DRIVERS AND BARRIERS TO THE ELECTRIFICATION OF INNER-CITY LOGISTICS

– Case Arkea Ltd. in Turku, Finland

Anna Satovuori, Annika Kunnasvirta, Hugo Huerta,
Timo Mieskonen, Aleksi Heinonen

BSR ELECTRIC
Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
TURKU AMK
TURKU UNIVERSITY OF APPLIED SCIENCES

Reports from Turku University of Applied Sciences 271

Turku University of Applied Sciences

Turku 2020

Graphic design: Avidly Oyj

ISBN 978-952-216-771-2

ISSN 1459-7764 (electronic)

Distribution: loki.turkuamk.fi

Contents

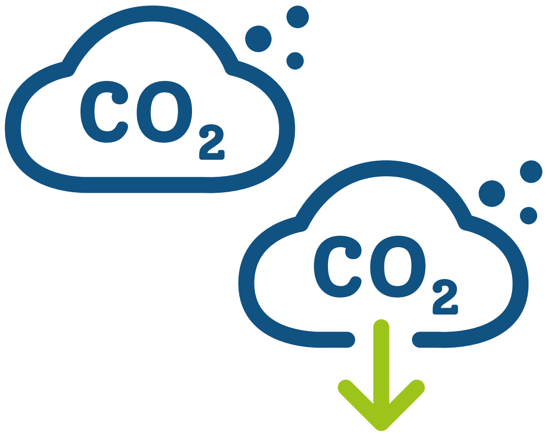
List of Figures

List of tables

Abbreviations

AC	Alternating Current
BEV	Battery Electric Vehicle
CO_2	Carbon Dioxide
CVD	Clean Vehicles Directive
DC	Direct Current
DCFC	Direct Current Fast Charging
EFV	Electric Freight Vehicle
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment. Also known as charging station
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
HEV	Hybrid Electric Vehicle
HVAC	Heating Ventilation and Air Conditioning
ICE	Internal Combustion Engine
kWh	KiloWatt-hour (energy measure)
LEV	Light Electric Vehicle (e.g. e-bikes, e-scooters)
PEB	Pro-environmental behavior
PHEV	Plug-In Hybrid Electric Vehicle
SOC	State of the Charge

1. INTRODUCTION



Urban freight and commercial vehicles make up a significant part of vehicle-kilometers travelled in cities worldwide. It has been estimated that urban freight accounts for approximately 10–15% of kilometers travelled in cities (CIVITAS 2015). In addition, commercial vehicle activity is on no account on the decline, leading to cumulative stress on urban systems in terms of emissions (greenhouse gases such as CO_2 as well as more local pollutants), congestion and noise. For instance, approximately 6% of all transport-related emissions have been estimated to be emitted by the urban freight sector (CIVITAS 2015).

City organizations play an important part in the transition to carbon-free transport, as they are responsible for a significant amount of GHG emissions in urban areas, particularly due to their various logistical functions. In terms of numbers, the role of the public sector is undeniable as across the EU around 575 000 vehicles are procured every year by the public sector (FREVUE 2017). Understanding the key factors that influence workplace travel behavior – from technological issues to individual employee and organizational behavior – is thereby crucial in view of achieving the needed emission reductions.

To combat the increasing emissions and air pollution resulting from the fast growth of commercial activities and urban logistics, different technological solutions and alternatives to conventional internal combustion engine

(ICE) vehicles need to be considered in addition to improving vehicle routing efficiency. To this challenge, electromobility (e-mobility) presents a solution that can be both economically and environmentally sustainable. With electric cars and vans currently being the most apparent form of e-mobility, many other solutions, such as LEVs (light electric vehicles such as e-bikes) are becoming more and more prominent.

From the life-cycle perspective, at this stage electric vehicles (EVs) are already competitive in terms of CO_2 emissions compared with their ICE counterparts. Given the current energy mix in Europe, EVs already produce two times less CO_2 than diesel engines (Miero 2018) and less than 50% of the CO_2 emissions of an average ICE (Platform for Electro-mobility 2017). In the future, the net GHG emissions will decrease even further as the share of renewable energy sources in electricity production will increase, the long-term objective of the EU being to reduce these emissions by 80–95% by 2050 (EEA 2018).

This report has been produced as part of the project "BSR electric – Fostering e-mobility solutions in urban areas in the Baltic Sea Region". The project, involving 15 partner organizations from eight countries, aimed to enhance the utilization of e-mobility in urban transport systems. The seven different use cases of the project have demonstrated the potential applications of various types of e-mobility, such as e-bikes, e-buses and e-scooters. The project started in October 2017 and was finished in September 2020. The project was funded by the INTERREG Baltic Sea Region Programme 2014-2020.

The use case in Turku, conducted by Turku University of Applied Sciences (TUAS), focused on inner-city logistics and was conducted in cooperation with a city-owned company, Arkea Ltd. As an organization offering various types of services, Arkea operations are often run with either cars or vans in the Turku city area. The demonstration actions included testing of two different LEVs for different functions, a survey among the employees regarding the use of the company's existing e-fleet and a winter test session for selected LEVs in cooperation with the CIVITAS ECCENTRIC project to examine their usability in Nordic winter conditions. In addition, a fleet track and route optimization tool was developed to assist organizations in making informed decisions regarding their future fleets and optimizing their logistics routes.

Replacing conventional vehicles with electric ones is an option cities can take to make the transport system more sustainable. This report examines the feasibility of replacing (city)-organization fleets with EVs or LEVs. It is based on the experiences and lessons learned from the demonstration phase and on a comprehensive literature review. First, the use case and the demonstration actions are introduced and then the usability of EVs and LEVs in citylogistics on a general level is described. Then, the focus is moved to identifying the barriers and drivers for the electrification of fleets, ranging from aspects such as city planning and technology to more behavior-related factors at the level of both the individual employees and the organization as a whole. Finally, the fleet track and route optimization tool is introduced in more detail, followed by final conclusions.

Arkea Ltd. introduction

- Arkea Ltd. is a city-owned company providing a wide range of maintenance, real estate, food, cleaning and security services in the Turku city area in Southwest Finland.
- Arkea employs approximately 1100 people and as such is one of the biggest employers of Southwest Finland.
- A cooperation agreement was made with Arkea to carry out a pilot with light electric vehicles within the scope of the BSR electric project.

2. THE TURKU USE CASE

The use case, carried out in close cooperation with Arkea, consisted of several actions. Two LEVs were leased and tested among the Arkea employees to explore their suitability for the company's operations and to assess their potential in replacing car use on work-related trips.

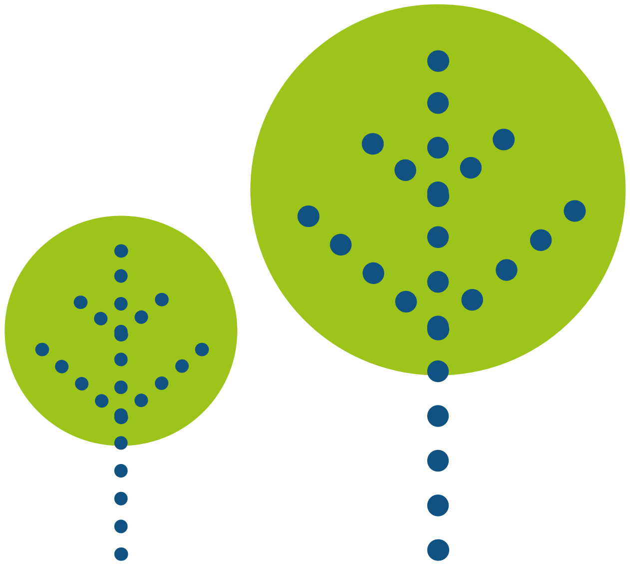
- A regular e-bike was used by the office personnel for commuting and other work-related trips at the Arkea headquarters.
- An electric cargo bike was tested by maintenance workers at a suburb location.

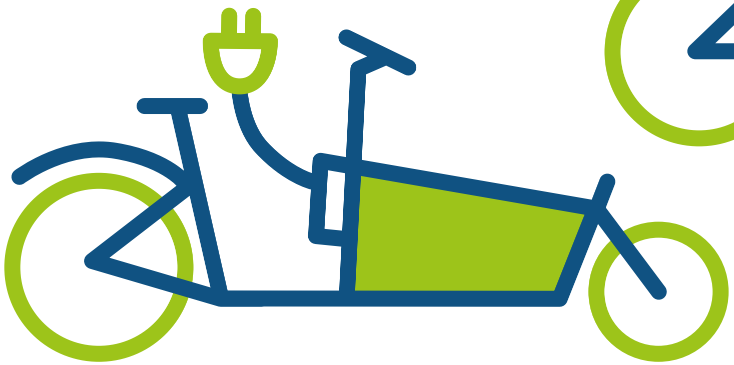
The suitability of different LEVs for winter conditions was also further explored in a winter test session, arranged together with the CIVITAS ECCENTRIC project. In the test, eight different LEVs, ranging from scooters to 4-wheelers and e-cargo bikes, were tested on icy and snowy streets and minus degrees.

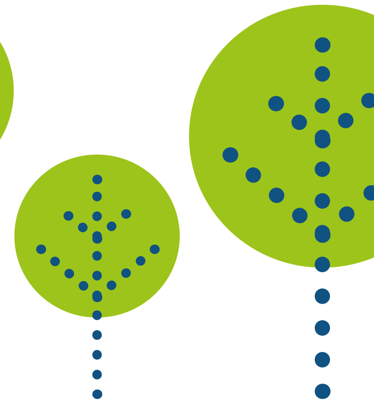
In addition, a survey was conducted with the Arkea employees concerning the use, experiences and opinions regarding Arkea's existing e-fleet.

- Arkea's current fleet consists of 23 vans or other motorized vehicles, of which four are electric vans (Nissan e NV200).
- The e-vans were introduced in summer 2016 and are leased for Arkea.

Finally, a fleet track and route optimization tool was developed as part of the project to assist city authorities or other relevant organizations in planning for the purchase of e-vehicles. The tool is introduced in more detail in chapter 5.







2.1. THE LIGHT ELECTRIC VEHICLE PILOT

Photo: Eetu Simpanen / TUAS

The two e-bikes were tested for two different purposes. A regular e-bike (Helkama E7) was piloted among the office workers at the Arkea headquarters in the inner city of Turku, and an e-cargo bike (Helkama e Cargo) was tested by property maintenance personnel at the Perno-Pansio location, in a suburban area approximately 8 km from the center of Turku. At the start of the pilot, a launching event was organized, and guidance manuals were prepared for both bikes. The period for the test phase was 11/2018 – 8/2019. Originally the pilot phase was intended to start earlier, but due to difficulties in finding suitable companies to lease the bikes the process, and hence the launch, were delayed.

Initially, the plan was that the office workers could freely use the **e-bike** for work-related trips. However, despite the efforts to promote the possibility to use the e-bike it was not too popular during the first few months. Then in December, as winter created very slippery conditions, it was decided by Arkea that the bike would be taken off use for the harshest wintertime due to safety reasons. In March, the bike was returned to use. At this point, the pilot approach was changed to allow for more in-depth user experiences – the e-bike was henceforth assigned to each user for a two-week test period. It was then used by seven different testers for a two-week period each. The testers could use the bike both for commuting and work-related trips as well as private purposes. The user experiences were generally positive, and the users appreciated the e-bike especially when biking in hilly areas and in headwind. Some issues that were identified as downsides were the weight of the battery and the charger, and that in an urban environment the e-bikes cannot reach their full potential.


Photo: Katja Tättäläinen / Arkea Ltd.

At the Perno-Pansio location, where the **e-cargo bike** was used, Arkea operates the maintenance of 10–15 apartment buildings. Some of the buildings are located within close proximity of each other but some are farther away, with the longest distances being 1.5–2 km. The bike was used by two persons who normally operate in the area by car. The container box of the e-cargo bike was used to carry tools.

Initially there was an issue with storing the bike during nighttime at the location due to the size of the vehicle; however, eventually it was stored at a youth space in one of the buildings. Another challenge that occurred was related to safety, as it was not possible to lock the bike's container where the tools were carried. This caused concerns about the possibility of theft or vandalism. Finally, the pilot took place in cold winter conditions, which made the use of the bike uncomfortable according to its testers.

Due to these practical challenges, the e-cargo bike was transferred to one of Arkea's hospital locations near Turku city center in May 2019. The bike was intended to be used for transporting laundry in the underground corridors of the hospital. In the end this was not possible, however, as the e-cargo bike turned out to be too wide to be operated in the narrow hospital corridors. The vehicle was thereby taken out of use in June 2019. Despite the various practical issues that emerged during the pilot, it was also recognized that if the practical issues were solved, the electric bicycle, whether a regular or a cargo bike, could be a convenient mode of transport for several of Arkea's functions.

2.2. ELECTRIC VEHICLE USAGE AND USER EXPERIENCES AT ARKEA

A survey regarding the use of EVs among Arkea employees was conducted online in autumn 2018. Some key results from the survey are presented here, and the results will be further discussed in the coming chapters. In total, 161 respondents answered the survey. All sectors within the organization were represented, with food services constituting a largest single share of respondents (45%). It should be noted that the needs for work-related transport and logistics vary among the sectors, which may show in some results. The work in cleaning services and maintenance sectors takes place at different destinations and thus requires the employees to move a lot during the day, whereas the work in food services and facility management services is more tied to a specific place and work-related transport is less common. Support services, on the other hand, are mostly located at Arkea headquarters in the Kupittaa area.

Most of the respondents, 61%, use their own private car also for work-related transport. Bus was used by 11% of respondents whereas 7% used a company ICE. Walking was preferred by 5% and the same amount chose “other”. It was concluded from the open answers that this 5% included those who don’t travel at all or who operate some other work-related vehicles than cars. **Finally, the company EVs were used for work-related transport by 3% of the respondents.**

The sectors at Arkea

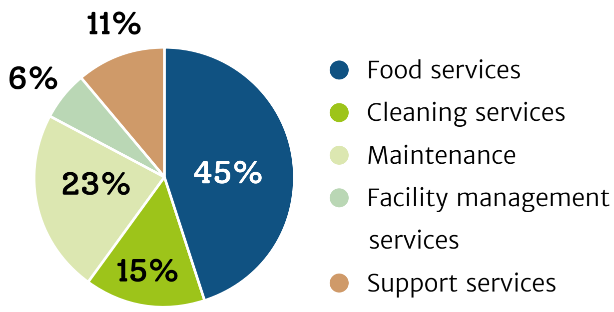


Figure 1. The sectors at Arkea

The usual mode of transport for work-related travel

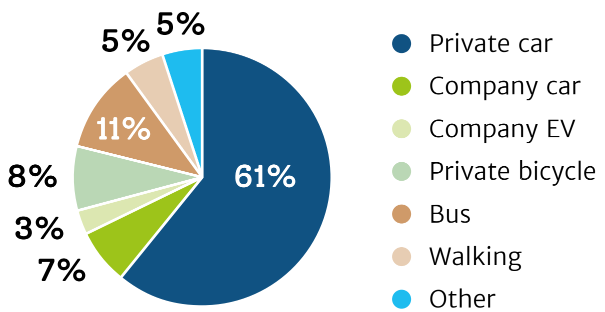


Figure 2. The usual mode of transport

As the suitability of both EVs and LEVs is to some extent dependent on the distances travelled, the respondents were asked to report the average length of their work-related trips. **As can be seen from the diagram, the average trip measured over 10 kilometers for only 17% of the people surveyed and for 60%, the average distance was five kilometers or less.** Although it is by no means the only affecting factor, in terms of distances, EVs or even LEVs would be suitable for work-related transport to a larger extent than what they are used now.

Average length of work-related trips

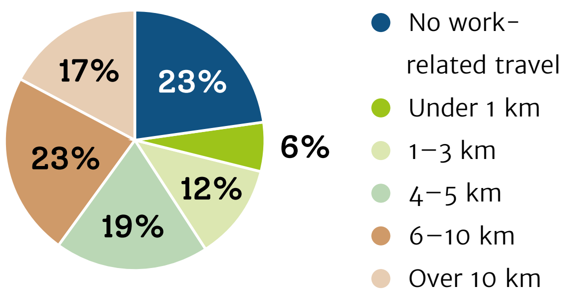


Figure 3. Average length of work-related trips

Only 14% of the respondents had tried any of Arkea's EVs and the most commonly reported reasons for not having tried one were not using company cars in the first place (51%), not having been provided an opportunity to try one (22%) and not having been aware of their existence (13%). In fact, quite a large percentage of all respondents, 40%, reported not having been aware that Arkea had EVs. **Regarding the interest in trying an EV for work-related travel there was some division among the respondents, as 35% were interested and 32% were not.**

Willingness to try an EV for work-related travel

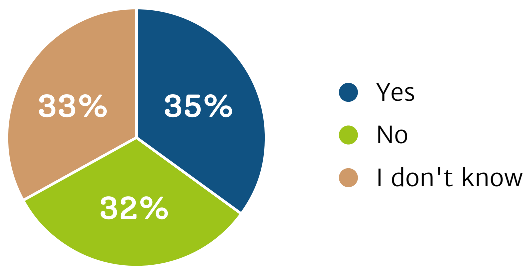


Figure 4. Willingness to try an EV for work-related travel

Among those respondents who had used the company EVs, the majority (52%) rated their experience as very positive and about 19% as positive. For only 10%, the experience had been more or less negative. Overall, the use of the vehicles was considered as pleasant and easy. What caused more division among the users were the sufficiency of range, suitability of the vehicles for winter use, sufficiency of the cars' equipment and the ease of getting access to the vehicles.

Experience with the company EVs

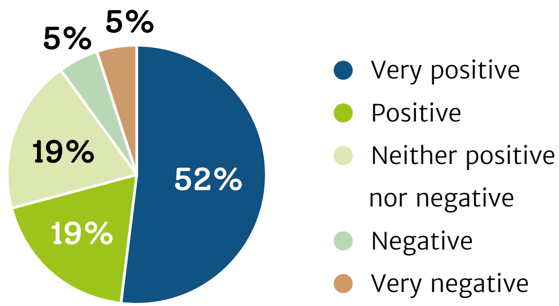


Figure 5. Experience with the company EVs

What also divided opinions was the suitability of the current EV models for work-related use, as 41% considered them suitable and 23% as not suitable. As Arkea operates in a variety of sectors with diverse needs for work-related travel, it was expected that the current fleet does not meet the needs of the entire personnel. From the open answers it could be observed that several respondents were hoping that also passenger cars were added to the fleet.

3. USABILITY OF EVs AND LEVs IN CITY LOGISTICS

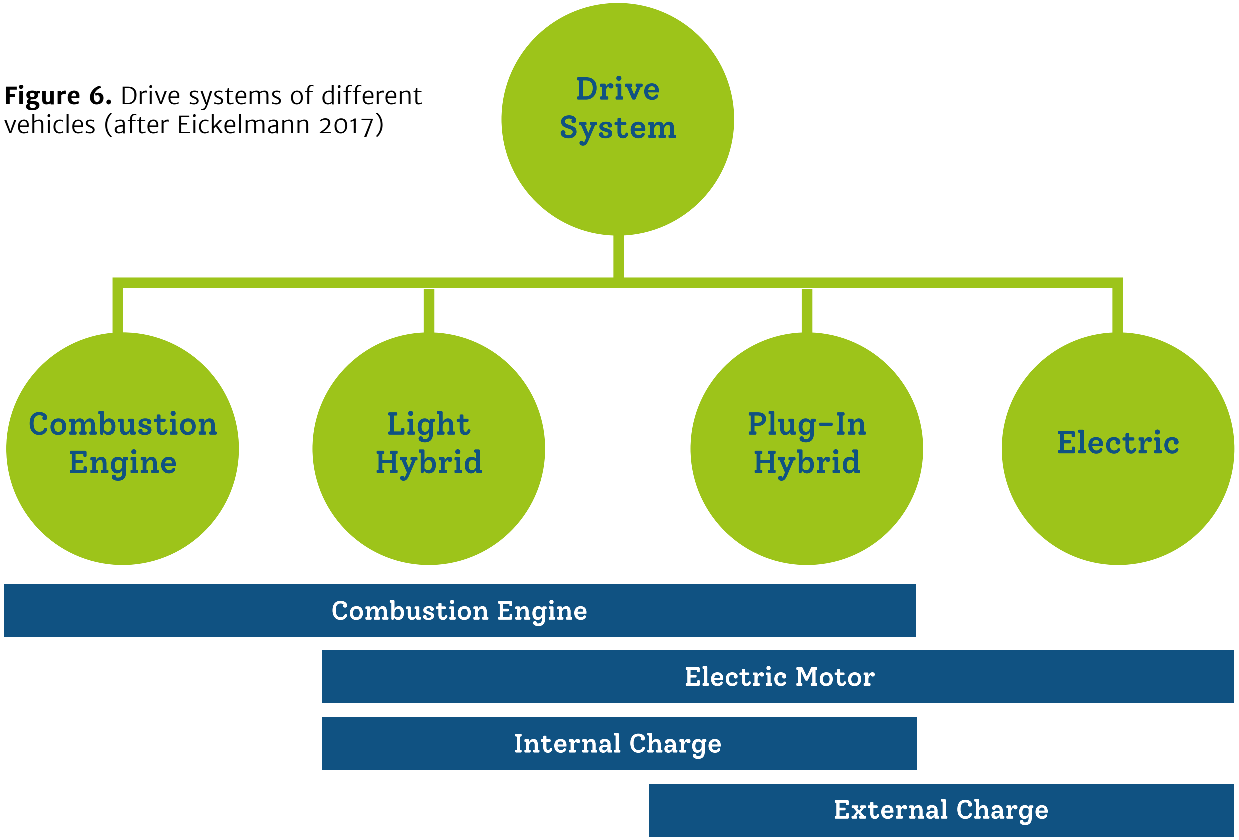
In this section we will discuss the general usability of both EVs and LEVs in city logistics, presenting their advantages and disadvantages. Several projects have demonstrated electric vehicles are suited for urban logistics (Quak et al. 2016). For instance, the 7th Framework Program funded project Freight Electric Vehicles in Urban Europe (FREVUE) with its demonstrations has provided examples of logistics reorganization, directly replacing the ICEs by EVs. Some examples of the EVs' usage from the demonstrators include:

- Post and parcel operations
- Maintenance operations
- Hotel supply, cafes, restaurants
- Waste collection and gardening
- City maintenance
- Consolidation centers
- Pharmaceutical distributions

3.1. ELECTRIC VEHICLES IN CITY FLEETS

Electric vehicles have gained attention as a way of reducing road transportation pollution. Benefits from EV usage are mainly associated with the human health, environment, and economics (Malmgren 2016). Nowadays the focus is, in fact, more on determining which kind of operations the EVs are suited for, rather than whether they are suitable for city logistics in the first place.
EVs rely on one or more electric motors that receive power from an on-board battery to provide the vehicle's propulsion and to operate its accessories. They also include a regenerative brake system: the motor acts as a generator, it brakes the vehicle and converts the kinetic energy of the vehicle to electrical energy. EVs can be differentiated according to the technology used, as demonstrated in the figure below.

Figure 6. Drive systems of different vehicles (after Eickelmann 2017)



Hybrid Electric Vehicle (HEV). HEVs retain the use of an internal combustion engine (ICE) and they can be classified according to their powertrain as:

- Parallel Hybrid System. The ICE and the electric motor provide torque to the wheels. The battery is charged through the regenerative braking system.
- Series Hybrid System. Only the electric motor provides torque to the wheels. The battery is charged with the on-board generator which is powered by the ICE.
- Power Split Systems. They use two electric motors: the ICE and the larger motor can provide torque to the wheels jointly or independently. The second motor acts as a generator to charge the battery.

Plug-In Hybrid Electric Vehicle (PHEV). PHEVs use an ICE and include an electric motor and a battery. The main drive is the electric motor. The PHEV's battery can power the vehicle for several kilometers purely on electricity with no assistance from the ICE. When the battery is depleted, the ICE can be used as a generator to power the electric motor and to extend the vehicle's range. The battery is charged by plugging the vehicle to the electric vehicle service equipment (EVSE) that receives the electrical power from the grid.

Battery Electric Vehicle (BEV). BEVs do not include an internal combustion engine (ICE). The primary drive is an electric motor. BEVs are propelled by the electric motor and only use the power coming from the on-board battery for propulsion. The battery is charged by plugging in the vehicle to the EVSE (charging station) that receives the electrical power from the grid.

EVs help to reduce the impact on human health caused by fine particle pollution PM2.5, coming from tailpipes emissions, which are responsible for several debilitating respiratory conditions, especially emissions from diesel engines. EVs can also significantly reduce the greenhouse gas emissions (GHG) in areas where clean energy generation is available by reducing the CO_2 emissions to the atmosphere (Taefi et al. 2014). In addition, EVs are three times more efficient than ICE vehicles and their operation is practically noiseless.

From a technical perspective, EVs have fewer moving parts compared to ICEs and thus their drive train requires no regular maintenance and they do not need regular oil changes. EVs react quickly, they are very responsive and have very good torque even at low speeds, as the electric motor instantly creates the needed force to move the car. The brakes of EVs require less maintenance due to the regenerative brake system. The motor, acting as a generator, brakes the vehicle and converts the kinetic energy of the vehicle to electrical energy. This energy is then returned to battery storage, so it can be reused.

Even though there are still arguments against the adoption of EVs based on their high cost, low range, long charging times and low number of charging stations, fleet vehicles especially in city logistics hold several special characteristics that make them clear beneficiaries from the electric drive technology. First, fleet owners may be more willing than private consumers to focus on the **Total Cost of Ownership** (TCO) of the vehicle. Whereas EVs tend to have higher upfront costs than ICEs, lower maintenance and service costs reduce the total costs. Second, fleets benefit from **centralized refuel, high utilization rates and predictable routes,** which allows the operators to optimize the battery requirements. Also, fleet operators can take advantage of **commercial and industrial electricity rates,** which are significantly lower than those for residential consumers (Electrification Coalition, 2010). To sum up, the fleet vehicles advantages for EV usage include:

- Total cost of ownership
- Route predictability
- High utilization rate
- Central parking facilities
- Maintenance and service costs
- Preferential electricity rates

Past experiences suggest that an adjustment of operational processes or routes (journey planning) is necessary in many cases for a successful deployment of EVs in city logistics. An EV fleet's operational limitations can be addressed by reducing the scope of the services, modifying transport operations, modifying the vehicle and by using all the opportunities for charging, for instance, during breaks, shifts changes and during loading/unloading activity (Teoh & Kunze 2018). Overall, the advantages and disadvantages of EV fleets can be summarized as follows:

Advantages

- Reduced emissions
- Reduced noise
- Driver comfort
- Local incentives (preferential access and parking)
- Lower maintenance cost
- Lower fuel costs
- Cleaner roadways and parking lots (no oil, transmission, coolants)

Disadvantages

- Longer time for charging the batteries
- Additional charging infrastructure costs
- Lower range
- Limited expertise available for repair
- High vehicle/battery repair cost
- Grid update cost

EVs at Arkea Ltd.

The BSR electric Turku use case was performed in close cooperation with Arkea Ltd. In 2016, Arkea took the decision to integrate 4 BEVs to its fleet, which at the time mainly consisted of diesel ICE vehicles. The acquisition was made through a leasing system that helped to reduce the front cost and the cars were handed over to Arkea in June 2016.

ICEs

- Ford Courier (9 units)
- Ford Transit (2 units)
- Ford Custom (5 units)
- Dacia Duster (1 unit)
- Citroen Jumper (1 unit)

BEVs

- Nissan e NV200 (4 units)

Photo: Arkea Ltd.

3.2. LEVs AND CITY LOGISTICS

The term “light electric vehicles” (LEVs) refers to a variety of different types of vehicles. As defined e.g. by LEVA (Light Electric Vehicle Association), light electric vehicles are “*battery, fuel cell, or hybrid-powered 2- or 3-wheel vehicles generally weighing less than 200 pounds (100 kg)*” (ExtraEnergy 2009).

The concept of LEVs comprises a wide range of vehicles from electrically assisted or motorized bicycles to different kinds of electric scooters and self-balancing micro vehicles. These vehicles are also sometimes referred to with the term micromobility. The presence of LEVs in transport systems has grown rapidly in the recent years and new applications are constantly emerging. As a well-known example, the provision of commercial, shared e-scooters has grown exponentially in many cities worldwide.

Legislation regarding the vehicles and their use varies significantly between countries and e.g. within the EU. Local and municipal laws and rules further complicate the issue and relatively different regulations can be applied to the same vehicle depending on the context. The infographic below presents some common LEVs and their technical requirements in the context of Finnish legislation.

Light electric vehicles and Finnish legislation

E-scooter (small standing)

Technical requirements
- Max width 80 cm
- Max power 1 kW
- Max speed 25 km/h

Place in traffic and traffic rules
- On bicycle lanes, cyclist traffic rules.

Safety requirements
- Front light and reflector in the back (both can also be on the person), a sound signaling device.

E-bike / e-cargo bike

Technical requirements
- Max width 80 cm for electrically assisted, 100 cm if motorized, 125 cm if more than two wheels.
- Max power 250 W for electrically assisted bicycles, 1 kW for motorized bicycles.
- Max speed 25 km/h

Place in traffic and traffic rules
- On cycleways, cyclist rules.
- If max speed of the bike exceeds 25 km/h (max 45 km/h) or max power exceeds 1 kW, the bicycle is classified as a moped and must be used on roads.

Safety requirements
- Front and back lights (can be on the person), reflectors in front, back and sides, sound signaling device.

E-scooter (regular)

Technical requirements
- Max width 100 cm (125 if more than two wheels)
- Max power 1 kW
- Max speed 25 km/h

Place in traffic and traffic rules
- On bicycle lanes and cyclist traffic rules if the max speed is 25 km/h.
- If the max speed exceeds 25 km/h (max 45 km/h), the scooter is classified as a moped and should be used on roads.

Safety requirements
- Front and back lights, reflectors in front, back and sides, sound signaling device.

Figure 7: Some common types of LEVs in Finnish legislation

It is noteworthy that the physical appearance of the vehicle doesn't necessarily reveal its legal status in traffic. According to Finnish legislation, a regular looking e-bike is in fact a moped if it is motorized with over 25 km/h speed. In contrast, a very moped-looking vehicle is parallel to an electrically assisted bicycle if the max speed is 25 km and the nominal power is 250 W.

In city logistics, the most suitable uses for LEVs are small shipments in e.g. food and service logistics as well as mail and parcel deliveries (Moolenburgh et al. 2020). Some examples of LEV applications utilized in logistics include electric cargo bikes or electric scooters/mopeds. In inner city areas LEVs, such as e-cargo bikes, are often a more convenient mode of transport compared to more conventional vehicles such as vans. As bikes have more options for routes and maneuvers in an urban environment, their chosen routes tend to be quicker or shorter than those of cars or vans (Butrina et al. 2019). In a study by Moolenburgh et al. (2020), it was found that as cycling routes on average in cities are actually shorter than motor roads, and loading and unloading is more flexible, time spent for deliveries by test operators was reduced by up to 30%. Other benefits of using LEVs for logistics or other work-related mobility purposes include, of course, reduced emissions and e.g. the fact that using LEVs doesn't usually require a driver's license.

The use of LEVs is naturally not without limitations or challenges. Due to their small size, their capacity is limited compared to vans, for example. If distances travelled are long, the limited range of the LEVs can also be a limiting factor. In northern climates, winter conditions can also be challenging for the vehicles. In the LEV winter test session arranged by the BSR electric project together with the CIVITAS ECCENTRIC project, it was observed that even moderate minus degrees significantly reduced the range of the vehicles and snow and ice on the streets posed a challenge to their usability (Heikkilä 2019).

It is clear that combining different types of vehicles in fleets is needed to guarantee flexibility in city logistics and that not all logistical needs can be met with LEVs (Moolenburgh et al. 2020). However, considering their obvious benefits, LEVs hold potential to be used especially in inner-city logistics more extensively than they currently are. In the BSR electric Turku use case, two LEVs, a regular electrically assisted bike and an e-cargo bike, were tested among the employees of Arkea and their potential in replacing cars in work-related logistics was examined. The use case details and experiences were described in chapter 2 and will be referred to in the coming chapters.

Photo: Kari Lindström / TUAS

4. BARRIERS AND DRIVERS TO E-VEHICLE DEPLOYMENT

As described in the previous chapter, EVs and LEVs are not only suitable for city logistics, but they also have clear advantages compared to conventional ICE vehicles. However, often the electrification of organization fleets is a complex process. First, it is affected by **policies** regarding electric mobility as well as the surrounding urban **infrastructure**. Second, the available **technology** still entails some limitations which need to be considered. Finally, there is the **human factor**: organizations need to make the decisions to adopt the vehicles and the employees need to be motivated to use them. In this chapter we will discuss the different drivers and barriers for the electrification of fleets in more detail.

4.1. E-MOBILITY POLICIES AND URBAN INFRASTRUCTURE

Densely populated urban areas have more and more importance in solving social, health and environmental issues as the world's population is moving to cities at an accelerating rate. Thus, it is important that cities take an ever stronger role in tackling these issues. City officials and politicians have funding and powerful city planning tools in their use to restructure the ways cities function. The reasons behind where and how cities have been built and structured are historical, but past choices also affect the modern city life and the possibilities to restructure the transport and mobility modes. The benefit of a dense population structure is that mobility and transport can be arranged more effectively.

Traffic in inner cities causes many kinds of problems, from noise and air pollution to health issues and traffic accidents. One way to make cities more sustainable is to rethink how we move from place to place inside cities and how we turn the mobility carbon-free. In addition to other sustainable mobility modes, transition to the use of electric vehicles plays an important part in getting there.

The time for widespread electric vehicle (EV) adoption is now. The vehicle industry is putting a lot of investments to EV product development. These actors include a wide range of businesses from charging station operators and car makers to power companies (IEA 2019). However, to drive this process public sector support is needed both in form of policies, incentives and infrastructural improvements.

4.1.1. Speeding e-vehicle adoption with policies

In recent years, the electrification of transport and mobility in cities has got wind under it wings. Especially in Europe, electric mobility in cities is getting more political support as well as wide approval from citizens and companies. For instance, Norway has been incentivizing the electric vehicle market heavily, which makes it the global leader in EV adoption. 46% of the newly sold cars in Norway in 2018 were electric, the highest proportion globally (IEA 2019). Norway's example highlights the major factor that affects the development and speed of adopting e-vehicles: **policies and incentives.** Usually the transition starts with the setting of targets, continued by adoption of vehicles and charging standards (IEA 2019).

Photo: City of Turku, Suomen Ilmakuva

Global, European-wide, national as well as local **policy instruments, such as different general agreements, directives, laws, programs, strategies and plans,** guide and influence the development and implementation of local city planning policies and practical infrastructural solutions. These policies are usually decided by democratically chosen politicians and city officials. Democratic processes can drive or hinder progress in city planning depending on the public attitude at any given moment. At the time of writing, in 2020, there is a lot of political support for e-mobility in Europe.

The EU is a major policy driver and lawmaker in Europe. In addition to other environmental directives the EU has, for instance, decided that EVs and related infrastructure will be prioritized in mobility development. The EU is also targeting to make urban freight transport free of emissions by the year 2030 (EC 2011). Another recent policy decision by the EU, which has major implications for the electrification of fleets, is the **Clean Vehicles Directive (CVD).** The aim of the directive is to promote clean mobility solutions in public procurement tenders. Not only is it applied in purchase procurements but also in leasing, renting and other relevant service contracts (EC 2020).

The specific targets set in the CVD vary among vehicle types and member states. Regarding light-duty vehicles (cars and vans) in Finland, for instance, in procurements made between 2021 and 2025, 38.5% of vehicles procured must be either fully electric or hybrids (emissions no more than 50g/km CO_2). Between 2016 and 2030, the same percentage of procurements must be zero-emission vehicles, in other words fully electric or hydrogen cars. In Finland, national legislation to apply the directive is still in the making but it is estimated that bigger cities will have a major role in reaching the targets. The directive will be applied starting from the 2nd of August 2021.

4.1.2. Money rules the world...

The role of the EU is also significant in developing open standards and interoperability, promoting research and smart charging solutions, just to name a few (Lutsey 2017). In the member states the national laws are then drafted to achieve the EU level objectives. National goals can also be more progressive than the EU-level targets, as they are e.g. in Finland where carbon neutrality is planned to be achieved by 2035 versus the 2050 goal of the EU (Finnish Government 2019).

At the local level, strategies, guidelines (such as building codes) and plans (such as Master Plans, Sustainable Urban Mobility Plans and climate plans) are used to achieve the national and the EU-level goals. In the BSR electric case city of Turku, the current guiding document for e-mobility is the **Turku City Climate Plan 2029.** It was published in 2018 and it outlines the general objectives, methods, and measurements on how the city will reach the goal of a carbon the goal of carbon neutrality by 2029. The Plan states: *"Car traffic emissions are reduced by investing in electric motoring and developing adequate conditions for it. Investments are also made into other emission-free and / or low emission sources of energy and new alternative means of transport such as electric bicycles and automatic tools of transport".* In addition to investing in the electrification of the city's and its subsidiaries' fleets, sustainability is achieved as the city aims to get its electricity mainly from renewable sources. (City of Turku 2018)

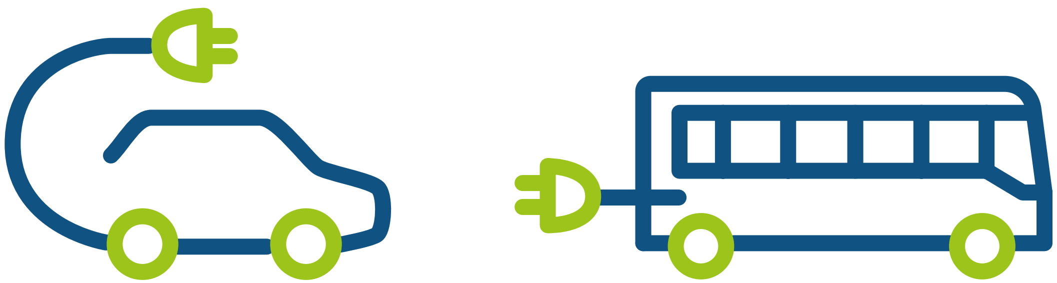
Building codes determine the minimum requirements for new buildings and guide renovations and retrofitting of the existing buildings. They are also important guidelines affecting the charging infrastructure. Constructing charging infrastructure to old buildings is rather costly. Local authorities should update their building codes to demand new buildings to have suitable electrical equipment for charging. This will reduce the costs of the charger installations in the future (Hall and Lutsey 2017).

The inconvenient truth is that the purchasing price of EVs is still higher than the price of conventional ICE vehicles, although the maintenance costs for EVs are lower (Quak et al. 2016). It has been noticed that while non-financial incentives may be beneficial, they are less effective compared to the price as a motivator in early adoption of e-vehicles. In addition, the required charging infrastructure must be built, which requires both public and private investments (ERA-NET Cofund Electric Mobility Europe 2019). The public sector is also a significant player that creates demand for EVs with different actions and procurement rules (Quak et al. 2016).

The public **financial incentives** include e.g. tax benefits and incentives for purchasing (ERA-NET Cofund Electric Mobility Europe 2019). For instance, in Finland you can get purchase subsidies (2000 euros) for fully electric cars. At the end of 2019, there was a whopping 430% rise compared to the previous year in subsidy applications. It seems that when the overall market prices become lower, the attractiveness of the subsidies increases (Traficom 2020). The suitability of different incentives differs from region to region and country to country but sharing experiences between cities is always beneficial and helps to formulate effective local policies and support actions (ERA-NET Cofund Electric Mobility Europe 2019).

4.1.3. ...But you can't buy everything

As mentioned before, **financial benefits** are the most effective single driver for widespread EV uptake. To reach more market-driven EV adoption, however, other types of incentives are also needed. Cities can provide free parking privileges to electric vehicles, which is a big benefit especially in densely built cities (Hall et al. 2018). Quak et al. (2016) found that free parking reduces the stress for freight drivers and difficulty resulting from (un)loading vehicles for the other traffic. Some cities have given EVs their own lanes and toll and bridge fee exemptions. Another way to promote and support electric mobility is to establish zero-emissions zones in some central areas of cities. Some cities have even made ambitious plans to get totally rid of fossil-fuel vehicles, for instance Amsterdam until 2025 (Hall et al. 2018). With these radical actions, public bodies can create demand for e-vehicles and send a message to the vehicle markets that real change is happening (Quak et al. 2016).



Ways to prioritize e-mobility on the city level:

- parking privileges for EVs
- lanes designated for EVs only or allowing EVs to use e.g. bus lanes
- exemptions to toll and bridge fees for EVs
- zero-emission zones
- exemption from congestion charges

4.1.4. EV adoption and charging infrastructure

In addition to the price and information about the EVs, **adequate charging infrastructure** is crucial for widespread e-vehicle adoption (Hall and Lutsey 2017). A wide existing network of charging stations lowers the threshold of purchasing EVs, as the fear of battery charging range is reduced (ERA-NET Cofund Electric Mobility Europe 2019). It has been observed that both standard and DC fast charging infrastructure promote EV uptake (Hall and Lutsey 2017).

No universal optimum for the number of charging stations per kilometer of per number of EVs has been defined. However, in the countries that are most advanced in terms of EV adoption, such as Norway and the Netherlands, there are about 10 times more public charging stations than in the average markets (Hall and Lutsey 2017). In Europe, the network of charging stations has generally been built by a wide group of relevant actors: private charge point providers, power companies, car manufacturers and the national and city governments (Hall and Lutsey 2017).

Photo: Andrew Roberts / Unsplash

Incentives and public investments play an important role in building adequate charging infrastructure. Many regions and countries use different funding schemes for different target groups. These schemes are most effective when they are combined with collaborative actions like driver feedback on charger network, connecting to smart charging systems and establishing public-private partnerships and consultation services (ERA-NET Cofund Electric Mobility Europe 2019). In addition, developing financially feasible charging infrastructure and related business models benefits from charging provider competition (Hall and Lutsey 2017). This can be influenced by the public sector in different ways, for example by holding bids or allocating financial benefits for developing innovations for infrastructural features (Hall and Lutsey 2017).

A Best Practice catalogue by EMEurope, targeted at policymakers, has gathered suggestions for incentives to support the deployment of e-mobility in the form of checklists (ERA-NET Cofund Electric Mobility Europe (EMEurope 2019). A summary of the main features related to the incentives for charging infrastructure from the perspective of commercial fleets is presented below.

Incentives for charging infrastructure – fleets' perspective

- installing charging stations in locations where their use is possible for many users (e.g. parking places and office buildings)
- considering property regulations, including rental agreements, as companies often rent buildings
- facilitating changes made to tenancy agreements to encourage property installations
- tax reductions for different organizations installing charging stations in their properties

There are many practical options to bring the charging infrastructure costs down to a more tolerable level. If possible, multiple stations should be centralized in one place, thus lowering the installation and electrification costs. The type of the station matters too – freestanding stations cost more than wall mounted chargers. Finally, planning the location of the charging station so that the grid connection is acquired as easily as possible saves costs as well (Hall and Lutsey 2017).

When charging infrastructure is built, it is important to choose **the locations of the charging stations** in the city strategically. This has not been the case in the early days of EV adoption. Often the public and private stations have been placed without a clear vision of the network (Hall and Lutsey 2017). Issues that should be considered when placing a charging station are, for instance, to locate the charger in a place where its usage is as high as possible, where traffic and parking issues are minimal and where the power grid is suitable. Stations where multiple EVs can be charged at the same time should be prioritized. Usability of the stations also includes taking into consideration the accessibility of the station also for people with disabilities as well as the visibility of the station (Hall and Lutsey 2017).

In Finland, many larger cities, such as Helsinki, Vantaa and Turku, have already made general plans for city-wide public charging networks to make the construction of the infrastructure more systematic. Many countries also support the development of workplace charging, in addition to the public charging network. Finally, it needs to be borne in mind that all the actions and instructions should be adapted to the local political, geographic, and demographic contexts in each country and region (Hall and Lutsey 2017).

Photo: Janne Sovela / TUAS

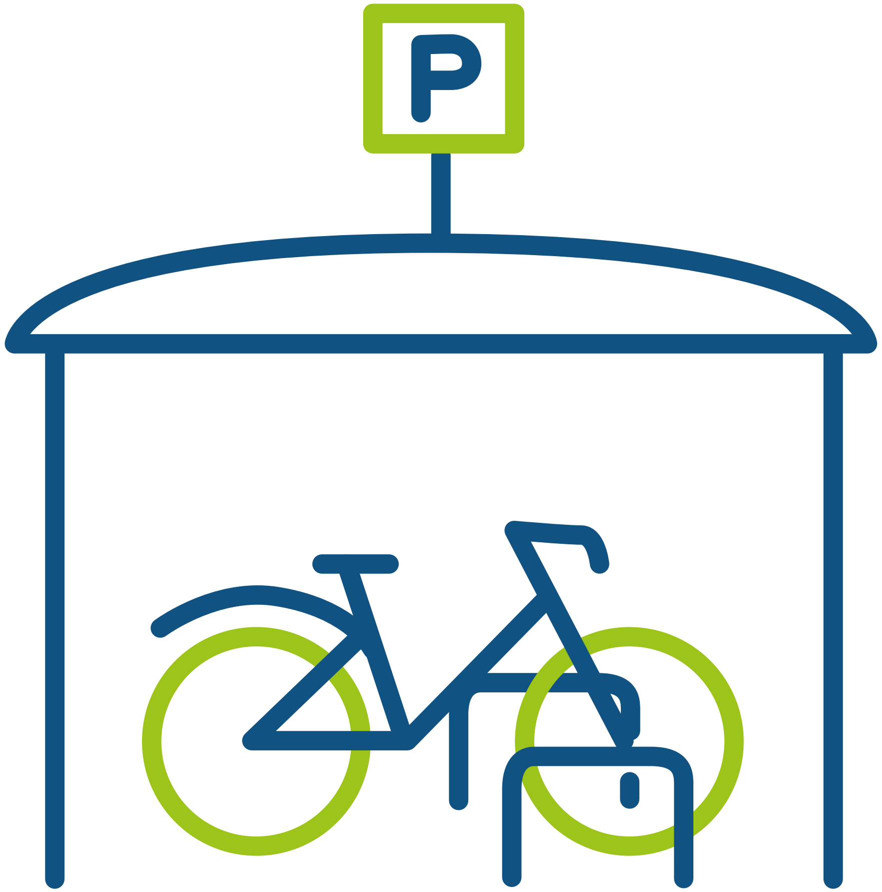
4.1.5. Light electric vehicles in the urban environment

This chapter has mainly dealt with challenges and possibilities related to EVs, which is reasonable as their wide-spread adoption requires major efforts from multiple actors. However, the chapter will be concluded with a few words about how city planning and policies can support the adoption of LEVs. Light electric vehicles, and especially electric bicycles present a viable option to ICEs in city logistics. In the Arkea use case it was specifically LEVs (a regular electric bike and an electric cargo bike) which were tested among the employees.

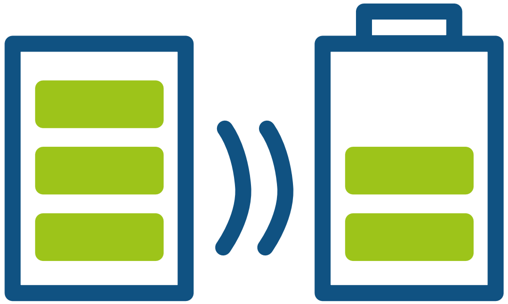
In terms of **city and transport planning**, LEV users benefit from many of the same efforts as conventional bicycle users. In the case of LEVs, investments in the charging network are not a major issue as electric bikes can usually be charged with standard domestic sockets. Instead, what is needed are **high-quality cycleways** and safe **bicycle parking facilities** which can also fit cargo bikes. Winter maintenance is essential in cities which experience snowy and icy winters.


Photo: Anna Satovuori

Finally, **urban geography** has a major impact on the viability of cycle logistics both for the organizations and the employees using the vehicles. For instance, high-density urban environments, as well as areas with narrow streets make bicycles in general seem like a more attractive mode of logistics (Schliwa et al. 2015). In addition, zero emission zones in city centers, which were earlier mentioned as a policy prioritizing EVs, naturally also favor LEVs.



4.2. TECHNOLOGICAL CHALLENGES WITH THE ELECTRIFICATION OF FLEETS



As described earlier, EVs hold many advantages when deployed in city logistics. However, there are still several challenges related to their adoption. EVs have some limitations in terms of **battery technology** and long times for **battery charging**, as well as more external factors such as limited **charging infrastructure** and **extreme temperatures**.

4.2.1. Issues with battery technology

The battery is the key component of an EV and has a critical impact on the range, as a battery has much lower energy density than gasoline. The battery is also the most expensive component of an EV and significantly increases the price of the vehicle. The adoption of EVs is a reality mainly due to the reduced costs of the batteries, a development of the recent years. Also, as the driving range has increased with the more efficient batteries, acceptance of EVs has followed suit.

There are several cell chemistries for the batteries. A comparison of the most popular batteries and their characteristics (Miao, 2019, Vidyanandan, 2019) is presented in the table on the right.

Type	Nominal Voltage (V)	Specific Energy (Wh/Kg)	Energy Density (Wh/l)	Specific Power (W/Kg)	Life Cycle
Lead Acid	2.1	30–40	100	180	500
Niquel Cadmium	1.2	50–80	300	200	2000
Niquel-Metal Hydride	1.2	60–120	180–220	200–300	<3000
ZEBRA	2.6	90–120	160	155	>1200
Lithium-Ion	3.6	120–250	200–600	200–430	2000
Lithium Ion Polymer	3.7	130–225	200–250	260–450	>1200

Table 1. Different types of batteries and their main characteristics

Today, the lithium-ion batteries are the most popular ones, as they have higher power, higher energy storage capacity and longer life. However, many technical challenges are still to be addressed for an optimal performance of an EV using this type of a battery, for example **battery degradation** and the **charging methods.**

The reduction of the energy and power capacity over time and usage cause battery degradation, limiting both the driving range and the acceleration rate, respectively. Batteries are considered to no longer be suitable for EVs when the capacity has been reduced to 80% of its original value. The causes for deterioration are related to:

- Degradation of the battery elements (anode, cathode and electrolytes).
- Frequent overcharging (charging battery to the maximum capacity).
- Battery at high states of charge (SOC) for long periods.
- Frequent discharge to very low levels.
- High power levels to charge the battery.
- Extreme operational temperatures.

Regarding charging methods, the charging rate of the battery is represented by the C-rate. 1C means a full charging is achieved in 1 hour, in 2C a full charging is achieved in 30 minutes, and in C/2 a full charging is achieved in 2 hours. Typical chargers are in less than 1C rate, needing several hours to a full charge. Fast chargers will refill 80% of the state of the charge (SOC) in 15–30 minutes. A study carried out to evaluate the impact of the fast charging in EVs (Shirk 2015) suggest that a greater loss for the battery capacity was presented for vehicles using the fast charging method, compared with those charged slowly during several hours. However, the loss was small in comparison to the overall capacity loss for all the vehicles, as demonstrated in the figure below.

Battery capacity remaining after 50k Miles

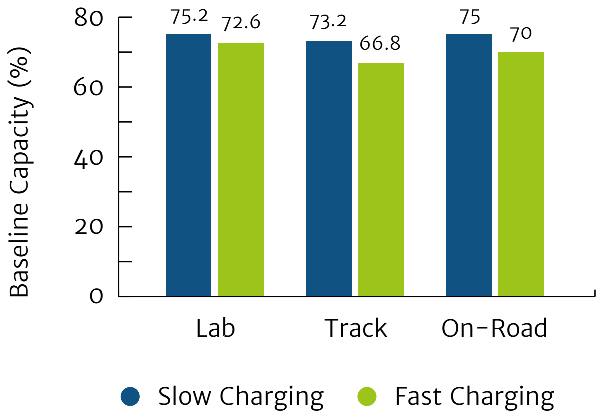
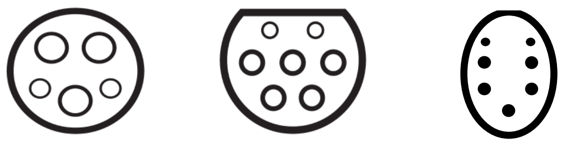


Figure 8. Battery capacity (after Shirk 2015)

4.2.2. Charging methods

The charging process and time are key factors for the market development and the acceptance of the electric vehicles. It takes only a few minutes to fuel up an ICE vehicle for a range of up to 1000 km. For an EV, then, the amount of time it takes to charge its battery is critical. The battery capacity of an EV and the charging equipment are fundamental for the time it takes to charge the battery. There are three types of charging approaches: **conductive, inductive and battery swap.** The most common, **conductive charging** is done with a cable connected from the charging infrastructure to the vehicle. There are two methods for the conductive charging: AC and DC charging.

The conductive **AC charging** is the simplest and the most common charging method. It is possible in the private sector, as well as at charging stations (public and semipublic), and the investment cost is relatively low. All commercial vehicles are equipped with an on-board charger. Charging is managed directly by this on-board charger, which converts the AC power from the EVSE (charging station) to the DC power used by the batteries.



Type 1 (Yazaki)	**Type 2 (Mennekes)**	**Type 3 (Scame)**
US, Japan	Europe	France, Italy

Table 2. AC Charging type connectors (after Eickelmann 2017)

Essentially, the difference between DC and AC charging is the location of the charger. DC charging uses a charger built into the charging station, so DC charging stations are more expensive (Hydro Quebec 2015). The external charger based on the data communicated by the EV manages the charging, and this can be as high as 170 kW (Denton 2016).

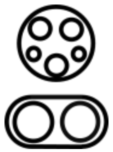
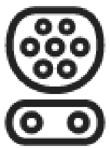
	**CCS Type 1 EE** **US**
	**CCS Type 2 FF** **compatible with Type 2 (AC)** **Europe**
	**CHAdeMO AA** **Europe**

Table 3. DC charging type connectors (after Eickelmann 2017)

Conductive charging has three standardized connection cases and four charging modes, they refer to the methods for the connection of the EV to the EVSE to supply energy to the vehicle. The different modes, cases and connectors are presented in more detail in the image below.

Electric Vehicles Charging Cases (IEC 61851-1:2017)

CASE A	**CASE B**	**CASE C**
EV connected to supply network with a plug and a cable permanently attached to the EV. Barely used!	EV connected to the EVSE with a cable detachable from both ends.	EV connected to supply equipment using a cable and a vehicle connector permanently attached to the EV charging station.
 Graphics created at LogoMakr.com	 Graphics created at LogoMakr.com	 Graphics created at LogoMakr.com

Electric Vehicles Charging Modes (IEC 61851-1:2017)

Mode 1-AC	**Mode 2-AC**	**Mode 3-AC**	**Mode 4-DC**
Connection of the EV to a standard socket-outlet of an AC supply network by using a cable which has not a supplementary pilot or auxiliary contacts.	Connection of the EV to a standard socket-outlet of an AC supply network by using an AC EVSE with a cable which has a control pilot function and a system for personal protection.	Connection of the EV to an AC EVSE permanently connected to an AC supply network by using a cable which has a control pilot function attached to the AC EV supply equipment.	Connection of the EV to an AC or DC supply network utilizing a DC EVSE, with a cable which has a control pilot function attached to the DC EV supply equipment.
1-Phase AC/3.7 kW up to 16A 3-Phase AC/11 kW up to 16A Case A, B	1-Phase AC/3.7 kW up to 32A 3-Phase AC/22 kW up to 32A Case B	1-Phase AC/7.4 kW up to 32A 3-Phase AC/43.5 kW up to 63A Case B, C	1-Phase AC to DC up to 400A 3-Phase AC to DC />50 kW Case C

Charging Connectors

The charging time is highly important for fleet managers and vehicle operators: it varies widely based on the charging methods, which were described above, the battery size or total capacity as well as the level of charge. A common measure of charging speed is how much time it takes for a battery to go from empty to an 80% state of charge, since charging slows down significantly, as the battery reaches full capacity. As an example, the table below gives the charging time estimation for different charging conditions.

Estimated charging times				
Charging time for 100 km range	Power supply	Power	Voltage	Max. Current
6-8 hours	**Single phase**	**3.3 kW**	**230V AC**	**16 A**
3-4 hours	**Single phase**	**7.4 kW**	**230V AC**	**32 A**
1-2 hours	**Three phase**	**22 kW**	**400V AC**	**32 A**
20-30 minutes	**Three phase**	**43 kW**	**400V AC**	**63 A**
20-30 minutes	**Direct Current**	**50 kW**	**400-500V DC**	**100-125 A**

Table 2. Estimated charging time for different charging conditions

4.2.3. Charging infrastructure

A further challenge related to the charging, and a requirement for the widespread adoption of EVs for both consumers and fleets, is the availability of charging infrastructure. The issues related to the infrastructure were discussed from the perspective of city planning and policies in chapter 4.1.

Although most of the consumers charge their vehicles while parked at home, charging stations at public places such as workplaces increase the acceptance of the EVs and help to ease **range anxiety**, a phenomenon which will be discussed in more detail in chapter 4.3. BEVs used for logistical purposes are often charged at depots during nights and do not necessarily use public charging stations regularly. For instance, in the case of Arkea, their e-vehicles are mainly charged during the night, off-peak hours, helping to reduce the energy costs (Jurmu 2020a). No additional infrastructure for charging is needed as the vehicles are charged using the wall outlet ~3.6 kWh. However, in some cases, commercial fleets will likely need to upgrade their electricity grid infrastructure to meet the needs of EV charging (FREVUE 2017).

In some applications, a mode 2 charging is enough without additional costs. If higher charging is needed, an upgrade to a mode 3 charging can be relatively inexpensive. As the fast charging infrastructure implies high costs, this is still often a barrier to a wider adoption of fast charging. The impact of the high-power demand from the electricity grid is another aspect to be considered, as many impacts associated with EV charging have been identified. Increased peak demand, voltage regulatory violation, increased power system losses, overloading of distribution transformers, distribution lines and cables are some of the impacts to the grid related with EV charging (Dharmakeerthi 2014). These impacts limit the number of vehicles in a depot that can be simultaneously charged with high power levels, requiring further investments for grid upgrades.

4.2.4. Extreme temperatures and driver behavior

Extreme temperatures have several effects on **EVs performance and their charging**. The efficiency of an ICE vehicle operating in an urban environment will experience about 12% lower fuel economy at -6 °C than it would at 25 °C (U.S. Department of Energy 2016). The impact on EVs can be worse as they may experience more than a 30% increase in energy consumption, especially when the cabin HVAC systems are used.

Studies have captured the effects of the temperature on **battery efficiency**. At low temperatures, higher resistance values are induced, decreasing the terminal voltage for a given current (Chacko & Chung 2012). In other words, a higher current is needed for the required power. The higher current depletes the battery faster, resulting in lower range for the vehicle (Neubauer & Wood 2014).

At freezing temperatures, the charging is also diminished: the internal resistance of the battery increases, and the maximum voltage is reached more rapidly. If a higher voltage is applied, damage to the battery can ensue. To avoid damage, the charging current must be reduced, which again results. in an increase in the charging time. At higher temperatures (> 40 °C), the charging and discharging performance are lightly affected, as the internal resistance decreases further, but battery degradation and self-discharge may be faster due to higher chemical activity. (Lindgren & Lund 2016).

Effects of climate and cabin HVAC in energy consumption

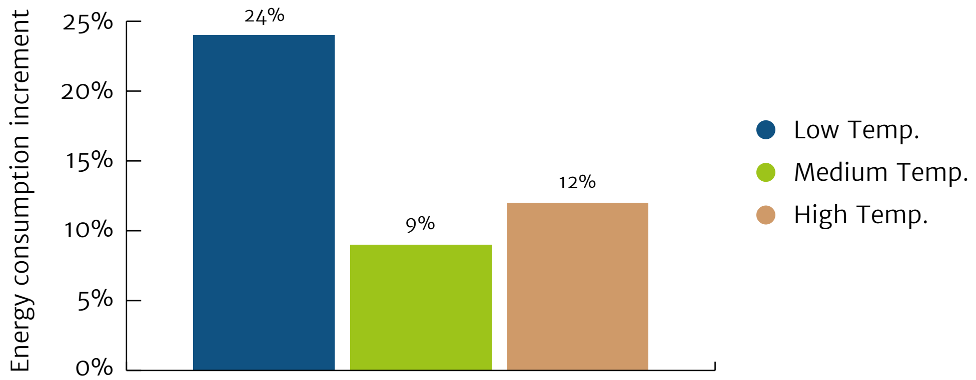


Figure 9. Effects of climate on EV energy consumption (after Nesbauer & Wood 2014)

Photo: Shutterstock

Effects of climate on BEV utility reduction after 10 years

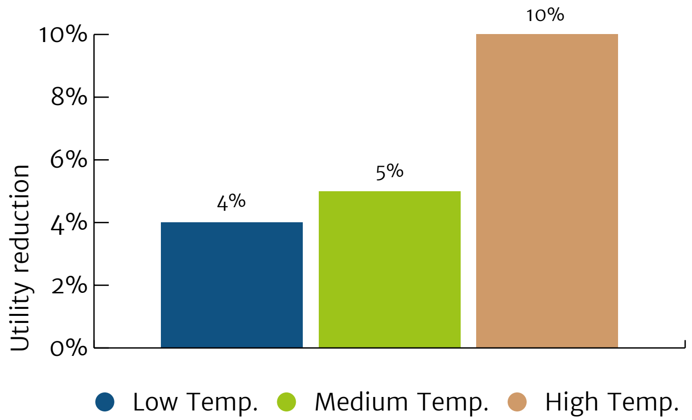


Figure 10. Effects of climate on BEV utility reduction after 10 years

Due to extreme temperatures and e.g. cabin climate control, which is often a result of the temperatures, winter conditions in e.g. the Nordic countries pose challenges to EVs. In the FREVUE project where the demonstrations with different EFVs were performed in different parts of Europe, the drivers in Oslo, Norway, reported a range reduction of 30–40% in winter, whereas in e.g. Madrid and Lisbon the reduction was reported to be only 10–15% (Dong & Polak 2017).

Technological barriers for electric bikes and other LEVs

For electric bikes, the charging infrastructure is not a critical factor in the same extent as it is with EVs. Even though e-bike chargers tend to be model-specific, the batteries are charged using a standard Schuko socket. Typically, the charging of the batteries takes up to 5-6 hours and the batteries should be charged indoors in warm conditions.

The range of electric bikes and other LEVs if of course limited, however in most of the current models the range is typically up to 100 km. Thus, when moving in the city area, the range should not be an issue for organizations. As with e-vans and e-cars, the range of e-bikes is not a constant, but is influenced by several factors such as temperature, the use of the electric assistance and the profile of the terrain.

Winter conditions pose some challenges to both EVs and LEVs, as the range of the vehicles is reduced in cold temperatures due to battery depletion. However, for LEVs the snow and slippery streets are also an issue. This became evident in the winter test session, conducted as part of the BSR electric use case, where a variety of different LEVs were tested. Studded tyres are a must, and especially for inexperienced cyclists the electric power combined with icy roads can be a safety issue. In addition, snowy conditions demand a lot from winter maintenance, as the bike paths can become narrower to the extent that e.g. passing other vehicles or two-way traffic can be difficult.

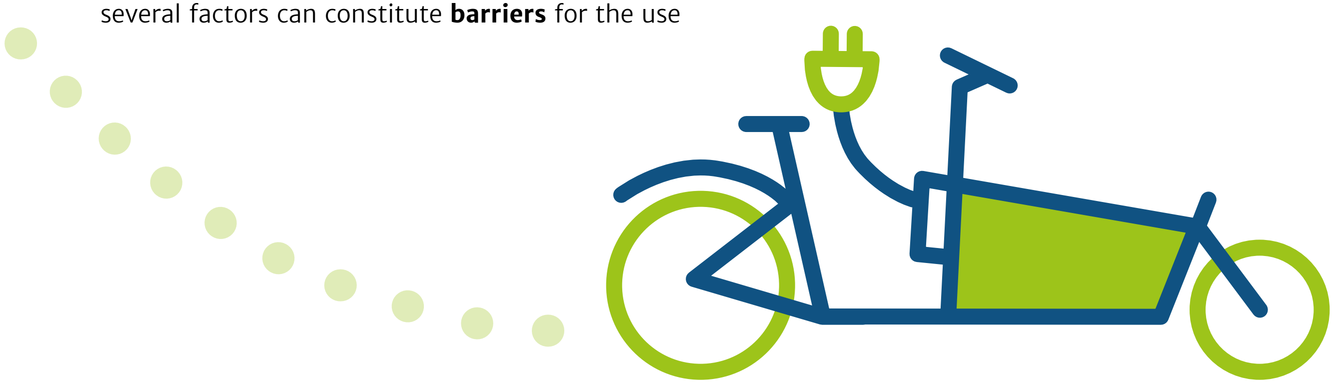
4.3. BEHAVIORAL INSIGHTS INTO EV DEPLOYMENT

When discussing e-mobility, whether its possibilities or challenges, technological issues are often the ones to receive the most attention. This is understandable, as there indeed are many technological aspects to consider, as became evident in the previous chapter. At the same time, the **human factor** should not be overlooked either. Even the most developed and environmentally friendly technology won't become widespread if organizations are not motivated to acquire it or the end-users are not willing to utilize it.

In this chapter, the focus is on the **behavioral aspect of EV and LEV adoption** specifically in the case of organization fleets. First, a closer look is taken at the individual user perspective and some concrete barriers for the use of electric vehicles in work settings are identified. Along with the barriers, potential drivers for e-vehicle adoption are presented. Then, the focus is turned to organizations and identifying the drivers and barriers influencing the decision-making and procurement processes regarding the electrification of fleets.

4.3.1. The individual perspective

Whereas electrifying commercial fleets provides a good opportunity to promote the take-up of EVs on a larger scale, for individuals the use of EVs in a work setting can enable positive experiences with the vehicles and increase the likelihood of adopting them to private use. However, as ICE vehicles are still the norm for most car users, several factors can constitute **barriers** for the use of both EVs and LEVs for individual users. At the same time, some other factors can be identified as **drivers**, facilitating the transition for the individuals. For the entire or partial electrification of any organization's fleet to take place successfully, understanding of both the drivers and barriers is needed.



4.3.1.1. Pro-environmental behavior of individuals

The decision to drive an EV, instead of an ICE vehicle, can be characterized as **pro-environmental behavior (PEB)** or **environmentally significant behavior**, which can be defined by the extent to which a specific behavior has an impact on e.g. the availability of materials or energy from the environment (Stern 2000, 408). Pro-environmental behavior of individuals is influenced by a variety of factors. For instance, Stern (2000) has grouped different factors in four categories: **attitudinal factors, personal capabilities, habits and contextual forces** (or situational factors, as they will be referred to in this report). According to Stern, the weight of each factor depends on which kind of pro-environmental behavior is in question, and the factors also interact with each other.

What is noteworthy about individuals' pro-environmental behavior in the context of this report is that people often behave differently in a work setting compared to their private lives. There are several reasons for this and although all of them can work in favor of promoting pro-environmental behavior, they can also make it challenging.

First, **the role of situational factors increases** in a work context, as individuals generally have less power to affect the circumstances there. As an example, the significance of personal attitudinal factors such as values decreases, whereas the role of the values of the organization increases (Blok et al. 2015, 61).

Secondly, in the context of a workplace, **employees do not usually directly benefit from possible financial savings resulting from pro-environmental behavior**, as they would in their private life. On the other hand, **this applies also to the costs resulting from pro-environmental behavior.** When adopting an EV for work-related driving and logistics, the high initial procurement costs, which can be a barrier for EV acquisition in the private context, are avoided. Using an EV (or a LEV) at work can also provide a good opportunity to get acquainted with these types of vehicles. For example in the case of Arkea, in the survey conducted to the employees as part of the use case, one motivation for the interest to try out EVs for work-related driving was the chance to explore the vehicles' suitability for private use.

Finally, **the role (responsibilities and position) of the individual in the organization** has an impact on what aspects of the EVs are valued (Nesbitt & Davies 2013). While managers, marketing personnel and sustainability officers are most likely motivated by brand and image aspects and sustainability goals, fleet managers appreciate the reduction of fuel costs. For the users of the vehicles it is, unsurprisingly, the user experience and operational efficiency that matter the most. Thus, even when in their private life the individuals would be interested in sustainable modes of transport, they may not use them in a work context if these modes are not functional for their daily needs.

Photo: Shutterstock

Why promoting pro-environmental behaviors might be challenging at the workplace?

- The role of situational factors increases compared to the private sphere and this can undermine the pro-environmental values of the individuals.
- Employees do not usually benefit directly from possible financial savings of pro-environmental behavior.
- An employee's role in the organization influences their motivation for promoting pro-environmental behavior.

Next, a closer look will be taken at the four types of variables (attitudinal factors, personal capabilities, habits and situational factors) and the issue of how they can function as barriers or drivers for the use of EVs or LEVs in an organizational context will be explored.

In addition, as a fifth, separate factor the issue of range anxiety will be explored, as it is a phenomenon closely related to using electric vehicles specifically.

4.3.1.2. Attitudinal factors

Attitudinal factors refer to norms, beliefs, and values of an individual (Stern 2000, 416), which can function as drivers or barriers for certain behaviors – including pro-environmental ones. The role of attitudes in inducing behavior has been found to be indirect rather than direct, predicting intentions more than actual behavior. In fact, the so-called **attitude-behavior gap**, referring to the inconsistency of people possessing environmental knowledge and awareness, yet not performing pro-environmental behavior, has been a widely studied topic for psychologists in the recent decades (Kollmuss & Agueman 2006).

Attitude-behavior gap

(also known as intention-behavior gap, attitude-action gap, or value-action gap) = The lack of correlation between values and behavior, often concerning environmental issues.

However, as the attitudes of single individuals have been found to affect decision-making also on an organizational level, for example in the case of EV acquisition (Globisch et al. 2018), understanding their potential role as drivers and barriers is important, also in the context of the fleet electrification process.

A clear attitudinal driver in the case of e-mobility is, of course, **pro-environmental attitudes**. It has been found, for instance, that people who define themselves as pro-environmental are more likely to adopt an EV than others (Schuitema et al. 2012). Interestingly, what makes electric vehicles different from many other "green products" is that **attitudes towards technology** are also relevant and can function as drivers for their adoption. For example, in a study on fleet managers in Germany it was discovered that those individuals who were technologically oriented were more likely to make EV adoption decisions than ones who were not (Globisch et al. 2018). Another study found that people with self-reported mechanical knowledge of cars in general were more likely to have positive attitudes towards EVs (Morton et al. 2016, 507).

Photo: Pexels

On the other hand, some general **car-related attitudes** can turn out to be barriers for EV adoption. In one study it was found, for example, that those individuals who considered their car as a representation of their identity and as a source of positive emotions were also more likely to question the instrumental performance of EVs (Morton et al. 2014). In other words, it seems that if a person attaches symbolic and emotional meanings to their own car, they are more likely to negatively value EVs.

Sometimes simply one's attitude towards changing the current situation can form a barrier. According to the **status quo bias**, people tend to compare new products to a reference point, which is the current situation, in this case ICE vehicles instead of EVs (Ministry for the Environment 2018, 13).

Status quo bias

= The tendency to prefer the current situation, which is considered as a reference point. New products are compared to this reference point and any changes from it are considered as a loss.

In the case of Arkea, for example, a person responsible for the environmental affairs presumed in an interview that **resistance to change** would most likely be the main attitudinal barrier in the case of substituting cars with LEVs such as electric bicycles, even if they were functional for many operations and working environments (Paloposki 2020).

Regarding the use of Arkea's current e-fleet (the four e-vans) according to the employee survey, 35% of the respondents reported being interested in testing the EVs for work-related driving, whereas 32% claimed not being interested. A few respondents gave more detailed answers. Some reasons for the interest that were brought up included e.g. environmental reasons and the interest in using a company car instead of one's own. Some reasons for the lack of interest were the unwillingness to use company cars or in general the lack of frequent work-related trips. Thus, in the survey no major attitudinal barriers came up directly.

According to a representative of Arkea, the employees were involved in the procurement process. They were informed in briefing sessions and provided with opportunities to test the vehicles prior to the procurement decisions and the possibilities for involvement were presumed to have improved the attitudes. (Lehtinen 2020).

Experience with the vehicles is in fact one effective way of turning potentially negative attitudes into positive (Quak et al. 2016). For instance, a study by Wikström et al. (2014) showed that nearly 80% of users were more positive towards EVs after using them than before, and the user satisfaction continued as the usage continued. The target group in the study were the employees of organizations that were involved with the National Swedish Procurement of Electric Vehicles and Plug-in Hybrids scheme in 2011–2013. Similar findings were made in the FREVUE project where EFV drivers' attitudes towards the vehicles were mapped before and after having used the vehicles for some time. While in the earlier survey 60% of the drivers were in favor of the EVs, the share had increased to 72% in the later survey, while the share of those not in favor of EVs decreased from 13% to 5% and a similar trend was observed not only among the drivers, but also the fleet managers (Dong & Polak 2017).

Attitudinal factors: actions for organizations

- Motivate different people with different approaches based on their attitudes. Acknowledge that for some users, EVs are first and foremost appealing due to their technological innovativeness rather than their environmental benefits.
- It might be a good idea to first target those who have positive attitudes towards the use of electric vehicles as they may be easiest to motivate and can work as an example for others.
- Enable experiences with the vehicles, e.g. via leasing for test periods, as experience can transform attitudes into positive ones.

4.3.1.3. Personal capabilities: Knowledge and skills

In addition to attitudes, several other personal attributes can constitute drivers or barriers to the adoption of different electric vehicles. Personal capabilities can refer e.g. to skills and knowledge to perform certain actions or more general capabilities such as money, availability of time or power (Stern 2000, 417).

In the context of using electric vehicles, whether EVs or LEVs, in a work setting, **knowledge** and **skills** are important. They are also the kind of factors that the employers can influence and thus are at focus here. Both knowledge and skills foster individuals' **self-efficacy**, which refers to the belief in one's ability to succeed in a situation or accomplish a task (Bandura 1986). In the case of EVs and LEVs, the users need to feel confident in using the vehicles and the lack of this confidence may constitute a barrier for their use in the first place.

Driving an EV or riding a LEV does not require special skills in comparison with their non-electric counterparts, but naturally some skills are needed from the users. Lack of knowledge and skills regarding their use can also increase the likelihood of experiencing **range anxiety**, an issue which will be explored in more detail in its own sub-chapter. According to some studies, knowledge of EVs also has a reducing effect on negative attitudes towards EVs (Morton et al. 2016).

When the EVs had been first introduced at Arkea, there had been some training arranged on e.g. charging the vehicles and prior to the official introduction of the vehicles opportunities for testing were arranged for some employees. In the survey on the use of the EVs, 80% of those who had used the company EVs considered the use to have been easy. On the other hand, 10% said they totally disagreed with the claim that the use was easy. For the LEVs that were tested during the BSR electric pilot, guidance documents were created to make their use easier. During the test period, no major difficulties in use emerged, except for the issues related to using the LEVs in winter conditions.

In addition to the concrete, vehicle-related knowledge, more general knowledge about environmental and sustainability issues is of course relevant, as is the understanding of the impact of the organization on e.g. local emissions. This awareness can be increased with different methods, such as training and peer education (Lulfs & Hahn 2014).

In addition to knowledge, experience with the EVs is important; according to some studies, even more so than mere knowledge (Barth et al. 2016, 323). Thus, even if providing knowledge is important, it does not replace the actual experience with using the vehicles.

Increasing knowledge and skills: actions for organizations

- Increase knowledge among employees about EVs, environmental issues in general and the role of the organization in this by providing information.
- Keep environmental and sustainability issues present in the internal communication on a regular basis.
- Provide instructions for the use of the electric vehicles. Arrange training when e-vehicles are introduced to the fleet to avoid skepticism about their usability.
- Enable experiences with the EVs and arrange training to improve driving skills.

Photo: "Lukas / Pexels"

4.3.1.4. Habits and how to break them

Habits are defined as "*behaviors that persist because they have become relatively automatic over time*" (Kurz et al. 2014, 114). Habits and **routines** significantly affect our everyday behavior. Yet, the role of habits in (pro-environmental) behavior is often neglected (Lulfs & Hahn 2014). However, habits can constitute a major barrier between intentions and actual behavior. In the case of switching from an ICE to an EV or a LEV, some kind of "habit breaking" is most likely needed.

Car use as a behavior becomes habitual easily (Steg 2006). Habits also tend to be generalized from a situation to another (Steg 2007, 60). For instance, if a person is used to commuting to work by (their own) car, it is easy to use it for other work-related driving. Meanwhile, it is good to keep in mind that habits are also strongly connected to contexts and thus they can be altered with interventions to existing circumstances (Lulfs & Hahn 2014).

According to the Arkea employee survey, 61% of the respondents used their own car for work-related driving (and not only commuting). 7% of the respondents reported they used the company ICE vehicles and 3% reported they drove company EVs. Furthermore, the most cited reason (51% of respondents) for not having used the company EVs was that the respondent didn't use the company vehicles for work-related trips. It is likely that this is connected to the habitual use of one's own car.

A peculiar feature of habits is that they tend to direct the way we pay attention to our environment, as we as humans cannot cognitively process everything around us equally. The **selective attention bias** directs our attention towards perceptual cues most familiar to us (Ministry of the Environment 2018). For instance, a person used to driving an ICE vehicle is more likely to notice gas stations while unconsciously ignoring the charging stations for EVs.

There are strategies and methods available aimed at breaking habits and creating new behavioral patterns. So called **nudges** refer to "*purposeful changes in the choice architecture that influence people's behavior by making changes in the environment that guide and enable individuals to make choices almost automatically*" (Lehner 2015, 167). Nudges are used to affect behavior or decision-making by not limiting options, but by modifying the choice environment to favor a certain outcome. In other words, their aim is to make the desired behavior, such as choosing an electric bike over an ICE for work-related mobility, easier.

Nudging can prove to be an effective strategy in changing especially context-specific behavior (Lehner 2015). Different methods of nudging include, for example, changes made to the physical environment to favor certain options, framing information (phrasing it to activate certain values) or changing the default policy (e.g. in the case of printing, providing the option of printing on both sides as a default, instead of printing on one side).

So called **rational overrides** can also be used to break habits. Rational overrides are defined as "*a small moment of intentional friction that attempts to influence people's behavior or decision-making by intervening automatic thinking and activating reflective conscious thinking*" (van Lieren et al. 2018, 2171). The logic behind rational overrides is slightly different from that of nudging.

Whereas nudging affects behavior by reducing the "choice overload", rational overrides aim at getting individuals to actively decide to behave in a certain way. As an example of a rational override, an extra decision-making point could be added to e.g. the selection of a vehicle to drive in a certain occasion.

Nudges

= Influencing behavior or decision-making by not limiting the options but making changes to the choice environment in favor of the desired behavior. Choosing the more pro-environmental option is rather automatic.

Rational overrides

= Influencing behavior by creating friction to distract automatic behavior. Conscious thinking is activated, and more pro-environmental choices are made as a result.

It has been argued that nudging is more efficient in a stable context, whereas rational override strategies work better when environments change or when changes in beliefs, attitudes or interpretations are needed (Frey & Rogers 2014). The latter is often the case when introducing electric vehicles and thus different rational overrides (for a list of nine intervention strategies, see van Lieren et al. (2018, 2172) can prove useful.

Breaking habits: Actions for organizations

- Communication and information provision: expressing information in a way that it is directly translated into benefits and costs.
- Making the use of EVs or LEVs a default option when possible and easier than ICEs. For instance, if the vehicle is reserved via an online system, set the electric option as the default choice.
- Utilize the strategies of rational overrides by creating moments of intentional friction to the decision-making environment. One can, for example, add extra decision-making points to the vehicle selection process.

4.3.1.5. The issue of range anxiety

Range anxiety is a phenomenon that has been closely connected with the use of electric vehicles to this day. It can be defined as a "*stressful experience of a present or anticipated range situation, whereby the range resources and personal resources available to effectively manage the situation are perceived to be insufficient*" (Rauh et al. 2015, 178).

As the experience of range anxiety influences both the satisfaction in and acceptance of the EVs (Franke et al. 2016, 16), it is hardly surprising that it is often named as a major barrier to large-scale adoption of the vehicles (e.g. Melliger et al. 2018, Egbue & Long 2012, Skippon et al. 2016). Thus, it should be acknowledged and taken seriously as a barrier also by organizations when electrifying fleets.

Range anxiety = In the case of electric vehicles, range anxiety refers to the fear of the EV not having sufficient range to complete its duty. The experience is essentially a psychological phenomenon and as such it is not necessarily related to the actual range of a vehicle in a specific situation.

As can be concluded from the conceptualization above, range anxiety is a psychological concept. **Personal characteristics**, such as some stress-buffering personality traits have been found to work against it (Franke et al. 2012). Simply driving, in other words **gaining experience of EVs**, has in itself also been found to have a reducing effect on the experience of range anxiety (Rauh & Franke 2015). Also, **a stable and predictable operational routine** has been found to reduce the users' concerns about the range (Quak et al. 2016).

Despite the psychological aspect, it should be noted that the range of electric vehicles is factually always more or less limited, as is the availability of charging points, especially if driving very long distances. In city logistics, however, driving distances are typically rather short and thus the actual range should not be an issue, as long as there is some charging infrastructure available. Here a noteworthy point is that the individual experience of range anxiety has been found to correlate with high range preferences, which are often higher than the actual demand (Li et al. 2017, 322).

As a concrete example, in a survey conducted with EFV drivers as part of the FREVUE project, it was discovered that as the drivers gained experience with the vehicles, their range preferences significantly changed. When in the earlier survey only 7% were happy with the EFVs' range, in the later survey 40% responded being happy with the current situation (Dong & Polak 2017). The status quo bias, which was discussed earlier in the case of attitudinal barriers, seems to apply here. Even if the range of the EV is adequate to an individual's needs, as it is less than of the range of the ICE vehicle, it might be that it is not considered to be adequate. Another finding from the same survey was that the majority of the drivers who were worried about the sufficiency of range reported their state of charge being less than 10% at the point of returning the vehicle to the depot. **Planning and optimization** could help in leaving a safety margin to prevent these situations.

At Arkea, the actual range of the EVs has not been a major barrier, causing only occasional issues in the case of their further-away locations. This makes sense, as 60% of all respondents to the Arkea employee survey have work-related driving trips of less than 10 km each way. In an interview with the representatives of Arkea, it came up that there had been one incident where a driver had been stranded as the car battery had run out, but it was not clear whether this had occurred as a result of a misjudgment by the driver (Jurmu 2020a).

On the other hand, the duration of the battery divided opinions in the employee survey as 19% of the respondents totally agreed with the argument that the battery lasted long enough, whereas 29% totally disagreed with the statement. In addition, in the open answers of the survey a couple of comments were made about the ranges of the vehicles being insufficient. Given the circumstances, it is unlikely that this insufficiency would be actual, and the opinions may reflect some attitudinal barriers, e.g. the status quo bias. On the other hand, 71% of those employees who had tried Arkea's electric cars reported their experience to be positive when 10% said the experience was negative.

Using an EV does require some behavioral adaption from the drivers, as the actual range of the vehicle is affected by their driving techniques and, among other things, the use of car accessories (Ministry for the Environment 2018, 28). For instance, in the wintertime the use of the HVAC system can significantly reduce range, which was mentioned in the previous chapter on the technological barriers for EV adoption.

Providing training and information regarding these issues can prove useful. Furthermore, in some studies drivers have been found to adapt their driving behavior as a result of using the vehicles (Rolim et al. 2012; Wikström et al. 2014). Here, again, gaining practical experience plays an important part.

Reducing range anxiety: actions for organizations

- As the use of EVs requires some changes to be made in driving behavior, training is needed both on driving the vehicles and on the factors that affect range, for example.
- Positive experiences with the EVs can be enabled by arranging test drives.
- Choosing suitable vehicles to different contexts, e.g. depending on the daily mileage, is important for many other reasons, including range anxiety.
- Careful planning and optimization of transport arrangements and routes prevents those “close call” situations which can cause the range anxiety experience.
- At the early stages of introducing EVs, it might be a good idea to identify enthusiastic individuals to be the early adopters, as early successes by those early adopters will benefit the whole transition.

4.3.1.6. Situational and organization-specific factors

The factors affecting behavior discussed above have primarily been related to the individuals themselves. However, the role of different kinds of situational factors (or contextual forces, as in Stern's categorization in the beginning of the chapter) should not be overlooked, especially as their role in influencing individual behavior increases when moving from the private sphere to a work setting.

The situational factors affecting behavior can be **organization-specific**, such as the **organizational culture** and **interpersonal influences** at the workplace, available **physical facilities** or **workplace-specific incentives** for different modes of transport. They can of course also be related to **external circumstances** such as the societal culture, national incentives, physical infrastructure, or totally uncontrollable factors such as the weather conditions or seasons. In the scope of this report, it is particularly the organization-specific factors listed above that are in focus.

Interpersonal influences

Humans are social creatures, and thereby it is hardly surprising that interpersonal influences also have an impact on our behavior (Stern 2000). **Social support** and **"role models"** for sustainable behavior within the organization have been suggested to foster intentions to behave in a sustainable way (Lulfs & Hahn 2014, 55). For instance, a study on a company bicycle leasing program in German companies identified the "role model effect" as a driving factor (Synek & Koenigstorfer 2018, 253). Program participants felt motivated when also their managers cycled to work and when they saw their colleagues adapting the bikes as part of their routines. In the same study, poor support from the employer's side was found to be a barrier, which further highlights the importance of the commitment of also the "top level" of the organization for individuals. Particularly, the importance of the example shown by the manager level has turned out to be crucial in several studies (Blok et al. 2015, Lulfs & Hahn 2014, Wesselink et al. 2017). This issue will be discussed in more detail on the next chapter.

Organizational culture

Moving on from the social realm of the organization to the more general organizational culture, there are a couple of noteworthy points to be made regarding influencing the employees' behavior. First, integrating environmental issues into the strategy and making sure the employees are aware of this are important in ensuring that this environmental orientation is taken into account in the organization's activities (Ture & Ganesh 2014, 142). On the other hand, formal structures to manifest sustainability, such as sustainability reports, may also turn out to become so called "legitimacy facades" covering the lack of real establishment of sustainability within the organization (Lulfs & Hahn 2014, 52).

From the employee's perspective, what is more important than official commitments is the so called **"perceived sustainability-related climate"** experienced by the employees. This basically refers to an organizational culture which is favorable to pro-environmental behavior and as such, affects the employees' behavior. The "climate" is created not only as a result of e.g. incentives and formal structures mentioned above, but also things like leadership support (Lulfs & Hahn 2014, 53).

Incentives

In general, there is a strong financial incentive to use one's own car for work-related driving, which of course reduces the willingness of employees to switch mode to company EVs or LEVs, especially for those employees who commute with their own cars. For example, in the case of Arkea, according to the employee survey, 61% of the respondents used their own car for work related trips as well. Often employees are compensated by mileage for using their own car for work-related travel, which of course makes it attractive. For instance, in Finland, employers may pay their employees 0.43€ per kilometer (in 2020) when using their own car for work-related travel, excluding commute (Tax Administration 2020).

However, organizations as employers can actively promote the use of the e-fleet with **organization-specific incentives**. In a study where the interplay of incentives for car-use, public transport and cycling or walking were compared, it was found that the benefit of free car parking undermined the provided benefits for all other modes of transport (Hamre & Buehler 2014). This highlights the strong position of private car use. As long as private car use is incentivized somehow, a lot is required from incentives to alternative modes of transport.

Physical facilities and suitability of vehicles

The physical facilities at the workplace should enable the use of electric modes of transport. Besides the charging infrastructure, the use of EVs does not require other facilities compared to their ICE counterparts. For LEVs, however, the situation is different. The use of e-bikes and e-cargo bikes requires safe and high-quality **bicycle parking and storage facilities.**

For example, at one of the Arkea locations where the e-cargo bike was tested, one of the main barriers for its use was finding a storage space for the bike during daytime. The users also reported safety concerns, as the container box of the cargo bike could not be locked, and some expensive tools were carried in the bike. As the bikes were leased, it was not possible to modify them by installing locks. This highlights the importance of choosing vehicles suitable in all aspects for a given purpose to guarantee functionality of the vehicle, as well as positive user experiences. Thus, in addition to the physical facilities enabling the use of the e-vehicles, the selection of the vehicles should be made carefully and it might be wise to enable the participation of the end users of the vehicles in the selection process. This is especially important in an organization such as Arkea, where the needs in terms of transport vary greatly depending on the tasks and positions of the employees. It came up in the Arkea employee survey that some employees would appreciate electric passenger cars in addition to the current fleet of e-vans. Also, as purchasing the vehicles enables further suitability through modifications, it should be considered as an alternative to leasing, even though leasing has its benefits.

Choosing LEVs for work purposes:

- Consider the purpose of use carefully and what is required from the LEV.
- Also consider the location of use in terms of e.g. distances that need to be travelled and how accessible different locations are with the LEV.
- Consider the storage needs of the LEVs.
- Allow your employees to have a say in which type of vehicle suits their needs the best, as the end-users' input may prove valuable and prevent possible failures in vehicle selection.
- Try and arrange a test period with different types of LEVs to ensure their suitability to the desired functions.

An interview with Arkea representatives revealed that despite the practical and situational barriers presented above, there is potential for the use of LEVs to substitute cars (Jurmu 2020b). When operating in more inner-city locations, for instance, a bike could be more convenient to operate than a van and the parking issues typical to central areas would be avoided. As an example, it came up in the same interview that earlier a non-electric cargo bike had been in use around a hospital area in Turku. Within the hospital area, distances were short and suitable for a bike, there were no safety concerns and there was a possibility to store the bike at a depot. It is important to note that although practical aspects such as the physical facilities of the use context as well as the suitability of the vehicles can form a barrier, appropriate facilities and vehicles can function as drivers, especially if the use of a LEV avoids a barrier typical for car use, such as finding a parking spot in the city center.

4.3.2. The organizational perspective

As demonstrated above, pro-environmental behaviors in the workplace may differ from the pro-environmental behaviors outside the work setting. In addition to the practical issues related to using e-vehicles in day-to-day workplace transport, these attitudes form one of the main barriers to e-vehicle deployment at the workplace. However, it is not just the individual attitudes or habits that contribute to EV adoption, but the **organizational attitudes** directing the deployment of low-carbon fleets at stake here.

Organizations and employees are one of the largest users of global energy resources. Social and environmental responsibility are nowadays a demand for most organizations, pushing them to recognize the importance of corporate sustainability. Although behavior in the workplace is to a large extent influenced by employee intentions and attitudes, company values and the means for pro-environmental behavior, the behavior of colleagues (peers) and supervisors also affect pro-environmental behaviors (Wesselink et al. 2017.), as was briefly described in the earlier chapter.

4.3.2.1. Leadership and pro-environmental behavior

One can only act in an environmentally beneficial manner if the external conditions at the workplace allow it. Thus, it can be concluded that the decisions made in the executive ladder can have a major impact on the behavior of employees. Put simply: the less possibilities there are to behave pro-environmentally at work, the less employees are likely to do so (Blok 2015). In the case of a company's logistical functions, this naturally means providing the means for travelling sustainably. Here, company policy and **commitment to company, city or national climate goals** are crucial. As a city-owned organization, Arkea, for example, is committed to promoting the climate goals set by the City of Turku to become carbon-neutral by 2029. This commitment on its part directs the fleet procurement decisions, for example (Lehtinen 2020). As demonstrated by Dumitru et al. (2016, 50), pro-environmental employee behaviors always need to include at least some degree of "organizational oversight".

In addition to strategy level commitments, the **exemplary role of leadership behavior** and manager influence should not be underestimated either. According to Wesselink et al. (2017, 1685), both the role of sustainability policy and direct supervisor's behavior are essential to workplace PEB. Supervisors should not only encourage their employees towards sustainable behavior, but also need to adopt the behavior themselves. In the case of promoting more sustainable work-related travel, this means that the supervisors avidly adopt LEVs to daily use themselves, for example. This can be described as leaders influencing employee behavior by setting up **descriptive norms** – giving an example of what is appropriate or desired behavior at the workplace – that may either support or hinder these types of behaviors (Dumitru et al. 2016).

Despite good intentions and the exemplary role of leaders, there is however a strong financial incentive to use one's own car for work-related

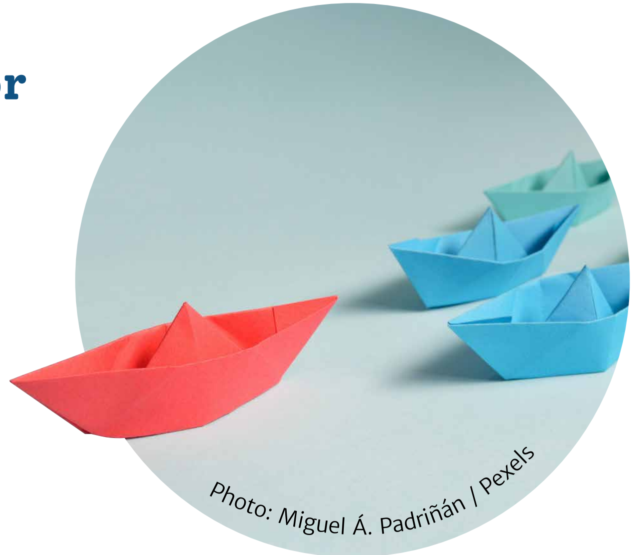


Photo: Miguel Á. Padriñán / Pexels

driving, as explained in the previous chapter. This makes changing the travel mode difficult from the employer's point of view. So, at workplaces where the employer offers LEVs for staff to use instead of personal cars for work trips, the motivation to use them might be hard to come by as long as the staff benefits from the mileage compensation.

4.3.2.2. It's all in the image (or is it?)

Environmental and corporate social responsibility can serve as a driver for some employers to carry out sustainable transport initiatives, as well as to recognize these issues as beneficial to business (Bartle et al. 2019). An organization's stance to EV adoption in particular is naturally dependent on the preferences and attitudes of the employees. What happens before the e-vehicles are purchased or leased – **the internal organizational processes preceding the procurements** – should not be overlooked when discussing electrification of fleets. It is obvious that making fleets and thereby company operations electric, or low-carbon, carries with it an **image benefit**.

It could even be stated that unless there is a strong image benefit involved, it might be difficult to convince so-called laggard companies in particular to start utilizing LEVs in their daily functions, or to adopt e-vehicles to their fleets. At Arkea, for example, image benefits related to fleet electrification and sustainable travel habits have been recognized to enhance the company brand and to build a positive reputation among stakeholders (Lehtinen 2020).

Managing a company's carbon footprint can be linked to the marketing strategy and hence be a strategic choice to gain more customers or satisfy the sustainability criteria stipulated by the current ones. For city-owned companies, sustainability requirements nowadays often stem from the city level, e.g. via the commitment to climate goals or strategies in the various city functions and sub-departments. Both commercial and city-level pressures can influence the uptake of LEVs in companies – however, as discussed by Skippon & Chappell (2019), given the operational-level barriers such as range issues related to EVs, the influence of these pressures might not be strong enough to drive EV adoption. In other words, vehicle selection can be influenced by corporate social responsibility goals or commercial strategies, yet they do not yet seem to surpass operational suitability and total cost of ownership.

Photo: Shutterstock

4.3.2.3. Is there a business case for e-vehicles?

The benefits of replacing ICEs with light electric vehicles in particular may seem obvious on the face of it – less emissions, less noise, possible health benefits, at least in the case of electric bikes. LEVs are also often rather affordable and relatively easy to maintain. For electric cars and vans, the benefits are similar – however, the procurement costs still greatly surpass those of ICE vehicles. **The business case** of e-vehicles is simply not always good enough of an incentive for companies due to these higher initial costs of procurement – even though the costs of running these vehicles are lower in the long run.

When reviewing the main factors affecting senior managers' attitudes towards sustainable transport for business operations, **efficiency** and **cost reductions** emerged as primary (Bartle et al. 2019). Here, however, the issue of **higher upfront costs** compared to ICEs comes to play, despite the **lower operational costs** of the total course of ownership. While consumers may value the environmental benefits and performance of EVs, the high initial purchase price of EVs still remains a substantial barrier to their adoption in many companies.

Photo: Shutterstock

4.3.2.4. Turning limiting factors to drivers

According to a review made by Bartle et al. (2019), so-called **transport problems** can also serve sustainable transport promotion. Problems with **congestion** or **parking issues** are among these "limiting" conditions which may well serve, for example, the use of light electric vehicles among staff members when framed right. Organizations with a limited ratio of on-site car parking, for example, benefit from provision of alternative modes of transport due to parking being an emotive issue that may cause dissatisfaction among staff. Despite the sensitivity of the issue, firm parking management on the side of organization management including providing alternative travel options increased acceptability among staff (Bartle et al. 2019, 308).

The Arkea headquarters is situated in a very densely populated, multifunctional district called Kupittaa in the Turku city center. In addition to diverse types of housing, a university hospital, several company premises and a train station, the area also hosts a Science Park and university campuses. In other words, a significant amount of people live, study, work, commute and spend their free time in the area. This naturally creates pressure for parking also at the Arkea headquarters, as only a small number of dedicated parking spaces are offered to the employees. For such companies, using LEVs for commuting and work-related trips around the city is a viable option, especially when framed as a time and money saving measure. Arkea encourages employees to use LEVs or bicycles at the headquarters and at their other premises around the city. However, it was acknowledged by the Arkea Service Manager that using LEVs or bikes is based on personal preference of the employees even when encouraged as a practical solution to limiting factors, such as parking space unavailability, or when motivated by environmental concerns. Sometimes practical issues do also create a barrier as Arkea has several locations around the city and using optional means of travel between them is just too time consuming. (Lehtinen 2020.)

Fostering employees' pro-environmental behavior

It's important to realize that to implement strategic initiatives to reduce the environmental impacts of city fleets, active support and participation from the employees are needed. Success in sustainability efforts is to a large extent dependent on individual employee efforts. This is naturally a two-way street – without concerted efforts on the organizational level to de-carbonize work-related transport, it is unlikely any major changes can be made to transport behavior solely based on the employees' own motivation. As proven before, employee motivation and participation are complicated as often sustainability efforts are voluntary, not a compulsory task. So, what can organizations do to promote the electrification of their fleets?

Actions for organizations: Identify barriers relevant in your organization and among the users

- Design targeted policies and incentives based on behavioral insights. Map the most prevalent barriers among the employees: are they related to attitudinal factors, lack of knowledge or awareness or perhaps more situational issues?
- Acknowledge that despite enthusiasm or initial eagerness towards change, practical issues may lead to unwillingness to use the vehicles.
- Winter conditions are a prohibiting factor for many, particularly in the case of LEVs and especially for those who don't cycle regularly.

Wintertime also poses challenges to EVs, so it might be wise to time the introduction of new vehicles to a more favorable time of the year. Besides barriers, acknowledge the drivers as well and utilize e.g. the employees' favorable attitudes towards EVs or LEVs.

Use incentives

- Apply different motivations to get your employees to use active modes of transport or LEVs. For some the main motivation can be the positive health effects, and for some e.g. the convenience of operating with the LEV in an urban environment.
- Use more than one strategy/policy/incentive/intervention. Combine enforcement policies and successful information provision.

Review the procurement criteria

Make an overall assessment of the fleet procurements in terms of both environmental and monetary benefits in the medium and long term. Although the upfront costs of e-vehicles are often higher than with ICEs, they do have some obvious benefits that should be taken into account when making procurement decisions.

- The total lifetime costs of EVs are often lower than those of conventional vehicles.
- EVs can lower the fleet operating costs significantly.
- EVs can help the organization to comply with local or government climate policies, demonstrating commitment to corporate social responsibility.

When preparing for fleet tenders, consider the following issues:

- Assess your fleet's driving requirements and vehicle needs- could some of the vehicles be replaced by LEVs?
- Make total costs of operation one of the main procurement criteria.
- Make energy efficiency one of the main procurement criteria.
- If some organizational functions are subcontracted, apply environmental criteria to subcontractor tendering as well.

Seek out opportunities to test different types of vehicles

- An organization's travel needs should naturally determine the variety of vehicles used. However, often other constraints such as infrastructural conditions and costs can complicate the procurement decision-making. Thus, the importance of careful research and the time it requires should not be underestimated.
- Also, within the organization the needs may vary greatly. If possible, allow the end users of the vehicles to be part of the vehicle selection process. This can also foster a sense of ownership and feelings of free choice and autonomy, which all tend to make people more receptive to change.
- Be open-minded towards different modes of transport – sometimes a LEV can turn out to be a more functional substitute for an ICE than an EV.

Communicate the benefits of e-vehicles to employees

- Today's electric vehicles are technically mature and do not really differ much from their ICE counterparts for the most part. Be sure to communicate this to the employees to avoid unnecessary skepticism on their usability.
- Also highlight the benefits of EVs as a driving experience, e.g. quietness and smoothness of the vehicles.
- Formulate the message according to the target group – the use of an EV for work-related driving can for instance also be marketed as an opportunity to try new, exciting modes of transport.

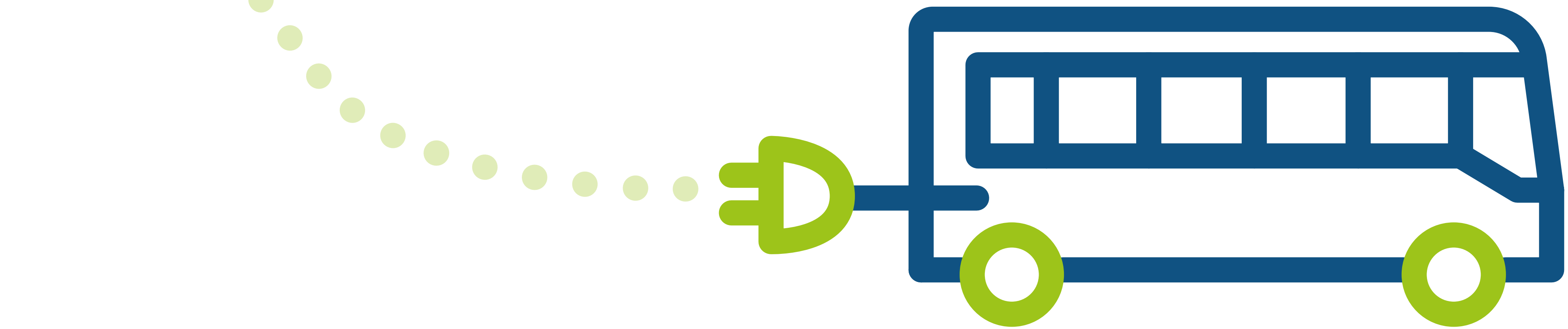
Arrange training and enable positive experiences

- In the case of EVs, training is needed on the practicalities of using the vehicle. Besides simply using and charging the vehicle, it is wise to provide training on the effects of driving techniques and behavior on range. This will increase the likelihood of positive user experience. As for LEVs, some guidance may be needed as well, especially for the users who are not that used to cycling.
- As has become evident, experience has a major impact on the acceptance of electric vehicles, as it can e.g. turn negative attitudes to positive and reduce the range anxiety experience. Providing the users with some low threshold chances to use the vehicles (e.g. test drives) can create positive experiences and allow the end users to gain practical driving experience.

5. SYSTEM OPTIMIZATION IN CITY LOGISTICS

Due to the limited range of electric vehicles and their long charging times, the fleet managers must allow for **proper planning of the routes to** acquire most benefits from the implementation of an EV fleet. Several studies (e.g. Pelletier et al. 2014) and demonstration projects (Quak et al. 2015, Quak et al. 2016), have summarized the implementation of EVs and the limitations in their use for goods distributions in city logistics. One of the main challenges is the adjustment or modification of their routes and operations, which are normally covered by ICE vehicles with no difficulties.

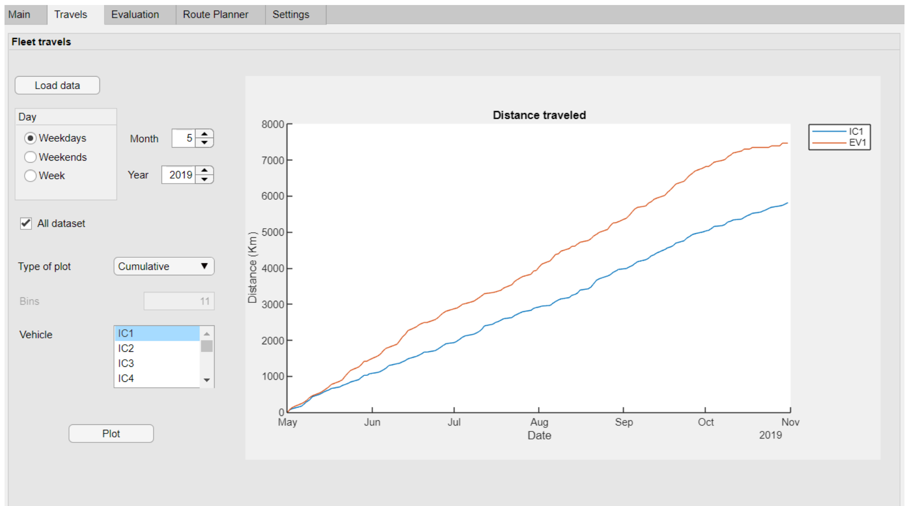
To make the decision to adopt EVs in such cases, an evaluation of the length of the routes covered by ICE vehicles and their frequency must be done. For instance, the type of vehicle used and historical data such as daily mileage must be studied to know if it is possible the use of an EV for those operations.

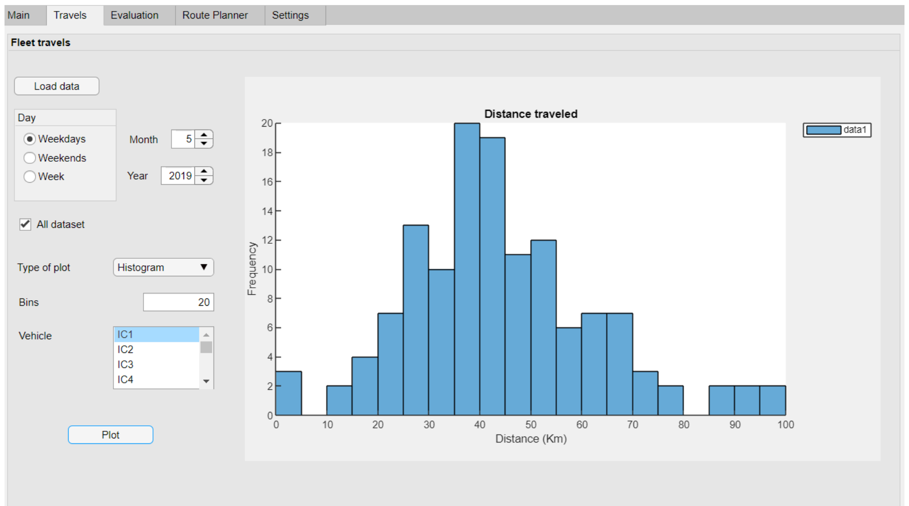


5.1. FLEET TRACK AND ROUTE OPTIMIZATION TOOL

As part of the BSR electric project, an application to help with the analysis and the decision to adopt EVs as part of the fleet was developed based on Arkea's fleet travels. This **fleet track and route optimization tool** helps the organizations to keep track and to evaluate the use of their fleets by analyzing the mileage covered by the vehicles with descriptive statistics. Furthermore, it helps with the planning of new routes for the EVs. Some of the tool's features include:

Evaluation of the mileage is based on the historical data available from a fleet. The tool allows vehicle by vehicle mileage visualization or the comparison between several vehicles. The different plots (daily, cumulative, histogram) help to analyze all the elements of the fleet, as demonstrated in the pictures below. For instance, the covered distances and the frequency under different periods of time can be analyzed for a set of vehicles.

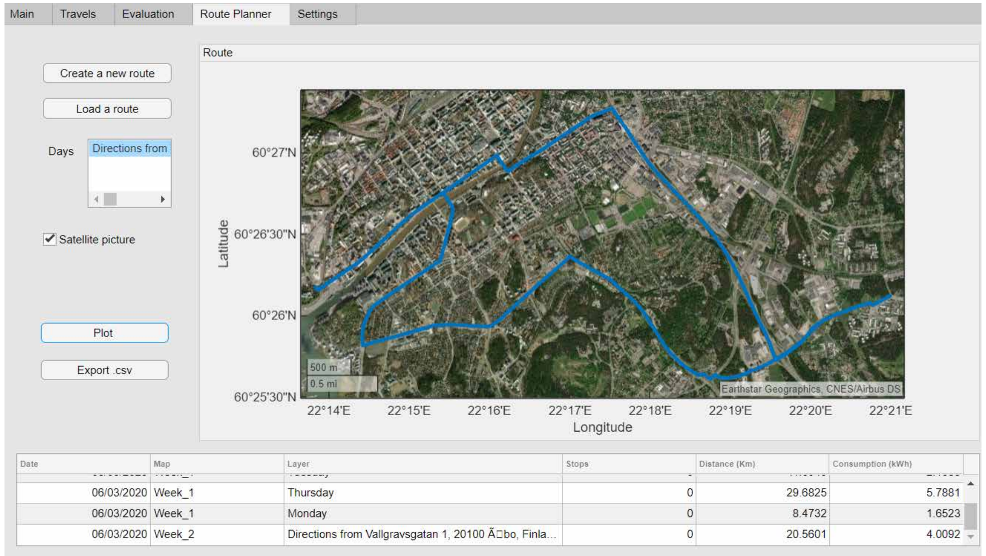




Descriptive Statistics. The tool allows decision-making in terms of covering some of the fleet's routes with electric vehicles, based on:

- Average daily driving comparison and probability evaluation for different distances based on the historical data.
- The box plots help to get a big picture of all the vehicles and their daily distances. In the example below data from ICE vehicles are compared with the BEVs.
- The GHG emissions can be estimated based on the type of the vehicle, type of fuel and its consumption.

Route optimization. Planning and optimization of the routes can be done with the implementation of a link to My Maps from Google where the routes can be planned and customized according to the needs. The app estimates the distances and the energy consumption of the vehicle for the planned route and the data can be exported as a csv or excel file. The routes will be available for the app and can be loaded and visualized any time. GPS data coming from the fleet can also be used if it is available.



The tool was developed as part of the BSR electric project and is available for anyone for download at Turku University of Applied Sciences' New Energy research group's website at: http://nerc.turkuamk.fi/bsr-electric/

The Fleet Track and Route Optimization Tool enables:

- Evaluation of the mileage covered by the vehicles under different periods of time.
- Evaluation between different type of vehicles (ICEs and EVs).
- Estimation of the GHG emissions per type of vehicle, based on the type of fuel, consumption, and electricity provider.
- Creation and optimization of the routes with the help of My Maps by Google.
- Estimation of the energy consumption for a vehicle based on the planned route.

6. CONCLUSIONS

This report presents the results of the Turku use case of the BSR electric project. The aim of the project was to enhance the utilization of e-mobility in urban transport systems around the Baltic Sea Region. Particular emphasis was placed on demonstrating potential applications of urban e-mobility solutions. In the City of Turku, the focus was on inner-city logistics at city-owned companies, taking into account both the technological and behavioral aspects as well as infrastructure and policy related aspects of e-vehicle deployment. The report results provide guidance to public authorities, companies, transport planners and operators who want to integrate e-mobility into their urban transport strategies.

Based on the findings of the demonstration phase and a literature survey, the feasibility of electric vehicles, both EVs and LEVs, in replacing conventional ICE vehicles among fleets of city organizations was reviewed. Factors driving the change as well as factors constituting as barriers to it have both been examined.

Adopting EVs and LEVs instead of ICE vehicles in fleets entails both potential and clear advantages. Regarding emissions their benefits are undeniable, but they also hold advantages in terms of usability e.g. in terms of a lack of noise and increased driver comfort. There are also logistical functions where LEVs may in fact turn out to be the most suitable mode of transport.

A core limitation for the widespread adoption of electric cars or vans is still their limited range, resulting mainly from the limitations of battery technology. On the other hand, typical distances traveled in urban city logistics are often lower than the ranges offered by most commercial electric vehicles. City logistics also imply frequent stops, generally low travel speeds and routes that are often rather predictable – all characteristics that make them more viable for EV replacement. In addition, as shown in the report at hand, at times the issue is more about range preferences or attitudes rather than actual insufficiency of the range.

Policies on supranational (such as the EU) and national to city level are crucial drivers in promoting e-mobility. Financial benefits have been found to be the most effective single driver for the widespread uptake of EVs. However, other policy measures are needed also and many cities have already implemented different measures which prioritize the use of EVs. While it should be remembered that all the policies and actions should be adapted to the local contexts and that the effectiveness of different measures varies between countries and regions, sufficient charging infrastructure is essential everywhere and needs input from multiple actors.

Technology or policies are still not really the key issue here – instead it is the people who are the actual users of the vehicles, whether EVs or LEVs, and thus their perspective should not be overlooked. For this reason, it was deemed crucial to identify some of the main behavioral drivers and barriers for EV or LEV use in the scope of this report. Attitudes, for instance, can function both as drivers and barriers. Car use as a behavior is habitual by nature, and private car use is often supported by financial incentives. These facts can make changing individuals' travel modes particularly challenging. Range anxiety, despite often being a result from preferences rather than actual need, should be taken seriously by organizations to avoid negative experiences and rejection. In addition, a variety of situational factors affect the employees' behavior, in a work context more than in the private sphere, and in the end it can be rather simple, practical issues that have pivotal impact on the functionality of the new vehicles.

Although the initial purchase costs of the EVs are still rather high, a more appropriate way to compare the costs competitiveness of EVs versus ICE vehicles is to study the vehicle's total cost of ownership, where all the incurred costs during the life of the vehicle are actualized to a net present value. When looking at it from this life-cycle perspective, there are urban environments where EV performance and their cost benefits can make a business case for the companies. It is also clear that deploying EVs in company fleets entails clear sustainability benefits which can boost the company's image in environmental and corporate social responsibility. It was nevertheless found that despite the apparent image benefit, EV procurements are still mostly guided by operational suitability and total cost of ownership. In other words, the influence of external pressures to de-carbonize fleets might not be strong enough to drive EV adoption.

Ultimately, the comparison between ICE vehicles and EVs, or in some cases LEVs, is always very context-specific and the extent to which a certain fleet can be electrified is influenced by a variety of factors and circumstances, which also interact. For instance, policies supporting e-mobility are strengthened by technological improvements and considering the feasibility of the current state of technology is needed for the policies to be effective (Mirhedayatian & Yan 2018, 33). Likewise, when looking at the drivers and barriers for EV adoption from the organizations' and its employees' perspective, the two affect each other. The organization provides the means for change and the employees, ideally, act upon these means.

REFERENCES

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ, Prentice-Hall.

Barth, M., Jugert, P., & Fritsche, I. (2016). Still underdetected – Social norms and collective efficacy predict the acceptance of electric vehicles in Germany. *Transportation Research Part F* 37, 64-77.

Bartle, C. & Chatterjee, K. (2019). Employer perceptions of the business benefits of sustainable transport: A case study of peri-urban employment areas in South West England. *Transportation Research Part a* 126, 297-313.

Blok, V., Wesselink, R., Studynka, O. & Kemp, R. (2015). Encouraging sustainability in the workplace: a survey on the pro-environmental behaviour of university employees. *Journal of Cleaner Production* 106, 55-67.

Chacko S. & Chung Y. (2012). Thermal modelling of Li-ion polymer battery for electric vehicle drive cycles. *Journal of Power Sources* 213, 296-303.

City of Turku (2018). Ilmastosuunnitelma 2029. https://www.turku.fi/sites/default/files/atoms/files/ilmastosuunnitelma_2029.pdf.

CIVITAS (2015). Smart choices for cities: Making urban freight logistics more sustainable. Policy Note. https://civitas.eu/sites/default/files/civ_pol-an5_urban_web.pdf

Denton, T. (2016). Electric and Hybrid Vehicles. CRC Press LLC.

Dharmakeerthi C., Mithulananthan, N. & Saha, T. (2014). Impact of electric vehicle fast charging on power system voltage stability. *International Journal of Electrical Power and Energy Systems* 57, 241-249.

Dumitru, A., De grgorio, E., Bonnes, M., Bonaiuto, M., Carrus, G., Garci-Mira, R., Maricchiolo, F. (2016). Low carbon energy behaviors in the workplace: A qualitative study in Italy and Spain. *Energy Research & Social Science* 13, 49-59.

EC (European Commission) (2020). Clean Vehicles Directive. https://ec.europa.eu/transport/themes/urban/clean-vehicles-directive_en Last access 10.8.2020.

EC (European Commission) (2011). Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. Whitepaper. Brussels.

EEA (2018). Overview of electricity production and use in Europe. https://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production-2/assessment-4 Last access 4.8.2020.

Egbue, O. & Long, S. (2012). Barriers to widespread adoption of electric vehicles: an analysis of consumer attitudes and perceptions. *Energy Policy* 48, 717-729.

Eickelmann, J. (2017). Driving Force Electromobility, Business development and growth strategies in the field of electromobility. Phoenix Contact, First Edition.

Electrification Coalition (2010). Fleet Electrification Roadmap: Revolutionizing Transport and Achieving Energy Security. https://www.electrificationcoalition.org/fleet-electrification-roadmap-revolutionizing-transportation-and-achieving-energy-security/. Last access 10.7.2020.

ERA-NET Cofund Electric Mobility Europe (2019). D6.4 - Best practice catalogue for policy makers No. 1. Version: 03 April 2019. https://www.electricmobilityeurope.eu/networks/ . Last access 10.5.2020.

ExtraEnergy (2009). Light Electric Vehicle Association (LEVA) established. Press release dated January 9, 2009. http://extraenergy.org/main.php?language=es&category=information&sub-categ=99&id=2285. Last access 3.8.2020.

Finnish Government (2019). Hallitusohjelma - 3.1 Hiilineutraali ja luonnon monimuotoisuuden turvaava Suomi. https://valtioneuvosto.fi/marinin-hallitus/hallitusohjelma/hiilineutraali-ja-luonnon-monimuotoisuuden-turvaava-suomi Last access 10.5.2020.

Franke, T., Neumann, I., Bühler, F., Cocron, P. & Krems, J.F. (2012). Experiencing range in an electric vehicle – understanding psychological barriers. *Applied Psychology: An International Review* 61(3), 368-391.

FREVUE (2017). Validating freight electric vehicles in urban Europe. Final Report. https://frevue.eu/wp-content/uploads/2019/04/FREVUE-Final-Report_v2.0.pdf

Frey, E. & Rogers, T. (2014). Persistence: How treatment effects persist after interventions stop. *Policy Insights from the Behavioral and Brain Sciences* 1(1), 172-179.

Globisch, J., Dütschke, E. & Wietschel, M. (2018). Adoption of electric vehicles in commercial fleets: Why do car pool managers campaign for BEV procurement. *Transportation Research Part D* 64, 122-133.

Hall, D. and Lutsey, N. (2017). Emerging Best Practices for Electric Vehicle Charging Infrastructure. ICCT Whitepaper. International Council of Clean Transport. https://theicct.org/sites/default/files/publications/EV-charging-best-practices_ICCT-white-paper_04102017_vF.pdf

Hall, D., Cui, H. & Lutsey, N. (2018). Electric vehicle capitals: accelerating the global transition to electric drive. ICCT Briefing. International Council of Clean Transport. https://theicct.org/publications/ev-capitals-of-the-world-2018 Last access 10.5.2020.

Hamre, A. & Buehler, R. (2014). Commuter mode choice and free car parking, public transportation benefits, showers/lockers, and bike parking at work: evidence from the Washington, DC Region. *Journal of Public Transportation* 17(2), 67-91.

Harrigan, M. & Head, D. (2015). Ready, set, charge, fleets! EV fleet deployment strategies. https://www.prospectsv.org/wp-content/uploads/2016/11/Ready-Set-Charge-Fleets-EV-Fleet-Guide.pdf

Heikkilä, V. (2019). Kevyiden sähköajoneuvojen soveltuvuus ympärivuotiseen liikennekäyttöön. Bachelor's Thesis, Turku University of Applied Sciences. https://www.theseus.fi/handle/10024/166560

Hydro Quebec (2015). Electric Vehicle Charging Stations. Technical Installation Guide. Second Edition. https://www.hydroquebec.com/data/electrification-transport/pdf/technical-guide.pdf

IEA (2019). Global EV Outlook 2019. Scaling up the transition to electric mobility Technology report — May 2019. https://www.iea.org/gevo2019 Last access 12.6.2020.

Jurmu, T. (2020a). Interview 15.5.2020.

Jurmu, T. (2020b). Interview 6.2.2020.
Kollmuss, A. & Agyeman, J. (2006). Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research* 8(3), 239–260.

Kurz, T., Gardner, B., Verplanken, B. & Abraham, C. (2014). Habitual behaviors or patterns of practice? Explaining and changing repetitive climate-relevant actions. *WIREs Clim Change* 2015(6), 113–128.

Lehner, M., Mont, O. & Heiskanen, E. (2016). Nudging – A promising tool for sustainable consumption behaviour? *Journal of Cleaner Production* 134, 166-177.

Li, W.; Long, R; Chen, H. & Geng, J. (2017). A review of factors influencing consumer intentions to adopt battery electric vehicles. *Renewable and Sustainable Energy Reviews* 78, 318-328.

Lehtinen, S. (2020). Interview via email 5.8.2020.

Lindgren J. & Lund P. (2016). Effect of extreme temperatures on battery charging and performance of electric vehicles. *Journal of Power Sources* 328: 37-45.

Lutsey, N. (2017). Integrating Electric Vehicles Within U.S. and European Efficiency Regulations. International Council on Clean Transportation. https://theicct.org/sites/default/files/publications/Integrating-EVs-US-EU_ICCT_Working-Paper_22062017_vF.pdf

van Lieren, A., Calabretta, G. & Schoormans, J. (2018). Rational overrides: Influence behavior beyond nudging. Conference Paper, Design Research Society 2018 Conference, Limerick 25-28th June 2018.

Lülfs, R. & Hahn, R. (2014). Sustainable behavior in the business sphere: a comprehensive overview of the explanatory power of psychological models. *Organization & Environment* 27(1), 43-64.

Malmgren, I. (2016). Quantifying the Societal Benefits of Electric Vehicles. EVS29 Symposium, Montreal, Quebec, Canada, June 19-22, 2016. *World Electric Vehicle Journal* 8 (4), 986-997.

Melliger, M., van Vliet, O. & Liimatainen, H. (2018). Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland. *Transportation Research Part D* 65, 101-115.

Miao Y., Hynan P., Jouanne A. & Yokochi, A. (2019). Current Li-Ion Battery Technologies in Electric Vehicles and Opportunities for *Advancements. Energies* 12(6), 1074-1094.

van Miero, J. (2018). The World Electric Vehicle Journal, The Open Access Journal for the e-Mobility Scene. World Electric Vehicle Journal 9(1).

Ministry for the Environment (2018). Reducing barriers to Electric Vehicle uptake: Behavioral insights analysis and review. https://www.iccc.mfe.govt.nz/assets/PDF_Library/ad42c96b5f/MfE-Reducing-Barriers-to-Electric-Vehicle-Uptake.pdf

Moolenburgh, E.A., van Duin, J.H.R., Balm, S., van Altenburg, M. & Ploos van Amstel, W. (2019). Logistics concepts for light electric freight vehicles: a multiple case study from the Netherlands. *Transportation Research Procedia* 46, 301-308.

Morton, G., Anable, J. & Nelson, J. (2016). Assessing the importance of car meanings and attitudes in consumer evaluations of electric vehicles. *Energy Efficiency* 9, 495-509.

Nesbitt, K. & Davies, J. (2013). From the top of the organization to the bottom line: Understanding the fleet market for plug-in electric vehicles. EVS27 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, Barcelona, Spain, 17-20th November 2013.

Nesterova N. & Quak, H. (2015). State of the art of the electric freight vehicles implementation in city logistics – update 2015. FREVUE, D1.3 addendum 1. https://frevue.eu/wp-content/uploads/2016/04/FREVUE-D1.3-State-of-the-Art-add1.pdf

Neubauer J. & Wood, E. (2014). Thru-life impacts of driver aggression, climate, cabin thermal management, and battery thermal management on battery electric vehicle utility. *Journal of Power Sources* 259, 262-275.

Paloposki, S. (2020). Interview 15.5.2020.

Pelletier S., Jabali, O. & Laporte, G. (2014). Battery electric vehicles for goods distribution: a survey of vehicle technology, market penetration, incentives and practices. CIRRELT, September 2014. https://www.cirrelt.ca/documentstravail/cirrelt-2014-43.pdf

Platform for Electro-mobility (2017). Frequently asked questions, electromobility. http://www.platformelectromobility.eu/wp-content/uploads/2017/07/FAQ-Electro-mobility.pdf

Quak, H., Nesterova, N., van Rooijen, T. & Dong, Y. (2016). Zero emission city logistics: current practices in freight electromobility and feasibility in the near future. *Transport Research Procedia* 14, 1506-1515.

Quak H., Nesterova, N. (2016). Zero Emission City Logistics: Current Practices in Freight Electromobility and Feasibility in the Near Future. Sixth Transport Research Arena, 18-21st April 2016.

Quak H., Nesterova, N. & Rooijen, T. (2015). Possibilities and barriers for using electric-powered vehicles in city logistics practice. The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015, *Transportation Research Procedia* 12, 157 – 169.

Rauh, N., Franke, T. & Krems, J. (2015). Understanding the impact of electric vehicle driving experience on range anxiety. *Human Factors* 57(1), 177-187.

Rolim, C., Gonçalves, G., Farias, T. & Rodrigues, Ó. (2012). Impacts of electric vehicle adoption on driver behavior and environmental performance. *Procedia – Social and Behavioral Sciences* 54, 706-715.

Schliwa, G., Armitage, R., Aziz, S., Evans, J. & Rhoades, J. (2015). Sustainable city logistics – Making cargo cycles viable for urban freight transport. *Research in Transport Business & Management* 15, 50-57.

Schuitema, G., Anable, J., Skippon, S. & Kinnear, N. (2013). The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. *Transportation Research Part A* 48, 39-49.

SFS-EN IEC 61851-1 (2019). Electric vehicle conductive charging system. Part 1: General requirements.

Shirk, M. & Wishart, J. (2015). Effects of Electric Vehicle Fast Charging on Battery Life and Vehicle Performance. SAE Technical Paper 2015-01-1190.

Skippon, S., Kinnear, N., Lloyd, L. & Stannard, J. (2016). How experience of use influences mass-market drivers' willingness to consider a battery electric vehicle: A randomized controlled trial. *Transportation Research Part A* 92, 26-42.

Skippon, S. & Chappell, J. (2019). Fleets' motivations for plug-in vehicle adoption and usage: U.K. case studies. *Transportation Research Part D* 71, 67-84.

Steg, L. (2006). Sustainable transportation – a psychological perspective. *IATSS Research* 31(2), 58-66.

Stern, P. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues* 56(3), 407-424.

Synek, S. & Koenigstorfer, J. (2018). Exploring adoption determinants of tax-subsidized company-leasing bicycles from the perspective of German employers and employees. *Transportation Research Part A* 117, 238-260.

Taefi T. & Kreutzfeldt, J. (2014). Comparative Analysis of European examples of Freight Electric Vehicles Schemes. 4th International Conference on Dynamics in Logistics - LDIC 2014, Bremen, Germany February 2014.

Tax Administration of Finland (2020). Kilometre and per diem allowances. https://www.vero.fi/en/individuals/vehicles/kilometre_and_per_diem_allowances/ Last access 5.8.2020.

Teoh, T., Kunze, O, Teo, C. & Wong, Y.D. (2018). Decarbonisation of Urban Freight Transport Using Electric Vehicles and Opportunity Charging. *Sustainability* 10(3258), 1-20.

Traficom (2020). Täyssähköautojen hankintatukea haettu ennätysmäärä. https://www.traficom.fi/fi/ajankohtaista/tayssahkoautojen-hankintatukea-haettu-ennatysmaara Last access 10.6.2020.

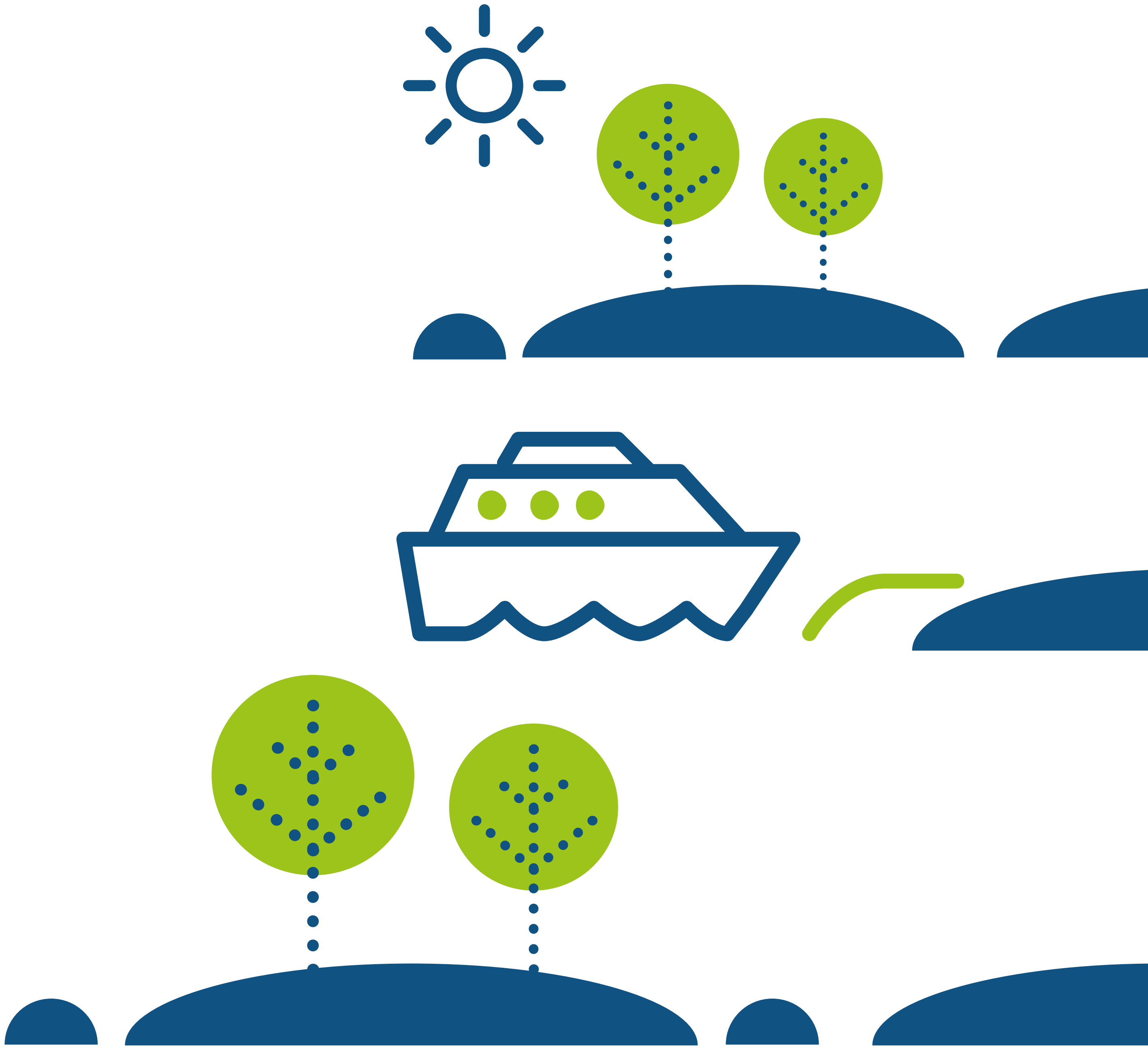
Ture, R. & Ganesh, M.P. (2014). Understanding pro-environmental behaviors at workplace: proposal of a model. *Asia-Pacific Journal of Management Research and Innovation* 10(2), 137-145.

U.S. Department of Energy (2016). Fleets for the future, Electric Vehicle Procurement Best Practices Guide. Clean Cities Program. https://www.electrificationcoalition.org/wp-content/uploads/2018/06/ElectricVehicleProcurementBestPracticesGuide.pdf

Vidyanandan K (2019). Batteries for Electric Vehicles. Power Management Institute, NTPC Ltd., India.

Wesselink, R., Blok, V. & Ringersma, J. (2017). Pro-environmental behaviour in the workplace and the role of managers and organization. *Journal of Cleaner Production* 168, 1679-1687.

Wikström, M., Hansson, L. & Alvfors, P. (2014). Socio-technical experiences from electric vehicle utilisation in commercial fleets. *Applied Energy* 123, 82-93.



BSR
ELECTRIC