D1.1 City Characterization Report

30/09/2020

ESP[1], LPZ[2], FHG[3]

[1] Fraunhofer IAO, Nobelstraße 12 70569 Stuttgart
[2] City of Espoo, Virastopiha 2 C, 02070 Espoo
[3] City of Leipzig, Digital City Unit, Martin-Luther-Ring 4-6, 04109 Leipzig

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Author(s)	Marielisa Padilla, Pieter Bult, Reef Qubailat, Gabriele Bielinskaite, Zoe Genet, Andrea Reindl (FHG)				
Description of the related task and the deliverable. Extract from DoA	**T1.1 City diagnosis, data collection & preliminary analysis** The D1.1. City Characterization Report is an output from Task 1.1. City diagnosis, data collection & preliminary analysis. The D1.1. allows an accurate understanding of each Lead City specific profile, focusing both on raw data from heterogeneous energy sources available in Lighthouse sites (e.g. general data, energy, buildings, mobility, ICT, etc.) and already available city-level, action-field indicators information that will allow to draft a profile for each city, highlighting the quantifiable sustainability performance in selected sectors (energy, emissions, transportation, buildings). (R/PU, M12)				
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0.2	09/09/2020	(SPI)	Reviewers checked the deliverable and sent a new version with comments to address back to authors
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About SPARCS

Sustainable energy Positive & zero cARbon CommunitieS demonstrates and validates technically and socioeconomically viable and replicable, innovative solutions for rolling out smart, integrated positive energy systems for the transition to a citizen centred zero carbon & resource efficient economy. SPARCS facilitates the participation of buildings to the energy market enabling new services and a virtual power plant concept, creating VirtualPositiveEnergy communities as energy democratic playground (positive energy districts can exchange energy with energy entities located outside the district). Seven cities will demonstrate 100+ actions turning buildings, blocks, and districts into energy prosumers. Impacts span economic growth, improved quality of life, and environmental benefits towards the EC policy framework for climate and energy, the SET plan and UN Sustainable Development goals. SPARCS co-creation brings together citizens, companies, research organizations, city planning and decision-making entities, transforming cities to carbon-free inclusive communities. Lighthouse cities Espoo (FI) and Leipzig (DE) implement large demonstrations. Fellow cities Reykjavik (IS), Maia (PT), Lviv (UA), Kifissia (EL) and Kladno (CZ) prepare replication with hands-on feasibility studies. SPARCS identifies bankable actions to accelerate market uptake, pioneers innovative, exploitable governance and business models boosting the transformation processes, joint procurement procedures and citizen engaging mechanisms in an overarching city planning instrument toward the bold City Vision 2050. SPARCS engages 30 partners from 8 EU Member States (FI, DE, PT, CY, EL, BE, CZ, IT) and 2 non-EU countries (UA, IS), representing key stakeholders within the value chain of urban challenges and smart, sustainable cities bringing together three distinct but also overlapping knowledge areas: (i) City Energy Systems, (ii) ICT and Interoperability, (iii) Business Innovation and Market Knowledge.

Partners

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
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EXECUTIVE SUMMARY

SPARCs's overall objective is to achieve citizens' inclusive free carbon urban community by integrating the following key factors: technologies for energy positivity in buildings and districts, citizen engagement, city planning and governance, flexible grid management and energy storage and; e mobility as an energy system element. SPARCs targets to tackle the multifaceted challenges that cities are called to solve by creating the ecosystems necessary for the urban energy transformation in cities towards a citizens-inclusive **Sustainable energy Positive & zero cARbon CommunitieS.** The cornerstones of SPARCs are two lighthouse cities; Espoo in Finland and Leipzig in Germany along with five follower cities across Europe. These two Lighthouse cities aim to prove that the urban energy transformation of a city into a carbon neutral urban community is socially and economically viable.

Lighthouse city of Espoo has joined in the **Covenant of Mayors 2020** commitment in 2010, forming the foundation of its decarbonization process, and in 2012, the Espoo **Sustainable Energy Action Plan** (SEAP) was accepted, setting the ambition for its greenhouse gas emissions target. Subsequently, in February 2018 Espoo signed, the **Covenant of Mayors 2030**, and is now in the process of signing the **Sustainable Energy and Climate Action Plan** (SECAP) commitment. Additionally, in 2018, the City of Espoo became a pioneer for the United Nations Agenda 2030, requiring Espoo to commit to reaching the UN's Sustainable Development Goals by 2025. The lighthouse city of Leipzig has joined in the German Climate Alliance in 1994, setting a strict goal to reduce the CO2 emissions with the Energy and Climate protection Concept already in 2011. This has been enforced with the endorsement of the Climate protection Work Program of 2014, receiving its first certification (**Gold Certification**) in 2017 by the European Energy Award (EEA) Benchmarking System.

This report acts as a city diagnosis that allows for a precise understanding of the conditions and characteristics of the Lighthouse cities on both the qualitative and qualitative levels. The city diagnosis, data collection & preliminary analysis allow for an accurate understanding of each Lead City specific profile, focusing on both the raw data from heterogeneous energy sources available in Lighthouse cities (e.g. general data, energy, buildings, mobility, ICT, etc.) and already available city-level, action-field indicators information that allowed the drafting of this report, highlighting the quantifiable sustainability performance in selected sectors (energy, emissions, transportation, buildings).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

1. INTRODUCTION

1.1 Purpose and target group

The Lighthouse Cities in SPARCS seek to further understand their present status in order to address current and forthcoming sustainability challenges. The personalized city diagnosis elaborates and allows for an accurate understanding of the city's baseline conditions to better address these challenges. The city characterization report shall support the development of a roadmap for urban transformation of the city while serving as a stepping stone for achieving the final City Vision 2050. The basis for this report was the analysis of strategic plans developed for Espoo and Leipzig, indicators from the fields of energy, buildings, mobility, ICT etc. and action field indicators to allow to quantify sustainability performance in the selected sectors. The report was undertaken in collaboration with the City of Espoo and the City of Leipzig.

1.2 Contributions of partners

The revision of the assessment framework prepared by Fraunhofer, was reviewed by SPI and Suite5. The data collection of indicators and action fields was carried out by both cities, the City of Leipzig and the city of Espoo. Likewise, both cities have revised this report and contributed with the feedback to the assessment carried out by Fraunhofer.

1.3 Relations to other activities

This report is linked with the overall SPARCs Monitoring and Impact Assessment in Work Package 2 and the Replication potential of SPARCs framework in Work Package 5.

The monitoring and assessment process defined in WP2 will help to assess the impact that will be achieved by the SPARCS interventions in the demo sites of Lighthouse's Cities of Espoo and Leipzig. The present Deliverable 1.1 directly supports these tasks by creating a base of understanding the status quo of both cities and builds the basis for the future assessment and monitoring. The information presented here shall help to create a common understanding of the Lighthouse cities and their current performance in the relevant sectors of the project such as energy and mobility.

This deliverable equally supports the Replication Tasks 5.1 and 5.3 and all the replication activities across the five SPARCS Fellow cities, Kifissia (Greece), Kladno (Czech Republic), Lviv (Ukraine), Maia (Portugal) and Reykjavik (Iceland). The in-depth understanding of the Lighthouse cities, the analysis of their data via indicators and action fields helps to better understand the local conditions and the process for the development of the LH cities interventions. This understanding shall facilitate the replication activities and the exchange with the Fellow Cities.

2. METHODOLOGY

The basis for the elaboration of the city characterization report of Espoo and Leipzig is the Morgenstadt assessment framework. The model was developed in the course of Phase

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

I „m:ci“ and is based on the deep-dive analyses of Freiburg, Berlin, Copenhagen, Singapore, New York City and Tokyo.

In order to achieve an in-depth understanding of the sustainability performance of cities both qualitatively and quantitatively, the Morgenstadt Model is structured into three levels of analysis:

1. Key performance indicators (quantitative analysis);
2. Action fields (qualitative analysis);
3. Impact factors (qualitative analysis).

The third level of analysis utilizes impact factors to identify the city-specific drivers and barriers which are determined by unique historic, cultural, economic, climatic, and morphological characteristics. Impact factors thus extend the general model and adjust it to the needs of each city, providing for an objective performance profile while laying out the basis for an individual sustainability profile.

To create the current report, the relevant indicators and action fields from the Morgenstadt Model, developed in 2012 by the Morgenstadt Initiative led by Fraunhofer IAO together with the University of Stuttgart, were applied. The analysis of this information shows a status quo inventory of Espoo and addresses the following question: “What is the sustainability performance of the city?” Additionally, it assesses what kind of data is being measured and available at the city level to provide a well-rounded understanding of the city’s sustainability within the energy sector, transport sector and other related sectors.

This **understanding phase** consisted of the analysis of strategic documents relevant to the energy sector and the initial data collection. It also included the initiation of data collection through online research and desktop analysis. Existing strategic papers and plans of the city were gathered and studied by the Fraunhofer assessment team. In parallel, data collection of the indicators and action fields described in more detail below took place. Gaps in the information and data collected were identified, discussed and cleared with the local team via conference calls and digital written communication.

2.1 The Morgenstadt Framework in the SPARCS project

Since the SPARCS project is focused on energy and related mobility impacts, a carefully considered selection of indicators and action fields from the original framework related to these sectors was carried out. SPARCS partners leading activities related to the replication strategy such as SPI, VERD and CiviESCo gave feedback on the updated/shortened model. A second round of filtering further refined the framework before it was then sent to the city for the respective data collection. Alongside this effort, benchmarks were updated, and a scoring system was developed to evaluate the city for international comparison. As mentioned above, this framework is divided into two levels quantitative of analysis:

Assessment of indicators: measures the current status quo of urban systems and shows the sustainable performance of the city with a focus on the energy sector. Indicators were tailored to cover energy and related sectors, such as economy and governance, emissions and waste, budget and finance, ICT and mobility. Out of the initial list of more than 100 Morgenstadt indicators, 62 were selected for this purpose. The respective benchmarks were updated to be more comparable with other cities within the project. These included data from the Morgenstadt Framework, International Organization for Standardization

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

(ISO) standards, „Indicators of the Emerging and Sustainable Cities Initiative" (ESCI) of the Inter-American Development Bank and World Bank and Organization for Economic Co-operation and Development (OECD) independent studies.

Assessment of action fields: analysis indicates how the city addresses sustainability and which activities it is focused on. It gives an overview of relevant fields of actions and related sub-aspects. In total, 35 action fields consisting of 118 „yes/no"-type questions to understand municipal challenges, select priority areas and identify key activities were defined. The adaptation of the existing framework tailored the action fields and questions to the SPARCS objectives. After that, each question was linked to an evaluation factor, which has been designed such that each action field can receive up to a maximum of 10 points if completely developed or implemented. The grading system has been developed to emphasize important fields such as the use of renewable energy and heat sources, intelligent traffic management, promotion of multimodal transport and building stock refurbishment.

ICT: These action fields address ICT specifically in the areas of data and governance, with applications in traffic management and participatory government. Intelligent traffic management allows for the public transit system as well as individualized transit solutions to respond to evolving conditions and for the city to use historical data to study the cost effectiveness of investments in infrastructure or new mobility solutions.

Governance: These action fields include the topics of municipal strategy and planning, organization and structure, and regulations and incentives. They can be loosely divided into concrete measures and structural action fields, with the first sections providing insight into the city's long-term vision and goals and the political stability necessary to implement them. Management structure and networks for sustainability-related policy management, innovation and reporting are assessed as the necessary predecessors for effective policy. Then, a few more specific action fields survey the existence of municipal level policies in place for transportation, air quality, and buildings. These areas provide a concrete starting point for the city in case of a lack of such measures.

Transport and Mobility: These action fields survey infrastructure for soft mobility such as pedestrian and cycling modes and corresponding uptake. Then, studying the linkages between soft mobility and the pricing and infrastructure for public transit, the questions assess the intermodality and vehicle-sharing availability. E-mobility prioritization and visibility through policies and charging infrastructure is addressed as well as traditional automotive decreasing measures through policies related to emissions, parking, tolls and charging (for example in congested zones). Finally, questions relating to urban freight assess a key component of traffic, the optimization of which represents a significant environmental impact factor.

Energy: These action fields assess municipal energy generation and distribution with respect to renewables share, networks for intersectoral resource sharing and the existence of district heating as well as its sources. As citizens are a crucial part of the energy transition, questions also focus on educational outreach to promote efficient consumption, the use of smart grids and meters (among other novel technologies) and distributed energy generation.

Building transformation: these action fields seek to understand the development of the various fields for building performance in the municipality, beginning with refurbishment of pre-existing stock. Questions regarding regulations for construction, demolition and

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

materials recycling technologies as well as the recognition of national and international certifications and standards aim to assess impact potential for pre-existing transformative processes. Finally, the level of use of new technologies related to energy and building performance represents the cutting edge of building transformation and indicates a city's ongoing investment into this area.

City Characterization Report: The sum of all assessment levels allows the research team to obtain an understanding of the current performance of the city in energy (and closely linked key areas), assisting in the development of coherent strategies. The process simultaneously respects the unique/impact factors of the city that are conditioned by external pressures, socio-cultural dynamics, geography and historical pre-determinations, among other factors. Moreover, a standardized data assessment throughout the whole evaluation process helps to identify critical challenges and opportunities. The assessment process is outlined in the following graph:

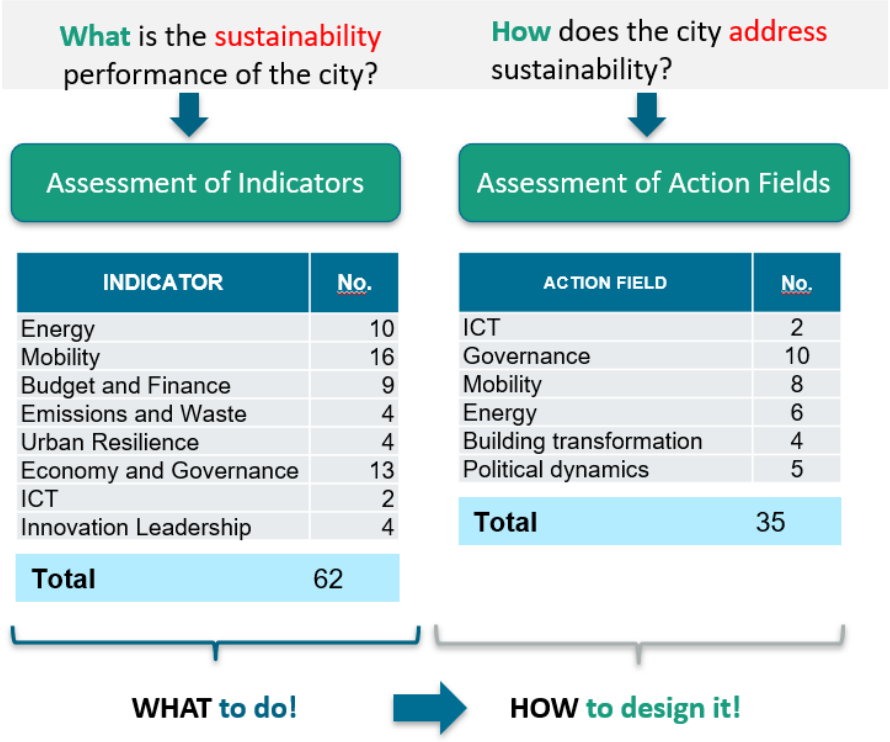

Figure 3: City Lab assessment framework for Espoo

3. CITY PROFILE ESPOO

3.1 Finland

Finland has a total population of 5,524,387 (Official Statistics of Finland (OSF), 2019) with the vast majority living in southern, urban areas. Demographically, Finland is fairly homogeneous, with approximately 7.3% of the population having an immigrant background (Eurydice, 2019). Its official languages are Finnish and Swedish. Notably, Finland ranks "happiest country in the world" according to the World Happiness Report

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

(Helliwell, Huang, & Wang, 2019). Per capita GDP is 37,559 EUR (This is Finland). In addition to being a wealthy country, Finland has a very established social welfare system decentralized to municipalities. This increases flexibility among municipalities to tailor solutions to the local needs.(Ministry of Social Affairs and Health, 2006).

In terms of demographics, Finland's rapidly aging population is one of its greatest challenges. It is third in the world among rich industrialized countries for largest increases in age of the population and is aging faster than any other country in Europe. It has calculated its sustainability gap, or the difference between government spending and income as a result of the aging population, as 4% of GDP currently (Milne, 2019). This resulted in a reform of the pension system in 2001, but health and social care is the responsibility of municipalities and thus more difficult to tackle comprehensively.

Finland's energy production comes from35% fossil fuels, 17% nuclear, and 5% peat/coal while renewable options contribute the bigger amounts of energy at 37% (Statistics Finlad, 2018).

As Finland's largest company and a considerable contributor to its growth in the electronics sector, Nokia remains an economic mainstay even after the company's big collapse and being acquired by Microsoft in 2013. ABB and HMD Global represent another important firms in electrical engineering too (Business Finland, 2018).

Products from the forest industry are another crucial export. The advanced technology employed in wood production can be seen in the efficient use of materials and power—a pulp mill generates more electricity than it consumes (although this is not the case with paper). The three main international forest corporations are Stora Enso, UPM and Metsä Group. The chemical industry is another important part of Finland's economy, adding 10.9% of total value (Vesikansa, 2008). This includes oil drilling, metallurgy and the processing of other chemicals. Furthermore, the history Finland has in paying war reparations to the Soviet Union until the mid-1940s contributed to the growth of shipyards, which are now frequented by luxury cruise liners (Vesikansa, 2008). Today, there is an ever-increasing importance of the services sector alongside technology and wood production.

In Finland as a whole, individual efforts in sustainability are emphasized in "**The Finland we want by 2050,**" a comprehensive emissions reduction project for the country. As the average CO2 footprint of a Finnish resident is 10300 kg/year, the goal by 2030 is for this number to be reduced to 3000 kg/year, requiring efforts across all sectors and levels. The website mentions facilitating cooperation between administration, organizations, companies, researchers and citizens, but the centerpiece of the page is a list of individual commitments to living more sustainably. The interface allows individuals and organizations to gain ideas and join commitments with tailored suggestions from a lifestyle test. Understanding the impact of these personal efforts can prompt the consumer to make conscious decisions, while overall impact and progress is monitored by the Finnish National Commission on Sustainable Development (Commission for Sustainable Development).

Another important national sustainability strategy, **6Aika** is focused on sustainable development among the 6 largest Finnish cities. It has the goal of facilitating smarter, more open cities, new business and serving to showcase Finnish urban development. With a budget of EUR 100 million, it is a project-focused effort, the basis of which is open data

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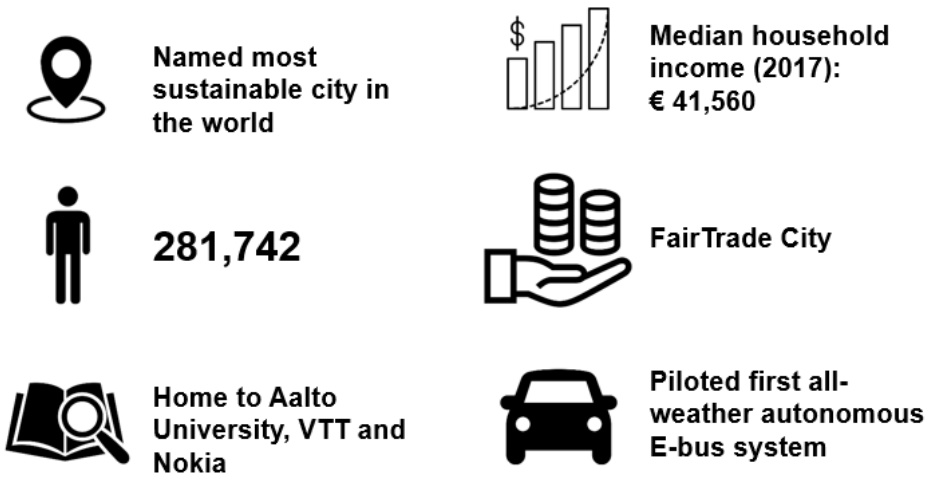
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

and interfaces, open innovation platforms and open participation and customership. As the second-largest Finnish city, Espoo is an active participant (City of Espoo).

3.2 Espoo — the most sustainable city in Europe



Espoo is the second largest and fastest-growing city in Finland, it is part of the capital region, and located within close proximity to Helsinki. Espoo itself is made up of five city and local centers (City of Espoo, 2017b) with a total population of 281,742 (City of Espoo). It expects to reach 300,000 inhabitants by 2022, and 400,000 residents with 180,000 jobs by 2050 (SPARS Proposal, 2019).

City	Espoo
Population	288.960
Area	528 km^2 (312 km^2 land)
Density	926.2/km^2
Income subject to state taxation median	30,231 EUR/year
Main economic pillars	Trade, accommodation and food service activities, information and communication, expert services, manufacturing (Espoo, 2019)
Main emissions sources	Land use, construction, transport and electricity consumption (City of Espoo)

Espoo has been named the most sustainable city in Europe in a benchmarking study using the Sustainable Development Goals (SDGs) and based on the idea of continuous improvement in the areas of ecological, socio-cultural and economic capitals of the city

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

(Zoeteman, Paenen, Mulder, Wentink, 2017). Perceived and actual safety, trust and access to basic welfare provided by the municipality was another crucial factor in gaining its status as most sustainable. Finally, access to nature is what rounds out the city's standing as such a sustainable city. The nearby Nuuksio Wilderness, Central Park and location by the sea, among other opportunities provide a number of avenues for inhabitants' connection to the outdoors (City of Espoo, 2016a). The figure below shows this relative performance in more detail.

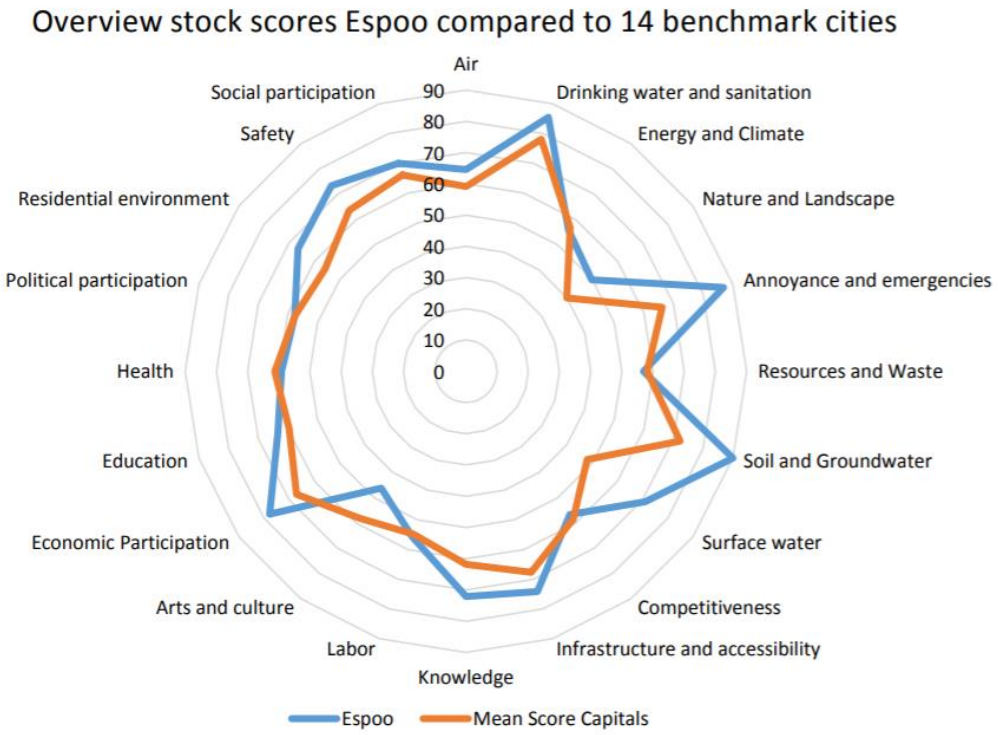

Figure 1: Espoo's benchmark performance in being named the most sustainable city in Europe (Zoeteman, Paenen, Mulder, Wentink, 2017)

Espoo furthermore fully intends to reach carbon neutrality by 2030 and reduce overall emissions 60% by the same time, in comparison to 1990. In 2018, Espoo joined the Covenant of Mayors for Climate and Energy 2030, though its goals surpass even those of the over 1000-city movement. In addition, Espoo is a part of UN's SDG City Leadership programme, acting as an official pioneer for goals 4 (quality education), 9 (industry, innovation and infrastructure) and 13 (climate action). The city will reach all targets by 2025 in order to demonstrate the ability for other cities to follow suit (City of Espoo).

The Espoo Story and the Covenant of Mayors (CoM) are the two main motivating factors for Espoo's commitment to carbon neutrality, and the coordination of expertise and sustainability in Espoo is a crucial component of its success today. Espoo is home to Aalto University as well as VTT, a research institution, as well as many other innovative companies such as Nokia and Rovio Entertainment. Industry has been the reason for continued responsible innovation, as can be seen in Espoo's award of Fairtrade City status in 2009 (City of Espoo).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Figure 2: The preservation of and connection to nature is an important part of what motivates Espoo's sustainability commitments (City of Espoo)

4. SMART CITY INITIATIVES

Throughout literature covering Espoo's efforts as a smart city, co-creation and collaboration (both within and outside of city administration) stand as common themes. The city produced a "Make With Espoo" (United Nations) set of tools from the national **6Aika** projects. Another 6 Aika pilot, the development programme **A Participatory Espoo** established knowledge sharing platforms and contacts throughout Finland related to best practices of SCC1 projects. As part of this, Espoo openly distributes a 3D city model under a creative commons license with the goal of encouraging citizens to participate in the urban planning process (Julin et al., 2018).

Another example of a successful pilot project, Haukilahti Upper Secondary School began utilizing Aalto University Campus facilities in 2015 to replace their own undergoing renovation (City of Espoo, 2017a). The **School as a Service** (Saas) model developed out of this project, which dissociates the idea of the school from the physical building it traditionally takes place in and optimizes asset usage to allow learning to take place in underused spaces. The experiment resulted in improvements in education quality due to student involvement in planning but also due to the interchange of ideas between university professors and teachers as well as students of the school and the university. Saas is just one example of a situation in which a non-traditional environment can be beneficial to all parties while utilizing vacant real estate that would otherwise be harmfully vacant as a drain on resources and producer of carbon emissions. The secondary school estimated operation costs to be 25% lower, which makes the case for taking advantage of upscaling and replication opportunities. These planned projects take place to facilitate both continued exchanges within the broader Espoo school system as well as in other university settings internationally (City of Espoo, 2017a).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

4.1 Strategic Plans

The Espoo Story is Espoo's official city strategy, co-created with Espoo citizens. In effect since 2017 per city council approval, it lasts until 2021 and pays homage to Espoo's over 500-year history, hence its name. The Espoo Story details its values and principles: resident- and customer- oriented, a responsible forerunner, and fair (Kattelus & Kuismin, 2015). With an extensive set of goals, objectives and measures, The Espoo Story resolution sets a concrete plan in place for the lofty ambitions the city intends to pursue.

It concedes its safety, growth and cultural diversity, and addresses challenges in an aging population and projected slow economic growth. Drawing on its strong position as the most sustainable city in Europe, the Espoo Story discusses plans for densification enabled by transit-oriented development and reinforcement of the existing 5 city centres. In addition, there is a strong focus on access to services and the City as a Service model to fulfill citizens' basic needs and increase quality of life through cultural and sporting events. The city plans to attract enterprises and innovation and maintain an open, participatory city administration based on trust and collaboration. As per the document, key objectives during the time period include: increased public participation, building upon the dynamic culture and economy, sustainability, and citizen health (City of Espoo, 2017b).

Espoo plans to be carbon-neutral by 2030 and is working to develop its district heating system, which is responsible for almost half of the city's emissions. Already, the city is scaling up the use of renewables and waste heat (City of Espoo).

In addition, dedication to ethics is underscored in the **City of Espoo Ethical Principles** ("Code of Conduct") document, which focuses on fairness, dedication to the resident and customer and a pioneering spirit through all of the city's undertakings (Kattelus & Kuismin, 2015).

Since the release of Espoo's **Climate Action Programme** (CAP) from the period 2016-2020, the city's carbon neutrality objective has been changed from 2050 to 2030, indicative of the commitment the city has made to innovation and existing as a forerunner in the smart city community. However, Espoo's strategies in reaching these goals have largely remained the same. The **CAP** focuses in public transit, cycling, improving housing to reduce cost and emissions, renewable energy sources, land-use planning and internal city reduction in climate impact (City of Espoo, 2016b).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

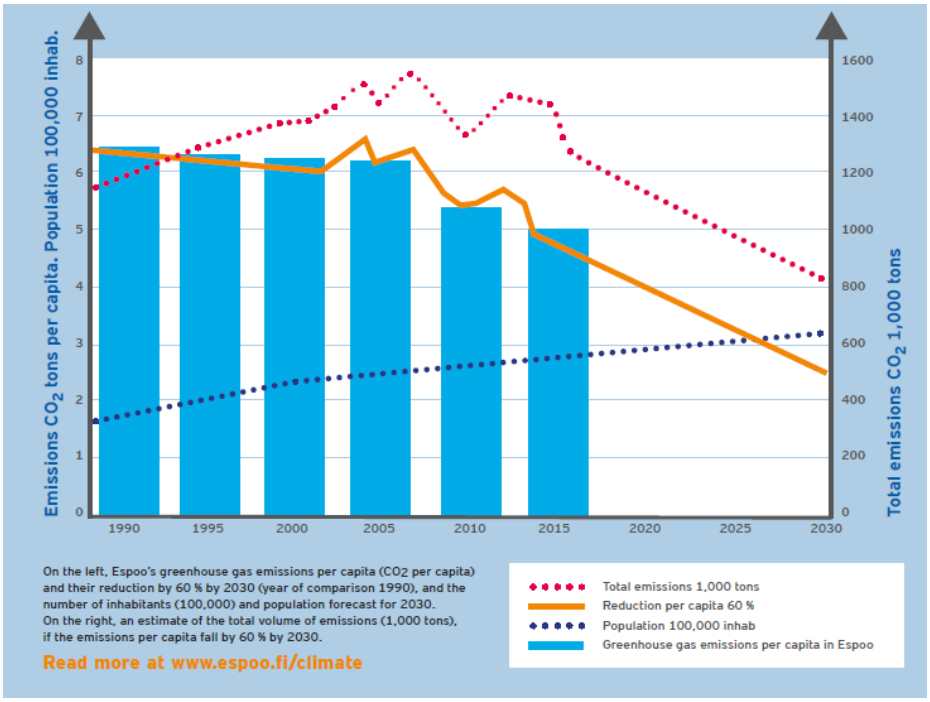

Figure 3: Espoo Historical and Projected Emissions per Capita (City of Espoo)

Within the **Sustainable Espoo Development Programme**, the city identifies five target benefits to achieve its lofty goals. They include an emphasis on innovation in solutions, revamping mobility, modifying energy generation, personal responsibility of residents and increased access to nature for recreation in order to reinforce the importance of the efforts the city is making. As the most up-to-date summary of everything the city is undertaking to achieve carbon neutrality by 2030 and remain the most sustainable European city, it highlights international cooperation as a crucial component of success, in addition to the collaboration of local businesses and residents in achieving this goal (Laitala & Järvinen, 2019).

In Espoo, 2016 emissions were 4.3 t CO2-e per capita, stemming mostly from the heating, electricity and transport sectors. The document addresses the challenges of a growing city (estimated at 5000 new residents per year) in decreasing emissions. Exemplary of this is that while per-capita emissions are declining, overall emissions continue to increase. Furthermore, the city aims to achieve the UN SDGs by 2025, and goes on to identify leadership, stakeholders and financing plans. As a result of the plan, 23 projects and operations were undertaken in 2018, including the introduction of electric buses and a Keran filming project (Laitala & Järvinen, 2019).

According to the **Sustainable Energy and Climate Action Plan** (SECAP), the target of reducing GHG emissions by 28% below 1990 levels was reached in 2016, prompting Espoo to set its 2030 carbon neutrality goal in 2017. More specifically, 2030 is the self-imposed deadline for an 80% absolute emissions reduction from 1990 levels, which amounts to 245 kt CO2-equivalent emissions. The plan identified in the SECAP includes 60 steps towards GHG emissions reduction in focusing on electricity, heating and transportation emissions. This includes the goal of carbon neutral district heating by 2030 with energy company Fortum and within mobility, a shift from personal automobile traffic to rail and bus traffic to further drive down emissions. The city notes that collaboration with Fortum in order to develop carbon neutral district heating as well as a wider array

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of stakeholder support will be necessary to drive the infrastructural and societal shifts necessary to achieve these goals (City of Espoo).

The mitigation measures are divided into the 5 categories: zero emission power and renewable energy, city as an example of clean and sustainable solutions, sustainable parts of the city and energy efficient buildings (focusing essentially on the lighthouse districts), low emission transport and smooth public transport solutions, energy efficient waste management and recycling economy solutions, and sustainable development as part of the action of the city (City of Espoo).

4.2 Indicators and Action Fields Analysis

Economic stability and low poverty rates

By analyzing the economy and governance **indicators** in Espoo, the economic stability is evident in a number of these indicators. A 0% absolute poverty and as low as 9% relative poverty which the city defines as "household with income less than 60% of the median", Espoo scores within the yellow threshold in population living in poverty. In addition, it is noticed that the city has a relatively low unemployment rate of 7.5%, this value is slightly above the green benchmark threshold therefore falling in the average range. Regarding home ownership, Espoo scores low with 59.2%. Here more relevant seems to be the very low percentage of city ownership over the building stock. A 2% of ownership might make it difficult and more expensive for the city when trying to implement big energy efficiency projects of housing and buildings in general. This shows a potential opportunity for the city of Espoo in this regard.

Indicator Description	City Value	Green	Yellow	Red
City population living in poverty (%)	9%	<9	9–15	>15
GDP per cap (€)	50000	>35000	25000 - 35000	<25000
Buildings owned by the city as percentage of total building stock (%)	2	>35	15 - 35	<15
Percentage of homes owned by residents (%)	59.2	>79.3	59.3 - 79.3	<59.3
Unemployment rate (%)	7.5	<7	7–12	>12

Figure 4. Sample economy and governance indicators for Espoo

A defined governance approach towards a sustainable future

Espoo's governance **action fields** show the city's aptitude for the implementation of sustainable policies. The city has a long-term strategy and sustainable vision for its resilience, where goals were developed in cooperation with key stakeholders. Action plans and concrete long-term plans have already been created and put in place to support sustainable management for the implementation of the sustainability goals, this comes

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

along with the development of an indicator system to trace the city's sustainability performance.

The city shows readiness through the analysis of its political dynamics as the city actively seeks expertise from local stakeholders where needed as well as the availability of inter-institutional bodies with the needed knowledge and competence regarding urban sustainability issues. In addition, Espoo has many political parties within its political mandate that explicitly and directly encourage and support digital issues.

5. ENERGY PROFILE ESPOO

Strategic plans provided by the City of Espoo and other strategic partners were studied and form the basis of this city characterization report.

Espoo's **Sustainable Energy Action Plan** (SEAP) addresses general solutions for the sectors composing the majority of greenhouse gas emissions: land use, construction, transport and electricity consumption. The city plans to decrease land use and transportation emissions by increasing the density of the city while improving the transit network to allow for more public transit usage and active mobility. Energy efficiency will be improved in new construction and existing buildings, and educational advisory services for property owners will promote further reductions in energy consumption. Within the business and economy sector, local businesses are encouraged to join energy efficiency agreements. In total, Espoo expects to achieve a 28% reduction of emissions (or 186,000 tons) in 2020 compared to 1990. This translates to a 5.80 t CO2-equivalent per capita emissions rate.

Table 1. 1990 and 2016 emission coefficients used in the SECAP calculations (City of Espoo)

Year	District heating		Fossil fuels			Renewable energies	
	Local		Heating oil	Diesel	Gasoline	Biological fuel	Other biomass
1990	0.418	0.255	0.268	0.271	0.271	-	0.010
2016	0.235	0.233	0.266	0.269	0.265	0.002	0.010

Total energy consumption increased 52% from 1990 to 2016 (from 3,771 GWh to 5,719 GWh with a minor 5% (from 22 MWh to 21 MWh) per-capita decrease. This increase was mainly due to a 102,000-inhabitant growth in population. In contrast, total emissions increased by only about 12%. The majority of emissions are produced in electricity consumption as well as district heating, while historical emissions of heating oil, gasoline, and waste management have declined. Heating oil consumption has declined by 17% and gasoline by 27% in the same time frame. Furthermore, biofuel came into use between 1990 and 2016 and thus does not appear in the first diagram (City of Espoo).

5.1 Strategic Plans and Goals

The action cards outlined in the **SECAP** comprise concrete responses to mitigation measures and goals. They are based on the Espoo story and the Espoo Climate Program as well as the Sustainable Espoo program. Within renewable energy, action cards include: carbon neutral district heating, the implementation of a new energy production plant, a

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

biofuel heating plant, the development of the photovoltaic market with the target of adding solar PV solutions for visibility, the Otaniemi geothermal plant pilot project and utilization of waste heat. SPARCS is a part of an action card which implements innovative energy solutions (City of Espoo).

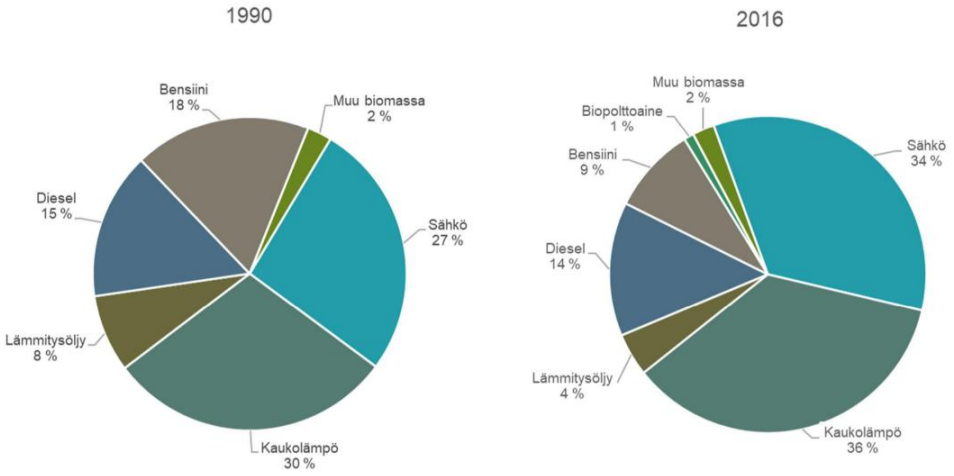

Figure 2. electricity, heat and fuels in different proportions of the total energy consumption in Espoo 1990 and 2016. In the year 2016 the energy consumption for heating is corrected by 1990.

Figure 5: Electricity, heating and fuels as part of the whole energy consumption in Espoo (1990 and 2016) (City of Espoo)

The Espoo Clean Heat project plans to make district heating carbon neutral, and Fortum (energy generation company) will discontinue coal use by 2025 (City of Espoo, 2019b). Data centre waste heat, wastewater treatment, geothermal and bioenergy are all currently options being explored. In the next few years, Espoo and Fortum will commence use of a new bioheating plant, geothermal plant, and a heat pump making use of heat from wastewater treatment. Espoo will achieve a 50% carbon neutral district heating system by 2022, which will rise to 85% in 2025 with the end of coal use (City of Espoo, 2019b). Data centres, geothermal heat, and increased building efficiency are cited as further avenues for development.

An **Energy Efficiency Agreement for Municipalities** (KETS) went into effect in 2017 and lasts until 2025. The associated action plan for the City of Espoo (since KETS was a national agreement) sets the goal of 7.5% energy savings by 2025 without necessarily dictating the energy generation transition, as efficiency was designated as an important part of the general CO2 reduction plan. Additionally, it names a 10,459 MWh reduction goal by end of 2020 and 19,611 MWh reduction overall goal by end of 2025. For reference, previous KETS estimated that saving one MWh is equivalent to saving 300-350 EUR, adding to the necessity of the measures in areas ranging: residential buildings, lighting, water and waste management, streets and other public amenities, and traffic and transport. Within these areas, the document focuses on reduction of current energy or prevention of future consumption, identifying that the sustainable energy transition will not be enough without these measures along with consumer education (Espoo).

KETS introduces a spreadsheet tool for measures and savings/investment information, in which the investment estimate for this plan is 5 million EUR. Further measures listed in the document include: guidelines in construction, land-use planning/zoning, energy

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

consumption through consumer advice, looking at other sectors, lighting (LED replacements), city vehicles and maintenance, new business models, efficiency of municipal property buildings (design guidelines regarding windows and ceiling height), use of recycled materials and recycling materials/demolished structures in new construction, cooperation with media for consumer education and training for municipal employees. KETS also names a task force on sustainable development and communication plan including Energy Saving Week (Espoo).

Noting ongoing measures in the renewable energy transition away from oil, the city mentions an agreement with Fortum in Spring 2017 to transition district heating to more renewable energy sources. Elasticity of demand programs are also slated to be piloted.

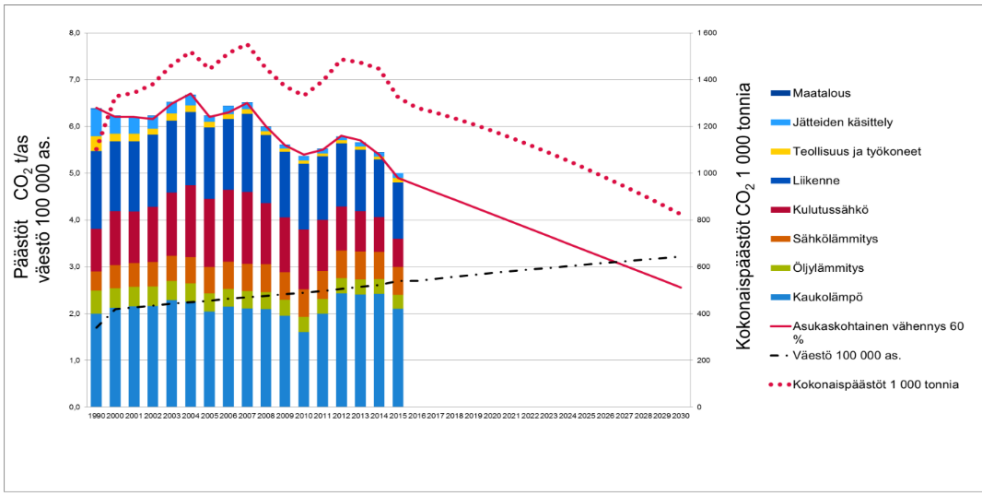

Figure 6: Espoo's GHG emissions reduction plan, with the goal of 60% by 2030 (City of Espoo, 2016b)

In planning for the future, the SECAP notes that extreme heat affects the most vulnerable parts of the population (the elderly, sick and children), and since many slightly older buildings were constructed without cooling systems, this is an important concern. Passive cooling systems in window design and materials selection as well as green roofs could serve as adaptation strategies, as well as prove beneficial in increasing energy efficiency *or decreasing overall energy usage (City of Espoo).*

5.2 Indicators and Action Fields Analysis

Need for reducing high energy demand

The analysis of the **indicators** shows a high energy demand at city level and the need for improvement in this area. This goes along with the low rate of refurbishment lower than 2%, this can be associated with the above-mentioned indicator referring to very low rate of city ownership of the building stock (2%). However, Espoo's energy related indicators reveal a high performance in renewable energies share of production. With a 43% share of end energy demand that is covered by renewable energies, Espoo scores well above the European average of the share of renewable energy in total energy generation. In addition, a high score of utilization of local district heating characterized by a 76% share of heat demand delivered by district heating. This is well supported through reviewing the **action fields** where it shows that Espoo has made the switch to 100% use of

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

renewable energies in public building and infrastructures as well as optimizing their energy use.

While district heating and cooling is already in place in the city, benefiting over 25% of all buildings, the action fields review for Espoo shows that these are not entirely run by renewable or waste energy. In this case, there is an opportunity here for action by city to use its progressive renewable energy share of supply to enhance their utilization in different fields as well as work on promoting them such as supporting the installation of solar panels or biomass plants.

Indicator Description	City Value	Green	Yellow	Red
Annual rate of refurbishment as a percentage of existing building stock (%)	1.7	>5	5 - 2	<2
Total energy use of the city per cap (MWh/a/cap)	21	<15	15 - 20	>20
Total electrical energy use per cap (kWh/a/cap)	7500	<3000	3000 - 7000	>7000
Electricity consumption per household (kWh/household/year)	13000	1,500–3,500	900–1,500; 3,500–5,000	<900 or >5,000
Share of electricity produced within the city in the grid (%)	88%	>10	10 - 5	<5

Figure 7. Sample energy indicators for Espoo

6. MOBILITY PROFILE ESPOO

Espoo's weather and land planning pose a unique set of challenges to overcome, but overarching mobility goals of the city include a reduction of private transport emissions and increasing emission-free traffic. Strategies include increasing the shares of electric cars and buses, streamlining and increasing use of public transit, developing the Mobility as a Service concept, providing the infrastructure for the transition to sustainable traffic (City of Espoo).

In terms of further infrastructure development, the city will ensure the widespread availability of biogas and biodiesel, electric vehicle charging, and developing the private stakeholder connections to continue such projects to establish public-private collaboration. For example, in rolling out electric buses, the City of Espoo aims for all metro feeder services to be emission free by 2025 and all public transit to be emission free by 2030. In addition, the city made the decision to use Neste MY Renewable Diesel on all diesel-powered city vehicles in 2018, which is produced entirely from waste and residues. For the vehicles which run on this fuel, GHG emissions are reduced by up to 90%, equal to about 400 fewer cars on the roads annually (Lipponen, 2018).

The **Climate Action Programme 2016-2020** (CAP) reports that public transit share is growing 1.1% annually (21% as of 2012), while the city plans to focus on metro traffic as point of growth, including park and ride stations for convenience and last-mile issues. This can help as some residents don't have stations as close to their homes as would be convenient (City of Espoo, 2016b).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Cycling is also an important part of the transportation measures listed in the **CAP**. In 2012, cycling had an 8% modal split, which the city plans to increase to 15% by 2024.This will be achieved by putting quality bike routes in place and expanding winter maintenance, especially on more important/high quality and traffic routes. Improved bike parking to avoid vandalism and exposure to weather was another key measure. As of 2015, the city had 1140 bike racks near public transit (City of Espoo, 2016b).

6.1 Strategic Plans and Goals

In the **SECAP**, transport solutions are planned to take place through the five city centres approach to land planning, enabling dense development and essential travel distances to be shortened. This, in addition to rail, biking and walking infrastructure forms the basis for the city's strategy in developing its transportation system sustainably (City of Espoo).

The **CAP** focuses in large part on transportation as an issue crucial to decreasing the city's impact on the climate and reducing emissions. The measures detailed in the report begin by emphasizing public transit, for example the Jokeri rail line and the rollout of low emission buses. 4 electric buses were tested from 2013-2016, and it was planned to replace entire fleet with low emission vehicles by 2025 (City of Espoo, 2016b). Furthermore, dedicated bus lanes and priority at traffic signals will improve quality and service level of public transit (City of Espoo, 2016b).

It is planned to replace the city-owned vehicle fleet with competitive tendering for hybrid, gas or diesel-powered cars (City of Espoo). In addition, the debut of an autonomous electric bus system in Espoo marked the deployment of the first all-weather system, a characteristic important especially in Espoo, where icy winter conditions posed a challenge to the development of an autonomous vehicle. Created by Finnish company Sensible 4 in collaboration with Japanese retailer Muji, Gacha began operating April 2019 in the Otaniemi area. Because of the level of data that must be transferred, the 5G network in the area is a necessary component of success. Upscaling is underway in Finland as well as abroad, and Espoo plans to have a permanent autonomous bus service by 2021 (City of Espoo, 2019a).

Further major infrastructure projects include West Metro expansion, Jokeri and City Rail (City of Espoo). The development of the West Metro corridor will also result in the construction of over 5000 housing units adjacent to it (Jouko Pöyhönen, 2018). This supports Espoo's goal to tackle its urban sprawl challenge with densification along areas served by the mass transit system (United Nations). The 25 km (9 of which will be in Espoo) Jokeri Light Rail line is planned for 2024 to replace an overcrowded bus line. It is expected to serve 91,000 people per weekday in 2030 (Raide-Jokeri). The first of its kind in the capital region, it will operate in its own lane and hopes to steer the growing population towards more sustainable forms of transit.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

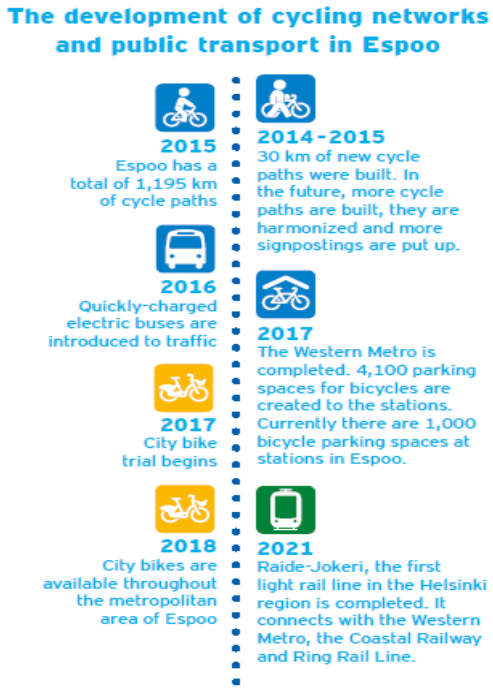

Figure 8: Completed and planned initiatives to increase bicycle transit within the city (City of Espoo)

To increase the modal split of cycling, Espoo plans to improve bicycling conditions, establish commuter cycling and focus on young people to bring up a next generation of bike-centered individuals. Improving the route network to ensure the roads themselves are of high quality and in good repair as well as serving to connect highly frequented zones or public transit nodes are the focus of improving physical conditions. Bike parking is of consideration, too. To strengthen the positive image of cycling and serve as an example to employers, the city of Espoo aims to establish commuter cycling among its own employees (City of Espoo).

Espoo has furthermore developed a Cycling Marketing Strategy developed in combination with HSL and held the international ThinkBike workshop in 2017, with more such events planned for the future. With outreach strategies for both children/youth and commuters, Espoo plans to ensure that school curriculum includes pro-cycling measures and that workplaces have the necessary facilities for washing up and bike storage (City of Espoo, 2016b).

Likewise, favourable walking conditions focused on environmental safety and comfort, for example in broad sidewalks, are important factors for increasing pedestrian shares. Marketing emphasizes the health benefits and importance of walking for the vitality of the city Centre. Finally, walking is also closely tied to public transit proliferation, and the city will ensure that residents are close enough to public transit stops to make walking a feasible and attractive mode of transit.

6.2 Indicators and Action Fields Analysis

Need for promoting the use of public transport and active mobility

The assessment of the mobility **indicators** in Espoo shows an opportunity for improvement in a number of areas due to a modest low performance in this field. One apparent issue is the personal vehicles share of the total traffic volume that is as high as 46% placing it in the "red" range. This issue might be connected to the fact that the daily average distance between an inhabitant's home and their place of work is 22 Kilometers/day, which is also a relatively high daily commute distance. Accordingly, the share of public transport use of the total traffic is as low as 18%, a value well below the average (25-40), in addition to 9% and 29% share of bicycle and pedestrian modes respectively.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Better road management to drive the modal shift

Through the analysis of the **action fields** related to the mobility sector in Espoo, it can be concluded that some of the above-mentioned issues can be avoided by better road management actions such as the implementation of pricing mechanisms to control commuting patterns. Likewise, the need for actively seeking to enhance and develop car-free areas is evident and this can well help in achieving a modal transition. Additionally, and most importantly, the action fields' analysis shows a high potential of intervention through adapting the prices of alternative modes of commuting to be cheaper than commuting by car. As the city's mobility plan includes cycling and pedestrian movement as key elements and has already implemented bike highways, it is of importance to promote and encourage active mobility. Furthermore, implementing car sharing and providing parks for shared vehicles can assist in the promotion of this idea, therefore decreasing the share of personal vehicles on the streets.

Indicator Description	City Value	Green	Yellow	Red
Share of traffic by public transport of total traffic (%)	18%	>40	25 - 40	<25
Share of traffic by bicycle mode of total traffic volume (%)	9%	>25	5 - 25	<5
Share of traffic by pedestrian mode to total traffic (%)	26%	>40	20 - 40	<20
Annual no. of public transport trips (per cap.)	321,2	>400 (ISO 37120)	200 - 400 (ISO 37120)	<200 (ISO 37120)
Personal Vehicles (including private vans, excluding motorcycles and trucks) to total traffic volume (%)	46%	<15	15 - 40	>40

Figure 9. Sample mobility indicators for Espoo.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Action Fields assessment Espoo (September 2020)

Mobility

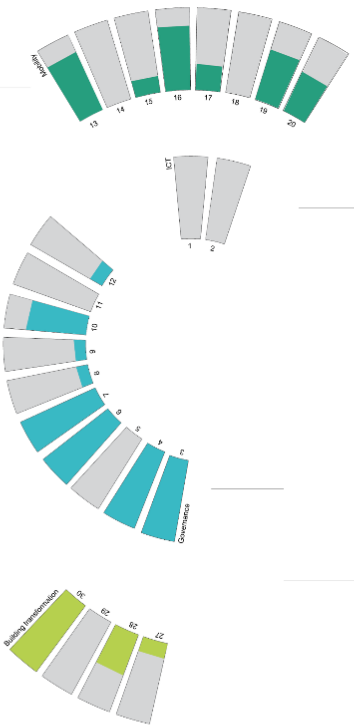
- Better road management needed to drive the modal shift.
- Need to actively develop car free areas.
- High Potential of intervention through adapting the prices of alternative modes of transport.
- City's mobility plan includes cycling and pedestrian movement as key elements.
- Need to design actions for promoting active mobility.

Political dynamics

- Actively seeks expertise from local stakeholders.
  availability of inter-institutional bodies with the needed
- knowledge and competence regarding urban sustainability issues.
- political parties within its political mandate that encourage and support digital issues.

Building transformation

- Measures for efficient construction processes are in-place.
- The need to develop construction management concepts related to old buildings, the use of rain water in the construction, and life cycle analysis processes.
- Need to encourage and incentivise buildings refurbishments.
- More than 10% of the office buildings are certified by one of the green building certification systems (LEED, DGNB,...).
- Need to enhance the city's regulations in buildings energy performance through employing visualization tools for buildings energy performance.



ICT

- E-tools for the participatory governance of energy services are missing
- Real-time information is not used for the development of intelligent traffic management system.

Energy

- Switch to 100% use of renewable energies in public building and infrastructures.
- Energy efficiency has been improved in public buildings and infrastructures.
- Opportunity of action to use the city´s progressive renewable energy share of supply to enhance their utilization in different fields.
- Need for more promotion for the use of renewable energies among citizens.

Governance

- City´s aptitude for the implementation of sustainable policies.
- Existence of long-term strategy and sustainable vision for resilience.
- Integration of citizens in political processes.
- Indicator system to trace the city´s sustainability performance.

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7. CITY PROFILE LEIPZIG

7.1 Germany

Figure 10: Map of Germany pointing out Leipzig (Travel Finders, 2016)

On an area of 357,340 square km, Germany has a population of 82.8 million (FAZIT Communication GmbH). Foreign citizens comprise 12.1% of the population and 13.3% of the Germans have a migrant background (Statistisches Bundesamt, 2019b). The unemployment rate in Germany is at 5.0% (2019) (statista, 2020a) and the employment rate is at 75.9% (2018) (Statistisches Bundesamt, 2019a). Full time employees have on average gross monthly earnings of 3.880€. While men working full time have an average income of 4.075€, women earn 3.432€ for a full time position (statista, 2019).

Germany had a GDP of 3,386 billion EUR in 2018. Services and industry form 68% and 26% of the GDP, respectively, while construction and agriculture comprise the remaining 6%. Germany is the largest economy in Europe, contributing to 21% of the European GDP, and is among countries with the highest foreign direct investment (FDI) in the world. The World Trade Organization (WTO) ranks Germany among the three largest export nations worldwide, behind China and the USA. Motor vehicles and components, machinery, chemical products, data processing equipment and electronics compose the largest sector of exports. In addition, Germany's foreign trade ratio (the sum of imports and exports in relation to the GDP) was 86.9% in 2017, characterizing it as the most open economy of the G7 countries (FAZIT Communication GmbH).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Germany's small and medium-sized enterprises (SMEs), drive exports and constitute about 99.5% of all companies (GTAI 2019). SMEs are characterised by having fewer than 250 employees and an annual turnover of less than 50 million Euros. German SMEs position themselves as world leaders through their rapid product development and their international orientation (FAZIT Communication GmbH). In addition, the theme of corporate social responsibility is strong in the German economic culture, ranking it as the sixth most sustainable industrial nation in the world.

The German government has first adopted a Sustainability Development Strategy in 2002, which introduces a model of sustainable development that focuses on intergenerational equity, quality of life, social cohesion and international responsibility. In addition key focus points and indicators to ensure the furthering of those fundamental concepts are set (The Federal Government, 2016). In 2016 the Strategy for Sustainable Development has been reworked as a response to align with the 17 sustainable development goals (SDG) which were published by the United Nation within the 2030 Agenda (The Federal Government). The overall goal of the strategy is to act as a directory for economic, environmental and social development (The Federal Government).

Germany published their energy efficiency strategy for 2050 (Energieeffizienzstrategie 2050) in 2019. The strategy is designed to make the German economy world´s most energy efficient economy. Therefore, the goal is to reduce the primary energy use by 50% compared to 2008. The strategy is also tailored to contribute to the overall EU energy efficiency goal for 2030, reducing primary and secondary energy consumption by 32.5% until 2030. Thus, the 2050 strategy bundles all necessary measures of the federal government in a national action plan for energy efficiency (NAPE2.0), sets a new energy efficiency target for 2030 and creates a roadmap from 2030-2050 with proposed trajectories to reach the 2050 goal (BMWI, 2019). Germany pledges to have renewables composing 60% of energy consumed by 2050. In 2019 40% of the energy is produced from renewable sources like wind power, biogas, photovoltaics. Around 60% of the energy is supplied by conventional sources, of which 30% is attributed to lignite/coal, 14% to natural gas and 14% stems from nuclear energy production (Statistisches Bundesamt, 2020).

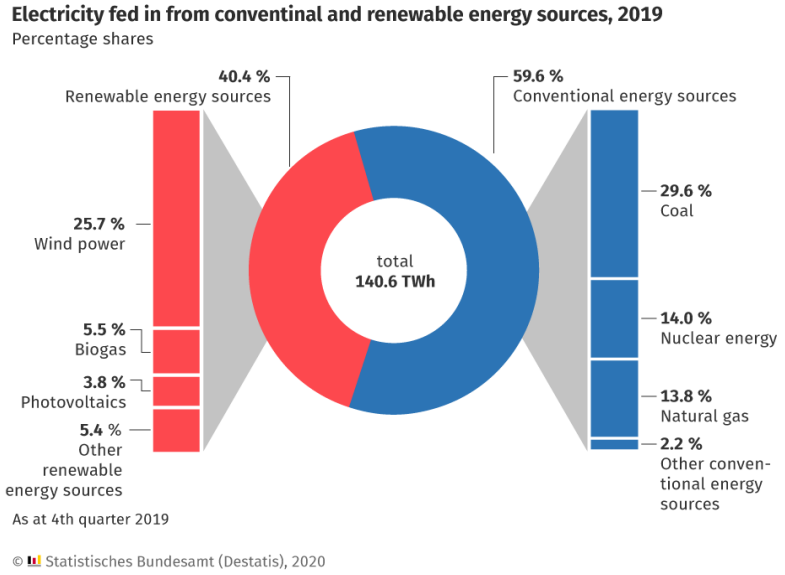

Figure 11: Electricity production in Germany in 2019 (Statistisches Bundesamt, 2020)

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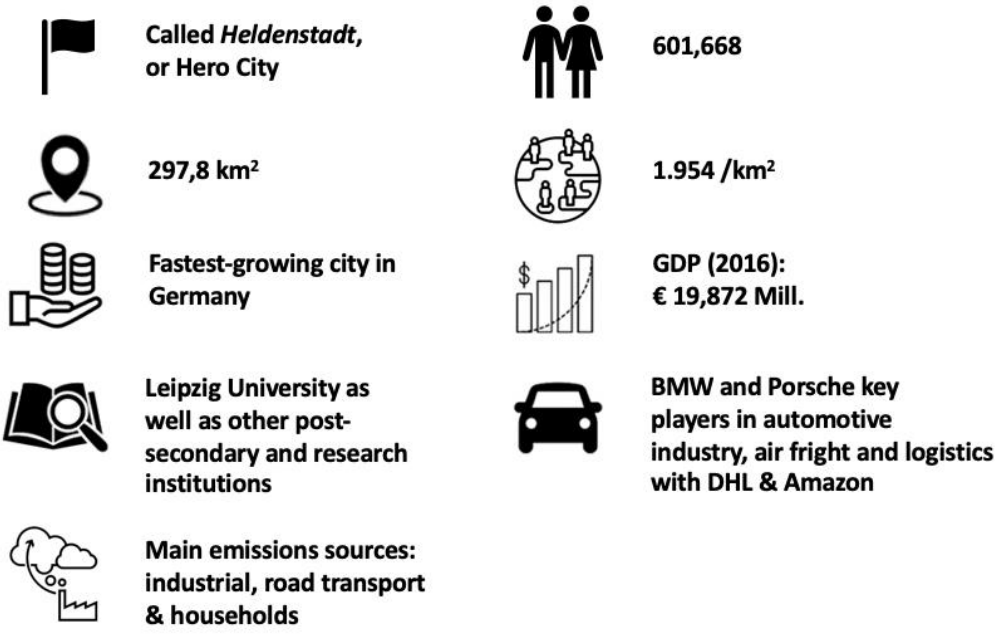
7.2 Leipzig — Hero City



Leipzig is part of the German state of Saxony and has an area of 297.8 square km with a total of 601,668 inhabitants (9% of which are foreigners) and a population density of 1,954 inhabitants per square km (Amt für Statistik und Wahlen, 2019). This makes Leipzig the 8th biggest city in terms of inhabitants in Germany (statista, 2020b). Leipzig was named European City of the Year at the 2019 Urbanism Awards, proving it an excellent example in combining industry, sustainability, and liveability (The Academy of Urbanism, 2018).

City	Leipzig
Population	601.668
Area	297,8 km²
Density	1.954/km²
Income subject to state taxation median	19,872 EUR/year
Main economic pillars	Automotive industry (BMW & Porsche), air freight and logistics (DHL, Amazon)
Main emissions sources	Industrial emissions, household emissions & Road Transport

Rich in culture and history, Leipzig has been home to many famous musicians (for example, Johann Sebastian Bach and Richard Wagner) and has a wealth of culture and art besides (Stadt Leipzig). Leipzig is attracting over 1.2 million visitors to various trade fairs,

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

congresses and events hosted at the venue 'Leipziger Messe'. The most famous trade fairs hosted in Leipzig are the 'Leipziger Buchmesse' (book fair) which attracts over 190.000 visitors and 2600 exhibitors and the 'Haus-Garten-Freizeit Messe' (house, garden and leisure trade faire) which attracts over 170.000 visitors and 1000 exhibitor (Stadt Leipzig, 2019b). Alongside universities and post-secondary institutions, the vibrant economy indicates a city that is rapidly combining 21st-century competitiveness with a unique flair, attractive to tourists.

To understand the importance of the boom that is currently taking place in Leipzig, one must go back to the 1989, when Leipzig was the second-largest city in the GDR, the former Eastern part of Germany. The Monday demonstrations, which began that year, prompted a peaceful revolution that led to the end of the GDR and reunification. The reunification of Germany brought about a rapid drop in the population of Leipzig. However, the city recovered economically and growth was visible even a decade later, with the highest number of overnight stays from tourists and expansion of industry and companies (Eberhorn, 2019).

Relative to rural East Germany today, Leipzig is an outlier in growth and attractiveness to younger generations (especially students). The population is expected to grow 16% by 2035, making Leipzig one of the fastest-growing city in Germany (Dunte, 2019). Furthermore, an average economic growth of 2.3% between 2013 and 2017 indicates rapid declines in unemployment. In 2017, there were 69 companies with 50 or more employees, employing 20,396 people (Stadt Leipzig). However, there was a total of almost 43,800 overall, the largest portion operating in professional, scientific, or technical areas, closely followed by the sale and repair of motor vehicles and motorcycles (Stadt Leipzig). BMW and Porsche are key players in the automotive cluster. Both have their main development centres for electric cars in Leipzig. With 10MW of wind energy generated locally, BMW and Porsche produced the first large series of e-cars with zero emissions in Leipzig (SPARCs, 2019). Other key players of the economy include tourism and the university system. Leipzig's airport enables DHL's air freight location expansion (Stadt Leipzig).

By participating in the 'European Energy Award' (EEA), since 2011 Leipzig emphasises the importance of climate protection (Stadt Leipzig, 2014; Stadt Leipzig, 2020c). It received its first certification in 2011 and Gold Certification in 2017 (Stadt Leipzig). The City of Leipzig sets concrete goals to use energy efficiently, to enhance the use of renewable energies and to conserve energy, which are controlled through yearly audits (Stadt Leipzig, 2014; Stadt Leipzig, 2020c). The greenhouse gas emissions have sunk from 6.42t in 2011 to 5.96t CO2-equivilent per capita in 2016. 46,8% of the CO2 emissions are attributed to the economic sector including public facilities, 30.4% are omitted by households and 22.8% can be traced back to transportation (Stadt Leipzig). For 2020 the City of Leipzig set the goal to reduce emissions to 4.47t CO2 per capita per year, which will not be reached if the current trend is continued.

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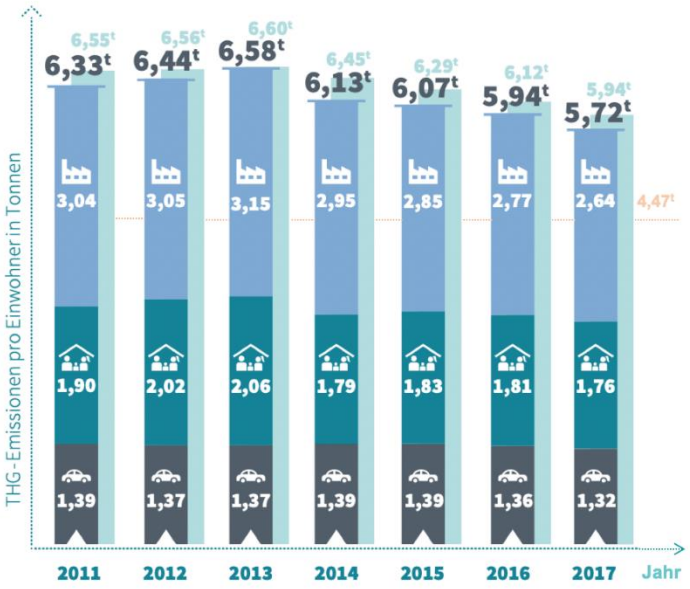

Figure 12: GHG emissions per person in tons by sectors (from top to bottom): 1. industry, 2. households, 3. Transportation, the doted red line marks the emission-goal for 2020 (Stadt Leipzig)

End of October 2019 the City of Leipzig officially declared a climate crisis and thus commits itself to combat global warming and actively promote effective measures to reduce GHG emission. All municipal decisions must therefore give priority to climate protection and the protection of the population from the consequences of climate change. The City of Leipzig is pursuing the ambitious goal of achieving climate neutrality by 2050 at the latest thus fulfilling its original responsibility for the livelihoods of present and future generations. As a long-term goal for 2050 the City of Leipzig wants to lower the CO2 emissions by 10 % per year to a sustainable level of 2,5t CO2 per capita (Leipziger Internet Zeitung, 2019). A step-by-step implementation plan with short-term, medium-term and long-term measures is to be drawn up for this purpose by the new city administration unit of sustainability and climate protection. Among other things, a concept for climate-neutral administration in 2035 is to be submitted to the city council by the 4th quarter of 2020 and a concept for climate-neutral electricity and heat supply for the City of Leipzig in 2040 is to be submitted to the city council by the 4th quarter of 2022. Leipzig will be climate-neutral by the year 2050 with the development of an immediate action program to achieve the municipal climate protection goals. At present, GHG emissions are falling far too slowly and the reduction targets for 2020 are not being met. The problem is according to the Paris Climate Convention, the available residual amount of CO^2 emissions will already be used up by 2026 if "business as usual" continues. The immediate action program defines the most important municipal measures for the coming years. The main areas of action are related to sustainable urban development, efficient municipal buildings, clean energy supply, sustainable mobility, communication, and nutrition (Stadt Leipzig). For the design and communication of future goals and measures in the energy and climate protection process, the existing advisory board of the Sustainable Leipzig Forum (Nachhaltiges Leipzig) will be involved in an advisory capacity and expanded to include representatives of parliamentary groups, members of the youth parliament and external experts from environmental associations. Additionally, the City

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

of Leipzig is introducing a climate protection monitoring system to measure the progress or regression of private and public climate protection measures (Stadt Leipzig, 2019a).

8. SMART CITY INITIATIVES

In 2015, the EU project **Triangulum** initiated a set of smart city innovations in energy, mobility and IT infrastructure. Leipzig was one of the three follower cities and in the course of the project developed a "Smart Cities Implementation Plan" for the city district "Leipziger Westen" after an extensive participation process with key stakeholders of the municipality, public utilities, research institutes, local businesses and the citizen of Leipzig (Fraunhofer & Triangulum, 2016; Triangulum, 2017a). The goal of the project was to replicate smart city solutions implemented in lighthouse cities in fellow cities (Triangulum, 2017b).

Through the project, it became clear that Leipzig was facing digitization issues. Therefore, the "Digital City Unit" was founded in 2019 under the department of "Economy, Labour and Digital Affairs" and is dealing with the development and implementation of innovation projects and acting as a competence centre for digitization. They work together with other utilities within the municipality, research and science institutions, different universities, private enterprises, and citizens, and implement several projects towards digitization, for example in the areas of mobility or energy. One central project is the establishment of an urban data platform in participation of the public utilities (so-called Leipziger Gruppe) that includes e.g. the Leipziger Stadtwerke (energy and heating), Leipziger Verkehrsbetriebe (public transport) and Leipziger Wasserwerke (water works). The basis for the mentioned project and the establishment of further Smart City solutions is the expansion of public WLAN and the 5G network (Stadt Leipzig, 2019a). Furthermore, all topics related to e-Government are covered by the Department of General Services. The introduction of e-Government eases administrative processes for example in tax reporting or other personal legal documentation. An important next step will be the merging of various portals expected to be complete in 2022 (atene KOM GmbH, 2019; Stadt Leipzig, 2020a).

The City of Leipzig created **opendata.leipzig.de** an open data platform to enable experts and developers to develop publicly available applications (Stadt Leipzig). The data provided is free, in open data formats and in machine-readable formats. Excluded are any form of data revealing personal information, security relevant data and data subjected to data protection. In total Leipzig's data platform is providing 710 data records in seven groups: 'building and living', 'population and society', 'citizen service and administration, leisure', 'culture and tourism', 'youth, family and social issues', 'environment and transport' and 'economy and science' (Stadt Leipzig). By providing raw data, various evaluations can be carried out, which may lead to new results and findings (Stadt Leipzig). Several projects were started using the data provided. For example, a project investigating gentrification in Leipzig was conducted in 2014. In the course of the project a geographic information system was developed as a tool used in planning and for political decision making (Leipzig Data).

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

8.1 Strategic Plans

Units, offices and departments of the City of Leipzig collaboratively created **INSEK Leipzig 2030**, which is an integrated urban development strategy aiming to bring together all topics important for Leipzig's urban development (Stadt Leipzig, 2018d). Its guiding principal is "Leipzig is growing sustainably!" The strategic vision is based on ensuring economic strength, handling financial resources responsibly, ensuring the use of democratic principles, the creation of social cohesion and using natural resources responsible to preserve and improve environmental conditions. The City of Leipzig predicts 10 challenges to arise, which are induced through the strong growth in population: Affordable housing, cultural identity, education infrastructure, green spaces in the city and quality of the built environment, high quality growth, modern and local administration, precautionary land and property management, social justice, sustainable mobility and urban safety. The City of Leipzig created INSEK to deal with these challenges in a strategic manner and divided its strategic goals and action fields in four categories (Figure 13) (Stadt Leipzig, 2018b).

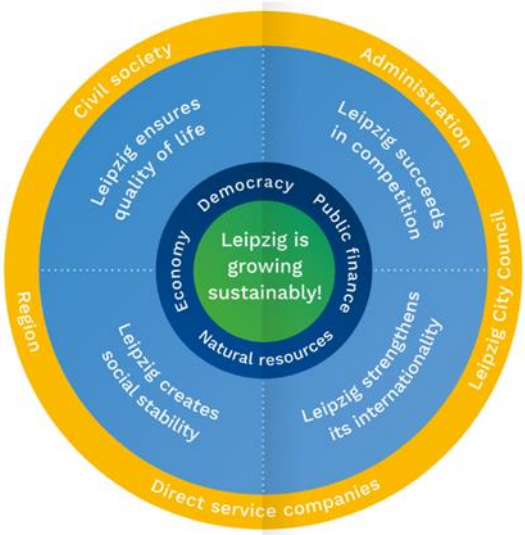

Figure 13: Strategic goals and action fields of Leipzig's integrated city strategy (Stadt Leipzig, 2018c)

The first goal is for the City of Leipzig to **ensure the quality of life** for its residents and this shall be included in evolving the city. The environmental conditions throughout this process must be maintained or, better even, improved through preservation and setting precautionary climate and energy strategies into action. The residents shall have access to neighbourhood-based cultural, sports and leisure facilities, and are provided with and encouraged to use sustainable mobility options. Furthermore, Leipzig strives to find a balance between managing densification and still providing high quality open public spaces.

The second goal of Leipzig is to **create social stability**, which means that Leipzig strives to develop inclusively, reduce inequalities and provide services to everyone no matter the age or income group. Within this goal the City of Leipzig wants to develop neighbourhoods collaboratively and provide affordable housing and equal opportunities for everyone. Leipzig shall therefore be an inclusive, safe city that practices lifelong learning.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

The third goal of the City of Leipzig defined for their city development plan is to **succeed in competition** and strengthen its economic base through innovative impulses, seeking expansion opportunities, raising the number of companies, increasing the number of jobs and boosting trade tax revenue. The City of Leipzig wants to create an attractive environment for start-ups, skilled professionals and innovative businesses. This includes providing efficient technical infrastructure and an outstanding networking between education, businesses and research. The City of Leipzig wants to be precautionary with land and property management and create a diverse, resilient economic structure.

As a fourth goal, **Leipzig wants to strengthen its internationality** and position itself as a progressive European City. Therefore, it is important to embrace a diverse range of cultural and sports activities, attract conventions, hold major image shaping events and appeal as a tourist destination. Leipzig strives to contribute to outstanding research in interdisciplinary fields of science. Leipzig wants to be open minded; apply global thinking while setting responsible local actions.

Furthermore, the City of Leipzig, with its holistic approach to city making, strives to be capable of implementing smart, forward-looking concepts for and with the community. The main actors involved with attaining Leipzig's goals are – the civil society, regional cooperation's, direct service companies and the city council and local administration. The City of Leipzig deems it crucial to create and facilitate the opportunity for residents to be actively involved in shaping their city. Furthermore, the City of Leipzig aims to enable direct service companies to deliver public services at a high quality, while being able to maintain fair and reasonable prices. The city council and local administration must align their actions to strategic goals and to current and future requirements (Stadt Leipzig 2018b).

The City of Leipzig created the **Flächennutzungsplan** (FNP), a land use plan, as a planning framework for urban development of Leipzig. The goal of the plan is to reflect the fundamental direction of the future economic, urban, infrastructural and natural development of Leipzig. Five goals were developed by the city, which shall ensure that attractive living conditions and an efficient transport network are maintained and further developed. Furthermore, spatial conditions for the development of the economy and the attraction of jobs needs to be ensured. The City of Leipzig includes also the maintenance and development of an attractive landscape in its strategic goals. Focus is also on the economic provision of new development areas. New development areas must consider environmental aspects and ensure the access or integration of social infrastructure like schools and day-care centres to ensure the intended demographic development (Stadt Leipzig).

8.2 Indicators and action fields analysis

High poverty rate and improvement in economic stability

By analyzing the economy and governance **indicators** in Leipzig, the need to ensure economic stability is evident in the indicators. With a nominal GDP per capita of EUR 35,123 is Leipzig below Germany's average but still performing well regarding the low unemployment rate (5,9 %), which is well below the average benchmark threshold (7 to 12%). The high quality of life is reflected in a life expectancy of 80 years, respectively. In

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

the City of Leipzig currently live 17 % in relative poverty, which the city defines as "household with income less than 60% of the median", Leipzig scores within the red benchmark threshold in the population living in relative poverty. Nevertheless, the higher risk to relative poverty rates is frequently noted to the newly arrived rather than the long-established population in Leipzig. The indicators also point out that the spending's on rent is due to 30% of the household's income and that only 14% of the population is living in owned housing in Leipzig. This also suggests that the city has a lower nominal GDP than the German average of EUR 41,342.

Indicator Description	City Value	Green	Yellow	Red
City population living in poverty (%)	17	< 9	9 – 15	> 15
GDP per cap (€)	35,123.0	< 40000	10000-40000	> 10000
Unemployment rate (%)	5,9	< 7	7 – 12	> 12
Spendings on rent of net household income (%)	30	< 20	20 – 40	> 40
Life expectancy at birth (years)	80,8	> 75	65 – 75	< 65

Figure 14: Sample economy and governance indicators for Leipzig

Long-term goals allow innovative and sustainable applications

In governance **action fields** of the City of Leipzig, there are different approaches towards climate protection implementations visible. The city has concrete long-term sustainability goals that have been agreed upon by the council, for instance, to lower CO^2 emissions by 50% until 2040. Even though climate protection concepts and strategies were defined, and the measures are already being implemented. However, there are still exemplified measures needed in case of meeting European regulation standards.

Generally, the City of Leipzig shows preparedness through its municipal management of the development and implementations regarding the set targets. Although there is still scope for improvement analyzing the actions fields, for example, it could be easier to meet the goals if an innovation strategy would be implemented and managed through a specific position in the department. In principle, this could allow a more effective allocation of resources and a targeted organization of the goals made and provide more significant opportunities to pursue implementations more quickly, even across departments. A consciously executed innovation strategy can lead to superior innovation performance in achieving sustainability. One of Leipzig's major strengths is that the vision and related goals were developed in cooperation with key stakeholders, including public participation, to respond to citizen needs in the city development.

9. ENERGY PROFILE LEIPZIG

Leipzig's inhabitants are supplied with energy from Leipziger Stadtwerke (LSW). LSW is a multi-utility company and, with its subsidiary Netz Leipzig GmbH, provides a range of

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

services surrounding the generation, transmission and distribution of gas, electricity and district heating. LSW tries to supply the inhabitants of Leipzig with reliable, environmental conscious, reasonably priced energy (City of Leipzig). One third of Leipzig's inhabitants are supplied with district heating by LSW (Rometsch, 2019). The district heating from LSW is produced by two main facilities. One is the gas and steam turbine plant in Leipzig, owned and operated by LSW, where electricity and heat is produced with natural gas. The thermal capacity of this gas and steam turbine plant is 200MW and its electric capacity is 174MW (Leipziger Stadtwerke). The second source of district heating is the lignite power plant in Lippendorf, 20 km from Leipzig, where LSW purchases additional heat. During an average winter, the City of Leipzig consumes 350MW of heat. 200MW, almost 60%, is supplied by the Lignite power plant. In some areas without an existing district heating connection, the integration of local heating solutions is desired. Overall the goal is to replace fossil fuels, especially coal, heating oil and night storage heaters and foster the integration of renewable resources (Stadt Leipzig 2014). As Leipzig is continuously growing, LSW aims to be fit for future demands on a social environmental and economic scale. Therefore, in 2016 they made an analysis of four future scenarios how the heat demand and technologies could develop in Leipzig. For each scenario, they developed a strategy defining in detail what measures on a technological and infrastructural level ought to be set. When creating the strategies, a special focus is put on providing reliable, reasonably priced supply and using practices low in CO2 emissions. Analysis showed that the scenario which divides heat generation into several sources, is the most resilient option and LSW will invest 300 million Euros to implement this. Therefore, in the south of Leipzig a second gas turbine plant including a thermal storage system (heat accumulator, heat reservoir), producing 150 MW of heat and 120 MW of electricity, is planned for construction to be finalized by 2022 (Leipziger Stadtwerke). Sourcing energy and heat from renewable sources is a goal of LSW. Therefore, a biomass power station, providing 25MW of heat and 10MW electricity, will be built in Leipzig's peripheral west (Rometsch, 2019). LSW also fosters heat generation through a thermal waste treatment plant generating 25MW and a combined heat and power plant generating 25MW. Additionally, solar thermal heat generation should also be a part of the future energy mix and produce 27MW of energy. The City of Leipzig wants to become a forerunner city of the post-fossil transition (Büttner & Rink, 2019) and therefore, the strategy of LSW for generating energy is focuses on a mix of innovative, renewable and conventional energies (Leipziger, 2019). The goal is to phase-out coal-fired district heating by 2023, which will enable the City of Leipzig to become a role model and provide valuable lessons to other cities and region depending on coal.

This ambition is also represented by scientific research institutions in Leipzig working within this field, such as the DBFZ German Biomass Research Centre, the UFZ Helmholtz Centre for Environmental Research, the IE Leipziger Energy Institute or the Institute for Infrastructure and Resource management, and the Institute for energy research at the University of Leipzig (Stadt Leipzig). The Energy and Environment Cluster and the Energy and Environment Association are exploring aspects of environmental and energy policy and thus make practical contributions to the energy transition. Furthermore, several companies operating as key players in the energy sector are located in Leipzig such as natural gas giant VNG, the biofuel producer Verbio AG, the EEX European Energy Exchange, and the service provider Energy2market focusing on electricity trading. These companies, along with other SMEs in the energy field, strengthen Leipzig's position aiming to become a pioneering city in the energy transition (Energiemetropole Leipzig). Leipzig's

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

focus in the Energy and Environmental Cluster is also represented by the development of jobs within this field. In 2017, over 12.000 people were employed in the Energy and Environment sector, which is 32% more than in 2005 (Stadt Leipzig).

9.1 Strategic Plans and Goals

In Germany there are several laws important for climate protection, like the Energy Industry Act 2005, the Energy Saving Act 2005, the Renewable Energy Sources Act 2008, Renewable Energy Heat Act 2008 and the Energy Saving Ordinance 2009. However, there is currently no statutory climate protection target for municipalities. The City of Leipzig nonetheless chose to set climate targets and goals and thus created a climate protection plan (Stadt Leipzig). Leipzig began working on its energy concept as early as 1992 (City of Leipzig, 2020). When the value of climate protection became increasingly present in Leipzig, the city joined the Climate Alliance in 1994. This helped the city to create an Energy and Climate Protection Concept in 1996, which was an improved and rewritten version of the first energy concept from 1992. In 1998, the City of Leipzig introduced the first Energy Quality Standards and in 2005 the first Climate Protection Program which included a catalogue of measures was adopted. In 2011 the integrated **Energy and Climate Protection Plan 2014-2020** (EKSP) was created to address several shortcomings of earlier concepts and has advanced on a conceptual level. Earlier measures were initially adopted without clear responsibilities, financing and prioritization (Büttner & Rink, 2019). The integrated **Energy and Climate protection program 2014 to 2020** (Energie und Klimaschutzprogramm 2014-2020) builds up on the studies conducted within course of the European Energy Award (EEA) and lists 100 detailed measures to achieve the long term goal of reaching 2.5t CO2 reduction per capita per year, while increasing energy efficiency (Stadt Leipzig, 2014; Stadt Leipzig, 2020c). The program also includes a comprehensive package of measures for municipal buildings and facilities. This includes, for example, the plan to gradually increase the share of certified electricity from renewable energy sources in electricity purchases for all municipal institutions and companies. The goal for 2016 was to provide energy of which 75% is produced by renewable energy sources (Stadt Leipzig, 2020c). This goal has been reached, according to the annual evaluation and reporting. The next step is to reach the goal of 2020, which is the production of energy to be done 100% with renewable sources (Stadt Leipzig, 2018a).

Following the climate protection program, the city formed six task groups with certain areas of responsibility. The task areas are climate protection in the land use planning and urban development sector, climate friendly communal buildings, environmentally responsible energy use and generation, climate protection in the mobility sector, compensation measures for emission impacts and public relations, communication and cooperation in the light of climate protection.

9.2 Indicators and Action Fields Analysis

Need for improvement of renewable energy infrastructure

In general terms, Leipzig shows some room for improvement regarding its energy and electricity demand, covered through renewable energies. The city has set a goal in the **Energy and Climate protection program 2014 to 2020** (Energie und Klimaschutzprogramm 2014-2020) to cover by 2016 75% and until 2020 100% of the

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

total energy use through renewable sources. However, this seems to be optimistic, and the analysis of the **indicators** (collected early 2020) now quite low value regarding covering energy demand through renewable energies (8%) and generating electricity with renewable energies (6 %). To come closer to the targets, it is needed to reduce energy consumption in the city, which is currently 16.49 MWh/a/cap. Overall is Leipzig goal to replace fossil fuels especially coal and to integrate completely renewable resources in the city. Currently 33 % of electricity is being produced within the city, meaning there is room for increasing these values through for example the utilization of Smart Grid technologies which would lead to a lower and more efficient use of it. The share of the heat demand delivered by district heating systems is with 35% within average European values but also showing some room for improvement.

Indicator Description	City Value	Green	Yellow	Red
Total energy use of the city per cap (MWh/a/cap)	16,49	<15	15 - 20	>20
Share of electricity produced within the city in the grid (%)	33	>10	10 - 5	<5
Share of end energy demand covered with renewable energies (% of end energy demand)	8%	>23	23 - 13	<13
Share of electricity demand generated by renewable energies (% of electricity demand)	6%	>40	30 - 40	<30
Share of heat demand delivered by disctrict heating systems (%)	35%	>50	15 - 50	<15

Figure 15: Sample energy indicators Leipzig

Raising awareness of renewable energy programs and the physical development of infrastructure

When referring to the Leipzig's performance in the **action fields**, there is an overall good score in the share of electricity production within the city. The city has a highly efficient and centralized energy supply with district heating and cooling that is provided through two main facilities. LSW operates one, and the other is the lignite power plant in Lippendorf, where LSW purchases additional heat. The analysis of the action fields also suggests that thermal heat such as environmental heat, or sewage generated heat is relatively low in Leipzig. In this sense the energy and Climate protection program's goal is aligned with these objectives and aim for more connectivity and efficiency of the industries through more efficient networks, such as linking production sites with each other. To come closer to sustainability, a geothermal plant should also be considered, and the flow of resources in the city should be mapped better and more efficiently so that the goal of expanding renewable energies can also be achieved.

Likewise, the city scores well in the **action fields** regarding the promotion of renewable energies and the high-efficient centralized energy supply, such as district heating and cooling, linked to the different educational programs provided from the environmental information centre (so-called Umweltinformationszentrum) (Stadt Leipzig, 2014; Stadt Leipzig, 2020c). However, there is a significant potential for increasing the already running city programs' visibility, such as informing and educating citizens on energy

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

efficiency and user behaviour. The program could be expanded to a larger scale, including companies and other organizations, and guiding them in decreasing the electricity demand with the help of new technologies in doing so with the installation of smart meters, demand-management technologies, and sensors throughout the city.

10. MOBILITY PROFILE LEIPZIG

Mobility is one of the main contributors to greenhouse gas emissions in Leipzig with over 20% of the emissions produced within the transportation sector (Stadt Leipzig). From the total emissions of transportation, around 65% can be attributed individual mortised transport. The second biggest contributor to transport emissions is freight transport by roads with 23.7% (Stadt Leipzig, 2018a).

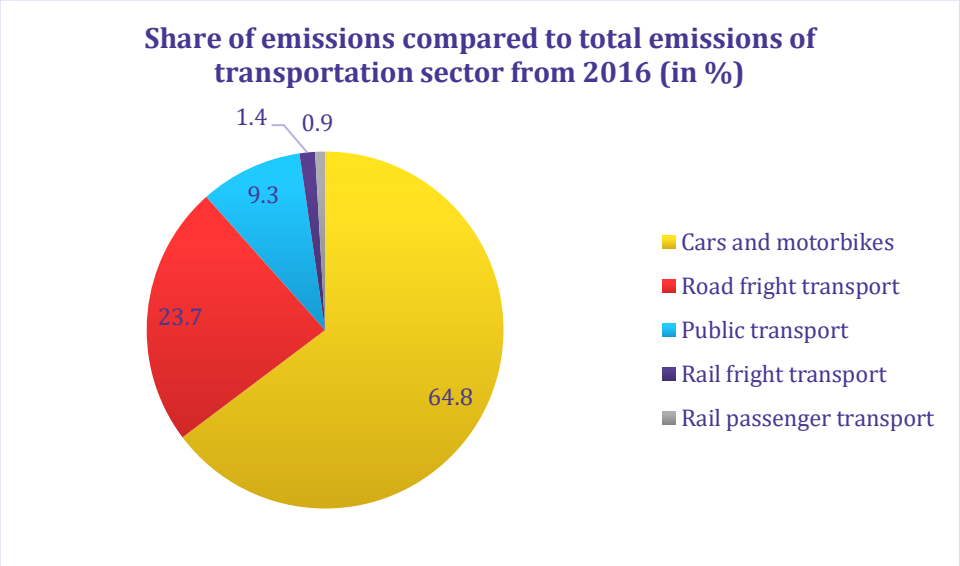

Figure 16: Share of emissions compared to total emissions of the transportation sector (Stadt Leipzig, 2018a)

The reasons for travelling can be separated in four categories and are listed with the respective share of trips: work 21%, education 16%, necessary errands 37% , leisure activities 16% and other purposes 5% (Gerike, Hubrich, Ließke, Wittig, & Wittwer, 2019). 40% of all private journeys by Leipzig's residents in 2015 were made by private motorized transportation, whereof 9.3% can be accounted to fellow passengers in individual motorized vehicles (Stadt Leipzig, 2018c). This number also reflects the vehicle ownership rate in Leipzig of 452 cars per 1000 inhabitants (Stadt Leipzig, 2019c). Alternatives to ownership like car-sharing are only used by 4% of Leipzig's inhabitants (Stadt Leipzig, 2017a) and 66% of all households in Leipzig own one or more cars (Dr. D. Auspurg & Dipl.-Geogr. C. Kreymann, 2015). Thus, the parking situation in Leipzig is considered problematic, especially by commuters (Stadt Leipzig, 2017a).

In 2015, 60% of private journeys were made with eco-friendly-mobility options including public transportation, cycling and walking. 17.3% of total trips are made by public transport, most of them by trams. The modal split for walking was 25,4% in 2015 whereas the modal split for biking increased from 12% in 2003 to 17% in 2015. The number of owned bicycles in Leipzig also reflects this as on average, 1000 inhabitants own 905 bicycles. Bike sharing offers are used by only 2% of Leipzig's population (Stadt Leipzig,

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

2017a). The City of Leipzig strives to increase the share of eco-friendly-mobility modes to 70% by 2025 (Stadt Leipzig, 2018c).

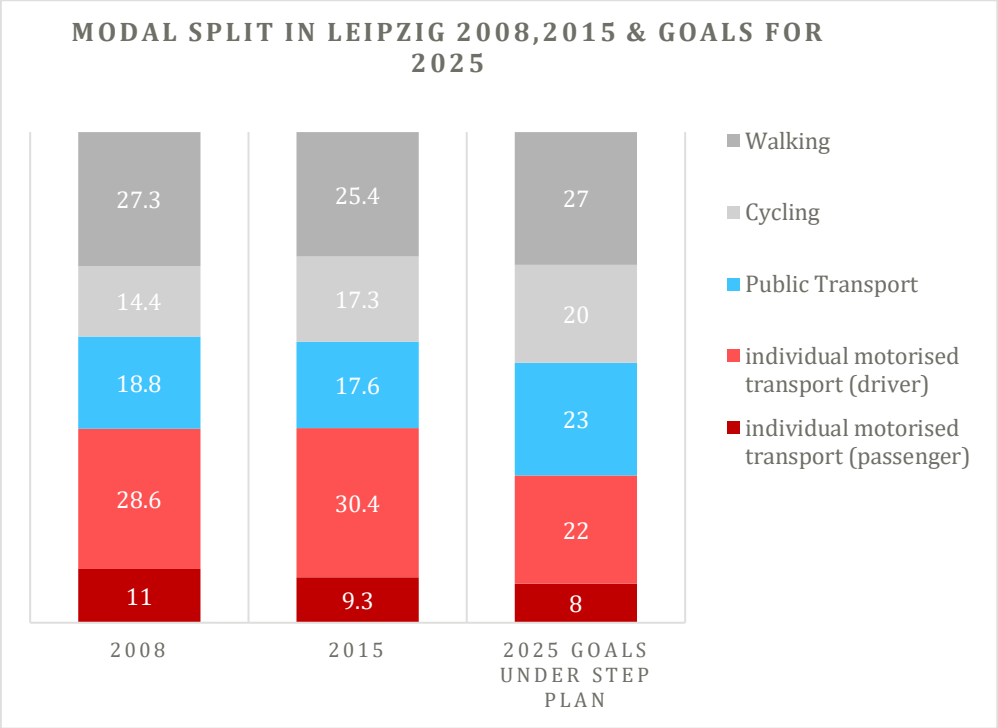

Figure 17: Modal Split in Leipzig (Dr. D. Auspurg & Dipl.-Geogr. C. Kreymann, 2015)

Leipzig's location at the centrepiece of the S-Bahn Mitteldeutschland public transit system, puts it in a prime location to showcase sustainable mobility initiatives to visitors. Through the LOW-CARB EU project, the city intends to (i) develop a master plan for public transit in the north of Leipzig and integrate new forms of mobility from the 2030 perspective, (ii) increase the knowledge of sustainable forms of mobility through stakeholder training and (iii) implement a mobility information system as a pilot measure. Measures to increase energy efficiency and renewable energy shares in public transport are especially crucial due to the large modal share of public transport in commuting (Stadt Leipzig, 2017a). This project furthers the goals of the EU White Paper to reduce transportation related emissions with 60% by 2050 and reduce the use of conventionally powered cars in urban transport by half by 2030 (LfULG, 2017).

The City of Leipzig´s focus on attaining a zero-carbon future is already showcased in its 2011 establishment of an *Umweltzone*, or Environmental Zone. Here, only vehicles that meet established emission standards are permitted to drive. The lowest standard allowed to enter the environmental zone is pollutant group four and is indicated through a green badge. Vehicles lower than emission class four receive yellow and red badges. Those vehicles are forbidden to access the zone, which is 62% of Leipzig's metropolitan area. This is a response to elevated concentrations of PM10 and NO2 (City of Leipzig). Through the establishment of the environmental zone, the air quality could be significantly improved. In 2016 the concentration of PM10 was reduced by 24%, PM2.5 by 32%, NO2 by 14% and NOx by 8% compared to 2010 (LfULG, 2017).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 864242
Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

10.1 Strategic Plans and Goals

The City of Leipzig developed several plans for the future of transport in Leipzig to become innovative, sustainable and carbon friendly:

- Leipzig - Stadt der intelligenten Mobilität (Leipzig – City for intelligent Mobility)
- Mobilitätsstrategie 2030 (Mobility Strategy 2030)
- Green City Plan
- Lärmaktionsplan (Noice Action Plan)

The City of Leipzig views mobility as an important instrument for developing and preparing the city in and for the future. The preparations for the "Mobility Strategy 2030" already started in 2015 with the City Council's request to present three scenarios for updating the local transport plan. Based on the objectives of the Urban Development Plan for Transport and Public Space (STEP VöR), a total of six possible scenarios were then developed, which reflect the vision of safe, clean, reliable, and affordable mobility in the time horizon up to 2030 with different focuses (Stadt Leipzig).

The City of Leipzig builds its **Mobility Strategy 2030** up upon the INSEK Leipzig 2030, the paper "Öffentlicher Raum und Mobilität" (public space and mobility) and transport policy guidelines. In order to create a liveable Leipzig with a sustainable mobility culture, a vision was created which is based on the following premises: *"Mobility ought to be safe, reliable, clean, affordable and accessible to all population groups" (Stadt Leipzig, 2017b, p. 3)* Furthermore, mobility should be easy and available at any time with the according means of transport (Stadt Leipzig, 2017b).

At the beginning of 2016, an extensive scenario process was carried out to investigate scenarios for future development of the public transport system and provide insights for updates of the local transport plan. Due to the growing population, a higher traffic volume is predicted and strategies for the future mobility to cope with that need to be set (Stadt Leipzig, 2017b). The goal of the mobility strategy for 2030 therefore is to ensure that the mobility requirements of Leipzig's inhabitants and commercial enterprises are considered and are guaranteed in the future. The traffic system shall be functional, social equitable, environmentally friendly and account for pedestrian, bicycles, motorizes vehicles as well as public transport (Stadt Leipzig, 2020d).

After all, six scenarios were developed, which show what consequences political decisions for a specific strategy would have. Special focus was put on urban mobility trends and the development and establishment of alternative mobility offers. One assumption worked with, is that shared mobility (car sharing, bike sharing, ride sharing) will gain significance. Another assumption is that acquisition costs and operation costs of fossil powered vehicles will rise, and, because of that, e-cars will become more attractive and more cost-efficient. In every scenario, topics like parking management and the promotion of bike traffic is considered. The following scenarios were developed:

1. *Continuation scenario:* keeps current traffic strategies and measures unchanged under the condition of growth.
2. *Continuation scenario with constant ticket fare:* keeps current traffic strategies and measures unchanged under the condition of growth and deters from increasing ticket prices.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

3. *Sustainability scenario:* aims to create a liveable city with sustainable and clean traffic solutions available for all population groups now and in the future (Stadt Leipzig, 2020d)
4. *Cyclist scenario:* promotes and supports bicycling as an environmental means of individual mobility. Bike traffic has the strongest priority next to local public transport in this scenario.
5. *Priority scenario for local public transport:* aims to maximize local public transport demand and expands public transport offers.
6. *Shared scenario:* tries to create a highly attractive, well-developed public transport system that is financed jointly (Stadt Leipzig, 2020d)

The scenarios were rated qualitatively regarding user attractiveness, ecological attractiveness, economic attractiveness and overall system attractiveness. The cyclist scenario and the sustainability scenario were highest ranked, followed by the scenario prioritizing public transport. In the second quarter of 2018 the city council, after a public participation process decided to continue with the sustainability scenario for the mobility strategy 2030 (Stadt Leipzig, 2017b). Central in the sustainability scenario regarding transport policy is the promotion of sustainable and clean mobility in order to develop Leipzig in a way that is compatible for all transport users. In addition to the ecological component, the focus is on economic and social sustainability. The City of Leipzig wants to increase passenger numbers and the capacity utilisation in local public transport. Therefore, high additional investments are allocated for local public transport. Additional, speed levels in local public transport, in motor vehicle traffic and in commercial traffic shall remain constant compared to today's speed levels. Through the sustainability scenario the City of Leipzig also contributes to the cities climate goals by meeting the limits for nitrogen oxide and CO2 emissions and reducing noise pollution (Stadt Leipzig).

Like other German cities, Leipzig is car-dominated and replacing conventional cars with electric vehicles is therefore not enough to fulfil future transportation needs. Leipzig rather wants to generate concepts to integrate a diverse offer of electric transportation, such as e-car sharing, e-bikes, e-scooters, e-public transport & e-boats. To enhance the mobility structure, technological advancements need to go hand in hand with mobility services. With the intention to make Leipzig a city deploying intelligent mobility, the city of Leipzig created the "**Leipzig Stadt der intelligenten Mobilität**" plan. The city thus created a guide for city development, noise reduction, climate protection and traffic development which is currently under review (Stadt Leipzig, 2017a).

The City of Leipzig wants to develop its electro mobility vision strategically and is building upon already established programs and plans. Plans used for the intelligent mobility plan are for example the Luftreinhalteplan (2009) and the Energie und Klimaschutzprogramm der Stadt Leipzig 2014-2020 (2014). In relation to e-mobility and e-mobility solutions, several projects have been conducted in Leipzig already. The City of Leipzig has thus set good preconditions for further developing this sector. Especially, with BMW and Porsche located in Leipzig, and several other cooperation partners like Leipziger Verkehrsbetriebe or Stadtwerken Leipzig, it has a stable network of economically strong partners. The goal is to set strong signals for the mobility transition and further increase the share of e-mobility. Additionally, the City of Leipzig set financial incentivises for initiatives increasing the share of e-mobility. The City of Leipzig also supports economic feasibility

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

measures and encourages the involvement of industrial partners to increase external financing of e-mobility projects (Stadt Leipzig, 2017a).

The City of Leipzig in cooperation with the Leipziger Verkehrsbetriebe GmbH (responsible for public transport), Stadtwerke Leipzig (responsible for energy, heat and utilities) and further institutions created the **Green City Plan** to help communes to design emission free mobility concepts. The overall goal of the plan is to reduce emissions, especially NOx emissions and thus improve the air quality within the city. Leipzig aims to become a "city for intelligent mobility" through low-emission, quiet, electric, efficient, intermodal and economic sustainable transportation. The green city plan incorporates inputs form several city plans: Mobilitätsstrategie 2030 (mobility strategy 2030), STEP "Verkehr und öffentlicher Raum" (a plan for traffic and public space), Luftreinhalteplan (clean air plan), Lärmaktionsplan (noise action plan), Energie- und Klimaschutzprogramm (energy and climate protection program), „Stadt der intelligenten Mobilität" (City for intelligent mobility) und INSEK Fachkonzept „Nachhaltige Mobilität" (integrated concept for sustainable transport) (Stadt Leipzig, 2018b).

The biggest contributor to NOx emissions in Leipzig is the transportation sector emitting 79% of all NOx, whereof 71% can be attributed to motorized road traffic. In order to reduce NOx emissions, the city has developed seven strategic work packages:

1. *Improving traffic flows and thus reducing emissions related to transport:* To achieve this, hotspots of traffic congestion will be examined carefully on their environmental impacts. Routes of public transport vehicles can be deviated through real-time data management, traffic light systems shall be adaptive to current traffic and signals for public transport will be prioritised, to reduce travel times of trams.
2. *Mobility as a service:* The mobility hub network is to be expanded within the city. The stations shall include car-sharing, bike-sharing, bike parking and lockers. The Bike&Ride network must be expanded and further connected and integrated into the public transport network. Park&Ride facilities will be equipped with sensors to share information about free parking spots (Stadt Leipzig, 2018b).
3. *Mobility platform:* Leipzig's local public transport provider (so-called Leipziger Verkehrsbetriebe) launched a mobility platform, "LeipzigMOVE", and will change its system architecture to incorporate flexible integration of other cooperation partners like intelligent multimodal route planning or ride-pooling. Furthermore, ticketing and pricing for multimodal transport shall be realized, and information about parking availability integrated (Stadt Leipzig, 2020b).
4. *Exhaust optimised bus fleet*: The diesel buses of the current bus fleet shall gradually be replaced by electrified buses to reduce emissions as well as noise pollution (Stadt Leipzig, 2018b).
5. *Infrastructure for e-mobility:* Based on the prognosis of e-mobility development in the private and commercial sectors, demand-based charging infrastructure will be implemented and is already linked to one of the public funding programs for a lead wheel promotion (Stadt Leipzig, 2018b).
6. *Autonomous vehicles:* In the north of Leipzig, industry and businesses are attracting high traffic flows. An autonomous e-bus shuttle shall help to mitigate this situation

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

by making the use of public transport a viable alternative and an attractive connection between the area of Messe Leipzig and the BMW-areal (Stadt Leipzig, 2020b).

7. *Low-emission logistics:* The goal is to develop an efficient city logistics system based on urban-hubs and micro depots. Goods are sorted in the centralized urban hubs located in the peripheral areas of the city, and then distributed further to micro-depots. The remaining distance between micro-depot and consumer is covered by a freight bicycle or small electric vehicles (Stadt Leipzig, 2020b).

Noise pollution is a problem for many people. Even though a city can never be without noise, noise reduction is an important goal and traffic plays a major role in it. The City of Leipzig therefore created the **Noise Action Plan** (Lärmaktionsplan) in 2013 and an update followed in 2019. The goal of noise action planning is to prevent or reduce ambient noise, particularly where noise pollution can have harmful effects on health (Stadt Leipzig). The plan is including planned measures and proposals for noise reduction of private and public transportation and rail traffic. Motor vehicle traffic has been identified as the main source of noise pollution and offers the most reduction potential for heavily used areas. Measures to reduce noise from motor vehicle traffic include the replacement of road surfaces, building new streets with noise cancelling construction measures, reducing the overall traffic volume and measures in relation to traffic laws and regulations. The City of Leipzig introduced an environmental zone, which only allows vehicles reaching a certain pollution emission standard within the area. This measure also had a positive effect on noise reduction. Furthermore, the city developed a plan with possible locations for the construction of noise barriers in the metropolitan area of Leipzig. The noise action plan also includes measures to reduce the noise level of trains and trams, like covered tracks or track arch lubrication systems. Another aspect when drawing up the noise action plan was the identification of quiet areas in the urban area. This is to prevent a deterioration in noise pollution in sensitive and sensitive areas of Leipzig. The noise action plan is intended to be a first step towards noise reduction in Leipzig (Stadt Leipzig, 2013). Medium and long term goals are to follow the recommendation of the Advisory Council for the Environment (SRU) and comply with a maximum of 65 dB during the day and 55 dB at night to avoid health risks induced by noise (Stadt Leipzig, 2019d).

10.2 Indicators and Action Fields Analysis

Need to decrease motorized traffic and promote public transport

The analysis of the mobility sector's **indicators** in Leipzig shows that there is a need to decrease the total number of passenger motorized vehicles. The mobility system's central issue is the dependence on personal vehicles, with the ownership rate of 446 cars per 1000 inhabitants. This number also reflects that a great amount of the journeys is made by private motorized transportation, which means there is an opportunity this regards and the need for promoting public transport. In the distance range of 5 to 10 km, 35.1% of journeys are made by public transportation compared with distance classes over 10 km there the share of public transport is low. This gap should be closed as such the public transport system needs to become more attractive for residents and commuters in the entire metropolitan region.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Nevertheless, there is a shift in the modal split visible. The modal split for walking was 25.4% in 2015, whereas biking increased from 12% (2003) to 17.3% (2015). However, there is an opportunity to promote the bike-sharing offers, which are now only used by 2% of Leipzig's population. The City of Leipzig strives to increase the share of eco-friendly-mobility modes to 70% by 2025. That can only be achieved if the personal motorized vehicle number (39.7 %) will be minimized. Currently, running programs are supporting public transport use for companies (Leipziger, 2019). That could be multiplied while encouraging their employees with various incentives to switch from individual to public transportation and help to achieve Leipzig's mobility shift.

Indicator Description	City Value	Green	Yellow	Red
Share of traffic by public transport of total traffic (%)	17,6	>40	25 - 40	<25
Share of traffic by bicycle mode of total traffic volume (%)	17,3	>25	5 - 25	<5
Share of traffic by pedestrian mode to total traffic (%)	25,4	>40	20 - 40	<20
Personal Vehicles (including private vans, excluding motorcycles and trucks) to total traffic volume (%)	39,7	<15	15 - 40	>40
The ratio between the total number of passenger motorised vehicles (incl. cars and taxis) within the urban agglomeration and the population (passenger vehicles per 1000 city inhabitants)	446	<250 (Amsterdam)	250 - 400	>400 (poorly performing German cities)

Figure 18: Sample mobility indicators for Leipzig

Creating incentives for promoting the modal shift

When referring to Leipzig's performance in the **action fields**, the high number of personal vehicles in the city determines the need for mobility alternatives. Leipzig's focus on attaining a zero-carbon future with its 2011 establishment of Environmental Zone supports the targets due to significant improvement of air quality in the city. The actions affirm the objective; likewise, the city administration already has electric vehicles in their municipal fleet, and there are also specific "free parking slots" reserved. The **action fields' analysis** shows that there are already initiatives taking place, likewise the promotion of soft mobility modes and public transport. That undermines that it is a political issue to support soft mobility modes than the motorized ones, even making the alternative modes of commuting more attractive and cheaper. According to the data collected, there are currently no initiatives in Leipzig implementing any of inner-centric bike highways for fast commuting, green waves such as traffic lights for bikes. However, there is a new planned initiative for a bike highway linking Leipzig and Halle because of a high potential demand (Stadt Leipzig, 2018b). The collected data also indicates that the transition would depend highly on the willingness of the residents to change in their habits. The City should therefore in creating this type of culture and encourage active mobility and highlight the importance of health and environmental issues.

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

Action Fields assessment Leipzig (September 2020)

Mobility

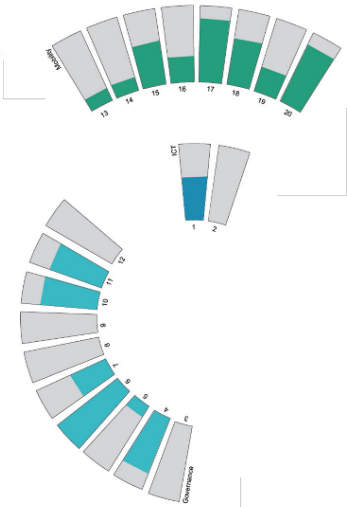
- Good scoring in road management, intermodality and sharing systems
- Optimized road network and transport routes for traffic distribution with provision of alternative routes
- Strategically linked public transport nodes
- Increasing provision of e-mobility infrastructure in the city
- Need for redeveloping areas and create more public green spaces as well as identifying and reconciling key danger areas for cyclist and pedestrians

ICT

- E-tools for the participatory governance of energy services are missing
- Leipzig uses real-time data from road traffic and public traffic systems while implementing intelligent traffic management

Political dynamics

- Political willingness and openness to new opportunities and to innovate
- Formed coalitions/political mandates focusing on sustainability issues
- Digital platforms as for public participation through ICT
- Has implemented control systems of corruption, is debating on future urban transformation strategies and long-term energy/decarbonization solutions



Energy

- Implementation and use of smart grid technologies missing
- Need for improvement in communal energy management and energy efficiency of industry
- Renewable energy sources are not implemented on a large scale especially recovering heat from the sewage systems, geothermal and environmental are viable options
- Public buildings and infrastructures could be optimized with smart grids and switch to renewable energies
- Need for more incentives for the implementation of renewable energies

Building transformation

- Many regulations aiming to minimize pollution, noise, and traffic through construction
- Control mechanisms adjusted to assure that the building standards are met, and energy performance improved.
- The rates of the refurbishment of municipal and private building stock should be improved, e.g. with financial incentives
- Lack of information regarding construction management

Governance

- Outranging performance in municipal climate change management/mitigation and in defining a long-term vision and goals for sustainable cities development
- Cooperation with key stakeholders from different sectors
- Need for more testing of innovative technologies and solutions
- Defined regulations and restrictions pursuing modal shift e.g., speed limits or implemented priority lanes for buses and trams
- Need for new structures for cross-sectoral cooperation's and joined responsibilities within the municipality
- Set of higher social and environmental standards useful through negotiated and voluntary agreements, e.g., to convey higher building standards and higher sustainable measures

11. CONCLUSIONS

This report provides a diagnosis of the cities and allows for understanding the status quo of the cities in the specific sectors of analysis. Both of the Lighthouse Cities in SPARCS proved to be progressive in the sustainability realm, the analysis of their status brings about the shift in city-level sustainability actions and lead the way for possible replication for the fellow cities. Furthermore, this report provides the opportunity for the Lighthouse cities to review possible fields of intervention based on the provided assessment of the various indicators and action fields as well as the points of action identified.

11.1 Summary of achievements

In spite of some missing data in both cities, the data available show for the City of Espoo a stable economy sector. In the energy sector, Espoo performs well and has already a number of concrete goals defined in both SEAP and SECAP but also through conducting projects that already show the city's commitment to these goals, such as "The Espoo Clean Heat" project which aims at creating a carbon neutral district heating. Espoo mostly shows opportunity for improvement in the field of mobility. Enhancing the connectivity

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Topic: LC-SC3-SCC-1-2018-2019-2020: Smart Cities and Communities

of public transport system, promoting active mobility as a mode of transport as well as incentivizing intramodality and sharing systems, would highly contribute to avoiding and mitigating the current city´s challenges. Furthermore, an important aspect to look at is the ICT sector, as the data seems to be not collected at this moment and was therefore missing for the assessment.

Leipzig is characterized in particular by being one of the fastest growing cities in Germany in terms of population and economic development. On the one side, there are also ambitious goals regarding the conversion from the usual to renewable energies. However, the targets are very ambitious and driven forward for implementation, primarily through the Energy and Climate protection program from 2014 to 2020. On the other hand, the Mobility Strategy 2030 leads to a rethinking in the population towards sustainable transport, but also the initiatives of the INSEK *integrated concept for sustainable transport* show many implementations regarding the promotion of soft mobility modes and the corresponding adaptation of the urban environment in Leipzig. The most significant gap in the assessment took place in the area of Budget Allocations and Financial Indicators, which should be further expanded. Furthermore, there are many initiatives and programs to be found in Leipzig, which can be concretized or lead to even more positive developments through cooperation.

11.2 Impacts

This report connects and relates to important tasks and activities held within SPARCS. Providing a concrete base for creating a city vision (Task 1.7). It is also an important guiding document for Work Package 5 which aims at developing a replication process and upscaling of solutions contributing to Energy Positive Districts for the Fellow Cities.

11.3 Other conclusions and lessons learnt

The process of creating a city diagnosis and a city profile requires an active involvement of the city. This allows for a more precise and coherent outcome. The findings shall serve the city as an orientation towards the definition of its vision and goals for the future.
The data collection process could be improved for guarantying a higher response rate. Cities could be more involved in the process of defining the framework, so they can, from the beginning, help to define the indicators and action fields based on the data which is available and collected. This could lead to a higher rate of response and the more efficient and accurate the assessment can be.

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