Urban mobility hubs - Case Espoo

Version 1.2

2022

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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

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.

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SUMMARY

The ways we move in and between cities are transforming rapidly in the wake of increasing calls for a green transition and sustainable urban mobility. Multiple trends, that are currently re-arranging the principles and behaviour of urban mobility can be identified: the global urbanization of the human population and the subsequent densification of cities; the shift from ownership of vehicles towards shared and subscription-based service models in transport, facilitated by digital solutions; the broad-scale electrification of vehicles including the introduction of new (shared) light electric vehicles; and the major impacts of sudden global events, such as the Covid-19 pandemic and its effects to human mobility patterns in and between cities. What does these transformative processes mean for mobility hubs, the major nodes of urban flows? How will the role of mobility hubs evolve as cities are built more densely around such nodes, vehicles are both shared and electrified, and global pandemics reshuffle our mobility habits?

This paper examines briefly some key notions related to the transformation of mobility hubs by examining research literature and case project examples on the topic. These insights are reflected with the objectives of the SPARCS project that aims to pave the ground for sustainable urban mobility transformation and the increased uptake of electric mobility in urban areas and hubs.

This paper is part of SPARCS Action E13-1 (*Multi-modal transport solutions with focus on last-mile*) under the 'Task 3.4 E-mobility integration' in Work Package 3. In addition, the paper also supports Actions E2-3 and E7-1 as the three Actions all aim towards the development of e-mobility hubs in the SPARCS Espoo demonstration sites (Espoonlahti, Leppävaara and Kera, respectively). This paper provides context and conceptual background for mobility hub development in the project.

Keywords: sustainable urban mobility, mobility hubs, urban nodes, 'last mile', green transition in mobility

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1. INTRODUCTION

A swift green transition towards zero-carbon societies and lifestyles are needed in order to achieve the target of a maximum of '1,5 degrees' increase in global temperatures, as set in the United Nations Paris 2015 climate agreement[1]. Urban mobility plays a key role in this puzzle as a major source of greenhouse gas emissions. Mobility and transportation are currently responsible of roughly one-third of the carbon-dioxide emissions in the EU[2], and roughly one-fifth globally[3]. The green transition in mobility means a shift towards sustainable mobility modes - walking, bicycling, public transportation use, and shared mobility services - together with critically re-examining how we build our cities and create both the *need* and the *possibilities* for the use of sustainable mobility modes. Next to cutting down emissions and finding greener solutions to power different vehicles, we need to consider the broader ecological (biodiversity, air particles, urban space use, vehicle manufacturing resources), economical (costs of operation, affordability) and social (accessibility, inclusivity, safety, mobility poverty) effects of transportation on cities and people. Therefore, sustainable mobility development requires a holistic and a system-based approach.

Mobility hubs, the spaces that gather mass transportation and shared mobility services under 'one roof', can have an increasingly important role to play in such sustainable urban mobility systems as central sites in the city. Mobility hubs - such as the metro station, the bus terminal, or the railway station - are spaces where different mobility modes and people cross paths on a daily basis. They are important infrastructural elements of the city and the urban transportation network, connecting people to mass transportation services and shared mobility services. They act as intermodal links where mobility mode is changed, and they usually are also social gathering and meeting places as sites of day-to-day mobility habits and routines. The hubs scale from a small local transportation node - a bus stop, for example - to large complex hubs with a range of mobility services and other services. Such large hubs are often urban centers with mixed-use zoning and a large number of daily users.

Mobility hubs are not new inventions or concepts - mobile trajectories and other uses of the city have also conglomerated into different both intended (from city and mobility planning perspective) and *informal* nodes. On a global scale, cities themselves can be seen as nodes in the global networks. However, the interest towards mobility hubs (or mobility stations) as key elements in the design of the city and urban mobilities, has increased during the recent decades (see Cervero et al. 2017). This increase can be attributed to multiple factors, of which the aforementioned calls for a rapid shift towards sustainable urban mobility, has, at least recently, been on the forefront of this process. Similarly, approaches that could be set under the umbrella term 'new urbanism' have already for decades highlighted the importance of human-scale urban spaces, proximity, quality of the urban environment, and the 'reclaiming' of the streets from the automobile that has

[1] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[2] https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12

[3] https://ourworldindata.org/co2-emissions-from-transport

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reigned transportation planning for an even longer period of time (for renowned approaches, see Lynch 1960; Jacobs 1961; Gehl 1971; Appleyard 1981; Calthorpe 2011).

Additionally, mobility hub - as a concept and a physical-social-technological space - is not a static structure but it is continuously transforming and evolving as our modes and habits of travelling in and between cities change and evolve. New policies, targets (e.g., carbon-neutrality), planning and design paradigms, technologies, and daily practices of travelling, working and consuming affect the way a hub looks and operates - the 'how' and the 'why' we move both change and transform in time. The Covid-19 virus pandemic has been a major force that has reconfigured many day-to-day travel habits anew, as, for example, remote working practices were enforced and different food and grocery delivery services increased in popularity, increasing the share of other than work/school/errand run kind of trips. Simultaneously public transportation modes received an impact that they have not yet fully recovered. What the 'new normal' of urban transportation is, will only be seen in the upcoming years and decades.

1.1 Aim and scope

This paper examines what are the key ingredients of functional and user-friendly mobility hubs today, and what might lay in the future. The paper makes use of research literature on mobility hubs and general mobility trends, and examines case projects and concept development of mobility hubs of the near-future. The paper also examines more closely Espoo city's situation in terms of mobility hubs, and the current stage of the three SPARCS demonstration sites in Espoo that each act as major local mobility hubs.

Urban logistics are an important topic and relate closely to how mobility hubs and the areas they serve work and function. Here, however, the focus is set more on the human side of urban mobility, and logistics are examined mostly from the end-user point of view.

In SPARCS Work Package 3, Task 3.4, the objective is to 'boost e-mobility' in the Espoo demonstration areas of Leppävaara / Sello blocks, Espoonlahti / Lippulaiva blocks, and Kera. The activities on e-mobility range from the increase of EV charging points, to providing facilities for e-bicycling uptake, to the further optimization of an e-bus charging system, and to conducting simulations on different scenarios related to how e-mobility increases in Espoo area by 2030 and beyond. Additionally, the activities in the Task aim to further develop the mobility hubs of the demonstration areas, considering the effects of electrification of mobility modes and the increase of service-based mobility behavior (and service availability). This paper supports these Actions (E13-1, E2-3, E7-1) by providing background and context for the e-mobility hub development in the project.

The structure of the paper is as follows. First, I examine briefly sustainable urban mobility and what the current role of mobility hubs in that context. Next, some key global drivers affecting urban mobility and mobility hubs are briefly introduced. This is followed by closer examination of SPARCS project aims and the project's demonstration areas. Next, other case project examples are examined around the world. The conclusions are presented in the end.

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2. Sustainable urban mobility - A mobility hub based approach

Transportation is the cause of a significant portion of greenhouse gas emissions. Transportation represented around one-fifth of the total CO2 emissions globally in 2018[4], 27% in EU in 2017[5], and 22% in Finland in 2020[6]. Depending on the region or city, transportation, thus, causes one-fifth to one-third of the co2-emission, and these shares probably will only increase in the near future as development on emission-free energy production, for example, is progressed rapidly in the EU, lowering the energy sector's impact on the overall emission. Private car use is a major factor in the emissions as around half of the transportation related emissions globally are produced by road passenger traffic (including cars, motorcycles, buses and taxis).[7] There are also globally no signs of people giving up private car use - on the contrary, car sales have been breaking new records in units sold globally.[8] Transportation related emissions are also on the rise, despite the fact that the Covid-19 pandemic caused temporary drops in transportation related emissions in different cities.[9] The emissions are 'rebounding' in a quick pace.[10]

As private car use is responsible of around half of all transportation related emissions, affecting it's use, powertrain types and popularity is critical for lowering the transportation related emissions. The electrification of the cars and other fossil free powertrains might provide positive development emission-wise (if, for example, the electricity used in the cars is also produced fossil free, e.g., through renewables) but it does not solve all the challenges of the mobility sector. The use-related local emissions are only one part of the equation as the whole life cycle of the vehicle needs to be considered - from the manufacturing to the recycling of the materials in the end of its life-cycle.

Calls for a swift green transition in the mobility sector are increasingly heard. Challenges related to congestion, accessibility and social inclusion, traffic safety, air quality, noise, and energy consumption and CO_2 emissions have been identified on a policy level.[11] SUMPs, or Sustainable Urban Mobility Plans are one tool on the European Union level for cities to frame and critically examine their current local mobility system, and set targets and actions to move towards a more sustainable urban mobility system.[12] The Finnish government has stated in the *Roadmap to fossil free transport* key aims to reduce the

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4 https://ourworldindata.org/co2-emissions-from-transport

5 https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12

6 https://www.tilastokeskus.fi/static/media/uploads/yymp_kahup_1990-2020_2021_23462_net.pdf

7 https://ourworldindata.org/co2-emissions-from-transport

8 https://www.iea.org/news/global-electric-car-sales-have-continued-their-strong-growth-in-2022-after-breaking-records-last-year

9 https://www.eea.europa.eu/ims/greenhouse-gas-emissions-from-transport

10 https://www.iea.org/topics/transport

11 European Union 2017. *European Urban Mobility. Policy Context.* Report.

12 European Commission 2013. *A Concept for Sustainable Urban Mobility Plans to The Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions. Together towards competitive and resource-efficient urban mobility.* Annex.

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transportation related emission by replacing fossil fuels with alternative transportation fuels, through the modernization of the public car fleet, and by improving the overall efficiency of the transportation system.[13] These measures reducing the emissions from transportation are part of the goal of carbon-neutral Finland by 2035.

Even though much of the discourse is based on the 'green' and zero-carbon targets, also the issues related to social sustainability in transportation have been increasingly accounted. The City of Vancouver's *Transportation 2040 plan*, for example, has adopted a hierarchy for different mobility modes, putting *walking* as the first priority (followed by bicycling, public transportation, commercial vehicles, and finally, the private car). Excessive private car use has a negative impact on urban space usage and liveability of the urban environments, and is a major cause (or its use and popularity is the result) of urban sprawl, air and noise pollution, and inefficient spatial use, which, in turn, is creating challenges for just, equal and inclusive transportation systems, such as 'mobility poverty' that refers to an individual's transport-related limitations of participating in different social communities (Kenyon, Lyons and Rafferty 2002). The social challenges related to mobility cannot be answered through cleaner technologies and powertrains alone but need a more holistic and systematic approach in linking transportation planning into urban planning and design practices - in other ways, how we plan and build our cities. When we think about the different issues that affect human mobility habits and routines, we need to take into consideration also the subjective, experienced, spatial, temporal imagined, politicized, and governed aspects of movement next to the material-technological solutions. (See Cresswell 2010; Cervero et al. 2017; Jensen and Lanng 2017; Tartia 2020.)

Improvements in walking and bicycling conditions, and in the usability of public transportation or shared mobility services, are some of the key elements in developing a sustainable urban mobility system. There is potential for reducing unnecessary private car use: for example, currently 40% of all trips made by car in Finland are less than five kilometers in length and 28% under three kilometers in length.[14] Such relatively short trips are potential targets for active mobility modes, public transportation and shared 'last mile' solutions. If we combine this with the fact that globally cities house over half of the global population (which is on the rise, see section 2.3.1), the possibilities for public and shared mobility modes are major.

2.1 Ingredients of mobility hubs

The 'urban nodes', or *mobility hubs*, are important points of 'strategic foci' both for how we plan and design our cities and transportation networks as well as how we each subjectively navigate and experience the city and interact with one another (Lynch 1960, 72). Mobility hubs play a key part in cities: the railway stations, metro stations, bus terminals, bus stops and mobility stations all connect public transportation services to walking and bicycling environments and public spaces in general. Residential areas, workplaces and centers of urban culture have formed around such hubs.

[13] Liikenne- ja viestintäministeriö 2021. *Roadmap to fossil-free transport. Government resolution on reducing domestic transport's greenhouse gas emissions.* Liikenne ja viestintäministeriön julkaisuja 2021:19.

[14] Henkilöliikennetutkimus 2016. *Suomalaisten liikkuminen.* Helsinki: Liikennevirasto 2018.

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Mobility hubs vary in size - basically a miniature hub is formed where-ever there is a change between two different mobility modes (Figure 1). A bus stop - where walking is changed from/to riding a bus - can already be regarded as a micro hub. If we add bicycle parking next to the hub (as a 'park&ride' concept) we already start to add to the hub's complexity and scale. Add a streetside kiosk to the mix and the 'hub' becomes even more complex, and starts to connect not only mobility practices (walking, riding, bicycle use) but also to other daily activities (utilization of the kiosk's services). A metro station is already a larger complex by the nature of the actual construct and the required space to build underground, which means that one can also often find a selection of services, and the spaces dedicated for these services, at the station area. Metro stations are also most often built as part of a dense urban structure, which means that other services beyond the immediate vicinity of the actual metro station are not far away - such as grocery stores or cafés. Larger bus terminals, railways stations and major metro stations can be found adjacent to shopping centers and other similar complexes that mix different uses. Airports are probably the largest hubs in a physical sense, and they also create whole microcosms inside them as they provide different shopping, restaurant and hotel services (though being highly controlled areas and disconnected from rest of the urban structure as separate 'islands').

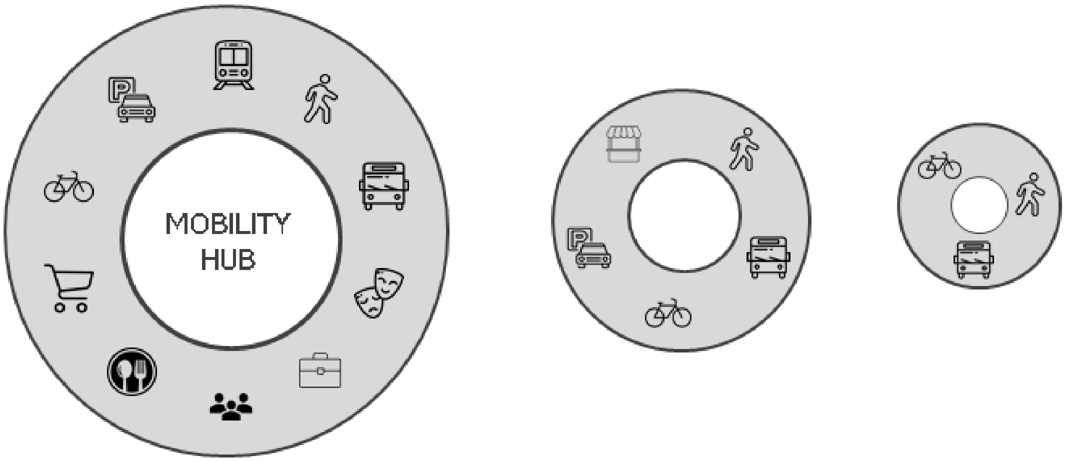

Figure 1. Mobility hubs vary in size. The services and uses of the area in a large/medium sized hub (left) are different from the medium/small (middle) and small (right) hubs. Figure: author

Mobility nodes are formed through both by chance and through active planning processes. Mobility nodes have always emerged where people have conglomerated as the natural sites of crossing trajectories and spatial uses. Early examples of hub-based city planning can be found from over a century ago.[15] In modern city planning, station areas and

[15] In early modern city planning schemes, like Howard's (1898) *Garden Cities of To-morrow*, the urban form was based on the idea of the railway as a connector between self-sufficient urban centers, each such urban core having their own services, housing, and production (industry, agriculture) areas (ideally as circularly) around the hub. Nowadays mobility hubs are seen as playing a key role in dense urban structures - however, in Howard's schemes, the Garden City was designed as an antidote for the over-crowding and air pollution of rapidly industrialized cities (such as London) of the time, as a *new* plan for a city structure.

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terminals have been used as central sites in traffic management. The London Underground - as the first subway system in the world - and its numerous stations are a case in point of the role of a mass transportation mode in creating mobility hubs in the city. The introduction of the automobile and the subsequent increase of private car use - together with urban planning and design paradigms supporting such car-oriented private transportation system since the early 20th century (see Jacobs 1961) - have both somewhat downplayed the role of mass transit hubs.

Mobility nodes have, however, grown again in popularity in recent decades. This re-emerging popularity has been pushed by the increasing demands for carbon-free transportation (together with calls for carbon-free societies in general), the increase of rail-based mass transportation in specific[16]. The nodes have been thematically connected with, in specific, the aims to create densely built urban areas that are walkable and bicycle-friendly (see next section).

The different elements contributing to a 'good' multimodal hub, have been identified in previous research and project development work. Multimodality refers to the changing from one mobility mode to another. Service availability, information and signage, safety, and accessibility are some of the often identified key elements of mobility hubs from a user perspective.[17][18] However, all the aspects of a 'successful' hub that gathers high numbers of users are difficult to define as the hubs also act as (semi)public spaces where other uses of the urban space - such as social gatherings, interactions and encounters - combine with mobility practices that are perhaps more functional and utilitarian in nature. Here, the elements are too many to count as different subjective uses, meanings and experiences connect with the intentions of a transportation planner aiming for a hazzle-free network of urban flows. Movement, of course, is not always utilitarian - needing to move from point A to point B - but can also be explorative, aimless, or the main 'destination' itself.

As the users of the hub are varied - each with their own aims and intentions - the same challenges and questions related to the openness, inclusivity and experiences of safety - among others - are relevant with hub spaces as they are with any (semi)public spaces (see e.g., Franck and Stevens 2007). Interlinked with this notion is also the point on the agency of the hub user - instead of a user utilizing a service in a pre-planned path, the user is a subject with different aims and intentions that might or might not go along with the intended uses and practices planned from the 'above' (de Certeau 1984), thus creating possible frictions and clashes also between the designed (from the 'above') and the used (from the 'below, the mobile subject) practices. It also might be that the elements creating the local hub space are not designed from the above but created by the local stakeholders from the below (Recio, Roitman and Mateo-Babiano 2019) which might cause frictions and negotiations between the formal and informal elements and uses of the space.

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[16] The 'renaissance' of the tramway (for an example see a case study in France, see Bouquet 2017).

[17] Aono, S. 2019. *Identifying Best Practices for Mobility Hubs.* TransLink report.; A Better City 2016. *A Guide to Placemaking for Mobility.* Report.; Shared-use Mobility Center 2018. Mobility Hubs. Report.; Heddebaut, O. 2018. Creating Sustainable and Efficient Transport Interchanges: Some Findings of the City-HUB Project. *Advancementsin Civil Engineering & Technology* 2018:1.; Metrolinx 2011. *Mobility Hub Guidelines For the Greater Toronto and Hamilton Area*. Report.

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2.2 Mobility hubs in the urban structure

Mobility hubs are physically defined spaces that require different kind of elements to work, as noted above. But the hub, of course, does not work in isolation but is inseparably part of the urban structure. The very nature of the hub is to be a transfer point between different mobility modes - the route and the whole travel chain is essential in the making of enjoyable, safe, reliable, and fast public transportation trips that incorporate last mile solutions or active mobility modes (walking, bicycling). The hub - as it gathers people and services together - are also essential to the public life of the area, and the district's vitality.

Transit oriented development (TOD) is one way of framing a planning and design thinking that is built around the idea of the mobility node as the heart and core of the area (Cervero et al. 2017). As the name suggests, transit or public transportation, is taken as the driving force of organizing the local (or regional in some cases) urban districts or areas. The transit station - i.e. a metro station, a bus terminal, a tramway-stop - acts as the heart of the area, and the transportation and non-transportation related services and further connections to the blocks and areas surrounding the hub area, are built around the station. Walking and bicycling conditions are essential here as they connect the local people to public transportation, and also help to generate liveliness and social activity in the area as people spend time in the public space. The TOD-approach does, thus, also link to 'new urbanism' and other similar movements, where elements like the 'human scale' and the human experience in general, 'livability' and heterogeneity of urban life, and quality of the urban environment are taken as focal points for the design of the urban environment. (Ibid.). The TOD-approach is closely linked with the aforementioned approaches carrying other names that focused on similar questions about how urban spaces and human mobilities were organized and choreographed in the city (see Lynch 1960; Jacobs 1961; Gehl 1971; Appleyard 1981; Calthorpe 2011).

The Institute for Transportation & Development Policy has listed key TOD benefits. These include environmental, societal, equality, health, road safety and city efficiency benefits.[19] These benefits are gained through the minimization of urban sprawl, by better addressing the needs of marginalized populations, enabling active mobility modes, reducing the number of car trips, and by encouraging efficient use of city resources. They have also developed standards for TOD that can also be measured and followed. These principles are presented as: walk (pedestrian safety, completeness, activity, comfortable), cycle (safety, completeness, parking spaces ample and secure), connect (walking and cycling routes are short and varied, and shorter than motor vehicle routes), transit (high-quality transit accessible by foot), mix (services and other amenities are within a short walking distance, public space is active through-out the day, diverse demographics occupy, work and live in the area) , densify (high residential and workplace density supports local services, active public space and high-quality transit), compact (a new developed area is adjacent to another urban area, moving through the city is convenient), and shift (the space occupied by motor vehicles is minimized).[20]

The *15-minute city* approach is one specific form derived from the aforementioned approaches that favor dense urban areas and mixed-use zonal planning, together with

[19] https://tod.itdp.org/why-tod-matters.html

[20] Institute for Transportation and Development Policy 2017. *TOD Standard*, 3rd edition. New York: ITDP.

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active mobility modes and public transportation. The 15-minute city is based on the idea that all daily services would be in the reach of 15minutes travel, made up of interlinked 5-minute neighborhoods. This also means that areas have not only housing, office spaces, or specialized activities, but provide the necessary everyday services. In contrast to planning how different services can be reached from specific areas, the 15-minute city planning principles aim to bring the services to the districts. The 15-minute city idea - although introduced before the global pandemic, and based on design principles dating back decades, has gained traction in the discussions on what the post-covid-19 cities will look like (Moreno, Allam, Chabaud, Gall and Pratlong 2021; Pozoukidou and Chatziyiannaki 2021). Here, as noted above, the question about accessibility and inclusion are central - for *whom* the city is reachable, both physically and socially.

'Walkability', for example, has been one key point of discussion in in current urban research and development practices, indicating the quality of the walking environment as a whole, including elements related to the infrastructure, traffic safety, social safety and access to services. The walkability, or walker-friendliness, is measured through different (often expert-led) measures that consider the human-scale elements, physical accessibility and distances, and the quality of the urban environment, and often also policies and other less tangible elements (Forsyth 2015). Bikeability is also used similarly to examine the bicycling-friendliness of the urban environment (Castañon and Ribeiro 2021) (for details, see also SPARCS internal report: *Electric bicycling and urban mobility in Espoo and beyond*).

Increasingly, mobility hub development is also examined through the trip between the mobility hub and the first/final destination (that rarely is the hub itself). This 'last' or 'first mile' (or 'kilometer') is the focus of piloting and new innovation in terms of mobility services - such as e-kick scooters, public shared city bikes, or automated shuttle-like feeder-line bus services.

2.3 Mobility hubs and global trends

Multiple global processes are currently transforming urban mobility. Here, four major drivers are examined in detail: urbanization and densification of cities, increase of shared mobility services and digitalization, broad electrification of vehicles, and the effects of COVID-19-like global pandemics that have direct effects to urban mobility behavior. This is not to say that other drivers could not be identified, or would be of lesser importance - rather, these four are interlinked closely with each other and with the mobility hub development on a system level. Next to these four global currents ageing population, network-type power and influence, war, technology integration (including data security), and strives for new types of economic models (including circular and sharing economy) are some of the key trends that can be identified (Duffa 2020). Additionally, there are also a myriad of other smaller and less visible currents brewing that can have major implications on how we live and move in cities and beyond. These trends all have an effect on the role of mobility hubs in (near-)future urban mobility systems and the making of urban public spaces.

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2.3.1 Urbanization and the densification of urban areas

The world is urbanizing in a rapid pace: over half of the global population already lives in urban areas, and by 2050 this number is expected to reach 68%.[21] The overall increase of global population, and its migration to urban areas, means that cities are increasing in size and complexity. The increase of the population migrating to cities also puts stress on the development of sustainable urban areas and on the urban land use policy in general, underlining the need for a dense enough urban structure to prevent the negative effects of urban sprawl whilst retaining urban green spaces and large enough living spaces to keep cities habitable and human-friendly spaces. Cities already consume two-thirds of the globally energy, and account for 70% of global carbon dioxide emissions.[22] This means that new urban solutions and practices need to be developed to combat the increasing resource use and emission production in a fair and just manner.

Mobility hubs can play a key role in fostering further sustainable mobile behavior in such a setting, connecting the spaces people live and work into mass transportation and different 'last mile' services between the hub and the ultimate destination of the journey. Efficient mass and shared mobility also make room for public spaces and green areas, as the need for vast car parking lots is decreased through the decreased car use and car ownership. New possibilities related to increasing interest towards service economy and shared mobility services, as well as the general electrification of different vehicles and the introduction of new ones, provide also potential for new approaches towards urban mobility. Automated delivery and freight services, remote working practices (see section 2.3.4) and new ways of social interaction between people (e.g., virtually) are also key elements that affect the way cities and urban spaces look like and function in the future.

The urbanization of the global population also means that the cities are important sites in the global network (as they have always been, see Jacobs 1969). Cities are the places where new solutions are developed to meet up with the, in many regards urban, challenges. Migration, inequality, land and resource use, emissions, prosperity, rights, and measures against pandemics, are some key issues related to the (un)sustainable growth of the cities in the future.[23]

2.3.2 Shared mobility services in the sharing economy

Shared and service-based mobility practices have emerged recently, partially due to the advances in digital connectivity and the emergence of app-based mobility services. Shared services are not a new invention but digital solutions have recently provided possibilities - e.g. through apps and platforms - to develop new service models and automated user interfaces. Instead of having to fetch a key for a shared bicycle from a dedicated office in the city center, a modern shared city bike system operates fully digitally. There have been no shortage of different solutions and companies recently, providing shared mobility services, both in micromobility (bicycles, e-bicycles, electric kick scooters) and in shared cars.

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[21] United Nations. 2018. *World Urbanization Prospects: The 2018 Revision.* Economic and Social Affairs, United Nations.

[22] https://unfccc.int/news/urban-climate-action-is-crucial-to-bend-the-emissions-curve

[23] United Nations 2020. *The Value of Sustainable Urbanization. World Cities Report 2020.* UN HABITAT report.

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These shared mobility services have developed alongside other subscription based services: things like Netflix and Spotify have changed how we watch films or listen to music. Similarly vehicles can be used for rental periods (ranging from minute-by-minute charging to hourly or daily rates). These services have been formed both around companies operating their own fleet, or around users who rent their own equipment through a peer-to-peer service model. It could be said that we are experiencing a shift towards temporary, subscription-based usership from ownership, which follows the basic principles of sharing and circular economy. Examples of shared mobility systems are aplenty. Public shared city bikes[24], e-kick scooters, shared cars and e-cars are common sights in different cities. Autonomous transport has also been piloted in different cities, which is often situated somewhere between traditional public transportation and mobility-on-demand (MOD) solutions.

Mobility as a Service, or MaaS, gathers this thinking under a single concept. Mobility, here. is thought of as a service, or a practice of moving from point A to point B, and not through the vehicles or the infrastructure facilitating it. A report from Ramboll concludes that new mobility modes, services and platforms can succeed in densely populated areas where there are high amount of commerce facilities and workplaces, and where bicycle access is high (as part of the travel chain). The report also notes that MaaS approach can make better use of the mobility system, rather than invent it anew.[25]

A question that remains mostly unanswered is that will the broader utilization of shared vehicles mean that urban space needs also be re-arranged in some way to better support, or even *favor*, shared vehicle use and mass transit over private vehicle use? How the services are placed in a given space, how accessible and easy to find they are, and what kind of policies are set to regulate their use, are relevant questions affecting the use of the shared mobility services. For example, the city-by-city regulation of shared e-kick scooters, which seemed to take many cities by surprise, and their operational models, have been developing step-by-step in collaboration between the cities and the companies.[26] Urban space is a scarce resource, and how it is used makes all the difference in the popularity of different mobility modes. Whereas a walking takes up 2 m^2 of space, and bicycling 5 m^2, a car travelling at medium speed already requires 140 m^2 of space around it.[27]

2.3.3 Electrification of urban mobility modes across the field

Electrification of different mobility modes is progressing in a rapid pace, motivated by the need for a transition away from fossil fuels and combustion engines. The electrification of buses, cars and bicycles happens alongside the emergence of new types of electric vehicles, such as the shared-service based electric kick scooters that have popped-up in many European cities in recent years. Aviation is also turning electric, and also seeping more into the urban mobility system as well. Electricity and electric motors are replacing

[24] For more details see SPARCS internal report *Electric bicycling and urban mobility in Espoo and beyond,* available in the project bank.

[25] Ramboll 2019. *Whimpact. Insights from the world's first Mobility-as-a-Service (MaaS) system.* Report.

[26] https://yle.fi/uutiset/3-12373100

[27] https://www2.deloitte.com/nl/nl/pages/real-estate/articles/mobility-hubs-real-estate-predictions.html

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petrol and diesel engines in different vehicle types, and in light vehicles, electricity is added to support or fully replace muscle power.

What, then, are driving the electrification of mobility? The different zero-carbon and emission-related targets are probably the key elements driving the rapid shift to electric powertrains. The EU is setting a goal of banning the sale of new petrol or diesel engine cars in 2035.[28] Car manufacturers are required to produce low emissions vehicles before that as well, with the penalty of a fine if the overall emissions of the newly sold cars is too high.[29] Similarly, emission targets are set for heavy duty and commercial vehicles, for example through the EURO classes.[30] Cities globally are aiming to electrify their own fleets. Public transportation sector's buses are electrifying rapidly as well, driven by, for example, the public procurement processes that score zero-carbon fleet higher than the traditional one, which means that operators that have capacity to provide electric buses are more prone to win the route operation tendering process. At the same time, also the charging infrastructure is being developed rapidly. The EU is setting a goal of having a charging infrastructure network where an EV charging station can be found at least every 60 kilometers.[31]

However, few cities have developed strategies or practical implication plans for the rapid electrification. The questions about roles and responsibilities between the private and the public sectors, and between the local, regional, national and international levels, on how the infrastructure will be built in the future. How are the costs shared, how the planning and decision-making processes are organized, and how is the operation and maintenance organized, are questions that seem to be still somewhat in the air. Some pilots have been made to develop new service models that also included the installation and operation of the chargers (for an example from Stockholm, see section 4.1 below).

The recent rise of electricity price poses one challenge to the rapid electrification. The general electrification of societies (not just in mobility but also in heating, manufacturing, households) is happening alongside with the fossil fuel dependency decoupling and the growth of the renewable energy source utilization. This can lead to an unjust and inequal transition - for example to the aforementioned mobility poverty, or similarly 'energy poverty' - if the risks are not managed on different levels. The whole life-cycle of electric vehicles also needs to be considered when examining the transition towards electric mobility and the policy related support of it. The raw materials needed for electric batteries, for example, are mined partially in areas where there are major social concerns.

2.3.4 Covid-19 and the 'new normal' of urban mobility

The whole mobility system experienced a massive shock in 2020, as the unprecedented global virus pandemic, the Covid-19 or 'corona virus', affected societies in multiple ways, The pandemic transformed both mobility and urban life habits and routines in cities globally. In the first waves of the epidemic, public transportation experienced a major

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[28] https://www.reuters.com/business/retail-consumer/eu-proposes-effective-ban-new-fossil-fuel-car-sales-2035-2021-07-14/

[29] https://ec.europa.eu/clima/eu-action/transport-emissions/road-transport-reducing-co2-emissions-vehicles/co2-emission-performance-standards-cars-and-vans_en

[30] https://www.transportpolicy.net/standard/eu-heavy-duty-emissions/

[31] https://op.europa.eu/webpub/eca/special-reports/electrical-recharging-5-2021/en/

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decrease in both users and operations. This was due to the various 'social distancing' measures applied in varying degrees in cities globally, such as endorsing remote working practices (where possible), limiting the availability of public transportation services, closing of schools, sports areas, restaurants and other public and private amenities, and even setting up of curfews and restrictions for movements in the city.

However, as the public transportation decreased as people opted to avoid mass transit options, the need for private mobility increased. Some larger European cities initiated measures to increase the walking and bicycling spaces in their street spaces, for example by closing streets completely from motor traffic, or by dedicating a car lane to a bicycle path. Such measures were done, for example, in Milan, London and Paris.[32] It seems that at least some of the actions done in cities have also been carried through to this day when the societies have been opened again. In addition to walking and bicycling related actions, we saw also a surge of different private car related changes. For example, a vast variety of different pop-up drive-in services emerged, where day-to-day life practices were conducted from the insides of the car. These measures included drive-in corona test-sites, grocery delivery pick-ups, and cinemas, as well as perhaps some more oddities, such as drive-in music concerts, weddings and school graduation ceremonies. Private mobility - whether walking, bicycling or car-use - all experienced a boost during the corona virus pandemic.

In the capital metropolitan region in Finland, the reported decrease of public transportation use in 2021 was 40% lower in comparison to 2019.[33] The main activities in Finland were the shift to remote working practices, closing temporarily public and private services, setting up different 'drive-in' and 'walk-in' service (such as virus test sites), reducing public transportation services, and endorsing the use of facial masks in all public areas and vehicles. There were no curfews set in any Finnish cities but the southern Uusimaa region - where the capital Helsinki metropolitan region is located - was isolated between 28.3.-15.4.2020 in an attempt to prevent the spread of the virus from the region where the infection rates were higher than rest of the country.[34]

As mass transportation modes were affected by the corona virus as decrease of users, this has also had effects to mobility hubs. The station areas became places people avoided (if possible), which also caused negative impacts to the different services in the hub area. It remains to be seen what the 'new normal' of transportation and urban mobility will be in the upcoming years. There are some indications that the biggest dip in mobility of 2020, has been already caught up, at least on some fronts. It remains to be seen whether the positive effects the Covid-19 pandemic had on walking and bicycle use outweigh the negative developments, i.e. the decrease of public transportation use and the increase of car use.

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[32] https://www.theguardian.com/lifeandstyle/2021/mar/12/europe-cycling-post-covid-recovery-plans

[33] https://www.sttinfo.fi/tiedote/hsln-tilinpaatos-2021-matkustajaluvut-kavivat-pohjalukemissa?publisherId=4396&releaseId=69936467&lang=fi

[34] https://yle.fi/uutiset/3-11692794

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3. DEVELOPING E-MOBILITY HUBS IN SPARCS PROJECT

In SPARCS project the general aim is to find solutions and models for sustainable *positive energy districts* (or PEDs). There is no singular *de facto* definition for a PED but one way of framing it - as used by JPI Urban Europe - is that it is a specific area or district that produces more energy than consumes it, and the energy generated is renewable, such as solar or wind energy[35]. The European Union has set a target for 100 PED areas in the EU by 2025.[36] These districts, in essence, are ones that produce more energy than they consume, and thus benefit also other areas where the excess energy can be transferred to. The area operates as a system, where the different elements producing/consuming energy interact and benefit from one another through flexibility, and local energy production and storage. Mobility plays a key role in these districts as major local energy consumers - and increasingly due to electrification of vehicles, are a key part of the way the local grid operates. The local citizens also play here a major part, being key stakeholders in local energy communities, which can potentially bring along community building benefits. The PEDs, thus, can help to lower emissions by increasing the energy production through renewable energy sources, and through using smart use of energy. Therefore, the development of different green mobility solutions - electric vehicles, shared mobility services, walkable built environment, biking conditions, and others - are important not only for general sustainability of cities, but for the PED framework as well, as they cut down the emissions in the district as well as on the city-wide scale.

3.1 Case Espoo

Espoo is part of the capital Helsinki Metropolitan Region, located in the southern Finland. Currently, there are 300.000 residents in Espoo, which makes it the second largest city in the country. Espoo is characterized, and actively developed, as a ‘network’ type of urban structure, as stated in the city strategy for the council term 2021-2025.[37] The city is composed of five urban centers - with all the relevant public services in each center - that are connected by rail and/or motorway connections (Figure 3). These centers are *Espoon keskus, Tapiola, Leppävaara* (SPARCS demo site), *Matinkylä* and *Espoonlahti* (SPARCS demo site). In other words, the city does not have one (historical) center (that would have grown in size over time, as many cities have) but that it has multiple center-like areas that have developed alongside one another. In addition to the five city centers, there are also multiple other smaller urban cores in between, such as the new and actively developed *Kera* (SPARCS demo site) and *Finnoo* districts. The different urban centers are developed as mobility hubs, connecting ‘last mile’ solutions to rail-based public transportation (metro, commuter trains, fast tramway). These major mobility hubs are actively developed by the city and different stakeholders, and they are used to house both public and private services.

Espoo has traditionally been known as a motor city. The Leppävaara and Espoon keskus centers have had trains connections for decades, but the other centers have been

[35] https://jpi-urbaneurope.eu/ped/

[36] https://jpi-urbaneurope.eu/ped/

[37] https://www.espoo.fi/en/city-espoo/espoo-story

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connected to a rail-based public transportation only rather recently in 2017 through the opening of the city's first metro line (which is directly linked to the metro line in Helsinki, opened in 1982). The modal split reflects this historical narrative: in 2018, 46% of all trips were made by using the private car (26% on foot, 18% with public transportation, 9% with bicycles)[38]. These numbers, however, are rather common for cities in Finland - trips made by private car in Helsinki is 39% (2018) and in Tampere 45%[39] (2016) but they are rather different in comparison to other Nordic cities that have actively developed their bicycle infrastructure. In Espoo, 32% of CO2 emissions were transport related in 2020[40]: roughly half of the mobility-related emissions are caused by private car use. In other cities the situation is similar: 23% in Helsinki, 48% in Stockholm and 34% in Copenhagen[41]. The train connections serving the centers of Espoo Centre and Leppävaara (of which the latter will be also serviced by a tram connection in 2024), and the new metro connection serving Tapiola, Matinkylä (metro line opened in both in 2017) and Espoonlahti centers (extension of the metro line opened in late 2022) form the key public transportation corridors in the city (Figure 2).

There are approximately ~500 public charging points for EVs in Espoo in around 80 charging stations (in 2021).[42] Most of these chargers are found in the city centers and shopping mall parking garages, gas stations or supermarket parking lots. The City of Espoo only own and operates around 45 charging points which are mostly located next to sports venues and other outdoor areas, such as the Halti visitor center in the Nuuksio national park. The city is currently examining the role of different stakeholders - including the city itself - in the further acceleration of the construction of charging spots in the city to answer the growing demand in the near future.

There are currently around 30 e-buses operating in Espoo area. Public transportation in Espoo and the whole Helsinki Metropolitan Region is organized by HSL (Helsinki Region Transport), which is co-owned by the municipalities in which it operates. HSL has set an ambitious target to electrify the bus fleet that operates on the routes by setting standards for e-bus uptake in the procurement process. The aim is to have one-third of the operating fleet electric by 2023, which means 400 electric buses.[43] The buses use certified RES-produced energy. The bus fleets are owned and maintained by different companies through a procurement process and contracts organized by HSL. In terms of charging the e-buses, different possibilities have been actively examined - whether the charging takes place along the route (the end stops and larger terminals) of whether charging is carried out in specific depots during the times the buses are not in operation.

[38] Espoon kaupunki 2021. *Liikennekatsaus 2021*. Report.

[39] https://www.tampere.fi/tiedostot/k/NhbU13wr1/Kestavan_kaupunkiliikkumisen_suunnitelma_SUMP.pdf

[40] https://www.hsy.fi/ilmanlaatu-ja-ilmasto/kasvihuonekaasupaastot/

[41] https://carbonneutralcities.org/cities/

[42] Espoon kaupunki 2022. *Espoon liikennekatsaus 2022*. Report.

[43] https://www.hsl.fi/hsl/sahkobussit

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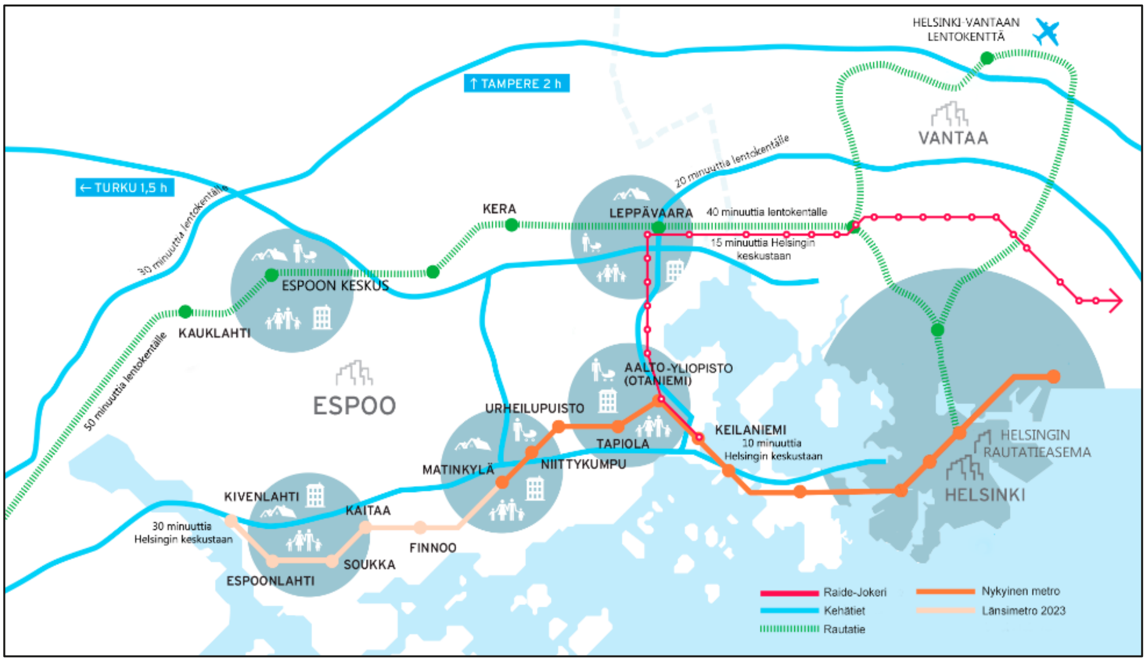

Figure 2. Map of Espoo. The five urban centres of Espoo (starting from top left, clockwise: Espoon keskus, Leppävaara, Tapiola, Matinkylä, Espoonlahti). Source: City of Espoo

Espoo's *public shared city bike system* was launched in 2018. The system is in use both in Espoo and Helsinki, and the users can use the same bicycles and docking stations between the two cities. There are currently 460 docking stations and 4.600 bicycles (non-electric) in the system. The system is organized by HSL. There are also multiple electric kick scooter operators active in the Espoo area. The City of Espoo works in collaboration with the service providers to set the common framework for the operation in the area. The City and the operators have also initiated pilots related to testing and further developing dedicated parking solutions for the electric kick scooters, that have initially worked in a fully free-floating system where parking is possible in any place inside the designated operation area. The development of the parking solutions has aimed to tackle the issue of parked e-kick scooters blocking sidewalks and entrances, and to generally further develop e-kick scooter use as a 'last mile' solution and their role in the local urban mobility system.[44] The public shared city bike system in Espoo (2018 onwards) and other recent development on shared micromobility (including shared electric kick scooter services operating in the city area) have been covered in more detail in the internal report 'Electric bicycling and urban mobility in Espoo and beyond' (available in the project bank.).

[44] https://www.sttinfo.fi/tiedote/espoossa-kehitetaan-sahkopotkulautojen-ohjattua-pysakointia?publisherId=3385&releaseId=69885959

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3.2 The SPARCS demonstration areas in a close-up

SPARCS Espoo demonstration areas Leppävaara / Sello blocks, Espoonlahti / Lippulaiva blocks, and Kera are examined below from mobility hub perspective. In size and role in the city's overall mobility system, they range from a major mobility hub (Leppävaara) to a redeveloped hub that will increase in importance in the near future (Espoonlahti), and to a future local district level hub (Kera) (Figure 3).

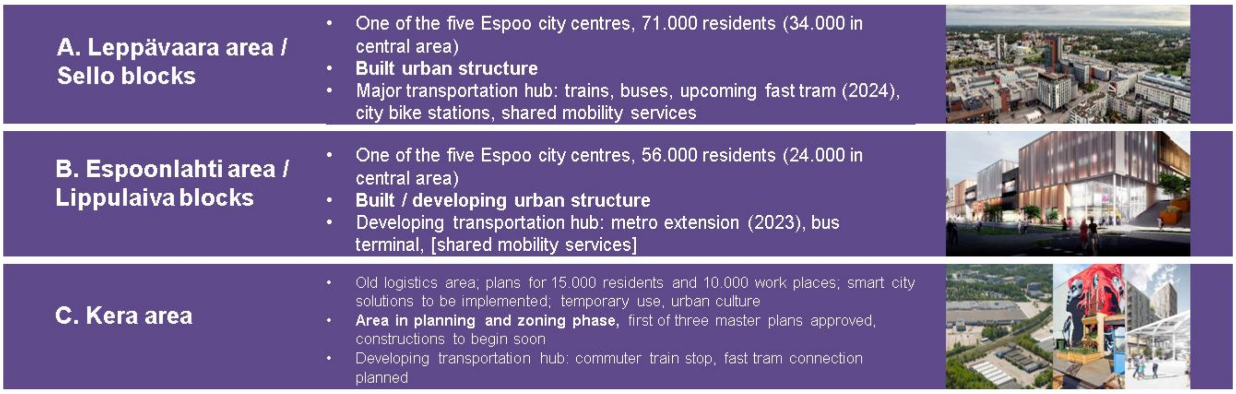

Figure 3. All three Espoo SPARCS demo areas also act as central mobility hubs in the city's network of urban cores. Figure from 2021. Source: author.

3.2.1 Leppävaara area and the Sello blocks mobility hub

Leppävaara is the largest urban centre in Espoo, with around 71.000 residents in the Greater Leppävaara area. Leppävaara is located in the eastern part of Espoo, right next to the Espoo-Helsinki municipality boarder. The area is composed of multiple city districts, including the Leppävaara centre (34.000 residents) where the main mobility hub of the area is situated.

The mobility hub in the heart of Leppävaara, next to the Sello shopping centre, is serviced by local commuter trains (also intercity trains in the Helsinki-Turku route) and buses (Figure 4, Figure 5). The Sello shopping centre is a major service point in the area - with shops, restaurants and cafés, cinema etc. - that also has public services, such as the library, situated under the same roof. The e-bus charging system - that is also developed and optimized further in SPARCS - is located in the area as well. Multiple public shared city bike stations are also situated in the area, together with other shared mobility services, such as e-kick scooters that operate in a free-floating system where parking is not dedicated to specific docking stations or areas. A sheltered bicycle park is located under the train tracks with access to the platforms. On the opposite side of the Sello shopping centre there is a dedicated 'park & ride' area for car parking. There is parking for the shopping centre users underground as well as on the roof of the Sello building for 2.900 cars. In one of the underground parking levels, there is also EV-charging points for 25 e-cars.

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Figure 4. Leppävaara mobility hub: the station area. The Leppävaara train station area is connected directly to the bus terminal with e-bus chargers. The dedicated bicycle path runs under the station and connects to an underground bicycle park. Photos: author (from Oct 2021)

The Leppävaara mobility hub is already an active mobility hub but there are also active development work going on. There have been plans to extend the Sello centre premises in the future, and to increase the commercial and public services provided in the area. A fast tram connection Raide-Jokeri currently under construction in the area - and to be opened for operation in 2024 - will add to the mobility mode selection in the hub in the near future. Leppävaara is also an attractive site for new shared mobility solutions due to its size (population, services, facilities) and location.

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Figure 5. Leppävaara mobility hub: the Sello shopping centre blocks. The multi-story Sello shopping centre has outdoor and indoor walking areas inside the blocks in multiple floors. There are basic bicycle racks in the area and public shared city bike docking stations. E-kick scooters can also be found in the area, parked next to the main entrances in a free-floating system. Inside the Sello shopping centre, there are also automated postal delivery lockers in different parts of the area. Photos: author (from Oct 2021)

3.2.2 Espoonlahti area and the new Lippulaiva blocks mobility hubs

The Greater Espoonlahti area, located in the south-western part of the municipality, is the second largest urban centre in Espoo with 56.000 residents. Like Leppävaara, Greater Espoonlahti is also comprised of multiple smaller districts, including the *Espoonlahti centre* (24.000 residents) where the Lippulaiva blocks are located. The old Lippulaiva shopping centre was demolished in 2017, and it was replaced by the new Lippulaiva, which was opened in March 2022. (Pikkulaiva shopping centre was constructed as a temporary replacement for the duration of the construction phase, and it will be relocated after the new Lippulaiva is completed). The new Lippulaiva centre, similarly to Sello, hosts both private and public services and facilities under its roof.[45]

[45] For more details, see also SPARCS internal report 'Sustainable urban mobility in Espoonlahti. Strategic approach for boosting sustainable mobility in the area' (available on the project bank.)

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Figure 6. The new Lippulaiva blocks under construction in Espoonlahti area. Taxi ranks, bicycle parking, and EV-charging were available in the area at the time of the site visit. Photos: author (from Oct 2021)

Figure 7. The upcoming Espoonlahti metro station, depicted in both visualizations and photos depicting the current status of construction phase, figures from: https://www.lansimetro.fi/asemat/espoonlahti/#ca882171 . Lippulaiva virtual room gives an overview of the whole blocks and the local mobility system (lower row, left picture), source: https://webar.arilyn.com/lippulaiva/

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The new metro station (opened in late 2022) located directly below the Lippulaiva premises, together with the feeder bus terminal located inside the blocks, will transform the new Lippulaiva into a central mobility hub in the area (Figure 6, Figure 7). The metro is the first rail-based public transportation in the area and will help to connect the area to the eastern Espoo and Helsinki. There is currently no city bike system in Espoonlahti, which decrease the number of available 'last mile' options in the area, but the developing metro line and the station area, together with Lippulaiva, will most probably be an attractive location for both public and private shared mobility services in the future. Lippulaiva has over 130 EV charging points, and parking for over 1.300 car parking spaces and 1.400 bicycle parking spaces.[46]

3.2.3 Kera area mobility hub

Kera is an old brownfield type logistics area, which is now being transformed into a new urban district. The new developed Kera district will provide housing for 15.000 residents and 10.000 workplaces. Kera is planned to be an international example for a sustainable and circular economy urban district, and it is actively developed with a broad stakeholder group, including organizations, companies, landowners and citizens. Multiple projects are also piloting new urban and circular economy solutions and practices in Kera together with SPARCS. Technological companies and polytechnical university premises are located in the area, making it an interesting hub for learning and innovation. The new Kera area will comprise three plans: first one of these is finished, the other two are in the planning and decision-making process. The construction of new buildings is expected to being in the upcoming years.

Kera has also become known for its temporary uses of the logistics halls for various craftmanship, sports and cultural activities.[47] The Keran Hallit or Kera Halls[48] have been actively developed to have temporary uses during the time when the previous activity in the halls ended (as a new logistics area was constructed elsewhere) and the construction phase has yet to begun (the activities are set to continue up to 2025). The temporary uses have included sports areas, breweries, workspaces, festival areas, art exhibitions, and others. The site has also been used as a living lab for new sustainable, circular and smart urban solutions, including urban farming and autonomous transport. The halls also have Kera Hub space which is operated City of Espoo to host different local events and meetings related to the development of the area and sustainable development solutions. In 2022, the first parts of the halls were demolished, and rest of the halls will eventually follow suit.

[46] https://lippulaiva.fi/saapuminen/

[47] https://www.hs.fi/kaupunki/espoo/art-2000008311138.html

[48] https://www.keranhallit.fi/en/etusivu-english/

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Figure 8. The old Kera logistics area with temporary elements of urban culture and temporary uses of the area depicted. Photos: author (from Oct 2021)

Kera is a unique site in the sense that it already has a train station with an active commuter train connection that is located in the heart of the soon-to-be redeveloped area (Figure 8, Figure 9). Kera is planned and designed as a walking, bicycling and public transportation focused area, and the commuter train station can aid in realizing this vision by providing fast, rail-based transportation with a frequent service. This station also supports the construction phase of the area: often, new urban districts face the challenge that public transportation options might come late into the picture in the area's development phase. The first residents might have low or non-existing public transportation service, or a level of service inadequate to attract users. This can easily lead to the vicious cycle that results into car dependency, and which affects the future development of the area (as parking spaces and car use is favoured as the area has 'grown into it'. In Kera, the area is already served by a rail-based connection, and the station can evolve as an already utilized station area. The station area itself might be used as a physical platform for pop-up services and activities, including explorative tests and pilots, mirroring the temporary uses -attitude from rest of the Kera Halls. Fort example, an automated bus (GACHA bus by Sensible4 and MUJI) has been tested publicly in the area in 2019, connecting the Kera train station to the office campus area.[49]

[49] https://sensible4.fi/company/newsroom/gacha-pilot-in-kera-espoo-begins/

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Figure 9. The Kera commuter train station, which is actively in use, provides a platform for mobility hub development and experimentation, e.g. with temporary modular construction solutions. Photos: author (from Oct 2021)

3.3 Sustainable Espoo development projects experimenting and piloting new sustainable mobility solutions

Mobility hubs have been developed in Espoo through recent Sustainable Espoo development program's projects that are related to the city's overall sustainable development work and aims towards low cardon transportation. They support the Carbon neutral Espoo 2030 target and the achievement of the United Nation's Agenda2030 Sustainable Development Goals by 2025, as stated in the city's strategy[50]. The projects have, in specific, focused to tackle the 'last mile' (or 'first mile') issue, meaning how to create sustainable mobility possibilities for the part of the trip that extends beyond the hubs utilized on the journey. These including through the use of autonomous robot buses, the city-as-an-employer policies supporting sustainable mobility mode use for its employees, and the development of services on station areas.

ÄLLI Älykkäät liikkumispalvelut (2019) project examined potential of smart mobility services in sustainable urban mobility, and the role of the city in promoting sustainable mobility. One central interest in the project was to map and identify current and potential mobility hubs in Espoo area, from the small scale hubs to large scale transportation

[50] https://www.espoo.fi/en/city-espoo/espoo-story

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terminals. The project identified smaller hubs of workplace accumulations, medium-sized hubs of urban cores, and the large scale hubs of the five city centers of Espoo.[51]

FiksuAssa (Smart stations) (2018-2021) project aimed to develop urban station areas, the 'tapping the potential of stations as a development platform of new low-carbon and climate friendly services and solutions', as stated on the project's website. Espoo, Helsinki, Vantaa, Riihimäki and Hämeenlinna were the partner cities of the project, all located in the southern part of Finland. In the project, station areas were transformed into pop up -platforms for new smart and low-carbon solutions. The project focused on new mobility and logistics services in collaboration with companies and organizations. [52]

In *6Aika: Low-carbon mobility in transportation hubs* project (2019-2022)[53] new mobility services have been piloted in Espoo (and in the other project cities). The project was funded by the European Regional Development Fund, and it was a joint effort by the City of Espoo, the City of Turku, the City of Oulu, Business Tampere and Turku University of Applied Sciences. The aim of the project was to developed smoother and easy-to-use low-carbon travel chains by adding new 'last mile' services to the local service selection in the form of practical pilots with companies and service providers. The pilots organized in Espoo have included, for example, a test run of a e-bicycle battery charging cabinet in Otaniemi campus to promote e-bicycle use in hub environments, and a district-level shared car system that helps to tackle the occasional need for private car use. The pilots have taken place in different parts of Espoo, including Otaniemi campus, Leppävaara and Tapiola. In addition to the new shared mobility service pilots, the project also has aimed to develop autonomous bus transportation as a near-future transportation mode in connection with mobility hub development and 'last mile' strategies.

Kestävä liikkuminen osana Espoo-tarinaa (Sustainable mobility as part of The Espoo Story city strategy) KESTO (2019) project, funded by the Finnish Transport and Communications Agency, aimed to increase the awareness related to sustainable mobility services of local citizens and the City of Espoo employees. The project conducted surveys on the current situation of multimodal station areas, and produced new visualizations to depict the concept, marketed sustainable mobility modes for people working in Espoo, including the use of public shared city bikes and folding bicycles as 'last mile' solutions, and examined possibilities to make the current economic support for commute trips that the city provides for its employees more balanced between private and shared/public mobility modes, and developed a vision for sustainable work related trips up to year 2025 to support the carbon-neutrality targets set in the city strategy.[54]

The Implementation Pathway for Environments that Accelerate Sustainable Growth (KETO) (2021-2023) project aims to develop new solutions in the context of the green transition and response to the Covid-19 pandemic. The project is a collaboration between the City of Espoo, Aalto University, Omnia (the Joint Authority of Education in the Espoo region) and VTT research institution. In one of the project activities, ZEMhub (Zero Emission Mobility Hubs) concept is developed in Espoo area that act as a test site for different

[51] Kestävä liikkuminen osana Espoo-tarinaa KESTO 2019. *Loppuraportti*. Report.

[52] https://www.asemanseutu.fi/in-english/

[53] https://6aika.fi/project/vahahiilinen-liikkuminen-liikennehubeissa/ (in Finnish)

[54] https://www.traficom.fi/sites/default/files/media/file/Espoo_Loppuraportti_KESTO_2019.pdf

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electric commercial and utility vehicles. The test site supports the development of new solutions for high power charging and electrification of logistic (trucks) and other heavy-duty vehicles.[55]

4. MOBILITY HUBS - CURRENT DEVELOPMENTS AND POSSIBLE FUTURES

In this section, examples from projects developing mobility hubs are examined. In the first subsection, the focus is set on the development of mobility hubs, e-mobility and shared mobility services in different projects. These projects, similarly to SPARCS, connect to the previously highlighted global trends of increasing electrification of all vehicle types and the increase of shared mobility service offering and use in urban environments. In the second section, the focus is set on examples that provide innovative real-life or concept-level solutions that provide new perspectives to mobility hub development and what urban mobility might be in the near future. Cases related to modular mobility hub concepts, bicycle parking, bus stops, and re-thought mobile spaces are presented.

4.1 Developing mobility hubs: shared e-mobility approaches

eHUBS - Smart Shared Green Mobility Hubs (2019-2022) is an Interreg North-West Europe project that aims to develop new small-to-medium sized on-street e-mobility hubs called eHUBS in six partner cities. On the project website, it is stated that 'eHUBS are on-street locations that bring together e-bikes, e-cargo bikes, e-scooters and/or e-cars, offering users a wide range of options to experiment and use in various situations.' The pilot activities creating such eHUBS have included the addition of shared light electric vehicles, such as electric bicycles and e-cargo bikes, and outdoor automated parcel machines to the on-site street location.[56] The City of Amsterdam, who leads the project, have, for example, created a total of 17 eHUBS in different parts of the city.[57]

The Interreg North Sea Region *SHARE-North: Shared Mobility Solutions for a Liveable and Low-Carbon North Sea Region* project has produced a mobility hub development guide that examines the different aspects that need to be considered in the making of a functional mobility hub. The mobility hub is divided into different 'components' that are crucial in its composition, including public transportation and shared mobility components (bus, trams, shared vehicles), mobility-related components (EV car charging, bike repair stations), and non-mobility and urban realm improvement related components (safer crossings, wi-fi availability, waiting area spaces, seating). The guide identifies different locations and contexts for the hubs, such as large interchanges, transport corridors, business parks, tourism hubs, and village hubs. The key lessons learned are that the mobility hub needs to be tailored to the local context, support and input is needed from the community groups, limitations need to be considered

[55] https://www.espoo.fi/fi/uutiset/2021/12/eun-elpymisrahoitus-vauhdittaa-espoon-kestavaa-kehitysta

[56] https://www.nweurope.eu/projects/project-search/ehubs-smart-shared-green-mobility-hubs/

[57] https://www.nweurope.eu/projects/project-search/ehubs-smart-shared-green-mobility-hubs/news/amsterdam-launches-its-last-ehubs-and-much-more/

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realistically, and that upkeep and maintenance of the hubs needs to be budgeted and planned in detail.[58]

Horizon2020 GrowSmarter (2015-2019) project has developed different mobility solutions, which include a green parking index for EV car-sharing pool, and an electrical and cargo bike pool, both demonstrated in Stockholm. The key lessons learned note that the technical elements of the solutions are already working, but that economic models and the issues related to usage (willingness to use the service, charging rates, anti-theft measures) still need to be considered in the local context. Mobility stations were also piloted in the project in Cologne: here, the main challenges related to the identifying of suitable locations for the stations, and the lack of complementing features from other mobility modes and car and bike sharing services.[59]

CIVITAS ESSENTRIC (2016-2020) project aimed to develop sustainable mobility options for areas usually 'forgotten in urban mobility policies and planning', which here refers to peripheral and suburban areas that are often heavily car-centric areas with low level of public transportation and lack in mobility services. The practical activities in the project included developing a 'park&ride' concept in peripheral districts, introduction of electric public transportation, marketing sustainable multimodal mobility services for neighborhoods, and developing e-mobility stations in suburban areas.[60] One of the activities to highlight from the ESSENTRIC project is the development of a master plan for developing electric vehicle charging in Stockholm, Sweden. The main charging strategy examined in the work was a 'charging street' concept where an operator is allowed to construct and operate charging spots in a street-side parking area. Cars are parked next to the street curb and small form charging stations can be used to charge up the vehicles. The learnings of the project highlight the importance of getting the local grid owner on board to ensure that the grid capacity and condition are in order when planning and constructing the site.[61] Such approaches that are integrated to the urban environment is one potential future for EV use in the city (in comparison to dedicated larger parking and charging areas, such as in parking garages. The use of streetside charging, however, retains the problematic issue of car-related use of public space, which is inevitably away from other activities or uses.

SPACE (Shared Personalised Automated Vehicles) project (2018-2021) examined the use of autonomous vehicles. One of pilots were about an autonomous bus service indoors. A pilot was located in a hospital setting in Zealand, Denmark. The key learnings of the project relate to the indoor setting: technical and signal related difficulties, precise alignment of the buses in the limited space (together with attempts to make the buses wheelchair accessible through ramps), and on the user's practices related to the on-demand service model.[62] The use of autonomous vehicles indoors has interesting

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[58] SHARE North 2019. *Mobility Hubs Guidance.* Report.

[59] GrowSmarter n.d. *Implementing sustainable urban mobility in European cities - conclusions from GrowSmarter.* Report.

[60] https://civitas.eu/projects/eccentric

[61] https://civitas.eu/resources/eccentric-replication-package-electric-vehicle-charging-infrastructure

[62] https://space.uitp.org/initiatives/copenhagen-hospital-av-denmark

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potential implications for mobility hubs as well, and how the different mobility modes, for example, can be connected.

4.2 Future mobility hubs: developing mobile architecture and practices

Arup and Rise have examined design principle for future mobility hubs for the *Innovation Programme InfraSweden 2030* on sustainable and resource-efficient infrastructure. They examine the hub as a modular construct where the modular pieces are not only physical spaces or services (such as 'bakery', 'restroom', 'parking' or 'bike sharing'), but also less tangible elements (such as 'quality of stay', 'adaptability', 'sustainable design' and 'connectivity') that together create the 'catalogue of elements" of which the mobility hub can be designed from. The elements are divided into elements related directly to 'mobility' and to 'supportive' elements that make the staying and being in the area or the use of the mobility related services enjoyable and functional. The design of the hub is thought of as a loop, where the initial configurations of the elements are observed after their initiation, then analyzed, which is then used to create further objectives, which further contribute to the choice of elements in the future and the re-configuration of the whole configurations. The modular elements can also be relocated if needed.[63]

The modular approach to hub design highlights the need to create specific compositions to specific contexts and areas. One solution does not fit all - and through easily interchangeable modular solutions, the optimal composition could be, for example, found through a process of trial-and-error.

Bicycle parking *Stationsplein*, in Utrecth, the Netherlands, is a three-story facility for 12.500 bicycles located in the Utrecht Centraal railway station, being one of the world's largest bicycle parks (if not the largest). The garage is a joint effort by the municipality of Utrecht, ProRail and NS (Dutch Rail). The garage was opened in 2019, and it is open 24/7, providing free parking for the first 24 hours. Bicycles can be used also inside the garage, and the bicycle traffic is organized in a one-way direction. Next to the bike racks, there are also parking spaces available for special bikes. A digital system guides the users to locate a free parking spot, and there is also a bike repair and maintenance point. Public shared city bikes (called OV-fiets) can also be rented at the premises.[64]

With such a large bicycle garage, the utilization of bicycles is not depended at least on the availability of parking space at the hub. Alone, it cannot solve the different challenges related to the whole sustainable travel chain, but by providing high quality bicycling infrastructure that is also spatially interesting, bicycle use is promoted. Investments into the parking facilities also tell a story of giving value for bicycle use, encouraging it as a feasible 'last mile' solution in the city.

Eco Cycle is an underground parking facility for bicycles in Tokyo, Japan by Giken Ltd. The facility is designed through the principle of 'culture aboveground, function underground'. Above the ground, the facility looks like a small kiosk, but underground the facility goes deep as the actual bicycle storage for 204 bicycles is in a tower like shape underneath the kiosk. The user leaves their bike on a loading area, where the automated process takes the bike underground, and stores the bike in a specific slot in the tower-like parking

[63] https://www.ri.se/sites/default/files/2020-12/RISE-Arup_Mobility_hubs_report_FINAL.pdf

[64] https://www.utrecht.nl/city-of-utrecht/mobility/cycling/bicycle-parking/bicycle-parking-stationsplein/

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facility, and then again retrieves it for to the user when needed. The facility, according to Giken, takes only the same space as a single bicycle, whereas a traditional parking facility for 204 bicycles would take the same spaces as 25 meter swimming pool. An 'aboveground' model is also possible where the parking-tower is located in a building above ground.[65] The first iteration of the facility was introduced in 2013, and there are over fifty of such facilities in Japan today. [66][67]

The ECO-cycle is a good example of the role of space utilization in a situation where the space is limited in a dense urban structure. Here, the solution of the bicycle parking lot is in a vertical rather than horizontal form. This has clear implications for mobility hub designs - by placing facilities in a vertical way (here, underground), the dimensions of the hub and the horizontal distances between different services and amenities can be kept small and walkable. Here, an otherwise medium-sized hub (with a parking area for bicycles) can be crunched into a smaller size. It also means that the space 'saved' by taking the parking underground (or aboveground) is available for other uses, which is an important factor in public space design.

The *Station of Being* (2019), in Umeå, Sweden, is a new model for bus stations (small mobility hubs). The experimental bus station was designed to boost public transportation experience and to decrease private car use in a situation where electric buses are already becoming the norm and public transportation is on a high level (frequent buses, short waiting periods). The idea of the bus is to make the waiting process relaxed so that the one waiting for the bus can have a moment for him/herself, and thus increase the attractiveness of public transportation use. The station is incorporated with lights and loudspeakers that give cues about the bus's status as it approaches the station, gently 'waking up' the travelers. Every bus line has its own unique aural and visual cues that are used at the station. The station is also fitted fit 'pods' - rather than traditional benches - that can be used to lean on. The pods rotate 360 degrees so they can be used to create social gatherings as well, and they also act as shelters from the wind. The station is a joint effort by The Research Institutes of Sweden and Rombout Frieling.[68]

The Station of Being project tackles the important question about user experience and its connection to mobility behavior. The electrification of public transportation - here: buses - is not enough to drive the transition towards sustainable mobility behavior, as also noted by the project. The buses in a city can all be zero-carbon electric buses, utilizing only certified green electricity, but it does not really have an impact towards sustainability if there are no users for the service. The challenge, ultimately, is not a technological one but a social one. The combination of artistic and creative approaches to the design of different sized mobility hubs - such as a bus stop - are important in the making of the travel experience.

Spaces on wheels (2018) is a future mobility concept from space10 company for Ikea. The concept features modular autonomous, or 'driverless' vans that can move around in the city and provide different services and spaces, such as miniature office, café, healthcare,

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[65] https://www.giken.com/en/products/automated-parking-facilities/eco-cycle/

[66] https://edition.cnn.com/style/article/japan-underground-bike-vaults/index.html

[67] https://www.bicyclescreatechange.com/eco-cycle-automated-bike-parking-in-japan/

[68] http://www.rombout.design/station-of-being.html

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cultural, or grocery shop spaces that can be entered and occupied on the move. The autonomous vans can be moved around in the city and combined together into different variations.[69]

The spaces on wheels -concept aims to re-examine what we mean with a mobile space: the space here itself is mobile, rather than the user being mobile to reach a destination (a café, for example). From a mobility hub perspective, the concept also hints of a possibility of a mobile and temporary hub: a camp like hub that temporally and in a pop up style appears in one location in one day, and in a separate location the next, or a combination of spaces moving in the city, where the user could change from one space to another at appropriate stops. The spaces could be arranged in different combinations and constellations, whether mobile or stationary.

5. DISCUSSION AND CONCLUSION

This paper has examined some of the key ingredients of mobility hubs and their contemporary role in cities in the sustainable urban mobility frameworks. The paper has also identified and examined some key trends that are currently affecting urban mobility and mobility hubs. SPARCS demonstration sites in Espoo and their current statuses as local hubs have also been covered, together with the presentation of case examples from abroad from projects and concepts developing shared e-mobility hubs and future mobilities.

Mobility plays a key role in cities: it is a major source of greenhouse gas emissions - and its role and share of the total emission output will most likely only *increase* in the future. Urban mobility is also something that has a huge impact on the planning and design of cities, and how we conduct and organize our daily lives. As much as mobility is about (green) vehicle technologies, (shared) mobility service models, and big data analytics on urban flows, it is about the subjective travel experiences, affordability and questions of access and inclusivity of public space. Thus, the mobility hub - as a central piece in the overall urban ensemble - is a complex matter, its impacts resonating on multiple different thematical (ecological, social, economic sustainability) and geographical (street, neighborhood, district, city, region) scales.

There are multiple pieces of the puzzle currently in the air. Service based mobility is creating a new kind of basis for future mobility hubs in connection with traditional public transportation service. Public transportation itself might be experiencing some kind of an overhaul in upcoming years as developments in automation and technologies facilitating mobility-on-demand solutions are advancing, and new service models are tested and piloted. The electrification of all types of vehicles changes also infrastructural requirements, and introduces time and synchronization of different mobility practices and charging scheduled into the picture in a new way, as the grid stabilization and peak-prevention becomes important (including vehicle-to-grid practices).

The transition (back) towards sustainable mobility behavior - which here could be simplified to the use of public transportation and shared mobility services together with

[69] https://space10.com/project/spaces-on-wheels-exploring-a-driverless-future/

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bicycling and walking - requires that such mobility hubs ultimately become routine and habitual parts of daily life and mobility patterns. It is not an easy task to change attitudes, and habits and routines, as urbanites have grown accustomed with the door-to-door service that the private car has provided. The urban structure, lifestyles, and the way we plan and design our cities (including the zoning process) all need to support the use of sustainable travel modes - without them, it is difficult to produce any behavioral change.

Mobility hubs together with urban mobility as a whole are in a continuous flux and change. *How* and *why* we move, *how often* and *how long distances* we move, *what* we use to *power* our vehicles, and *how* we *use* them, are all in the continuous process of transformation. The vehicles - such as the bicycle, the bus, the car, or the train - or infrastructural components - the streets, sidewalks, boulevards, parks, motorways, bike lanes - that we consider as basic elements of the city are all rather recent inventions if we situate them into the historical timelines of the evolution of cities. Still, they have each transformed the cities and societies we know fundamentally, creating the overall settings and frameworks for how we live, move, and interact with each other on a daily basis.

The need for a rapid green and sustainable transition in urban (and rural) mobility requires that we think current and existing mobility habits and practices critically. The mobility practices need to be thought together with the urban environment in general, examining the two as one interlinked system. Large societal and political changes - like the acute need for a transition towards sustainable mobility - are shaping cities at large. How can we ensure that the transition is sustainable ecologically, socially, and economically? Actions in all the different stages of the travel chain and beyond are needed: the trip from a place A to place B and everything and every moment in between, and the possibilities and barriers related to the practices and potentials of movement. This requires a holistic view in planning and design of such hubs that combines the technical solutions, service models and policy issues with other crucial and larger socio-cultural themes, such as the quality of the built environment, zoning and building density, social equality and inclusion, service development, and spatial design, under the same analytical lens.

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