SPARCS: Electric bicycling and urban mobility in Espoo and beyond

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About SPARCS

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

Partners

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SUMMARY

Bicycle use is increasingly seen as an important element of sustainable urban mobility systems. Bicycles can provide an active, personal, and low-carbon mobility mode for daily travel in urban areas (and beyond). Electric bicycles can introduce bicycling to an even larger audience, enable bicycle use on longer trips, and to adapt into more diverse mobility needs than the traditional bicycles than through motorized movement assistance. The increasing use of e-bicycles and other electric light vehicles, or micromobility, is changing the urban mobility landscape in a rapid pace.

SPARCS project aims to boost e-mobility in Espoo demonstrations sites. This includes activities related to the electrification of all vehicle types. One of the activities relating to this goal is the boosting of e-bicycling in Espoo and Espoonlahti district. This paper examines some key concepts on (electric) bicycling as a mode of urban mobility, the current status of bicycle use in Espoo, and case examples on (e-)bicycling and its recent development in other cities. Also, recent developments in micromobility and light electric vehicles are also discussed. The aim of the paper is to support the increase of (e-)bicycling in Espoo by identifying key developments and trends that are paving the way for (e-)bicycling in the future, including bike sharing systems, city strategies on bicycling and micromobility, and (e-)bicycle-friendly urban environmental designs.

This paper is part of SPARCS project Work Package 3 'Espoo demonstrations', Task 3.4 'E-mobility integration', Subtask 3.4.1 'Boosting E-mobility uptake in the Espoonlahti district, Lippulaiva blocks', Action E2-2. It also supports Actions E2-3, E7-1 and E13-1 on e-mobility hub development as (e-)bicycles play a major role in the 'first' / 'last mile' of sustainable urban travel chains.

Keywords: sustainable urban mobility, bicycles, electric bicycles, micromobility, urban strategies, bicycling pilots and projects

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1. INTRODUCTION

Bicycling is increasingly seen as a central element of sustainable urban mobility systems. The bicycle can act as a replacement for the private car as a means of personal mobility in the city. It can provide an active, personal, and low-carbon mobility mode for daily travel in urban areas (and beyond). Although the bicycle is already an over two-hundred-year-old invention[1], the popularity of bicycling seems to be growing year-by-year, and cities globally are implementing new strategies and policies to increase its use and share in the modal split of a city's overall mobility. Studies suggest that cities that are good at providing high-quality bicycling infrastructure and biking possibilities are also cities that experience less traffic congestions, have healthier people, and have more lively public spaces and urban environments, together with other benefits supporting carbon-neutrality and other sustainable development targets of cities (see e.g., Fishman 2016; Vaismaa et al. 2011). From a social sustainability perspective, the relatively low cost of purchase and maintenance of bicycles (in comparison to a private car) can also support social equality in urban transportation[2]. These questions are becoming increasingly critical as already over half of the global population lives in urban areas, and cities are growing fast globally as people are migrating to cities[3].

The frontrunner countries in bicycle traffic management, namely Denmark and the Netherlands, have actively pushed forward policies supporting bicycle as a day-to-day mobility mode from the 1960-70s onwards[4], and many countries are now looking at their experiences and learnings as a guideline for the future. The key learning from the two countries is the same: the urban structure, policies and the transportation infrastructure needs to support, and even prioritize, the use of the bicycle for it to replace the more space and energy consuming private car. Without a bicycle-friendly environment, it is difficult to increase the popularity of bicycle use through other more direct means - such as promoting its benefits for users, by providing parking facilities, or by setting taxation benefits - as the fundamental building block is missing.

During the past decades, the markets have gradually been introduced to *electric* bicycles - although first concepts of electric bicycles date back already to the 1890s - with sales increasing rapidly. Recently, the developments in battery technology, in specific, has given a jolt for the e-bicycling market. In 2020 in the EU, already 17% of all new bicycles sold were electric bicycles - and here, the Covid-19 outbreak seems to have been one further key accelerator of this development[5]. The electric bicycles, with full or partial motorized travel assistance, can make biking possible to broader and more heterogeneous user groups, and facilitate its use on longer journeys and in different kind of life situations than the 'traditional' non-electric bicycle that relies on pure brawn. Cargo-bikes, for example, make it possible for the whole family unit to move as a group, and with the motorized

[1] https://www.nationalgeographic.com/history/article/how-bicycles-transformed-world

[2] *European Mobility Atlas. Facts and figures about transport and mobility in Europe 2021.* Brussels: Heinrich Böll Stiftung, 2021.

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

[4] https://www.theguardian.com/cities/2015/jul/29/how-groningen-invented-a-cycling-template-for-cities-all-over-the-world

[5] *European Mobility Atlas*, *2021*.

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support, make it feasible to use it on most day-to-day travels and personal logistics similarly to the private car. However, the initial cost of purchase is here significantly higher than with the non-electric bicycles, and it is a significant barrier for a broad utilization in different socio-economic groups (Behrendt 2018.)[6]

Additionally, the Covid-19 pandemic has recently sparked investments to biking infrastructure in cities, such as London, Paris and Milan[7]. In these, and most cities globally, public mass transportation was partially halted due to restrictions and policies aiming for 'social distancing' during the pandemic. The bicycle - as well as the private car - gained new appraisal as a private mobility mode over mass transportation services, with both positive and negative consequences. Although this focus on private mobility means negative effects to mass transportation use - and through that, possibly on carbon-neutrality targets as well - the Covid-19 pandemic increased investments to bicycle infrastructure, which was to be improved on the expanse of car traffic, such as trough the changing of a car lane into a bicycle lane. The long-term effects of these investments and changes in the urban mobility system of major European cities will remain to be seen - however, the potential to be major driving forces for more bicycling is evident.

SPARCS project (2019-2024) aims to boost e-mobility, and one of the more focused targets is the increase of e-bicycling possibilities. Therefore, this brief paper reviews some key concepts on electric bicycles (and micromobility in general - the different electric and 'light' mobility modes, including electric kick scooters) from urban planning and design, and urban policy perspectives, as well as some recent national and international (EU-level, global) case examples. The aim of this paper is to draw a picture of the current development of e-bicycling in cities, and what might be coming behind the corner regarding e-bicycle development and its role in urban mobility in the near future. The role and importance of electric motors in sustainable mobility frameworks of cities and nations is increasing rapidly, and this includes all vehicle types, including the bicycle and other smaller mobility devices that are often legislation-wise compared to bicycles.

To make it clear, bicycling here is first and foremost approached as *a mode of transportation*. Here, with bicycle trips, we mean the kind of journeys between a point A and a point B - commutes, errand runs, shopping trips, and the like - that are fully comparable with any similar trip made with any other mode of transportation. Here, bicyclists represent *all* age groups and socio-economic backgrounds. Bicycling, here, is *not* regarded as a recreational leisure activity.

The structure of the paper is as follows. First, the basic elements related to bicycle use as part of a mobility system are discussed, with key learnings from literature on bicycle-friendly environments are examined. Next, some current key issues related to bicycling in Espoo are presented, including the city's bicycling advancement program, the city's public shared city bike system, and previous development projects on sustainable mobility and bicycling. Then, insights from other national and international projects are briefly examined. The paper concludes with a discussion and a conclusion.

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[6] See also:
European Mobility Atlas, 2021;
https://www.nytimes.com/2021/11/08/business/e-bikes-urban-transit.html;
Technology, Media, and Telecommunications Predictions 2020. Deloitte Insights 2019.

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

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2. E-BICYCLES AND SUSTAINABLE URBAN MOBILITY

Bicycle use plays a major part in sustainable urban mobility systems. It can have a major impact on greenhouse gas emissions reduction through its potential to replace private car use, especially on shorter trips in the city. In 2016 in Finland, 28% of all private car trips were less than three (3) kilometers in length, and roughly 40% of all car trips were under five (5) kilometers in length[8]. This means that there is a large potential in the reduction of private car trips as they are relatively short in distance, indicating their potential to be replaced by other means, such as through e-bicycle use. In the *Roadmap to fossil free transport*[9] that presents practical steps for transport development in Finland, it is noted that: "High-quality pedestrian and bicycle infrastructure is one of the most important means of influencing the choice of modes of transport and increasing the volume of pedestrian and bicycle traffic." (page 32).

The Finnish National program for advancing walking and bicycling[10] states that walking and bicycling conditions need to be improved to support the decrease of transportation related greenhouse gas emissions, and to improve public health. The program sets a goal of 30% increase in walking and bicycling trips by the year 2030, which is the same goal as in the *National energy and climate strategy*[11], connecting the walking and bicycle trip increase to climate actions. This means that the modal share of walking and bicycling in all trips in all parts of Finland should rise to 35-38% from the current 30%. The program presents 31 different action points, including the development of the infrastructure and land use, affecting attitudes and mobility habits, and developing legislation and policy, among others, to reach these targets.

The further increase of bicycle use, thus, is acknowledged as an important factor in the future sustainable urban mobility systems. But how can bicycling use be increased? What are they key elements related to the popularity of bicycle use - what are the enablers and the barriers?

2.1 Bicycle-friendly environmental design, and 'bikeability'

Bicycles, whether electric or non-electric, require an infrastructure and larger urban structure that supports and enables bicycle use in daily life, and on different kind of journeys. Bicycle-friendly environment does not happen idiomatically but requires active decision-making in urban planning and development processes, supportive urban policies, and investments into the infrastructure. Some of the key elements of favorable bicycle environments have been identified in earlier research and practice. The examples are often drawn from the Netherlands and Denmark. These global frontrunner countries in developing bicycling as a mode of urban transportation - together with other cities,

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

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

[10] *Kävelyn ja pyöräilyn edistämisohjelma.* Liikenne- ja viestintäministeriön julkaisuja 5/2018.

[11] *Valtioneuvoston selonteko kansallisesta energia- ja ilmastostrategiasta vuoteen 2030.* Työ- ja elinkeinoministeriön julkaisuja 4/2017.

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such as Bogotá, Columbia[12] - have done active work to create bike-enabling urban environments from the 1970s onwards (Vaismaa et al. 2011). The identified activities include a wide scale of practices, including the more holistic approaches of re-examining critically urban planning and design approaches to favor bicyclists over car drivers through street and path designs (ibid.), taxation issues, and land use policies, to the more detailed and tangible approaches, including dedicated bike path and lane infrastructure planning and development, intersection planning and modification, traffic calming measures, safe and rightly placed and sized bike parking facilities, integration of bicycle use to public transportation, and training, education and promotion of bicycle use in different age groups (Pucher & Buehler 2008).

The critical view on urban planning and design paradigms has meant, for example, the adaptation of a sector based urban transportation planning principle. This means that the city or a city district is divided into sectors, and that the sectors are interlinked directly with active sustainable mobility modes - walking paths and bicycle paths, also public transportation connections to some extent - and that the private car traffic is directed on the outskirts of these sectors, on the 'ring-roads' around the sectors. Sector-based planning means that the trips are always shortest in distance, and often also shortest in duration, with sustainable mobility modes, as the car is put on detour routes on the outskirts of the areas, with unconnected streets directed inwards the sector. This also calms the core of the sector from pass-through car traffic as the streets enabling car traffic do not connect inside the sector to one another. (See Vaismaa et al. 2011.) Pass-through car traffic often has negative effects to urban environment quality, for example through traffic congestions, high car traffic speeds and low traffic safety for other mobility modes, noise, smog and other pollutants, and inefficient urban space use resulting into larger distances and vacant lots (broader roads to prevent congestion, parking areas etc.) (Appleyard 1981).

If we zoom in the picture from the larger district/sector level to the street level, multiple best practices and critical elements have been identified to create bicycling-friendly environments. Dedicated bicycle paths, both as part of the street space and as separate 'bicycle highways' are one key element, together with the larger street-grid network and intersection planning. The paths can be assigned different maintenance level categories, indicating their priority in the network (including winter-time management). Parking facilities need to be attractive, easy to use, safe, well located, and to have enough capacity. Clear path signs and route information is also important, and, for example, colors can be used to indicate the main paths and directions. Traffic signals, and generating 'green waves' for bicyclists, such as in Odense, Denmark, can also be used to improve the bicycling experience and affect the travel time by taking the needs of bicycle traffic into a heightened account. Additionally, some more indirect means can also be used to increase bicycling popularity, such as producing aesthetically interesting and thought evoking designs for bicycle parking facilities or other related infrastructure. (Vaismaa et al. 2011.) Traffic legislation can also take bicycling into a special consideration, such as the bicycle-priority streets, and traffic signs that enable two-way traffic for bicycles in otherwise one-way streets, were added to the Finnish traffic legislation in 2020, following the example of many others.

[12] https://www.cyclist.co.uk/in-depth/4690/bogota-colombia-a-place-for-bikes-books-and-coffee

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These same design principles and guidelines relate to both to the full bicycle-only kind of trips, as well as to the (shorter) 'first' and 'last mile' type of trips, where bicycle use is part of a more complex travel chain, and includes, for example, a modal change from bicycle to a metro connection in a transit node. Bicycle-friendly environment is, thus, also closely interlinked with mobility hub development - the multimodal transit spaces - that connect different personal and shared mobility modes together, as well as act often as central public spaces in the city for social interaction. Integration of parking, path design, orientation, and other bicycle-friendly solutions needs to be examined in detail when (re)developing such transit spaces.

Recently, 'bikeability'[13] has emerged as term to describe the bicycling-enabling or bicycling-hindering qualities of the urban environment. The use of term - similarly to the more familiar term 'walkability' (see e.g. Forsyth 2015) - varies between different contexts and stakeholders, referring to things like the quality and extent of the bikeway network, user experience, and the overall comfort of biking to different parts of the city (Schmid-Querg, J., Keler, A. & Grigoropoulos, G. 2021; Castañon & Ribeiro 2021). There is no single definitive definition of the concept (Schmid-Querg et al. 2021). In essence, it aims to highlight the possibilities (or the lack of them) of bicycle use in cities, and more broadly, the urban environment's capacity to support lifestyles where daily trips are made with the bicycle (rather than the private car). High bikeability corresponds to high bicycle use, and this, in turn, has effects to the city's mobility system, public health, urban environment quality and the like. One such index is the Copenhagenize Index by Copenhagenize Design Co., started in 2011[14]. The company scores cities of over 600.000 inhabitants through different parameters, including bicycle infrastructure, bicycle facilities, traffic calming, gender split, modal share, safety, politics, and urban planning.

The winter-time bicycling learnings from Oulu, Finland, are also here worth noting as key insights on enabling bicycling as a mode of transportation through-out the year. Enabling bicycling year-round is crucial in making bicycling as viable mode to move in the city as it could be imagined that the infrastructural and maintenance investments a city is willing to make would be higher if the share of the bicycle journeys is consistent the whole year round, and not only a seasonal activity. The Nordic weather conditions - especially cold and dark winters with snow, ice and freezing temperatures - are difficult but not impossible to tackle. The City of Oulu has gained international fame on enabling bicycling on the high-quality bike paths also during the winter by pedantic maintenance of the paths, and the real-time surveillance of the maintenance need. The maintenance is procured as a joint effort, which means that the level of maintenance is uniform in the whole main bicycle-path network.[15] In Oulu, one fifth (20%) of all trips in 2016 were made by bicycles year-round, and 12% during winter-time. The depth of the snow is crucial for enjoyable and safe winter-time bicycling.[16] Additionally, traffic signs projected on the snow have been piloted as solutions for snow blocking the signs that direct traffic.[17]

[14] https://copenhagenize.eu/

[15] https://blog.hamk.fi/hamk-smart/maailmankuulua-pyorateiden-talvikunnossapitoa-oulussa/

[16] https://yle.fi/uutiset/3-11762870

[17] https://yle.fi/uutiset/3-12298805

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2.2 Electric bicycles and the general increase of (shared) (e-)micromobility?

Electric bicycles differ from non-electric, or 'traditional', bicycles from the fact that they provide motorized support. Rather than relying purely on brawn, the e-bicycle provides either partial or full motorized assistance - in other words, the e-bicycle can be pedaled with motor-assistance or used as a fully electric motor vehicle that does not require any physical input. The benefits of the e-bicycle for the user can be, for example, that is puts less physical strain on the driver (but is still considered as an 'active' form of mobility), which makes it easy to use for commutes, it makes longer journeys possible, which can translate into a broader palette of use cases (see Johnson & Rose 2013; Behrendt 2018). For the urban environment, it can help to decrease car traffic congestion, and decrease air pollution, and increase the quality of the environment as a replacement for private car use, among other benefits.

Electric bicycles can be of different sorts. *Electrically assisted bicycle* is a bicycle that is fitted with up to 250W electric motor. The motor runs during pedaling and switches off when 25km/h speed is reached. If the motor is up to 1kW, and the maximum speed is 25km/h (whether pedaling or not), it is classified as a *motorized bicycle*. No driver's license is required for either type of electric bicycle in Finland. But if the motor is of larger power and/or the motor-assisted maximum speed is higher, the vehicle is classified as a moped, which means that vehicle registration is required together with a traffic insurance, and the driver needs to have a driver's license and wear a helmet.[18]

Some studies suggest that electric bicycle use replaces private car trips more than other kind of trips (e.g., walking, public transportation) (Söderberg, Adell & Hiselius 2021). The purchase of an electric bike is reasoned by the possibility to replace car use, extending the range of use (in comparison to non-electric bicycle) and environmental concerns (Johnson & Rose 2013). The price of electric bicycles is relatively high, however, which can limit the user base.

2.2.1 Shared micromobility

Micromobility, the light electric vehicles that occupy same spaces as bicycles, can further increase the access to personal transportation in different types of user groups.[19] E-scooters are not necessarily a one-size-fits-all kind of a mobility solution, but the range in different types of light electric vehicles is broad, and getting even broader as new types of vehicle solutions are introduced. These include self-balancing vehicles (with or without handlebars) such as skateboards and monowheels, vehicles for the disabled (powered wheelchairs), 'mini-cars', and perhaps in the future also self-driving small pods.[20] The mobility-as-a-service (MaaS) type of solutions can further provide access to occasional mobility needs. However, as the Eurocities report on the e-scooters notes, the e-kick-scooters have caused some unforeseen issues related to urban mobility, the space use in specific and the lack of parking etiquette. Cities have responded by limiting the number of scooters or the number of different service providers, and by applying localized speed reductions and driving bans to specific areas. The report also stresses that cities play an

[18] https://www.motiva.fi/ratkaisut/kestava_liikenne_ja_liikkuminen/nain_liikut_viisaasti/sahkopyora

[19] *Small is beautiful. Making micromobility work for citizens, cities, and service providers.* Deloitte Insights, 2019.

[20] *Experiences with light electric vehicles in Europe.* TNO reports, 2020.

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active role in how e-scooter use and operation develops. Cities can affect this development by for example, limiting the number of vehicles, creating license fees for additional vehicles, and establishing procedures how complaints are handled. Parking practices can be steered through designating unauthorized parking zones (with implemented fines), limiting the number of parked vehicles in a given area, and by establishing means through which unauthorized parking can easily be reported to authorities or operators. In terms of usage, limits can be set on specific timeframes, limiting phone use during the drive, or limiting the number of riders to one. In terms of sustainability, the cities can favor operators with fleets with low ecological life cycle impacts (such as easily reparable vehicles), requiring zero emission electricity in the fleet charging, and requiring end-of-life pathways for the used batteries.[21]

The kind of a role electric bicycles and micromobility solutions will play in the future urban mobility landscape remains to be seen. The development on the front has been rather rapid, and the policies and legislation, as well as urban planning and design practices and catering for these new needs and uses, and traffic management, are all still catching up. The shared use of these light electric vehicles has grown rapidly in many cities across Europe in the timespan of only a few years. This has put stress on the urban mobility system, and required swift action to create new policies, codes of conduct and service models to fit these new types of vehicles into the existing street grid. The technologies and services are also in the process of maturing. Together, these elements highlight that the landscape is in an active process of change and transformation.

[21] *Playing by the rules. Report on e-scooter operators and fleets in cities - a survey of city approaches and options to optimize regulations.* Eurocities reports, 2020.

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3. BICYCLE DEVELOPMENT IN ESPOO

The role of bicycling in sustainable urban mobility system has been acknowledge in Espoo as well. Bicycling traffic is on the city's agenda, including a program for advancing bicycling 2013-2024, and the implementation of a public city bike service (2018 onwards). A survey from 2017 shows that 95% of the people are in favor of promoting and advancing bicycling in their area, which provides fertile ground for policy changes as well as infrastructure investments.[22]

Regarding electric bicycles, the City of Espoo currently has no officials plans or strategies, and there is no overall e-mobility advancement framework either. From an urban development perspective, bicycling and e-bicycling do go hand in hand to some extent - both working on mostly similar principles, including infrastructure, policies and investments - but there are also some additional issues to be covered regarding e-bicycling development and planning, including practical issues related to charging and safe parking solutions (Jones, Harms & Heinen 2016).

3.1 City of Espoo's Program for advancing bicycling 2013-2024

In 2013, the City of Espoo launched a program for advancing bicycling in the city for the term 2013-2024.[23] The program grew from the identified need to develop bicycling to support the upcoming investments into rail-based transportation, including the new metro service (first phase Ruoholahti-Matinkylä completed in 2017; second phase Matinkylä-Kivenlahti to be completed in 2023) and tram services (to be completed in 2024), and the existing railway connections for commuter trains. At the time, there were around 1015km of pedestrian and bicycling paths in the Espoo area, and 8% of all the journeys in Espoo were made by bike. The program defines two central goals for Espoo: the city is a model city for travel chains and high-quality paths, and that by the end of the program in 2024, 15% of all the journeys made in Espoo are made by bike, in accordance with The Charter of Brussels[24] from 2009.

The program identifies twenty-one (21) separate action points that should be completed in order to reach the set targets. The action points can be divided under different categories, including the increase of political will and the allocation of resources, the development of the transportation system, the building of high-quality biking paths, the ensuring of safe biking routes, the development of station areas' accessibility, communication and marketing activities, and the close monitoring of these actions. In practical terms, the action points cover issues related, for example, to the improvement of bicycle parking facilities and guiding, optimizing and safe-guarding bicycle travel in intersections, creating high-quality biking paths, and taking bicycling better into account in master plan phase of urban development processes. The local action points are also

[22] *Faktaa ja fiiliksiä pyöräliikenteestä.* Pyöräilymetropoli 2017.

[23] *Pyöräilyn edistämisohjelma 2013-2024.* City of Espoo 2013.

[24] The Charter of Brussels, developed in Velo-city conference in Brussels in May 2009, called policy-makers to set targets for cities in terms of bicycle modal share (>15% by 2020) and bicycle road fatalities reduction (>50% reduction). See: https://ecf.com/who-we-are/our-mission/charter-brussels

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guided by other national, regional (including the regional bicycles path network) and international guidelines.

The program has a couple of years left before the aimed 2024 finish, and the possible update of the program and goals. The most recent publication on the local mobility habits from 2018 (HSL 2018) informs us that the current share of bicycling use on all trips in the Espoo area is 9%. It remains to be seen whether the set goal of 15% modal split share will be achieved in time. In 2022, there is approximately 1350km of bicycle paths in the city, which is a 300km increase to the numbers in 2013.

3.2 City bike service, Espoo and Helsinki areas (2018-)

The City of Espoo introduced a public bike sharing service in 2018. The bike sharing service has its origins in the pilots made by the City of Helsinki, which implemented the same system already in 2016.

Currently, there are 110 city bike stations in Espoo, located mostly in the eastern parts of the city. The stations are situated next to major mobility hubs, such as metro and commuter train stations, and other popular areas, such as the Otaniemi campus, and the renown Tapiola garden-city area. Espoo and Helsinki both utilize the same system, which means that users can use the same city bikes in both Espoo and Helsinki cities' areas. Therefore, there are together over 460 stations and 4.600 bikes available for shared use in the two neighboring cities.[25] The city bikes can be rented and returned to these locations - leaving the bicycle outside the stations is not possible, and this practice is controlled by fining for failing to return the vehicle.

The yellow-colored city bikes - nicknamed as 'Alepa-fillarit' (or 'Alepa-bikes' in English), due to the main sponsor, the grocery store chain Alepa by the S-Group that also gives the bikes their distinctive bright color - are operated by CityBike Finland Oy. HSL (Helsinki Regional Transport), the cross-municipal organization in charge of public transportation services in the capital region of Finland, including Espoo, is responsible of the city bike service marketing activities as well as the customer relations in both cities. The user can purchase a season pass that includes unlimited trips that take under thirty (30) minutes, with rides taking longer than thirty minutes have an additional charge. There are also week and day-passes available for less frequent and touristic use. The system is not currently in use during the winter months from November to March. The bikes can be used both for 'last mile' type of trips - as most stations are located next to public transportation stops and station areas - or for the whole trip.

The Espoo-Helsinki shared city bike service has been popular, as also reported by the national media.[26] A survey by the City of Helsinki notes that the city bike system in Espoo-Helsinki is one of the most often used in the world, with close competition with cities like Dublin, Valencia, Barcelona and Lyon. The survey notes that the high use of the bike system might decrease the user satisfaction as bicycles are less available, and require increases in the maintenance and operation budget, but at the same time it creates visibility for the service, makes it more financially feasible, creates environmental and

[25] https://www.hsl.fi/kaupunkipyorat/helsinki

[26] https://yle.fi/uutiset/3-10716286

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health benefits, and creates more buzz around bicycle infrastructure development and the general attitude towards cycling.[27]

One of the identified challenges of the city bike service in Espoo is the lack of service in many parts of the municipality with a large ground area. The current city bike system does not cover the whole Espoo area - the current 110 stations are located mostly in the eastern and south-eastern areas. The increase of stations will be a relevant point of discussion in near future, especially in connection with the upcoming metro extension line (2023) and its' new station areas acting as local mobility hubs. Also discussions about full/partial electrification of the bikes might be relevant, as they have been popular in other Finnish cities, and the demands of the users towards electric motor movement support might be on the rise (see section 5.1 for additional examples of city (e-)bike systems in Finland). The utilization of the electric kick scooters might also tell the message that people are looking for modes of mobility that do not cause excessive physical strain to move in the city. Additionally, in the northern latitudes of the Nordic, winter-time bicycle use has been growing in popularity. Winter-time use of the public city bike service can also play a key role in making bicycle use a year-round possibility and a habit.

Figure 1. A city bike station, with bikes available for use, in front of the Sello shopping centre in Leppävaara (Leppävaarankatu). The PV panel that is integrated to the system feeds power to the digital locking mechanism of the bikes. Photo: author.

[27] *Helsingin kaupunkipyöräjärjestelmän suosiovertailututkimus.* Helsingin kaupunki 2019.

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3.3 Sustainable development projects on bicycling in Espoo

In recent years, there has been different projects - with outside funding - under the Sustainable Espoo development program that support achieving the city's carbon-neutrality target by 2030 and UN Agenda2030 Sustainable Development Goals by 2025. Some of these projects have also tackled the sustainable urban mobility challenge through pilots and policy developments related to bicycling as a mode of urban transportation.

In *Kestävä liikkuminen osana Espoo-tarinaa KESTO* (2019) project[28], shared city bike system for company workers, and folding bike use as a 'last mile' option were tested and piloted in Espoo. The pilots focused to increase the knowledge about bicycle use as a sustainable mobility mode for everyday commutes. The project also examined worker benefits related to different mobility modes - noting that private car use is favored through hidden benefits such as free parking over public transportation or bicycle use - and created a vision for Espoo as a frontrunner in sustainable commute trips, and identified different action points that could be used to achieve this vision. These points included, for example, the improvement of walking paths and bicycle paths, prioritization of sustainable mobility modes in winter-time maintenance work, developing mobility hubs, i.e. stations, as attractive and safe environments with a broad array of (mobility) services, developing mobility-on-demand services, and real-time information systems.

6Aika: KIEPPI - Kestävien kaupunginosien kumppanuusmalli (2019-2021). In the project, different circular and sharing economy solutions were piloted with companies and other service providers through open procurement processes. One of the selected pilots in the project was a test-run of an electric cargo-bike in shared use in an apartment building[29]. The bike was available for shared use, and it proved out to be a popular service amongst the test audience. Cargo-bikes are bicycles that have a 'container' attached to the bike (usually in the front) that makes it possible to carry large quantities of goods or persons (e.g., one's children) with the bike. Cargo-bikes can replace private car use as they provide carrying capacity and possibilities for a family unit to move together, similarly to the car.

6Aika: Low-carbon mobility in transportation hubs (2019-2022). In the project, different 'last mile' solutions were piloted with companies and other service providers through open procurement processes. One of the selected pilots in the project was a test-run of 'a charging cabinet' for electric bicycle batteries[30]. The charging cabinet makes it possible to store and charge e-bicycle batteries. The cabinet was first of its kind in Finland, with an automated fire safety measures in case of a malfunction of the battery during charging.[31] The cabinet was tested in three areas around Espoo in 2020: in the Otaniemi/Aalto University campus area, in the (temporary) Pikkulaiva shopping center in Espoonlahti, and in the Iso Omena shopping center in Matinkylä. The cabinets were located in these mobility nodes to support multimodal mobility habits.

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

[29] https://www.espoo.fi/fi/uutiset/2021/05/yhteiskaytolla-eroon-omasta-autosta

[30] https://abloc.fi/ensimmainen-suomessa-sahkopyoran-akkujen-paloturvallinen-latauskaappi-a-blociin/

[31] https://futuremobilityfinland.fi/city-of-espoo-launches-first-fireproof-charging-cabinets-for-electronic-bicycle-batteries/

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4. (E-)BICYCLING IN SPARCS DEMONSTRATION AREAS – AN OVERVIEW

SPARCS aims to 'boost e-mobility' in the three demonstration areas of Leppävaara/Sello blocks, Espoonlahti/Lippulaiva blocks, and Kera in Espoo. The three areas are all in different stages of land development, from the already built area (Leppävaara), to one in a process of strong redevelopment (Espoonlahti), and to one in the early stages of being turned from a brownfield industrial area into a new urban mixed-use district (Kera). The project's Actions in the three areas aim to develop e-mobility holistically, including all vehicle types - additionally, Espoonlahti Actions also include one specifically dedicated for e-bicycling development.

Leppävaara is the largest district in Espoo by population (71.000), and the Leppävaara center, with the Sello blocks is, one of the key mobility hubs in the city. The area is serviced by commuter train and (electric) bus services. There are also multiple public city bike stations in the area, and free-floating shared mobility services, such as e-kick scooters, are available in the area (except during winter-time when these services are on hold). An outdoor weather-protected bicycle park is located at the station next to the train platform access. There are dedicated biking lanes in the area that run alongside the sidewalk.

Leppävaara has potential for electric bicycles related development, as it is already a major transportation node with a large number of daily travelers. E-bicycles can play a crucial part as 'last mile' solutions, connecting people to the train connection originating from Leppävaara. In addition to the local urban residential and workplace area, which is largest in Espoo by population, the area is also relatively close to other major areas, such as Otaniemi campus, Espoo, and Pasila, Helsinki that has a major local and intercity train station. Further focus on safe parking and storing facilities, and the further development of bike paths and bicycle-friendly environment, can support the increasing role of (e-)bicycling in the area.

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Figure 2. Pedestrian bicyclist underpasses at the Leppävaara station area. A dedicated bicycle path next to the pedestrian path runs under the train tracks (front) and the adjacent motorway (back). Electric kick scooters parked (free-floating system) next to the stairways leading up to the train platforms. Photo: author.

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Figure 3. The bicycle parking area in Leppävaara station area, located under the train tracks (Leppävaaranaukio). A dedicated bicycle path runs right next to the parking area. Photo: author.

Espoonlahti is the second largest district in Espoo with 56.000 residents. The Lippulaiva blocks in Espoonlahti are rapidly being redeveloped as the old shopping center was demolished and replaced by the new Lippulaiva in 2022. The new Lippulaiva building will also bring along the new metro line that will start operation for the first time ever in the area in 2023, strengthening the building's role as a major future mobility hub. Additionally, there also residential buildings in the new Lippulaiva, as well as a feeder-bus terminal, connecting local areas to the metro line. There is currently no city bike system in Espoonlahti, which decrease the number of available 'last mile' options in the area.

As a potentially major mobility hub, the area, though, probably will gather interest from both public and private mobility service providers. The new metro line and stations, together with the tightening land use, provide a genuine possibility to introduce the shared city bike system to Espoonlahti as well. The relatively close connection with the sea can also attract new types of electric 'last mile' solutions. The increase of (e-)bicycling requires further focus on the bicycle infrastructure, street design, and other elements that contribute to the area's bicycle-friendliness.

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Figure 4. Bicycle parking in front of the temporary Pikkulaiva shopping center (Kivenlahdentie). Photo: author.

Kera is an old logistics area that is being turned into a new urban district with 15.000 residents and 10.000 workplaces during the course of the next few decades. Kera is set to be an international example of sustainable and circular economy urban district, and it is actively developed with a broad stakeholder group. Multiple projects are piloting new solutions and practices in Kera , including SPARCS. Kera is planned to be a walking, bicycling and public transportation oriented area, and in SPARCS, the focus is set on advancing the consideration of e-mobility and multimodal mobility habit solutions already in the planning phase of the 'new' urban district. Kera is serviced currently by a commuter train connection, which provides a strong basis for shared mobility services and public transportation use as the station area will form the new center of the developed district. There currently are no public city bike stations in Kera area, but as the

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area grows, it will probably attract both public and private mobility service providers. The old logistics halls in the area have been in temporary use since the logistics center was moved from the area in 2019 to a new location. The temporary uses related to cultural activities, sports facilities, brewing, and other local production, have attracted already a considerable amount of attention in the media, building the future identity and image of the area.

Figure 5. A combined pedestrian/bicycle path runs under the train tracks at the Kera station area. Local commuter train pictured. The station area will be redeveloped fully in the upcoming years as the construction of the new Kera district begins. Photo: author.

Kera, as a 'new' urban district that is still mostly on paper in planning documents, provides a unique possibility for bicycle-friendly environment design. The area can be re-thought almost from the ground up, as much of the existing buildings will be replaced by new residential, commercial and office spaces. The area is planned to be bicycling oriented (together with walking and public transportation) but it remains to be seen what kind of a role bicycle traffic will play in the area in the future, based on the final realized plans. Also, the construction phase, that will last a relatively long time as much of the area is redeveloped, will increase the importance of construction-phase traffic management.

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Ensuring well maintained, safe, direct, and fast bicycling connections is essential for the future development of the modal habits in the area and beyond. E-bicycling could also be incorporated into the area through designated parking facilities and through building integration of new kind of parking and charging facilities.

Figure 6. Bicycle parking area in Kera next to the Keran Hallit entrance (Karantie). Keran Hallit is where much of the temporary activity in the soon-to-be-demolished logistics halls have been developed. Photo: author.

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5. LEARNINGS FROM OTHER PROJECTS

In this section, we look at a few projects and other activities that have developed electric bicycling in recent years in the EU. First, case examples from Finland are presented, then followed by case examples from abroad.

5.1 Public shared (electric) city bike service development in Finland

In Finland, many cities have adopted a (modern) city bike sharing service. These cities include the major cities Helsinki, Tampere, Turku, Espoo, Vantaa and Oulu, as well as the smaller cities Kuopio, Oulu and Lahti. The public bike system here in question refer to the use of the bicycle as part of daily urban travel rather than on sightseeing kind of touristic practices. The systems all use apps to facilitate the lending/return process digitally without face-to-face interaction. City bikes are also in use in other cities as well - and have also been used in the larger cities mentioned above in the past - but in these cases they are mostly related to touristic use rather than to day-to-day commutes and other similar trips.

Kuopio is the first city in Finland to introduce a shared city bike system that uses electric bicycles, called 'Vilkku-fillarit' ('Blinker-bikes' in English)[32]. The service began in 2019, and currently, in 2022, includes 26 stations and 350 bikes in the system. The city bikes have been popular, as noted in the national media[33], prompting some challenges and issues related to the charging of the bikes in-between uses. Kuopio's example has also been followed elsewhere. The City of Lahti piloted a similar city e-bike system in autumn 2021 as part of the city's European Green Capital year. The pilot included 250 electric bikes and 31 stations. The pilot was successful and the city bike system, called 'Mankeli' (after an open popular vote) was picked up for fixed use as the city signed a five-year contract with the service provider.[34] The City of Turku has also piloted a small number of e-bikes as part of their 'Fölläri' city bikes[35].

The *Road map for pedelecs* (2015) report[36] presents survey and workshops results together with project reviews on the potential of e-bicycling as a mode of sustainable urban mobility. The report highlights the role of a few central megatrends - urbanization, scarcity of natural resources and climate change, digitalization, and the ageing population - as drivers for increasing e-bicycle use in the future. It further notes that e-bicycles can play crucial role in mobility hub development as 'last mile' solutions and decrease the required assigned space in comparison to private car use in dense transportation hub areas. The e-bicycle-friendly environment does not also require any additional elements in comparison to high-quality bicycle environment. The report also lists different roles that different stakeholders have as 'gatekeepers' for e-bicycling development, including

[32] https://kaupunkipyorat.kuopio.fi/

[33] https://yle.fi/uutiset/3-11500741

[34] https://www.lahti.fi/asuminen-ja-ymparisto/liikenne-ja-kadut/pyoraily/

[35] https://www.foli.fi/fi/ef%C3%B6ll%C3%A4rit-tulivat-%E2%80%93-kokeile-s%C3%A4hk%C3%B6k%C3%A4ytt%C3%B6ist%C3%A4-kaupunkipy%C3%B6r%C3%A4%C3%A4

[36] *Road map for pedelecs. The potential of this transport mode to promote a sustainable transport system.* Finnish Transport Agency, Planning Department. Helsinki 2015.

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the state (legislation, national health programs), municipalities (infrastructure), energy companies (energy counselling, cooperation in pilot projects), as well as user groups, such as the teenagers (trends, schools, leisure activities) and the elderly (active mobility, safety). The report presents 16 action points aimed for the 'gatekeepers' that would increase e-bicycle use, such as developing the bicycle paths, lowering the threshold for e-bicycle purchase, giving a role for e-bicycles in the schools' traffic education, developing a guide for land developers to take e-bicycling into account when building residential or office buildings, and giving people possibilities to test e-bicycles themselves.

ECCENTRIC (2016-2020) was an EU CIVITAS ELEVATE funded project, which aimed to enforce sustainable urban mobility by testing new MaaS concepts, by enabling safe walking and bicycling, and by promoting the uptake of clean vehicles (including light electric vehicles), among other themes. The work was done in cities of Madrid, Spain, Munich, Germany, Ruse, Bulgaria, Stockholm, Sweden and Turku, Finland. The project's final report[37] highlights the importance of political will and commitment in the adaptation of new cleaner vehicles, and the early involvement of different stakeholders in the pilots and policies relating to the adaptation of new type of mobility modes in the city. In terms of safe walking and bicycling environments, the project notes that the process of change is a long-term challenge.

The state-owned Motiva and Mobinet companies have created a guide for housing companies to promote bicycling parking.[38] The project was funded by the Ministry of the Environment. The guide provides a checklist for assessing the current level of bicycle parking in the building, including: Is there enough room for parking? Is it easy to access the parking space? and Is the parking space safe and enjoyable to use? The guide also presents different types of bicycles, and their specific requirements, different types of parking solutions, as well as general requirements for a good bicycle parking. The guide provides tools for the planning of new parking facilities, including their integration to the building premises, as well as the decision-making and legal processes. The guide also briefly examines safety issues related to e-bicycle charging, as well as potentials for shared use bicycles, owned by the housing company.

5.2 International examples

Shared public city e-bike systems are developed in different parts of Europe and the world. The city of Stockholm, Sweden, will introduce a public electric city bike system in 2022[39] with over 5.000 e-bikes. The city of Tartu, Estonia, has introduced electrically assisted public city bike system in 2019 with 69 stations around the city and 500 electric bicycles (of the total of 750 available bicycles).[40] Cities of Lisbon[41], Portugal, and Los Angeles[42], U.S., have also electric bikes in their public city bike systems alongside non-

[37] *ECCENTRIC - New Mobility for all beyond the urban centres*. Final report, CIVITAS ECCENTRIC, 2020.

[38] *Pyörällä koko talo. Opas taloyhtiöille parempaan pyöräpysäköintiin.* Motiva & Mobinet 2019.

[39] https://cities-today.com/stockholm-to-launch-new-e-bike-sharing-service/

[40] https://tartu.ee/en/bike-share

[41] https://www.gira-bicicletasdelisboa.pt/sobre-a-gira/

[42] https://bikeshare.metro.net/

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electric bicycles. Vancouver is piloting shared e-bikes in a two-year pilot program that started in 2021[43].

In Horizon 2020 Lighthouse project *Sharing Cities*, e-bicycling has been developed in the cities of Milan, Italy, Lisbon, Portugal, and London, UK. In Milan, there are over 1.150 electric bicycles in a shared public system, and over 300 docking stations. The electric bikes are part of the city's e-mobility strategy, that aims to electrify mobility fully and to decrease car ownership. In Lisbon, there are +600 electric bicycles in the city's public bike system, and in the project, an app was piloted to direct users to return their bikes to less crowded areas, decreasing the operational costs of relocating bicycles between different docking stations. In London, a pilot was set in the Royal Borough of Greenwich to assess the existing demand for e-bicycles by providing them for a limited test audience, which also provided insights of mobility habits and preferences. The estimated costs of the pilot projects were calculated for each city, totaling up to 1.300-2.000 euros per e-bicycle. 70% of the total costs were calculated to go to the management and relocation of e-bicycles between the empty and over-full stations. The project conclusions note that a successful e-bicycle system requires co-creative approach in the design of the service, including the location of the docking stations so that they respond to the actual need. Additionally, the right kind of a docking system is crucial for the service, as both Milan and Lisbon have had negative experiences with a free-floating system which has resulted in damages and decrease of pedestrian safety.[44]

The European CIVITAS initiative report[45] sets some working steps for stimulating bicycle use in cities. The report highlights information and knowledge gathering, development of a strategic action plan, tendering processes detailing, and promotion campaigns launch as some of the key steps. The report notes that the key drivers for successfully increasing urban bicycle use are identifying the key target groups, creating sense of urgency related to traffic and environmental issues locally, creating political support and acceptance for the development work, and engaging different stakeholders in the process.

[43] https://www.dnv.org/streets-transportation/e-bike-share-pilot-program

[44] *Electric Bike Sharing. Towards a healthy new mobility model.* Smart booklet. Sharing Cities 2020.

[45] *Cycle-friendly cities - How cities can stimulate the use of bicycles.* Policy advice notes, CIVITAS, 2010.

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6. DISCUSSION AND CONCLUSION

This paper has examined e-bicycling as an urban phenomenon from different perspectives, including the mobility system, sustainable development, and urban policy perspectives. The paper has examined national and international development projects and emergent e-biking services, as well as the requirements that (e-)biking sets for the urban environment and transportation system in order to compete with the private car as a personal mode of urban mobility.

Electric bicycles, and other light electric vehicles, might help to reduce the number of car ownership and private car use in urban areas as they provide multiple benefits both for the rider and the environment. They provide personal mobility that is not tied to physical fitness and they take only a small portion of the shared public space in relation to cars, both in motion and when parked. In Espoo (and rest of the capital metropolitan area), the average bicycle trip is 3,5 kilometers in length.[46] E-bicycles can make longer journeys feasible, and connected with good year-round maintenance of the bicycling paths, as well as to new thinking in urban planning and design when it comes to planning bicycling infrastructure and integrating it to the rest of the urban environment, significant changes in the number of bicycle use as a daily urban mobility mode might be seen in the future. The popularity of the different electric micromobility solutions and public e-bike sharing systems give some idea of a potential that remains to be reached.

The post-Covid-19 world might indicate an increase of (e-)bicycling (and other private mobility modes, including micromobility) popularity as public transportation services experienced severe blows globally in terms of decreased number of users. Public city bike sharing systems can play a large role in these types of post-pandemic scenarios (Pase et al. 2020), in which a personal mobility option is provided as a public shared service. The experiences from Finnish cities from the pre-Covid-19 era, might provide some key learnings of organizing such service in the post-pandemic world as well.

The increasing number projects developing the framework of urban electric bicycling, and the similarly increasing number of academic research on the topic, shows that the issue of electric bicycle use as part of a sustainable urban mobility system is an increasingly relevant one. The advancements in battery technologies in recent years have made electric bicycles (and other light electric vehicles) more readily available for consumers - both through ownership and shared services - which has also pushed the legislation and urban policy side on the issue forward, sometimes in a rather hurry. This development has taken place simultaneously with the overall *reappraisal* (Fishman 2016) of bicycles in urban mobility and policy, which has in many cases been part of the larger emergent discussion on sustainable development in cities, which has been further accelerated by the ongoing climate crisis and its global acknowledgement. This, in turn, has pushed the technological development of e-mobility in general onwards through the increasing need for zero-emission urban mobility. The total life-cycle effects of increased e-bike (and micromobility) battery production though remains to be seen.

As it is evident here, the overall picture of electric bicycling is a complex one, and it is difficult to state in full clarity, what elements of this complex system affect what, and in what direction. It remains to be seen, what kind of a role electric bicycle use in cities will

[46] *Faktaa ja fiiliksiä pyöräliikenteestä.* Pyöräilymetropoli 2017.

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gain - and how it will be incorporated into the urban environment, resulting into new kind of spaces, practices, imageries, and policies.

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