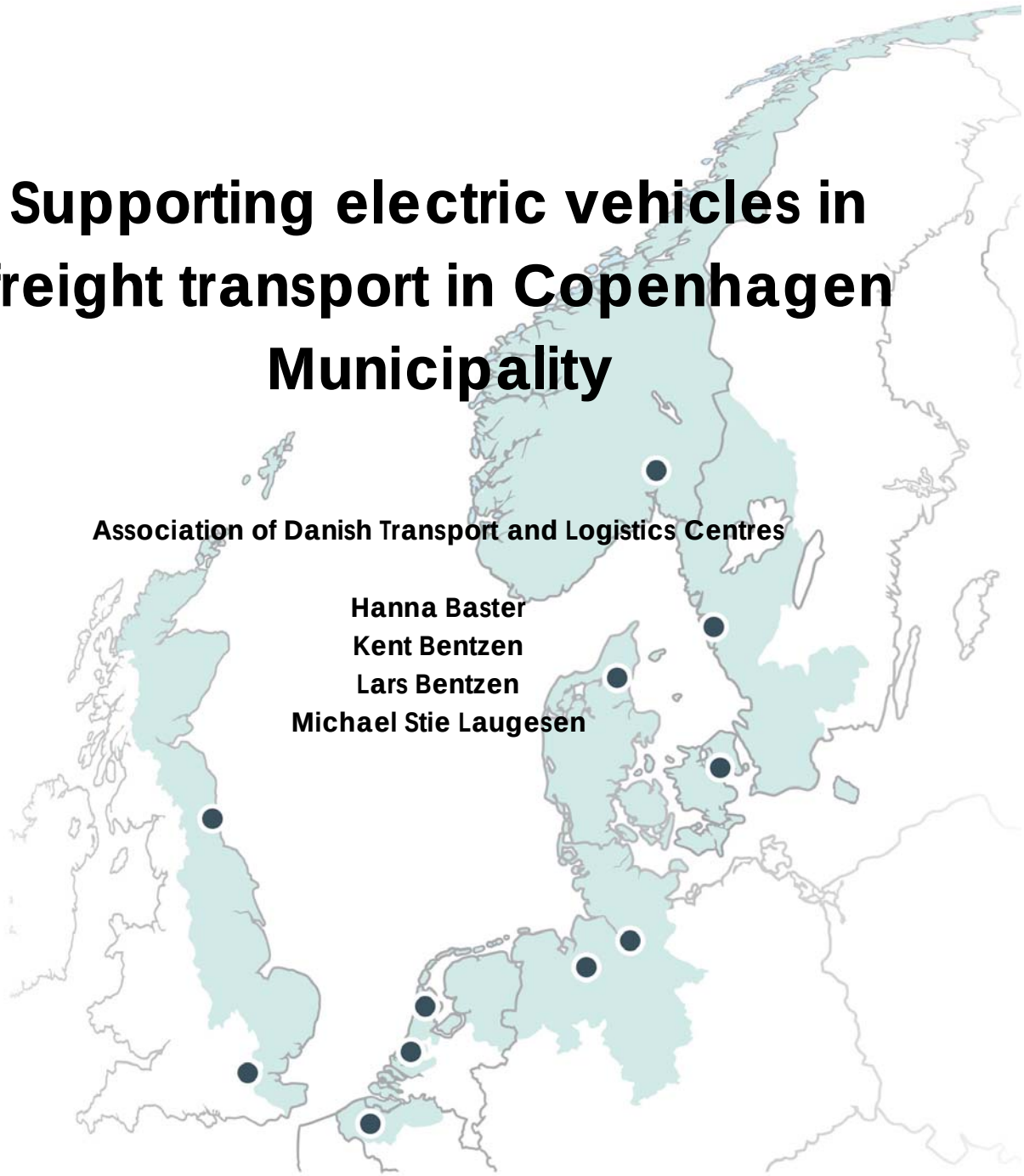
NORTH SEA REGION ELECTRIC MOBILITY NETWORK

e-mobility NSR

Supporting electric vehicles in freight transport in Copenhagen Municipality



Association of Danish Transport and Logistics Centres

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Executive Summary

Copenhagen is one of the most environmental conscious and active municipalities in Denmark, including a focus on air and noise pollution, which are closely related to health problems. The transport sector remains one of the most polluting business sectors, including both light- and heavy-duty vehicles. Freight transport takes 13.4% in number of vehicles in Copenhagen Municipality. Even though it seems as a small share, emissions caused by the freight transport sector are considerable and can be estimated around 40% of the total costs of pollution from transportation in Copenhagen.

One of the solutions is implementation of electric freight mobility, which is the main focus of the Copenhagen action plan. Electric vehicles are an advanced technology, compared to other alternative fuelled vehicles. It is widely applied to passenger cars in Denmark, including Copenhagen, and is on the way towards deployment for freight transport. Even though Denmark has announced sound goals and Copenhagen Municipality has taken initiatives in order to support green transport, there are some problems and obstacles identified, such as:

- Purchase price and cost of establishing the charging infrastructure are still high;
- Technological characteristics, such as payload, capacity, range or life expectancy of the vehicles are not competitive with conventional vehicles yet, hindering flexibility of the business;
- Higher availability of maintenance and its quality is needed.

In addition to overcoming these obstacles, some other actions are identified as necessary:

- Further incentives, both financial and non-monetary, such as public spatial planning;
- Promotion and support of green and sustainable image, emphasising benefits for both society and delivery companies.

In the end of the action plan more detailed recommendations are presented, focusing on how to deal with the obstacles mentioned above. These recommendations strengthen the path towards the deployment of electric vehicles not only from the delivery companies' point of view, but also involving state, municipality and receivers. Therefore, regulatory tools, cooperation between stakeholders, promotion of green and sustainable solutions, financial support tools and optimisation of logistic chain are discussed more thoroughly. From this, short term recommendations are the following:

- Taxation based on level of emission produced by vehicles;
- Regulatory incentive tools;

- Promotional tools, which are not directly focusing on electric vehicles, but emphasising the benefits of possessing green image.

On the long term, direct subsidies for purchasing electric freight are not among the most favourable means. A better way to further introduce alternatively fuelled vehicles is to give them competitive advantages related to spatial planning, such as driving in bus lanes or driving for free in congestion zones.

To sum up, the aim of information given and actions developed in this action plan is to support the deployment of electric freight vehicles in Copenhagen Municipality. As a result, benefits for both users and the city inhabitants can be achieved.

Methods applied

In order to build the recommendations included in this paper, the following sources were used: interviews (for section I, III, V and VI), analysis of policy documents of Copenhagen Municipality (for section I, V and VI), literature review (for section VI) and quantitative data analysis (for section II).

Six of seven interviewed companies are transport companies. The companies who participated in the interviews are the following: Danske Fragtmænd, DHL, Loomis, KLS Grafisk Hus, Post Danmark, SEAS-NVE and UPS. Recommendations included in this report are extensively build on the basis of information and opinions gathered from the interviewed companies. This should ensure a high level of applicability of the proposed actions. Actions proposed are built on the basis of information gathered from the local actors, who additionally are important players on this market. From the interviews, information is gathered about companies' requirements for deployment of electric vehicles and about their general problems associated with performing urban deliveries by these companies, as well as about their currently used and potential strategies to fight them.

Aim

To provide information on how to achieve a significant reduction of air pollution and noise emission from transport **through implementation of electric freight mobility in Copenhagen Municipality**. In the best case, **implementation of electric freight mobility will not be followed by increased congestion or decreased accessibility in** the city for pedestrians and cyclists**, this way being better integrated with other municipal strategies in the transportation field is envisioned.**

Purpose

Develop actions supporting the deployment of electric freight vehicles in Copenhagen Municipality. **Focus of the document should be put on actions, which do not require extensive public spending and do not violate market competition.**

I. Description of urban freight traffic situation in Copenhagen Municipality

1. Overall traffic and emission situation in Copenhagen Municipality

Traffic situation[i]

Copenhagen is the largest city of Denmark with approximately 600.000 inhabitants in the Municipality of Copenhagen and 1.250.000 million people in Greater Copenhagen.

- Passenger vehicles are the biggest group of vehicles driven in Copenhagen Municipality; freight vans are the second biggest group of vehicles utilised (Table 1).
- Passenger vehicles generate also the biggest traffic on Copenhagen's roads as shown in Table 2: approximately 4 times more km is travelled daily by this mode than by the second largest group, freight vans, which travel 0.89 million km daily (19% of the total daily traffic). Trucks are responsible for generating a much smaller part of the traffic; they travel on average a total of 0.11 million km per day (2% of the total daily traffic) in Copenhagen (COPENHAGEN MUNICIPALITY 2013 A).

Table 1 Composition of road transport vehicle fleet in Copenhagen

Type of vehicle	Share in number of vehicles
Passenger vehicles	69.8%
Freight vans	13.4%
Trucks and trailers	10.3%
Motorcycles and scooters	5.3%
Tractors, fire trucks and trucks and vans for cleaning purposes	1.0%
Buses	0.3%

Source: STATISTIKBANKEN 2013.

Table 2 Composition of an average daily traffic in Copenhagen on a normal weekday in 2012 [% of km travelled]

Type of vehicle	Mln km	traffic share
Passenger vehicles	3.60	76%
Freight vehicles	0.89	19%
Trucks	0.11	2%
Buses	0.08	2%
Motorcycles	0.04	1%

Freight vehicles fleet characteristics[ii]

- The most common weight of a freight van utilised in Copenhagen Municipality is 2-3 tons. The average weight of freight vans driving in Copenhagen Greater Region is 3 tons, and of trucks 9,5 tons (DTU 2013)[iii].

Table 3 Composition of freight vehicles registered in Copenhagen Municipality

Freight vans below 2 000 kg	Freight vans 2.001-3.000 kg	Freight vans 3.001-3.500 kg	Freight vans in total
4.637	14.594	10.864	30.095

Source: STATISTIKSBANKEN 2014.

- An average payload of freight vans operating in Copenhagen Greater Region is about 1 ton (BACKGROUND REPORT 2013). The average fleet size is 33 for freight vans, and 37 for trucks operating in the Copenhagen Greater Region (DTU 2013).
- An average daily distance travelled by vans used for freight transportation activities in Copenhagen Greater Region is 135 km and for trucks it is 134 km (DTU 2013)[iv].

The most suitable market niche for electric vehicles within the market of urban goods deliveries

Currently, according to the interviews performed in relation to this action plan, those who can potentially be interested in large scale deployment of electric freight vehicles are mainly transport companies. Almost all (99%) shipments performed in Copenhagen Municipality by one of the biggest Danish transport companies are below 4 tons, within which an average weight of delivery to an individual customer is below 140 kg. Also deliveries performed within Copenhagen Municipality by other big transport companies, such as UPS, DHL, Loomis and Post Danmark are of a small size, with the average weight of delivery lower than 100 kg (INTERVIEWS 2013). On the other hand, payload of vehicles required by big retailers performing urban goods deliveries on their own is much higher than the payload offered by the biggest electric freight vehicles currently available on the market. Based on the above, transport companies operating within the Copenhagen Municipality should be a core focus group, when it comes to implementation of delivery electric vehicles in this municipality. This because small size shipments are much better suited for the usage of electric vehicles currently available on the Danish market (mainly below 3.5 t).

Cost of pollution generated in Copenhagen Municipality[v]

- Air pollution in Copenhagen Municipality generates high pollution related health costs (DMU 2010 A) and transport activities are responsible for a great part of these costs.
- The biggest total cost of pollution per km is caused by $PM_{2.5}$ emission (1.88 DKK/km for all the vehicles) and not much lower by NO_x (1.35 DKK/km for all vehicles); cost of emission of SO_2 per km is much smaller.

Table 4 Costs of air pollution generated from road transport in Copenhagen

Vehicle type	$PM_{2.5}$ [DKK/km]	NO_x [DKK/ km]	SO_2 [DKK/ km]	Cost of pollution generated per km travelled ($PM_{2.5}$, NO_x, SO_2)[vi] [DKK/ km]	Cost of pollution generated daily ($PM_{2.5}$, NO_x, SO_2) [DKK/ day]
Personal gasoline vehicle	0.03	0.05	0.01	0.09	612 000[vii]
Personal diesel vehicle	0.20	0.05	-	0.25	
Bus (diesel)	0.66	0.63	0.02	1.31	104 800
Freight gasoline van	0.05	0.08	0.01	0.14	364 900[viii]
Freight diesel van	0.32	0.09	0.01	0.41	
Truck (diesel)	0.62	0.45	0.02	1.09	119 900
Total cost from all vehicle types	1.88	1.35	0.08[ix]	3.29	1 201 600

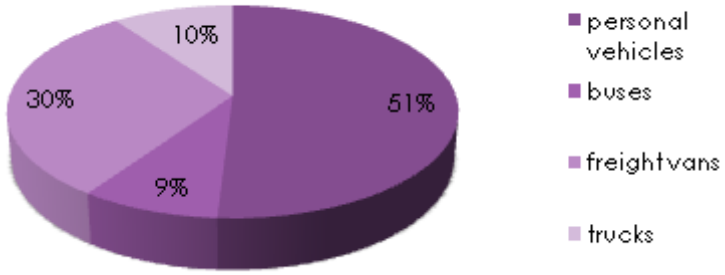
Source: own elaboration on the basis of Jensen, S.S., Ketzel, M., & Andersen, M.S. 2010, p.44 and Table 2

Further, it is also important to note, that differences in the level of $PM_{2.5}$ generated by gasoline and diesel vehicles are huge; emission of NO_x and SO_2 differs insignificantly between these types of propulsion, what can be noted from Table 4. Since freight vehicles drive primarily on diesel, the share of cost of pollution generated by these vehicles is high. Freight vehicles cover 24% of the daily distance travelled in Copenhagen Municipality, but they are responsible for 40% of costs of pollution in this area (see Table 2 and Figure 1).

Not surprisingly the biggest cost generated by one vehicle per km is caused by buses and trucks, further by freight vans and the smallest by passenger vehicles. Together, taking into account the distance travelled daily within Copenhagen Municipality, freight vans generate

cost of 364 900 DKK daily in this area; trucks 119 900 DKK (BACKGROUND REPORT 2013, P.58). This accounts for 30 % and 10 % of total cost of pollution generated daily by traffic in Copenhagen Municipality, respectively[x]. On top of these costs come the costs of CO_2 emission. However, these costs could not be included in the estimations due to lack of data.

Figure 1 Estimation of composition of cost of pollution generated daily in Copenhagen Municipality by road traffic

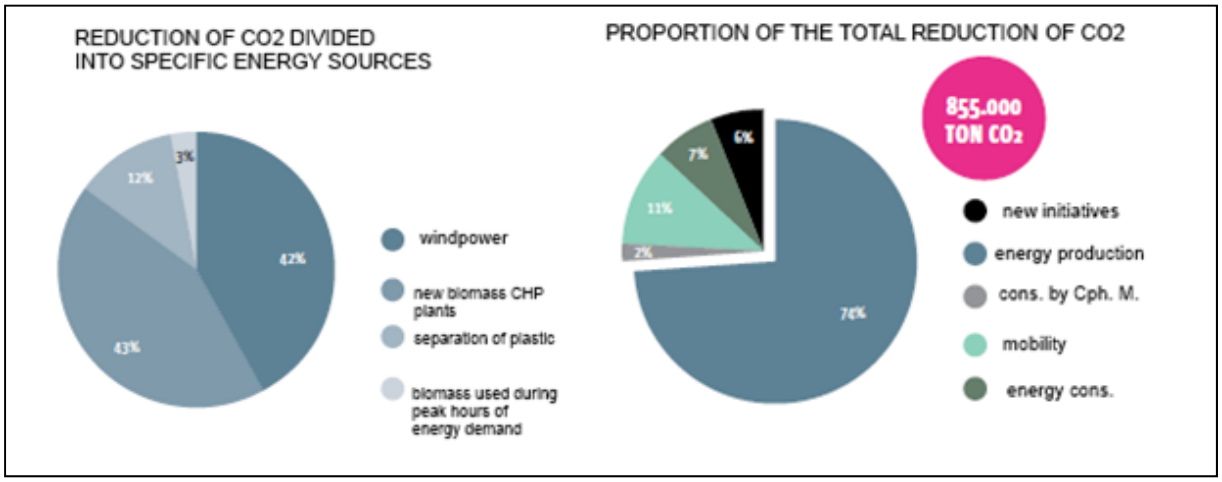


Source: own elaboration on the basis of
Jensen, S.S., Ketzel, M., & Andersen, M.S. 2010, p.44.

Pollution generated from electricity production in Copenhagen Municipality

Energy production accounts for 51% of greenhouse gas emissions in the municipality of Copenhagen. This could become an issue for electric vehicles introduction, as greenhouse gas emission will continue rising if no other sources of energy are provided (DMU B, 2006). Fortunately, according to policies of reduction of air pollution in Copenhagen Municipality, reductions from energy supply is a main focus and major reductions in this field are planned to be achieved till 2025. Production of electricity should primarily be based on wind and biomass power in 2025 (COPENHAGEN MUNICIPALITY 2012 B). This way a shift to more electric vehicles in the municipality should not increase the global emission from coal based electricity production.

Figure 2 CO_2 emission goals for energy production in 2025 in Copenhagen Municipality



Source: COPENHAGEN MUNICIPALITY 2012 B, P. 36.

Policies aiming to decrease negative effects of urban freight transport in Copenhagen Municipality[xi]

The main goals of policies directed towards urban freight transport in Copenhagen Municipality are: *to ensure an effective and environmentally friendly movement of goods and to increase traffic safety through minimization of accidents with freight vehicles. This way, better movement conditions for pedestrians and cyclists will be ensured and an improved liveability of the city in general will be achieved.* The following initiatives are put into action in order to achieve the stated objectives:

1) An improved traffic safety through development of guidelines for technical changes in the vehicles, focused mainly on improved overview options for drivers.
2) Implementation of designated routes for trucks within the main roads of municipality. Outside of them, there will be higher technical requirements for vehicles, limited access hours and lower speed allowed. In effect there will be attained an increased accessibility and traffic safety, as well as decreased noise levels on all the other smaller roads shared by pedestrians, cyclists and motorists within the Copenhagen Municipality.
3) Improvements in traffic management such as better navigation attained through implementation of GPS systems and active traffic management through the following: broadcast traffic reports and updated traffic information integrated with navigation tools, optimization and central management of traffic lights and reduction of noise and accidents with traffic control in places most exposed to accidents. In result, there are expected less stress related accidents, less congestion (and lower energy usage) and decreased noise emission.

4) Implementation of zones with limited accessibility for trucks: time access, zones forbidden for trucks to stop and zones with the requirement of a low cab (increased visibility thus safety). As a result, the following benefits will be attained: number of conflicts between vehicles and vulnerable road users is reduced and there is a positive effect on traffic safety in general.
5) Introduction of the *City Logistics Project* aiming at reducing the number of freight vehicles in the city through establishment of urban consolidation centres. Smaller and more suitable vehicles could be used in congested areas to deliver from the consolidation facility to the final customers. Further, because of the better use of car spaces, the number of car trips could be limited despite the smaller cars.
6) Introduction of several projects focused on information dissemination and dialog with actors involved in goods transportation within the Copenhagen Municipality area.

2. Problems/challenges identified within the urban freight transport activities performed in Copenhagen Municipality

Problems/challenges experienced by transport companies and companies delivering products operating within the Copenhagen Municipality and working on their own, are presented in the following section. Problems/challenges were divided into the following groups, based on the party responsible for their creation:

The most important cost factors for urban goods deliveries in Copenhagen Municipality

- Labour cost is the most important cost factor for operating the vehicle, also when warehousing costs are included. Labour cost can hardly be decreased by lowering wages, since they are regulated by the unions. Labour costs can be decreased when the delivery time of the individual vehicle drops or the number of shipments/vehicles required to deliver goods is decreased (keeping all the ordered goods delivered).
- The second most important cost factor is fuel cost. Though, as stressed by some of the interviewed companies, it does not play a big role, since a huge part of costs are created by labour cost. Therefore, the main focus of the actions supporting implementation of electric delivery vehicles should not be put on the decrease of this cost.
- Third, parking fees are also perceived as an important cost factor.

The most important problems linked to traffic conditions in Copenhagen Municipality

- Low accessibility due to a high number of vehicles and a relatively small number of parking places, especially those reserved for delivery vehicles. Very few loading bays

are established in the Copenhagen Municipality, what causes a need for delivery vehicles to look for a regular parking space, which can be very problematic and cause deviations from the optimal route. Furthermore, even these loading bays, which are established, are sometimes occupied by passenger vehicles.

- Congestion, which is often caused by road works or traffic incidents. The problem is that publicly available information about the schedule of these works is often out of date, what further causes that road users do not know in advance where the works will take place, and how long time they will take. This is an especially severe problem for transport companies, who cannot plan in advance the necessary changes in their routes. Most probably, reason for this problem was that there was not an authority in charge in case of traffic problems generated by the road works. In order to solve this problem, in October 2013, 58 Danish Municipalities and the Danish Road Directorate have agreed to cooperate more closely with each other to ensure better coordination of road works[xii].

Problems linked to requirements from receivers in Copenhagen Municipality

- It is impossible to deliver in the evenings and early mornings (due to different reasons, depending on the company; the problem is mainly caused by the smaller retailers, who do not want to give transport companies access to their properties outside normal working hours. Bigger receivers are not problematic; they often pay additionally fees to have their goods delivered later and picked up earlier.
- Receivers want to have their goods delivered within a very short time period, mainly between 9 and 10 o'clock in the morning. This causes a need for using a larger number of vehicles and has the effect that vehicles must be operated during hours with heavy traffic. The second negative aspect is mainly important due to higher labour costs and not so much due to increased fuel costs.
- The increasing number of private deliveries; Private receivers are often not at home during the working hours of transport companies. A better flexibility for private customers to retrieve packages during hours, which suit them better, is needed. This problem is expected to be partially solved via partnerships with retail locations to implement so-called 'package shops' at strategic locations (shops, malls, gasoline stations, post offices, etc.). In such a situation, deliveries could be potentially performed during night time, however, when deliveries are to be made in a day to day mode (24 hour service), goods can seldom be delivered to boxes during the night time (since during night time shipments are performed over big distances, while in the day they are delivered the last mile to the customers). An urban consolidation centre (UCC) can potentially also serve as a solution for this problem, where customers from

Copenhagen Municipality can pick up their packages, thus serving as a bigger version of a “package shop”.

Problems linked to requirements of other traffic actors, inhabitants and those established by the city administration of Copenhagen Municipality

- The time frame for delivering parcels in the inner city is very short. The problem is that deliveries can be performed only till 11 o’clock; if they could be performed later, a majority of retailers would agree for this.
- Low accessibility due to restrictions for deliveries for trucks within the city, such as pedestrian streets being access-restricted from 11.00 and environmental zone regulations, which restrict the fleet utilization flexibility.
- Night distribution is desired, but a problem is complaints about noise produced by vehicles during unloading/loading activities. Only one complaint from an inhabitant about the noise in the morning or night time and the operator can no longer deliver in the area during night time.
- An easy access for passenger vehicles to parking places next to shops (this way less space can be reserved for delivery vehicles).
- General requirements such as: pedestrians should not be in contact with freight traffic; an increased accessibility for pedestrians and cyclists (plans aiming at a constant reduction of the number of freight vehicles in the Municipality).

3. Status of E-mobility in Copenhagen Municipality

Facts about electric vehicles in Copenhagen Municipality

- By the end of 2013 there were 1.600 electric vehicles in Denmark and a well-developed network of public charging points distributed across the whole Copenhagen Municipality (both slow and quick charging points).
- Copenhagen Municipality has in summer 2013 purchased 48 Nissan Leaf
- Several companies already perform city distribution with electric vehicles. Further, there are operating car rental companies such as Avis and SIXT, which lease electric vehicles, both for private users and for companies (including leasing of electric vans used for city distribution); electric taxis are also in operation (Clean drive).

Initiatives on electric vehicles in Copenhagen Municipality

Copenhagen municipality is involved in projects concerning electric passenger vehicles and establishment of charging infrastructure. These projects are as follows:

- *E-mission in the Øresund Region aims to promote the spread of electric vehicles and stimulate sustainable economic growth in the Øresund Region. The main points of this project are: collaboration on payment, information campaigns, an annual electric car rally and a regional mayor summit. The project was initiated 1st of January 2011 and ended on 31st of December 2013.*
- *Green eMotion: The aim of the project Green eMotion is to create better conditions for a greater use of electric vehicles in Europe. The project aims to: develop and test the user-friendly and standardized technical solutions, collect data and exchange experiences between partners to identify "best practice". Green eMotion consists of 42 partners from industry, energy industry, electric car operators, municipalities, universities and research institutions. The project was started 31st of March 2011 and will be completed by 1st of March 2015.*
- *The project Greening European Transportation Infrastructure for Electric Vehicles is a TEN-T financed project for electric vehicles, which aim to analyse and test the deployment of integrated solutions for intelligent charging of electric vehicles such as charging stations and battery swap stations. The solution will enable the long journeys between several countries in electric cars and combine electric car journeys with train journeys. The method will be tested in Spain, Austria, Belgium and Luxembourg and in more depth in Denmark and the Netherlands, where three pilots will make it possible to optimize the technical and operational requirements. This would allow the same solution could be deployed across Europe at a later date. TEN-*

T started 1st of September 2010 and was ongoing until 31 December 2012 (COPENHAGEN MUNICIPALITY C, 2013).

- The City Logistic Project aims to study effects of integration of city distribution activities with an urban consolidation centre (UCC) located at the edge of the Copenhagen Municipality, where goods for distribution within the Municipality are delivered. The City Logistic Project also aims to investigate effects of integration of electric vehicles for last mile deliveries, i.e. from UCC to customers.

Regulations concerning electric vehicles in Denmark and in Copenhagen Municipality:

- Electric vehicles are exempted from registration and annual tax in Denmark. Not only newly produced electric vehicles are tax exempted, also previously utilised vehicles with retrofitted diesel/gasoline engines to electric motors are exempted when registered (DANSK ELBIL KOMITE, 2013). Tax for registration of a van depends on the car: 50% for vans below 4 tons, though the first 17 300 DKK of the price is excluded from taxation. For new vans with a maximum total weight of above 2.5 tonnes, (which are either open or without side windows behind the driver's seat in the car's left side), the tax is 0 DKK of the first 34,100 DKK of the taxable value and 30% of the remaining. (SKAT 2013). Annual tax, also called “green tax” is paid each half year. Its level depends on the vehicle’s fuel consumption per km and therefore, electric vehicle is inherently exempted from this tax, using 0 litres of petrol per kilometre.
- Electric vehicles are neither allowed to drive in bus lanes nor to enter pedestrian zones. One benefit available used to be free parking, but that was cancelled after 1.12.2011, due to national regulations. Therefore currently electric vehicles do not enjoy any special rights in Copenhagen Municipality.
- However, currently existing law can give an advantage to electric freight vehicles in the future, when electric trucks (above 3.5 tons) will begin to be utilized on the Danish market. Environmental zones in Denmark, “Miljøzoner”, are established in Copenhagen Municipality, as well as in the inner urban areas of three other cities in Denmark: Aalborg, Aarhus and Odense. In order to enter the environmental zone in Copenhagen, trucks above 3.5 tons needs to be equipped with filters, which reduce emission of PM2.5 by 80% and significantly reduce NO_x emission. Filter installation costs are 40 000-50 000 DKK. This cost can be avoided with electric truck, since electric vehicles emit 92% less of $PM_{2.5}$ and 76% less of NO_x than diesel vehicles meeting Euro IV standard (TRAFIKSTYRELSEN 2010)[xiii]. Currently, this benefit from using an electric truck is not used by the companies, since electric freight vehicles operating in Copenhagen Municipality are almost exclusively vans (WP 7.3 report).

- In Denmark there is no differentiation between a driving license for an electric and a conventionally fuelled freight vehicle. All vehicles below 3.5 tones have license category B, and all vehicles above 3.5 tonnes have a license category C.

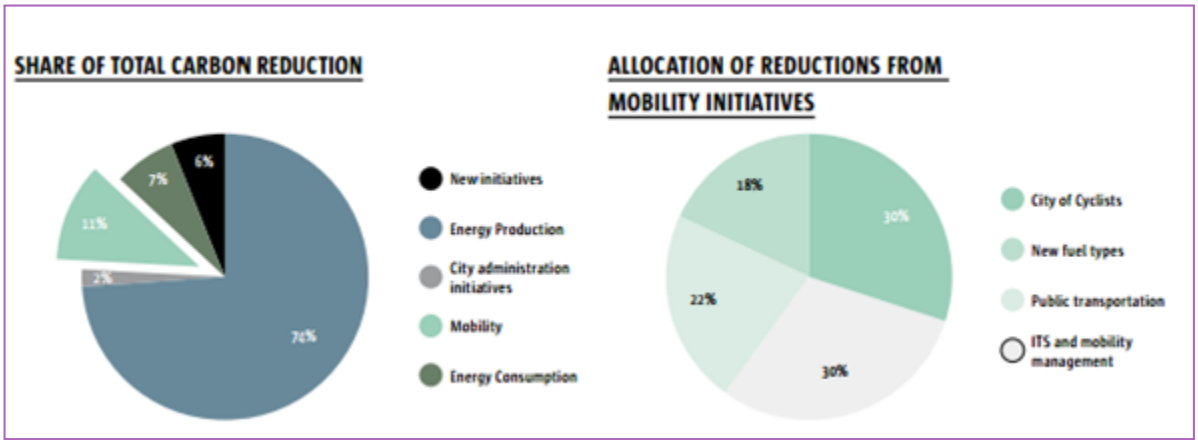
II. Goals

Goals established by Copenhagen Municipality

Copenhagen Municipality has within the *CPH 2025 Climate Plan* established ambitious goals regarding implementation of alternatively fuelled vehicles. The goal is to replace 20-30% of vehicles below 3.5 tons and 30-40% of vehicles above 3.5 tons with vehicles fuelled by alternative fuels by 2025. In case of vehicles below 3.5 tons, it is mainly electricity, bio fuels and hydrogen, while in case of vehicles above 3.5 tons these are mainly bio fuels.

Policies towards reduction of CO_2 emission in Copenhagen Municipality do not have a core focus on encouraging companies to switch their delivery vehicles to electric or any other alternative propulsion. This is mainly because **the transport area, and within it, alternative fuelled vehicles, are not planned to play a major role in achieving the CO_2 reduction goals established**. The main focus is put on the energy sector (81% of planned total CO_2 reduction), and not on transport (11% of planned total CO_2 reduction), where only 18% of CO_2 reduction is planned to be achieved through the introduction of new fuel types:

Figure 3 CPH Climate Plan: Role of alternatively fuelled vehicles in achieving CO_2 goals.



Source: COPENHAGEN MUNICIPALITY 2012 B p.21.

Therefore, **despite ambitious goals for the share of alternatively fuelled vehicles,** larger reduction seems to be possible from the accomplishment of actions directed into reduction of CO_2 emission from energy production.

Possible reasons for a low focus on reduction of CO_2 emission from the switch to alternatively fuelled freight vehicles

Firstly, **the freight transport sector is very hard to influence**, due to the diversity of activities performed and types of providers and customers. Actions undertaken might only have an impact on a small group of actors. Other sectors tend to be easier to influence from a municipality point of view. Therefore the low hanging fruits might be easier obtainable in e.g. the energy production sector where public administrations have more direct influence.

Secondly, **completion of goals is heavily dependent on changes and updates in national legislation**; very few regulations supporting the use of alternative fuels can currently be implemented at municipal level.

Thirdly, **the municipality is reluctant to ease access for freight transport, even if it is electric**. This is due to congestion produced by the vehicles and noise produced during unloading/loading activities, which are present, both when a silent engine of an electric vehicle and an engine of a diesel vehicle, are concerned.

Summing up, especially for the second reason, **market uptake by electric freight vehicles will not take place in the Copenhagen Municipality in the next few years, if national regulations do not strongly support it.** In Europe examples of an intense public support for electric passenger and freight vehicles can be found. Good examples are United Kingdom and Norway; one of the companies interviewed for the needs of this project directly pointed out, that it would deploy electric freight vehicles in Copenhagen, if similar incentives as in United Kingdom were available in Denmark.

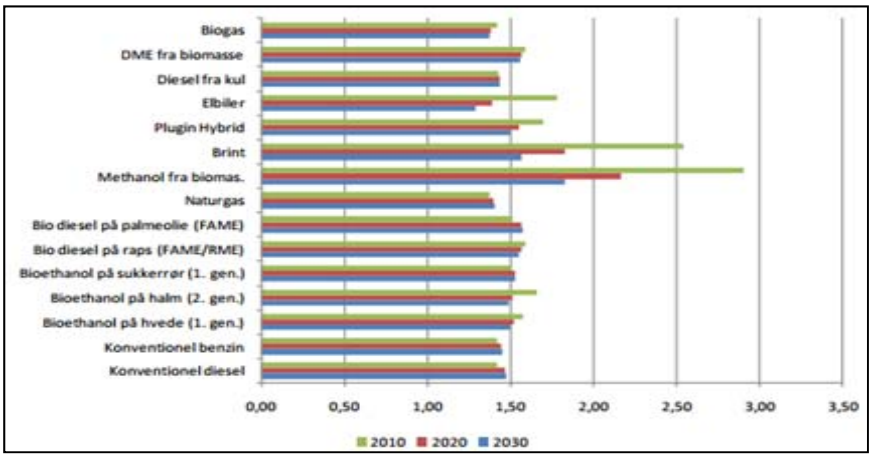
Non-financial support in form of regulatory changes and collaboration enhancement seems to be the most reasonable measure. This situation applies also to a few other types of alternatively fuelled vehicles, since currently these technologies are equally or more expensive than electric propulsion (Figure 5). Gas and bio fuels are currently cheaper than electric propulsion, but electric vehicles are the most cost-effective for simultaneous reduction of PM and CO_2 from all alternative fuels (see Figure 4 and 5).

Figure 4 Level of air pollutants produced by different types of alternative fuels (kg/GJ mech.)[xiv].

År 2006	Miljøpåvirkning (luftemissioner)					
Teknologi-spor	CO2 kg/GJ mek	CH4 kg/GJ mek	N2O kg/GJ mek	SO2 kg/GJ mek	NOx kg/GJ mek	Partikler kg/GJ mek
Konventionel diesel	394 (390)	0,00	0,02	0,01	1,12	0,04
Konventionel benzin	516 (511)	0,00	0,00	0,02	0,22	0,00
Bioethanol (1. gen.)	451 (322)	0,01	0,01	0,14	1,00	0,00
Bioethanol (2. gen.)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Bio diesel (RME)	164 (151)	0,00	0,02	0,02	1,60	0,04
Bio-olie	163 (152)	0,00	0,02	0,01	1,61	0,04
Naturgas	422 (396)	1,32	0,00	0,03	0,20	0,00
Methanol fra biomas.	90 (26)	0,00	0,00	0,06	0,25	0,00
Brint	670 (88)	0,01	0,03	0,59	1,61	0,00
Elbiler	249 (31)	0,01	0,01	0,22	0,60	0,00
Diesel fra kul	513 (446)	0,00	0,02	0,07	1,49	0,04
Diesel fra biomasse	158 (45)	0,01	0,02	0,12	1,38	0,04

Source: AARHUS MUNICIPALITY 2009, P.21.

Figure 5 Cost of different alternative fuels (DKK/km).



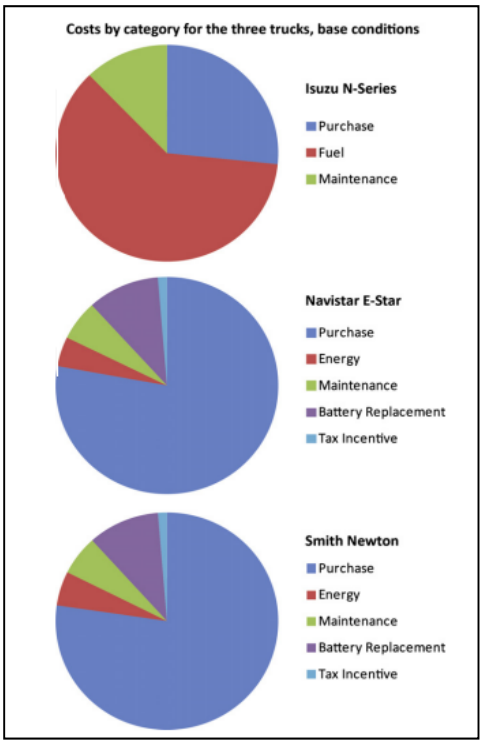
Source: Energistyrelsen 2013, p.50.

III. Definition of the required conditions for deploying delivery electric vehicles

1. Problems identified

- **First and foremost: purchase price should be lower**. The majority of the interviewed companies perceived the purchase price as being too high. Some companies have retrofitted their vehicles with an electric engine what decreased investment cost, however it seems to be that the retrofitted vehicles experience more technical problems than new mass produced electric vehicles.
- **Cost of establishing charging infrastructure should be lowered**.
- **Payload/capacity should be similar to this of conventionally fuelled vehicle**. Since payload/capacity is decreased, it leads to an increased travel time and therefore increases in labour, maintenance and fuel costs, where raise of the labour cost seems to be the biggest problem. Maintenance cost is a component, which can occur to be both lower and higher for electric vehicles compared to conventional ones. Some researchers argue that maintenance costs of electric vehicles are lower than of vehicles with internal combustion engines (B. A. DAVIS, M. FIGLIOZZI 2012 P.18), since the electric engine consists of fewer moving parts and therefore is less exposed to break downs (E-MOBILITY NSR 2013 A). On the other hand, there are opinions such as this of the director of Danish Association of Automotive Manufacturers "SKAD", who argues that maybe electric vehicle break down rarely, but its repair is extremely expensive. Second problem present in Denmark is that it can occur to be impossible to repair an electric vehicle, because costs of reparation are so high, that the vehicle risks being demolished. It is because it is required by Danish law to demolish a vehicle, if the reparation cost is higher than 80% of the vehicles' value (PHONE-BASED INTERVIEW WITH THOMAS KREBS, DIRECTOR OF DANISH ASSOCIATION OF AUTOMOTIVE MANUFACTURERS "SKAD") (MOTOR-MAGASINET, 2012, P.16).

Figure 6 Cost components for electric light conventional and electric truck



Source: B. A. DAVIS, M. FIGLIOZZI 2012 p.20.

- **Weight of the electric vehicles should be lower**. If a vehicle exceeds 3.5 tones GVW, a driver with an upgraded driving license (category C) is required, hereby labour costs may increase. Further, in some areas of Copenhagen, maximum 12 tonnes trucks are allowed, what, if electric trucks are deployed, would cause that trucks would be allowed to carry smaller payload than currently, due to high battery weight. This would of course cause higher costs for transport companies, who need to perform more shipments to deliver the same amount of goods.
- **Range should be higher**. An average distance travelled by freight vans in Copenhagen city is 135 km and by trucks is 134 km (DTU 2013). However, distance travelled daily by transport companies is higher, because they make deliveries not only within the city of Copenhagen, but also outside, within the same day; in the evening they perform a second shift outside of the Copenhagen area, after deliveries within Copenhagen Municipality are completed. One of the major transport companies in Denmark covers within the Copenhagen region distance up to 160 km per day on average (60 km outside Copenhagen city). There are already electric freight vehicles available, able to cover this distance, but the problem is that companies need to have also an energy backup, to make sure that vehicles are able to drive longer when needed (e.g. delivering under more difficult weather conditions when the range of electric vehicle decreases significantly). For the company covering daily a distance of 160 km, 200 km range is a minimum required before deployment of electric vehicle would be considered. **With the currently available range, electric vehicles could be used only for short routes**, inside Copenhagen Municipality. This however **decreases flexibility of the business**; in case of a need for additional vehicles at the longer routes, they simply cannot serve them.
- **Higher availability of repair shops with staff trained to cope with electric vehicles and higher availability of spare parts.** Long waiting time for a repair results in a diminished flexibility of the company when an electric vehicle breaks down. Further, in the meantime when vehicle is being repaired, a backup vehicle will not be provided; there is no such service available from electric vehicle dealers yet. It is only available for the leased vehicles, but the cost of leasing is still very high compared to leasing costs of conventional ICE vehicles.

If these problems are not dealt with, or investment costs are not further subsidised by public authorities on national level, then **electric vehicles should provide other benefits such as making it easier to drive and park in the city. First then they will be able to** compete with ICE vehicles. One of the interviewed international transport companies would like to implement electric delivery vehicles on the Danish market, but sufficient incentives making

usage of these vehicles economically reasonable are not yet available in Denmark. The company has implemented electric delivery vehicles in United Kingdom. Here, next to tax exemption for purchasing an electric vehicle, zero congestion charging for EV's is implemented. In Denmark, tax exemption from registration and annual tax is not sufficient to make the price of electric vehicles competitive: still they are twice as expensive as conventional ones. ***Action needed:*** since financial commitment of public authorities is already high, other types of incentives, such as these connected with spatial planning should be provided, if an authority is interested in supporting deployment of electric vehicles.

2. Conditions required to enable green image becoming profitable

Creation of a green image is one of the main benefits associated with deployment of electric freight vehicles, as perceived by the companies. Therefore it is extremely important to enable this benefit to be used.

- **A green and sustainable profile is a necessity on today's market** according to the interviewed transport companies. Customers request an environmental strategy and are looking for partners, who can support their own initiatives in the field. *If customers have a green image, they will have problems not choosing the greenest supplier*, according to one of the interviewees. However, what was also underlined is that customers will not pay more for a product because it is "greener"; price of the goods provided must still be competitive. According to one of the major transport companies supplying shops in Copenhagen Municipality, 98% of their customers are primarily interested in the competitive price of their services. Therefore, **it is an advantage to offer a product supporting a green image of a commercial customer, but only if the price stays competitive**; it can be higher, but cannot be significantly higher. Therefore transfer of costs connected with the use of electric vehicles to customers of transport companies is possible, but only a minor part of these costs.
- **A green image is perceived as a future investment and not as an investment which can provide profit today**. Concerning specifically electric vehicles it is expected that their deployment today will give an advantage over competitors in form of experience with operation of these vehicles.
- **The goods delivery business is a well-suited sector for building a green image through investments into vehicles**. Companies invest into a green image in fields of their activity where it can be most visible for clients; mainly in the fields where the majority of the business' expenses are borne. Therefore, urban goods delivery activity seems to be a good market to create a green image through investments into vehicles. Firstly, transportation of goods accounts for a big part of expenses borne

within this business. Secondly, vehicles are well visible for companies' clients – as they are present on city's roads.

- **It is much easier to attract private than commercial customers to pay additionally for "greener" products and services** when it comes to energy supply. According to one of the biggest energy suppliers in Denmark, private energy users (residential users) are a vast majority of this company's clients. Clients who switched their energy supply plan to a more expensive one, but hereby ensuring a larger share of green energy sources used to produce the electricity provided; the interest from commercial energy users for such green solutions are lower. This information can lead to the reasoning that it would be easier to attract private buyers of electric vehicles than commercial ones, since the main profit associated with these vehicles are benefits for environment and not for the economic profit. Whether this is true is left as an open question.

To sum up main requirements of the interviewed companies: if purchase price of electric vehicle was the same as for conventional vehicle and the available range was at least 200 km, one of the interviewed transport companies would deploy electric vehicles to their fleet. The major problem is still the too high price and the decreased flexibility of vehicle usage. One other interviewed transport company, would deploy EVs, but only when the life time cost of an electric vehicle become equal to the life time cost of a diesel vehicle. Purchase cost does not have to be equalized; what matters is the total cost of ownership. The company perceives public support as a necessity for now to deploy further electric vehicles to their fleet; they would not deploy EVs if incentives from public authorities and programs from European Union were not available.

Another interviewed company does not see much space for electric commercial vehicles in Denmark for now; it perceives private customers as much more willing to invest additional funds into environment friendly solutions; they have experienced a very positive feedback from their customers for switching to more expensive, but cleaner electricity supplies.

Within the field of electric freight vehicles, it is easier to attract big companies to invest into electric vehicles. It is because cost of a vehicle is often not an important cost component in the total costs of their business. Companies performing goods distribution are usually of a moderate to big size. Therefore, it can be suspected, that a majority of them can afford investment into electric vehicles; question is what they can get in return.

IV. Summary of findings (Section I-III)

4 aspects of required conditions for deploying electric vehicles were identified:

FIGHTING PROBLEMS LINKED TO DEPLOYMENT OF ELECTRIC FREIGHT VEHICLES

- The most important: focus on (lowering ↘) of purchase cost, where the most important is reduction of the battery cost.
- Focus on ↘ of cost of deployment of charging infrastructure.
- Focus on ↘ the negative impact of a low range
- Focus on ↘ the negative impact of reduced payload on the increased labour cost
- Maintenance and fuel cost were found less important to be decreased for an electric vehicle

ENABLING BENEFITS OF ELECTRIC FREIGHT VEHICLES TO COME TO SURFACE

Focus should be put on strengthening the impact of the benefits associated with electric vehicles, which can bring considerable profits:

- Possession of a green image

ARE THE POTENTIAL INCENTIVES SUFFICIENT TO ENCOURAGE COMPANIES TO DEPLOY ELECTRIC VEHICLES?

YES 

So focus mainly on the transport companies, but create also promotional actions about benefits of green image to the other actors within the delivery chain.

 **NO**

Costs of electric vehicles should also be covered by other actors and incentives should therefore be directed to them as well:

- suppliers of the company,
- company's clients (retailers)
- final customers

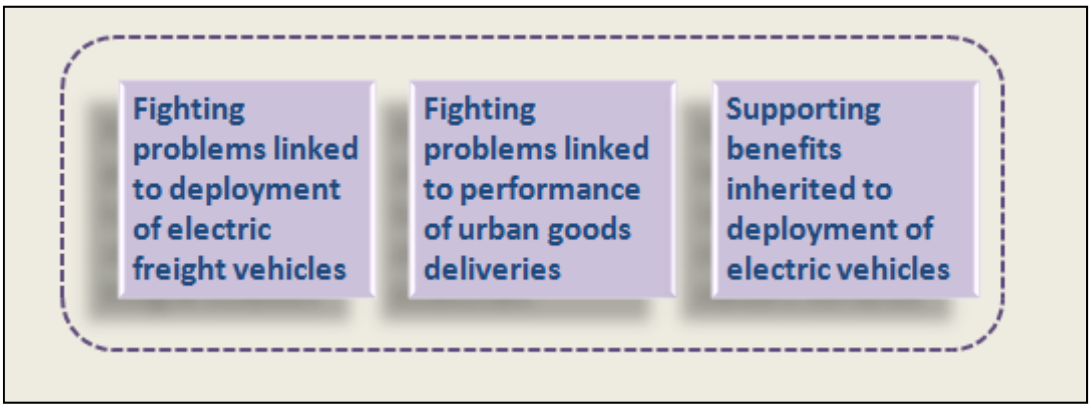
In addition to supporting the implementation of electric vehicles for public authority use, conditions required for deploying electric freight vehicles by transport companies is a crucial piece of information to develop a beneficial action plan for. For this information on the problems associated with urban deliveries and the ways in which the switch to electric propulsion can assist their solving, is also essential information, since it provides information on conditions, which may support deployment of electric vehicles. This was elaborated in section I3 of this document, and in here a short summary of its findings is presented:

FIGHTING PROBLEMS LINKED TO PERFORMANCE OF URBAN GOODS DELIVERIES ACTIVITIES

- The most important: Actions enabling ↘ of labour costs in relation to the deployment of electric vehicles; this is the most important cost factor for transport companies in Copenhagen Municipality.
- Focus on decrease of fuel cost through deployment of electric vehicle should not be the main focus.

V. Recommendations for supporting the deployment of electric delivery vehicles in Copenhagen Municipality

The recommendations presented focus on how to bring to life recommendations provided in section I and III (summarized in the end of section III), including how to enable **a decrease of costs associated with urban deliveries through a switch to electric vehicles,** how to **decrease costs associated with electric vehicles** and how to enable **benefits associated with switch to electric vehicles to come to surface.**



While developing recommendations for this section, all relevant actors in the urban delivery chain were considered and therefore focus is not only put on delivery companies – (purchasers of electric freight vehicles). In general, the creation of simultaneously environmental friendly and effective city logistics is not possible, if only delivering companies are to realize this vision; there must be a cooperation of all city logistics actors: state, municipality, receivers and the delivery companies (Danske Fragtmænd Aarhus 2010).

1. Regulatory tools

RECOMMENDATIONS FOR SOLVING PROBLEMS ASSOCIATED WITH URBAN DELIVERY ACTIVITIES, WHICH CAN BE SUPPORTED WITH THE INTRODUCTION OF ELECTRIC VEHICLES

- *Problem*: High labour cost, which is the main cost associated with urban deliveries. These are decreased when the delivery time of the individual vehicle drops or the number of shipments/vehicles required to deliver goods is decreased (keeping all the ordered goods delivered). *Action proposed:* Firstly, labour cost can be decreased if electric vehicles have an extended delivery window allowed; this way time of deliveries can decrease, because goods can be delivered outside the hours of the heaviest traffic. **Night time delivery also has the potential decrease time of deliveries**.
- *Problem:* Low accessibility due to spatial and time-related access restrictions. *Action proposed:* firstly, **electric vehicles could be allowed to access pedestrian zones and have a longer delivery window**, under the condition, that the environmental benefits associated with these vehicles prevail over the cost of increased traffic in the area[xv].
- *Problem:* Low accessibility for freight vehicles above 3.5 tonnes due to environmental zones. *Action proposed:* **Electric vehicles could be allowed to drive in the environmental zone even if the GVW is above the restricted value**, considering their low local impact on the environment. This could be done by e.g. deducting the battery weight from the GVW of the vehicle.
- *Problem*: Low accessibility due to scarcity of places to unload/load goods from vehicles. *Action proposed:* **Parking restrictions could be abolished for delivery electric vehicles or the addition of loading bays reserved only for electric vehicles could be implemented**[xvi].

Copenhagen Municipality is not interested in the following regulatory solutions:

- Allowing entrance into restricted (e.g. pedestrian) areas.
- Usage of bus lanes for electric freight vehicles.

RECOMMENDATIONS FOR SOLVING PROBLEMS ASSOCIATED WITH THE INTRODUCTION OF ELECTRIC VEHICLES

- *Problem addressed*: decreased payload/ increased weight of a vehicle due to a heavy battery, resulting in access restrictions and higher labour cost (more expensive drivers with license for vehicles above 3.5 tones might be required and a longer time needed to deliver products due to less payload). Labour cost is a main cost driver for companies performing urban distribution, so this can give a visible impact. *Action proposed:* **Changes in the law excluding battery weight from the GVW**.

- *Problem addressed*: high purchase price. *Action proposed*: It is important to **keep tax exemptions** till the time of equalization of prices of electric and conventionally vehicles (which is expected to happen no earlier than in 2020).

- *Problem addressed*: higher range required. *Action proposed 1*: **Establishment of charging infrastructure in new urban development areas**. [xvii] *Action proposed 2*: **Active traffic management implementation** (see pp. 9-10) can help to increase efficiency of fuel usage, this way extending range of electric freight vehicles.

- *Problem addressed:* Electric vehicle are in risk of being demolished if they are involved in tough crashes. *Action proposed:* **Changes in the legislation increasing cost of repair after which (electric) vehicle is not allowed to be repaired, but must be demolished** (80% damaged currently).

- *Problem addressed:* It is risky to drive electric vehicles, because the safety is not thoroughly proved. It is not that the electric vehicle is risky to drive, but there is no proof that it is not risky to drive. *Action proposed:* **Legislation regulating safety conditions under which an electric vehicle is allowed to be sold at the Danish market should be further developed, including safety aspects of the electric power system in case of accidents**.
- *Problem addressed:* Workshop workers might not be fully aware that it is a high voltage vehicle, and that these vehicles therefore require a different way of handling at the workshop. Today, electric vehicles are not registered as vehicles using high voltage, but they do use high voltage for charging the battery. *Action proposed:* **Special safety steps (training/spread of information among mechanics) must be undertaken in order to ensure security of working environment at the workshops**.

2. Cooperation between stakeholders

Citing a goal established by Copenhagen Municipality: *Collaboration with the business community and other public authorities including incentives to encourage the business community to purchase electric cars*. Support of cooperation between the following stakeholders is recommended: transport companies, suppliers of transport companies, retailers, electric vehicles' dealers and insurance companies (both between the groups and within the groups). Only recommendations concerning cooperation to solve problems linked to electric freight vehicles were identified.

RECOMMENDATIONS FOR SOLVING PROBLEMS

ASSOCIATED WITH THE INTRODUCTION OF ELECTRIC VEHICLES

- Problem addressed: Electric vehicles is a new technology, and therefore there is a scarcity of repair shops specialized in dealing with these vehicles. *Action proposed* 1: **Sharing experiences with usage of electric freight vehicles** between public authorities in Copenhagen Municipality and companies owning these vehicles, as well as between companies. This can help to quicker solve problems etc. *Action proposed 2:* Cooperation **of public authorities with dealers or manufacturers of electric vehicles** to encourage them to conduct training concerning handling electric vehicles in the repair shops. Encouraging electric car dealers to offer services of delivering interim vehicles.

- Problem addressed: high insurance price. *Action proposed*: **Enabling/supporting dialog between manufacturers/dealers of electric vehicles with insurance companies**. This can support development of broader insurance opportunities for EV's, differentiation between the insurance fee for an ICE vehicle and an EV (E-mobility NSR WP 7.3 report).

- Problem addressed: high purchase price. *Action proposed*: More opportunities for leasing of electric vehicles. Enabling more companies to offer leasing of electric vehicles could be an option; as it is for now in Denmark, leasing of electric vehicles is too expensive, prices must go down. The most important is to **build a stronger competition on the leasing market**: it can probably be partially achieved through leasing of electric vehicles by the municipality, instead of buying them.

- Problem addressed: high cost of establishing charging infrastructure for electric vehicles. *Action proposed:* As a way to decrease costs of charging, **building and using charging infrastructure together by several companies** utilizing electric vehicles can be considered, this way decreasing costs associated; maybe collaboration can even be supported by the municipality in form of PPP's. Action which is not needed: public charging points. It is cheaper to own charging infrastructure than to pay for using it in a long term, therefore, this option is preferred, at least by big companies. Further, it is also cheaper, because labour cost is saved this way; drivers do not spend their working hours on looking for an unoccupied charging spot.

- *Problem addressed:* Public workers responsible for handling road accidents should be trained to be able to cope safely with electric vehicles. *Action proposed:* **Cooperation between dealers of electric vehicles, users of electric vehicles and the public authorities should be established in order to share information** and on this basis train those responsible for handling road accidents: police and fire brigades.

- *Problem addressed:* High total cost of ownership, where the battery cost is a major part of the purchase cost of an electric vehicle. *Action proposed:* **Public authorities can stimulate dialogue between the batteries' owners and potential purchasers**, informing both sides about possible benefits of their cooperation. Since purchase price is the main obstacle discouraging companies to switch to electric vehicle, it is very important to take steps to reduce battery's cost. Purchase price of a battery cannot be currently reduced, for this technological breakthrough is required, but the lifetime cost of a battery can be reduced. When the battery's capacity decreases that much that it cannot any longer supply sufficient power to a vehicle, it can be used as energy backup at home or sold. IKEA is one company, which already started purchasing partially used batteries and using them as energy storage (E-MOBILITY NSR, 2013).

3. Promotion

A big part of promotion of electric vehicles is made by companies selling them and the related services and products (e.g. charging infrastructure). For instance public charging points are established mainly for promotional and CSR reasons, and to ensure that clients feel safe about driving their electric vehicle around the city. This way, it seems to be unnecessary to conduct promotional actions, which aim purely at informing inhabitants that electric vehicles exist and are on the market; this stage is already passed. What should be done is to show that electric vehicles are reliable and that there are actually companies and institutions, who decided that it is convenient and beneficial for their businesses to drive electric vehicles.

As experiences show, the majority of charging is done at private charging points: either at homes or at work; company vehicles are mainly charged at the company's own premises. It is mainly because companies do not know if the public charging point is occupied at the moment of their arrival, they cannot be sure about its availability. Potentially, communication between the charging points and the vehicles could deal with this problem, but still, delivery vehicles cannot look around the city for a free charging spot; transportation expenses and time account for a too big part of the total costs of performing business activities in this sector of economy.

The aim of goals established for the city administration of Copenhagen, is to promote alternatively fuelled vehicles (COPENHAGEN MUNICIPALITY 2012 B, P.42). However, initiatives such as deployment of electric vehicles by the City of Copenhagen cannot be expected to significantly contribute to the achievement of the goal of a 20-30%/30-40% change to alternatively fuelled vehicles throughout the whole Municipality area. These actions will hardly contribute to achievement of the described goals, since the fleet of the municipality only accounts for a small percent of the total number of vehicles operating in Copenhagen. Therefore, these actions can give only an indirect effect: an increased visibility of alternatively fuelled vehicles on roads would show that they are reliable and worth investing in. This action should not be expected to give a significant promotional effect on the transport companies.

According to the interviewed companies, lack of knowledge about the alternatively fuelled vehicles (at least when it comes to electric vehicles) and lack of trust in their reliability, are not the core reasons for companies being reluctant to deploy them. The main reasons were described in chapter III, clearly showing, that such promotional actions conducted will hardly change companies' attitude towards purchase of electric vehicles. **Instead, in the current situation of significantly higher purchase prices of electric freight vehicles, more tangible incentives, such as changes in spatial and time access**

restrictions can give a competitive advantage to the companies using more environmentally friendly vehicles, and are therefore considered necessary.

RECOMMENDATIONS FOR ENABLING THE BENEFITS ASSOCIATED WITH DEPLOYMENT OF ELECTRIC VEHICLES TO COME TO SURFACE

- *Problem addressed:* Investing in a green image is not considered profitable for companies performing urban goods distribution. *Action proposed:* Support for creation of a well visible green image – through electric vehicles: **award of a sustainability label and other kinds of promotion of companies deploying vehicles, which reduces their environmental footprint**.

- *Problem addressed:* Suppliers of companies performing urban deliveries (meaning: all companies selling services and products to the companies performing urban goods distribution) do not perceive benefits coming with green image of their company. *Action proposed:* **Information campaigns and promotional actions as described above for the goods receivers should also be directed to suppliers of companies performing goods distribution**, so that they are aware of the positive impact and effects created by the green image. An example of one of the big international transport companies operating in Copenhagen Municipality shows, that new customers came, because of the company's focus on reduction of CO_2 emission, and if suppliers also reduce it, even more could come, what would also increase the turnover of suppliers. This way, suppliers can be encouraged to build their green image through e.g. giving discounts for their services or products to these customers, who focus on building a green image.

- *Problem addressed:* Only if the price of the provided service stays low it gives a competitive advantage to offer a product supporting green image to a retailer; transferring costs of building a green image to their clients can cause loss of clients. *Action proposed 1:* **All promotional actions from the public authorities are needed in order to grow a group of retailers interested in building their green image.** Information campaigns to shops/receivers, so they don't perceive increased transport costs coming from greening of transportation, as a reason to resign from services of the company. The municipality from its side can also conduct promotional campaigns directed to all inhabitants of the city, so that they consider paying a little bit more for a product, knowing that this way they support a cleaner, less congested and less noisy city; this way part of the green image costs can maybe be divided between: transport companies, receivers and customers of receivers. *Action proposed 2:* **Part of customers might be interested in having an opportunity to pay additionally for a product/delivery, which CO_2 emission or environmental impact in general is lower than a delivery proposed at a standard price**. This way, companies are not threatened by a loss of customers due to higher price of their services; customers who want to create a green image this way will pay more and those who are not interested will pay a standard fee. They can pay e.g. for deliveries performed with an electric vehicle. Since electric vehicles are significantly more expensive, then it is possible that a group of customers interested in a "greener" service must be sufficient, to enable intensive usage of the electric vehicle. Part of the cost of electric vehicle covered by receivers, who improve this way their image by becoming greener. This way spending on electric vehicles are to be paid by more stakeholders.

- *Problem addressed:* Many retailers do not require companies delivering products to them to possess a green image. *Action proposed:* **Providing a good example by public authorities**: external suppliers of Copenhagen Municipality are requested to use electricity, hydrogen and bio fuels.

4. Financial support tools

Which actions should be undertaken, if tax exemptions for electric vehicles are not kept after 2015? Should other financial incentives than tax exemptions be implemented? What should be done now by the municipality and government to avoid a situation where sales of electric vehicles drop after termination of tax exemptions? In general, **direct financial support tools, such as subsidies for vehicles purchase are not recommended over indirect financial support tools such as e.g. tax dependent on pollution produced by the vehicle** (WORLD BANK 2004, P. XX).

It is recommended, that the value of tax put on a vehicle should not aim to encourage a specific vehicles' technology, such as electric vehicles, but should be dependent on the level of pollution produced by specific fuels, so that tax decreases are available, only for specific types of alternative fuels, as it is in Denmark by now. This way, consumers are free to decide what is most profitable: obtaining higher tax exemption or lower, considering costs of specific technologies decreasing emissions. This way vehicles reducing pollution in the most cost effective way are chosen.

Alternative fuels

Many alternative technologies for vehicles' propulsion are expected to develop and become cheaper in the next years (see Figure 5). Policy makers can support these processes by tightening restrictions for emission of air pollution today. This way a need of vehicles' manufacturers to develop technologies and compete with each other in this field rises. This competition causes a drop of prices of technologies. Since the presence of competition between different alternative technologies of vehicles' propulsion is crucial for enhancing their fast development and drop of prices, actions harming this competition should not be undertaken by public authorities. Therefore, actions such as subsidies/tax exemptions directed only to specific vehicles' technologies chosen by public authorities are not recommended. On the other hand, actions recommended would be support of new technologies through tax system based on the emission level produced by a vehicle.

5. Logistic chain optimization

Off-peak deliveries and urban consolidation centre concepts can potentially support the implementation of electric freight vehicles to the market. However, this is only possible under two conditions: firstly, one of these concepts is found attractive by the companies, meaning: more attractive than the concepts currently utilised by them for their logistics system, and secondly, inclusion of these concepts is reserved/prioritized for the companies using low emission/electric vehicles. **If only the first condition was met, companies would switch to night distribution/consolidate goods, but not to low emission/electric vehicles.** Recommendations concerning actions meeting the first condition are presented in this chapter. Recommendations regarding the second goal can be summarized in one action - **the setting up of regulations, enabling night deliveries in general, but decreasing the possibility of vehicles producing high noise and high emission to operate in this time**, providing this way an advantage for more silent and cleaner vehicles.

Off-peak deliveries[xviii]

Off-peak deliveries concept

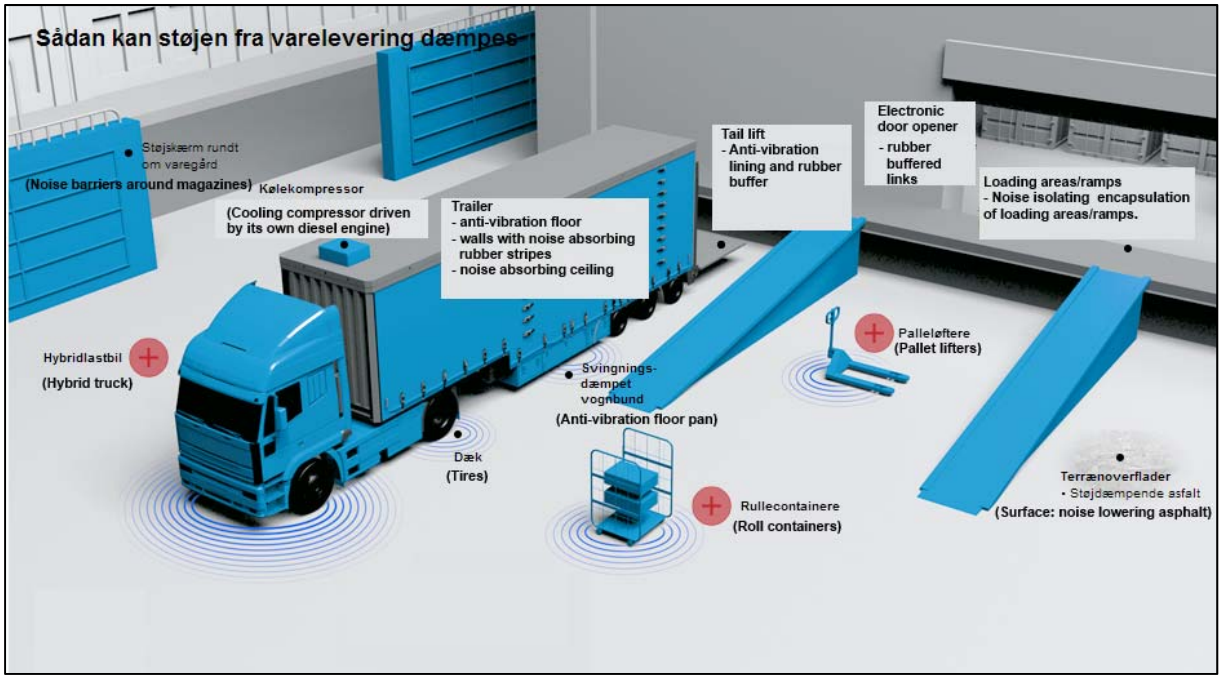
The concept is considered as a potential tool for supporting the deployment of electric freight vehicles for urban goods distribution as it enables conversion of the low noise emission character of EVs, into a tangible benefit for transport companies. Since EVs produce low noise, they could deliver between 10 pm and 7 am, while other vehicles are not allowed. However, gas and hydrogen fuelled vehicles can also deliver within these hours, since they also produce low noise. Good information for EVs is that the cost of retrofit to gas and electric engine would cost the same: both investments costs are 40-50% higher (conference on night distribution 2013).

Off-peak delivery is a promising idea to benefit the city environment and the transportation companies. It decreases congestion, because it allows removing a part of the vehicles from the peak hour traffic. Through this, it decreases the total emission and noise produced. The off-peak delivery reduces delays of logistics providers, because they can use the 'free roads' capacity during the night. Thus, transportation companies can reduce the most important cost factor: labour cost, provided that drivers are paid the same rates during both day and night hours.

Additionally, access restrictions in operation during day time, can potentially be removed, since they are mainly established to ease movement of pedestrians, who are almost absent during night time. Moreover, road safety will be increased by this method, because there will be less vehicles running on the roads during day.

One of the **problems to implement night delivery** is that it requires that transportation companies invest in quiet vehicles and loading equipment (NICHES Consortium). However, electric vehicles can solve parts of this problem, since they produce much lower noise. They are better suited for the night time operation, but still noise reducing retrofits of the loading and unloading equipment are required (BACKGROUND REPORT 2013).

Figure 7 Noise reduction possibilities for goods deliveries



Source: Ingenioren 2013.

The other problem is that many retailers within Copenhagen Municipality are too small to organise a separated locked facility in order to get deliveries when the shop is closed. Therefore, only big retailers having such a facility can have goods delivered within the off-peak hours. Continuously, **support of this concept as encouragement to deploy electric vehicles will affect only a part of delivery activities in the municipality and other tools should be used in parallel**.

Example: Off-peak deliveries programmes conducted in Denmark

In Denmark, several pilot projects and programs supporting spread of the night distribution concept have been conducted. More information about the biggest one can be found at: http://www.trafikstyrelsen.dk/DA/Groen-Transport/Forsogspuljen/Fors%C3%B8gsprojekter/Gods/DYT--Distribution-i-Ydertimerne.aspx

Another problem is that vehicles should have at least a 12 ton payload to be perceived by companies as profitable to be used for off-peak deliveries, while electric delivery vehicles currently available on the market are not sufficiently spacious to meet these requirements (Communication with NETTO Denmark, 2012). However, it is possible to be changed in the near future: in October 2013, a special 19 ton GVW Smith Electric truck designed for Heineken was released. It is a first truck which payload is around 12 t. The positive information is that, if the problem of an insufficient payload is solved, the second major noise problem present for the day time operation will not appear. Cost of noise reducing retrofits of a vehicle required for the night time deliveries is the same when switching to gas and/or electric engines. As a result, **difference in investment cost for silent equipment for electric and conventionally fuelled vehicles, allowing them to operate during night time is expected to be similar**.

RECOMMENDATIONS FOR ENCOURAGING DEPLOYMENT OF ELECTRIC FREIGHT VEHICLES THROUGH DELIVERIES OUTSIDE PEAK HOURS

- As long as electric trucks are tax exempted, they can occur to be more cost-competitive than gas fuelled trucks, since the cost of retrofit to gas and electric engine is expected to be the same. Therefore, it **is crucial to keep the currently available tax exemption for electric (freight) vehicles in Denmark**.
- **In case the tax exemption is not in place anymore, implementation of a system of fees based on the criterion of level/cost of pollution produced is recommended** as a second best, but a radical option. In the day time fees would be higher than during off-peak hours, this way encouraging vehicles to deliver in the latter time period. During off-peak hours fees would be lower for e.g. electric vehicles than gas propelled ones. Level of fees should potentially correspond to cost of pollution produced in each situation.

Additionally, few recommendations concerning encouragement of off-peak deliveries alone were developed. They do not directly support implementation of electric vehicles, but the off-peak time of deliveries.

RECOMMENDATIONS FOR ENCOURAGEMENT OF OFF-PEAK DELIVERIES[xix]

- Regulations on night distribution should be aligned through the whole municipality; as it is more expensive for the transport company if transportation in some districts it is not allowed during night. This way, the trucks drives through many districts within the off-peak hours where it has to deliver goods, but can do it only in some of them. This way, the rest of deliveries must be performed during the day time, so to sum up trucks must drive longer distance in total.
- It is not a problem for transport companies to deliver during off-peak hours; they perceive the benefits associated as prevailing over additional costs. The major problem lies at the receiver side, since they need to spend additional funds on labour/ adaptation of the shop's space in order to get deliveries in during night time. Therefore in order to encourage off-peak hour deliveries, the following steps should be considered:
  - Decrease costs of receiving goods in the night time: one of the options can be to build an UCC, where goods can be delivered during the night time and transported only for short distances, the so called *last mile,* in the morning: this way shops do not need to hire additional workers and adapt the space, instead they will have to finance the operation costs of the workers at the UCC. A benefit of such a solution for retailers is a consolidation of deliveries, so that they can be made at once. Another way could be to undertake an informational campaign, which would show the receivers that it could give cost saving to have goods delivered outside the normal opening hours.

Goods consolidat*ion*

*It is benef*icial for the city environment and its liveability to consolidate goods and in this way decrease the number of vehicles, thus reducing congestion, noise and pollution. Goods consolidation also has benefits for the goods receivers: they can have goods delivered once a day instead of coping with multiple deliveries conducted separately by different suppliers. In result, there is more time to serve clients and sell products. This benefit was realised by e.g. retailers in Ghent city, Belgium, who share costs of UCC's operation and maintenance.

Goods consolidation concept

It was considered as a potential tool for supporting the deployment of electric freight vehicles for urban goods distribution, because it can fight one of the most important problems associated with these vehicles: a decreased payload compared to conventionally fuelled ones.

However, with regard to companies delivering goods in Copenhagen Municipality, additional costs associated with goods consolidation prevail over the benefits, especially when it comes to the urban consolidation centre (UCC). The benefit is that goods consolidation increases the utilization ratio of the loading space since vehicles can be loaded with goods from many suppliers, which would normally be transported with separate vehicles by different companies; this way the cost of deliveries is lowered. Additional cost coming with goods consolidation appears, because this activity requires an additional transhipment spot in the logistic chain, what is connected with higher expenses. This cost is an important cost factor in the total cost of performing urban goods deliveries – warehousing costs accounts for 38 % of total costs of urban goods deliveries (the other cost components is goods movement - 60% of the total cost and administrative cost – 2%) (Information for the delivery market in USA, M. Hesse, J.-P. Rodriguez 2004, p. 180). The cost coming with goods consolidation is especially visible when goods are consolidated within the core city area, since land cost is very high in such districts.

Example: City Logistics Project conducted in the Copenhagen Municipality

The scope of the project is to launch a City Logistics Centre in CPH. Project coordinators of the project argue that companies performing goods distribution are not interested in this concept due to higher costs associated with goods distribution requiring an additional reloading point in the logistic chain. Therefore, they focus instead on retailers, who this way might save costs and inconveniences associated with deliveries, since all goods ordered by a retailer can be packed to one vehicle and be delivered at once. In order to make retailers aware of the benefits, pilot tests projects involving 150 shops is planned to be undertaken, followed by an information campaign.

RECOMMENDATIONS FOR ENCOURAGEMENT TO DEPLOY

ELECTRIC FREIGHT VEHICLES THROUGH GOODS CONSOLIDATION

- The possibility of using **goods consolidation at UCC's will not in itself encourage transport companies performing Copenhagen Municipality to deploy more electric** vehicles, since goods consolidation at UCC creates additional costs for these companies. In result, besides of the cost of switching to an electric vehicle another cost must be borne, what can even discourage companies to deploy electric vehicles.
- An option to cope with this might be that UCC's are established, so **associated costs are borne by retailers (customers) and not by companies delivering goods**. Retailers is a group, which can gain much from goods consolidation, thus they can be interested in covering costs of this process. However, market analysis of retailer's attitude towards this solution should be performed before establishment of UCC, because only a big number of shipments through this facility can keep it profitable.

VI. Recommendation

There are different ways to reduce air pollution from transport. The switch to alternatively fuelled vehicles is one of them. Even though this document focuses on recommendations for deployment of electric vehicles, it does not mean that authors of the report perceive alternative propulsion for vehicles as the ultimate and supreme solution to fight problems associated with transport in cities. It should be noted, that policies supporting deployment of electric vehicles is only a part of the picture. Air pollution can be significantly reduced with electric vehicles and spread of other alternative vehicle's technologies. However, the problem of congestion and to some extend of noise produced by urban goods distribution activities stays.

In the field of urban goods deliveries, this field could be supported by logistics solutions described in this document: off-peak deliveries and goods consolidation. In general, there should be a focus on decreasing the number of vehicles/shipments required to deliver demanded products or by decreasing the distance required to be travelled by the respective vehicles for performing their transport services. Copenhagen Municipality is aware of this need, focusing not only on support for deployment of alternatively fuelled vehicles, but also on improving city logistics systems, e.g. in form of creation of urban consolidation centre within the City Logistics Project.

Short term goals

- **Taxation based on level of emission produced by vehicles is recommended,** instead of the current one giving tax reliefs only to technologies chosen by public authorities. In the long term this could also cause a decrease in the price of new technologies.
- **Regulatory incentive tools are the most desired**. In the current situation of uncompetitive investment costs of alternatively fuelled vehicles, further financial support is not desired due to high "opportunity costs". On the other hand properly designed spatial and time access incentives are not linked to such costs.
- **Promotional tools not directly focusing on electric vehicles** are recommended. Emphasize should be put on:
  - Advertising benefits of possessing green image to suppliers and customers of companies performing urban goods distribution. This way they are encouraged to accept higher cost of deliveries in exchange for a green image being provided.
  - Increasing the need for companies to possess a green image through informational campaigns directed to citizens, increasing their knowledge on

health costs associated with air pollution and noise and in this way encouraging them to accept higher prices of products and services in exchange for reduced environmental impact.

Long term:

- Direct subsidies for purchasing electric freight vehicles (or other alternatively fuelled vehicles) is not among the best means for reduction of emissions from the transport sector – a better way to further introduce alternatively fuelled vehicles, is to give them competitive advantages, such as those seen in e.g. Norway, where electric vehicles can drive in bus lanes, run free in congestion zones, charge for free at certain urban charging points operated by the municipalities, pass toll roads for free, etc. Hereby savings on the running costs provides incentive for the purchase of more environmentally friendly vehicles for the benefit of both users and the city inhabitants.

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Footnotes

[i] Section is based on and uses parts of the Background report 2013.
[ii] Source is based on and uses parts of the Background report 2013.
[iii] Data does not including construction of vehicles
[iv] Ibidem.
[v] Section is based on and uses parts of the Background report 2013.
[vi] Including only PM2.5, NO_x and SO_2, since this data was the only one available.
[vii] Assumption, that personal vehicles fleet in Copenhagen Municipality consists of 50% of gasoline and diesel fuelled vehicles. It is a rough estimation, used only in order to enable estimation of share of cost of pollution produced by freight vehicles.
[viii] Diesel is almost the only propulsion used for freight vehicles operating In Copenhagen Municipality. However, a specific data on percentage share of diesel and gasoline within the vehicles operating in Copenhagen Municipality was not available. Therefore it is assumed that diesel vehicles account for 100% of freight vehicles operating in Copenhagen Municipality.
[ix] Excluding personal diesel vehicle.
[x] Assumption, that personal vehicles fleet in Copenhagen Municipality consists of 50% of gasoline and diesel fuelled vehicles. It is a rough estimation, used only in order to enable estimation of share of cost of pollution produced by freight vehicles.
[xi] Section based on information included in “Strategi for tung trafik i Kobenhavns kommune.”
[xii] http://www.fdm.dk/nyheder/kommuner-skal-koordinere-vejarbejder.
[xiii] However, it must be noted that these differences are counted between the passenger diesel and electric vehicles, and not between trucks; these differences for trucks could be even more in favour for electrically propelled vehicles.
[xiv] Numbers in brackets show values of pollution produced without inclusion of a part of emission associated with electricity production. Kg/GJ mech. unit is used in order to show value of emission produced per 1 unit (1 GJ mech.) of energy consumed while driving a vehicle.
[xv] An access restriction is not recommended to be abolished, if the main reason for their establishment was not to decrease noise or pollution, but to decrease an intense traffic and increase accessibility for passenger vehicles and pedestrians.
[xvi] Again, this recommendation is valid under condition, that the environmental benefits associated with electric vehicles prevail over costs of reduced space for pedestrians/ reduced attractiveness of the area for pedestrians.
[xvii] Sign ✓ means that the described action is already implemented/planned to be implemented by Copenhagen Municipality.
[xviii] By off-peak deliveries are understood evening, night and early morning deliveries.
[xix] It excludes encouragement of deployment of electric vehicles.
[xix] Cost of reduction of air pollution with electric freight vehicles was measured on the basis of level of tax exemptions for these vehicles. This way the pure public cost of support of electric freight vehicles was assessed. Cost of reduction was further compared with the benefit linked to this reduction. In result, cost of reduction of air pollution with electric vehicles occurred to be significantly higher than the benefit achieved. Therefore, it was recommended to wait with a further financial support of electric freight vehicles in Copenhagen Municipality. This decision was also made, because there exist other, more effective tools for reduction of air pollution; electric vehicles are certainly not the only option. However, it is also important to underline, that results of the comparison of costs and benefits of reduction of air pollution associated with deployment of electric freight vehicles could have been even opposite, if one more important pollutant was taken into account. This research took into consideration cost of pollution produced by SO_2, NO_x and PM, but did not this produced by CO_2. Data for cost of CO_2 for Copenhagen Municipality were not available, and this is mainly due to the fact, that costs associated with CO_2 emission are primarily future ones. There exist forecasts for future costs of CO_2 emission, but it is very hard to assess probability of their appearance. Summing up, on the one hand, on the basis of current costs of local air pollution, no other recommendation than wait with further

support of electric freight vehicles could be made. On the other hand, public authorities cannot ignore enormous future costs of pollution associated with CO_2 emission. Though, it would be still recommended to wait with further financial support of electric freight vehicles, having knowledge that cost of electric vehicles will fall significantly in the following years, Future costs of CO2 emission can be avoided in a more effective way if support actions for electric freight vehicles start few years later. Other, already now effective tools for reduction of CO2 should be supported in the meantime.

About E-Mobility NSR

The Interreg North Sea Region project North Sea Electric Mobility Network (E-Mobility NSR) will help to create favorable conditions to promote the common development of e-mobility in the North Sea Region. Transnational support structures in the shape of a network and virtual routes are envisaged as part of the project, striving towards improving accessibility and the wider use of e-mobility in the North Sea Region countries.

www.e-mobility-nsr.eu

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