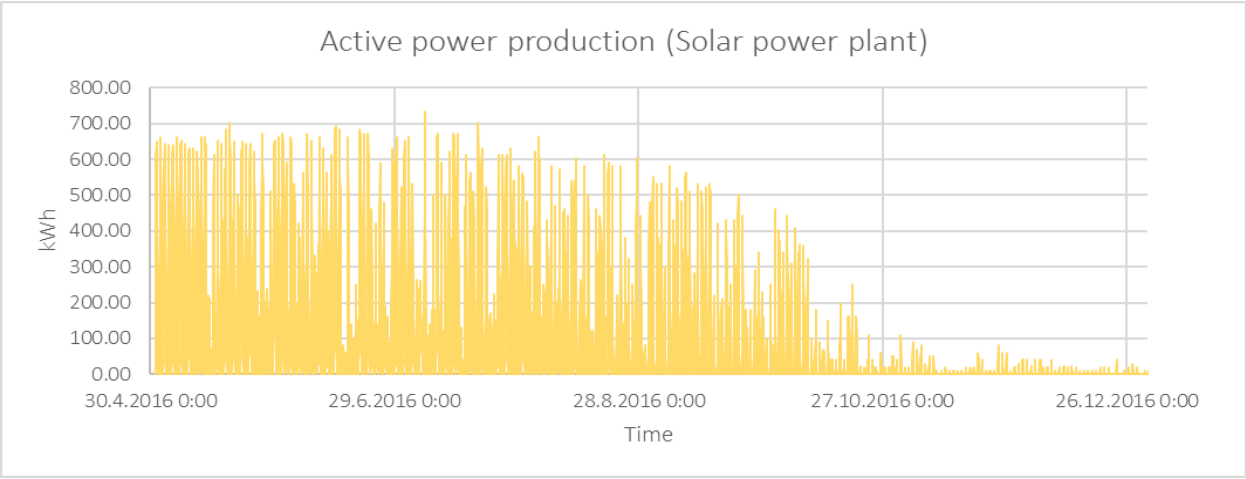

Figure 35. Hourly production data of Kivikko solar power plant (HELEN 2017).

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Kivikko solar power plant production from April 2016 to the end of year 2016 was around 650 MWh. Solar power plant is connected to the same transformer substation with Kivikko Arctic Sport Center and therefore produced solar power is used to cover part of the consumption in the Arctic Sport Center. Sport Center also consumes reactive power because there are cooling devices installed in the building. Currently the solar power plant is not producing reactive power but the inverters could be set to produce also reactive power. That way the reactive power supply from the grid could be decreased and the costs for reactive power consumption are reduced. Reactive power consumption (11.4.2016-31.12.2016) in the Arctic Sport Center is shown in Figure 36.

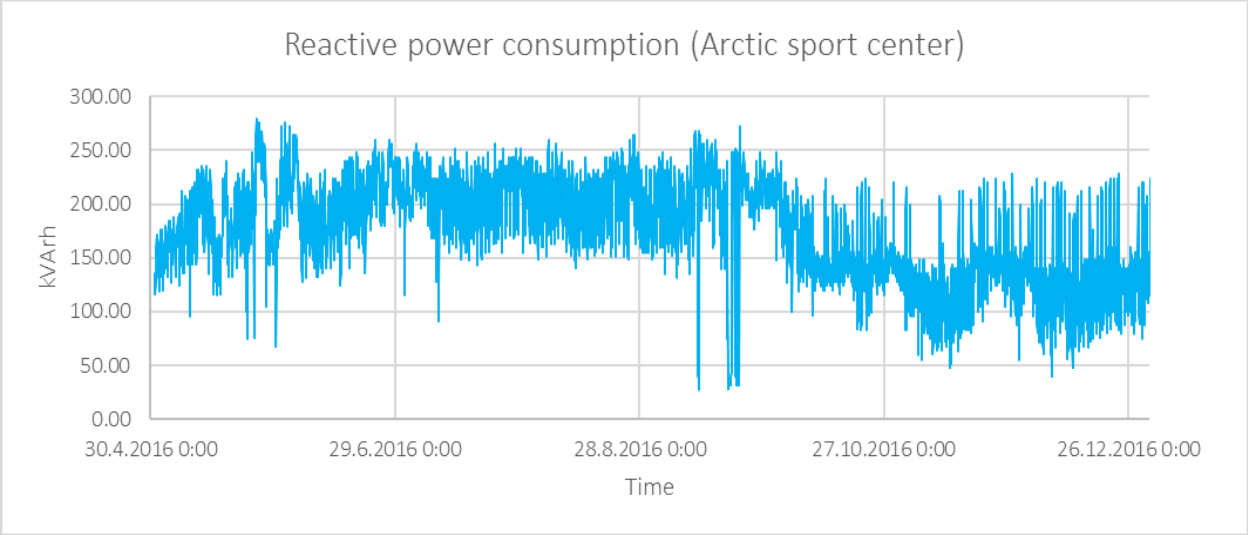

Figure 36. Kivikko Arctic Sport Center reactive power consumption

This action consists of development of technical and business model for reactive power compensation when applying solar power systems. The aim is to find out how reactive power can be most economically compensated when applying photovoltaic systems in the network.

Table 42. KPIs for actions 12 and 18

Action KPIs	Calculation	Unit	Baseline
Cost savings	Savings in reactive power costs = cost with compensation - cost without compensation (monthly)	EUR	Comparative KPI, no baseline
Amount of compensation	Change in reactive power in/out = compensation in use - compensation not in use (change calculated for peaks in kvar/month and amount in kvarh/month)	kvar/month	Comparative KPI, no baseline

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13.4 Estimation of demand response cost value (Action 13)

The impact of demand response in a tri-generation system where power, heat and cooling production is connected will be evaluated. The system enables very high efficiency rates (over 90% in power and heat production). The cooling is using excess heat from buildings and sea water for cooling source. In mySMARTLife, the optimum will be sought, from city network perspective, by seeking control strategies enabling low carbon efficient solutions at district level. The action includes the integration of waste heat sources in network (new Buildings in Zone 2, Kalasatama area complementing Action 2). Smart integration of waste heat to the heating and cooling networks makes it possible to achieve yearly renewable share in the district heating 50-150 % of the heating demand depending on the building application.

Table 43. KPIs and baselines for action 13

Action KPIs	Calculation	Unit	Baseline
Reduction of peak demand		%	Average heating peaks in Merihaka / Zone 1 Haapaniemenkatu 12 (167 flats) from the years 2012-2016 have been 551.6 kWh/h, the biggest of those being 638 kWh/h in 2016.
Reduction of heat consumption		%	165 kWh/m2,a Average district heating demand in Merihaka / Zone 1 demo building Haapaniemenkatu 12 (167 flats) between 2012-2016 normalised with local degree days. See chapter 12.2.2.1 for details on calculation.
Cost savings per investment	operating expenses (OPEX) / Capital expenditures (CAPEX)	€(OPEX)/ €(CAPEX)	Comparative KPI, no baseline.
Energy savings per investment		MWh / €	Comparative KPI, no baseline.

13.5 Optimize the amount of renewables in d.h. (Action 14)

District heating systems are different and the production can be solely for heating or it can be co-generation of heat and power. This task focuses on the optimisation of solar heat in different district heating systems trying to maximise its use. Recommendations about how to better optimize the user demand response and the producer interests, for different systems to achieve optimum system performance under different conditions will be provided. The optimisation focuses on heat and cooling system-level storages use in the network.

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Table 44. KPIs and baselines for action 14

Action KPIs	Unit	Baseline
Share of renewables (% of total heat supply)	%	Share of renewables 5.7 % (9 % heat pumps (2/3 renewable) and 1 % biogas)
Cost effect of added renewables	€/MWh	Comparative analysis, no baseline

13.6 Dynamic public lighting (Action 15)

A dynamic, adaptive LED-based outdoor lighting system to replace the current gas-discharged lamps will be up-taken in Zone 2, Kalasatama in 2016-2017, followed by mySMARTLife intervention in Korkeasaari (Zoo) 2017-2018. Korkeasaari ZOO is an island connected by bridge to Kalasatama district. Currently the gas-discharge lamp network adapts to lighting conditions on city-level. The dynamic lighting up-take adapts the lighting to micro-level, e.g. to follow the pedestrian/bicycle presence, and other local conditions (events, logistics, emergencies). In Kalasatama the smart lighting solution is already co-designed with the residents and consists of for example navigation and communication features in addition to energy savings. Also, the lamp post infrastructure will be connected to the urban platform (See Action 48 IoT).

Table 45. KPIs and baselines for action 15

Action KPIs	Calculation	Unit	Baseline
Lighting electricity consumption	measured or estimated	kWh	N/A. Currently not possible to measure.
User satisfaction	Survey. (Not yet defined; Planned to include questions on comfort, user satisfaction and/or wayfinding)	Not yet defined	No baseline
Coverage of dynamic public lighting in Korkeasaari	lit paths / paths total	%	0

13.7 Integration of renewables and waste heat into network (Action 16)

As explained in Action 14 (District Heating), RES and waste heat will be integrated to the heating and cooling network to achieve system performance optimisation. Although this is a district-city intervention, the demonstration will be implemented in Zone 2, Kalasatama new construction area. In this action, it will be developed the description of the RES and waste heat integration concept.

Table 46. KPIs and baselines for action 16

Action KPIs	Unit	Baseline
Share of renewables (% of total heat supply)	%	Share of renewables 5.7 % (9 % heat pumps (2/3 renewable) and 1 % biogas)
Cost (increase?) due added renewables	€/MWh	Comparative analysis, no baseline

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13.8 Solar power plant at Zoo (Action 17)

A partially visitor crowd-funded solar power plant will be uptaken for Korkeasaari, next to Zone 2. It is based on the business model of already existing Suvilahti and Kivikko citizen crowd-funded solar power plants, but developed further for the Zoo visitor crowd-funding and integration of the crowd-funding into Zoo ticket prices (both per visit ticket price and annual ticket price). The exact business products for panel "ownerships" will be co-designed with visitors (see Business Models and Citizen Engagement actions). The plant innovation is business model innovation (world-first this kind of business model).

Table 47. KPIs and baselines for action 17

Action KPIs	Calculation	Unit	Baseline
Amount of crowd-funding	The amount of crowd-funding collected in Korkeasaari for solar power plant extension will be monitored	EUR	0
Solar power plant capacity	The increase in power plant capacity with crowd-funding will be evaluated	kW	0

13.9 Optimize the thermal storage system (Action 19)

As a complement to Action 14 (District heating), strategies to better optimize the user demand response and the producer interests will be developed, focusing on maximizing heat and cooling system-level storages in the network. There is one 11 million liter water cooling storage (Pasila), one 35 million liter water cooling storage (Center, in the lighthouse map), heat pumps 2 x 7,5 MW cooling and 2 x 11 MW heating will be added in 2017-2018, and there are heat storages 1 x 25 million litter with Vuosaari power plant and 2 x 10 million litter with Salmisaari power plant. The optimization of heating and cooling system level storages enables possibilities to save 10% of heating energy and 12% of cooling energy. In addition it can reduce the peak power demand by 15 %.

Table 48. KPIs and baselines for action 19

Action KPIs	Calculation	Unit	Baseline
Cost savings per MWh of storage (€/MWh)		EUR	Comparative indicators (current storage capacity is 45 000 m3, 220 MW (heating) and 38 000 m3, 58 MW (cooling))
Cost savings per investment	operating expenses (OPEX) / Capital expenditures (CAPEX)	€(OPEX)/ €(CAPEX)	Comparative indicator, no baseline

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14. Mobility action KPIs and baseline (Actions 21-30)

Most of the mobility actions are related to electrification of the transport system in Helsinki, large-scale up-take of electric buses, related charging infrastructure and effects on grid and citizens. The innovative aspects also include the piloting of autonomous e-bus within mySMARTLife. The specific actions and KPIs to monitor their impact are discussed in the following sections. Overall Helsinki transport system analysis is presented in Part I Chapter 8.

14.1 e-Bus up-take (Action 21)

Large-scale up-take of electric buses in Helsinki region will take place in mySMARTLife, from three (3) e-buses (3/2016) to 12 e-buses (1/2017), to 140 e-buses (2020), to 260 e-buses (2022). The target plan for the Helsinki region transport authority is to have 30% of the bus fleet electric by 2025 (390 e-buses), and 10% of fleet electric by 2020. mySMARTLife project intervention will monitor the up-take from 1) grid perspective by analysing the effect to the distribution grids of the electric bus fleet charging (see also Action 11/27 section 13.2), 2) detailed measurements of the 12 of the pre-commercial pilot and extending this operational analysis to the growing fleet from roll-out, including energy and charging management monitoring of all buses, and 3) impact to the residential areas from sensoring perspective (see Action 48 IoT). Also, with this monitoring, features for "use electric transport only" (whole city) and "fresh air route" (IoT Action areas) will be integrated in the public transport navigator of the city (see Action 45).

Table 49. KPIs and baselines for action 21

Action KPIs	Calculation	Unit	Baseline
Rapid voltage change at on/off of the charger	According to standard EN50160	% (V)	Comparative on/off analysis once the chargers and power quality meters will be installed
Harmonics and total harmonic distortion of the connection point voltage (with and without the charger)		%	Comparative on/off analysis once the chargers and power quality meters will be installed
Percentage of available buses with data collection		%	Number of available buses: 12, Percentage of buses with full data collection: 25% (including Wapice IoT & LLB)
Changes in air quality in electric bus routes	Provided by the micro-level air quality sensors to be installed within Action 48	$PM_{2,5}$, PM_{10}, T, RH %	No baseline

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Action KPIs	Calculation	Unit	Baseline
Changes in noise levels in electric bus routes	Provided by the noise sensors to be installed within Action 48	dB	No baseline

14.2 Electrification of maintenance fleet (Action 22)

The first part of this action is referred to the City Maintenance fleet. There is large depot of the city maintenance unit at the project district, and first electrification pilots are on-going. mySMARTLife interventions are the following: 1) integration of the charging infrastructure for maintenance fleet in concert and optimal synergy with the electric bus fleets to support the charging and operation of the hybrid-electric machinery fleet (see Action 26 Charging), 2) measurement and monitoring of the fleet to collect the big data for operational and impact analysis (see also Actions 47-48 IoT), as well as 3) analysis of the performance and operation of the maintenance fleet as a whole, including shares of fully electric, hybrid and conventional machine operation. This subtask also includes operational concept analysis of the electric maintenance fleet operation and further innovation of the operational models for expansion of the operations. Secondly, this action is referred to the Electrification of the City logistics and delivery, where fully electric medium-sized truck for city logistics will be brought into operation by a commercial logistics operator Niinivirta in the greater Helsinki area. This truck will serve freight and deliveries.

Table 50. KPIs and baselines for action 22

Action KPIs	Unit	Baseline
CO_2 emission reduction per vehicle	tons (CO_2)	0% (not yet in operation)
Number of HD vehicle compatible charging points installed		2 (ABB Pitäjänmäki CCS, Hesburger Konala CCS)

14.3 Autonomous Electric buses pilot to address Urban last mile mobility issues (Action 23)

Based on previous real-life demos of the autonomous electric buses in Helsinki, the project will address two local urban mobility issues with electric autonomous bus pilot lines. The buses are electric, produce no emissions and very low noise, are smaller than normal buses and are able to operate only on low speeds (30 km/h in urban streets). The routes of the bus are not yet finalized at the moment of writing this report but are being scouted so that they would address first/last mile issues and contribute to life quality and modal shift away from private cars. One longer lasting pilot bus route is planned to implement in Jätkäsaari and Ruoholahti areas near the Helsinki urban port West Harbor. The possibility of conducting a shorter demonstration in Kalasatama at Zone 2 is being investigated during the project. Also, the location of the bus will be integrated in the mobility planner for electric transport options (see Action 45). Autonomous first/last mile small buses have the potential to increase energy efficiency of the public transportation fleet while improving the service for the customer. Within mySMARTLife both the pilot

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operation and estimate of large scale fleet operation will be analyzed. This operation is closely connected to integrated EV Monitor: Energy efficiency / passenger transferred, operational costs, user experience.

Table 51. KPIs for action 23

Action KPIs	Calculation	Unit	Baseline
CO2 emission savings	Savings by autonomous electric bus per transferred passenger compared to traditional bus	CO_2 / passenger	Will be further defined once the route is fixed.
Energy efficiency	Energy efficiency/passenger transferred	kWh / passenger	No baseline (not in operation)
Number of passengers		nro	No baseline
User experience	Will be analysed through a survey that is not yet fixed	qualitative	No baseline
Operational costs		EUR	No baseline
Mileage	Will be monitored	km	No baseline

14.4 Up-take of e-bus charging stations (Action 24)

Fast charging stations at the end-of-line locations and night depots, together with the strategy to up-take of the electric buses also e-bus charging stations will be installed. With the first set of 12 e-buses 2016 the amount of fast charging stations to be implemented is 6, and the amount of charging station network will grow with the bus-up take. An estimate of the total number of high power opportunity charging electric bus charging stations by 2020 in the greater Helsinki region is about 20 â€“ 30. While the majority of these charging stations are procured from the normal city budget, two charging stations will be equipped as project intervention, with the additional capability of charging maintenance fleet machinery and electric logistics trucks and with the tentative locations of Kamppi terminal and Kalasatama/Suvilahti area. These charging functionalities coincide with the electric bus fast charging infrastructure. These charging points involve the innovative aspects of shared use node as described in Actions 22, 23 and 26.

Table 52. KPIs and baselines for action 24

Action KPIs	Unit	Baseline
Number of charging points	nro	4 (6.10.2017)
Utilization ratio of charging points (last 6 months)	%	6.4.-6.10.2017: Point 1 (Ruskeasuo): 4.6% Point 2 (Koskela): 4.4% Point 3 (Hakaniemi): 0% Point 4 (Malminkartano): 0%. NOTE: Points 3 and 4 have just been installed, not in line use yet

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Action KPIs	Unit	Baseline
Electricity charged by charging point (total)	kWh	On 6.10.2017: Point 1 (Ruskeasuo): 64185 kWh; Point 2 (Koskela): 42493 kWh; Point 3 (Hakaniemi): 10 kWh; Point 4 (Malminkartano): 0 kWh. NOTE: Points 3 and 4 have just been installed, not in line use yet.

14.5 Solar-powered e-bike charging stations (Action 25)

These charging stations will support longer e-bike legs to and from the Korkeasaari Zoo and Kalasatama Redi Shopping center in Zone 2 / Action 2. The objective of the charging stations is to alter the modal shift from private car usage towards bicycling for the Korkeasaari Zoo visitors.

Table 53. KPIs for action 25

Action KPIs	Unit	Baseline
Number of e-bikes charged	nro	not yet installed
Amount of charging electricity and power	kWh and kW	not yet installed

14.6 Commercial vehicle e-mobility charging node (Action 26)

An innovative electromobility charging node, which integrates fast charging for e-bus, fast charging for the city maintenance fleet and commercial logistic fleet, charging of the autonomous e-buses will be implemented. Currently there are separate systems for charging the electric buses and no charging stations for commercial electric maintenance fleet machinery and commercial logistics trucks or other commercial vehicles. The first intervention consists in modifying two electric bus charging stations with automatic opportunity charging by equipping them with the additional function of high power (~100 kW) socket chargers using the CCS standard, so that this enables the charging of the maintenance fleet and logistics (Action 22). With the uptake of the electric maintenance fleet, logistics operations and normalization of the autonomous e-bus routes the issue of usage load of the charging system arises, especially with the more expensive fast charging stations: how to ensure the charging system infrastructures are not overlapping and in low use each. This requires monitoring the system and fleet status including the availability and status information of the chargers, possibly also ensuring the right prioritisation for using them. The integration includes also technical and invoicing aspects. The charging node will be set up in project area to support the maintenance fleet and autonomous e-buses uptake. An innovation intervention is to chart out the technical, operational and innovation aspects for scaling up such multi-use commercial electric vehicles charging nodes for wider market up-take of the systems. This part is carried out in co-operation between all parties active and will lead to concrete roll-out plan and actions.

Table 54. KPIs and baselines for action 26

Action KPIs	Unit	Baseline
Number of external charging events	nro	0

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Action KPIs	Unit	Baseline
Utilization ratio of shared charging (external charging events / e-bus charging events)	%	0
Total charged electricity from shared connection	kWh	0
Ratio of electricity charged from shared connection (external charged electricity / e-bus charged electricity)	%	0
Availability of the charging nodes	%	0

14.7 Personal ev charging with dynamic load balancing (Action 28)

Personal EV-chargers that enables flexible charging process during optimal low-cost energy hours will be implemented at Zones 1 and 2. Charging process communicates with EV (battery status), grid (electricity prices) and consumer (when EV needs to be fully charged). Charging process enables the use EV battery as energy cache for renewable grid resources. Prior pilots show that the electricity costs can be reduced by 30%-40%.

Table 55. KPIs and baselines for action 28

Action KPIs	Unit	Baseline
Electricity cost savings	%	Comparative KPI
Number of EV-chargers installed	nro	0
Charging capacity installed	kW	0

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15. Non-technical action KPIs (Actions 31-43)

The non-technical actions are related to innovative concepts for citizen engagement, replication of results, business models, urban planning and city's climate strategies. Since there are no baseline data for those actions, only the KPIs defined together with the project partners for their monitoring are presented in this chapter. The current situation in Helsinki in these topics is presented in Part I of the report (see chapters 5-7).

Table 56. KPIs for non-technical actions

Action nro & name	KPI	Remarks
31 – RES strategies towards Hanasaari B decom.	1. Strategy defined Y/N 2. Strategy implemented Y/N	RES Strategy to cover new production means for this 220MW electricity 445MW thermal energy demand that needs to be in use latest by 2024 (coal based CHP plant decommissioning)
32 – Energy Reneissance	1. Strategy defined Y/N 2. Number of citizen engagement events 3. Number of people reached	Strategy for district-level energy renovation based on interventions in mySMARTLife and collected open energy data in Action 44.
33 – RES-as-a-Service business model development	Citizens / stakeholder involvement (nb of people, events) in business model development	
34 – Hackathon to IoT platform	1. Number of groups participating in hackathon 2. Total number of participants in hackathon	One large-scale hackathon for external developers will be arranged to further probe and exploit the data and APIs generated in mySMARTLife
35 - Advanced urban planning	1. Number of mySMARTLife relevant new results benefitting urban planning 2. % of those implemented	Potential for implementing in in Helsinki's urban planning concepts developed within WP1 on urban transformation strategy.
36 - SECAP - Sustainable Energy and Climate Action Plan	Number of new mySMARTLife solutions benefitting SECAP	mySMARTLife results to support Helsinki's adoption of SECAP
37 - SUMP- Sustainable Urban Mobility Plans	Number of new MSL results that can be implemented in SUMP	Identifications of useful mobility results in mySMARTLife to be implemented in Helsinki's SUMP.

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Action nro & name	KPI	Remarks
38 - Replication Plan	Number of good practices selected from elsewhere to be further developed in Helsinki Number of good practices taken to be further developed elsewhere Number of cities/locations that adopted practices	
39 - Smart Kalasatama Living Lab	Number of events / participants Number of ideas selected for further development	Living labs not restricted to Zone 2 only
40 – Energy Advisor	1. Number of people reached by the energy advisor 2. User satisfaction survey	
41 – Real-time large scale visulizations	1. Number of facility visualisation locations 2. Estimation of people reached by visualisations 3. Number of plays of energy animation (HEN)	Increasing citizens/users energy awareness by visualisation methods including physical screen visualisation and interactive webpage and animation visualisations at HEN webpages
42 - City mentoring strategy	Number of good practices selected for mentoring Number of mentors selected Will be refined in WP1	Part of WP1
43 - City coaching strategy	Number of coaches named Number of coached cities / other stakeholders Will be refined in WP1	Part of WP1

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16. ICT action KPIs (Actions 44-48)

The actions in this this chapter focus on the urban platform, collection of data with new sensors to support other activities in the project and to provide services to citizens. These actions don't have baselines since they create new data and services. KPIs have been defined together with partners in Helsinki ICT actions to monitor the progress of the actions. In addition to the actions presented below, the actions 34 and 41 presented previously in Chapter 15 are ICT focused.

Table 57. KPIs for ICT actions

Action nro & name	KPIs	Remarks
44 – Open energy data	1. Coverage of buildings 2. Number of new open services made available 3. Number of open datasets made available	Helsinki urban platform will be upgraded by up-take of new open data generated in the project, especially opening building-level energy data, including data that is coming from the systems the project actions address, as well as sourcing the heat leakage images of building facades to support the building refurbishment activities. The data is used to support Zone 1 and 2 building actions and to implement the City Energy Reneissance strategy (Act. 32).
45 – Digitransit features	1. Number of app downloads 2. Usage count (number of app accessing API) 3. Number of usage of advanced features, e.g. EV routing	Features "Use Electric Transport Only", "use only transport that uses renewable energy", "Clean Air Route" will be integrated into the existing open source public transport navigator app. The features are based on data that mobility and IoT actions in the project generate.
46 – Carbon Neutral Me app	1. Number of app downloads 2. Usage count (number of app accessing the API)	Carbon Neutral Me, a mobile app will be implemented and distributed to the residents and job-goers of the project area to make the project interventions visible and to provide easy access to the project services (Energy Advisor, IoT data) and related services in the zones (e.g. e-car sharing, last-mile parcel delivery pop-up).
47 – IoT repository up-take	1. Number of new sensors and data points 2. Amount of new measurements	To accommodate the needs of the project actions and the connection of the actions to urban platform and monitoring requirements, an IoT real-time repository and IoT middleware for the project real-time data will be up-taken and integrated into the Helsinki Urban Platform. Integration to systems in specific actions will be made (Actions 21, 22, 26, 31, 32, and others).

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Action nro & name	KPIs	Remarks
48 – Sensoring infrastructures	1. Number of air quality sensors installed 2. Number of noise sensors installed 3. Total number of sensors providing real-time data 4. Total number of aggregated data sets available at HRI	Micro-level air quality and noise sensors will be installed in the conditioned areas to provide additional information on the effect of the interventions to micro-level air quality and noise. This data will be used in both analysis activities as well as the Urban Platform Apps that integrate the electric mobility and user comfort. The aim of the sensor network is to demonstrate and measure the local impact of the project actions. This will support for instance in assessing the local air quality and noise impacts of e-buses within mobility actions (see Chapter 13).

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17. Summary of action KPIs and baselines

The 48 actions that will be implemented in Helsinki within mySMARTLife project have been presented in this Part II of the report. A baseline for the Zones where the actions take place were presented in Chapter 12. The actions introduced in other sectoral chapters (energy, mobility, ICT etc.) are taking place either in those districts or concern the whole city in which case the baseline values are partly found also in the city KPI tables concluding each sectoral chapter in the Part I of the report.

Since each of 48 Helsinki actions has very specific aims and scope it is in most cases not possible to correctly assess their impacts with existing generic indicators. Therefore the partners involved in each action have together designed KPIs (or used existing KPIs from CITYkeys or SCIS if available) for their action in order to be able later to correctly assess the impacts achieved by the action corresponding to its objectives.

The baseline values, i.e. performance before the intervention action takes place, are also presented, and if available, over a measurement period of one year. However, in several cases the impact of the actions will be assessed through a comparative analysis within the action and in those cases, no baseline is available. The same applies for example for actions involving the development of a new service or solution in which case naturally no baseline exists. The impacts achieved within the actions will be later monitored against these baseline values within the WP5 of the project. In addition to the action specific KPIs presented in this report, the WP5 on monitoring of the project will also use some common KPIs to assess the overall impacts achieved and to ensure the comparability of the three lighthouse demonstrations with help of a common framework.

It is to be underlined that KPIs are in many cases simplifications of complex issues for communication purposes and the results of actions will be more thoroughly presented in specific deliverables of WP4.

Table 58 summarises the KPIs defined for each Helsinki action in mySMARTLife as well as the baseline when applicable.

Table 58. Summary of action specific KPIs and baselines

Action nro & name	KPIs	Baseline or Remarks
1 – Zone 1: Merihaka and Vilhonvuori residential retrofitting districts		Demo zone description, several baselines, see chapter 12.2
2 – Zone 2: New construction area in Kalasatama		Demo zone description, several baselines, see chapter 12.3
3 – Zone 3: Viikki Environmental House		Demo zone description, several baselines, see chapter 12.4

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Action nro & name	KPIs	Baseline or Remarks
4 – Heat demand response in an apartment building at Haapaniemenkatu 12	1. Reduction in heating energy consumption 2. CO_2 reduction 3. Reduction in heating costs 4. Payback period for heat demand response	1. 165 kWh/m2,a (average 2012-2016 normalised with heating degree days) 2. Comparative analysis 3. 80 000 EUR (whole building 2016) 4. Total investment costs 87000 EUR (519 EUR/flat), after EU funding the costs for inhabitants are 26 000 EUR (155 EUR/flat).
5 – Kalasatama smart home regulation revisit	Changes in plot assignments enabling easier integration of smart building to the grid	Descriptive and comparative
6 – Smart demand response system at the Viikki Environment House	1. Thermal sensation (taking into account measurements, surveys and users' personal parameters) 2. Maximum hourly deficit (MHDe for electricity and MHDh for heat) 3. Monthly ratio of peak hourly demand to lowest hourly demand (RPLe for electricity and RPLh for heat)	Not yet available
7 – "Flexispaces" space reservation system	1. User satisfaction 2. Room booking rate	New solution
8 – Viikki Environment House RES production	Potential for additional RES	No baseline (analysis of potential for addition)
9 – Viikki Environment House Electricity Storage	1. Peak load reduction (SCIS) 2. Degree of energetic self-supply by RES (SCIS) 3. Reduction of energy cost (SCIS) 4. Battery capacity factor 5. Functional capacity factor 6. Capacity allocated 7. Benefit from a functionality	No baseline yet
10 – Data and demand response (grid)	1. Increased system flexibility for energy players (SCIS) 2. Peak load reduction (SCIS)	No baseline
11, 20 & 27 – Technical integration of EV charging, energy storage and solar plant	1. Peak load reduction (SCIS) 2. Degree of energetic self-supply by RES (SCIS)	The EV charging station is not yet in use. However, based on two-months simulations on EV charging and BESS storage 1) the peak load is 265 kW, and 2) the degree of self-supply by RES would be 25%.

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Action nro & name	KPIs	Baseline or Remarks
12 & 18 – Compensation of reactive power with solar power in Zone 4 / Kivikko	1. Cost savings 2. Amount of compensation	Comparative KPI
13 – Estimation of demand response cost value	1. Reduction of peak demand 2. Reduction of heat consumption 3. Cost savings per investment 4. Energy savings per investment	1. 551.6 kWh/h (average annual heating peaks 2012-2016) 2. 165 kWh/m2,a (average 2012-2016 normalised with heating degree days) 3. Comparative KPI 4. Comparative KPI
14 – Optimize the amount of renewables in d.h.	1. Share of renewables (% of total heat supply) 2. Cost effect of added renewables	1. 5.7 % (9 % heat pumps (2/3 renewable) and 1 % biogas) 2. Comparative KPI
15 – Dynamic public lighting	1. Lighting electricity consumption 2. User satisfaction 3. Coverage of dynamic public lighting in Korkeasaari	1. No baseline (not yet possible to measure) 2. New service 3. 0
16 – Integration of renewables and waste heat into network	1. Share of renewables (% of total heat supply) 2. Cost (increase?) due added renewables	1. 5.7 % (9 % heat pumps (2/3 renewable) and 1 % biogas) 2. Comparative KPI
17 – Solar power plant at Zoo	1. Amount of crowd-funding 2. Solar power plant capacity	1. 0 2. 0
19 – Optimize the thermal storage system	1. Cost savings per MWh of storage (€/MWh) 2. Cost savings per investment	1. Comparative KPI; (current storage capacity is 45 000 m3, 220 MW (heating) and 38 000 m3, 58 MW (cooling)) 2. No baseline (comparative KPI)
21 – e-Bus up-take	1. Rapid voltage change at on/off of the charger 2. Harmonics and total harmonic distortion of the connection point voltage (with and without the charger) 3. Percentage of available buses with data collection 4. Changes in air quality in electric bus routes 5. Changes in noise levels in electric bus routes	1. Comparative on/off analysis once the chargers and power quality meters will be installed 2. Comparative on/off analysis once the chargers and power quality meters will be installed 3. Number of available buses: 12, Percentage of buses with full data collection: 25% (including Wapice IoT & LLB) 4. Comparative KPI 5. Comparative KPI

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Action nro & name	KPIs	Baseline or Remarks
22 – Electrification of maintenance fleet	1. CO_2 emission reduction per vehicle 2. Number of HD vehicle compatible charging points installed	1. 0 (buses not yet in operation) 2. 2 (ABB Pitäjänmäki CCS, Hesburger Konala CCS)
23 – Autonomous Electric buses pilot to address Urban last mile mobility issues	1. CO_2 emission savings 2. Energy efficiency 3. Number of passengers 4. User experience 5. Operational costs 6. Mileage	No baseline (bus route not fixed yet)
24 – Up-take of e-bus charging stations	1. Number of charging points 2. Utilization ratio of charging points (last 6 months) 3. Electricity charged by charging point (total)	1. 4 (6.10.2017) 2. 6.4.-6.10.2017: Point 1 (Ruskeasuo): 4.6% Point 2 (Koskela): 4.4% Point 3 (Hakaniemi): 0% Point 4 (Malminkartano): 0%. NOTE: Points 3 and 4 have just been installed, not in line use yet 3. On 6.10.2017: Point 1 (Ruskeasuo): 64185 kWh; Point 2 (Koskela): 42493 kWh; Point 3 (Hakaniemi): 10 kWh; Point 4 (Malminkartano): 0 kWh. NOTE: Points 3 and 4 have just been installed, not in line use yet.
25 – Solar-powered e-bike charging stations	1. Number of e-bikes charged 2. Amount of charging electricity and power	New service
26 – Commercial vehicle e-mobility charging node	1. Number of external charging events 2. Utilization ratio of shared charging (external charging events / e-bus charging events) 3. Total charged electricity from shared connection 4. Ratio of electricity charged from shared connection (external charged electricity / e-bus charged electricity) 5. Availability of the charging nodes	1. 0 2. 0 3. 0 4. 0 5. 0
28 – Personal ev charging with dynamic load balancing	1. Electricity cost savings 2. Number of EV-chargers installed 3. Charging capacity installed	1. Comparative KPI 2. 0 3. 0

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Action nro & name	KPIs	Baseline or Remarks
31 – RES strategies towards Hanasaari B decom.	1. Strategy defined Y/N 2. Strategy implemented Y/N	RES Strategy to cover new production means for this 220MW electricity 445MW thermal energy demand that needs to be in use latest by 2024 (coal based CHP plant decommissioning)
32 – Energy Reneissance	1. Strategy defined Y/N 2. Number of citizen engagement events 3. Number of people reached	Strategy for district-level energy renovation based on interventions in mySMARTLife and collected open energy data in Action 44.
33 – RES-as-a-Service business model development	Citizens / stakeholder involvement (nb of people, events) in business model development	
34 – Hackathon to IoT platform	1. Number of groups participating in hackathon 2. Total number of participants in hackathon	One large-scale hackathon for external developers will be arranged to further probe and exploit the data and APIs generated in mySMARTLife
35 - Advanced urban planning	1. Number of mySMARTLife relevant new results benefitting urban planning 2. % of those implemented	Potential for implementing in Helsinki's urban planning concepts developed within WP1 on urban transformation strategy.
36 - SECAP - Sustainable Energy and Climate Action Plan	Number of new mySMARTLife solutions benefitting SECAP	mySMARTLife results to support Helsinki's adoption of SECAP
37 - SUMP- Sustainable Urban Mobility Plans	Number of new mySMARTLife results that can be implemented in SUMP	Identifications of useful mobility results in mySMARTLife to be implemented in Helsinki's SUMP.
38 - Replication Plan	1. Number of good practices selected from elsewhere to be further developed in Helsinki 2. Number of good practices taken to be further developed elsewhere 3. Number of cities/locations that adopted practices	
39 - Smart Kalasatama Living Lab	1. Number of events / participants 2. Number of ideas selected for further development	Living labs not restricted to Zone 2 only
40 – Energy Advisor	1. Number of people reached by the energy advisor 2. User satisfaction survey	New service

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Action nro & name	KPIs	Baseline or Remarks
41 – Real-time large scale visualizations	1. Number of facility visualisation locations 2. Estimation of people reached by visualisations 3. Number of plays of energy animation (HEN)	New solution
42 - City mentoring strategy	Number of good practices selected for mentoring Number of mentors selected Will be refined in WP1	Part of WP1
43 - City coaching strategy	Number of coaches named Number of coached cities / other stakeholders Will be refined in WP1	Part of WP1
44 – Open energy data	1. Coverage of buildings 2. Number of new open services made available 3. Number of open datasets made available	New data
45 – Digitransit features	1. Number of app downloads 2. Usage count (number of app accessing API) 3. Number of usage of advanced features, e.g. EV routing	New service
46 – Carbon Neutral Me app	1. Number of app downloads 2. Usage count (number of app accessing the API)	New service
47 – IoT repository up-take	1. Number of new sensors and data points 2. Amount of new measurements	New service
48 – Sensoring infrastructures	1. Number of air quality sensors installed 2. Number of noise sensors installed 3. Total number of sensors providing real-time data 4. Total number of aggregated data sets available at HRI open data platform	New infrastructure

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18. Conclusions

The objective of this task was to describe the baseline situation in Helsinki. That was done by analysing the current situation in Helsinki on various domains in the report's Part I Helsinki city audit and by presenting baselines for each demonstration action to be implemented in Helsinki within mySMARTLife project in Part II Action specific KPIs and baseline values.

The Part I Helsinki City Audit provides a diagnosis of Helsinki in the following areas: Chapter 4 overall city characterization (socioeconomic, climatic, urban morphology, environmental), Chapter 5 urban plans promoting low energy districts and sustainable mobility, Chapter 6 public procurement and regulations, Chapter 7 existing actions for citizen engagement, Chapter 8 transport status, Chapter 9 Energy supply and resources, Chapter 10 Integrated infrastructures. The characteristics and current performance of Helsinki are described by calculating 132 City Level indicators. This wide spectrum of the city's characteristics are also analysed by summarising existing good practices and potential for improvement. The summary and conclusions from the city audit are presented in the form of a SWOT analysis in Chapter 11.

The Part II of the report, in contrast, focuses on project level and more specifically on the actions that will be implemented in Helsinki during mySMARTLife project. The baseline of the actions is described with help of Project level indicators that are defined and calculated within the specific scope of each action in order to be able to later monitor the impacts of the actions within their scope. The main aim is to precisely describe (in the context and boundaries of each action) its state or performance before the action starts so that the impacts or achievements of the actions can be assessed after implementation by following similar measurement procedure. It was found out that in many case no indicators existed to properly capture the impact of the actions. Therefore, the action specific KPIs were selected or developed together by the partners involved in the actions to best capture the aims and scope of the actions. They will be used later to monitor the impact achieved by the actions within WP5 of the project (together with some KPIs common with other cities). Baseline values are calculated for the action level KPIs based on measured data over one year, whenever applicable. The Part II of the report is structured to action KPIs and baselines related to 12. Buildings and districts, 13. Energy infrastructures, 14. Mobility, 15. Non-technical (Citizen engagement, Business models, Urban planning), and, 16. ICT. The results are concluded in Chapter 17 in form of a table that summarises all the 48 actions, the KPIs specifically designed for their assessment as well as the baseline of each action.

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20. Annex_ Helsinki City Level indicators

Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City characterization	Size	Size	-	km2	Land area of city	216.5
People	City characterization	Population	Population	-	Inh	Total number of persons inhabiting a city	628,208
People	City characterization	Population	Population density	-	Inh./km2	Population per unit area in the city	2,901.7
People	City characterization	Population	People > 75 years	-	%	Population elder than 75 years old	6.7
People	City characterization	Population	Average population age	-	-	Average of the age of the population (man+woman)	42.45
Planet	City characterization	Type of city	Type of city	-	-	Typology of the city under study: metropolitan, urban, suburban - Metropolitan areas are urban areas with more than 500,000 inhabitants - Urban area is a functional economic unit characterised by densely inhabited 'cities' with more than 50,000 inhabitants and 'commuting zones' whose labour market is highly integrated with nearby cities - Suburban areas correspond with a residential district located on the outskirts of a city and with a population less than 50,000 inhabitants	metropolitan
Planet	City characterization	Land use	Land consumption	Nº Buildings/Total city surface	nº build/Km2	Measure of land use intensity and urban areas density	195.0
Planet	City characterization	Land use	Land consumption 2	Total built surface/Total city surface	Km2/Km2	Measure of land use intensity and urban areas density	0.31
Planet	City characterization	Land use	Balance between residential and no-residential building use	[Built surface for terciary sector/Total build surface] x100	%	Measure of land use diversity	0.40
Planet	City characterization	CO2 target	Overall CO2 emission reduction target	-	%	That is the objective of each one of the cities according to the SEAP	30.0

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Prosperity	City characterization	Tourist intensity	Tourism intensity	Number of tourist nights per year per 100,000 inhabitants	(# of tourist nights / total population) *100,000	The ratio of tourists that spent nights at tourist accommodation establishments divided by one million of inhabitants in a year	550,782.0
Planet	City characterization	Climate	Climate koppen geiger classification	-	-	The Köppen climate classification scheme divides climates into five main groups (A, B, C, D, E), each having several types and subtypes. Each particular climate type is represented by a two- to four-letter symbol. http://koeppen-geiger.vu-wien.ac.at/pdf/kottek_et_al_2006_A4.pdf	Dfb
Planet	Local energy supply	City energy profile	Final energy consumption per capita	-	MWh/capita	-	22.84
Planet	Local energy supply	City energy profile	Final energy consumption (Transport)	-	TWh/year	-	2.60
Planet	Local energy supply	City energy profile	Final energy consumption (Buildings, equipments/facilities and Industries)	-	TWh/year	-	11.81
Planet	Local energy supply	City energy profile	Final energy consumption (Municipal)	-	TWh/year	-	1.57
Planet	Local energy supply	City energy profile	Final energy consumption (Tertiary)	-	TWh/year	-	4.01
Planet	Local energy supply	City energy profile	Final energy consumption (Residential)	-	TWh/year	-	5.75
Planet	Local energy supply	City energy profile	Final energy consumption (Public lighting)	-	TWh/year	-	0.05
Planet	Local energy supply	City energy profile	Final energy consumption (Industry)	-	TWh/year	-	0.7
Planet	Local energy supply	City energy profile	Final energy consumption (electricity)	-	TWh/year	-	4.42

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	Local energy supply	City energy profile	Final energy consumption (Heat/Cold)	-	TWh/year	-	DH consumption (used by 92% of inhabitants) 6.633 TWh/year; district cooling 0.141 TWh/year
Planet	Local energy supply	City energy profile	Final energy consumption (Fossil fuels)	-	TWh/year	-	11.94
Planet	Local energy supply	Renewable energies	Final energy consumption (Renewables)	-	TWh/year	-	2.47
Planet	Local energy supply	Renewable energies	Share of local energy production to overall final energy consumption	-	%	-	103% (Taking into account electricity exports, HELEN produces more in Helsinki than is the total consumption in Helsinki)

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	Local energy supply	Renewable energies	Renewable electricity generated within the city	The share of renewable electricity produced within the city is calculated as the total consumption of electricity generated from renewable sources (numerator) divided by total energy consumption (denominator). The result shall then be multiplied by 100 and expressed as a percentage. Consumption of renewable sources includes solar, wind, hydro, tide and wave energy, and combustibles used for electric generation, such as biomass. (ISO/DIS 37120, 2013).	%	The percentage of electric energy derived from renewable sources, as a share of the city's total energy consumption	0.13%
Planet	Local energy supply	Renewable energies	Non-RES Heat/ Cold production	-	TWh/year	-	6.43
Planet	Local energy supply	Renewable energies	RES Heat/Cold production	-	TWh/year	-	0.64
Planet	Local energy supply	City energy profile	Total buildings energy consumption per year	-	GWh/inhab. year	Residencial consumption in the city for heating and electricity uses	18.50

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	Local energy supply	Renewable energies	Renewable energy per carrier	-	GWh/RES_ supplier	Energy that each renewable systems provides to the city	Local utility's heat pump plant: 440 for DH, 125 for district cooling; Solar PV pants 0.975; small-scale (solar) production unknown, estimated around 100 producers; Imported electricity 13% renewable, mainly hydro; Some wood and waste used in CHP plants.
Planet	Local energy supply	Renewable energies	Percentage of renewable energy	RES_energy/total _energy	%	Amount of energy coming from the renewable sources	13.00%
Planet	Local energy supply	City energy profile	Primary energy consumption in the city per year	-	GWh of PE/year	Gross inland consumption of the city excluding non-energy uses	8,000 GWh DH, 7,500 GWh electricity
Planet	Local energy supply	City energy profile	Primary energy consumption per capita	-	MWh/capita	-	24.70
Planet	Local energy supply	City energy profile	Primary energy consumption (Transport)	-	TWh/year	-	non-available*
Planet	Local energy supply	City energy profile	Primary energy consumption (Buildings, equipments/facilities and Industries)	-	TWh/year	-	non-available
Planet	Local energy supply	City energy profile	Primary energy consumption (Municipal)	-	TWh/year	-	non-available
Planet	Local energy supply	City energy profile	Primary energy consumption (Tertiary)	-	TWh/year	-	non-available
Planet	Local energy supply	City energy profile	Primary energy consumption (Residential)	-	TWh/year	-	non-available
Planet	Local energy supply	City energy profile	Primary energy consumption (Public lighting)	-	TWh/year	-	0.08

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	Local energy supply	City energy profile	Primary energy consumption (Industry)	-	TWh/year	-	non-available
Planet	Local energy supply	City energy profile	Primary energy consumption (electricity)	-	TWh/year	-	7.50
Planet	Local energy supply	Energy mismatch	Maximum Hourly Deficit (MHDx)	The maximum yearly value of how much the hourly local electricity demand overrides the local renewable electricity supply during one single hour	kWh	Energy mismatch	non-available
Planet	Local energy supply	Renewable energies	Green electricity purchased	-	%	The percentage of green electricity purchased from the municipality, as a share of the city's total electtricity consumption	non-available
Planet	Local energy supply	Energy monitoring	Smart energy meters	-	% of buildings	The percentage of buildings in the city with smart meters This indicator shows the coverage on the energy distribution network with energy meters; it could be distinguished for electric and methane or heat networks.	100%
Planet	Local energy supply	Potential of retrofitting	Refurbished buildings improving energy performance	-	% of buildings	Number of buildings subject to refurbishment improving their energy profile above the EPBD (Energy Performance of Buildings Directive) requirements	non-familiar
Planet	Local energy supply	Energy systems	Number of connections to a district heating network	It is calculated as the total number of buildings connected to a DH (numerator) divided by totalnumber of buildings in the city(denominator) .	% of buildings	Percentage of buildings connected to a district heating network of the city	92.00%

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City characterization	City environmental impact	Greenhouse gas emissions per capita	-	tonnes CO2/capita	-	4.20
Planet	City characterization	City environmental impact	Greenhouse gas emissions (tertiary)	-	Mtonnes CO2/year	-	0.96
Planet	City characterization	City environmental impact	Greenhouse gas emissions (transport)	-	Mtonnes CO2/year	-	0.60
Planet	City characterization	City environmental impact	Greenhouse gas emissions (Residential)	-	Mtonnes CO2/year	-	1.40
Planet	City characterization	City environmental impact	Greenhouse gas emissions in buildings, equipment/facilities and Industries	-	Mtonnes CO2/year	-	2.05
Planet	City characterization	City environmental impact	Greenhouse gas emissions (Public lighting)	-	Mtonnes CO2/year	-	0.01
Planet	City characterization	City environmental impact	Greenhouse gas emissions (Municipal)	-	Mtonnes CO2/year	-	2.7
Planet	City characterization	City environmental impact	Greenhouse gas emissions (Industry)	-	Mtonnes CO2/year	-	0.2
Planet	City characterization	City environmental impact	Transport greenhouse gas emissions per capita	Transport GHG emissions, in equivalent CO2 units, generated over a calendar year / Total city population	t /(pers.·a)	Measure of the total greenhouse gas emissions per capita due to public and private transport.	0.90
Planet	City characterization	City environmental impact	Percentage of renewable energy use in public transport	[Renewable energy use in public transport over a calendar year (kWh) / Public transport energy use over a calendar year (kWh)] x100	%	Measure of the use of renewable energy in public transport.	28%

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City characterization	Water resources	Water consumption	(City's total water consumption in litres per day)/(total population)	m3/cap/day	Water resources	0.18
Planet	City characterization	Water resources	Water re-used (rain/grey water)	[(houses with grey and rain water reuse capability)/(total number of houses)]*100%	% of houses	Water resources	non-available
Planet	City characterization	Air pollution	NOx emissions	[annual NO2 emissions (g)]/(total population)	g/cap	Air pollution	10.49
Planet	City characterization	Air pollution	PM2,5 emissions	[annual PM2.5 emissions (g)]/(total population)	g/cap	Air pollution	304.00
Planet	City characterization	Air pollution	Air quality index	((NO2_YEAR_AVERAGE/40) + (PM10_YEAR_AVERAGE/40) + (LOG((PM10daily > 50µg)+1)/LOG(36)) + ((DAYS_WITH_Ozone_8h_AVG >= 120)/25) + (SO2_YEAR_AVERAGE/20) + (Benzene_YEAR_AVERAGE/5)) / 6	index	AQI calculations focus on major air pollutants including: particulate matter, ground-level ozone, sulfur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO). It is a distance to target indicator that provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives). If the index is higher than 1: for one or more pollutants the limit values are not met. If the index is below 1: on average the limit values are met. NANTES is involved on this initiatives. http://www.airqualitynow.eu/index.php	0.27

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City characterization	Waste	Recycling rate	[(total amount of the city's solid waste that is recycled in tonnes) / (total amount of solid waste produced in the city in tonnes)]*100%	% tonnes	0	48%
Planet	City characterization	Noise	Exposure to noise pollution	Share of the population affected by noise > 55dB at night time	%of people	0	40%
Planet	City characterization	Waste	Amount of solid waste collected	(Annual amount of genererated municipal solid waste t/yr) / (total population)	tonnes/capita/year	Waste	0.312
Planet	City characterization	Land consumption	Brownfield use	[brownfield area redeveloped in the last year (km2)] / [total brownfield area in the city (km2)]	% of km2	Share of brownfield area that has been redeveloped in the past period as percentage of total brownfield area	non-available
Planet	City characterization	Urban Heat Island	Urban Heat Island	Maximum hourly difference in air temperature within the city compared to the countryside during the summer months	°C UHImax	Maximum difference in air temperature within the city compared to the countryside during the summer months	5-10 °C
Planet	City characterization	Food consumption	Local food production	Share of food consumption produced within a radius of 100 km	% of tonnes	Share of food consumption produced within a radius of 100 km	non-available
Planet	City transportation status	Mobility city profile	Total number of public transport vehicles	#	Number of vehicles	Number of public vehicles that are destinated to public transport (bus, taxis…)	3,016

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City transportation status	Sustainable transport	Number of Electric Vehicles (EV) in the city	Number of electric vehicles in the city per 100.000 (# EVs / total population)*100 000	n/100.000	Number of electric vehicles in the city including private, public and service (taxi and first mile) vehicles including also motobikes	141.0
Planet	City transportation status	Mobility city profile	Number of fossil fuelled four wheels vehicles per capita	Number of fossil fuelled vehicles (four wheels) of the city distinguishing by type (public and private) and divided by the population	n/ cao	Number of fossil fuelled vehicles (four wheels) of the city divided by the inhabitants of the city (public and private)	0.38
Planet	City transportation status	Transport problems	Traffic accidents	number of fatalities related to transportation of any kind/(totalPopulation/100000)	#/100 000 people	Number of transportation fatalities per 100 000 population in a year. Fatalities includes dead but also hospitalization	1.90
Planet	City transportation status	Sustainable transport	Public transport use	# of trips made annually in the city with public transport / total population	#/cap/year	Annual number of public transport trips per capita	381.0
Planet	City transportation status	Sustainable transport	Access to public transport	(Number of inhabitants with a transportation stop <500m/total population)*100 %	%of people	Share of population with access to a public transport stop within 500m	96%
Planet	City transportation status	Sustainable transport	Access to vehicle sharing solutions	(# vehicle for sharing / total population)*100 000	#/100 000 people	Number of vehicles available for sharing per 100.000 inhabitants	49.0
Planet	City transportation status	Sustainable transport	Lenght of bike route network	total Kilometers Of Bicycle Paths And Lanes_(Km/population)*100000	km/100000 people	Lenght of lanes in the city for bikes per 100,000 inhabitants	191.0

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Planet	City transportation status	Transport problems	Congestion	((travel times in peak hours - travel times during non-congested periods (free flow*))/travel times during non-congested periods)*100%	% in hours	Increase in overall travel times when compared to free flow situation (uncongested situation)	26%
Planet	City transportation status	Mobility city profile	Vehicle fuel efficiency	Total energy consumed for vehicules/total amount of vehicle kilomentres completed	kWh/100km	#	83.0
Planet	City transportation status	Mobility city profile	Fuel mix	Percentage of the market share of transport fuel for each type of fuel used in given period	%	#	Petrol 65.7% Diesel 33.6% Electric 0.34% Flexifuel 0.16% Gas 0.11%
Planet	City transportation status	Mobility city profile	Average occupancy	Average of number of passengers per vehicle per trip	number of passengers per vehicle	#	1.29
Planet	City transportation status	Mobility city profile	Average vehicle speed	Average network speed by vehicle (peak/off-peak)	0	#	Peak: 18 km/h Off-peak: 24 km/h
Planet	City transportation status	Charging points	Total kWh recharged in the public EV charging stations.	#	kWh	Number of kWh recharged during a year in the public charging stations. It will be required to infrastructure operator and vehicle owners in order to compare this indicator with energy consumption and distance travelled.	59.0
Planet	City transportation status	Charging points	Charging points per eVehicle	Total charging points/# eVehicles	%	This indicator measures the number of public charging points related to the total amount of electric vehicles in the city.	0.12
Planet	City transportation status	Charging points	Total charging points	#	#	Total number of public charging points	84.0

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Planet	City transportation status	Charging points	Recharges per year	Number of charges/year	#/year	Usage of the recharging points	59,045.0
Planet	City transportation status	Charging points	infrastructure growth e-car	number of e-car charging points available	[number of e-car charging]	Total number of public charging points in the city for e-cars	84.0
Planet	City transportation status	Charging points	infrastructure growth e-bike	number of e-bike charging points available	[number of e-bike charging]	Total number of public charging points in the city for e-bikes	26.0
People	Urban infrastructures	Lighting management	Lighting system connected	-	YES/NO	Is there an automated lighting management system in the city?	YES
People	Urban infrastructures	Waste management	Waste management system	-	YES/NO	Is there an automated waste management system in the city?	YES
People	Urban infrastructures	Traffic management	Traffic management system	-	YES/NO	Is there an automated traffic management system in the city?	YES
People	Urban infrastructures	Traffic management	Parking management system	-	YES/NO	Is there an automated parking management system in the city?	YES
People	Urban infrastructures	Traffic management	Public bicycles management system	-	YES/NO	Is there an automated public bicycles management system in the city?	YES
People	Urban infrastructures	Traffic management	Public transport management system	-	YES/NO	Is there an automated public transport management system in the city?	YES
People	Urban infrastructures	Traffic management	Number of public transport stops with real time info	-	%	Number of public transport stops with real time information regarding the total number of public transport stops. ICT applied to public transport needs accuracy and territorial coverage	8.94%
Planet	City characterization	Land consumption	Compactness	Relation between the usable space of the buildings (volume) and the urban space (area)	inhabitants or workplaces / m2	Relation between the usable space of the buildings (volume) and the urban space (area)	0.0029
People	Urban infrastructures	Liveability of neighbourhoods	Use of groundfloors	(ground floor space used commercially/publically (in m2)/total ground floor space (in m2) *100%.	m2	Liveability of neighbourhoods Percentage of ground floor surface of buildings that is used for commercial or public purposes as percentage of total ground floor surface.	non-available

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
People	Urban infrastructures	Green spaces	Green and blue space	{ [(Water area) + (Green space area)] / (Total land area) } * 100%.	m2	Nature and recreation possibilities The surface that correspond with green space and water spaces in the city in relation to the total surface of the city	10.34
People	Urban infrastructures	Communication infrastructure	Access to public free WiFi	(sum of wifi node coverage)/total city urban surface)*100%.	%	Attractiveness, accessibility of online services This indicator measures the percentage of a city's public space which is covered by a public Wi-Fi network	0.19
People	Urban infrastructures	Communication infrastructure	Access to high speed internet	(Number of Fixed (wired)-broadband subscriptions /inhabitants) *100000	%	Ensure good city connectivity and the provision of efficient digital infrastructures	26.88%
People	Urban infrastructures	Communication infrastructure	Number of phone connections per 100,000 inh	(Number of cell phone connections /inhabitants) *100000	Connections/100.000 hab.	Total number of cell phone connections in the city in relation to the population of the city	197.9
People	Urban infrastructures	Communication infrastructure	Number of Internet connections per 100,000 inh	(Number of internet connections /inhabitants) *100000	Connections/100.000 hab.	Total number of internet connections in the city in relation to the population of the city	non-available
Governance	Governance	Urban planning	Existence of plans/programs to promote energy efficient buildings	-	Number of plans	Is there any specific plan for promoting energy efficient buildings in the city?	+5?
Governance	Governance	Urban planning	Existence of plans/programs to promote sustainable mobility	-	Number of plans	Is there any specific plan for promoting sustainable mobility in the city?	+5?
Governance	Governance	Urban planning	Existence of regulations for development of energy efficient districts	-	Number of regulations	Is there any specific regulation for developing energy efficient districts in the city?	YES

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Urban planning	Existence of regulations for development of sustainable mobility	-	Number of regulations	Is there any specific regulation for developing sustainable mobility in the city?	1.0
Governance	Governance	Urban planning	Existence of local/national Energy Performance Certificate (EPC)	-	YES/NO	Is there any specific EPC for buildings in the city?	YES
Governance	Governance	Urban planning	Share of Green Public Procurement	-	%	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration	75%
Governance	Governance	Level of correspondence between local energy codes	Level of correspondence between local energy codes	-	YES/NO	Is there any discrepancy between different local energy codes for buildings?	NO
Governance	Governance	Level of correspondence among regulations	Level of correspondence with national regulation	-	YES/NO	Is there any discrepancy between local codes and national regulation?	NO
Governance	Governance	Level of correspondence among regulations	Level of correspondence with European legislation	-	YES/NO	Is there any discrepancy between local codes and European legislation?	NO
Governance	Governance	Level of correspondence among regulations	Level of correspondence with international construction standards	-	YES/NO	Is there any discrepancy between local codes and international construction standards?	NO

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Online governance data	Availability of government data	-	Qualitative Likert scale	The extent to which government information is published Likert scale Not at all – 1 – 2 – 3 – 4 – 5 – Excellent 1. Not at all: most of the information is not available to the public or only upon appointment with an expert 2. Poorly: most of the information is available to the public, but available in the form of a hard copy which cannot leave city hall 3. Somewhat: most of the information is available to the public, some in the form of a hard copy, some online. 4. Good: most of the information is available online, but structure is lacking 5. Excellent: all government information is available online and neatly structured.	4.0
People	Urban infrastructures	Quantity of open data	Quantity of open data	(# of open government datasets/ Inhabitants)*100, 000	#/100.000	Quantity of open data sets provided by city's open data portal	96.10

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Governance collaboration	Cross-departmental integration	-	Qualitative Likert scale (1 to 5)	The extent to which administrative departments contribute to“Smart City” initiatives and management. The level of cross-departmental integration will be estimated by analyzing the number of departments involved in smart city initiatives, whether by contributing financial, data sources or human resources 1. There is a silo-ed smart city governance structure, only one department actively contributes to smart city initiatives and decides on the strategy. 2. The local authority is poorly oriented towards crossdepartmental “smart city” management: officially there is no “mainstreaming approach”, some civil servants from a few departments work on this portfolio on the side or provide data for the initiatives, but there is no real strategy and commitment. 3. The local authority is somewhat oriented towards crossdepartmental “smart city” management: there is a strategy for a “mainstreaming approach” and several departments contribute in human, data or financial resources. 4. The local authority is clearly oriented towards crossdepartmental “smart city” management: there is a strategy for a “mainstreaming approach” and almost all departments provide financial, data and human resources for the smart city themes. 5. The local authority is committed towards crossdepartmental “smart city” management: there is a wellanchored mainstreaming approach” with shared performance targets and all departments are actively contributing to the smart city themes in financial, data and human resources.	4.0

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Urban planning	Smart city policy	-	Qualitative Likert scale	The extent to which the city has a supportive smart city policy Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very supportive 1. Not at all: the complete absence of a long-term smart city vision (including and absence of long-term targets & goals) from the side of the government or an opposing vision create a difficult environment for starting smart city initiatives. 2. Poor: The long-term vision of the government does, to some extent, hamper the environment for smart city initiatives. 3. Neutral: The long-term vision of the government has had no significant, positive or negative, impact on the environment for smart city initiatives. 4. Somewhat supportive: The long-term vision of the government has to some extent benefitted the environment for smart city initiatives. The city has created roadmaps and actions to support vision implementation 5. Very supportive: The comprehensive long-term vision on the future of the city stimulates the environment for smart city initiatives to a great extent.	4.0
Governance	Governance	Citizen participation	Voter participation	(number of people who voted in last municipal elections/total population eligible to vote)*100%	%	The percentage of people that voted in the last municipal election as share of total population eligible to vote	61.8

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Governance collaboration	Multilevel government	-	Qualitative Likert scale	The extent to which the city cooperates with other authorities from different levels Likert scale: Not at all – 1 – 2 – 3 – 4 – 5 - Very much 1. Not at all: there is no cooperation or coordination with other municipalities and/or other levels of government whatsoever. 2. Poorly: there is little cooperation with other authorities, but this is irregularand very dependent of the people involved. 3. Somewhat: there is some cooperation or coordination with other municipalities and/or other levels of government, which is formalized in a partnership policy. 4. Good: there is good cooperation or coordination with other municipalities and/or other levels of government, which is formalized in partnership policies and in process through regular participation in meetings. 5. Excellent: the city is a driving force in the cooperation or coordination with other municipalities and/or other levels of government, which is formalized in policy and in process through regular meetings initiated by the city.	5.0
Governance	Governance	Urban planning	Climate resilience strategy	-	Likert scale	The extent to which the city has developed and implemented a climate resilient strategy Qualitative Likert scale (1 to 7) 1.No action has been taken yet 2. The ground for adaptation has been prepared (the basis for a successful adaptation process) 3. Risks and vulnerabilities have been assessed 4. Adaptation options have been identified 5. Adaptation options have been selected 6. Adaptation options are being implemented 7. Monitoring and evaluation is being carried out.	6.0

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Urban planning	Existence of local sustainability plans	-	YES/NO	Is there any specific sustainability plan in the city?	YES
Governance	Governance	Urban planning	Existence of Smart Cities strategies	-	YES/NO	Is there any specific Smart Cities strategy in the city?	YES
Governance	Governance	Urban planning	Existence of an Agenda 21	-	YES/NO	Has the city elaborated an Agenda 21?	YES
Governance	Governance	Urban planning	Signature and compliance of the Covenant of Mayors	-	YES/NO	Has the city signed the Covenant of Mayors. And Is the city complying with it? (both questions need to be aswered)	YES
People	Citizens	Channels of communicatio n	Number of local associations per capita	Number of associations / Total city population	Number of consultation s / inhab.	Total number of civic associations registered with the local authority related to total city population	+200
People	Citizens	Channels of communicatio n	Number of information contact points for citizens	-	Number of information points	Total number of contact points established in the city by the municipality to share information from the city to the citizens (tourism, events, mobility, environment, etc)	20.0
People	Citizens	Channels of communicatio n	Number of municipal websites for citizens	-	Number of municipal websites	Total number of municipal websites which belong to the municipality for sharing information of the city to the citizens (citizen participation portal, open data, transparency, etc.)	Numerous
People	Citizens	Channels of communicatio n	Number of interactive social media initiatives	-	Number of social media links	Number of accounts in social media created by the municipality for sharing information about the city (e.g. news, cultural agenda, etc).	Numerous
People	Citizens	Channels of communicatio n	Number of discussion forums	-	Number of forums	Total number of discussion forums organized by the municipality dedicated to discuss with citizens about the needs, opportunities and solutions to be implemented the city	Numerous

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
People	Citizens	Accesibility of services	Access to public amenities	-	%	Basic services available close to home Share of population with access to at least one type of public amenity within 500m. Examples of the types of public amenities considered here are social welfare points, social meeting centers, theatres and libraries. (note: other public amenities such as green spaces, public recreation and healthcare facilities are already covered in separate indicators).	non-available
People	Citizens	Accesibility of services	Access to commercial amenities	-	%	Basic services available close to home Share of population with access to at least six types of commercial amenities providing goods for daily use within 500m. Commercial amenities are services/goods for daily use provided by private actors. Typical commercial amenities include shops for bread, fish, meat, fruits and vegetables, general food shops (i.e. supermarkets), press, and pharmaceutical products	non-available
Prosperity	City characterization	Equity	Diversity of housing	-	%	Diversity Percentage of social dwellings as share of total housing stock in the city	19.9%

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
Governance	Governance	Urban planning	Preservation of cultural heritage	-	Qualitative Likert scale	Identity of place based on its history The extent to which preservation of cultural heritage of cultural heritage of the city is considered in urban planning The indicator provides a qualitative measure and is rated on a fivepoint Likert scale: Not at all – 1 — 2 — 3 — 4 — 5 — Very much 1. Not at all: no attention has been paid to existing cultural heritage in urban planning. 2. Fair: heritage places have received some attention in urban planning, but not as an important element. 3. Moderate: some attention has been given to the conservation of heritage places. 4. Much: heritage places are reflected in urban planning 5. Very much: preservation of cultural heritage and connections to existing heritage places are a key element of urban planning.	4.0
People	City characterization	Education level	Number of high edu degrees per 100,000 population	(Number of high edu degrees /inhabitants) *100000	n/100,000 inh	It is an indicator of well being and development. Number of city inhabitants with high education degrees per 100000 inhabitants. Tertiary education broadly refers to all post-secondary education, including but not limited to universities	34,181.0

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
People	Urban infrastructures	Urban platform	Cybersecurity	-	Qualitative Likert scale	Data protection, security of ICT systems Low level of cybersecurity — 1 — 2 — 3 — 4 — 5 — High level of cybersecurity 1. Maximum one of the following conditions is met. 2. Two of the following conditions are met 3. Three of the following conditions are met. 4. Four of the following conditions are met. 5. All the five following conditions are met. 1. There has been no serious information leakage or cyberattack with ignificant negative impact on the organisation, its employees or citizens during the past two years. Serious means that it results in disclosure of information (e.g. confidential or sensitive personally identifiable information) or financial lost, due to illegal system access, unauthorized data storage or transmission, unauthorized hardware and software modifications or personnel's lack of compliance with security procedures. 2. The city makes annually a risk assessment on risks of cybersecurity and has a contingency plan against the identified risks. 3. All city personnel receive basic security training when they are employed to conduct adequately to security incidents. 4. The city has recruited personnel dedicated to cybersecurity and they have signed a security pledge. 5. Employees' devices deploy an antivirus program for mitigating malware including viruses residing in them and remote access protected, i.e. controlled with security function for intrusion prevention or intrusion detection.	non-available

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Theme	Category	Application field	Indicator	Formula	Units	Objectives of the indicator	Value
People	Urban infrastructures	Urban platform	Data privacy	-	Qualitative Likert scale	The level of cybersecurity of the cities' systems Likert scale Not at all — 1 — 2 — 3 — 4 — 5 — Very high 1. City doesn't follow national regulations/laws on protection of personal data. 2. City follows national regulations/laws on protection of personal data. 3. City follows relevant national regulations on protection of personal data and the EU Directive on the Protection of Personal Data (95/46/EG). 4. City follows all the relevant national and European regulations/laws related to data privacy and protection. If personal/private data is collected from citizens, proper authorisations with written agreements are made. 5. Relevant national and European regulations on data protection and privacy are followed and written agreements are made for use of citizens' private/personal data. All the collected personal/private data, especially sensitive personal data, is accessed only by agreed persons and is heavily protected from others (e.g. locked or database on internal server with firewalls and restricted access).	non-available
People	Urban infrastructures	Urban platform	Number of data publishers	-	#	Number of data publishers that publish data into the existing urban platform (e.g. website)	50.0
People	Urban infrastructures	Urban platform	Number of sensors/devices connected**	-	#	Number of IoT sensors/devices from any field that are connected in the current urban platform (e.g. website)	100.0
People	Urban infrastructures	Urban platform	Number of services deployed	-	#	Number of available services in the current urban platform (e.g. website)	174.0
People	Urban infrastructures	Urban platform	Number of available Open APIs	-	#	Number of available APIs in the current urban platform (e.g. website)	27.0

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People	Urban infrastructures	Urban platform	Number of available Open Data sources	-	#	Number of available Open Data sources in the current urban platform (e.g. website). Open means anyone can freely access, use, modify, and share for any purpose (subject, at most, to requirements that preserve provenance and openness)."	480.0
People	Urban infrastructures	Urban platform	Number of accesses to the urban platform APIs	-	#	Number of accesses that have been made into the APIs of the urban platforms (e.g. website)	21,620,218.0
Prosperity	City characterization	Employment	Unemployment rate	% people not working among those available for work	%	Unemployment	12.60%
Prosperity	City characterization	Employment	Youth unemployment rate	% youth (<24y) labour force unemployed	%	Youth unemployment	9.60%
Prosperity	City characterization	Equity	Fuel poverty	-	% of households	Equity The percentage of households unable to afford the most basic levels of energy	non-available
Prosperity	City characterization	Economic performance	Costs of housing	% gross household income spent on housing	% in €	Equity	28,3% of income €
Prosperity	City characterization	Green economy	Green public procurement	-	%	Stimulating eco-innovation Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration	75%
Prosperity	City characterization	Economic performance	GDP	GDP per capita	€/cap	Economic performance	50.7
Prosperity	City characterization	Economic performance	Median disposable income	Median disposable annual household income	€/household	Economic wealth	25.0
Prosperity	City characterization	Economic performance	New businesses registered	(Number of new business registered /inhabitants) *100000	#/100.000	Economic activity, attractiveness Number of new businesses registered (including start-up) in a year per 100,000 population. An average of the last 5 years with available data	non-available

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Prosperity	City characterization	Innovation	New startups	(Number of startups registered /inhabitants) *100000	#/100.000	New business Number of new businesses registered (including start-up) in the last year per 100,000 population. An average of the last 5 years with available data It shows how attractive is the city for starting new economic activities	non-available
Prosperity	City characterization	Innovation	Research intensity	R&D expenditure as percentage of city's GDP	% in euros	Innovation	non-available
Prosperity	City characterization	Equity	Population Dependency Ratio	0	#/100	Economic development Number of economically dependent persons (net consumers) per 100 economically active persons (net producers)	45.7

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