



Final Report

The use of environmentally friendly freight vehicles

Technical report

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

Authors:
van den Bossche, M. and Maes, J. (Ecorys)
Vanellander, T. (University of Antwerp)
Macário, R. and Reis, V. (University of Lisbon)
with contributions from experts:
Dablanc, L.

December – 2017



EUROPEAN COMMISSION

Directorate-General for Mobility and Transport
Directorate B - Investment, Innovative & Sustainable Transport
Unit B4 – Sustainable & Intelligent Transport

E-mail: MOVE-B4-SECRETARIAT@ec.europa.eu

*European Commission
B-1049 Brussels*

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ISBN: 978-92-79-70609-7
doi: 10.2832/17750

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Glossary and definitions

BEV:	Battery-Electric Vehicles
EFFVs:	Environmentally Friendly Freight Vehicles
EFVs:	Environmentally Friendly Vehicles:
EC:	European Commission
EU:	European Union
GDP:	Gross Domestic Product
GHG:	Green-House Gas
GPP:	Green Public Procurement
ICE:	Internal Combustion Engines
ICEVs:	Internal Combustion Engines Vehicles
IWT:	Inland Waterways Transport
LEZ:	Low Emissions Zone
NBGD:	Non-Binding Guidance Documents
PZEV:	Partial Zero Emissions Vehicles
SULEV:	Super Ultra-Low Emissions Vehicles
SULP:	Sustainable Urban Logistics Plan
SUMP:	Sustainable Urban Mobility Plans
UCC:	Urban Consolidation Centres
ULEV:	Ultra-Low Emission Vehicles
WTW:	Well-To-Wheel
ZEV:	Zero Emissions Vehicles
ZEZ:	Zero Emissions Zone

Executive Summary

This technical report (No. 5 out of 6) covers the use of *Environmentally Friendly Freight Vehicles* – EFFVs – in urban logistics. EFFVs is a vehicle that produces less harmful impacts to the environment than comparable conventional internal combustion engine vehicles running on gasoline or diesel or one that uses certain alternative fuels. Presently, the term is used for any vehicle complying or surpassing the more stringent European emission standards (such as Euro 6 for road vehicles).

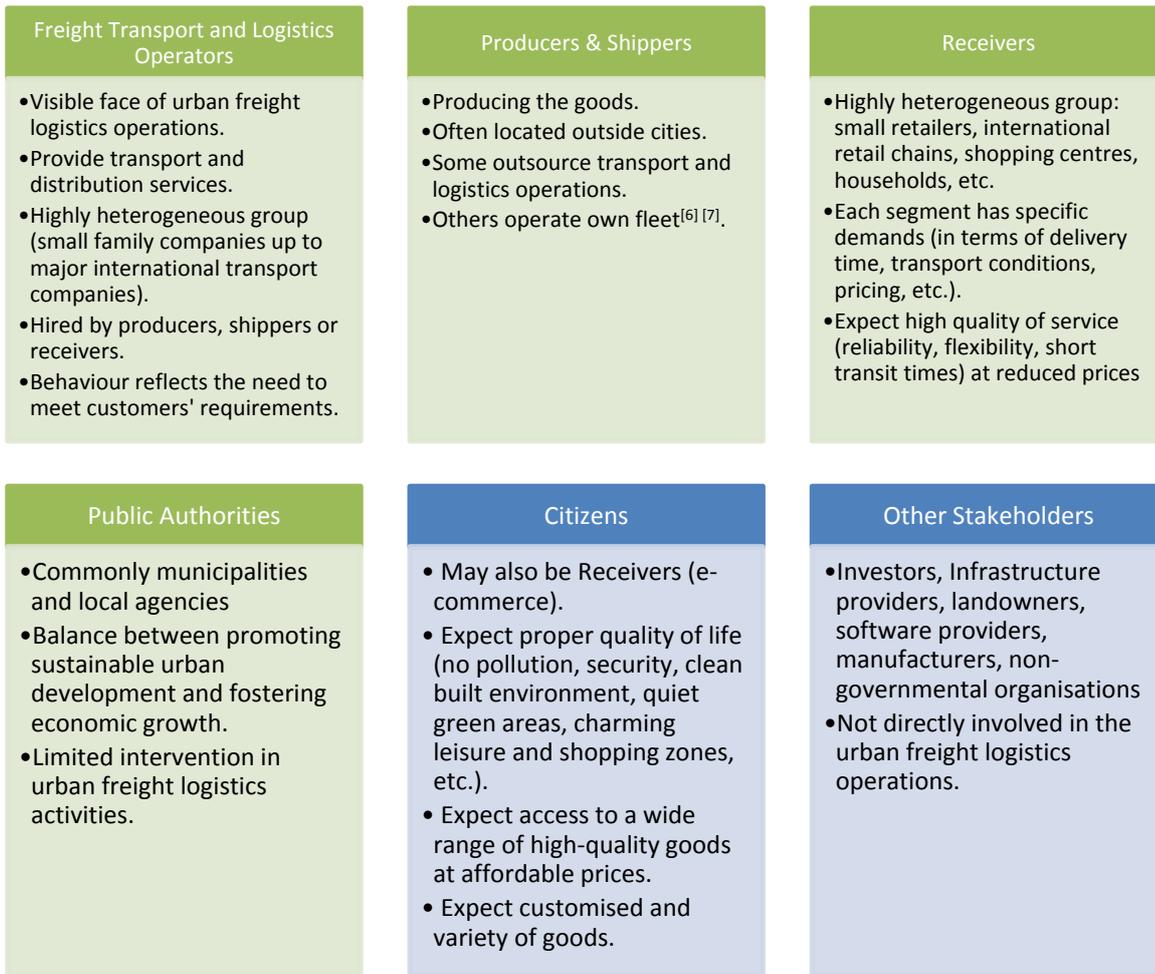
Over recent decades, the expansion of urban areas and their populations resulted in an increasing consumption of freight transport services. Internal Combustion Engine Vehicles (ICEVs), such as trucks, vans and cars, and motorbikes, are primarily used in distribution and logistics operations. Urban logistics has thus become an active contributor of road congestion, pollutant emissions and accidents. 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 gases emissions (e.g., CO₂) and 30 to 50% of other transport related pollutants (particulate matter, nitrogen oxide)^[1]. These figures are expected to grow in the coming decades, as the consequence of continuous urbanisation, consolidation of e-commerce and home deliveries, among other trends.

The European Commission (EC) has been promoting a shift towards sustainable urban freight logistics, not only through policy documents but also through related funding opportunities and research. Relevant publications include:

- The Clean Vehicle Directive (Directive 2009/33/EC) was published. The directive aims at promoting and stimulating the market for clean and energy-efficient vehicles and improving the contribution of the transport sector to the environment, climate and energy policies of the Community.
- The 2011 Transport White Paper (COM(2011)144final) is very clear: emissions of air pollutants from transport that harm our health need to be drastically reduced without delay. In this document, the EC set several relevant goals: i) achieving essentially CO₂-free city logistics in major urban centres by 2030, ii) emitting by mid-century greenhouse gas emissions from transport at least 60% lower than in 1990, iii) encouraging the exchange of best practice, development of integrated strategies and iv) improving public procurement procedures.
- The 2013 Urban Mobility Package (COM(2013)913final)¹ proposed further actions to improve efficiency and reduce environmental impact of urban freight logistics, e.g. integration of urban logistics into Sustainable Urban Mobility Plans (SUMP).
- The communication *A European Strategy for Low-Emission Mobility* (COM(2016)501final). In this document, the EC presents an action plan to accelerate to shift towards low-emission mobility.

A most distinguishing feature of urban freight logistics systems is the coexistence of a large number of distinctive stakeholders, with unique strategies, business models and roles. Consequently, their role and participation in the adoption of EFFVs also differs. The following diagram provides an overview of the attitude of key stakeholders towards EFFVs. Potential users of EFFVs are highlighted in green.

¹ Together towards competitive and resource-efficient urban mobility.



The EC is presently supporting four main alternative types of fuels and propulsion technologies: i) battery-electric vehicles and hybrid-electric vehicles with plug-in, ii) hydrogen and fuel cells, iii) biofuels, with priority for 2nd generation biofuels, and iv) natural gas pure or blended with bio methane. Whilst an EFFVs is any vehicle – road, rail, air or water - that produces low or no harmful air pollutants, main development efforts are nowadays concentrated on road BEVs. BEVs are considered one of the most promising technical solution to replace ICEVs in the context of urban logistics^[2]. Indeed, electric mobility is increasingly regarded as a solution to promote the sustainable development of European Union^[3]. Major efforts have been put in developing new BEVs and preparing regions to receive them. The following EFFVs were considered in this Technical Report:

- **Road Transport**
 - Electric Vehicles include several types of technologies
 - Other Road EFFVs including road non-BEVs
- **Rail Transport**
- **Inland Waterways Transport**

Each type of EFFVs is characterised along three dimensions, being: i) financial and economic factors, ii) operational factors and iii) environmental factors.

The market take-up of EFFVs in urban logistics remains very slow^{[2], [4]}, largely influenced by the challenges discussed in Chapter 3. As an example, only one out of 923 registered trucks between two and five tons was an BEVs by 1st January 2015 in Germany^[5]. Choosing an EFFVs is a complex decision because stakeholders must consider parameters that are irrelevant in case of an ICEVs.

The primary business of freight transport and logistics operators is transport or logistics. Therefore, any increase of costs or negative impact on performance will directly impact their business and reduce their willingness to use EFFVs. In what concerns 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.

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. Owing to the relevancy of road transport, this Technical Report suggests fourteen policy measures that, either individually or collectively, will contribute to the adoption of road EFFVs.

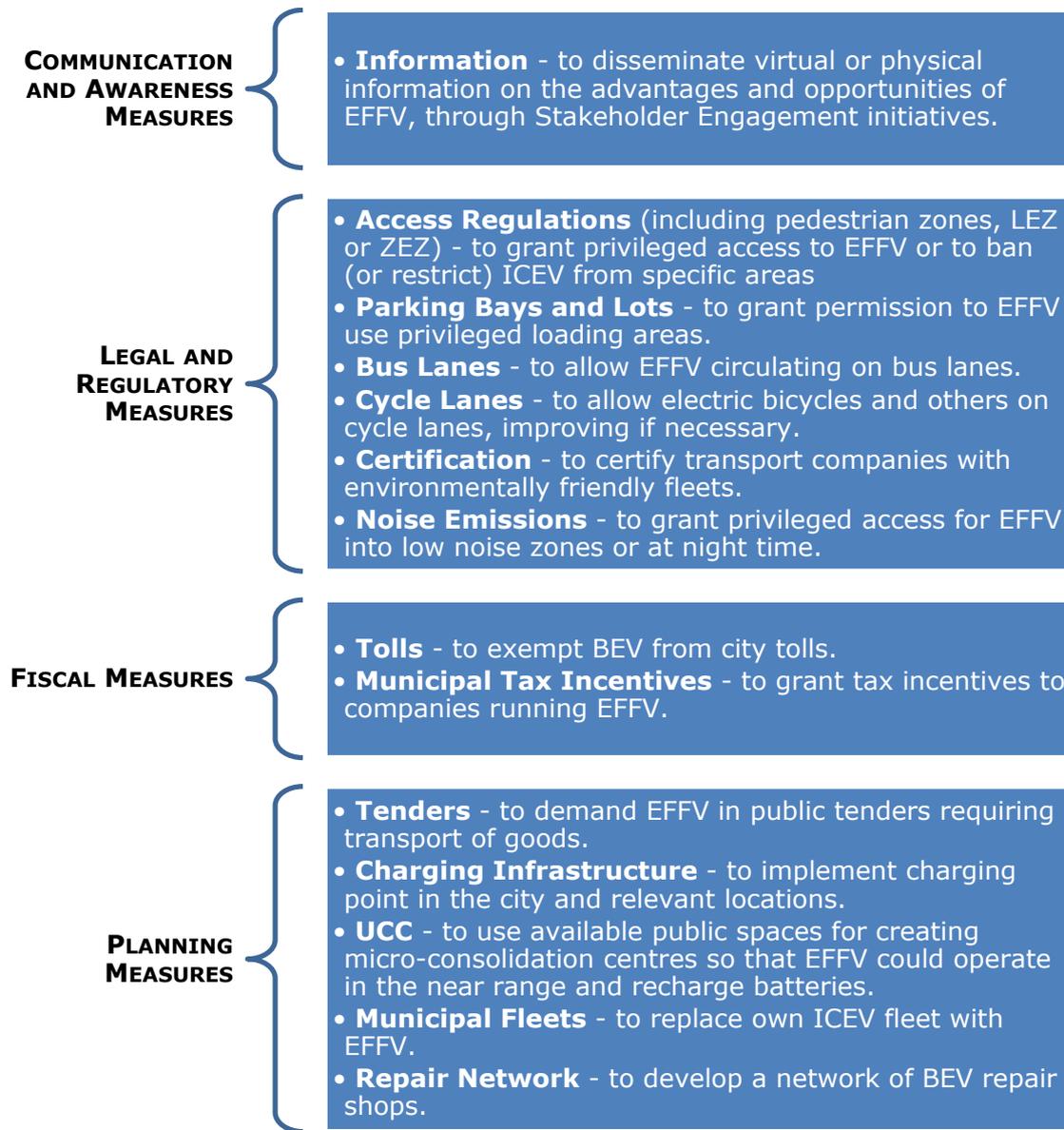
The policy measures have been clustered into four groups according to their nature and application (Figure 1):

- *Communication and awareness measures* are used to inform and educate stakeholders.
- *Legal and 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 choice of policy options should be supported on technical analysis (social, environmental, economic and operational dimensions), ideally accompanied by stakeholder engagement initiatives. Stakeholder engagement initiative is a recognised method to achieve enhanced decision and promote stakeholders' acceptability².

² One of the NBGD is dedicated to stakeholder engagement initiatives in the context of urban logistics.

Figure 1 Public measures to promote adoption of EFFV (adapted from^[5])



Chapter 1 Introduction

1.1 Approach

This technical report is the fifth of a series of six prepared within the scope of the Study on Urban Mobility - Preparation of EU guidance on Urban Logistics (MOVE/C1/2014-370) commissioned by the European Commission. Technical reports 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 report is the basis for NBGD 5.

This report covers *the use of Environmentally Friendly Freight Vehicles (EFFVs)*. An EFFV is a vehicle that produces less harmful impacts to the environment than comparable conventional Internal Combustion Engine Vehicles (ICEVs) running on gasoline or diesel or ones that use certain alternative fuels. The technical report analysis the technical and operational properties of diverse EFFV, including road vehicles (e.g., bikes, scooters, or light and heavy-duty vehicles), rail vehicles (e.g., freight trains), waterborne vehicles (e.g., boats) or airborne vehicles (e.g., drones and airships). The usability of each type of vehicle in the context of urban logistics is also analysed. Finally, options that public authorities may deploy to promote and accelerate the adoption of such vehicles are discussed.

The primary target group of this technical report are public authorities, such as municipalities or local agencies, responsible for the management of the traffic, transport and transport infrastructures within urban regions. Furthermore, logistics and freight transport operators with city operations may likewise benefit from this report.

1.2 Contextualisation

The European Union went through an extensive urbanisation phenomenon, which has not yet stabilised. "Today, approximately 359 million people - 72% of the total EU population - live in cities, towns and suburbs"^[6]. The speed of transformation has slowed down, yet, current estimates predict that the share of the urban population continues to grow and will reach 80 % by 2020^[7]. In Europe there are 26 cities of more than 1 million inhabitants and additional 373 cities of more than 100,000 inhabitants in the European Union, representing around 165 million people^[6]. Understandably, the demographic evolution of the cities varies greatly. Some such as London or Brussels are expecting a very significant growth of their population in the coming decade while others are shrinking. Cities are also the economic engine of Europe, as about 85% of the European Union's GDP is generated in cities.

Urban areas are in continuous need of goods and freight and are also focal generators of freight and waste. In the literature^{[8]-[15]} various terms are used to refer to the general concept of logistics and, particularly, of transportation of goods and waste in urban areas, such as "urban goods movement"^[8], "city logistics"^[9], "urban freight transport"^[10]. Logistics can be defined as the part of the supply chain that relates to planning, implementing and controlling the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption, in order to meet customers' requirements^[11]. Dablanc^[14] stated that urban freight logistics can be defined as the attempt to reorganize goods flows within urban areas in the interest of sustainability by restructuring cities' supply systems, justifying this need with the negative effects that come with urban goods transport due to the expansion of urban areas and growth of their populations. Urban freight logistics should ideally conciliate the efficient distribution of goods with the promotion of innovative schemes for the reduction of the operations' total cost, including economic, social and environmental costs, with the ultimate objective of reducing the clash between the interests of logistics companies and those of other stakeholder groups involved in urban mobility^[16].

According to Quak and van Duin^[17] urban freight logistics deals, mainly, with three different domains: transportation network, supply demand and traffic, where urban goods is common entity in all three domains.

Urban goods transport issues result from a wide pattern of developments in our society. These include a movement toward a post-industrial society, ageing and individualization, urbanization, and the quest for sustainable development. Road transport vehicles, such as trucks, vans or cars, are the predominant mode to move freight around. Several studies^[18] concluded that, on average, a city generates the following freight transport needs:

- 0.1 delivery or pick-up per person per day;
- 1 delivery or pick-up per job per week;
- 300 to 400 truck trips per 1000 people per day; and
- 30 to 50 tons of goods per person per year.

Cities are also known to be places of considerable production of waste and other residues that must be safely deposited or disposed elsewhere. Evidences collected for the TURBLOG project^[18] suggest that on average:

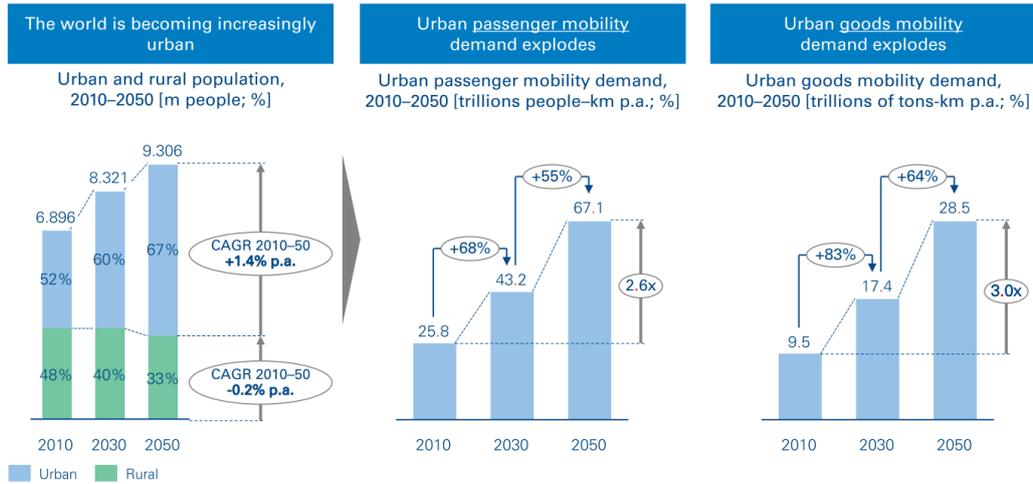
- 20 to 25% of all truck-km in urban areas are outgoing freight,
- 40 to 50% is incoming freight, and
- 25 to 40% is originated from and is delivered within the city.

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 Gases (GHG) emissions (e.g., CO₂) and 30 to 50% of other transport related pollutants (particulate matter, nitrogen oxide)^[1]. These figures are expected to grow in the coming decades (Figure 2), as the consequence of European urbanisation, consolidation of e-commerce and home deliveries, or emergence of new autonomous vehicles.

The European Union (EU) has a clear commitment of achieving a sustainable development. In particular, the EU has taken the lead in the fight against climate change and the promotion of a low-carbon economy. In 2009, the European Commission (EC) adopted the 2009 Review of EU sustainable development strategy (COM(2009)400 final)³.

³ Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Mainstreaming sustainable development into EU policies: 2009 - Review of the European Union Strategy for Sustainable Development

Figure 2 Increased urbanisation and its impact on passenger and goods mobility demand



Source: Arthur D. Little^[19]

The EC strongly supports the shift towards sustainable urban freight logistics, not only through policy documents but also through related funding opportunities and research. Relevant strategic goals and clear timelines have been established.

In 2009, the Clean Vehicle Directive (Directive 2009/33/EC)⁴ was published. The directive aims at promoting and stimulating the market for clean and energy-efficient vehicles and improving the contribution of the transport sector to the environment, climate and energy policies of the Community. It set the rules to take into account lifetime energy and environmental impacts, including energy consumption and emissions of CO₂ 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. Meanwhile a number of accompanying documents have been published⁵.

The 2011 Transport White Paper^[3] (COM(2011)144final) is very clear: emissions of air pollutants from transport that harm our health need to be drastically reduced without delay. In this document, the EC set several relevant goals: i) achieving essentially CO₂-free city logistics in major urban centres by 2030, ii) emitting by mid-century greenhouse gas emissions from transport at least 60% lower than in 1990, iii) encouraging the exchange of best practice, development of integrated strategies and iv) improving public procurement procedures.

The 2013 Urban Mobility Package (COM(2013)913final)⁶ proposed further actions to improve efficiency and reduce environmental impact of urban freight logistics, e.g. integration of urban logistics into Sustainable Urban Mobility Plans (SUMP). Already in 2016, the EC release the communication *A European Strategy for Low-Emission Mobility* (COM(2016)501final). In this document, the EC presents an action plan to accelerate to shift towards low-emission mobility. The action plan focus on three main domains: 1) higher efficiency of the transport system, 2) low-emission alternative energy for transport, and (3) low- and zero emission vehicles. This action list is to be complemented and reinforced by other horizontal enablers such the Energy Union strategy, research and innovation, industrial and investment policy, the Digital Single

⁴ Directive on the promotion of clean and energy-efficient road transport vehicles

⁵ Further information can be obtained at the respective EC's website http://ec.europa.eu/transport/themes/urban/index_en.htm

⁶ Together towards competitive and resource-efficient urban mobility

Market Strategies or the skills agenda. The focal point of the action plan is road transport since it is responsible for over 70% of transport greenhouse gas emissions and much of the air pollution.

In what concerns the action *low-emission alternative energy for transport*, the EC aims to scale up the use of low-emission alternative energy for transport, to develop an appropriate legal framework and infrastructures for alternative fuels, and to promote the standardisation and interoperability of sustainable mobility technologies. In what concerns the action *low- and zero emission vehicles*, the EC proposes to improve vehicle testing aiming to regain trust of consumers, and is already preparing post-2020 strategies for cars, vans, lorries, buses and coaches, aiming at reaching the objectives set to 2030.

The low- and zero-emission vehicles have entered the political agenda and are currently regarded a plausible contributor to the achievement of the above-mentioned strategic ambitions. These vehicles are also designated as Green Vehicles or Environmentally Friendly Vehicles (EFVs). We may define EFFVs as a vehicle that produces less harmful impacts to the environment than comparable conventional internal combustion engine vehicles running on gasoline or diesel or one that uses certain alternative fuels. Presently, in some countries the term is used for any vehicle complying or surpassing the more stringent European emission standards (such as Euro 6 for road vehicles), or California's zero emissions vehicle standards (such as ZEV, ULEV, SULEV, PZEV), or the low-carbon fuel standards enacted in several countries. It is important to emphasise that the concept of EFFVs solely refers to the quantity and type of air pollutants emissions and not with the vehicles' actual technology. Hence, ICEVs may be converted into EFFVs by changing the fuel composition (which may require some technological adjustments in the engine and ancillary systems).

Technological advancements over the last decades resulted in the development of alternative solutions to the conventional ICEVs. Yet, owing to the relatively low costs of fossil fuels and the reliability of the ICEVs, the alternative technologies remain underdeveloped. Nowadays, the increasing pressure towards sustainable development led to a revival of those alternative technologies.

The EC^[20] is presently supporting four main alternative types of fuels and propulsion technologies which are being developed within the time horizon of 2020: i) battery electric and hybrid electric vehicles with plug-in, ii) hydrogen and fuel cells and iii) biofuels, liquid or gaseous. Each alternative still faces significant limitations.

- *Battery Electric vehicles (BEVs)* still struggle with autonomy issues and capacity limitations, owing to the energy capacity retention and weight of the batteries. Notwithstanding, major advancements are being achieved in this area. Also, prices of BEVs vehicles prices are above the price of a similar ICEVs. The lower consumption rates and public subsidies can alleviate that burden, but the difference is still an important factor.
- *Hydrogen technology* is relatively mature, however, cost-efficient hydrogen production techniques are damaging to the environment, since they use fossil fuels. A clean technological solution to the production of hydrogen is being sought. As a consequence, there are several prototypes of vehicles and no mass production of vehicles is planned. Understandably, a proper refuelling stations network is still inexistent.
- *Biofuels* present a suitable alternative, provided costs of production are competitive against fossil fuels. An advantage is that the traditional fossil fuel stations can be adapted to supply biofuel. Yet, there is still lacking a proper network of refuelling stations.
- *Natural Gas* offers today a well-developed technology, with performances equivalent to those of petrol or diesel units and with very clean exhaust emissions

The penetration of EFFVs is however being slowed down by a phenomenon commonly known as the chicken and egg problem. On the one hand, the demand for EFFVs is low because supply is limited and expensive vis-à-vis ICEV. On the other hand, vehicles' manufacturers are not interested in developing more EFFV, since demand is low. Adequate public policies may break this vicious cycle and foster demand and supply. Several public policies with this intention are proposed in this Technical Report. Additionally, public authorities may work together to incentivise both producers and consumers changing behaviour. By way of example, the EU co-funded LoCITY and FREVUE projects have been working on such a solution, promoting cultural and business changes by appealing to stakeholders' environmental responsibility⁷.

1.3 Structure of the Technical Report

The document is structured into six chapters. Chapter 2 provides a brief overview about key stakeholders' roles, expectations and strategies. Chapter 3 is dedicated to the description of selected EFFVs. Chapter 4 discusses a set of public policies to accelerate the adoption of EFFVs. Chapter 5 lists a set of examples of cities, which have promoted in different ways the utilisation of EFFVs. Finally, Chapter 6 concludes the technical report and summarises the main ideas.

⁷ More information available at: <http://frevue.eu/newsroom/join-movement-send-us-declaration-intent/>

Chapter 2 Stakeholders in Urban Freight Logistics

One of the most distinguishing features of urban logistics systems is the existence of a large ecosystem of agents (Figure 3). Agents do not necessarily have aligned strategies or business models, which eventually leads to tension and conflicts within the system^[21]. Such conflicts are the source of many problems and challenges. Here follows a discussion on their attitude towards EFFVs⁸.

Figure 3 Key features of selected urban logistics stakeholders

<p>Freight Transport and Logistics Operators</p> <ul style="list-style-type: none"> • Visible face of urban freight logistics operations. • Provide transport and distribution services. • Highly heterogeneous group (small family companies up to major international transport companies). • Hired by producers, shippers or receivers. • Behaviour reflects the need to meet customers' requirements. 	<p>Producers & Shippers</p> <ul style="list-style-type: none"> • Producing the goods. • Often located outside cities. • Some outsource transport and logistics operations. • Others operate own fleet^{[6] [7]}. 	<p>Receivers</p> <ul style="list-style-type: none"> • 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
<p>Public Authorities</p> <ul style="list-style-type: none"> • Commonly municipalities and local agencies • Balance between promoting sustainable urban development and fostering economic growth. • Limited intervention in urban freight logistics activities. 	<p>Citizens</p> <ul style="list-style-type: none"> • May also be 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. 	<p>Other Stakeholders</p> <ul style="list-style-type: none"> • Investors, Infrastructure providers, landowners, software providers, manufacturers, non-governmental organisations • Not directly involved in the urban freight logistics operations.

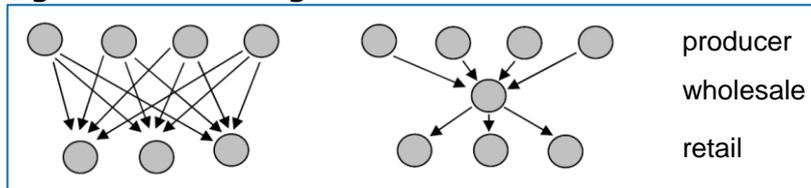
- **Producers and Shippers** are the stakeholders that dispatch the goods towards the receivers. They may also be the owners of the goods. Their responsibility may also include other logistics operations, such as bundling and packing; although such services are increasingly being outsourced. These stakeholders may run a proprietary fleet of vehicles. In these cases, they also assume the role of transport companies. ICEVs such as motorbikes, cars, vans or trucks are primarily used. The adoption of EFFVs could thus contribute to improve sustainability of the urban areas. Changes are already visible, although still rather limited. By way of example, the Dutch beer producer Heineken, as part of its cooperate

⁸ The previous NBGD and Technical Reports provide other discussions towards the respective topics. The NBGD and Technical Report on Stakeholder Engagement provides a more comprehensive overview.

social responsibility, is introducing electric trucks in the urban freight logistics operation worldwide. The objective is naturally to reduce the carbon footprint and contribute to improve the quality of urban areas life. At a different level, producers and shippers may undergo a reorganisation of their logistics process favouring the concentration of flows (both in time and in space). A concentration of flows favours the adoption of high capacity vehicles such as trains or boats, which tend to be EFFVs.

- **Wholesalers** are intermediaries between Producers and Receivers (Figure 4). Often they own (or manage) warehouses in the outskirts of cities. Wholesaler activity can promote the rationalisation of the number of vehicles and transport kilometres, since they promote the concentration of flow in a reduced number of locations. The scope for promoting EFFVs is somewhat limited, albeit these stakeholders may act in different fronts. Firstly, BEVs require electric plug-ins and other specific technologies, which can be installed in the wholesalers' warehouses and other premises. Secondly, they can work together with customers and providers to introduce the EFFVs in the logistical chains. In addition, they can promote changes in the logistical chains that favour the EFFVs. If closer to railways track, wholesaler may work with other stakeholders to analyse the viability of urban freight distribution in trains.

Figure 4 Positioning of Wholesalers



- **Freight Transport and Logistic Operators** are responsible for the physical movement of goods. Logistic operators provide additional services, such as invoicing and billing, warehousing, or inventory management. They may work in a similar fashion as the wholesalers, in the sense that they also collect and bundle the freight flows from different producers (or wholesalers), before making the distribution among retailers. As such, Figure 4 is also valid in the context of logistic operators.

Logistic operators tend to be the visible facet of urban logistics, as they run the vehicles, commonly, road ICEVs (such as motorbikes, vans or small trucks). Therefore, these are pivotal stakeholders 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), while optimising processes. The adoption of EFFVs depends on the ability of keeping fulfilling the demands. It is important to note that the market of freight transport companies is quite heterogeneous, ranging from small family-run companies, with a fleet of one or some vehicles, to large international companies, with a fleet of hundreds of vehicles, either owned or sub-contracted. Smaller companies tend to be riskier adverse than larger companies, as they have lower financial capacity, lower capacity to conduct pilots/tests or reduced human resources force (for learning or training). Yet, larger companies can give the example by changing logistics processes and adoption EFFVs. Indeed, already several initiatives have been undertaken. By way of example, in the Netherlands, DHL uses bikes on several distribution routes. Other examples are provided in Chapter 6. There are also several cases of small transport companies only running EFFVs. It is the case of ENCICLE, a Spanish parcel delivery company focused on e-commerce deliveries, runs a fleet of electric cargo tricycle. Each one has a load capacity equivalent to 10 standard e-bikes or one van.

- **Receivers (e.g. retailers, shopkeepers, offices, construction sites, etc.)** are the end of the transport chain. In what concerns retailers, there is a wide diversity, ranging from small street shops to major commercial centres. Each one sells specific products and therefore has specific transport demands (e.g. frequency, quantities, type of vehicles, etc.). Smaller retailers often own, at least, one car or van. They negotiate with wholesalers and pick-up the goods at the wholesaler' warehouses using their own cars. Hence, they are directly involved in urban logistics services. This type of transport, commonly designated as own account transport, may account to up to 30% of urban deliveries^{[22]-[24]}. Also of importance is that many times when receivers buy products the delivery service is included in the price tag.

Retailers can have an active role in the promotion of EFFVs. They may influence producers and shippers, or freight transport and logistics companies to adopt sustainable transport solutions, including EFFVs. They may favour those stakeholders that already deploy EFFVs.

There are several advantages in pushing towards EFFVs. By way of example, having EFFVs stopping at the front of their stores conveys a positive perception of environmental protection and promotion of sustainable development, which may have a positively attract more customers. The promotion of EFFVs can thus be a valuable marketing initiative.

- **Urban Area Residents & Users** refer to the people who live or spend a substantial amount of time in the urban area (e.g. working, leisure, shopping, etc.). They expect proper living standards and quality of life. Inevitably, urban logistics services, such as emissions, smell, noise, vibrations, etc., are much unwanted. Air pollutants and particulate matter, particularly in hot days, can become quite inconvenient for pedestrians and road users. Residents and city users may voice their discontentment towards urban logistics activities in different ways, such as sending letters to city halls, audiences with public representatives or even lawsuits. Residents can, in this sense, be an active voice in the promotion of EFFVs. They can put pressure on public authorities to act and on private stakeholders to change.

A major trend concerning this type of stakeholders refers to home deliveries and e-commerce. Residents are increasingly resorting to internet-based commerce to acquire goods, ranging from groceries and other fast-consumption goods, to technology, books and even fashion. Commonly, goods are delivered to a designated location, e.g. home, office or drop off point. They expect a high quality of service (e.g. on-time deliveries, real time tracking of their shipments, diversity of delivery options including deliveries at pick up points, flexibility of delivery, etc.). This trend is introducing profound changes in the organisation and structure of urban logistic systems (i.e. new delivery schemes, different route planning or different vehicles) and the actual impacts are still unknown⁹. In this role, residents may favour those producers and distributors that make use of EFFVs, or demand them to adopt EFFVs.

Another group to consider is the Visitors and Tourists. Although they spend shorter periods of time in the urban area, the exposure to the harms of urban logistics may nonetheless create a negative image. Tourism Office, travel agencies and other stakeholders with interest in tourism may also press both public and private stakeholders to reduce the utilisation of ICEVs.

⁹ The reader interested in the topic of E-commerce is referred to Technical Report No. 4.

- **Public Authorities** are responsible for ensuring the social, economic and sustainable development of urban regions. We may distinguish three levels of public authorities: the local government, the national government and the EC (e.g. setting EURO-standards for truck engines). Local authorities refer to the municipalities, regional and metropolitan agencies. The intervention of the national or European level authorities is at different level, funding tailored research and development, creating adequate legislation (e.g., technology, labour, safety, etc.), or promoting territorial cooperation between national and international regions and municipalities.

Local public authorities play a double role in what concerns the promotion of EFFVs: i) as users or managers of freight vehicles, ii) as legislators.

Indeed, public authorities either own or manage a substantial fleet of freight vehicles for different uses (e.g., cleaning or waste collection, civil works and maintenance of built environment, gardening, etc.). These vehicles primarily circulate within the city. Hence, the adoption of EFFVs is a important contribution. There are other beneficial consequences. Private stakeholders are often risk adverse. Public authorities, as first adopters, will serve as example to other private stakeholders. They will bear the cost of using EFFV. Private stakeholders will benefit from the knowledge of a local stakeholder. They could avoid the pitfalls and barriers. Secondly, the adoption by the public municipality will generate demand for EFFV and other associated services (e.g., spare parts, repair shops etc.), helping breaking the chicken and egg problem.

The EC published a voluntary instrument – the Green Public Procurement¹⁰ (GPP) - to help public authorities adopting sustainable behaviours. The GPP is “a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured”. The GPP requires the inclusion of clear and verifiable environmental criteria for products and services in the public procurement process. The utilisation of the GPP instrument in the public procurement and tender will promote the utilisation of EFFVs.

Another important instrument is the Clean Vehicle Directive (Directive 2009/33/EC)¹¹. The directive aims at promoting and stimulating the market for clean and energy-efficient vehicles and improving the contribution of the transport sector to the environment, climate and energy policies of the Community. It requires, amongst other points, the calculation of the full lifecycle costs of the vehicles. It set the rules to take into account lifetime energy and environmental impacts, including energy consumption and emissions of CO₂ 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.

In what concerns the promotion of EFFVs by the private stakeholders, the scope of intervention of (local) authorities is also relevant. Public authorities have various legal mechanisms¹² to influence private stakeholders behaving on a given way, including the implementation of favourable public policies, promotion and coordination of urban logistics measures, or engaging stakeholders^[25].

¹⁰ More information available at: http://ec.europa.eu/environment/gpp/index_en.htm

¹¹ Directive on the promotion of clean and energy-efficient road transport vehicles.

¹² Several public policies measures are suggested in Chapter 4.

- **Other Stakeholders** – the above list does not exhaustively indicate the stakeholders with interests in urban logistics. Among these, we would like to highlight the so-called resource supply stakeholders^[26], including: investors, infrastructure providers and managers (such as ports, airports, intermodal terminals, road networks), landowners and providers of vehicles or of information technologies (IT) support systems. These stakeholders may not be directly involved but their investments and innovations determine the possibilities for urban logistics to evolve. This is particular relevant in the case of EFFVs. By way of example, the adoption of EFFVs depends on research and development of more reliable, efficiently and economic technology. The introduction of EFFVs may also be favoured through special funding lines or agreements. In addition, EFFVs often require specific infrastructure for refuelling (electric plug-in or biofuel stations). Without such infrastructure, adoption of EFFVs is not feasible. Transport infrastructure managers may work on the provision of such services and products.

Chapter 3 Characterisation of Environmentally Friendly Freight Vehicles

3.1 Introduction

In principle, an EFFV is any vehicle – road, rail, air or water - that produces low or no harmful air pollutants. The main development efforts for urban areas are however concentrated on road-based electric vehicles (BEVs). BEVs are considered one of the most promising technical solutions to replace ICEVs in the context of urban logistics^[2]. Indeed, electric mobility is increasingly regarded as a solution to promote the sustainable development of the European Union^[3]. Major efforts have been put in developing new BEVs and preparing regions to receive them.

The following EFFVs were considered in this NBGD:

- Road Transport
 - *Electric Vehicles*: they include several types of technologies (see box below).
 - *Other Road EFFVs*: they include road non-BEVs.
- Rail Transport
- Inland Waterways Transport (IWT)

Electric Vehicles Technologies:

BEV are vehicles powered only by one or more electric engines. Electricity is stored in batteries. Batteries are recharged by plugging in the vehicle into the electric grid.

Hybrid EV are vehicles equipped with electric and Internal Combustion Engines (ICE). Electric engine is powered by batteries, ICE or other propulsion. Batteries are charged by the ICE or other propulsion source and during regenerative braking. Hybrid EV is not plugged in to charge.

Plug-in Hybrid EV is a Hybrid EV, whose batteries can be recharged by plugging in into the electric grid or any source of electricity power.

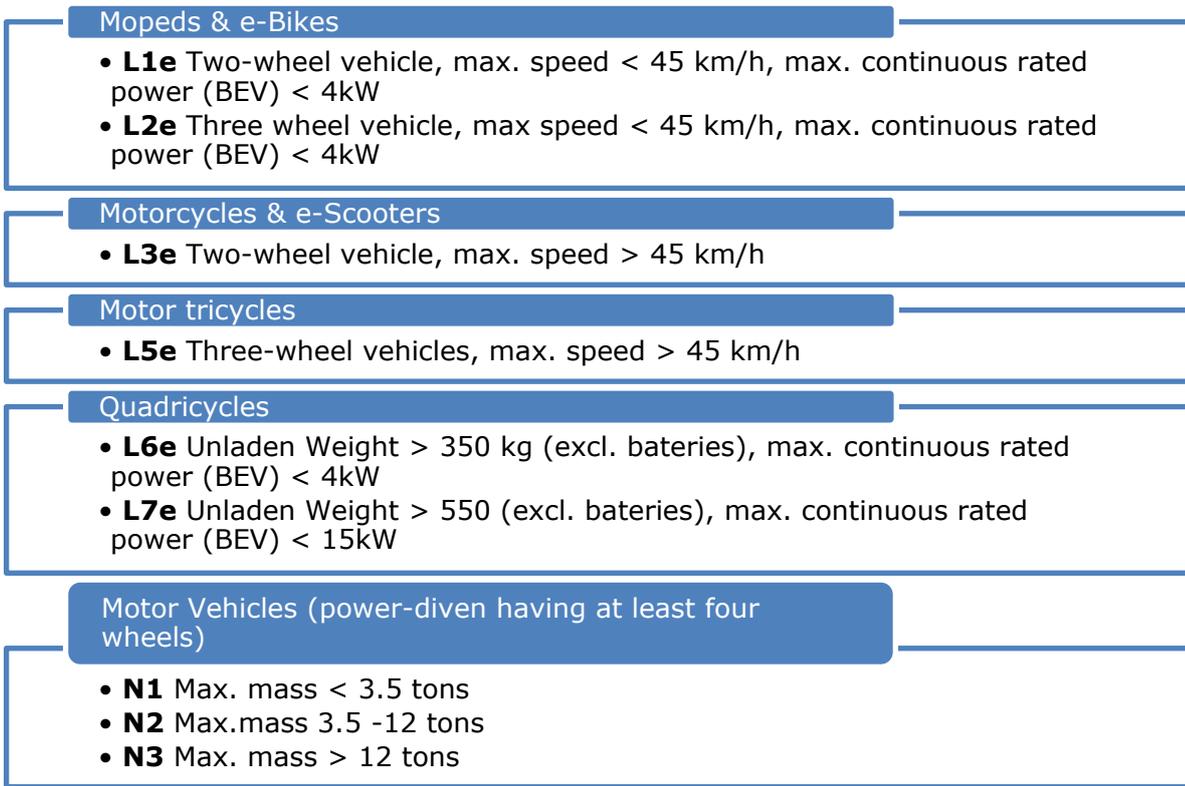
Also alternative technologies and fuels to be attractive for transport companies must be “fit for purpose”, they should first be affordable: to have a Total Cost of Ownership (TCO) equal or better than conventional vehicles and second to meet performance criteria consistent with the concerned missions, the most important being:

- Loading capacity (weight and volume capacity must be consistent with the concerned mission);
- Driving performance (range, torque, speed, acceleration, ...);
- Durability, reliability and safety;
- No additional restrictions (limited fuel distribution network, parking restrictions, long refuelling time, additional periodic technical inspections, extra maintenance operations, specific access limitations, ...) ^[27].

3.2 EFFV Road Vehicles

At present time, there are several technologies of road BEVs capable of replacing ICEVs. Figure 5 identifies the available road BEVs according to the EU vehicle classification.

Figure 5 Available road BEV following EU Vehicle Classification

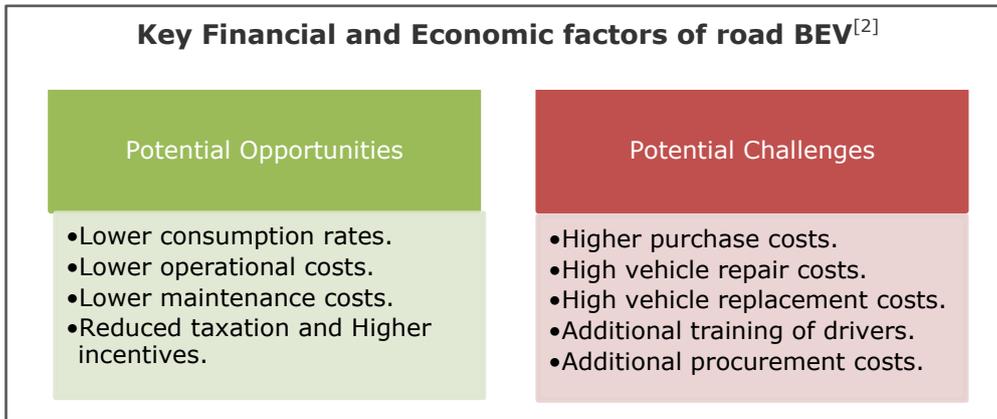


In the right context, road BEVs can offer multiple benefits, ranging from financial and economic, operational and environmental. Yet, this technology still faces a set of market barriers relating to aspects such as technology limitations, high investment costs or lacking or inadequate incentives.

Table 1 Typical technical properties and prices of selected road BEV

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	5 600 kg & 19.6 m ³	250 km	From € 100 000

Type of EVFs	Max. Typical Payload	Max. Typical Range	Average Cost Range
(Class N2)			



E-Bikes and E-Scooters (Class up to L3)

BEV technology is well advance in the segment of e-bikes and e-scooter. At present, e-scooters are competitive vis-à-vis traditional scooters (ICEV) both in terms of performance as in prices. E-bikes are an upgrade of the traditional bikes, augmenting their technical capabilities (e.g., capacity or range). More and more, bikes are by themselves natural EFFVs. Over the recent years, several EU co-funded projects have been launched to assess the potential of e-Bikes and e-Scooters and to promote their adaptation at EU level¹³. 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 projects compiled a list of running companies worldwide¹⁴.

Figure 6 e-bike used by DHL^[30]



Key properties of e-bikes include^{[28][29]}:

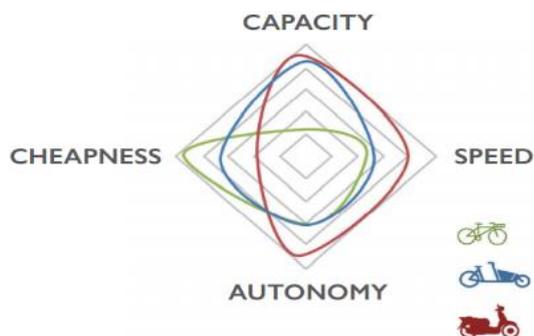
- A full recharging cycle takes between three and eight hours;

¹³ Either the Transport Research & Innovation Portal (<http://www.transport-research.info/>) or the European Cyclist Federation website (<https://ecf.com/>) provide comprehensive information about the past and on-going research project.

¹⁴ More information available at: <http://www.pro-e-bike.org>

- The range is variable, ranging between 30 to 90 km and can be extended by substituting the discharged battery with an extra-battery stored at the depot;
- Typical payload varies between 35 to 160 kg;
- The costs of acquisition, maintenance and insurance are also lower when compared with other vehicles, approximately between 1000 € and 4200 EUR.

Figure 7 Comparison on various mode of transport^[30]



The importance of the choice of the right type of transport is depicted in Figure 7, which sums up the main performance of e-bikes (green), cargo e-bikes (blue) and e-scooters (red). In general, e-scooters have the best performance in the field of capacity (150-180 l), speed (maximum speed is over 100 km/h and in urban context it can travel at 35-40 km/h, if congestion permits) and autonomy/range (160- 180 km). However, their cost is almost 2-3 times the cost of e-bikes and double the cost of e-cargo bikes^[30].

An e-bike offers similar performance in terms of capacity as an e-scooter (160 l) since it can travel at the same speed as an e-bike (25 km/h) with the same autonomy/range (around 70 km). E-bikes offer the best performance in terms of costs (cheapness) but offer considerably less capacity than e-cargo bikes or e-scooters.

The EU co-funded research project Pro-E-Bike has developed an interactive tool to calculate the economic and environmental gains accruing from replacing ICEV by e-bikes, cargo e-bikes or e-scooters¹⁵. Figure 9 exemplifies the yearly gains that a business company may expect by replacing one ICEV. The average costs for each delivery made by e-bike is lower than those made by van (around 25 % lower), considering 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^[30].

It is important to note that, in some countries, limitations to the utilisation of electric bicycles may occur owing to severe weather. Low temperatures have a negative impact on the battery performance as well as on the biker’s comfort. In countries where winter time is not severe, there is still a concern about comfort. Appropriate clothes should be used for specific weather conditions (such as warm and waterproofs clothes)^[30].

Figure 8 Tricycle^[74]

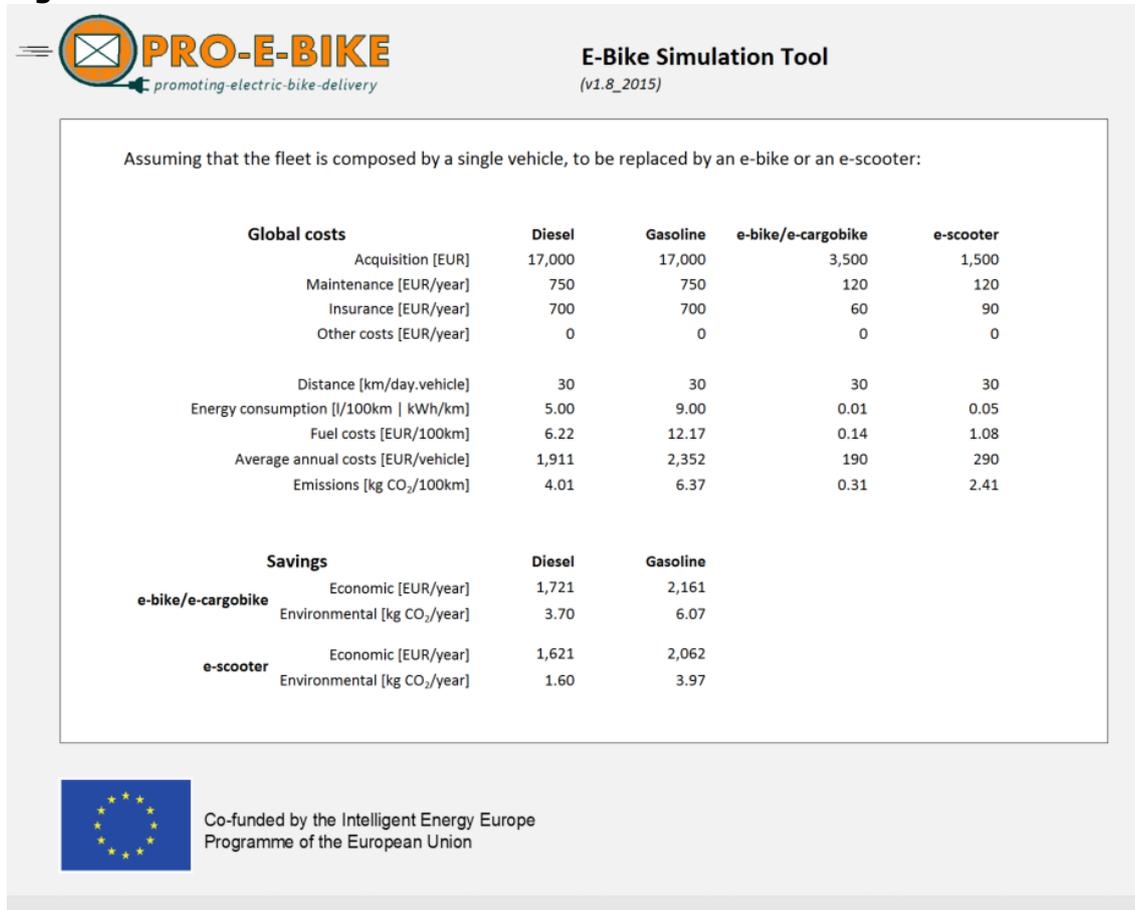


Cargo tricycle speeds are limited by human effort, or in the case of electric-assisted freight tricycles, by the relative power output of their batteries. They have an estimated typical operating speed of 12-15 km/h for electrically assisted freight tricycles. However, speed and reliability benefits depend on the flexibility of operations^{[31], [32]}. Parking flexibility is consistently recognized as a major benefit of cargo tricycles. Cargo cycles take up considerably less space than trucks or vans, and can often park in a space that would be inadequate for a larger vehicle. When curb widths and regulations allow, cargo tricycles can park on sidewalks directly in front of delivery locations or access pedestrian plazas that are not open to motor vehicle traffic^[32]. In cases of streets with reduced inclination, cargo tricycles can complete tours more quickly and travel longer distances while expending the same amount of energy. In areas with significant hills or over long distances

Further information is available at: <http://www.pro-e-bike.org/> The tool can be downloaded from <http://www.pro-e-bike.org/publications2/>

cargo tricycle on human power alone is not adequate. This challenge can be somewhat mitigated through the implementation of electric-assist on the cycle. However, electric tricycles still have limited autonomy.

Figure 9 Screenshot of Pro-E-Bike simulation tool



Vehicles used in Paris and London have an estimated four hours of autonomy, covering approximately 30 km before the battery needs to be recharged. The battery can be changed, so that the vehicle does not stop^{[32], [33]}. Cargo tricycles can transport a payload between approximately 80 to 100 kg, although when using an electric tricycle body, load capacity can go up to 180 kg^{[34], [35]}. A recent study in the city of Madrid^[36] concluded that in a total of 120 daily operations, with 16.8 km tricycle made by day, the utilisation of tricycles would enable savings of 5.3 % of journeys in van. In practice this reduction of 5.3 % is equivalent to less than 225 km travel by van and truck and consequently the corresponding savings in emissions and noise pollution.

Cargo tricycles are less expensive than motor vehicles to purchase, maintain, and operate^[33]. The cost of acquisition, maintained and insurance, can vary from approximately 1,700 € up to 3,600 €, depending on the type of tricycle (human powered or with electric motor) and on the country regulation where it is going to operate^[29]. Besides cargo tricycles, there are other solutions like 3 wheel electric scooters that, although having a higher cost of acquisition, maintenance and insurance (approximately 9,000 €), have a higher payload volume of around 400 Kg or 700 l. This type of tricycles also have a greater range of between 180 km and 240 km, with a 4 to 6 h charge^{[34], [35]}.

Summing up, the key advantages of bikes, e-bikes and e-scooters are:

- **Financial and Economic Opportunities:**

- Bikes are inexpensive and with long lifecycle costs.
- E-bike and E-scooter are more expensive than bikes but far cheaper than ICEV (e.g., vans).
- Maintenance and repair costs of these vehicles are relatively reduced.
- Member states commonly have subsidies or tax reduction schemes to promote acquisition.
- Operational costs of e-bikes and e-scooters are lower than ICEV. Calculations made in Pro-E-Bike project point out for cost reductions around 25%, considering fuel/electricity costs, maintenance costs, insurance and salary for drivers ^[30].

- **Operational Opportunities:**

- Cargo capacity of E-bikes and E-scooter is substantial and fulfils the freight transport demand of many urban freight segments (e.g., parcel deliveries, home deliveries, groceries, etc.).
- Cargo capacity of bikes is limited, but even so suitable for parcel and home deliveries of small volumes
- Bike and e-bike, and in some countries e-scooter, may avoid traffic congestion by using bike lanes and other dedicated canals.
- Autonomy range of e-bike or e-scooter is of several tens of kilometres, which is suitable for urban deliveries.
- Maintenance of these vehicles is simple and straightforward.

- **Environmental Opportunities:**

- These vehicles have no tail pipe emissions. Additionally, bikes do not require electric energy.
- The light weight and reduced size of these vehicles results in lower damage on the transport infrastructure (e.g., road or sidewalks) and on the built environment.
- These vehicles are almost noiseless.
- These vehicles tend to have a low visual intrusion (reduced size and positive visual identify).

Motor Vehicles (Class N - vans and trucks)

Urban logistics stakeholders, notably freight transport and logistics operators, acknowledge the potential of EFVs. Although, at present time these vehicles are still not competitive compared against ICEVs, it is expected that they become in the coming five to ten years. At present times, the main factors of concern include: i) unknown impact on business operations and new business needs, ii) high capital expenditure, iii) infrastructure availability and iv) small sized market of EFVs ^[2].

Overcoming these barriers will create a favourable momentum towards BEVs, particularly in smaller vehicles (class N1 and inferior), which is the primary type of vehicles used in urban logistics. However, in what concerns larger vehicles (classes N2 and N3), the advantage of ICEVs is expected to remain a little longer^[2].

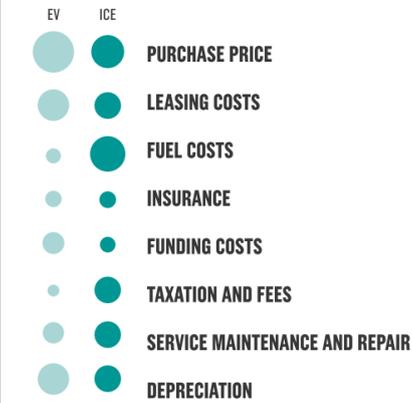
Financial and Economic Opportunities and Challenges of Road BEVs

Available studies on the economics of road EFVs tend to converge, when analysing the life cycle costs or the total costs of ownership (Figure 10). The running and operational costs are lower than ICEV.

Conversely, the acquisition costs are substantially higher, mainly due to the batteries price. Overall, road EFV remains not competitive.

Since private stakeholders commonly are focussed on the short term, the wide market uptake of road EFV is difficult^[37]. Yet, the gap is closing fast and in the coming year is expected to change.

Figure 10 Comparing typical life cycle cost elements of BEVs and ICEVs ^[41]



The EU co-funded research project FREVUE^[37] identified the main sources of advantage, being:

- *Fuel Costs* are the main advantage of an EFVs vis-à-vis an ICEVs. Depending on the country's actual costs of fuel and electricity, the costs of powering a road BEV can be as low as 80% compared with diesel ICEV.
- *Taxation and Fees* – a diversity of public subsidies and incentives have been implemented to counterbalance the excessive initial purchase costs for EFVs.
- *Service, maintenance and repair* – the difference in the maintenance costs solely concern powertrain components, as all other costs are similar comparable for EFVs and ICEVs. An EFVs has generally fewer moving parts, which can result in lower maintenance costs and downtime. Cost advantage can range between 20 to 30%.

In what concerns the source of disadvantage, the same study concluded that:

- *Acquisition costs* of a road EFV is substantially higher than a road ICEV. The available subsidies or tax reduction reduce the gap and, in some countries, already close it (e.g., London, UK)^[38]. By way of example, in Slovakia, there a subsidy of 5000€ for acquisition of road EFV. The electric recharging company GreenWay is planning start offering road EFVs leasing services^[39].
- *Extra equipment* –in some countries, extreme weather conditions may require the acquisition of extra cooling/heating equipment, which further adds the costs.
- *Higher repairing costs* - reparation costs of a broken road EFVs are higher than of an ICEVs, due to the scarcity of specialised repair stations^[2].

A recent study^[40] assessed the TCO of two vehicles from different manufacturers, being:

- Mercedes Bens – Sprinter (ICEV and BEV)
- Toyota - Dyna (ICEV and BEV)

The key technical characteristics are listed in the following table (Table 2).

Table 2 Detail on the compared vehicle characteristics^[40]

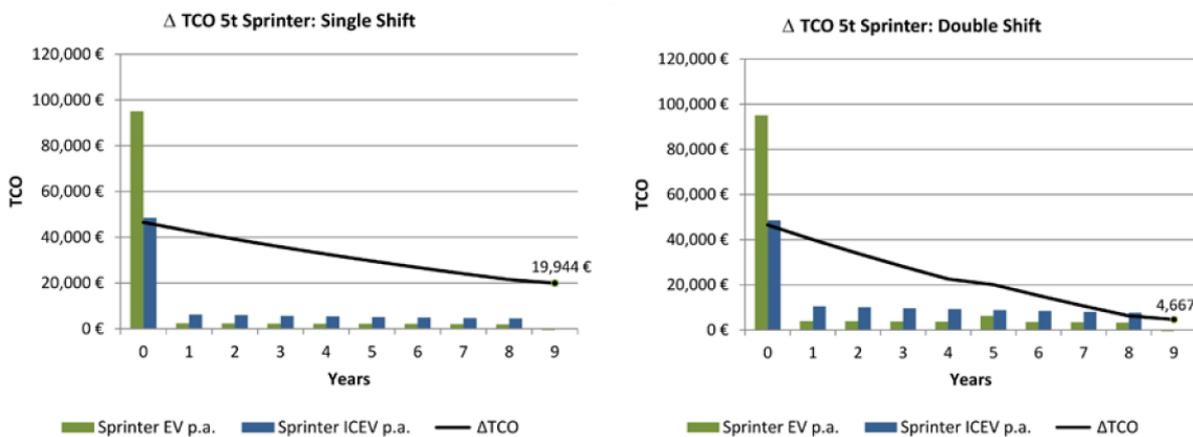
Vehicle parameters	Sprinter ICEV	Sprinter EV	Dyna ICEV	Dyna EV
<i>Fuel consumption [l/km] for diesel models / Energy consumption [kWh/km] for EVs</i>				
Vehicle model	Sprinter 513	Plantos	Dyna 200	Dyna EV 200
Manufacturer	Mercedes 5.0	German E-Cars 5.0	Toyota 7.49	Emoss 7.49
Gross vehicle weight [t]				
Purchase price ^a [€]	48,518	95,000	31,765	110,000
<i>Fuel consumption [l/km] for diesel models / Energy consumption [kWh/km] for EVs</i>				
NEDC	0,0853 ^b	0,32	0,099 ^b	0,75
Assumed realistic	0,153	0,464	0,173	1,088
<i>Battery parameters</i>				
Battery energy [kWh]	n.a.	38,6	n.a.	120
Battery type	n.a.	Lithium ion	n.a.	Lithium iron phosph.
Range [km]	n.a.	120	n.a.	160
Battery warranty	n.a.	2,000 cycles	n.a.	100,000 km or 3 years
Duration full charge [h]	n.a.	14 (230V/16A)	n.a.	n.a.
	n.a.	2.5 (400V/32A)	n.a.	8 (380V/32A)

^aExcluding VAT

^bFuel consumptions for the standard platform model (Toyota Dyna), standard model (Mercedes Sprinter)

The analysis considered two cost elements: cost of acquisition and costs for operation and maintenance. The TCO considered a period of depreciation of eight years, beginning in 2016. The study was done in the German market and it makes a series of assumptions concerning the energy costs, working days, annual mileage and batteries cycles (including one shift per day and two shifts per day). The following graphs present the results of the calculations (Figure 11 and Figure 12).

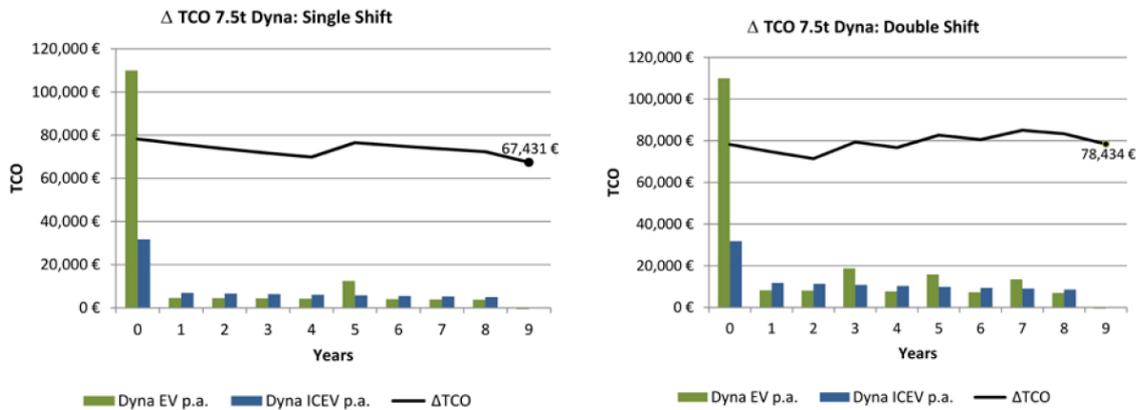
Figure 11 TCO differences of the Mercedes Sprinter^[40]



Results are very much in line with previous studies: the TCO of the ICEV is lower than the EFV. The penalising element is the cost of acquisition. Also, results differ between vehicles. In the case of the Mercedes Sprinter, the EFV has lower operational and maintenance costs, which are higher in the case of double shift. Yet the yearly gains do not compensate the initial difference in the acquisition costs. The break-even would be reached in the year 10 of operation. In what concerns the Toyota Dyna vehicle, the operational and maintenance costs are very similar to the ICEV and, in some cases, even higher (owing to the need to replace batteries). This is particularly visible in the case of the double shift.

We may expect that technological evolutions at the level of batteries would change these figures in the coming years.

Figure 12 TCO differences of the Toyota Dyna^[40]



Key Financial and Economic factors of road BEVs ^[2]

Potential Challenges	Potential Opportunities
<ul style="list-style-type: none"> • Higher purchase costs. • High vehicle repair costs. • High vehicle replacement costs. • Additional training of drivers. • Additional procurement costs. 	<ul style="list-style-type: none"> • Lower consumption rates. • Lower operational costs. • Lower maintenance costs. • Reduced taxation and Higher incentives.

Operational Opportunities and Challenges of Road BEVs

There is a growing consensus about the suitability of road BEVs for many daily freight duty cycles in urban and suburban areas, considering travel distances or payload^{[2], [4]}. Looking into

Table 3 that lists the adequate and acceptable conditions for the utilisation of road BEVs, the overall conclusion is that they are able to fit into typical daily urban logistics operations.

Whilst road BEVs can easily replace ICEVs, when payload and cost are concerned, this will likely result in a logistics performance reduction, because of the operational performance of conventional and electric vehicles still differ. Currently a reorganisation and adaption of logistic processes to the BEVs’s operational properties is normally still deemed necessary. The scope of change depends on the routes driven. In general, parcel and postal deliveries routes commonly fit BEVs use, since they begin and end in depot (in which charging points can be installed), run short distances and have a high density of drop-off and pick-up points^[2].

Table 3 Compatibility conditions for the utilisation of road BEV^{[40], [41]}

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.

(*) There is discrepancy between the value announced by the manufacturer and the actual range. The realistic value is lower than the announced value (difference may reach 45%)^{[42], [43]}. Moreover, the range decreases overtime with the successive charging cycles. By way of example, the Toyota Dyna BEV is announced with a range of 160km, a realistic range would be 110km with a fresh battery and around 88 km at the end of its life. The Mercedes Sprinter is announced with 100 km range, a realistic value would be around 83 km with a fresh battery and around 67 km at the end of its life^[40].

Summing up, road BEVs also offer their users quite a few **operational advantages**:

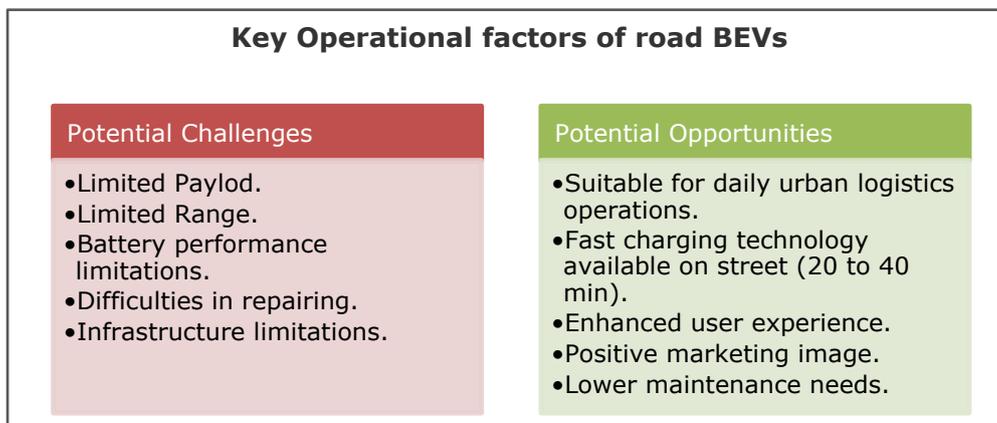
- *Reduced maintenance needs, though higher difficulties to repair* – as explained above, BEVs have fewer moving parts, do not use lubricants and have a simpler architecture which therefore reduces the need for and cost of maintenance compared to an ICEVs. Yet, the repair services are sometimes costlier and more difficult to be organised. The point is that in case of ICEVs there is already a well-established and competitive network of dealers for supplying spare parts and components. This is not the case with BEVs, as there is a lack of efficient and competitive repair shops and spare parts are scarcely available.
- *Enhanced User Experience* – Drivers and users consistently report a positive experience in driving road BEVs in the context of urban logistics ^{[2], [4], [41]}. The silent and powerful drive train is perfectly fit for urban areas. Positive aspects include the automatic gear-box, adequate driving performance, superior interiors and on-board technology (e.g., dashboard with vehicles’ performance metrics) or reduced noise. As negative aspects, users reported anxiety related with vehicles’ actual range, high truck bed (due to battery space) and limitations to the utilisation of the air conditioning. Anxiety on the actual

range has been successfully overcome with the establishment of daily routines, because it allowed drivers to learn about the vehicles' behaviour [2].

- *Positive marketing and branding* – Producers, shippers, and receivers also appreciate receiving goods in BEVs. A BEVs conveys a strong image of concern for environmental protection and sustainable economic development. The willingness of freight receivers to pay a surplus for “green deliveries” remains however very limited [2].
- *Payload* – payload of EFV is commonly suitable for many urban logistics service. The weight and volume of the batteries limit the available transport capacity, both in weight and volume. Payload reduction, compared with ICEVs, can reach 200 kg in the case of an BEVs and up to 700 kg in the case of retrofitted vehicles[4].
- *Range* – existing technology offers driving range up around 150 to 200 km in motor vehicles (Class N). This range is enough in many urban logistics cases, except in some specific weather conditions (see above). Yet, warehouses are often located in suburbs, several tens of kilometres from the city centre. If vehicle has to return base to recharge, the remaining power may limit distribution range.

However, even with the technological development of recent years, the performance of an BEVs is still limited and remains behind of ICEVs. The table above presented typical technical and operational figures of some analysed road BEVs. The current main operational limitations include:

- *Charging technologies* - there are four main charging types: in-house charging, public charging stations, inductive charging and battery changing. In-house charging time can take up to 8 hours. Yet, technological advancement led to the development of high capacity charging stations which can charge in as little as 20 to 45 min [4].
- *Need of 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 1000 to 2000 cycles, corresponding approximately 6 years of operation[4], [40]. Battery performance is influence by several factors, such as weather conditions (extreme temperatures reduce battery efficiency), use of air conditioning systems, driving style or topography.
- *Insufficiencies in the infrastructure* - a difficult may lie with the inadequacy of the power grid to effectively simultaneously charge batteries of a fleet in short periods of time. In these cases, investments in the charging infrastructure are required. In addition, there is the need to implement recharging stations in parking bays for freight vehicles.



Environmental Opportunities and Challenges of Road BEVs

A main advantage of road BEVs compared to current ICEVs, are found in their **environmental benefits**. Indeed, BEVs are regarded as a key element to promote the sustainable economic development of EU cities and regions. When charged with renewable energy they contribute to the reduction of road vehicle's environmental impact. Their local air pollution is in any case limited. The 2011 White Paper on Transport called for the decarbonisation of cities in the coming decades and suggests the evolution towards electric mobility ^[3], BEVs are a supporting tool to reach this goal.

As BEVs have no local (tailpipe) emissions of air pollutants, they considerably contribute to the reduction of urban air pollution. However, this does not mean they do not pollute at all. The assemblage process of an BEVs, like the one of an ICEVs, is prone to pollution related with the production and transportation of the components, the assemblage process and distribution of vehicles until final user. In addition, batteries contain pollutants and other harmful elements, which require proper handling and recycling at the end of life cycle.

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.

Feedstocks are raw material used in the production of an energy carrier. Examples: oil, natural gas, coal, nuclear or renewables (wind or solar).

Finally, air emissions may result from the production and distribution of electricity. It will depend on the actual feedstock and distribution scheme. The air emissions generated elsewhere in the production of electricity that is being consumed should be accounted as pollution of the BEVs. The concept of Well-To-Wheel¹⁶ (WTW) is used to compare the total air emissions of different energy carriers (example in Figure 13).

The electricity sector is not fully decarbonized. Gas and coal play important roles in the mix. Some Member States such as Poland and Estonia are still very dependent on CO₂ intensive energy sources. Energy storage and grid balancing might be the biggest issues at a time of increasing electricity demand ^[27].

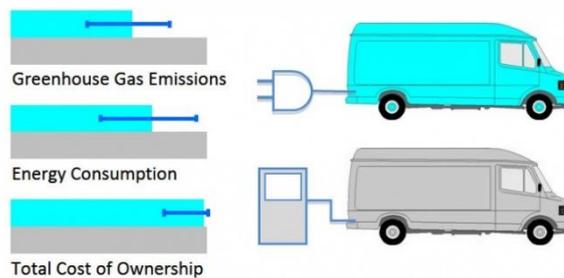
Another environmental benefit is related to noise emissions. Noise emissions of BEVs are lower than ICEVs ^[44], because conventional combustion engines are noisier than electric engines. Moreover, changing gears produces noise spikes due to engine accelerations. Conversely, electric engines produce low levels of constant noise, because they have no gear system. This makes road BEVs suitable for night deliveries, in Low Emission Zones (LEZ) or Zero Emission Zone (ZEZ), or in any location/occasion where noise is a relevant factor. Finally, BEVs have less maintenance needs than ICEVs, which reduces waste production (e.g., defected spare parts) and other types of pollution (e.g., used oils and lubricants).

¹⁶ The WTW concept entails the calculation of every emission linked with the extraction, production, refinement, distribution, storage and final consumption of the energy carrier.

Figure 13 Relative benefits of BEVs (WTW emissions) ^[41]



Figure 14 Electric and diesel urban delivery trucks comparison in terms of lifecycle greenhouse gas emissions, energy consumption and cost ^[45].



Key Environmental factors of road BEVs	
Potential Challenges	Potential Opportunities
<ul style="list-style-type: none"> • Disposal of batteries. • Variable well-to-wheel emissions. 	<ul style="list-style-type: none"> • No local air emissions (tailpipe). • Reduced noise emissions. • Reduced maintenance needs.

Other Road EFFVs (Non-BEVs)

Road vehicles are arguably the most popular vehicles in urban logistics. The ubiquity of road network coupled with a high fragmentation of delivery points, scattered across the urban areas, favoured the utilisation of this type of vehicles ^[46]. A wide diversity, in terms of size, capacity or functions, has been developed.

In addition to BEVs, the EC ^[20] is presently supporting two other energy carriers and propulsion technologies, presently being developed within the time horizon of 2020:

- Hydrogen and Fuel Cells:
 - 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, which discourages vehicle manufacturers from investing in these types of vehicles^[47]. In addition, there is still no proper network of refuelling stations^[48].

At present, the market of hydrogen vehicles is rather limited. Even so, available trials in road vehicles of Class N1 reveal potential on 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 consumptions and maintenance costs are expected to be lower than ICEV counterparts^[49]. There are also attempts to develop smaller road vehicles, Class L, notably try-cycles^[50].

- Biofuels¹⁷ (liquid or gaseous):
 - 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 renewable 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 be also 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.

- Natural Gas (Compressed Natural Gas or Liquid 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. 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 significantly reduce the greenhouse gas' emissions from natural gas vehicles.

Financial and Economic Opportunities and Challenges of Other Road EFFVs

The diffusion on the market of these technologies is at a niche level. However, there is a positive growth for natural gas vehicles areas where the NG distribution network is already developed^[27].

Looking into the financial and economic cost elements, challenges and opportunities of other road EFFVs are:

- Natural Gas - Some different engine technologies (stoichiometric, HPDI, Dual-fuel) capable to minimize both pollutants and CO2 emissions have already been developed and are available on the market at affordable cost^[27];

¹⁷ Biofuel is a fuel that is produced through biological processes.

- Hydrogen - Current electrolysis technologies are costly and inefficient, which discourages vehicle manufacturers from investing in these type of vehicles. In addition, fuel consumptions and maintenance costs are expected to be lower than ICEVs [49];
- Biofuels – Considerable time/investment needed to develop the large scale production [27].

Figure 15 Average Fuel Price Trends (adapted from [51])

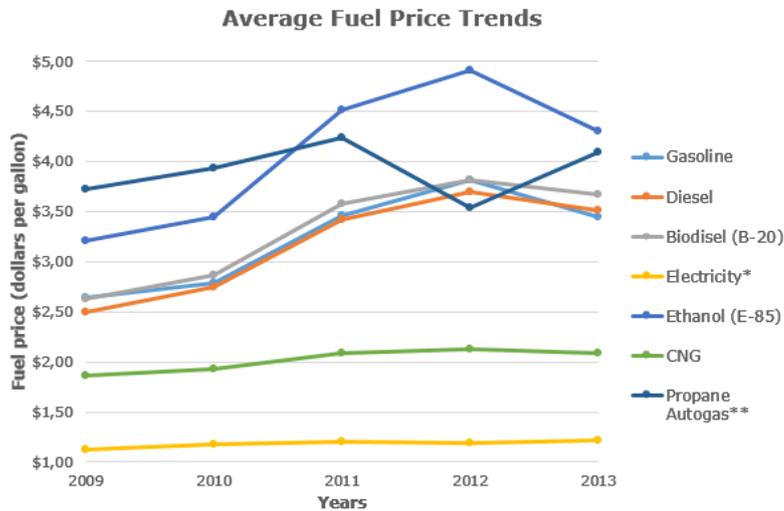


Table 4 Typical technical properties and prices of selected Other Road EFFVs.

Type of EFFVs	Type of Energy	Typical Payload	Typical Range	Average Cost Range (€)
Tricycles	Hydrogen	150 kg	250 km	2,900
N1 Motor Vehicles	Hydrogen	500 kg	120 km	-
N2 Motor Vehicles	Hydrogen	29,500 kg	2,000 km	336,000
Motor Vehicles	Natural Gas + Biofuel	-	-	-

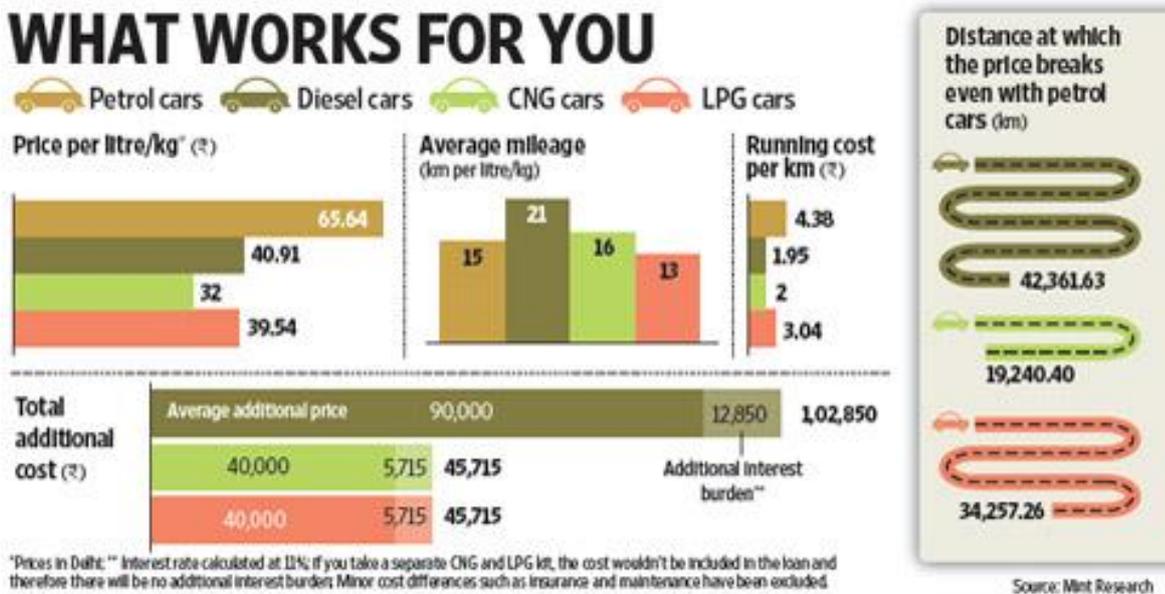
Key Financial and Economic factors of Other Road EFFVs

<p style="text-align: center; background-color: #c00000; color: white; padding: 2px;">Potential Challenges</p> <ul style="list-style-type: none"> • Costly and Inefficient hydrogen technologies; • Time/investment to large scale production of biofuel; • Lack of fuel taxation harmonization and stability; • Excessive fragmentation of cities local markets; • Access to finance. 	<p style="text-align: center; background-color: #80c080; color: white; padding: 2px;">Potential Opportunities</p> <ul style="list-style-type: none"> • Affordable market cost of CNG vehicle; • Hydrogen lower maintenance costs.
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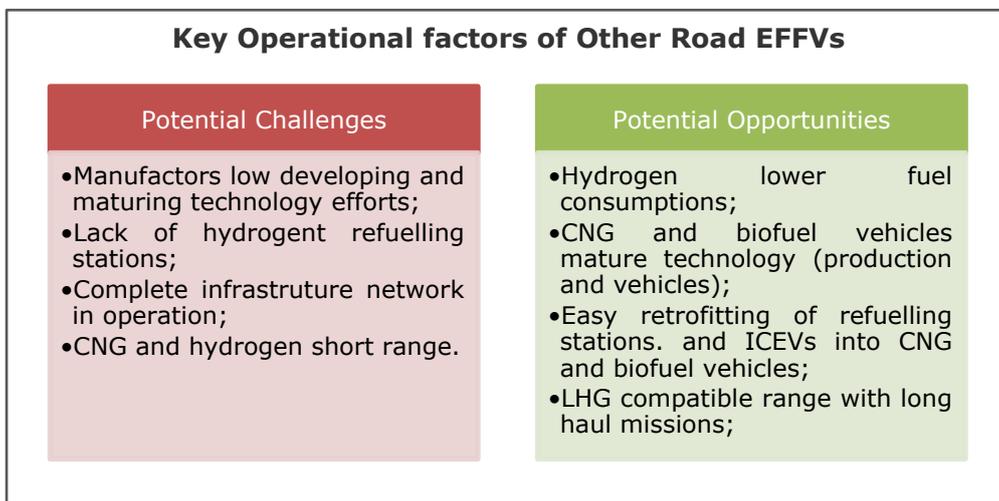
Operational Opportunities and Challenges of Other Road EFFVs

At present time, hydrogen technology in vehicles is in early stages of development. There are no plans for mass production and the available vehicles are in prototype stage. Even so, available trials in road vehicles of Class N1 reveal potential on this technology: an expected range of 120 km with two 20 litre hydrogen tank. These vehicles transport up to 500 kg of payload and reach a maximum speed of 50 km/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 tonnes and a range of around 2000 km.

Figure 16 CNG vehicle features versus ICEVs [52]



Some trial tests are running in a number of cities as local bus fleets and as fleets of warehouse handling equipment, such as fork-lift trucks [27]. There are also attempts to develop smaller road vehicles, Class L, notably tricycles [34]. Another limitation is the lack of a proper hydrogen refuelling stations network. Biofuels are another alternative energy carrier. The technology is mature and ready for deployment. However, biofuels limitation concerns the lack of refuelling stations network. The challenge for the growing penetration of biodiesel is the large scale availability of second generation biodiesel. The LNG ensures a vehicle range compatible with long haul missions. It enables NG for this key mission. The key challenge for NG is the limited distribution network (especially for LNG) [27].



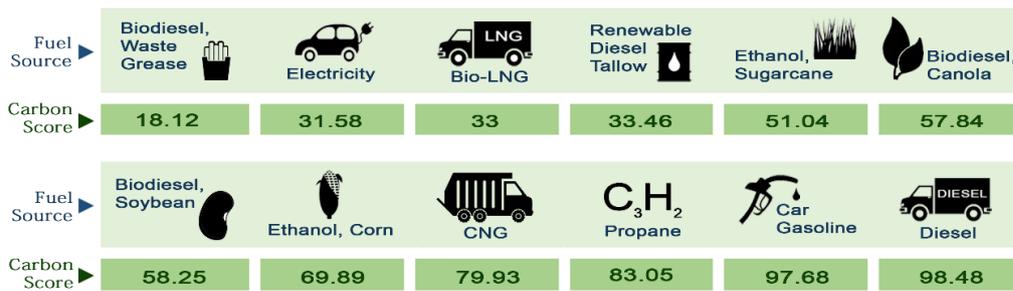
Environmental Opportunities and Challenges of Other Road EFFVs

Whilst the potential of hydrogen technology in transport applications has been recognised, it is unlikely that it could surpass electric technology in the coming years. The main advantage of hydrogen vehicles is that air emissions are water vapour and hydrogen. Thus, the vehicles are non-pollutant.

The main disadvantage lies with the production of the energy carrier – the hydrogen. Currently, most hydrogen is produced from fossil fuels, which greatly prejudices the WTW air emissions. It is possible to produce hydrogen in a clean way through a process called electrolysis, using renewable sources, such as solar power.

Despite the fact that hydrogen is largely present in nature it is not available as a pure element so it must be produced using other sources of energy. Hydrogen is an energy carrier. Life cycle GHG emission of the whole value chain (feedstock and energy) depend from the balance between the CO₂ reduction from the usage of hydrogen in fuel cell powered vehicles and the possible CO₂ emissions generated to produce hydrogen depending on how the hydrogen is created.

Figure 17 Carbon score by fuel source ^[53]



The possibility the use the fully renewable bio-methane (generated from non-food feedstock) already in the current CNG and LNG vehicles will amplify the benefit in terms of WTW greenhouse gas emissions to the same level of the battery electric vehicles when the electricity is produced from renewable sources ^[27].

The benefits in terms of greenhouse gas emissions depend on the market penetration and can be significant only in a medium term (around 2030). According to a recent study by Transport & Mobility Leuven (TML), the additional greenhouse gas (GHG) reduction potential of biofuels by 2020 (compared to 2014) is estimated to be 0.5% to 1.4%, according to discrepancies in projections and assessment of the fuel industry. In the long term, biofuels have the potential to realise a much higher reduction, depending on how fast technology will advance and to which extent different feedstock, transformation processes and distribution will reduce (well-to wheel) CO₂ emissions.

Even for natural gas (NG), the time horizon of 2020 is too short to achieve a significant CO₂ reduction, particularly given the need for an extensive network of refuelling infrastructure and the low market shares of natural gas vehicles for the time being. Shifting to NG decreases dependency on crude oil, but still requires the extension of a refuelling network throughout Europe. When it comes to local transport, a single refuelling point can supply an entire fleet ^[27].

Carbon score, or carbon intensity, is lifecycle emissions (sometimes called “well-to-wheels”) and refers to how much total pollution is generated in the production, transport, storage and use of a fuel in a vehicle ^[53].

Key Environmental factors of Other Road EFFVs	
Potential Challenges	Potential Opportunities
<ul style="list-style-type: none"> •Environmental and social concerns (production); •WTW emissions comparable to diesel for some biofuels; 	<ul style="list-style-type: none"> •No direct air pollutant emission from hydrogen vehicles; •Lower direct air pollutant emission from some biofuels; •Reduce crude oil dependency; •Renewable sources (feedstock and solar energy).

3.3 EFFV in Rail Transport

Railways vehicles, such as trains or trams, are plausible EFFVs. The utilisation of railways vehicles will contribute to i) a better through-flow of traffic in the inner city due to fewer trucks on the streets; ii) an improved security for the city because of better through-flow from the periphery; iii) a reduction in the number of traffic accidents caused by trucks; or iv) lower costs of road maintenance because fewer heavy trucks are using the roads.

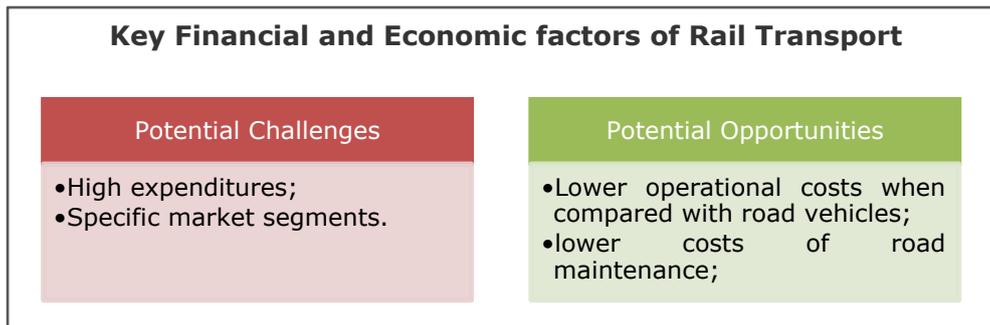
Table 5 Typical technical properties and prices of Rail Transport

Type of EFFVs	Type of Energy	Typical Payload	Typical Range	Average Cost Range (€)
Cargo trams	-	214 m ³	-	-

Financial and Economic Opportunities and Challenges of Rail Transport

Rail transport has very high expenditures^[57]: 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 railways operations adds extra costs. Only specific market segments are suitable for delivery by freight rail, such as the HORECA¹⁸ business, or large retail stores.

¹⁸ HORECA stands for Hotels, Restaurants, and Coffee Shops and similar.



Operational Opportunities and Challenges of Rail Transport

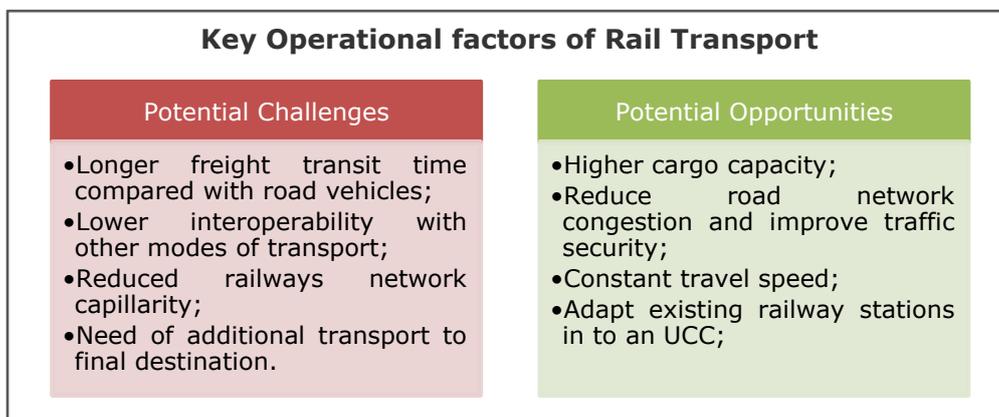
Rail transport brings other advantages. One railway vehicle carries as much as several trucks. By reducing the number of trucks circulating in a city, rail transport may alleviate road network congestion, improve traffic conditions and security, and mitigate air emissions. Moreover, railway vehicles circulate on dedicated 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 BEVs for the final delivery.

From the operations point of view, the utilisation of railways vehicles offers some challenges. Although the railways network, either train or metropolitan, is relatively dense in many EU cities, their capillarity is nonetheless far more reduced than road network. Typical distance between tram stations range from 500m up to 1200m, whereas between metro stations range from 1000m up to 2000m.

Figure 18 Comparing rail cargo capacity with truck and waterway [59]



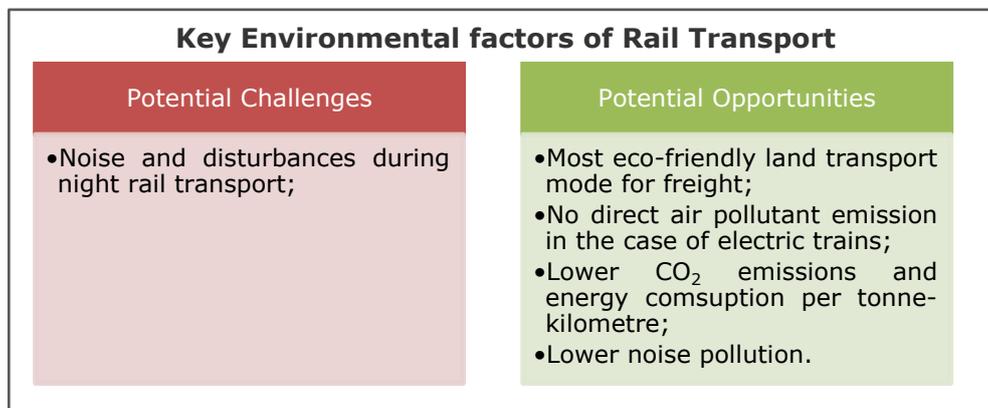
Organisation of rail services is more complex than road services. Rail vehicles can only circulate on specific routes in given time slots and deliveries are determined by the location of railway stations. Additional road transport is required when final destination is away from railway station.



Environmental Opportunities and Challenges of 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 BEVs is comparable to road BEVs, because the energy carrier is the same. These vehicles have no tailpipe emissions, as they are electric vehicles. Environmental advantages include a reduction of the particulate matter, carbon dioxide (CO₂) and nitrogen oxides (NO_x). In addition, these vehicles produce lower noise pollution as ICEVs.

Even so, the opportunities for the utilisation of railway vehicles in the context of urban logistics have been narrow^[60]. Furthermore, urban and suburban rail networks are busy with passenger trains in day time, which mainly leaves the night time for freight rail services. Night rail transport, particularly in residential areas, implies additional attention to keep down noise and other disturbances.



3.4 EFFV in Inland Waterway Transport

Many European cities are served by inland waterways, either canals or rivers, that are suitable for urban logistics^[61]. The utilisation of inland waterways, such as canals or rivers, to distribute goods in urban context is not new, although it remains relatively unexplored. Inland waterways vehicles can be effective EFFVs.

The common vessels used in inland waterways are the barge. A barge is a flat-bottomed boat, built mainly for river and canal transport of heavy goods. Some barges are not self-propelled and need to be towed or pushed by towboats^[62]. The most common European barge measures 76.5 by 11.4 m and can carry up to about 2 450 tons. Self-propelled barges may be used as such when traveling downstream or upstream in placid waters; they are operated as an unpowered barge, with the assistance of a tugboat, when traveling upstream in faster waters. Barges are usually made for the particular canal in which they will operate. Several types of barges have been developed depending on the purpose and canal. If infrastructure for loading and unloading operations (e.g., docks) is not available, barges can be equipped with cranes.

Table 6 Typical technical properties and prices of selected IWT

Type of EFFVs	Type of Energy
Dry bulk cargo Barges	Hybrid
Hopper barges	
Split barges	
Liquid cargo barges	
Electric boats	Electricity

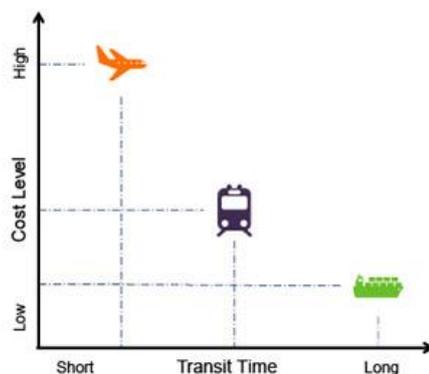
Key advantages of inland waterway transport include ^[63]:

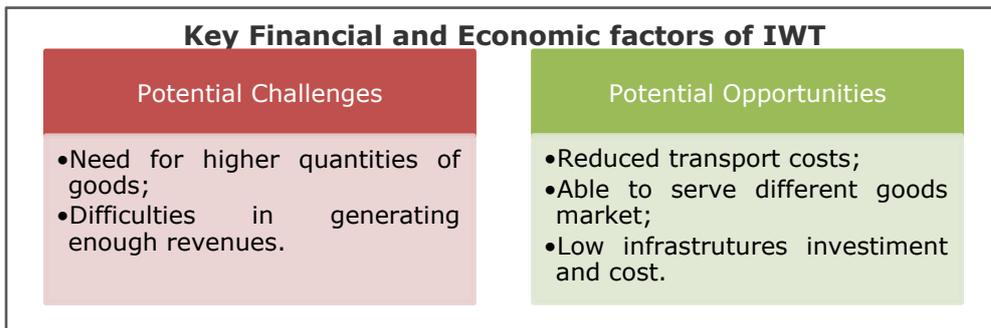
- safety levels - there is a very low record of accidents and accident tend to have reduced impact;
- time reliability – provided an adequate canal, transport services are unlikely to suffer significant perturbations;
- carrying capacity - inland waterways vessels may offer significant carrying capacity. A vessel with a load of 2 000 tons carries as much cargo as 50 railway cars at 40 tons each or 80 trucks at 25 tons each;
- reduced transport costs – depending on the carrying capacity, inland waterway transport may offer very competitive values of costs per ton;
- free capacity – in general, EU inland waterways still have available capacity. Notwithstanding, congestion already exists in specific parts of the network;
- abnormal loads – due to their size and loading capacity, inland vessels are especially suitable for transporting goods with unusual sizes and weights (e.g., turbines, silos, boilers or aircraft sections);
- tailor-made transportation – shipping companies offer a wide range of vessels types such as dry cargo vessels, liquid cargo vessels, container vessels and Roll on/Roll off-vessels which suit any transport need;
- infrastructure costs – inland waterway docks for urban logistics require low investments, since handling equipment is reduced (e.g., crane or gangway) and vessels may transport their own handling equipment (e.g., cranes).

Financial and Economic Opportunities and Challenges of Inland Waterways Transport

IWT presents several limitations. These are similar to those mentioned above 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 waterways networks. In some cities, it is a single river. Consequently, the suitable amount 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 amount of potential receivers, but also the cost.

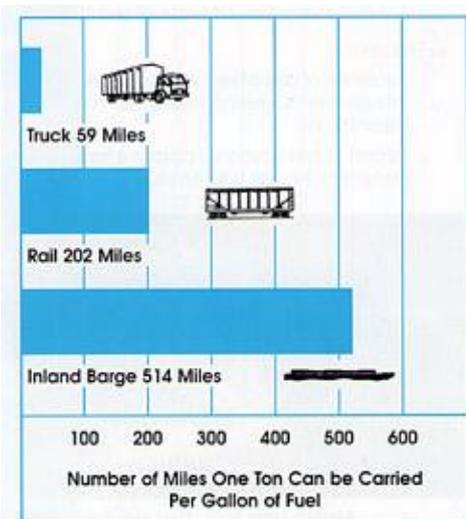
Figure 19 Cost level vs transit time for freight train, airplane and barge ^[64]





Operational Opportunities and Challenges of Inland Waterways Transport

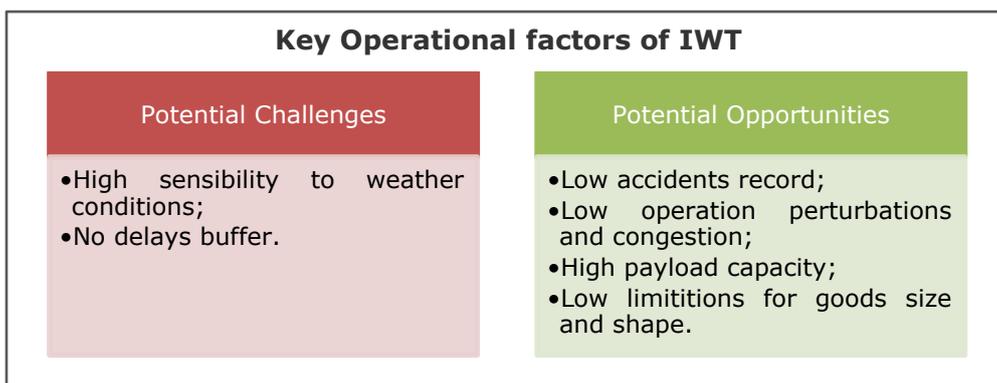
Figure 20 Comparing relative energy efficiency barge, freight train and truck ^[92]



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 eight and nine hour sailing time, with a recharging time of eight hours ^[35].

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 predicabile.

Waterways quays tend to be simple structures without advance 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 sensibility of IWT to weather conditions, particularly in case of rivers. Windy or rainy days, drought or flood seasons may affect the inland waterways navigability.



Environmental Opportunities and Challenges of Inland Waterways Transport

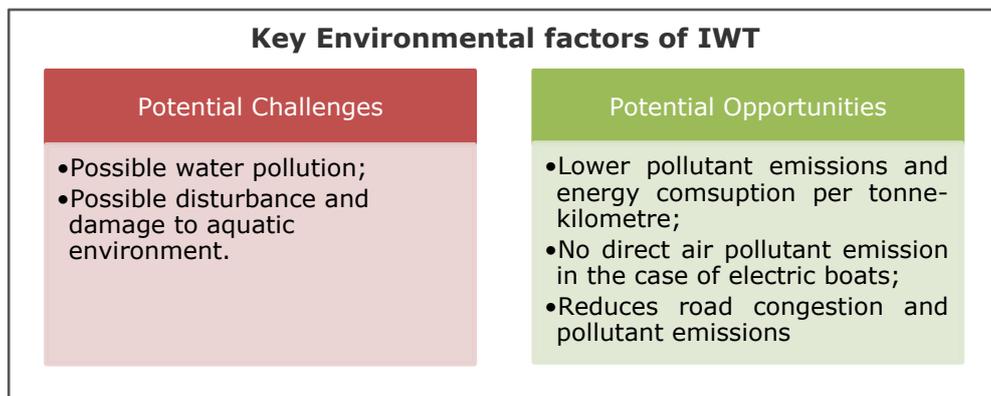
The energy consumption of IWT per kilometre-tonne of transported goods is approximately 17% of that of road transport and 50% of rail transport ^[65].

IWT has advantages similar to those previously mentioned for rail transport (Table 7).

However, IWT can have significant impacts on the ecological value and water quality of water bodies. Water pollution or damage caused by the inland vessels, dredging pose a threat to aquatic environment. Another significant threat to the environment is caused by operational discharges of mineral oil and lubricants, as well as organic substances (mainly PAHs) due to shipping operations. The nature and extent of the impacts depends on the vessel types and on the characteristics of the water body itself ^[66].

Table 7 Running cases of Urban Logistics and Inland Waterway Transport ^[67]

Initiative	City	Stakeholders	Estimated environmental benefits
Beer Boat: deliveries to local shops, hotels and restaurants	Utrecht, 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 NO _x (100%).
DHL floating distribution centre	Amsterdam, Netherlands	DHL (transport operator), City of Amsterdam.	Avoiding 10 truck/day (reduction of 150000 truck-kilometres and 12000 litres of diesel per year).
POINT-P: transportation of palletized 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 Public Policy to Promote the Utilisation of Environmentally Friendly Freight Vehicles

4.1 Introduction

The market take-up of EFFVs in urban logistics remains very slow^{[2], [4], [69]}, largely influenced by the challenges discussed in Chapter 3. As an example, only one out of 923 registered trucks between two and five tons was an BEVs by 1st January 2015 in Germany^[5]. The above mentioned barriers and challenges have likely played an important role for this situation. Even so, the expectable material contribution that a widespread utilisation of EFFVs could do to reduce the amount of air pollutants emissions justifies public intervention. However, the stakeholders typically involved in urban freight logistics operations are private operators (e.g., logistic or transport operator or retailers). In addition, EU has clear legislation limiting the scope of intervention of public authorities in open and competitive markets such as the urban freight logistics. Ultimately, the decision lies with the private stakeholder. An exception concerns the fleet under direct control of the public authorities, such as waste management vehicles, recycling and garden, etc. In this case, the EU Directive on the promotion of clean and energy-efficient road transport vehicles (Directive 2009/33/EC) defines rules for implementing EVFs.

Choosing an EFFVs is a complex decision because stakeholders must consider parameters (listed in Figure 21 below) that are irrelevant in case of an ICEVs. Ultimately, the stakeholder will look to the viability of its business models, that is: on the ability to keep the quality of service while generating profits. The primary business of freight transport and logistics operators is transport or logistics. Therefore, any increase of costs or negative impact on performance will directly influence their business and reduce their willingness to use EFFVs. In what concerns 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 21 Assessment parameters for selecting EFFVs^[6]



The definition of policy measures should take into consideration the special requirements and particularities stakeholders consider in the decision-making process.

In this Technical Report we suggest a number of road EFFVs¹⁹. By way of example, the measures that positively influence the assessment parameters are the following:

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

The policy measures have been clustered into four types according to their nature and application. **Error! Reference source not found.** presents for each categories the public policy measures, in a total of fourteen, analysed in this Technical Report, along with their key strengths and weaknesses (others exist). The selection of the public policy measures should be done according to two conditions^[70]: coherence and effectiveness. Coherence refers to alignment between the incentive and the ultimate purpose to be achieved; whereas the effectiveness of an incentive refers to how close the market's behaviour is to what was initially foreseen. It is important to note that since difference incentives target different technologies, the effectiveness will also be different.

The types of policy measures are^{[70], [71]}:

- *Communication and Awareness measures* can be defined as "attempts at influencing people [and organisations] through the transfer of knowledge, the communication of reasoned argument and persuasion"^[71]. This type of incentive aims to convince people or organisations to behave in a certain way by demonstrating the benefits or disadvantages of certain actions. This is widely used by interest and research groups for dissemination and training purposes. They aim at informing stakeholders about the potentialities and opportunities granted by EFFVs. They also aim at educating stakeholders on how to effectively and efficiently deploy these vehicles.
- *Legal and Regulatory Measures* can be defined as a "measure taken by governmental units to influence people [and organisations] by means of formulated rules and directives which mandate receivers to act in accordance with what is ordered in these rules and directives"^[71]. The regulation entails an authoritative relation between the ruler and the controlled people or organisations. Two types of regulation may be identified: technical regulation and economical regulation. Technical regulation defines the properties and characteristics of products and services. Economical regulation defines the conditions of access and operation within the market. Regulation tends to be quite an effective incentive because it is compulsory. In the EU, this type of incentives takes, amongst others, the form of Directive or Regulation.
- *Fiscal Measures* can be defined as measures that will change the impact taxes and fees have in business economy. This type of measures uses the market properties (namely: willingness to pay) to lead people and organisations to behave in a certain way. A typical example of fiscal measures is the subsidies.

¹⁹ Rail or IWT depend on very specific contextual conditions, which are essentially case specific. Air transport is awaiting proper regulations and legislation. Pipeline transport remains more of a concept than a reality. Because of this, these modes of transport are not considered in this Technical Report.

POLICY	MEASURE	STRENGTHS	WEAKNESSES
Communication and Awareness Measures	Information, Consultation, Involvement, Collaboration, Empowerment.	<ul style="list-style-type: none"> Promote acceptance of decisions, Promote behavioural change. 	<ul style="list-style-type: none"> Uncertain outcome, Difficult to mobilise stakeholders, Requires investment.
Legal and Regulatory Measures	Access regulation: <ul style="list-style-type: none"> Setting air pollutant emissions Setting dimensions and load capacity Setting time based Conditions Setting pedestrian zones access 	<ul style="list-style-type: none"> Improve air quality, Enhance liveability, Social acceptability Increase efficiency, Reduce infrastructure damage, Promote off-hour deliveries. 	<ul style="list-style-type: none"> Require capital investment (fleet renovation), Opposition from private stakeholders. Difficult to implement (load capacity), Unintended consequences (e.g., increase of number of deliveries). Opposition from private stakeholders
	Access to privileged parking bays and lots	<ul style="list-style-type: none"> Improve efficiency, Increase accessibility 	<ul style="list-style-type: none"> Reduces spaces for other users, which may lead to some opposition.
	Setting dedicated corridors <ul style="list-style-type: none"> Bus lanes Cycle lanes 	<ul style="list-style-type: none"> Increase efficiency. Gives advantage to EFFVs. 	<ul style="list-style-type: none"> Opposition from public transport companies. Opposition from bike users.
	Certification	<ul style="list-style-type: none"> Increase transparency and visibility, Raise awareness. 	<ul style="list-style-type: none"> Need to define clear rules, which may be difficult to monitor.
	Noise Emissions	<ul style="list-style-type: none"> Improve quality of life, Promote off-hour deliveries 	<ul style="list-style-type: none"> Require capital investment (fleet renovation), Opposition from private stakeholders.
Fiscal Measures	Exempt EFFVs from city tolls	<ul style="list-style-type: none"> Stronger incentive, Increase efficiency. 	<ul style="list-style-type: none"> Opposition from private stakeholders, Difficult to implement, Reduces public income (revenues).
	Subsidies, Tax Incentives or Allowances Schemes	<ul style="list-style-type: none"> Higher acceptability. 	<ul style="list-style-type: none"> Requires public investment, Weaker incentive, Reduce public income (revenues).
Planning Measures	Implementing an Electric Vehicles Charging System	<ul style="list-style-type: none"> Improve air quality, Increase efficiency. 	<ul style="list-style-type: none"> Requires public investment.
	Urban Consolidation Centres	<ul style="list-style-type: none"> Improve efficiency, Reduce congestion, Reduce kerbside occupation time. 	<ul style="list-style-type: none"> Requires capital investment, May require public subsidy, Economic viability difficult to achieve (increase the operational costs).
	Tenders	<ul style="list-style-type: none"> Promote technological shift. 	<ul style="list-style-type: none"> Requires investment capacity and it may exclude some stakeholders.
	Municipal Fleet	<ul style="list-style-type: none"> Adopt the principles of the Clean Vehicles Directive. 	
	Repair Network	<ul style="list-style-type: none"> To promote the implementation of a BEVs repair shops across the city. 	<ul style="list-style-type: none"> Shops may not be profitable requiring municipal funding to continue running.

Table 3 Strengths and weaknesses of different policy measures

- *Planning measures* are key incentives that the governmental bodies have to drive the market behaviour. In this incentive, the governmental bodies change the properties of the transport network, in terms of capacity, technological properties and or even access (e.g.: construction or removal of parking places). These incentives target the transport network and not the stakeholders. We may then consider them as an indirect type of incentive. They are nonetheless effective since the stakeholders will change their behaviour accordingly to the properties of the transport network.

4.2 Information and Stakeholder Engagement

Information and Stakeholder Engagement are a set of measures aimed to educate, train or inform stakeholders on EFFVs. The measures may serve to debunk misunderstanding or conceptions, to raise awareness about the available solutions, their advantages, disadvantages, limitations or uses; or to explain how to deploy and implement. The underlying idea is to promote change through education and enlightenment. Other advantages include^[72]:

- It makes decision-making processes more transparent.
- It raises mutual understanding between citizens/companies and public authorities.
- It considers ideas, concerns and everyday knowledge.
- It improves the knowledge basis.
- It has a positive influence on planning processes as it increases acceptability.

Participation and behavioural changes are done on a voluntary basis. The results take considerable amount of time to become visible, so information and stakeholder engagement should be part of a clear strategic plan (e.g., SUMPs).

The involvement of stakeholders can be promoted at different levels, depending on the specific purpose of the involvement and the envisaged outcome. There are five levels of involvement, as follows: to inform, to consult, to involve, to collaborate and to empower²⁰. At the lower end of the engagement chain, information is used to convey information to stakeholders about a specific topic. There is a one-way flow. Information commonly complements other policy measures as a way to reduce opposition and promote acceptability. At the higher end of the engagement chain, empowering consists in acknowledging the importance of stakeholders to achieve successful decisions. As such, stakeholders are involved in the decision process and are co-responsible for the decisions and outcomes.

It is possible to elaborate some recommendations concerning the utilisation of each type of stakeholder engagement, as follows:

- **Information** is used to convey citizens and stakeholders' decisions, investments or any other worthy piece of information.
- **Consultation** is useful to grasp citizens and other stakeholders' opinion, expectations or anxieties on a given situation, either actual or hypothetical.
- **Involvement** and **Collaboration** entail the participation of stakeholders in the decision making process, albeit final decision lies with the public authority (decision maker). In these cases, stakeholders participate in a set of restricted actions (e.g., roundtables, seminar, etc.), where they voice their opinions and expectations about the options, alternatives and decisions.

²⁰ NBGD and Technical Report #3 present a more detailed discussion about these five levels.

- **Empowerment** is the highest degree of engagement, in which stakeholders are co-responsible for the decision. In this situation they are involved and actively participate in the decision making process.

Stakeholder engagement initiatives often complement other on-going initiatives, as a way to convey or retrieve information, or to help the convergence towards a consensual decision. Stakeholder engagement is seen as one of the most promising tools to change behaviours and obtain support from stakeholders. Nevertheless, the results are inherently uncertain, and often intangible, because they depend on the stakeholders' wellness to change. Additionally, stakeholder engagement is a costly initiative. Public authorities have to support costs related with the planning and execution of the initiatives (e.g., catering, rooms, printing material, travel expenses of invited speakers, hiring specialised human resources etc.); whereas stakeholders have to bear the costs human resources participating in the initiatives.

4.3 Legal and Regulatory Measures

Regulations are currently used to define access conditions of freight vehicles into urban areas. Advantages of these measures include: i) impacts are visible upon deployment, ii) some important regulations can be implemented with very low resources and costs (e.g., vertical or horizontal signalling is relatively inexpensive), or iii) regulations have a visible public facet (e.g., signalling has a physical materialisation), which in political terms is relevant. Regulations can be used to induce a technological transition towards EFFVs, by defining the characteristics that freight vehicles must comply.

The success of a regulation depends on its effective implementation, which naturally entails adequate monitor and enforcement. Yet, enforcement of urban logistic activities is often weak or neglected. Available resources of the police forces (or other authorities) tend to be scarce and other priorities jump in diverting the forces. Also, monitoring urban logistic activities is a difficult task. Firstly, many deliveries are fast; hence, spotting them would require permanent surveillance of every street, which is impracticable. Secondly, many urban logistic activities are done with small and uncharacterised vehicles. Identification of such vehicles is difficult. Thirdly, often the available public space is scarce and simply there is no available parking space. Yet, urban logistics activities must occur, otherwise, local commerce goes bankrupt. In these situations, unlawful acts are almost inevitable.

This last point is a relevant one. Regulations must be carefully designed, considering the requirements and needs of the intervening stakeholders (e.g., the loading/unloading needs of a vehicle delivering medicines at a pharmacy are quite distinctive of another delivering at a restaurant).

Recent technological developments delivered new automatic solutions to monitor urban logistics activities (Figure 22). Examples include closed circuit TV (CCTV) systems, vehicle's plate recognition system or radio communication systems (e.g., radio-frequency identification tags in the vehicles). These systems can be linked to web-based reservation management systems. Such systems automatically manage the supply of freight parking places. Transport companies are required to book in advance the time-slot for the utilisation of a parking place. Or, in case of systems without reservation, the system simply manages vehicles' access.

4.3.1 Access Regulation Measures²¹

The regulation of the access can be done with respect to different variables:

- Setting air pollutant emissions
- Setting dimensions and load capacity
- Setting time based Conditions
- Setting pedestrian zones access

Setting Air Pollutant Emissions

In terms of air pollutant emissions, there is a relevant distinction to be made between the vehicle manufacturing standards (EU level) and access regulations based on Euro standards (municipal level). The vehicle manufacturing levels refer to EU wide level regulations that cap emission levels of new vehicles. Current standards are: for light duty vehicles (cars and vans) Euro 6, while the current standard for heavy duty vehicles is Euro VI.

The access regulations refer to municipal regulations that determine which type of vehicles is allowed to circulate within a specific area. Such imposition may be done according the Euro standard, meaning that no vehicle with a Euro standard below a certain level can circulate. In certain locations (e.g., historic areas), local authorities may set limits stricter than current Euro standard. Such areas are commonly designated as LEZ²², if emissions are allowed, or ZEZ, if no emissions are allowed.

Figure 22 Automated systems to enforce access-based regulations



The City of Lisbon is an example. As recently as 2015, the Municipality of Lisbon has set Low Emission Zones with the purpose of curbing emissions and improve the quality of air. Those areas were recording levels of air pollutants above maximum recommendations. The solution was to cut the main source of such situations: vehicles.

Two types of LEZ were defined (Figure 23):

- Zone 1 (Zona 1 in Figure 23) only vehicles build as of 1996 can circulate;
- Zone 2 (Zona 2 in Figure 23) only vehicles build as of 2000 can circulate.

²¹ NBGD and Technical Report #2 is dedicated to the topic of Access Regulation.

²² The Non-Binding Guidance Documents (NBGD) #2 is dedicated to Low Emission Zones.

Zone 2 includes the entire City of Lisbon, while Zone 1 includes particular critic road in Lisbon Downtown.

Figure 23 Low Emission Zones in the City of Lisbon



Setting Dimensions and Load Capacity

Alternatively, regulations can be used to set the dimensions or load capacities, such as maximum weight, height or number of axles. Figure 24 presents an example of the City of London, where a scheme limiting the size of vehicles is in place.

Commonly, such limits are set because of limitations of the transport or built infrastructure (e.g., number and width of lanes, turning radius, ground vibrations, or parking places). Yet, environmental concerns may also justify the implementation of such measures. The underlying rationale is that there is a relation between vehicle's weight, and energy consumption and air emissions^[73]. By setting limits, the emissions are inherently being limited. However, these political measures have some side effects, which offset the benefits. Firstly, by limiting capacity, more vehicles will be required to carry the same amount of goods, increasing the number of trips. Secondly, although the absolute amount of air pollutants is lower in smaller vehicles when compared with larger vehicles, the relative emissions per unit weight of cargo is higher. A possible way to overcome this risk is by setting minimum load factors. As a way of example, the city of Parma (Italy) has implemented the ECOLOGISTICS initiative.

The scheme allows stakeholders to choose between two options for accessing the city centre. Stakeholders can accredit their vehicles if they meet some specific requirements regarding: i) type of goods to be transported, the use of eco-friendly fuels (e.g., CNG, bi-fuel or electric and/or Euro 3, 4, 5), ii) the use of vehicles not exceeding 3.5 tonnes, iii) a threshold value loading factor of at least 70% and iv) the use of a location system for vehicle traceability. Alternatively, they simply do not have access to the city centre: they unload their goods at a consolidation warehouse: goods are then consolidated and delivered in the city centre by the ECO CITY service^[74].

Figure 24: Access Regulation based on vehicles weight and time windows

Setting Time Based Conditions

Regulations may also set time windows for the circulation of freight vehicles in the urban area. The idea is to limit the presence of freight vehicles to specific times of the day or week, when congestion levels are reduced (Figure 25). Typical access time windows for freight vehicles are: i) dawn up to early morning (05H00 to 09H00), ii) mid-day (11H00 to 15H00) or iii) evening (19H00 to 00H00).

A particular case of time based access refers to set access during night time. In this case, freight vehicles use the transport infrastructure in the period of lowest demand and, hence, lowest congestion levels. Advantages include i) higher speed, since congestion is reduced, ii) enhanced reliability, since delays and other unforeseen events are reduced, or iv) speed-up of loading and unloading operations, since vehicles can park closer to the entry and there is lower pedestrian and other traffic. Yet, there are also several potential disadvantages: i) freight vehicles and operations tend to be noisy (e.g., engines, handling goods, opening/closing doors), which becomes particularly notorious during night when surrounding noise is reduced, and ii) costs with human resources increase since employees have to work overnight.

In what concerns the noise, it is important to mention that recent technological advancements have been reducing noise (e.g., engines are increasingly noisy, trailer's floor can be coated with a rubber-like material and the handling equipment can have rubber tires).

A recent pilot study^[75] conducted in the city of Brussels concluded about advantages of night deliveries. Advantages included low average fuel consumption and higher average speed. Additionally, truck drivers preferred to work over night, since driving stress were reduced and driving conditions were enhanced. Conversely, both receivers and shop employees were unhappy due to the need to work overnight. In what concerns the noise mixed results were obtained. The pilot also evidences the advantages from an environmental perspective as there was a reduction of air pollutant emissions.

Advantages of time based regulations include a raise of reliability and efficiency, general improvement of parking availability, and enhancement of environmentally sustainability & safety. In what concerns the disadvantages, it may require significant operational changes, which may result in a raise of the cost structure. It also requires investment in monitoring and enforcement actions, which have to be supported by the public authorities^[74].

Figure 25 Traffic conditions at Place De Brouckère at different times (Brussels, Belgium)

Source: Verlinde and Macharis^[76]

4.3.2 Access to privileged parking bays and lots

Loading and unloading operations are sources of inefficiency and costs, since the vehicle is immobilised and there is a higher risk of damage or theft. There is then the need to minimise these operations, which incentivises drivers to park as close as possible to the receivers' door, even in illegal situations, such as outside-designated loading bays in illegal conditions (e.g. second lane, bus lanes, on sidewalks or in illegal parking places). The outcome is also a conflict with other users of the public space (e.g. with pedestrians in case of parking on the sidewalk).

The roots are diverse, but include the lack of suitable parking places (indeed, parking places for freight vehicles are scarce, often located in secondary roads away from shops, and when available can be occupied by private vehicles). Also, many deliveries are done in a very short period of time (less than three minutes). In these cases, there is a higher propensity to illegal actions (for example, parking the vehicle in double lane). The time of the illegal act is short and the probability to be caught by public authorities is low.

Granting access to EFFVs in privileged locations, closer to receivers, equipped with recharging stations is a relevant benefit.

In parallel, parking bays or lots may be tailored to the electric vehicles' uniqueness^[77]. Measures may include an appropriate length for parking (avoid short parking places to prevent the need to do many manoeuvres) and avoid gaps between street and curb side, since electric vehicles spend substantial amount of energy to overcome obstacles. By way of example, in London (United Kingdom) the Transport for London has prepared a comprehensive guide to help planners designing proper freight parking places²³.

The main disadvantage of this measure concerns the required space of kerb, which may not be always available. Additionally, it will reduce the space of private vehicles, including retailers' customers; thus, resistance by citizens and retailers may emerge.

4.3.3 Using dedicated corridors: bus and cycle lanes

Dedicated corridors such as bus or cycle lanes offer advantages vis-à-vis the rest of the network, namely lower congestion levels and higher accessibility. Hence, the utilisation of such corridors by freight vehicles is well regarded by stakeholders since they can expect efficiency

²³ More information available at: <http://content.tfl.gov.uk/kerbside-loading-guidance-2009.pdf>.

gains and cost reductions. Main benefits include: higher and more regular speed, lower consumption levels.

There is however some potential dangers. Foremost the entry of freight vehicles will increase the congestion levels, reducing the speed for all other users. In the case of bus lanes, the operations of public transport services are quite sensible to speed variations. Secondly, there will be a high temptation of short-term stops for fast deliveries (e.g., pharmacy deliveries). Such situation will inevitably result in major conflicts with other users, notably buses, which will be inevitably blocked eroding all the benefits of bus lanes. Thirdly, there is a unwanted negative side effect related with the increase of freight trips owing to the enhanced accessibility.

4.3.4 Certification of Stakeholders

Local authorities may officially recognise those stakeholders that use EFFVs, by awarding certificates. The award of certificated should be based on a clear regulation. The certificates may work in different ways. They are a public recognition of the stakeholder's efforts in protecting the environment. Stakeholders can then use the award in the marketing campaigns to raise the value of the brand as a "green company". The local authority may decide that the award of incentives or exempt of taxes depend on such certificates. Finally, access measures may also be determined in function of the certificates.

The main difficulty is related with the costs of certification. On the one hand, the public authority must ensure a proper monitoring and conduct regular visits to ensure that stakeholder continues to fulfil the requirements. On the other hand, the stakeholders must invest in the certification process.

4.3.5 Noise Emissions

Public authorities may set maximum limits on the vehicles' noise emissions. Available reports suggest maximum noise level of 65 db(A) up to 23H00 and 60 db(A) thereafter (distance of 7.5 meters)^[78]. Yet, these values should be assessed on a local basis, since the maximum noise level should be set in relation to the average background noise.

This is particularly relevant in the case of night deliveries or in sensitive locations (e.g., health care facilities). Since internal combustion engines are noisier than electric engines, BEVs are a suitable replacement. It should be noted however that the engine is not the single, or more important, source of noise. In case of loading and unloading operations, other sources are relevant such as opening and closing doors, carts (moving between vehicles and shop), cooling systems (i.e., air conditioning systems may require additional engines), loud conversations or radio on.

In this sense, the Transport for London has published a valuable code of practice for quieter deliveries^[79].

4.4 Fiscal Measures

Fiscal measures should be based on clear supply-demand mechanisms, so that urban logistics stakeholders can understand the underlying rationale and adapt accordingly^[19].

The fiscal measures which municipalities can take are naturally limited by their own local jurisdiction (e.g., municipality). Regional or country-wide incentives naturally have to be deployed by regional or national governmental authorities.

4.4.1 Exempt EFFVs from city tolls

A number of cities have over the last years implemented active measures to curb congestion, including city tolls (e.g., London or Stockholm). The pricing mechanism is city specific, but it varies with the hour of the day and type of vehicle. City tolls increase the stakeholders' cost structure. An option advocated in several studies^{[2], [80], [81]} is to exempt EFFVs from city tolls. The underlying idea is to reduce the transport costs and, thus, improve the competitiveness of EFFVs vis-à-vis ICEVs.

4.4.2 Subsidies, Tax Incentives or Allowances Schemes

- Subsidies, Tax Incentives or Allowances Schemes are used to decrease prices, taxes, or fees, and foster behavioural changes. These schemes work on a reverse way than Pricing or Charging Schemes way through a bonus principle.
- *Subsidies, Tax Incentives or Allowances* can be applied for the acquisition of EFFV (e.g., electric vehicles or alternative fuels), through tax discounts or any reduced tax scheme. In which EFFV have lower taxes than conventional vehicles. By way of example, the Environment and Health Administration of Stockholm runs since 1994 a clean vehicles programme. The aim is to speed up the transition to clean vehicles and renewable fuels. The scheme introduced monetary incentives for clean vehicles. Subsidies may also be given to incentivise stakeholders changing behaviour. Subsidies will reduce the actual price of vehicles. Stockholm offers subsidies for a few, chosen clean vehicle models that still were expensive, making the costs 10 - 50% lower (vehicles included 3,000 delivery vans running on ethanol). The City of Graz (Austria) offers subsidies for cargo bike (two and three wheelers) investments with 50% of the investment costs up to 1000 euros^[74].
- *Parking Charge Schemes* can be used to benefit EFFVs through reduced or exemption of charges. Linking tailored schemes with technological advancements may bring further benefits, for example through advanced parking space booking system. Current technology allows the development of web-based platforms, where stakeholders can book and manage parking schemes^[74].
- *Land-based Taxes Schemes* can be used to reduce the implementation and running costs of Urban Consolidation Centres (UCC) and other transport infrastructure to support the operation of EFFVs. It is acceptable that Municipalities create specific tax discounts to those stakeholders that envisage running an UCC in urban area using EFFVs.

The City of Madrid (Spain) is an interesting example of a comprehensive approach to promote electric vehicles. As part of the Air Quality Plan 2011-2015, the municipality has developed a group of measures specifically focused on e-mobility, including: i) mobility advantages for cleaner vehicles, ii) vehicles tax incentives, iii) voluntary agreements with the private sector, iv) exemption from the municipal street parking regulation (unlimited free parking is available for electric and plug-in electric hybrid vehicles), v) free recharge at 24 street points, vi) time-limited 75% reduction in municipal tax on motor vehicles and vii) a discount on the annual fee for freight operations for hybrids (free for electric and plugin electric vehicles)^[74]

These kinds of schemes does not lead to a raise of stakeholders' costs structure, hence, their acceptability is higher. On the other hand, the intensity of the incentive is lower when compared with the previous scheme; since stakeholders only perceive the benefit if they change behaviour. So, there is the need to overcome inertia.

Parking charges exhibit two particular limitations. Parking charges seem to have limited effectiveness as a demand management tool. It requires monitoring and enforcement actions which are costly^[74].

4.5 Planning Measures

Planning measures modify the characteristics of the infrastructure and built environment with the purpose of creating favourable conditions for the adoption of EFFVs. The responsibility for such measures lies with the public authorities, due to the high cost of planning, implementing, and maintaining transport infrastructure in urban areas and their perception as being for the “public good”. Moreover, reaching the break-even point may take a long time. Notwithstanding, contracts and other agreements with private stakeholders can be established transferring to them the partial or complete responsibility.

An increasingly relevant tool public authorities may develop to integrate logistics planning into land used planning is the Sustainable Urban Logistics Plan (SULP). The SULP is inspired by the sustainable urban mobility plan. A SULP takes on and develops the city logistic elements. In this sense, a SULP is a strategic plan designed to satisfy the mobility needs of urban logistics stakeholders in cities and their surroundings for a better quality of life. A SULP builds on existing planning practices and takes due consideration of integration, participation, and evaluation principles^[82]. The EU co-funded project ENCLOSE – Energy Efficiency in City Logistics Services for Small and Mid-Sized European Historic Towns²⁴ developed a total of nine case studies. In each case study a SULP was developed and are now publicly available²⁵. A SULP hence fits into the long-term, strategic planning of a city. Although it takes considerable amount of years to be concluded, it is nowadays considered by experts as the most suitable tool to promote the sustainability of cities.

4.5.1 Electric Vehicles Charging System

Implementing an Electric Vehicles Charging System can help transport and logistic operators charging their freight vehicles while parked during loading/unloading operations. An important limitation in what concerns electric vehicles is their short autonomy, commonly below 100 km. Recharging at the parking places may help mitigate this limitation. This option is only functional when parking time is long enough to justify the recharge.

The implementation of this measure requires investment from the public authorities to support the installation of the charging points, which may not always be possible. Alternatively, a business model may be developed, in which there is a payment for the utilisation of the charging points (e.g., consumed energy and parking). It is important to set a price that will not offset the benefits of using electric vehicles. An interesting example is the initiative *Vule Partagés*²⁶, in the city of Paris. A fleet of twelve road BEVs is now available for use by retailers and shoppers in their daily operations. The fleet can be charged on six recharging stations. The purpose is to raise awareness and promote electric mobility.

4.5.2 Urban Consolidation Centres

Urban Consolidation Centres are warehouses located inside urban areas where diverse logistics activities take place, such as: consolidation of various transport companies, storage, bundling, picking or transport. E-commerce and home delivery services have created the demand of dedicated and centrally-located urban logistics spaces. An UCC results in the implementation of a two-phase delivery system:

- Phase 1: Transport from Warehouse to UCC:
 1. Goods are consolidated in large batches (e.g., pallets) in warehouses outside the urban area.

²⁴ More information available at: <http://www.enclose.eu/>

²⁵ More information available at:

http://www.eltis.org/sites/eltis/files/trainingmaterials/enclose_d5_2_sulp_methodology_final_version_0.pdf

²⁶ More information available at: <http://clem-e.com/fr/vule>

2. Trucks transport the batches into the UCC located near the denser urban area.

▪ Phase 2: Last Mile Delivery:

3. Goods are deconsolidated at the UCC.
4. Goods are transported to receiver, which is located near the UCC in the urban area.

Phase 1 is commonly conducted with a conventional truck, albeit there is no limitation to the utilisation of an EFFVs, particularly, when the transport distance is short. Phase 2 is commonly conducted with EFFVs, notably electric vehicles. The transport distance is of a few kilometres.

In recent years, several case studies and pilot tests were performed in order to evaluate the advantages and disadvantages of the UCC. Mixed results were obtained^[74]. The UCCs have the potential to i) improve load factors, ii) reduce congestion, iii) reduce vehicle kilometres travelled, or iv) promote environmental sustainability. Conversely, economic viability is difficult to achieve, since UCC raise the costs of the logistic chain (recall that UCC are located at premium locations, in which land prices are high). Profitability would require large volumes which may not be feasible. Commonly, subsidisation is a common practice, to ensure the economic viability of the UCC.

A well-known example takes place underneath the Place de la Concorde in Paris (France). Here, Chronopost, an express delivery company, implemented an UCC (Figure 26). Conventional trucks move the goods from Chronopost's warehouse outside Paris, near Bercy train station. Then diverse electric vehicles are used to do the last mile distribution (Figure 27). Advantages include: 1) reduction of travelled distance in around 75%, 2) less noise and pollution, or 3) improvement in quality of service. As a disadvantage, profitability of the service is not guaranteed. This is even more relevant when the municipality of Paris does not charge Chronopost the use of the Place de la Concorde.

Figure 26 Last mile distribution scheme of Chronopost



Figure 27 Electric vehicles used in the last mile distribution (electric cart on the left, electric van on the right)



4.5.3 Tenders

The purpose of this public measure is to introduce in the public tenders involving transport of goods clauses favouring or even requiring the utilisation of EFFVs. Public institutions (e.g., municipality, schools, hospitals and clinics, etc.) generate substantial freight transport, particularly in smaller cities. It is an interesting solution in order to introduce change.

4.5.4 Municipal Fleet

Public authorities can renew the fleet by EFFVs. This is aligned with the abovementioned EU clean vehicles directive (Directive 2009/33/EC) that established the procurement procedures of vehicles. In addition to inherent benefits of a fleet of EFFVs, such a measure has other additional benefits. Firstly, public authorities give the example, being in position to ask the same from the other stakeholders. Secondly, public authorities can serve as example and advisor to the others. As first movers, public authorities will have to adapt and learn to use a fleet of EFFVs. The gathered knowledge can then be conveyed to the other stakeholders.

4.5.5 Repair Network

A barrier to the adoption of road BEVs is the lack of a suitable network of repair shops and the difficulty of finding spare parts^[2]. Consequently, EFFVs users have to rely on the services offered by the manufacturers. Not only is the network of specialised shops scarce, as prices are above the ICEVs counterpart. Indeed, in what concerns ICEVs, there is already a comprehensive network of spare parts and repair shops. The market is mature and competitive, in which these network of shops compete with vehicle manufacturers. Such situation acts another barrier to the adoption of EFFVs.

Public authorities may give incentives to the establishment of repair and spare parts shops. This will accelerate the development of the market.

4.6 Characterisation of the Policy Measures

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 differently the urban logistic activity, 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 supported on technical analysis (social, environmental, economic and operational dimensions), ideally accompanied by stakeholder engagement initiatives. Stakeholder engagement initiative is a recognised method to achieve enhanced decision and promote stakeholders' acceptability²⁷.

This Technical Report characterises the measures along four factors, as follows:

- *Implementation Time* is the time that elapses between the moment of the decision and the moment the policy measure comes into action. 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 classified in Table 3 between:
 - *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.
- *Implementation Efforts* are the resources – human, financial, technological, etc. – required to bring the measure into action. Implementation efforts are another determinant parameter, because without available resources the policy measure cannot come into action. Again, the actual efforts will depend on the local contextual specificities. The results of a study^[5] (listed in Figure 28) show that fiscal measures would require higher efforts, because of the lengthy legislative processes (e.g., public audiences, political negotiations, etc.). On the other hand, organisation measures tend to consume fewer resources because they depend only on the public authority.
- *Influence Level* is the probability that the measure will lead to more EFFVs. Along with the implementation efforts, the influence level measures how effective, a policy measure is in being able to influence stakeholder's behaviour towards adopting EFFVs. In the above-mentioned study, no group of measures can be considered universally preferable over the others (Figure 29). In any local implementation, a stakeholder's analysis is required for a thorough assessment of potential effectiveness.
- *Acceptability Level* translates how well a policy measure is received by the stakeholders. Albeit not necessarily required for the implementation of a policy measure, the acceptability level will influence its ultimate success. Early stakeholder engagement initiative can contribute to both identify 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 30) 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 ICEVs conditions (e.g., green taxes). Policy measures that directly influence urban logistics operations were also highly regarded, including: charging points, dedicated parking bays and lots or access restriction measures.

²⁷ One of the NBGD is dedicated to stakeholder engagement initiatives in the context of urban logistics.

Table 3 Implementation time of policy options^[5]

	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) Bays Bus Lanes Cycle Lanes Certification Noise	Access (other, ZEZ)
Fiscal Measures	Tax Tenders	Tolls (depending on political supporting environment)
Planning Measures	Charging Repair	UCC Fleet

Note: survey conducted in Germany with public authorities

Figure 28 Estimated Implementation Efforts (adapted from^[5])

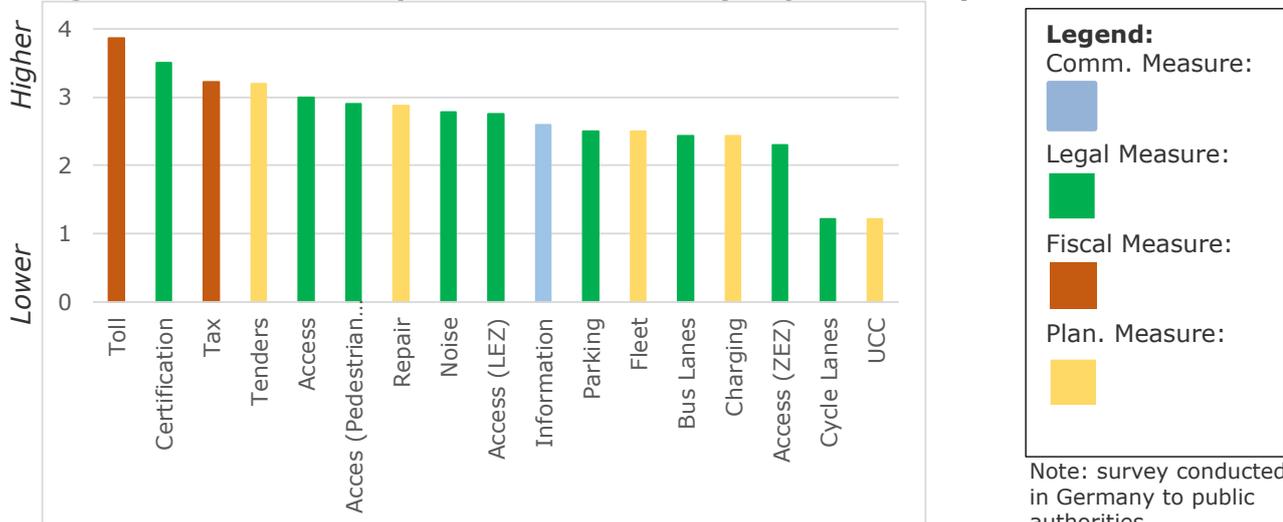
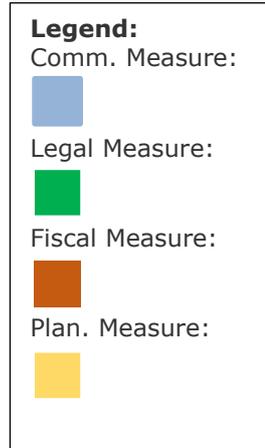
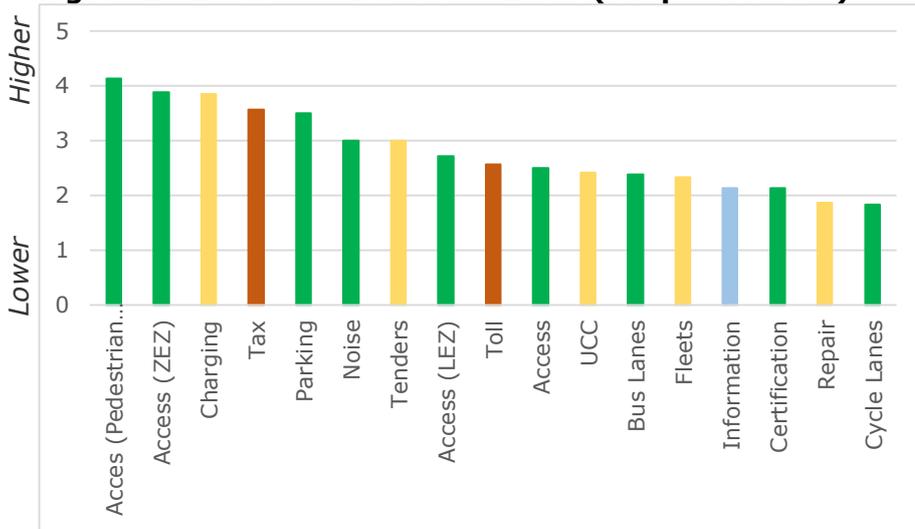
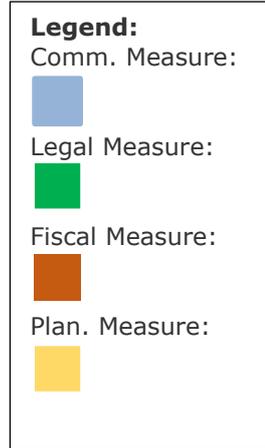
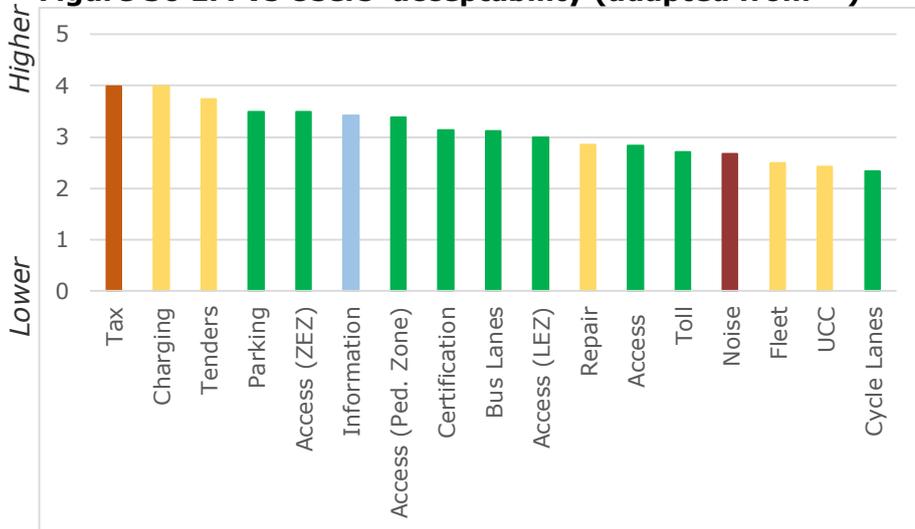


Figure 29 Estimated Influence Level (adapted from^[5])



Note: survey conducted in Germany to public authorities

Figure 30 EFFVs Users' acceptability (adapted from^[5])



Note: survey conducted in Germany to public authorities

Chapter 5 Cases of Utilisation of Environmentally Friendly Freight Vehicles

This Chapter presents several utilisations of EFFVs. The purpose is to evidence the adequacy and capabilities of EFFVs, and to serve as reference for future implementations. In some cases, the EFFVs are part of the company's business model, while in other are trials. The presentation follows the same order as used in Chapter 3.

5.1 Road Transport

5.1.1 Kiki e-Cart, Netherlands

A barge – Kiki – is in operation since October 2010 in the city of Amsterdam. The vessel is used in deliveries to the city of Amsterdam making use of the canal system. If the vessel cannot directly deliver in front of the door, a short haul over land (max. 150 m) is carried out by a manual or electric pallet cart which is on board. Thus, there is the possibility to transport pallets, roll containers as well as big bags, gauze containers and eco cassettes. Many different products can be transported, e.g. food and beverage, linen for hotels, books for museums and book shops, building materials and even cool and freeze products (in a cool container). "Kiki", has a payload of 85 m³ or 56 ton. This is the capacity of about 3 to 4 fully loaded city trucks. The payload in units is 57 roll containers or 38 Euro pallets^[35].

Figure 31 Kiki e-Cart^[35]



5.1.2 Hydrogen Forklifts, USA

Figure 32 Toyota FCHV-F^[83]



Fuel cell forklifts have potential to effectively lower total logistics cost since they require minimal refilling and significantly less maintenance than electric forklifts, whose batteries must be periodically charged, refilled with water, and replaced. In addition, the fuel cell hybrid system ensures constant power delivery and performance, eliminating the reduction in voltage output that occurs as batteries discharge. Due to the frequent starting and stopping during use, electric forklifts also experience numerous interruptions in current input and output^[83].

There already have been several successful demonstrations of hydrogen fuel cell-powered forklifts, including at such large company warehouses of Wal-Mart, GM or FedEx. Cellex Power Products, Inc. has completed field trials of its Alpha fuel cell-powered forklift at the logistics subsidiary of Wal-Mart Stores, Inc. in Missouri. Cellex had four fuel cell power units in operation for two weeks and Wal-Mart was so impressed, the company has decided to support Cellex's Beta field trials and commercialization process of fuel cell power systems for electric lift trucks. Cellex Power Products supplied Wal-Mart with 14 fuel cell vehicles for the trial. The vehicles are successfully running two shifts a day and being fuelled indoors by lift truck operators^[83].

5.1.3 YouLog e-bike, Italy

YouLog is a company that provides delivery services for GLS Enterprise in the Milan region. GLS Enterprise is a subsidiary of General Logistics Systems. GLS realises reliable, high-quality parcel services for 220,000 customers in Europe, complemented by logistics and express services. Since March 2014, YouLog company diesel van fleet is enriched with 4 electric bicycles (e-bikes) for 'last mile' delivery of letters and small parcels in the Milan centre. An urban consolidation centre for the operation of e-bikes was set up. A van delivers parcels and letters from the extra-urban consolidation centre to the urban consolidation centre, from which the deliveries are done to the final customer by e-bike.

Figure 33 e-bike used by GLS



The operation of the van is optimal in the wider Milan area, while the operation of the e-bikes is optimal in the inner city area^[30]. In the beginning of April, the number of e-bikes increased to nine with an electric assistance to pedalling, and five/six hour of autonomy. YouLog's value proposition is delivery on time (96% of deliveries are on time) offering a reliable service. Their new sustainable service is also contributing to their value and they are planning to have a logistic platform just using electric vehicles. To deal with externalities, YouLog is replacing diesel vans with electric vehicles, contributing to the improvement of the urban air quality. By introducing ten clean and silent e-vehicles in Milan, CO₂-emissions could be avoided. Finally, four e-bikes replace two vans which reduces congestion^[30].

5.1.4 La Petite Reine, France

La Petite Reine (today group Star' Service), France, is a freight transport company that uses electrically powered tricycles – Cargocycles® - with a container 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. La Petite Reine uses urban warehouses (mostly in underground car parks) provided in partnership with the City of Paris. Each tricycle can carry about 180 kg of merchandise in its 1,400 litre cargo space. The tricycle weight is only 80kg^[84].

Figure 34 La Petit Reine Paris (France)^[84]



5.1.5 Camisola Amarela, Portugal

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 1 to 4 hours.

Their operations are based in 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 electric vehicles can carry up to 40 kg^[84].

Figure 35 Camisola Amarela Lisbon (Portugal)^[84]



5.1.6 TNT Express e-scooter, Italy

TNT Express Italy, the Italian Business Unit, is one of the main players in the industry, with over 180 000 consignments delivered every day. TNT Express Italy operated with one electric scooter in Genoa for last-mile delivery in substitution of an ICEVs^[30].

The e-scooter performances were of high quality, similar to the ones of the traditional scooter. The driver saved around 25 € per week on fuel costs. Even though some malfunctions affected the trial^[30]. Furthermore the e-scooter was perfect for promoting and giving visibility to the company^[30].

Figure 36 E-scooter in use in Genoa (Italy)^[30]



Figure 37: Hychain Project Tricycle^[50]



5.1.7 Hychain Hydrogen Tricycle, EU

HYCHAIN Project main goal is to initiate a new stage in the Transport Sector, and facilitate a sustainable development through H₂ technologies. The Projects deploys several innovative vehicle fleets in four European Regions (France, Spain, Germany and Italy) operating with Hydrogen as an alternative energy source^[50]. Key Features include: i) 1 passenger, ii) 250 W electric motor, iii) 100 km of range, iv) 100 kg of maximum payload, v) 18 km/h maximum speed.

5.1.8 DELIVER - Zero Emissions for Urban Delivery (Concept electric LCV), EU

The DELIVER project's objective was to explore and identify conceptual design options for the next generation of electric delivery vehicles. The project partners, which bundled different competence fields throughout Europe, developed and built an innovative and sustainable vehicle concept that fulfils the demands of tomorrow. The result is represented by a demonstrator of a 700 kg payload electric vehicle for city use. Its design provides an improvement in efficiency of over 40 % as well as innovations for the delivery vehicle duty cycle - one of the many use cases the vehicle concept can serve^[85].

The project generated, investigated and analysed innovative design concepts for electric LCVs with motorised wheels. It delivered an advanced architecture, which enables the same high level of intrinsic safety as known from current best-in-class conventional vehicles at minimal weight, maximised energy efficiency, optimised ergonomics & loading space at affordable costs as well as acceptable levels of comfort and driving performance. The program culminated in a driving concept validation vehicle, which embodies the optimum integration of systems as researched during the design and development stage. The purpose of the vehicle was to validate the research results with the highest degree of

Figure 38 DELIVER LCV^[85]



reality possible ^[85].

5.1.9 Posten Norge, Norway

The company Posten Norge, Trondheim (Norway), has been replacing its diesel vehicles with EFFVs – 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 EFFVs in the context of urban logistics ^[4].

Figure 39 Posten Norge Trondheim (Norway) ^[4]



5.1.10 LuccaPort, Italy

Figure 40 LuccaPort in Lucca (Italy) ^[86]



Access restriction measures were implemented to reduce the number of ICEVs 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 BEVs. The services are based in a warehouse in the city's outskirts.

It makes around 120 daily deliveries in 15 round trips, which correspond to 15% of city deliveries. The scheme achieved a reduction of 44% in the number of ICEVs accessing the historic centre ^[86].

5.1.11 Electric HCVs, Rotterdam

The utilisation of electric HCVs is relatively incipient. In Rotterdam, TNT operates four large electric vans, UPS operates 4 large electric vans, or Heineken operates one large 19 ton electric truck (Hytruck) ^[87].

Figure 41 Two Rotterdam demonstrators, Heineken and UPS ^[87].



5.1.12 Hychain Hydrogen LCV, EU

The European Commission has launched the Hychain project that consists of 24 partners who are co-ordinated by Air Liquide. Hychain deployed a great number of hybrid fuel cell battery vehicles in four regions of Europe. The project objective is to test, under real-life conditions, 158 urban vehicles fuelled by electricity via a fuel cell battery using hydrogen in 4 regions of

Europe: 30 scooters, 40 tricycles, 34 medical armchairs (mobility vehicles), 44 light commercial vehicles and 10 minibuses. Budget: 37.6 million Euros. Of which 17.2 million is financed by the European Commission ^{[50], [88]}.

5.1.13 CNG and biogas vehicles, Belgium

The City of Ghent, Belgium, has a stated policy to be CO₂-neutral by 2050. Within this framework the city is committed to introducing EVFs and EFFVs into the public fleet to help drive market development, and to encourage the uptake of these vehicles amongst the general public. The City launched tenders for electric and CNG passenger and freight vehicles. So far 30 electric and 11 CNG vehicles have been purchased, out of a total fleet of 900 vehicles ^[89].

The key characteristics of the vehicles are: i) main fuel is natural gas, with possible conversion to biogas, ii) minimum Euro V emissions standard, iii) gas tank capacity of at least 190 litres, iv) silent and energy efficient radial tyres with a normal road profile. Recently a public CNG-station was constructed on the outskirts of Ghent. The CNG driven vehicles cost approximately € 5,000 more per vehicle plus the costs for the slow fill station ^[89].

Figure 42 CNG Fiat Ducato vehicles ^[89]



CNG vehicles also offer substantial reductions in local emissions. Biogas will be purchased for the CNG vehicles, if available on the market, but currently there is no biogas provider in Ghent ^[89].

5.2 Rail Transport

5.2.1 CarGoTram, Germany

The CarGoTram is a freight tram service located in the City of Dresden, Germany. It is promoted by the car manufacturer Volkswagen. The tram service supplies Volkswagen's Transparent Factory located in the city centre. The CarGoTram runs over infrastructure normally used to move passengers. The freight tram was introduced officially in Dresden on 2000 and had its first test run on 2001, which replaced the use of trucks that would have caused an increase of traffic in the city.

Figure 43 CarGoTram ^[93]



CarGoTram uses five self-propelled bidirectional carriages, using electricity as power, and seven middle cargo carriages. The standard formation is three freight units and two combination freight/control units. The control cars have less capacity (7 500 kg) than the middle cars (15 000 kg), because of space devoted to the driver's cab. The total capacity is of 60 tonnes or 214 m³. Maximum speed is of 50 km/h ^[90]. Every day the trams transport the equivalent of 60 trucks. Over the year this is the same as 200 000 km by road, according to Volkswagen AG's own calculations.

5.2.2 Waste Collection Cargo Tram, Switzerland

Figure 44 Waste Collection Cargo Tram in Zurich (Switzerland) ^[94]

Cargo Tram is in operation in the city of Zurich. The cargo tram serves nine stations, collecting bulky waste from households and electronic home and industrial equipment. It was launched in 2003 with a condition of neither disturbing nor slowing down the public transport network. The tram runs on the city's tram network and has replaced 5000 km of trucks, corresponding to a saving of 37500 litres per year ^[60].



A Waste Collection Zurich. The collecting disposable equipment. pre-slowing passengers. network. and have

5.3 Inland Waterways Transport

5.3.1 Beer Boat and Ecoboot, Netherlands

Figure 45 Beer Boat ^[91]



The Beer Boat is a zero emission boat aiming at contributing reducing air pollutant emission in the City of Utrecht. It began operations in January 2010 ^[91]. Another ICEVs boat was already in operations. The trial was successful. The Beer Boat is currently operating 6 times on 4 days per week, supplying more than 60 catering businesses. A key result is 38 tons of CO₂, a 31 kg of NO_x and an 6 kg PM saved emissions, during the CIVITAS MIMOSA period.

A market survey and feasibility study was conducted to investigate the potential for new customers and new suppliers – not only catering businesses but also other branches - for waterborne transport in the Utrecht city center. The study evidenced that there was enough potential to justify another vessel ^[91]. In the summer of 2011, the City of Utrecht signed a contract for another electric multi-purpose vessel, designated as Ecoboot. The Ecoboot began operations in April 2012 and replaces the existing garbage boat which had been running in Utrecht to collect garbage from businesses on the wharves ^[91].

5.3.2 Vert Chez Vous, France

Vert Chez Vous was a delivery service of parcels and small packages running on the river Seine in the city of Paris (France). Goods were consolidated in a warehouse outside the city. From here, they were transported to the river and loaded onto a barge, which served as a moving urban consolidation centre, docking along the river Seine. The final delivery was made with electric tricycles. The urban barge route was of around 16 km (round trip) with five berthing stops. Tricycle deliveries took about 30 minutes each. The service delivered around 2000 to 3000 parcels a day.

Figure 46 Vert Chez Vous in Paris (France) ^[95]



Chapter 6 Conclusions

Policy orientations clearly set the path to reduce and eliminate carbon footprint out of urban areas by 2030^[3]. Yet, transport of goods and people remains heavily dependent on fossil fuels to power the vehicles' ICE. Urban freight logistics is no exception. 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 gases emissions (e.g., CO₂) and 30 to 50% of other transport related pollutants (particulate matter, nitrogen oxide)^[1]. Changes are deemed necessary.

A widespread use of EFFVs can contribute to achieve those targets. An EFFV is any vehicle that produces less harmful impacts to the environment than comparable conventional internal combustion engine vehicles running on gasoline or diesel or one that uses certain alternative fuels.

The EC is presently supporting four main alternative types of fuels and propulsion technologies: i) battery-electric vehicles and hybrid-electric vehicles with plug-in, ii) hydrogen and fuel cells, iii) biofuels, with priority for 2nd generation biofuels, and iv) natural gas pure or blended with bio methane. Each one presents its advantages and challenges. At current time, road BEVs are arguably the most successful EFFVs. This is visible at several levels: growing diversity of road BEVs, amount services with road BEVs, and number of publications on the type of vehicles.

This Technical Report, reflecting such success, reviewed the following EFFVs:

- **Road Transport:**
 - Road Electric Vehicles
 - Road Hydrogen Vehicles
 - Road Biofuel Vehicles
- **Rail Vehicles**
- **Waterborne Vehicles**

Currently, the utilisation of EFFVs, notably BEVs, in the context of freight urban logistics is limited to a few initiatives either subsidised by government (e.g., EU co-funded research projects) or lead by private stakeholders, as part of a corporate social responsibility initiative. The notable exception has been in the road vehicles Class L, in which a growing of services has been implemented across the EU.

This is the outcome of the well-known chicken and egg problem. On the one hand, demand for EFFV is low as prices are high and availability is low. On the other hand, supply of EFFV is also low as manufacturers do not see enough demand to justify investing in new vehicles. Public authorities may work to break this vicious cycle, by actively working with both sides.

There is then the need of a step change attitude. Public authorities can promote this change and incentivise the widespread adoption of EFFVs, although the scope of intervention of public policies is somewhat limited. The point is that the stakeholders typically involved in the transport are the private operators, such as logistic or transport operator or retailers. Moreover, the decision process of an EFFVs is more complex and different from an ICEVs, entailing unique variables. The public measures should take into consideration such specificities.

This Technical Report considers fourteen public policies measures, which are grouped in four categories, as follows:

- **Communication and Awareness Measures are used to inform and educate stakeholders:**
 - Information - to disseminate virtual or physical information on the advantages and opportunities of EFFVs.
- **Legal and Regulatory Measures influence the behaviour of stakeholder by enabling or prohibiting certain selected activities in specific conditions:**
 - Access Regulations (including pedestrian zones, LEZ or ZEZ) - to grant privileged access to EFFVs or to ban (or restrict) ICEVs from specific areas
 - Parking Bays and Lots - to grant permission to EFFVs use privileged loading areas.
 - Bus Lanes - to allow EFFVs 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 EFFVs into low noise zones or at night time.
- **Fiscal Measures will change the impact taxes and fees have in business economy:**
 - Tolls - to exempt BEVs from city tolls.
 - Municipal Tax Incentives - to grant tax incentives to companies running EFFVs.
- **Planning Measures refer to changes in the city (e.g., infrastructure, built environment, business activities):**
 - Tenders - to demand EFFVs 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 EFFVs could operate in the near range and recharge batteries.
 - Municipal Fleets - to replace own ICEVs fleet with EFFVs.
 - Repair Network - to develop a network of BEVs repair shops.

Summing up, the adoption of EFFVs in urban freight logistics is necessary, if the environmental targets are to be attained within the time frame. Yet, available EFFVs are not yet comparable against the very mature and stable ICEVs. Technological advancements are needed, but arguably insufficient owing to the risk aversion nature of stakeholders. In this sense, the public authorities, within their limited scope of intervention, can nonetheless play an active role in the promotion and adoption of the new technologies.

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