



TOWARDS SMART ZERO CO₂ CITIES ACROSS EUROPE
VITORIA-GASTEIZ + TARTU + SONDERBORG

Deliverable 4.9: Bike sharing and electric bike rental system purchased and in operation WP4, Task 4.6

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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
SEC	SmartEnCity
WP	Work package
TAR	Tartu City Government
Smart bike share	Bike share + electric bike rental system
RES	Renewable energy source

Table 1: Abbreviations and Acronyms

0 Publishable Summary

On 8th of June Tartu City launched a bike sharing (450 bicycles + 69 parking stations) and electric bike rental system (300 electric bicycles) consisting in total 750 bicycles and 69 parking stations. During first months within the systems was made 210 000 rides and the total distance traveled by the bicycles was 600 000 kilometers. Bike sharing has been extremely popular in Tartu.

Total investment in the bike sharing system is about 2.200.000 € and was financed by the city of Tartu. Total investment in establishment of electric bike rental system is 792 300 € and is partially in amount of 496 000 € financed by the SmartEnCity project.

Developing a bike sharing system has been one of the mobility priorities of the City of Tartu. A respective feasibility analysis was carried out in 2014 and a business model was developed based on the findings. The aim of setting up a public bike sharing system aimed to encourage the use of bicycles and make this a considerable alternative to cars. It is expected that the bike sharing system will bring about decreased environmental problems (noise, air quality), parking issues and problems with traffic intensity. Bike sharing is considered a part of the public transport system of the City of Tartu.

Bike sharing- and electric bike rental systems are connected into one combined Smart bike sharing system in order to ensure efficient management and both have been set up within the SmartEnCity project. The system is mainly targeted at people who need to travel ca. 2-5 km to work, school, home etc. Broadly speaking, the bike sharing system consists public city bikes, parking lots with safety locks and a software system that enables to manage rides, rent out a bike in one of the parking locations and redock it in another. The service users are identified through Tartu's smart card (also used for other modes of transport) or mobile app. Visitors and tourists can join temporarily with their credit cards. The system is operated by the substructure of the Tartu City Government – Tartu Linnatransport.

Expected annual saving of CO2 emissions in Tartu's transport system is thanks to bike sharing and electric bike rental system is in total 1890 tons.



Figure 1: Grand opening of Tartu bike-sharing system on 8th of June of 2019

1 Introduction

Tartu, with its population of 100,000 is the second largest city in Estonia. Lying 185 kilometers south of Tallinn, Tartu is also the centre of South-Estonia. Tartu is known as a green, innovative and environment-friendly city. The slogan of Tartu is "The City of Good Thoughts". Tartu is a city of education and well known for the University of Tartu founded in 1632.



Figure 2: Location of Tartu City

The aim of the transport policy of Estonia and of Tartu is to ensure accessible, convenient, safe and sustainable mobility for people and businesses. High-quality infrastructure and a well-functioning transport system are essential for the functioning of everyday life.

1.1 Purpose and target group

The purpose of this deliverable is to document the details and processes made by TAR related to implement bike-share and electric bike rental system in Tartu within the SmarEnCity project. The details include a description of the technical details process and also first results and lessons learned so far.

Target group include other partners of SEC project but also target groups interested in implementation of bike share systems.

1.2 Contributions of partners

The following Table 2 depicts the main contributions from participant partners in the development of this deliverable.

Participant short name	Contributions
TAR	Overall & general content

Table 2: Contribution of partners

1.3 Relation to other activities in the project

The following Table 3 depicts the main relationship of this deliverable to other activities (or deliverables) developed within the SmartEnCity project and that should be considered along with this document for further understanding of its contents.

Deliverable Number	Contributions
D4.1	This deliverable provides the overall description of the current state of the lighthouse city area and will provide a comparison in future after demo actions have been implemented
D4.11	This deliverable connects all demo actions into ICT platform. Data will be easily used for evaluation and replication purposes
D4.13	This deliverable summarizes all demo actions in the Tartu Lighthouse project.
D7.8	This deliverable provides the overall description of the KPI's and therefore the measurements to be implemented in bike-sharing

Table 3: Relation to other activities in the project

2 Objectives and expected Impact

Across Europe transport accounts for about 20 per cent of all greenhouse gas emissions, nearly half of those are related to passenger transport. To reduce the carbon footprint of mobility, public transport-, alternative modes of movement (modality) and usage of RES has to be strengthened, especially in rural and suburban regions.

A significant part of the growth of daily traffic flows in cities is caused by private vehicles from urban sprawl areas. The situation is similar in Tartu, where according to the last 2018 mobility study, car traffic in the city is growing by 1.5% a year, thanks to urban sprawl. In order to break this trend and shape a sustainable urban environment, it is necessary to redesign city transport system to meet the needs of both urban and suburban populations and to minimize environmental impact of the transport system.

Development of cycling is one of the transport priorities of the City of Tartu. The vision for developing cycle traffic in Tartu entails a network of cycle roads and lanes covering the whole city and creating safe and comfortable cycle parking. The objective is to facilitate travelling by bicycles, making this a considerable alternative to cars. Bike sharing will bring about decreased environmental problems (noise, air quality), parking problems and problems with traffic intensity.

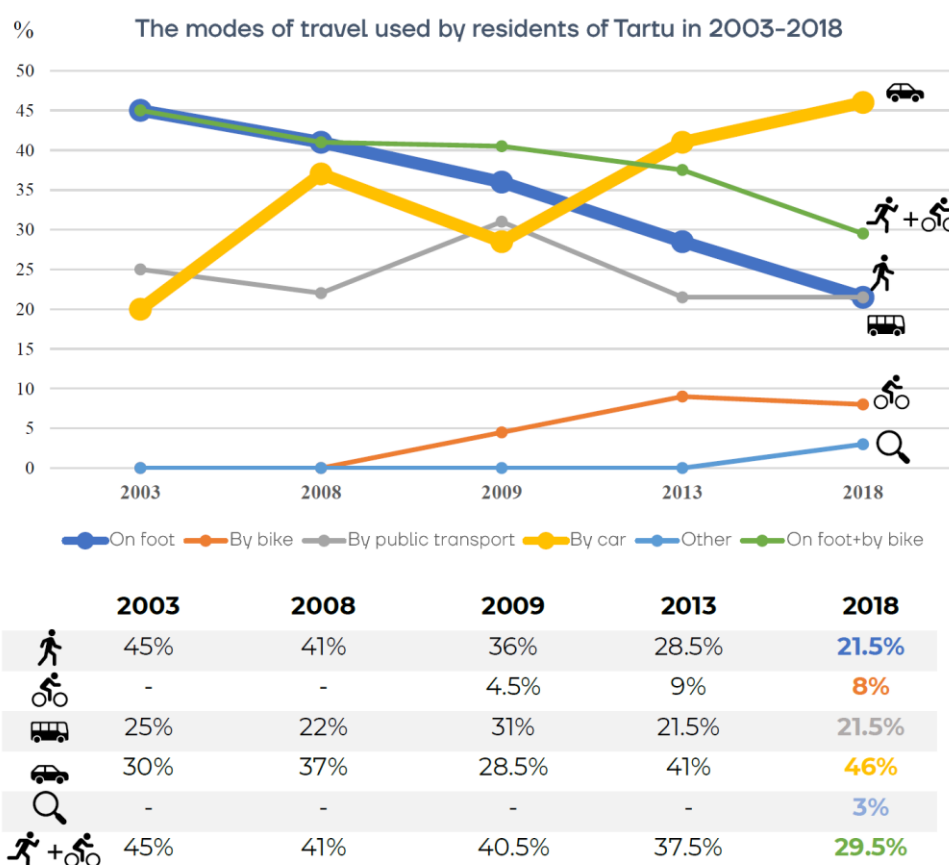


Figure 3: Modal Split of Tartu

2.1 Objective

The main objective of this deliverable is to implement a city-wide bike sharing- and electric bike rental system that complements the existing public transport system and ultimately helps to reduce car traffic in the city. The further goal is to achieve zero carbon urban environment.

2.2 Expected Impact

The expected impact of deliverable is multiple. Main impact is a reduction of CO² emissions from city transport system, but there are several side impacts, which are significant in terms of city environment and sustainability – cleaner city environment, reduction of private car traffic, change of movement patterns of citizens, better health of citizens etc.

The reduction of usage of private cars and thus reduction of CO² emissions in transport system is the main expected impact. The estimated annual reduction of CO² emissions will be 1079 tons in case of bike sharing and 711 tons in case of electric bike rental system. In total is annual expected reduction of CO² in Tartu transport system at minimum 1890 tons from implementation of Smart bike sharing system.

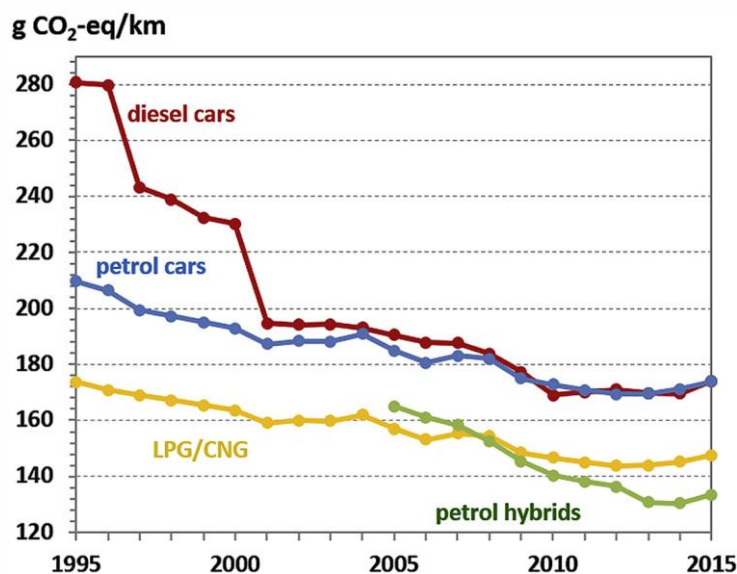


Figure 4: CO₂ emissions by car production year and type of fuel

3 Overall Approach

Ambition of TAR in SEC project is to turn hrustovkas into 'smartovkas' with accompanying innovative solutions in public transport, street lighting and monitoring. The aim of the investments is to create a high-quality living environment that inspires the pilot area community to make environmentally aware decisions and change their patterns of behaviour.

The implementation of bike sharing – and electric bike rental systems in Tartu is innovative, as there is no other city with similar size in Nordics having city-wide public bike sharing system based mostly on electric bikes.

The mobility action of Tartu is aligned with its current strategy to develop environmentally friendly urban transportation. The City of Tartu has set as its task to decrease environmental impact from city transport and a more efficient use of natural resources and city space, thus the development of light and public transportation modes are priorities. From the perspective of transport, more environmentally friendly fuels or types of movement should be chosen to decrease air pollution.

In this context, the Smart bike sharing system will bring a win-win situation for anyone who is willing to ditch the use of a car for a bike. The central concept of this innovative system is to provide free or affordable access to bicycles for short-distance trips in an urban area as an alternative to motorised private vehicles, thereby reducing traffic congestion, noise and air pollution. Innovative Smart bike sharing system is cited as a way to solve the "last mile" problem and connect users to public transit networks. It can really revolutionize the way of transport inside the city. Electric bicycle can be used by anyone (including non-fit and elderly people) and in different conditions (for hill climbing etc). Electric bicycles could be innovatively integrated with the public transport infrastructure, making the last few miles from the station to your place of destination more accessible. New business opportunities arising from ICT solutions used will benefit development of new business models. With this background in mind, after analysis of the most promising alternatives within the city's strategies,

The establishment of a Smart bike sharing system allows for the best possible result in environmental sustainability and public good in mobility activities within the set budget in the SmartEnCity project. Initially it was planned to create within the project EV rental system (consisting 8 electric cars and 16 electric bicycles). There are significantly more potential users of an electric bike rental system than of electric cars. In terms of environmental protection, the establishment of a Smart bike sharing system will help reduce CO² emissions annually by an additional 711 tons compared to the initially planned activities. Smart bike sharing system will also reduce other emissions that are harmful to people's health, in addition to carbon dioxide (for example PM, HC, etc.).

Smart bike sharing ICT solutions, linked to the city's open information platform (CIOP) developed in the frame of SmartEnCity project, will yield additional benefits for diverse stakeholders: public, private (business opportunities) and ultimately citizens. Data collected from Smart bike sharing system will be made through CIOP available for third parties for research purposes and for creating new business solutions/models. New arising business opportunities will increase a novelty of the system.

4 Bike sharing and electric bike rental system purchased and in operation is commissioned and deployed

Development of a Smart bike sharing system has been one of the mobility priorities of the City of Tartu. A respective feasibility analysis was carried out in 2014 and a business model was developed based on the findings. The aim of setting up a public Smart bike sharing system is to encourage the use of bicycles and make this a considerable alternative to cars. It is expected that the Smart bike sharing system will bring about decreased environmental problems (noise, air quality), parking issues and problems with traffic intensity. Smart bike sharing is considered a part of the public transport system of the City of Tartu.

Tartu Smart bike share has acquired next generation electric assist bikes, which can communicate with the IoT-system in real-time. This gives us information about the bike's location and in case there is some problem, we can react quickly. Software installed in the bikes collects data for statistics about your rides, speed, distances etc.

Smart Bikes are an important part of the Smart City way of thinking. One of the most important objectives of Tartu City is to develop environmentally friendly mobility. With Smart bike share, we can reduce the number of cars, encourage users to get some physical activity and maintain the "15 minutes to anywhere" phenomena in Tartu. In addition to the data-based and smartly planned bike network, using a Smart bike is a lifestyle choice valued by citizens and visitors.

Launch of bike share system

From June of 2019, Tartu has a brand new Smart bike share system including bike share and electric bike rental system, comprised of 750 bikes in 69 bike share stations across the city. A total of 510 bikes are electric and the remaining 240 are regular bikes. Tartu Smart bike share system is included into city's public transportation network which gives the city a modern and integrated public transportation network, where users will be able to combine bicycle riding with bus rides.



Figure 5: Opening of Tartu bike share

Planning of bike share

Various bike sharing systems have been successfully set up in ca. 700 cities all over the world. In most of the cases, these systems have been established by large cities that have taken a strategic goal to increase the use of bikes and bring down the use of private cars. A considerable decrease in the cost of respective technologies has also brought cities closer to the point from which the implementation of bike sharing systems is attractive. However, as cities mostly set up bike sharing systems partly, e.g. in the central area or between major attractions, the comprehensive approach taken by Tartu to cover the entire city can serve as a good practice. After all, it is more likely that people will use the system if they can get to their exact destinations, not just the approximate neighborhood.

As such, the main factors that determine the success of the bike sharing solution are the following:

- Coverage of the system/number of parking lots
- Availability of bikes and docking stations
- Safety (e.g. requirement to wear a helmet)
- Simplicity of the solution
- Weather conditions (e.g. whether the service can be used in wintertime)
- Affordability Population and density

Creation of a Tartu's Smart bike sharing system was started in 2017 when a survey (including public survey) was carried out to determine the location of bicycle parking lots. The survey was conducted by Positium LBS, which used more than 15 different data layers to determine potential parking locations (including mobile positioning data). In addition, a public web survey was organized. Over 2,000 proposals for parking lots were received from public. Finally, 84 of the most suitable locations were chosen out of which 69 were also deployed within the SmartEnCity project.

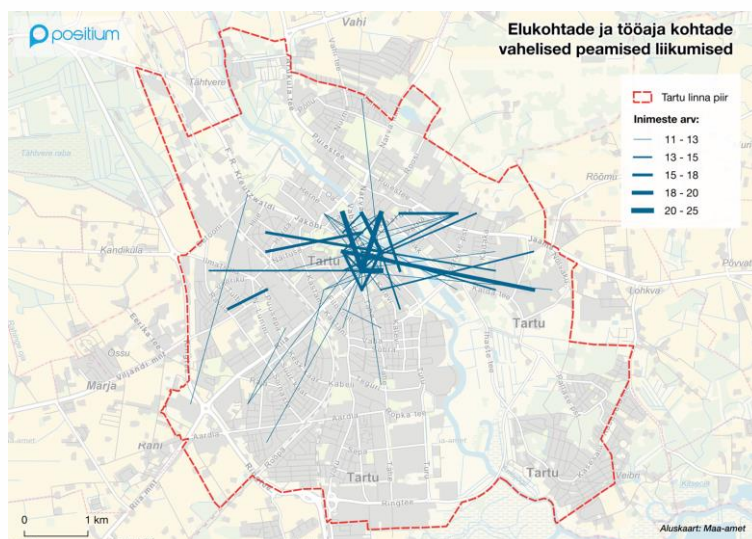


Figure 6: Data from mobile positioning (daily movements of citizens)

Results of online survey

During the planning phase was also conducted a survey among citizens and inhabitants of neighbouring areas of the city in order to find out how residents view cycling and what is their willingness to use bike share in the future. The main results from survey shows that 28% of respondents who is using private car for daily movements agree to give up on car rides In favour for bike sharing system. Respondents find that the bike station could be an average of 536 meters from their place of residence or work and 25% of respondents are ready to use the bike sharing system year-round if the system is well-accessible.

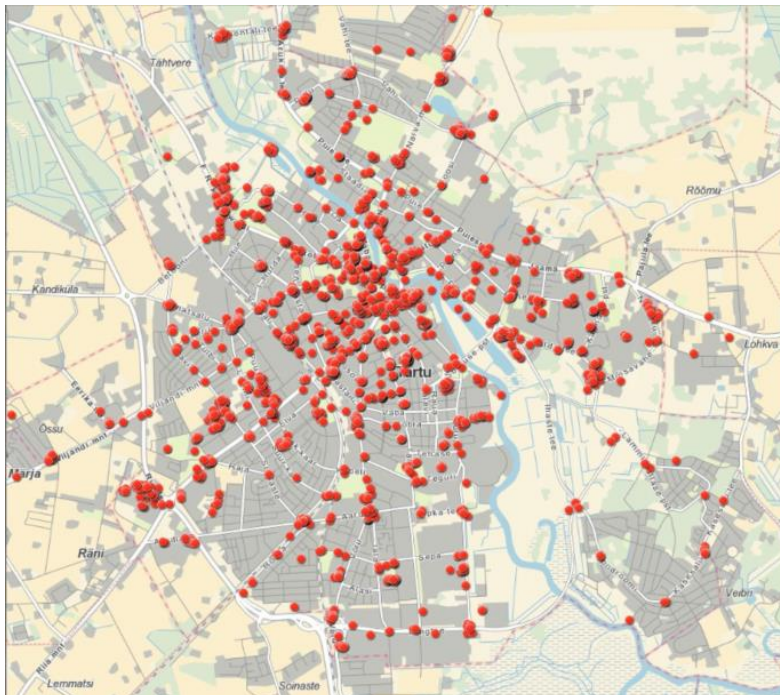


Figure 7: Proposals from citizens

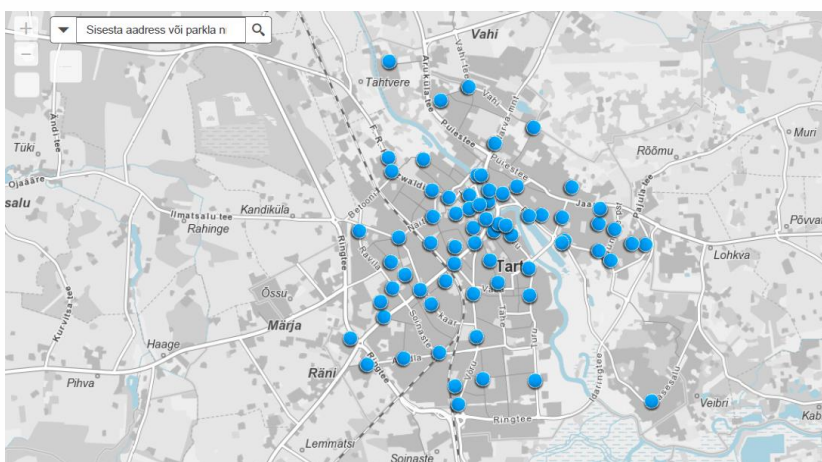


Figure 8: Final locations (69) for bike share stations

Use of bicycles

Electric assist bikes within the Smart bike share system are easy to use, with the electric motor starting when pedalling and the bike being free of any additional control devices. Electric assist bikes will remain in circulation until temperatures fall below freezing, and during cold periods only regular bikes will remain in circulation.

The bike share and electric bike rental systems were being supplied by the Canadian company Bewegen Technologies Inc, who won the public procurement organised in spring of 2018.



Figure 9: Electric bicycle

In order to rent a bike, the user must purchase a season ticket (one day, week or year) for the bike share network or must have a valid period ticket for Tartu city's urban lines. The user must create a bike share account, either on-line or via the Tartu Smart Bike mobile app, and connect it to a credit card. User can use a bus card or mobile app to unlock the bicycle. When returning the bike, the bike should be left in any bike share station, making sure that the bike has been properly locked. If there are no available spaces in the station, the bike can be secured with an additional lock near the station.

Pricing

User can obtain a bike share membership for €5 (Day), €10 (Week) or €30 (Year 1st hour of every ride is included in the price. Each succeeding hour will cost +1 €/h.

Bicycles

Another characteristic of the bicycles used in the Tartu bike sharing system is that all the smartness is installed on the bicycles. All bicycles have SIM cards for data communication and GPS sensors. This allows you to get an accurate overview of the current state of the system (where the bicycles are, what their current technical condition, etc.) and to provide the necessary maintenance work as well as bicycle logistics.


D4.9 Bike sharing and electric bike rental system purchased and in operation

Non-pedelec Specifications



Size	Comfortable for people of 1,49m (4'-11") to 2m (6'-7")
Frame	AL6061-T6 with integrated battery compartment, powder coated.
Fork	AL6061-T6, 1.1/8"-1.1/4" steerer, integrated Lock-System housing, powder coated.
Headset	VP Components®, threadless.
Stem	Bewegen, alloy, direct mount.
Handlebar	Bewegen, alloy, 650mm width.
Grip	Bewegen, overmolded with anti rotation device.
Brakes	Shimano® BR-1M 81 roller brakes.
Brake Levers	Bewegen, alloy, power cut-off.
Crank	Bewegen, forged alloy with overrunning clutch.
Pedals	Bewegen, die-cast aluminum body with overmolded Kraton® pattern.
Bottom Bracket	VP Components®, ISIS Drive.
Chain	KMC®, rust proof.
Front Hub	Shimano®.
Rear Hub	Shimano® NEXUS Internal Geared Hub, 8 speeds, Gear Ratio Total Difference : 3.07
Spokes	Stainless steel, J-Bend, PG 14G.
Rims	Alexrims® 24" and 29" 6061H-T6 aluminum, 17mm width, double wall with stainless steel eyelets.
Tire	Schwalbe® Big Apple 2".
Seatpost	Bewegen, anti-theft device, height marks and alignment line.
Saddle	Bewegen, moisture and UV resistant.
Kickstand	Bewegen, double legged.
Battery	Bewegen, 250Wh, 48V Hi Efficiency Li-Ion, Samsung® cells.
Console	Bewegen, Worldwide compatibility, GPS, CVGA color display.
Basket	Bewegen, polyamide 6/6, capacity of 19 liters (5 gallons) and up to 25kg (55lbs)
Lock-System	Bewegen, Low energy consumption, double locking.
Certifications	Comply with ISO4210, UL 2054 (battery)

Figure 10: Technical specification of regular bicycle



Size	Comfortable for people of 1,49m (4'-11") to 2m (6'-7")
Frame	AL6061-T6 with integrated battery compartment, powder coated.
Fork	AL6061-T6, 1 1/8"-1.1/4" steerer, integrated Lock-System housing, powder coated.
Headset	VP Components®, threadless.
Stern	Bewegen, alloy, direct mount.
Handlebar	Bewegen, alloy, 650mm width.
Grip	Bewegen, overmolded with anti rotation device.
Brakes	Shimano® BR-1M 81 roller brakes.
Brake Levers	Bewegen, alloy, power cut-off.
Crank	Bewegen, forged alloy with overrunning clutch.
Pedals	Bewegen, die-cast aluminum body with overmolded Kraton® pattern.
Bottom Bracket	VP Components®, ISIS Drive.
Chain	KMC®, rust proof.
Hubs	Shimano®.
Spokes	Stainless steel, J-Bend, PG 14G.
Rims	Alexrims® 24" and 29" 6061 H-T6 aluminum, 17mm width, double wall with stainless steel eyelets.
Tire	Schwalbe® Big Apple 2".
Seatpost	Bewegen, anti-theft device, height marks and alignment line.
Saddle	Bewegen, moisture and UV resistant.
Kickstand	Bewegen, double legged.
Motor	Dynamo®, 250 Watts, silent gearing, built-in telemetry and power supply.
Battery	Bewegen, 650Wh, 48V Hi Efficiency Li-Ion, Samsung® cells.
Torque Sensor	Bewegen, one-piece design, measured on the chain.
Console	Bewegen, Worldwide compatibility, GPS, QVGA color display, customizable level of assistance.
Basket	Bewegen, polyamide 6/6, capacity of 19 liters (5 gallons) and up to 25kg (55lbs)
Lock-System	Bewegen, Low energy consumption, double locking.
Certifications	Comply with EN 15194:2009+A1:2011, ISO4210, FCC 47 CFR, ICES-003, UL 2054 (battery)

Figure 11: Technical specification of electric bicycle

Stations

Bike sharing station prioritizes adaptability and flexibility. The stations require minimal anchoring, making them easy to install, remove and reconfigure. The lightweight design eliminates the need for large vehicles for installation. The anchor system is thin and can be assembled onsite, with the informational board and docks being mounted directly to the rail. This provides additional flexibility by eliminating requirements for excavation or trenching works. Station technology enables configuring of stations in a variety of manners that respond to the needs of each location. Stations can be configured continuously, discontinuously, curved, or customized. Individual docking points can be straight facing, double sided, right-oriented or left-oriented.

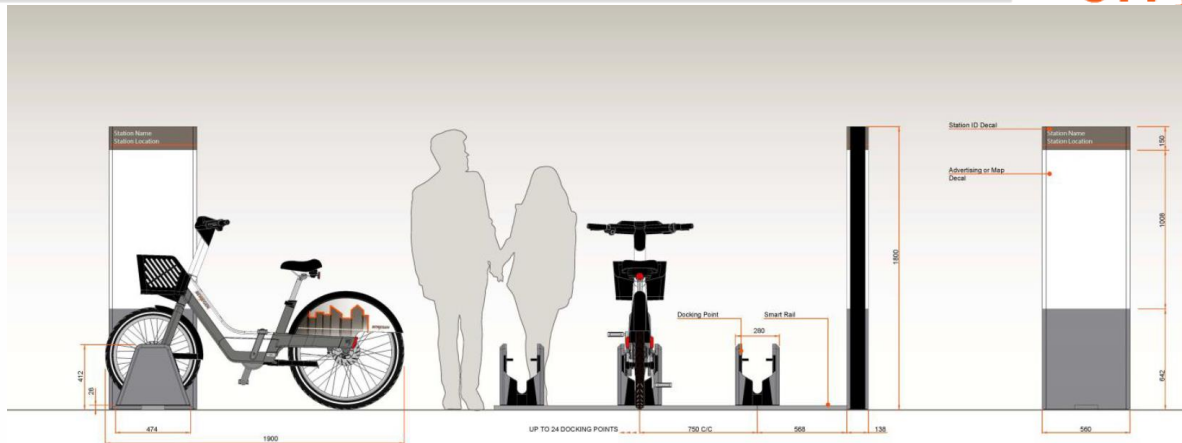


Figure 12: Scheme of docking station

Tartu's Smart bike share station technology have also a virtual or „dockless“ option which is revolutionizing bike sharing. GPS technology enables dockless bike sharing. The system operator may create virtual stations within seconds. Geo-fenced area that is GPS designated to match clearly marked region. Secondary lock of the bicycle and double-sided kickstand are used for parking. Hybrid systems using both virtual and physical stations Temporary virtual station is ideal solution for special events (concerts, gatherings etc.).

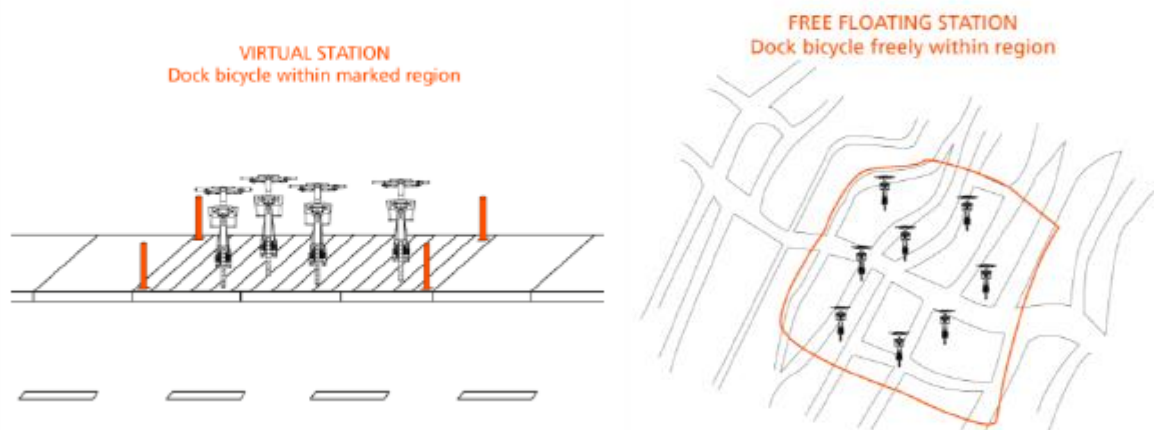


Figure 13: Virtual station technology

Citizen engagement:

The residents of Tartu have been involved in the implementation of the Smart bike sharing system already from the beginning of planning the solution and they have several roles in this process. First of all, the residents were involved in deciding on the locations of the docking stations and drafting the service pricing policy (e.g. length of free driving time, daily and monthly pass prices). After the launching of the Smart bike sharing system, residents are involved in improving the service quality. More specifically, questionnaires will be conducted to identify user expectations and needs, and the design of the service will be adjusted accordingly.

Citizens are also engaged through awareness-raising – citizens are informed of how the system operates, how they can register as users, use the system and pay for it, how they can ensure their own and others' safety etc. Similar content is communicated to visitors and tourists. The main communication messages include the following aspects:

- Smart bike sharing is convenient, practical, safe, healthy, fast, flexible and affordable;
- Smart bike sharing will make the urban environment more human friendly and approachable;
- Users need to make sure that they take care of the safety of themselves, others and the bike sharing equipment.

Monitoring

Deliverable “Bike sharing and electric bike rental system purchased and in operation is commissioned and deployed” will be monitored within the project during the period 01.08.2019 – 31.07.2021. Monitoring will be carried out with help of smart city platform (Cumulocity) developed within the project by company Telia Eesti AS. GPS data from bikes will be analysed.

5 Lessons Learned

Establishing a Smart bike sharing in Tartu has been a rather long and complicated process. When we started with planning of Smart bike share our understanding was that about 200 bicycles and free-floating system could be built in Tartu. 5 years later after the launch of the Smart bike sharing, we can say that the current system with 750 bicycles and 69 parking stations will definitely need to be expanded in the coming years. The system may be up to 2 times larger in the future. The opening of the Smart bike share showed that the interest of the city residents in this kind of transportation option is extremely high and during the first month, proposals have been made by the residents as well as the companies for the additional bicycle parking stations.

The phase of active implementation of the Tartu Smart bike share lasted about 2 years. Based on our experience, we also recommend those cities who plan to create a bike share system to take a time for at least 2-3 years. Planning of locations for bicycle parking stations alone and building their bases and electrical connections takes at least 1.5-2 years. It is a long-term process, but thorough preparatory work will also ensure success later.

Since cycling and walking are the foundations of the Tartu transport system and the development of these modes of movement has been a political priority in Tartu for the last two decades, it was easier for us to get political support for a bike share project than in some other cities. It is obvious that without active political support it can be quite difficult to say that it is impossible to successfully implement the bike share.

At the time of the report, the Smart bike share has been in operation in Tartu for 2 months, and some weaknesses have also come to light during this period - information systems may go out of line in active use, people tend to use bicycles unintentionally and also vandalize. In order to reduce the impact of possible problems, it is advisable to have different operational strategies in the start-up phase for a flexible response. It is very important to pay attention to security (IT systems, traffic, general security) and to inform the public proactively.

In conclusion, it can be said that the implementation of the Smart bike share is definitely very positive and undoubtedly has a healing effect on the city traffic and the urban environment as a whole.