TOWARDS SMART ZERO CO_2 CITIES ACROSS EUROPE

VITORIA-GASTEIZ ✣ TARTU ✣ SONDERBORG

Deliverable 4.8: Mobility infrastructure set up and in operation

WP4, Task 4.6

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Author(s):	Jaanus Tamm (TAR)

[1] PU = Public
PP = Restricted to other programme participants (including the Commission Services)
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Abbreviations and Acronyms

Abbreviation/Acronym	Description
SmartEnCity	Towards Smart Zero CO2 Cities across Europe
RES	Renewable Energy Sources
SEC	SmartEnCity
WP	Work package
TAR	Tartu City Government
TAKSO	Takso OÜ
AC	Alternate current
DC	Direct current
PV	Photo voltaics
CHAdeMO	Quick charging method for battery electric vehicles (Japan)
EV-charger	Quick-charger for electric vehicles
EV-battery	Used batteries of electric vehicles
CCS	Quick charging method for battery electric vehicles (Europe)

Table 1: Abbreviations and Acronyms

0 Publishable Summary

One important part of Tartu city transport policy is the promotion of the use of alternative fuels in the city transport system. The city itself sets a good example here - public transport in the city was recently completely converted to gaseous fuel, at the disposal of city government officials (mainly social workers) are 26 electric cars, etc. As of November 2018, there are 5 electric car chargers available to the public, which were installed in the city centre area of Tartu as part of the SmartEnCity project. What makes the installation of these chargers special is the fact that they are the first public electric car chargers in Estonia that can use both the CCS and CHAdeMO charging modes. The chargers have been already subjected to 5566 charging sessions since they were installed.

In addition to installing electric car chargers, OÜ Takso, a partner in the SmartEnCity project, created an electric car battery re-use system for charging electric taxis. The system allows to use electric car batteries to store electricity and then charge the electric car. Solar panels are also integrated into the system, so that mostly renewable energy is used for charging. Only a small part of the electricity from grid is needed to charge vehicles (usually in the night-time and in winter when solar energy is scarce). This solution is unique as no similar commercial solution is available on the market today. Thus, the system developed by OÜ Takso has great market potential.

Figure 1: EV-charger in Uueturu street

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

The aim of the transport policy of Estonia and 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.

Electric vehicles and the infrastructure needed to service them are playing an increasingly important role in the development of a sustainable transport system.

1.1 Purpose and target group

The purpose of this deliverable is to document the details and processes made by TAR and TAKSO related to install EV-chargers and create a EV-battery re-use 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 new gas buses.

1.2 Contributions of partners

The following ***¡Error! No se encuentra el origen de la referencia.*** *depicts the main contributions from participant partners in the development of this deliverable.*

Participant short name	Contributions
TAR	Overall & general content
TAKSO	Content of EV-battery re-use

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 DHC

Table 3: Relation to other activities in the project

2 Objectives and expected Impact

EU transport policy aims to provide efficient, safe and environmentally friendly mobility solutions for Europeans and to create the conditions for a competitive industry generating growth and jobs.

In the EU level there are identified three priority areas for action:

- Increasing the efficiency of the transport system by making the most of digital technologies, smart pricing and further encouraging the shift to lower emission transport modes,
- Speeding up the deployment of low-emission alternative energy for transport, such as advanced biofuels, electricity, hydrogen and renewable synthetic fuels and removing obstacles to the electrification of transport
- Moving towards zero-emission vehicles. While further improvements to the internal combustion engine will be needed, Europe needs to accelerate the transition towards low- and zero-emission vehicles.

Cities and local authorities will play a crucial role in delivering this strategy. They are already implementing incentives for low-emission alternative energies and vehicles, encouraging active travel (cycling and walking), public transport and bicycle and car-sharing /pooling schemes to reduce congestion and pollution.

Across Europe transport accounts for about 20 % of all greenhouse gas emissions, nearly half of it is related to passenger transport. To reduce the carbon footprint of mobility, alternative fuels has to be strengthened, especially in rural and suburban regions that represent bottlenecks in transport networks.

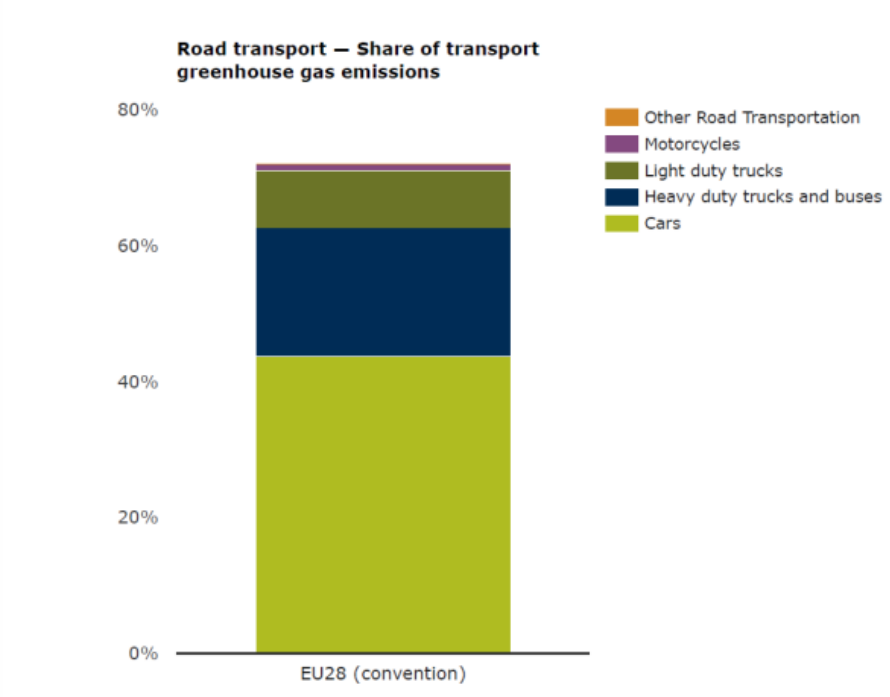

Figure 3: Emissions from transport in EU

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 strengthen alternative fuels to minimize environmental impact of transport system.

2.1 Objective

The main objective of this deliverable is to strengthen the usage of alternative fuels (electricity) and RES in transport sector and create an innovative EV-battery re-use solution. Implementation of this deliverable will reduce CHG emissions from transport sector and make the city more livable place. 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 CO^2 emissions from car usage, but there are several side impacts, which are significant in terms of city environment and sustainability – cleaner city environment, better health of citizens etc.

The reduction of usage of fossil fuels and thus reduction of CO^2 emissions in transport system is the main expected impact.

This deliverable plays a significant role in innovation and have great impact on future trends. As part of the activities, public EV-chargers for electric cars were installed in the downtown area of Tartu, which enables the use of chargers in addition to the CHAdeMO charging standard for CCS charging standard vehicles. Thanks to the new possibilities, new electric vehicles have already appeared in the cityscape.

However, the re-use system for old electric car batteries developed by OÜ Takso enables the creation of a widely used commercial solution, which helps solve the problem of batteries that have become obsolete - to give them a new life as energy storage devices.

3 Overall Approach

Ambition of TAR in SEC project is to turn hrustsovkas into ‘smartovkas’ with accompanying innovative solutions in mobility, integrated infrastructures, engagement 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 mobility actions of Tartu are aligned with its current strategy aiming to develop environmentally friendly urban transportation. The City of Tartu has set a goal to decrease pollusion from transport and to have a more efficient use of natural resources and city space. From the perspective of transport, more environmentally friendly fuels or types of movement should be chosen as to achieve the desired air pollution decrease. In other words, in order to decrease the negative environmental impact of the transportation system it is necessary to facilitate the use of alternative motor vehicle fuels in city transport.

To date, 11 electric car chargers belonging to the national network ELMO and using the CHAdeMO charging standard have been in public use in Tartu. The 5 new fast chargers installed within the SmartEnCity project will open the door to the CCS charging standard. The market situation for EV-charging is quite complicated in Estonia as the cost of electricity in the chargers of the ELMO network is quite low due to government grants and it is very difficult to compete with these prices. Therefore, the opportunity created by the SmartEnCity project is of special significance and investment support can provide users with more affordable charging options. The city of Tartu procured the chargers through public procurement and also acquired the operator of the chargers. The city does not charge the operator for the use of the equipment, but at the same time the operator is obliged to sell the electricity according to the contract to customers at a fixed price, which is 15 cents / kWh. As the national ELMO quick charger network is currently in the process of privatization, it is expected that in the near future the market situation will change.

SmartEnCity project partner Takso OÜ owns a considerable number of electric taxis in Tartu - a total of 36 vehicles. The company has long-term experience (since 2012) in operating electric vehicles and is one of the most experienced users of electric vehicles in Estonia. The electric vehicles used by OÜ Takso cover usually up to 400,000 kilometers, after which the remaining battery capacity of the vehicles' batteries is about 70%. Such batteries are difficult to use on a daily basis in cars as they require frequent charging. However, it is possible to successfully use batteries as energy storage devices. The desire to use environmentally friendly energy sources and the need to find a solution for the re-use of end-of-life electric car batteries joined the SmartEnCity project to create an electric car battery re-use system that will work on renewable energy - solar power.

4 Task 4.6 / Mobility infrastructure set up and in operation is commissioned and deployed

EV-chargers

Quick chargers are in general referred to as min 50kW direct current (DC) chargers, which allow you to charge for example Nissan Leaf electric car batteries (24 kW) for approximately 30 minutes. Significantly cheaper AC (Alternating current) chargers with a lower power rating (typically 11-22 kW) for public use are also available on the market, which can charge for example Nissan Leaf batteries for approximately 8 hours.

In 2012 was established national quick charging network - ELMO consisting 167 50-kW chargers all-around of Estonia and 11 of them are located in Tartu. ELMO network is available for cars using CHAdeMO standard.

Due to the fact that the ELMO network chargers are located not in the centre part of Tartu and are not easily accessible to SmartEnCity pilot area residents and only allow charging according to CHAdeMO standard, it was decided to install 5 new electric car quick chargers enabling charging also according to CCS standard in the Tartu city centre area.

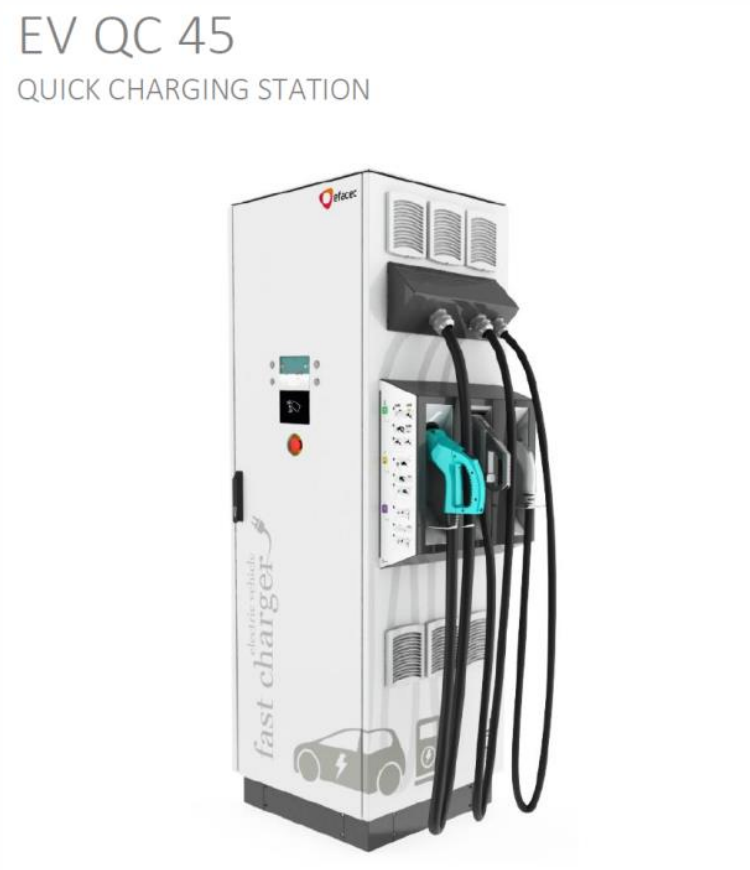

Figure 4: EV-charging station installed in Tartu

The process of installation of quick chargers started at the beginning of 2016 when the most suitable locations for chargers was determined. The choice of locations based on the precondition that the chargers have to be located in easily accessible locations and where electric vehicle users move on a daily basis. In total of 4 locations was selected, with one charger to be installed in 3 locations and two chargers in one location.

Figure 5: Locations of chargers in Tartu

After the appointment of the locations, contracts were signed with the network service provider for electricity connection. In April-May of 2018 was carried out a public procurement on purchase of chargers and the company Elektritransport OÜ was awarded as a winner in procurement. Equipment was installed in October of 2018.

Technical Data		CE	ETL
Nominal Input	Phases/Lines	3 phases + neutral + PE	3 phases + PE
	Voltage	(400 ± 10%) V a.c.	(480 ± 10%) V a.c.
	Current	73 A	64 A
	Power	53kVA (@50kW peak power); 48kVA (@45kW)	
	Frequency	(50 ± 10%) Hz	(60 ± 10%) Hz
	Efficiency	> 93%	
	Power Factor	0,98	
	THD Input Current	12,3	
DC Output: CHAdeMO	Voltage	(50 to 500) V d.c.	
	Current	120 A d.c.	
	Nominal Power	50kW at peak; 45kW at continuous	
	Communications with EV	JEVS G104 - CHAdeMO	
	Plug	JEVS G105 - CHAdeMO	
DC Output: CCS	Voltage	(50 to 500) V d.c.	
	Current	120 A d.c.	
	Nominal Power	50kW at peak; 45kW at continuous	
	Communications with EV	PLC	
	Plug	CCS – Type 2	SAE – Type 1
AC Output: AC43 (or AC22)	Voltage	(400 ± 10%) V a.c.	
	Current	63 A a.c. (or 32 A a.c.)	
	Nominal Power	43kVA (or 22kVA)	Not Available
	Plug (or Socket)	IEC62196 Type 2	
Insulation	Input / Output / Ground	1500 V a.c.	1500 V a.c.
	Control Circuit / Ground	500 Vac	
Cabinet	Dimensions(WxDxH)	600 x 600 x 1800 mm	24" x 24" x 74.5" high
	Weight	600 kg	1,323 lbs.
	Protection Degree	IP54, IK10	IP54, IK10, NEMA 3R
HMI and Command Unit	Contactless card specification	Mifare Classic 1K&4K | Mifare DesFire EV1 (Others under request)	
	Local interface	TFT Color display 6.4" Buttons	
	Communication Protocol (others under request)	Web Services over IP; Router 3G (GSM or CDMA) OCPP; Efacec; others	
	Emergency STOP	Yes	
Environment Conditions	Temperature	-25º to +50ºC	-13º to +122ºF
	Cold option (under request)	-35º to +50ºC	-31º to +122ºF
	Humidity	5% to 95%	
	Place of installation	Indoor / Outdoor	
	Altitude	Up to 1000m	Up to 3280 feet
	Sound Noise	<55 dB in all directions	

Figure 6: Technical specification of chargers installed in Tartu

The most difficult part of this deliverable was securing operations. As in the National ELMO network the cost of electricity is subsidized by the state, it was very difficult on a commercial basis to compete with the ELMO network. In order to ensure the most attractive way for consumers to recharge their electric car, a call for tenders was organized and evaluation of tenders was on the basis of the fixed price of electricity for small consumers. The tender received 2 bids and the winner was a bid with a cost of 0.15 € / kWh for a small consumer. In comparison, the cost of charging of 1 kWh of electricity in the national ELMO network is € 0.11 - € 0.14 depending on the package.

EV battery re-use

One of the new ideas of the project in the field of transport is to re-use of EV batteries for storing energy. As electric vehicles are gaining popularity virtually everywhere, solutions for repurposing their rather quickly deteriorating, but still valuable batteries (delivering 70-80% of their original output at end of life) have significant market potential and could yield many environmental benefits. Tartu – having built up a considerable electric taxi fleet is a suitable test site for piloting these solutions.

Figure 7: EV-battery re-use system in operation in Tartu at Takso OÜ workshop

The objective of the activity is to use in sustainable way EV batteries giving them a second life. Re-use of old batteries will benefit the protection of environment as there is needed to use less resources in production of energy storages and in the same time will be used renewable energy from sun to charge EV-s.

The EV taxis of the private company OU Takso will be partially recharged based on renewable energy that is produced on-site with PV panels and stored in used EV batteries.

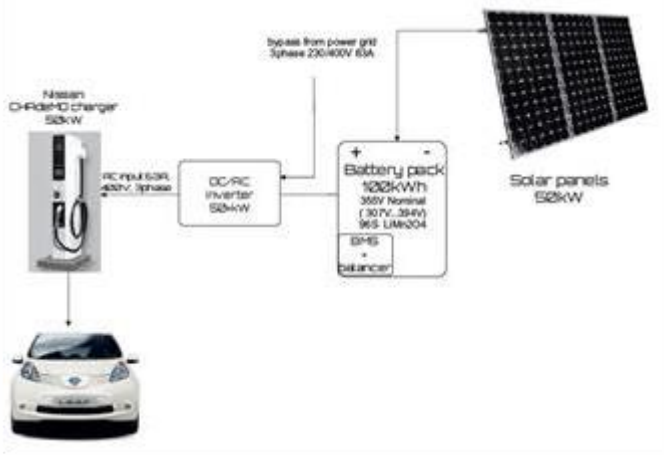

Figure 8: Scheme of EV-battery re-use system

The battery re-use system allows to charge in the sustainable way around 30 EV-s during the day (depending on location of the system). For the system is needed up to 6 EV used batteries. As a lifetime of the EV battery is around 5 years (in case of taxis) then it is needed around 30 EV-s to supply the solution with needed used batteries. In this way the solution is autonomous and suitable for fleet of 30 EV-s. Depending on climate conditions supernumerary electricity produced by PV-panels can be used for other purposes on site (lighting) or sold to grid.

The system consists 100 kW of used batteries. Battery have 26 modules series, each module have 4 elements in parallel and in total of 424V. Batteries have over voltage, overheat and under voltage protection circuits, and also emergency OFF button. Every module have individual BMS module manufactured in Estonia. Batteries will be re-charged during the day-time with Solar power. If the car is charged during the day-time it will get power from PV panels and from batteries as well. During the night-time when the power of batteries is almost used and battery voltage is low inverter will switch charging on grid power.

Figure 9: Batteries

The power of installed solar panels (PV) is in total 50kW. Panels are installed in 2 sections - 6x20 panels in series and 3x20 panels in series. In total 180 panels. Total voltage of PV-panels is over 700V.

Figure 10: PV-panels at Takso OÜ workshop

The most complex part of the solution is the management of the Nissan electric vehicle battery system and re-converting of current (from AC to DC and from DC to AC) OÜ Takso had a good cooperation with Tallinn University of Technology for the development of the equipment. The rest of the system components (solar panels, charger, inverters) are freely available on the market.

Figure 11: Solar combined box (left) and inverter (right)

Solar combined box – is connector box where solar cables is connected in parallel and protected each line with double breakers. Solar converter – is converting solar 760 voltage power to 430 voltage power what is suitable for inverter for charging.

Figure 12: Solar combined box

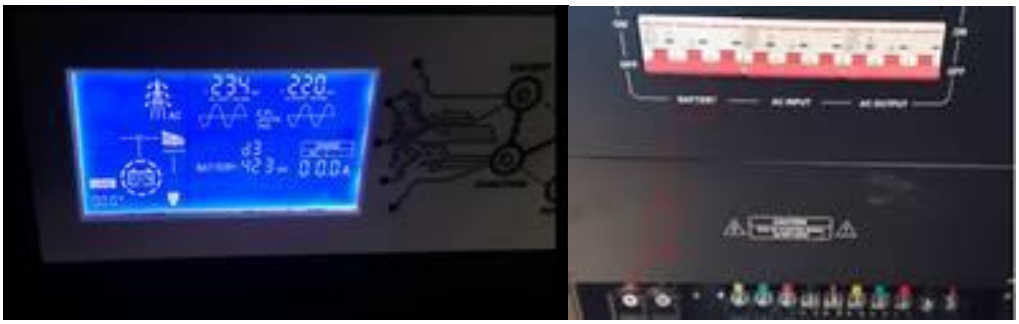

Figure 13: Inverter

Inverter used in the system is a 60VA rated to 48kW off-grid inverter, with backup input from grid and is isolated from the grid by transformer. Each line is protected with automatic fuse and with ordinary fuse as well.

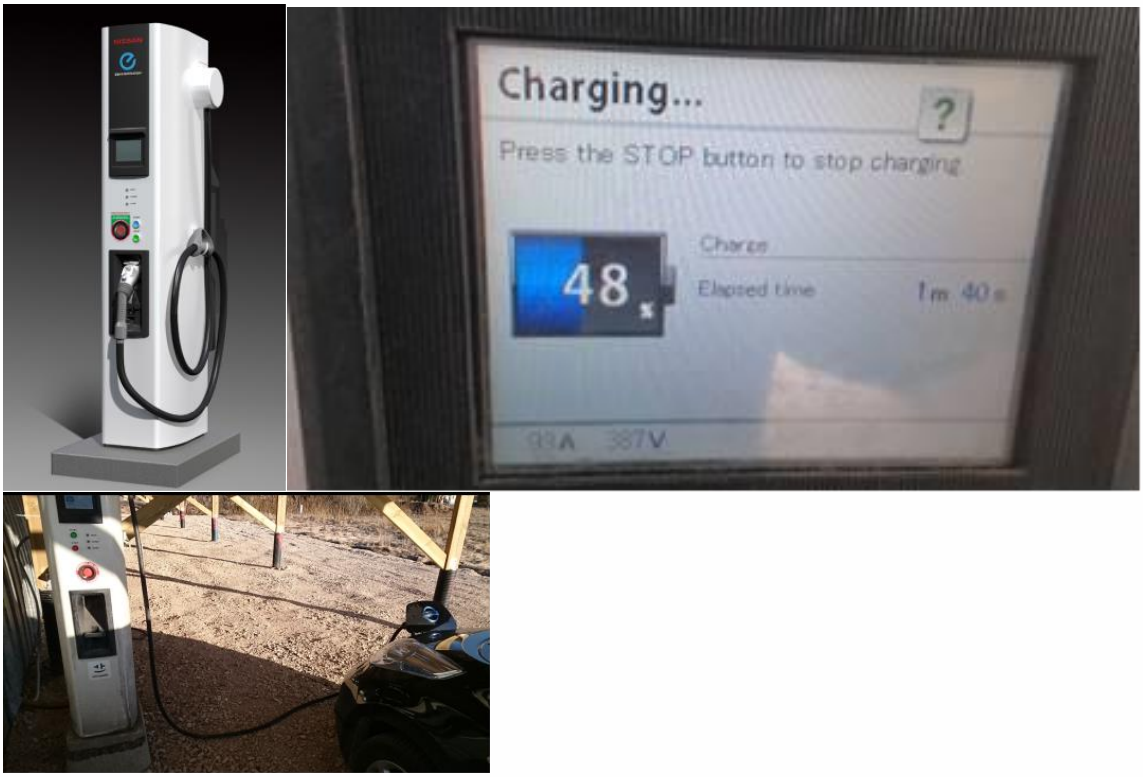

Figure 14: Nissan charger

Car Charger - Nissan CHADEMO charger with rated 44kW

The EV-battery re-use system have many benefits:

- Decarbonizing the electricity supply
- Increase of grid stability
- New business opportunities
- Increased resource efficiency

- Independence in energy supply
- Batteries lifespan extended (environmental impact from manufacturing of batteries reduced)
- System is able to work in off-grid mode (autonomy)

As the EV market continues to grow and manufacturers are announcing more and more models that are affordable to the end users, the market for second-use EV batteries can be expected to increase remarkably as well. Besides offering a solid business opportunity as replaced batteries are expensive to discard and recycle while still having most of their capacity, reusing batteries reduces waste and adds another 5-10 years of effective lifetime. Several automakers are already experimenting with alternative uses for these second-life batteries in stationary energy storage, so the solution that is developed and piloted in Tartu could considerably contribute to these efforts.

Solution can be easily replicated everywhere.

Monitoring

Deliverable “Mobility infrastructure set up 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.

5 Lessons Learned

When implementing this deliverable, we experienced two main problems that should be considered in implementing similar activities:

- finding the right development partner to create a recycle system for electric car battery re-use system proved difficult. Innovation is often a situation where market players are uncertain and not always ready to contribute enough. There is a high chance of failure and therefore thorough preliminary work to involve a trusted and competent partner is crucial.

- in case of installation of quick chargers for electric cars, we had to carry out more than one procurement in order to reach a satisfactory final result. Our experience shows that market participants need to be consulted in order to obtain similar low-profile and innovative solutions. It´s crucial to identify the technical nuances that will affect the later operation of the solution as well as the business model.

As a positive experience we would like to point out that, as a result of the installation of innovative quick chargers, the private sector has invested in environmentally friendly vehicles and several electric cars have appeared in the city in recent months.