# Final Report

# The use of Environmentally Friendly Freight Vehicles

Non-binding guidance documents on urban logistics
N° 5/6

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# Glossary and definitions

| | |
|---|---|
| BEV: | Battery-Electric Vehicle |
| EFFV: | Environmentally Friendly Freight Vehicle |
| EC: | European Commission |
| EU: | European Union |
| GHG: | Green-House Gas |
| ICE: | Internal Combustion Engine |
| ICEV: | Internal Combustion Engines Vehicle |
| IWT: | Inland Waterways Transport |
| LEZ: | Low Emission Zone |
| NBGD: | Non-Binding Guidance Document |
| SULP: | Sustainable Urban Logistics Plan |
| SUMP: | Sustainable Urban Mobility Plan |
| TCO: | Total Cost of Ownership |
| UCC: | Urban Consolidation Centres |
| ZEZ: | Zero Emission Zone |

# Chapter 1 Introduction

## Non-Binding Guidance Documents

This document is one of a series of six Non-Binding Guidance Documents (NBGDs) prepared within the scope of the Study on Urban Mobility - Preparation of EU guidance on Urban Logistics (MOVE/C1/2014-370) as commissioned by the European Commission. The documents aim to help stakeholders understand the challenges brought about by logistics activities in an urban context, and identify the most suitable measures and actions to overcome these challenges. This non-binding guidance document (N° 5 out of 6) covers the issue of "*The use of Environmentally Friendly Freight Vehicles (EFFVs)*". It provides the user with an overview on technical and operational properties of EFFVs, and on policy measures to promote their utilisation in the context of urban logistics.

## Utilisation of EFFVs in urban logistics

Following the European Union (EU) strategic orientations, the European Commission (EC) has been promoting a shift towards sustainable urban freight logistics. The Communication *A European Strategy for Low-Emission Mobility* (COM(2016)501final) presents an action plan aimed at i) achieving a higher efficiency of the transport system, ii) fostering low-emission alternative energy for transport, and (3) promoting low- and zero emission vehicles. It builds on the objectives described in the *2011 White Paper on Transport* (COM(2011)144 final): i) achieving essentially $CO_2$-free city logistics in major urban centres by 2030, ii) by mid-century, greenhouse gas emissions from transport should be at least 60% lower than in 1990, iii) encouraging the exchange of best practices and the development of integrated strategies, and iv) improving public procurement procedures. Other Relevant publications include the *Green Public Procurement* (COM(2008)400final), the *Clean Vehicle Directive* (Directive 2009/33/EC), or *the 2013 Urban Mobility Package* (COM(2013)913 final).

Internal Combustion Engine Vehicles (ICEV), such as motorbikes, vans or trucks, are primarily used in distribution and logistics operations. Overall, urban freight traffic is estimated to account for about 10-15% of kilometres travelled, and for approximately 25% of urban transport related Green-House Gas (GHG) emissions (e.g.: $CO_2$) and 30 to 50% of other transport related pollutants (particulate matter, nitrogen oxide)[1]. These figures are expected to increase in the coming decades, as a consequence of continuous urbanisation and development of e-commerce and home deliveries, among other trends [1].

Increased deployment of Road EFFVs can curb this trend. An EFFV is a vehicle that produces less harmful impacts to the environment than comparable conventional ICEV running on gasoline or diesel, or ones that use alternative fuels[1]. Hence, a technological transition towards road EFFVs could materially contribute to alleviate the production of greenhouse gas emissions and other pollutants. There are currently four main alternative energy carriers[2] and propulsion technologies for EFFVs available, in different stages of market maturity:

- battery-electric vehicles and hybrid-electric vehicles with plug-in,
- hydrogen and fuel cells,
- biofuels, with priority for 2nd generation biofuels,
- natural gas pure or blended with biomethane.

[1] In accordance with Directive on the Deployment of Alternative Fuels Infrastructure (Directive 2014/94/EU), alternative fuel include, inter alia: electricity, hydrogen, biofuels, synthetic and paraffinic fuels, natural gas, or liquefied petroleum gas.

[2] Energy carrier is either a substance or phenomenon that contains energy which will be converted into mechanical energy to move a vehicle. Examples: electricity, fuel, hydrogen.

Among these, market momentum for Battery-Electric Freight Vehicles (BEV) has increased most over the years.[2]. Key advantages include zero tailpipe emissions, or reduced energy consumption and noise emissions. The sales of light commercial BEVs (e.g.: vans) have been increasing at a fast pace. In 2016, the number of sales was above 12000 units in EU28 and Norway[3] (Figure 1)[3]. Already, main vehicle manufacturers are producing commercial BEV. In 2016, Nissan and Renault were the top sellers (Figure 2). Despite the positive evolution, sales of BEVs still represent a marginal value (below 1% in 2016). Indeed, prices of BEVs remain higher than ICEV counter parts, which precludes a wider market uptake.

**Figure 1 BEV Class N1 Sales (EU28 and Norway)[3]**

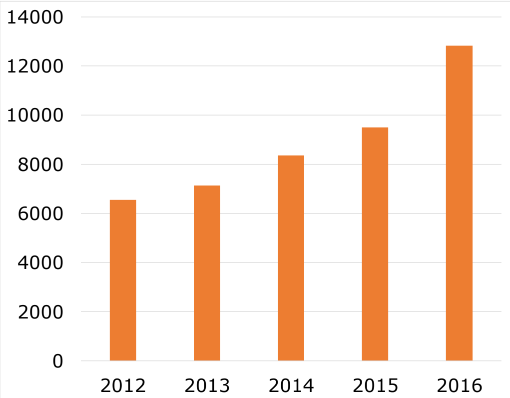
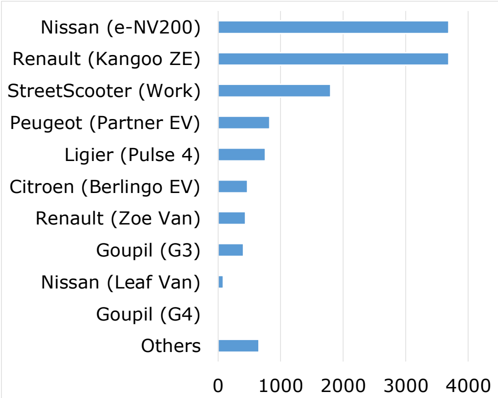



**Figure 2: Sales per BEVs Manufacturer (EU28 and Norway, year 2016)[3]**




Finally, it is important to note that EFFVs are not limited to road vehicles. We may find EFFVs in other modes of transport such as rail and inland waterways transport. Depending on the availability of infrastructure, they are increasingly being seen with interest by stakeholders, as suitable alternative to road vehicles.

The goal of these Non-Binding Guidance Documents (NBGD) is to support local authorities who are planning to reduce transport-related pollutants by promoting EFFVs. The guidance is primarily aimed to be used by public authorities, such as municipalities or local agencies, responsible for the management of the traffic, transport and transport infrastructures within urban areas. Logistics and freight transport operators with operations in cities may also benefit from this document. No background in logistics or freight transport is required to understand this document. More in-depth examples, references and practical guidance can be found in the fully referenced Technical Report on which this less technical NBGD is based.

[3] The number of registrations of light commercial vehicles (class N1) was of 1.56 million in 2014[41].

# Chapter 2 Urban Logistics Stakeholders and their Environmentally Friendly Freight Vehicles uptake

A distinguishing feature of urban freight logistics systems is the coexistence of a large number of distinctive stakeholders, with unique strategies, business models and roles. The following diagram (Figure 3) provides a general characterisation of the key urban logistics stakeholders. Potential users of EFFVs are highlighted in green.

**Figure 3 Key features of urban logistics stakeholders**

**Freight Transport and Logistics Operators**

- Visible face of urban freight logistics operations.
- Provide transport and distribution services.
- Highly heterogeneous group (small family companies and self contractors up to major international transport companies).
- Hired by producers, shippers or receivers.
- Behaviour reflects the need to meet customers' requirements.

**Producers & Shippers**

- Producing the goods.
- Often located outside cities.
- Some outsource transport and logistics operations.
- Others operate own fleet[6] [7].

**Receivers**

- Highly heterogeneous group: small retailers, international retail chains, shopping centres, households, etc.
- Each segment has specific demands (in terms of delivery time, transport conditions, pricing, etc.).
- Expect high quality of service (reliability, flexibility, short transit times) at reduced prices

**Public Authorities**

- Commonly municipalities and local agencies
- Balance between promoting sustainable urban development and fostering economic growth.
- Limited intervention in urban freight logistics activities.

**Citizens**

- Are also Individual Custumers or Receivers (e-commerce).
- Expect proper quality of life (no pollution, security, clean built environment, quiet green areas, charming leisure and shopping zones, etc.).
- Expect access to a wide range of high-quality goods at affordable prices.
- Expect customised and variety of goods.

**Other Stakeholders**

- Investors, Infrastructure providers, landowners, software providers, manufacturers, non-governmental organisations
- Not directly involved in the urban freight logistics operations.

*Freight transport and logistics operators* are primary users of freight transport vehicles, as they are responsible for transporting goods between locations. Commonly, they use road ICEV such as motorbikes, vans or trucks. Hence, they are pivotal for the widespread adoption of EFFVs. Their operations reflect the need to satisfy customers' demands (for example, opening hours of stores or designated time windows to make the deliveries). The market of freight transport companies is quite heterogeneous, ranging from small companies with fleets of one or a few vehicles, to large international companies with fleets spanning hundreds of vehicles, either owned, rented or sub-contracted. Several initiatives have already been undertaken. In the Netherlands, for example, DHL uses bikes on several distribution routes. An example of a small transport company using EFFVs exclusively is Encicle[4]. This Spanish parcel delivery company focused on e-commerce deliveries runs a fleet of electrically assisted cargo tricycles. Each one has a load capacity equivalent to ten standard e-bikes or one van.

*Producers and Shippers* are the owners of the goods or are responsible for them. Commonly, they outsource transport and logistics activities to the previous stakeholders. In this sense, they do not operate freight vehicles. However, their role in the promotion of EFFVs must not be neglected, as they can influence or request freight transport and logistics operators to run on EFFVs. Producers and shippers may also own their own fleets. In this case, they behave similarly to the freight transport and logistics operators discussed above. An example is provided by the Dutch beer producer Heineken that, as part of its corporate social responsibility, is introducing electric trucks on its urban freight logistics operations worldwide[5].

*Receivers* are located at the end of the transport chain. Up to 30% of all urban freight deliveries are made by the receivers' own fleet[4]–[6]. When they own no fleet, they behave similarly to producers and shippers.

*Public authorities* may have a pivotal role in the promotion of EFFVs[7] through the implementation of policy measures. Some are suggested in Section 4. Additionally, public authorities sometimes run and manage a sizable fleet of freight vehicles (e.g. maintenance). The adoption of EFFVs is beneficial at two levels: i) positive impacts due to fleet change and ii) leading by example. The EC published a voluntary instrument – Green Public Procurement (COM (2008) 400 final) - to help those public authorities seeking to procure goods, services and works with a reduced environmental impact throughout their life cycle. Another relevant legal instrument is the Clean Vehicle Directive of 2009[6], which sets the rules to take into account lifetime energy and environmental impacts, including energy consumption and emissions of $CO_2$ and of certain pollutants, when purchasing road transport vehicles. The directive is applied to operators for the discharge of public service obligations under a public service contract and other specific contracting authorities or contracting entities.

*Citizens*, albeit not users of freight vehicles, may influence stakeholders in different ways. As final consumers, they may change their consumption habits to favour those goods transported in an environmentally friendly way. They may voice, in different forums, their expectations and demands for more sustainable transport. This will put the entire supply chain – producers and shippers, freight transport and logistics operators, as well as receivers – under pressure[8]. Secondly, they may work with local authorities to design and implement EFFV-friendly public policies (e.g. regulations).

Finally, the *other stakeholders* group includes a miscellany of stakeholders which, in different ways, may collectively contribute towards the adoption of EFFVs. A relevant stakeholder group is the vehicle manufacturers, as they ultimately determine the pace of introduction of new technologies and vehicles. Currently some major brands already offer an electric version of urban freight vehicles (e.g. Peugeot Partner Van, Renault Kangoo Van or Nissan E-NV200 Van), while others are still working on their own electric versions. Overall, however, the offerings remain comparatively limited.

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[4] Website. http://enciclebicimensajeros.com

[5] Further information available at: http://goo.gl/RwoJWG

[6] Directive on the Promotion of Clean and Energy-efficient Road Transport Vehicles (Directive 2009/33/EC).

# Chapter 3 Environmentally Friendly Freight Vehicles

## 3.1 EFFV in Road Transport

### 3.1.1 BEVs

Table 1 characterises the available BEVs (categories according to the EU vehicle classification) along key operational properties – payload and range – and costs of purchase.

**Table 1 Typical technical properties and prices of selected road BEVs[9], [10]**

| Type of EVFs | Max. Typical Payload | Max. Typical Range | Average Cost Range |
|---|---|---|---|
| **Standard Bike** | 40 kg | - | € 750 - 1 500 |
| **Mopeds & e-Bikes (Class L1e and L2e)** | 80 kg & 0.5 $m^3$ | 75 km | € 1 000 - 4 500 |
| **Motorcycles & e-Scooters (class L3e)** | 180 kg | 130 km | |
| **Motor Tricycles (Class L5e)** | 250 kg | 150 km | €3 500 - 10 000 |
| **Vans (Class N1)** | 700 kg & 4.5 $m^3$ | 170 km | € 20 000 - 30 000 |
| **Trucks (Class N2)** | 5 600 kg & 19.6 $m^3$ | 250 km | From € 100 000 |

#### Bicycles: Bikes, E-Bikes and E-Scooters (Class up to L3)

Traditional bikes are, by themselves, natural EFFVs. E-bikes are an upgrade of the traditional bikes, augmenting their technical capabilities (e.g. capacity or range). BEV technology is well advanced in the e-bike and e-scooters. In addition to the key properties of e-bikes and e-scooters listed in Table 1, full recharging cycles takes between three and eight hours[11][12].

**Figure 4 E-bike used by DHL[13]**

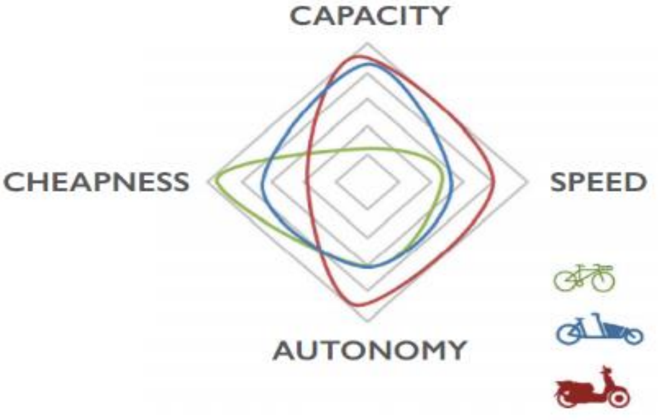
In recent years, several EU co-funded projects have been launched[7] to assess the potential of bikes, e-bikes and e-scooters and to promote their adaptation at EU level. Outcomes are increasingly visible, with a growing number of delivery companies using bikes, e-bikes or e-scooters EU wide. By way of example, the EU co-funded research project Pro-E-Bike compiled a list of running companies worldwide[8].

[7] Either the Transport Research & Innovation Portal (http://www.transport-research.info) or the European Cyclist Federation website (https://ecf.com) provides comprehensive information about the past and on-going research project.

[8] More information available at: http://www.pro-e-bike.org

Figure 5 compares two types of e-bikes (e-bike in green and cargo e-bike in blue) with e-scooters (in red) against different performance criteria. Each vehicle offers its own strengths and weaknesses. Cost is the main competitive factor of e-bikes. The cargo e-bike presents a good balance between the four components. Finally, the e-scooter outperforms the e-bike in the operational factor, but is substantially more expensive[13].

**Figure 5 Performance comparison of e-bikes and e-scooters**[13]




The EU co-funded research project CycleLogistics estimated that up to 51% of all logistics trips and 25% of commercial delivery trips in EU cities could be done by these vehicles[14]. Another investigations estimated separately that e-bikes could take between 19% and 48% by distance of courier logistics (ex.: DHL) now done by motor vehicles[15]. These results indicate that bicycles are capable of competing with ICEV.

The EU co-funded project Pro-E-Bike estimated that the average costs related to an e-bike are around 25% lower than those related to a van (class N1), in terms of fuel/electricity costs, maintenance costs, insurance and salary for drivers. Moreover, e-bikes have been faster, more effective and less polluting, with benefits for both citizens and delivery companies[13]. This project has developed an interactive tool to calculate the economic and environmental gains accruing from replacing ICEV by e-bikes, cargo e-bikes or e-scooters[9]. Summing up, the key advantages of bicycles are:

- Financial and Economic Opportunities:
  - Bikes are inexpensive and with long lifecycle costs.
  - E-bikes and e-scooters are also inexpensive compared with ICEV (e.g. vans).
  - Low maintenance and repair costs.
  - Member States have implemented subsidies or tax reduction schemes to promote acquisition.
  - E-bikes and e-scooters have lower operational costs than ICEV.
- Operational Opportunities:
  - Cargo capacity of e-bikes, notably cargo e-bikes, and e-scooters is adequate for various urban logistics business (e.g. parcel deliveries, home deliveries, groceries, etc.).
  - Bikes and e-bikes, and in some member states e-scooters, may avoid traffic congestion by using bike lanes and other dedicated channels.
  - Autonomy of e-bikes or e-scooters is also adequate to most urban logistics business.
  - Maintenance of these vehicles is simple and inexpensive.
- Environmental Opportunities:
  - No tail pipe emissions. In addition, bikes require no additional energy source, beside the cyclist.
  - Little damage to transport infrastructure.
  - Almost noiseless.
  - Low visual intrusion (reduced size and positive visual identify).

[9] Further information is available at: http://www.pro-e-bike.org. The tool is available for download at: http://www.pro-e-bike.org/publications2

### Motor Vehicles: vans and trucks (Class N1 and N2)

Urban logistics stakeholders, notably freight transport and logistics operators, acknowledge the potential of EFFV. Indeed, a key factor in favour of EFFV is the ability to maintain urban logistics chains' continuity, in a context of growing limitations and constrains on the utilisation of ICEV.

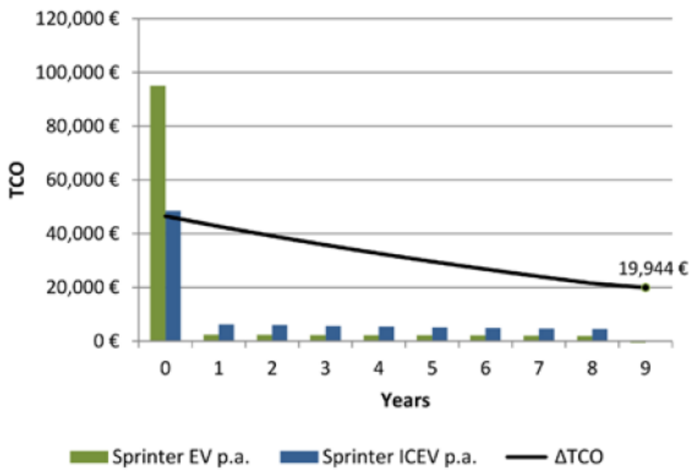
BEVs can offer multiple benefits, ranging from financial and economic, operational and environmental. Yet, this technology still faces a set of market barriers relating to aspects such as technology limitations, high investment costs or lacking or inadequate incentives. Overcoming these barriers will create a favourable momentum towards BEVs, particularly in smaller vehicles (class N1), which is the primary type of vehicle used in the context of urban logistics. Signs of change are visible, as large scale freight transport and logistics operators (e.g.: Hermes or DHL) have been ordering EFFV. The challenge remains for smaller operators to afford the additional cost in a highly price competitive market. In the segment of heavier vehicles, such as classes N2 and N3, the ICEV remain the single viable solution as the BEVs are limited in terms of load capacity and range[16].

#### Financial and economic opportunities and challenges

Available economic studies tend to converge that BEV remains uncompetitive vis-à-vis ICEV when analysing the life cycle costs or the Total Costs of Ownership (TCO)[17]–[20] (Figure 6). Bearing in mind that private stakeholders are commonly focussed on the short term, the wide market uptake of road BEV remains difficult[18].

**Figure 6 Comparing TCO elements of BEV and ICEV[23]**


**Figure 7 TCO differences of the Mercedes Sprinter[21]**




Indeed, the main disadvantage remains on the substantially higher acquisition costs, mainly due to the price of batteries (Figure 6 and Figure 7). A number of member states (e.g.: Belgium, Germany or United Kingdom) offer subsidies or reducing taxes. By way of example, in Slovakia, there is a subsidy of 5000 EUR for the acquisition of a BEV; or the electric recharging company GreenWay is planning to start offering road BEV leasing services[22]. The operational costs are lower than ICEV. Fuel Costs are the main advantage of an EFFVs vis-à-vis ICEV. Depending on the country's actual fuel and electricity costs, the costs of powering a road BEV can be as low as 80% compared with a diesel ICEV. Another advantage lies with the inferior service, maintenance and repair costs. BEVs have generally fewer moving parts, which can result in lower maintenance costs and downtime, and longer lifetime. Cost advantages can range from 20 to 30%. Figure 7 presents the results of a study aimed at assessing the TCO of two versions – BEV and ICEV – of a Mercedes Sprinter vehicle in an urban logistics context (in Germany).

The BEV version is costly, owing to the acquisition costs. The breakeven would be achieved by year 10 of operation.

**Key Financial and Economic factors of road BEV**[16]

| Potential Opportunities | Potential Challenges |
|---|---|
| •Lower consumption rates.<br>•Lower operational costs.<br>•Lower maintenance costs.<br>•Reduced taxation and Higher incentives. | •Higher purchase costs.<br>•High vehicle replacement costs.<br>•Additional training of drivers.<br>•Additional procurement costs. |

### Operational Opportunities and Challenges

Principally, BEV are suitable for urban logistics, considering average travel distances or payload[16], [19]. Looking into Table 2 that lists the adequate and acceptable conditions for the utilisation of road BEV, the overall conclusion is that they can fit into typical daily urban logistics operations.

**Table 2 Compatibility conditions for the utilisation of road BEV**[21], [23]

| Influential Parameters | Duty Cycle Compatibility Rank | | |
|---|---|---|---|
| | Adequate | Acceptable | Avoid |
| Daily distance | Adequate | Acceptable | Avoid |
| Return to base frequency | Low | Medium | High |
| Potential for opportunity charging | (- 80 km) | (80 – 110 km) | (+ 110 km) |
| Time available for charging | Two or more times per day | Once per day | Never |
| Variations in speed | Two or more times per day | Once per day | Never |
| Load capacity required | Above 30 min | 20-30 min | Under 20 min |
| Payload variations | Low | Medium | High |
| Topography terrain | Half or less | Full | n.a. |

BEVs offer their users quite a few operational advantages:

- *Promotes urban logistics chains' continuity*, in a context of growing limitations and constrains on the utilisation of ICEV.
- *Reduced maintenance needs but more difficulties in terms of repair* – BEV have fewer moving parts, do not use lubricants and have a simpler design, which reduces the need for maintenance, when compared with an ICEV. Yet, the market of repair shops is not as mature as the market for the ICEV. Hence, prices tend to be higher and the network less dense.
- *Enhanced User Experience* – drivers and users consistently report a positive experience when driving road BEV in the context of urban logistics.[16], [19], [23]
- *Positive marketing and branding* – producers, shippers and receivers also appreciate receiving goods in BEV. A BEV conveys a strong image of concern for environmental protection and

sustainable development. The willingness to pay extra for "green deliveries" remains, however, very limited[16].

- *Range* – existing technology offers a driving range of around 150 to 200 km in motor vehicles (Class N1). This range is enough in many urban logistics cases, except in some specific weather conditions (see above). Eventually, anxiety regarding the actual range is overcome in the presence of daily routines, because this allows drivers to learn about the vehicles' behaviour[16].
- *Payload* – of a BEV is commonly suitable for many urban logistics services. BEV have a lower payload than ICEV (200 kg in the case of an BEV and up to 700 kg in the case of retrofitted vehicles[19]), owing to the heavy weight and volume of the batteries.

On the other hand, the operational limitations include:

- *Charging technologies* - in-house charging time can take up to 8 hours. Yet, high capacity charging stations can charge in as little as 20 to 45 min.[19]
- *Need for additional air conditioning equipment* – in regions of hard weather conditions (hot or cold), supplemental air conditioning equipment (cooling or heating) may be required, as these systems consume high quantities of energy.
- *Battery performance* determines the range and weight of the vehicle and, ultimately, the fields of utilisation. Currently, lithium ion batteries have a typical lifetime of approximately 6 years of operation[19].
- *Insufficiencies in the infrastructure* – a network of recharging points is still lacking in many cities, and in some parts of urban areas the electric grid may not support simultaneous charging.

**Key Operational factors of road BEV**

| Potential Opportunities | Potential Challenges |
|---|---|
| •Promote continuity or urban logistics' chains.<br>•Suitable for daily urban logistics operations.<br>•Enhanced user experience.<br>•Positive marketing image.<br>•Lower maintenance needs. | •Charging time.<br>•Battery performance limitations.<br>•Infrastructure limitations. |

## Environmental Opportunities and Challenges of Road BEV

A main advantage of BEVs compared with ICEV is the environmental benefits. BEVs have no local (tailpipe) emissions of air pollutants (and CO2). Hence, they materially contribute to the reduction of city pollution. BEVs are currently regarded as a key element to promote the sustainable development of EU cities and regions. The 2011 White Paper on Transport calls for the decarbonisation of cities in the coming decades and suggests the evolution towards electric mobility[2].

Another environmental benefit is related to noise emissions[10]. Noise emissions of BEV are lower than ICEV[24], because conventional combustion engines are noisier than electric engines. Moreover, changing gears produces noise spikes due to engine accelerations. Conversely,

[10] Note that noise abatement rate is not a linear function of the amount of EFFV. Noticeable reduction levels are only perceptible in cases of high replacement levels.

electric engines produce low levels of constant noise, because they have no gear systems. This makes road BEV suitable for night deliveries in Low Emission Zones (LEZs) or Zero Emission Zones (ZEZs), or in any location/occasion where noise is a relevant factor. Finally, BEVs have less maintenance requirements than ICEV, which reduces waste production (e.g. defective spare parts) and other types of pollution (e.g. used oils and lubricants).

**Key Environmental factors of road BEV**

| Potential Opportunities | Potential Challenges |
| --- | --- |
| • No local air emissions (tailpipe).<br>• Reduced noise emissions. | • Disposal of batteries. |

**La Petite Reine**, Paris (France), is a freight transport company that uses electrically powered tricycles – Cargocyles ® with a container at the front or at the back. It was founded in 2001, in Paris, and since then expanded to other cities such as Bordeaux, Rouen, Dijon, Geneva, and Lyon in September 2010. It makes around 2,500 deliveries every day. La Petite used an urban warehouse provided by the City of Paris. La Petite Reine maintained a fleet of around 75 vehicles. Each tricycle can carry about 180 kg of merchandise in its 1,400 litre cargo space. Weighting is only 80kg[43].

**Camisola Amarela**, Lisbon (Portugal), was founded in 2009. They offer express deliveries of parcels and small packages in any part of Lisbon, including outskirts, in the shortest time possible, between 1 and 4 hours.
Their operations are based at two small urban warehouses. The fleet is a mix of bicycles, electric scooters, and electric bicycles and tricycles. Bicycles can carry up to 4 kg, while BEVs can carry up to 40 kg[43].

The company **Posten Norge**, Trondheim (Norway), has been replacing the diesel vehicles with EFFV – electric and hybrid vehicles – for deliveries in the urban centre. Mail and small packages are distributed by electric trolleys, whereas larger packages and pallets are distributed by vans or trucks. The initiative has the public support of the City of Trondheim, which plans to promote the use of EFFV in the context urban logistics[19].

Access restriction measures were implemented to reduce the number of ICEV in the historic centre of Lucca (Italy). **LuccaPort** is a subsidiary company of the local municipality that offers transport and logistics services with a fleet of 6 BEV. The services are based at a warehouse in the city's outskirts
It makes around 120 daily deliveries in 15 round trips, which corresponds to 15% of city deliveries. There was a reduction of 44% in the number of ICEV accessing the historic centre[44].

### 3.1.2 Hydrogen and Fuel Cells vehicles

These are zero tailpipe emission vehicles. The only emissions are water vapour and hydrogen. The main disadvantage lies with the production of the hydrogen. Currently, most hydrogen is produced from fossil fuels, hence a non-renewable fuel source. It is possible to produce hydrogen in a clean way through a process called electrolysis, using renewable sources, such as solar power. However, current electrolysis technologies are costly and inefficient[25]. In addition, there is still no proper network of refuelling stations[26].

At present, the market of hydrogen vehicles is rather limited. Even so, available trials in road vehicles of Class N1 reveal potential of this technology: an expected range of 120 km. These vehicles transport up to 500kg of payload and reach a maximum speed of 50km/h. Refill of hydrogen tank is fast. Prototypes of larger vehicles, Classes N2 and N3, are also under development. Current prototypes have payloads up to approximately 29.5 tons and range of around 2000 km. In addition, fuel consumption and maintenance costs are expected to be lower than for ICEV counterparts[27]. There are also attempts to develop smaller road vehicles, Class L, notably try-cycles[28].

### 3.1.3 Biofuels

Liquid biofuels are currently the most important type of alternative fuels, accounting for almost 5% of the total fuels consumed by road transport. Biofuels could technically substitute oil in all transport modes, with existing power train technologies and existing re-fuelling infrastructures. Blending biofuels with fossil fuels not exceeding the limits specified by the Fuel Quality Directive (10% ethanol, and 7% biodiesel) has the advantage that neither new engines nor new infrastructure are necessary. Higher blends will require some adaptations to the existing engines and infrastructure and a dedicated distribution system.

The Commission's proposal of Directive (COM(2016) 767 final) on the promotion of the use of energy from renewables intends to limit the use of first generation biofuels (food based) from 7 % in 2021 to 3.8 % in 2030. It also establishes a minimum share of advanced biofuels, which should also be gradually increased from at least 0.5 % in 2021 to reach at least 3.6 % in 2030. Advanced biofuels with very low ILUC emissions bring substantial greenhouse gas (GHG) emission savings and do not enter into competition with food production. Advanced renewable diesel is fully fungible with diesel.

### 3.1.3 Natural gas

Natural gas vehicles offer today a well-developed technology, with performances equivalent to those of petrol or diesel units and with very clean exhaust emissions.

**Key Opportunities and Challenges of Alternative Fuels and Technologies**

| | HYDROGEN | BIOFUELS | Natural Gas |
|---|---|---|---|
| Opportunities | • No air pollutant emissions.<br>• Renewable sources (feedstock). | •Easy retrofitting of ICEV and refuelling stations.<br>•Mature technology (production and vehicles).<br>•Renewable sources (feedstock). | •Mature Technology<br>•Reduction of greenhouse gas emissions |
| Limitations | •Costly production from renewable sources.<br>•No mass production is planned.<br>•Lack of refuelling stations. | •Environmental and social concerns (production).<br>•Limited amount of refuelling stations. | •Non renewable source |

The advantages of natural gas vehicles in terms of greenhouse gas reduction are significant compared to petrol vehicles (about 15%- 20%) but less important against diesel vehicles. Nevertheless, it is expected that the new generation of natural gas engines, or the higher use of bio methane blended with natural gas will increase significantly the greenhouse gas’ emissions reduction from natural gas vehicles.

## 3.2 EFFV in Rail Transport

Many European cities have railway networks crossing relevant locations from an urban logistics point of view, such as historic centres, business or residential areas, or logistics zones in the suburbs. In such cases, electric trains or trams can be used to transport goods in an environmentally friendly way. Indeed, the environmental impact, in terms of air emissions, of rail BEV is comparable to road BEV, because the energy carrier is the same.

Rail transport brings other advantages. One railway vehicle carries as much as several trucks. By reducing the number of trucks circulating in a city, rail transport may alleviate road network congestion, improve traffic conditions and security, and mitigate air emissions. Moreover, railway vehicles circulate on dedicate corridors and, with good planning, at constant speed. Hence, transport operations can be better organised. Also, the railway station may serve as an Urban Consolidation Centre (UCC), which favours the utilisation of road BEV for the final delivery.

Even so, the opportunities for the utilisation of railway vehicles in the context of urban logistics have been narrow[29]. Foremost, urban and suburban rail networks are busy with passenger trains in daytime, which mainly leaves the night time for freight rail services. Night deliveries have additional requirements, particularly in residential areas where noise levels are quite relevant.

On the other hand, the universe of locations to be directly served by rail services is limited to those located close to the rail network[30]. Delivering others require additional road transport services which will increase the organisational complexity of the logistics chains and may add costs.

In addition, the rail transport has very high expenditures[31]: i) rail vehicles are expensive, particularly, if additional noise reduction measures are needed; ii) there is a fee for the utilisation of rail network infrastructure, and iii) the complexity of railway operations adds extra costs. Only specific market segments are suitable for delivery by freight rail, such as HORECA[11] business, large retail stores, or working construction sites.

The **CarGoTram**[12] is a freight tram service that supplies Volkswagen's Transparent Factory located in the City of Dresden (Germany). The CarGoTram moves on urban tram network. The service began in January 2001, replacing diesel trucks. A CarGoTram uses two self-propelled bidirectional wagons, using electricity as power, and three cargo wagons. The control cars have less capacity (7,500 kg) than the middle cars (15,000 kg). Total capacity is of 60 ton or 214 $m^3$. Maximum speed is of 50 km/h. Every day the trams transport the equivalent of 60 trucks[29].

[11] HORECA stands for Hotels, Restaurants, Cafés, Coffee Shops and similar.
[12] Image credits: http://ericforfriends.deviantart.com

A **Waste Collection Cargo Tram**[13] is in operation in the city of Zurich (Switzerland). The cargo tram serves nine stations, collecting bulky waste from households and disposal electronic home and industrial equipment. It

was launched in 2003 with a single pre-condition of neither disturbing nor slowing down the public transport for passengers. The tram runs on the city’s tram network. The tram is made of retrofitted trams and wagons. The service is estimated to have replaced 5,000 km of trucks, corresponding to a saving of 37,500 litres per year[29].

## 3.3 EFFV in Inland Waterway Transport

Many European cities are served by inland waterways, either canals or rivers, that are suitable for urban logistics[32]. The energy consumption of Inland Waterway Transport (IWT) per kilometre-tonne of transported goods is approximately 17% of that of road transport and 50% of rail transport[33]. Recently developed hybrid barges are equipped with electric and combustion engines. Electric engines are used to operate within urban areas, whilst combustion engines are used outside those areas and/or to recharge batteries. The typical operating range of electric barges varies between 8 and 9 hours sailing time, with a recharging time of 8 hours.[34]

Inland Waterway Transport has advantages similar to those previously mentioned for rail transport (See Table 3). Additionally, barges have higher payload capacity than trains or trucks, and fewer limitations as to the size or shape of the goods. IWT, albeit subject to specific regulations, is more flexible than rail transport, meaning that freight transport and logistics operators have greater flexibility organising delivery schemes. There are no significant congestion levels on most urban canals or rivers and no restrictions to the movement of barges in day time. Consequently, IWT tends to be reliable and predictable.

However, the use of IWT presents several limitations. These are similar to those mentioned above with regard to the rail transport, yet amplified to some extent due to the bigger transport capacity of the barges. Business viability depends on the transport of higher quantities of goods than rail transport, which is even more difficult to achieve. Add to this the lower density of the inland waterway networks. In some cities, it is a single river. Consequently, the suitable number of receivers is naturally very limited and, unless they are big and close to the waterway (e.g. construction sites or large retail areas), there will be difficulties in generating enough revenues. Road services can be used to serve longer distances, increasing the number of potential receivers, but also the cost.

An existing case is the *Fanprix* grocery delivery service in Paris, France (see box below). Waterways quays tend to be simple structures without advanced equipment (e.g. cranes) or space for storage. Hence, the barge must be equipped with all handling equipment, and all the goods must be either immediately dispatched or ready for loading. This situation creates additional organisational complexity, because there is no buffer for delays or other situations. Another limitation concerns the higher sensitivity of IWT to weather conditions, particularly in

[13] Image credits: http://www.thetransportpolitic.com

the case of rivers. Windy or rainy days (floods), or drought seasons may affect the inland waterways' navigability.

**Fanprix entre en Seine** is an IWT initiative of the grocery retailer Franprix. Goods are conveyed in containers, from the river harbour of Bonneuil-sur-Marne to the Port de la Bourdonnais. At the port, reach stackers load the containers onto delivery trucks. The urban barge route is around 21 km. The service began in 2012. Currently, it supplies 135 out of the 350 stores in Paris. On an annual basis, the service replaces around 2600 truck deliveries and 75000km. The initiative has received some financial support from public stakeholders. Even so, it is costlier than road services[45]. (image credits: http://www.haropa-solutions.com)

**Table 3 Running cases of Urban Logistics using Inland Waterways Transport[35]**

| Initiative | City | Stakeholders | Estimated environmental benefits |
| --- | --- | --- | --- |
| **Beer Boat**: deliveries to local shops, hotels and restaurants | Utrecht, The Netherlands | City of Utrecht (Department of Public Works), 4 breweries, 1 catering industry wholesaler, 65-70 final customers. | Electric Beer Boat: reduction of particles emissions (98%) $CO_2$ emissions (94 %), and NOx (100 %). |
| **DHL floating distribution centre** | Amsterdam The Netherlands | DHL (transport operator), City of Amsterdam. | Avoiding 10 trucks per day (and 150,000 veh.km + 12,000 litres of diesel / year). |
| **POINT-P**: transportation of palletised construction material | Paris, France | Point-P (construction material distributor), Le Freedom (river transport), Navigable Waterways of France, Paris Port Authority | Avoiding 2000 trucks/year and 220 tonnes of $CO_2$ per year. |

# Chapter 4 Policy Options to Promote Environmentally Friendly Freight Vehicles

## 4.1 Decision parameters for selecting EFFV

Choosing an EFFV is a complex decision as it involves decision parameters that normally are not considered in the case of an ICEV.
Figure 8 presents an unordered list of typical decision factors considered in the moment of choosing an EFFV.

Ultimately, the stakeholder will look at the viability of its business model and the ability to maintain quality of service while generating profits. The primary business of freight transport and logistics operators is transport or logistics. Therefore, any increase in costs or negative impact on performance will directly impact their business and reduce their willingness to use EFFVs. Concerning producers, shippers and receivers, the situation is somewhat different, because their primary business is not freight transport or logistics. Other factors (e.g. corporate social responsibility, branding or marketing aspects) may favour the utilisation of EFFVs, even in cases of increasing transport costs.

**Figure 8 Assessment parameters for selecting EFFVs**[36]

- Availability of vehicles to purchase or lease
- Availability of spare parts for the vehicles
- Perceived maturity of the propulsion technology
- Availability of own fuelling/charging infrastructure (in the case of BEV)
- Maximum payload of the vehicle
- Declared GHG emissions (and other pollutants)
- Declared range of the vehicle
- Cost to buy or lease
- Availability of qualified service staff
- Availability of purchase incentives
- Privileges in access restriction schemes
- Reputation of the vehicle’s manufacturer or supplier

## 4.1 Identification of Policy Measures

Public authorities can accelerate market take-up of EFFVs by implementing appropriate measures that could allow stakeholders overcoming the barriers of EFFVs and fully exploiting their benefits. An important first is the consideration of EFFVs in the Sustainable Urban Mobility Plan[14] (SUMP) or in the Sustainable Urban Logistic Plan (SULP). A SUMP is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life[37]. A SULP proposes a set of measures and actions that, collectively, will contribute to reduce the energy consumption and environmental impacts of urban freight logistics enabling its economic sustainability[38].

[14] The European Commission defined the concept of SUMP in the Urban Mobility Package[42].

This NBGD suggests 14 policy measures that, either individually or collectively, will contribute to the adoption of road EFFV[15]. By way of example, the measures that positively influence stakeholders' assessment parameters are the following (Figure 8).

- Privileges in access restriction schemes.
- Availability of own fuelling/charging infrastructure (in the case of BEV).
- Cost to buy or lease.
- Availability of purchase incentives.
- Availability of spare parts for the vehicles.

The policy measures have been clustered into four groups according to their nature and application (illustrated in Figure 12):

- *Stakeholder Engagement*[16] *through communication and awareness raising measures* aimed at informing and educating stakeholders.
- *Regulatory measures* influence the behaviour of stakeholder by enabling or prohibiting certain selected activities in specific conditions.
- *Fiscal measures* will change the impact taxes and fees have in business economy.
- *Planning measures* refer to changes in the city (e.g., infrastructure, built environment, business activities).

The selection of the policy measure depends on the identification of the drivers and nature of the problems and challenges, expected objectives, physical properties of the city, national and local legislation, or even the nature of the logistic and transport chains. Urban regions often present distinguishing and unique features and policy measures must be chosen accordingly. Moreover, each category of policy measure will impact the urban logistic activity differently, either in terms of intensity or scope. Also, the transfer of policy measures between cities should as such be subjected to ex-ante impact studies. Just because a policy measure was successful in city A is not a guarantee that it will be successful in city B.

The choice of policy options should be built on technical analysis (social, environmental, economic and operational dimensions), ideally accompanied by stakeholder engagement initiatives. A stakeholder engagement initiative is a recognised method to achieve enhanced decision and promote stakeholders' acceptability.

## 4.2 Characterisation of the Policy Measures

This NBGD identifies four factors to characterise the policy measures that can be also used as decision factors:

- *Implementation Time* is the time that elapses between the moment of the decision and the moment the policy measure comes into action.
- *Implementation Efforts* are the resources – human, financial, technological, etc. – required to bring the measure into action.
- *Influence Level* is the probability that the measure will lead to more EFFVs.
- *Acceptability Level* translates how well a policy measure is received by the stakeholders.

[15] Rail or IWT depend on very specific contextual conditions, which are essentially case specific. They are not considered in the NBDG. The Technical Report provides additional information.
[16] One of the NBGD is dedicated to stakeholder engagement initiatives in the context of urban logistics.

**Figure 9 Public measures to promote adoption of EFFV (adapted from[39])**

**COMMUNICATION AND AWARENESS MEASURES**

- **Information** - to disseminate virtual or physical information on the advantages and opportunities of EFFV, through Stakeholder Engagement initiatives.

**LEGAL AND REGULATORY MEASURES**

- **Access Regulations** (including pedestrian zones, LEZ or ZEZ) - to grant privileged access to EFFV or to ban (or restrict) ICEV from specific areas
- **Parking Bays and Lots** - to grant permission to EFFV use privileged loading areas.
- **Bus Lanes** - to allow EFFV circulating on bus lanes.
- **Cycle Lanes** - to allow electric bicycles and others on cycle lanes, improving if necessary.
- **Certification** - to certify transport companies with environmentally friendly fleets.
- **Noise Emissions** - to grant privileged access for EFFV into low noise zones or at night time.

**FISCAL MEASURES**

- **Tolls** - to exempt BEV from city tolls.
- **Municipal Tax Incentives** - to grant tax incentives to companies running EFFV.

**PLANNING MEASURES**

- **Tenders** - to demand EFFV in public tenders requiring transport of goods.
- **Charging Infrastructure** - to implement charging point in the city and relevant locations.
- **UCC** - to use available public spaces for creating micro-consolidation centres so that EFFV could operate in the near range and recharge batteries.
- **Municipal Fleets** - to replace own ICEV fleet with EFFV.
- **Repair Network** - to develop a network of BEV repair shops.

## Implementation Time

The implementation time is an influential factor on the choice of the policy measure. Firstly, some urban logistics problems may require immediate actions, while others may allow more time for solving. Secondly, the implementation of certain measures depends on windows of opportunity, such as political cycles or funding opportunities, which often have a definitive timeline. For illustrative purposes, policy measures are divided as follows:

- *Short Term Implementation* when they typically take less than three years to be implemented, and
- *Long Term Implementation* when they are likely to take over three years.

**Table 4 Implementation time of policy options**[39]

| | Short Term Implementation (Up to 3 Years) | Long Term Implementation (Above 3 Years) |
|---|---|---|
| **Communication and Awareness Measures** | Information | |
| **Legal and Regulatory Measures** | • Access (pedestrian and LEZ)<br>• Bays<br>• Bus Lanes<br>• Cycle Lanes<br>• Certification<br>• Noise | Access (other, ZEZ) |
| **Fiscal Measures** | • Tax<br>• Tenders | Tolls (depending on political supporting environment) |
| **Planning Measures** | • Charging<br>• Repair | • UCC<br>• Fleet |

Note: survey conducted in Germany with public auth

### Implementation Efforts

Implementation efforts are another decisive parameter, because without available resources the policy measure cannot come into action. The actual efforts will depend on the local contextual specificities. The results of a study[39] (listed in Figure 10) show that fiscal measures would require higher efforts, because of the lengthy legislative processes (e.g., public audiences, political negotiations, etc.). On the planning measures require fewer resources as they depend only on the public authority.

### Influence Level

The influence level measures how effective a policy measure is in influencing stakeholders' behaviour towards adopting EFFVs. In the above-mentioned study, no group of measures can be considered universally preferable over the others (Figure 11). In any local implementation, a stakeholder's analysis is required for a thorough assessment of potential effectiveness.

### Acceptability Level

Albeit not necessarily required for the implementation of a policy measure, the acceptability level will influence its ultimate success. An early stakeholder engagement initiative can contribute to both identifying those measures with higher acceptability and dilute much of the likely barriers to the initiative.

In the above-mentioned study, EFFVs users' acceptability was assessed (Figure 12) and positive discrimination measures are preferred to negative ones, that is: tax measures were preferred among EFFVs users, particularly, if the measures would benefit EFFVs (through exempts or subsidies) instead of worsening ICEV conditions (e.g. green taxes). Policy measures that directly impact urban logistics operations were also preferred, including: charging points, dedicated parking bays and lots, or access restriction measures.

**Figure 10 Estimated Implementation Efforts (adapted from[39])**

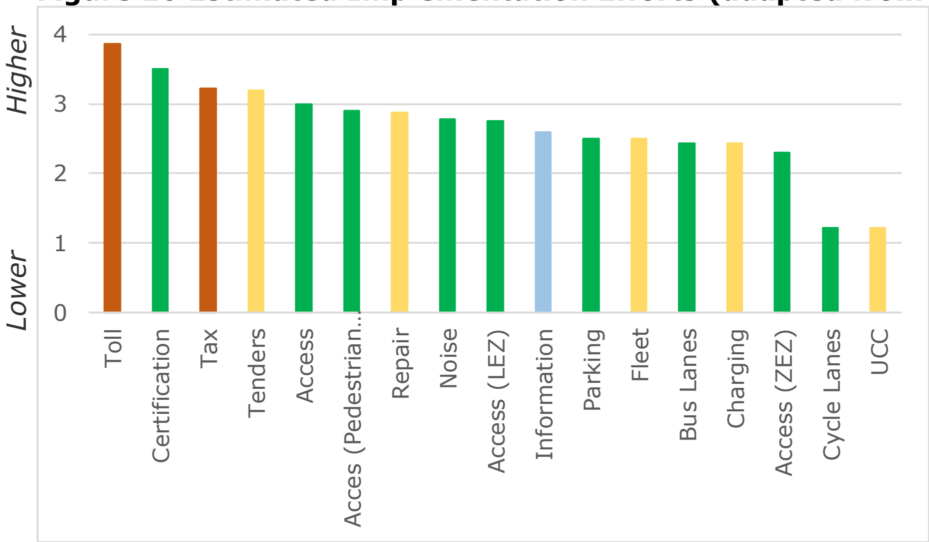



**Figure 11 Estimated Influence Level (adapted from[39])**

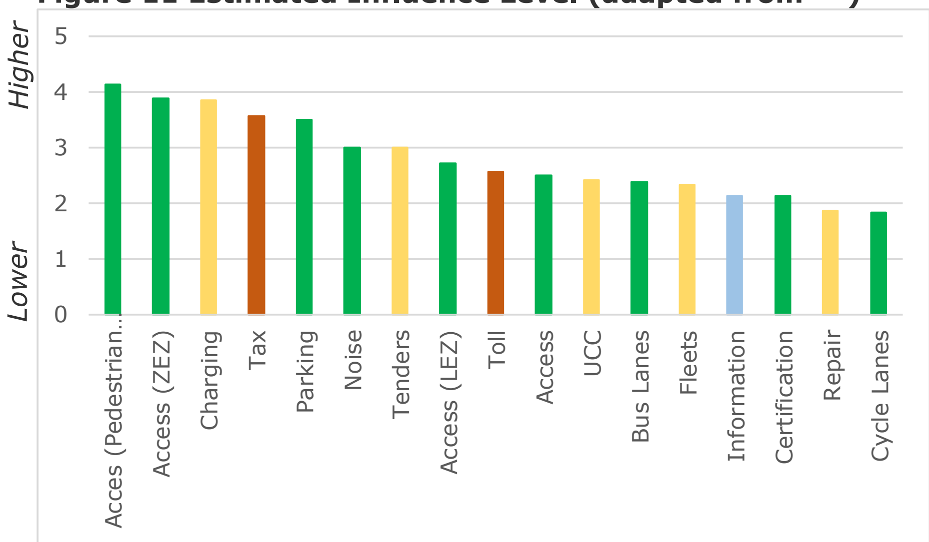
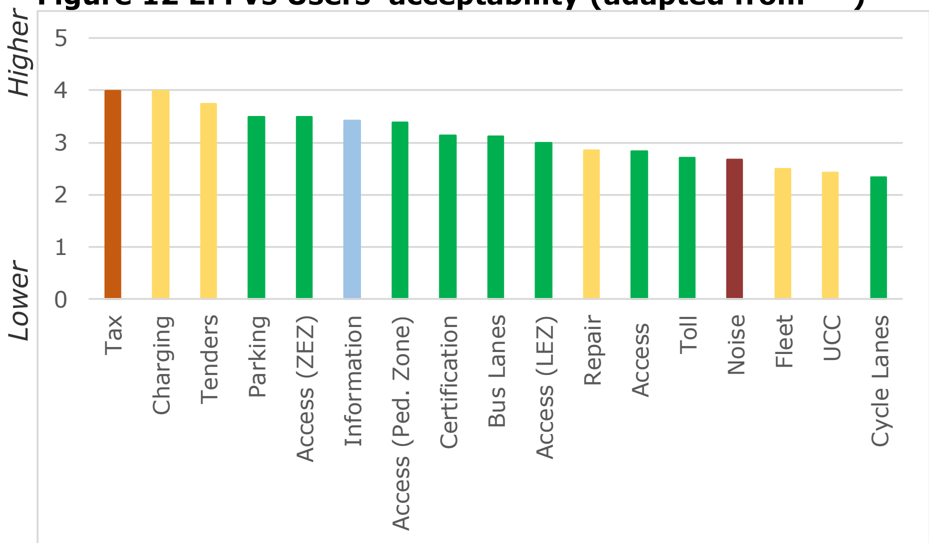
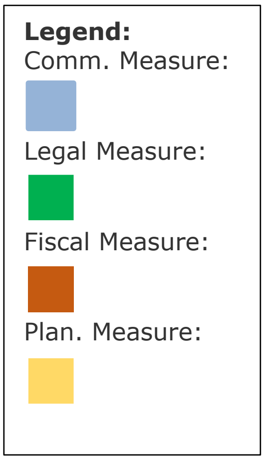



**Figure 12 EFFVs Users' acceptability (adapted from [39])**




Note: survey conducted in Germany to public authorities

# Chapter 5 Recommendations

In this last Chapter, we elaborate and present recommendations for promoting the market uptake of EFFV in urban freight logistics.

***Recommendation 1:*** *Frame the promotion of EFFVs within the context of a Sustainable Urban Logistics Plan.*
The promotion of EFFVs should not be an isolated initiative but a piece of a broader strategy for the sustainable development of the city, including restricting access to the most polluting ICEV. In this way, synergies could be generated and the full benefits of EFFVs could be exploited.

Engage stakeholders in this systemic view with the objective of identifying the challenges and barriers to the adoption of EFFVs. Identify plausible measures and assess their feasibility. Establish a medium to long term policy framework and action plan. This will create a stable and trusting environment that will help stakeholders define their business plans and strategies.

***Recommendation 2:*** *Promote Awareness of EFFVs' Benefits and Advantages.*
Electric mobility is recent and still unknown to many freight stakeholders. Often stakeholders' knowledge is incomplete or incorrect. Informative campaigns (e.g. debates, seminars or discussion forums) will help to clarify doubts and promote a better understanding of the performance and costs of road EEFV.

***Recommendation 3:*** *Take the initiative and Lead by Example.*
Public authorities have the possibility to make a difference by either acquiring or using BEV or any other appropriate EEFV. EU instruments such as the Green Public Procurement or the Clean Vehicles Directive, could help them in this transition. Furthermore, there are many actions that public authorities can take to create the conditions favourable for the utilisation of EFFVs, notably bikes, e-bikes and e-scooters. By way of example, the Cycle logistics project webpage offers interesting insights, and the European Cyclist Federation has recently published a booklet on "Recommendations on Cyclelogistics for Cities"[40]. Also, there is no reason to go alone. Public authorities may cooperate in terms of learning and deployment. Associations such as Polis[17] or Eurocities[18] already have working groups on this topic.

***Recommendation 4:*** *Adapt Legal and Fiscal Municipal Regulations to Promote EFFVs.*
A total of eight legal and fiscal regulations have been reviewed. Among these, access regulation and taxes are regarded favourably by EFFVs users. Moreover, they complement each other: legal measures have immediate impact whereas fiscal measures have deferred impact, aiming at changing the stakeholders' behaviour. To effectively obtain benefits from synergies, measures should be coherently packed together with a clear stated objective and reflect local context conditions.

***Recommendation 5:*** *Establish a Recharging Infrastructure Network.*
The autonomy of BEV in the context of EEFV is a reported concern of stakeholders, even if their daily routes are consistently compatible. The installation of (fast) recharging points would greatly help mitigate this barrier.

***Recommendation 6:*** *Foster Public Procurement of EFFVs.*
Public procurement of EFFVs should be the norm and not the exception. The Clean Vehicle Directive established clear rules on how to proceed. The transition to BEV is beneficial at several levels: i) it provides an exemplary practice leading stakeholders by example, ii) it will serve as a valuable use case to other stakeholders, and iii) it will contribute to a better environment.

[17] More information available at: http://www.polisnetwork.eu
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