Decarbonising Urban Freight Transport: Experimentations in European Research Projects

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DECARBONISING URBAN FREIGHT TRANSPORT: EXPERIMENTATIONS IN EUROPEAN RESEARCH PROJECTS

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ABSTRACT
One of the objectives of European research programs is to decarbonise freight transport while maintaining its competitiveness and economic strength, reduce negative externalities such as pollutant emissions, congestion and accidents, and foster innovation. Multiple initiatives have started in Europe to reach these objectives and this paper reviews some of these schemes in the field of urban freight transport. It is based mainly on 3 EC-funded projects (BESTFACT (2016), SOLUTION (2015) and SMARTFUSION (2016)). These 3 projects are either testing (Smartfusion) or examining and disseminating European 'new solutions' or 'best practices' in freight transport. The paper mainly focuses on the most decarbonizing solutions.

1. Introduction

The freight intensity of the economy is increasing substantially. This is caused by different business trends such as globalisation, the reduction of storage, increasing e-commerce and individualisation of demand, which leads to smaller consignments and shorter delivery intervals. The importance of the urban part of freight transport is not easy to quantify but, in France, we estimated that urban freight is responsible for about half of the total CO_2 emissions from freight transport (Rizet et al. 2014). Urban areas face numerous challenges: lack of space for loading/unloading and logistics facilities, pollution and noise, conflicts with other road users, high costs of last mile distribution, congestion and reduced reliability of deliveries, and traffic safety problems. Within urban areas, travel distances are generally short, which may simplify the use of electric vehicles. Electric vehicles may have a lot of advantages for freight transport, mainly local pollution and noise. Furthermore, if electricity is not produced from fossil energy, it may also be an advantage for CO_2 emissions. This is why many projects and experimentations aiming the improvement and decarbonisation of Urban Freight, are combining a new organisation of urban logistics with electric vehicles.

Many initiatives, which might be able to substantially decarbonise Urban Freight, have been analysed in the European Research programs; in this paper we started from 3 EC-funded projects : BESTFACT, SOLUTIONS and Smartfusion, which are socio-economic research projects, not technical projects.
- The objective of the BESTFACT project (Best Practice Factory in Freight Transport www.bestfact.net) is to develop, disseminate and enhance the utilisation of best practices and innovations in freight transport that contribute to meeting European transport policy objectives with regard to competitiveness and environmental impact.
- The SOLUTIONS project (http://www.urban-mobility-solutions.eu/) also aims to support the exchange on innovative and green urban mobility solutions. The 2 main differences between BESTFACT and SOLUTIONS are that SOLUTIONS is concerned by passenger as well as freight transport and it is only on urban but not only within Europe; the exchange are between cities from Europe, Asia, Latin America and the Mediterranean. The project also try to disseminate best practices across the world by facilitating dialogue, promoting successful policy, and fostering future cooperation on research, development and innovation.
- The Smartfusion project (Smart Urban Freight Solutions http://www.smartfusion.eu/) aimed at demonstrating and evaluating the technical and logistical feasibility of introducing electric vehicles and the second generation of hybrid truck technology into the business environment, to apply these vehicle technologies, in conjunction

with information technology, operational, managerial and regulatory innovations, including urban consolidation centres and telematics systems.
- These 3 projects also build upon the previous EU research projects fostering the best practice of urban freight such as BESTUFS, FIDEUS, SUGAR, CITYMOVE, C-LIEGE, TURBLOG, STRAIGHTSOL (cf CORDIS[1] website)

Freight transport operations provide the goods and services required by companies and final customers, and make an important contribution to employment, thereby playing a vital role for the economy. But these operations, mainly done by road, also cause social, environmental and economic impacts across the world including greenhouse gas emissions traffic congestion, air and noise pollution, and the consequences of traffic collisions. To face this challenge, a high number of initiatives and solutions are developed and research is increasingly being conducted on decarbonisation of freight transport in Europe.
The handbook on green logistics presents a wide range of strategies, examples and results (McKinnon et al 2015). Liimatannen et al (2014) investigated solutions currently implemented in Finland. McKinnon and Piecyk (2009) presented how decarbonisation scenario might be developed at the country level. Balm et al. (2014) presented how to investigate and initiate collaborative demonstrations of trials in Europe. Leonardi et al (2014) showed some Best Practice examples and the evaluation criteria for the selection of good cases. The handbook by Bohne et al. (2016) presents a lengthy version of the most prominent of the 156 BESTFACT Best Practice cases, with extensive data collection and networking contacts.
One of the possible ways of tackling decarbonisation with the support of scientific research consists of a bottom-up approach, analysing and performing research assessments on good practices, which gives evidence and robust data on some solutions and allows formulating advice for decision makers.
Our objective in this paper is to synthetize the results of previously mentioned EU research projects on urban freight transport improvement, while giving the conditions under which selected urban freight solutions represent innovations that are technically feasible, economically profitable, sustainable, transferable, and with tangible CO_2 reduction. This CO_2 reduction often relies on electric vehicles: vans but also tricycles with electric assistance or even heavy trucks in the Smartfusion project. The offer of electric vehicles is very comparable all over Europe and probably in other countries but their potential impact on CO_2 mitigation is depending on the carbon intensity of the electricity they use, which may be very different among countries, even within Europe : France for example has an average emission factor of 0, 054 kg CO_2 per kWh, while this factor is 0,224 in UK. We did not try in this paper to asses in depth the CO_2 mitigation of each project.

2. Urban Consolidation Centers and clean vehicles

Urban Consolidation Centres (UCC) are operational concepts that reduce freight traffic circulating within a target area by fostering consolidation of cargo at a platform (www.coe-sufs.org). In most cases, carriers that otherwise would make separate trips to the target area with relatively low load factors, instead transfer their loads to a neutral carrier that consolidates the cargo and conducts the last leg of the deliveries. Conceptually, this may include “joint delivery systems”, “cooperative logistics,” and “urban distribution centres” although strictly speaking, these operations are not necessarily equivalent to a UCC. The following table gives an overview of urban consolidation centres in Europe, selected in the BESTFACT project.

[1] CORDIS is the European Commission's primary public repository and portal to disseminate information on all EU-funded research projects and their results in the broadest sense; http://cordis.europa.eu/home_en.html

Name (City, Country)	Main Characteristics	Impacts and benefits	Costs	Success Factors	Barriers	Innovation	Transferability
Binnenstadservice (Various, Netherlands)	Network of UCC in different cities	Reduction of mileage, pollution and noise	Lower costs for operators, reduced stock for shop keepers	Cooperation Rules Win-win for actors involved	Willingness and behaviour change, critical mass	Business model	High, adopted by further cities
Cityporto Padova (Padova, Italy)	Urban consolidation centre in combination with clean distribution vehicles	Reduction of pollution, noise Increasing efficiency	Profitable since 2007	Location of UCC, access rules	Additional handling at UCC Provision of service quality	UCC and Clean vehicles, incentives by regulation	High, adopted by further cities in Italy
Gnewt Cargo (London, United Kingdom)	Urban micro-consolidation centre in combination with clean distribution vehicles	Reduction of mileage, noise and emissions	Not higher for clients, Profitable	Creation of new company supported by retailers Positive support of local authorities	Private decision	Micro Consolidation in combination with electric vehicles and cargo bikes	High, confirmed
Gothenburg City Logistics Initiatives (Gothenburg, Sweden)	Urban consolidation centre in combination with clean distribution vehicles	Lower emissions, less noise, less space for loading/unloading, reduction of delivery vehicles	Profitability expected	Communication and cooperation; consultation	Agreement between involved parties	UCC, clean vehicles integrated in urban freight policy	High
Beaugerelle UCC Chronopost (Paris, France)	Urban consolidation centre in combination with clean distribution vehicles	Reduction of mileage, emissions and noise	Not available Profitable	UDC close to delivery addresses. Business model	Availability of land, cost of land at central locations	Central UCC and Clean vehicles	High
Distripolis (Paris, France)	UCC in combination with electric vans and trycicles	Traffic reduction, reduction of pollution and noise	Higher costs per parcel	Central location for UCC (available), Integration of IT solutions	Private investment decision,	Central UCC and Clean vehicles	High, confirmed

Tableau 1 : Overview on selected UCC best practices

In the following we develop the example of Binnenstadservice, a case of UCC implemented in the Netherlands. BinnenStadService (BSS) is an innovative concept applied since five years ago in 15 cities in the Netherlands: Arnhem, Nijmegen, Den Bosch, Amsterdam, Arnhem, Beuningen, Dordrecht, Gouda, Heerlen Maastricht, Nieuwegein, Rotterdam, Tilburg, Utrecht and Wijchen. BSS operates a warehouse and distribution service on behalf of the joint retailers and other organizations located in the (inner) city. The basic approach is that goods are delivered at a distribution centre on the edge of the city. From there the goods are bundled and the last mile to retailers is performed with a high load factor, high density of delivery points, and where possible, with clean vehicles which are subcontracted to local service providers (bicycle, (e)cargo-bike, electric vehicles, and natural gas vehicles). Simultaneously, empties/packaging/paper is returned to the consolidation centre.

Figure 1 - Clean vehicles in operation for Binnenstadservice

Source: BESTFACT 2016

The business model is based on the fact that the shopkeepers do not pay for the delivery of goods. They however have to pay for the additional services provided by BSS (collection of packaging material, empties, paper). It is the transport company that used to deliver the freight to the city centre customers that now has to pay a fee to BSS. Then, BSS bundles the freight and contracts it out to one logistic service provider per city.
Binnenstadservice started with a public subsidy to allow time to encourage the shopkeepers to participate. Currently, it is a franchise organisation. Every franchisee in a city is an independent local entrepreneur. Ideally the local entrepreneur locates the BSS depot 'under the same roof' with some other warehouse (not competing with the Binnestadservice function). In this way the BSS entrepreneur can start up without huge investments and she/he can operate at low cost because of the combined functions at the warehouse/cross dock location. The estimated costs in a start-up phase would be of around 10.000 Euros a month.

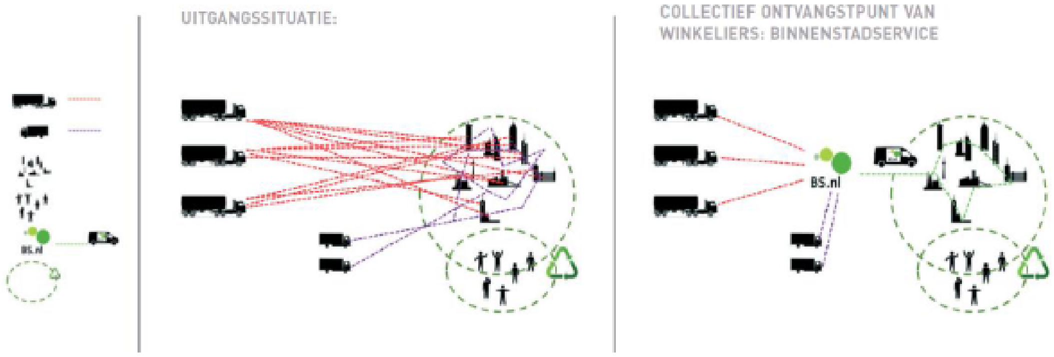

Figure 2: the new organisation after the implementation of BSS

left: situation without BSS depot and distribution (before); right: situation with BSS depot and distribution (after)
Source: BESTFACT 2016

In 2010 TNO made a study on the effects of cooperating with BSS (BSS) considering two companies already following this scheme (TWI and Lekkerland).The results showed that if more cities would implement BSS, carriers and shippers could benefit from large time-windows, have enough space for (un)loading, comply with local regulations and simplify the administrative issues by having only one contract with BSS for many cities. Considerable savings per delivery were calculated for different scenarios :

- Kilometres: 48-72%
- Time: 60-70%
- Costs: 59-71%
- CO_2 emissions: 47-71%

The savings would vary depending on type of deliveries, limiting factor for length vehicle round-trip, number of kilometres between city and carriers' and the number of deliveries in the city.
In 2009-2010 The BSS solution was tested by the 'Transumo' research team (the Erasmus Rotterdam and Radboud University in the city of Nijmegen with two national suppliers). This research team considered the effects for the city of Nijmegen (air pollution, traffic safety, and noise), the effects on the local entrepreneurs and their willingness to join this solution, and the perception of local consumers and national carriers. The team used different models to calculate the effects on kilometres, CO_2, time and costs, both at the local and national level. The zero measurement was the current situation, so without a BSS; surveys with local entrepreneurs and national carriers were also carried out. In addition, in 2012-2013 Dinalog Schone Ketting' and the 4C4D research team carried out a study with 6 national shippers on what would be the effects on the same variables as mentioned above (kilometres, CO_2, time, costs) in case a shipper/carrier would cooperate with 8 local BSS points. The team

did a survey amongst local entrepreneurs in 3 cities. The main conclusions from the study are:

Sales Line shippers and carriers: The first revenue line is the savings realized by suppliers / carriers that will create a single point of delivery for all its customers based in that city. The analysis of 6 companies shows time and mileage saving and increase of the degree of loading in all cases. The effects are company dependent. For example, the effect in the reduction of time per stop ranges from 5 to 25 minutes. The whole effect is a strong indication of the reduction of costs for shippers and thus revenue-opportunities for BSS.

Retail Sales Line: The second line is the appreciation by retailers. The conclusion is that the value is largely determined by the conditions in and around the shop and it is largely based on unburdening of the entrepreneur. This study found that entrepreneurs, who recognize that unburdening helps in their business, choose for BSS and are also willing to pay for it.

The research team has placed both revenue lines next to the cost of a BSS establishment and notes that this results in a sound business case.

Success factors and barriers

BSS is very efficient thanks to the collective receiving and shipping of goods, benefiting all involved parties:

For shopkeepers: a shopkeeper does not have to sign multiple times for a package that is delivered, but gets it all in one load.

For transport companies: they can deliver the goods at the distribution centre on the outskirts of the city. They thus do not have to enter the city themselves, which could save them time and money. It also eases the pressure of time windows and environmental zones.

For shippers: ultimately they will pay less for the transport of the goods, since the ‘last mile’ becomes cheaper.

For the city: it reduces environmental pollution and makes the city more liveable due to fewer trucks and more environmental friendly trucks/delivery vans.

On the other hand BSS needs a lot of retailers to join to create the critical mass to make it successful. In many cities BSS started with a subsidy to create some time to convince the shopkeepers to participate.

One factor that could benefit the scheme would be if shippers require from their logistics service providers to deliver the goods to the BSS consolidation centre, and not to the inner city shopkeepers.

Innovation and transferability

Technically speaking BSS is not a real challenge. Only a warehouse (urban distribution centre) is needed, and a local carrier with a clean distribution vehicle needs to be sub-contracted. The ICT system for handling orders, labelling, etc. is already available by the Franchise organisation BSS Netherlands. The BSS approach is now being transferred to the E-logistic market, to other actors and end receivers in the cities and to other areas beside the inner city.

The BSS concept is on a voluntary basis. However, some conditions could facilitate the introduction, as for example strict time windows, limited loading/unloading facilities and strict environmental conditions (environmental zones), since it will ‘force’ transport companies to look for cheaper and easier solutions. The more cities participate in the BSS concept, the easier it is for shippers or transport companies to make use of the concept, because it becomes a common practice. In the current situation, where BSS does not cover all cities, shippers and transport companies have to deal with different situations and conditions in different cities. Since BSS is a franchise organisation with a ‘history’ of 5 years, every new BSS entrepreneur in a new city has ‘easier’ conditions to start up, thanks to the ‘lessons learned’ and the coaching from the national organisation. This organisation even provides support to other European cities at this moment (e.g. previous cases included City Depot in Belgium and Citylogistik in Denmark).

The transferability also depends on the absence of the ‘not invented here syndrome’. If the new city wants to “invent” its own solution, it takes some more time to

implement such a scheme. The slowest cases are in the cities where a local government is trying to implement their own solution (by procurement for instance).
Synthesis of results
This case is a good example of an urban consolidation centre and clean vehicles scheme with relatively low operation costs. Thanks to the consolidation of goods, less delivery vehicles circulate in the city leading to a reduction of traffic congestion and emissions. One of the main barriers for its implementation relates to the acceptance of such a concept by shop owners. Therefore, a good cooperation between different partners is important for the set up and expansion of this solution. Being a franchise, 'replicating' the existing model is a key for its transferability.
The customers in the cities where BSS is present are all SME's., i.e. the receivers of the goods are all retailers (shops, restaurants, café's, etc.). The impact on SMEs relies on a more co-ordinated approach of the deliveries and sending of their goods (fewer deliveries at suitable times), which eases their daily activities. Furthermore, retailers need less storage space in their shops, and their shopping street also becomes more attractive, potentially leading to more clients.
Another famous case of UCC and electric vehicle is the Como trial. This Como experimentation was about testing the use of a new consolidation centre, run electric vans of 3.5t large enough for 1t payload, and test new electric routing software. It has been assessed during the Smartfusion project, which measured a 39% reduction of CO2 per parcel.

Como trial: impact results

Distance per parcel = -37%

Logistics / Units	km/day diesel vans	km/day diesel trucks	km/day electric vans	km/day total all vehicles	Distance in km per parcel	Index distance per parcel
Before: Diesel vans starting at Arco depot	32			32	0.56	100
After: Electric vans + UCC Via dei Mulini	0	10	10	20	0.35	63

CO_2 per parcel = -39%

	Energy		CO_2 equivalent			
	Litres diesel/ day	kWh/ day	$kgCO_2e$ / day	$kgCO_2e$/ parcel	Index $kgCO_2e$/ parcel	Reduction in $kgCO_2e$/ parcel
Before	4.1	0	13	0.222	100	-
After	2.5	2.6	8	0.136	61	-39%

Costs = +6%

	Staff		Costs						
	Number of staff	Index number of staff	Parcels delivered per staff per day	Total costs per staff/ day in €	Total costs energy/ day in €	Other fixed and variable costs €/day	All vehicles costs €/day	Total costs €/ parcel	Index total costs per parcel
Before	1.2	100	48	108	5	51	164	2.88	100
After	1.6	130	37	140	3	30	174	3.05	106

Smart Urban Freight Conference 2015

Figure 3: Impact of Smartfusion demonstration in Como.

Source: Smartfusion 2016

3. Urban delivery management

Freight demand management strategies influence the demand for freight to improve sustainability and efficiency of urban freight transport. Freight demand management focuses on changing the behaviour of the receivers of the supplies or of the logistics and transport service providers. Demand management solutions can be supported by ICT and IT solutions. The following table gives an overview on selected best practices for urban delivery management in Europe.

Name (City, Country)	Main Characteristics	Impacts and benefits	Costs	Success Factors	Barriers	Innovation	Transferability
Logistics tool for delivery management (Basel, Switzerland)	Planning and reservation of delivery slots	Time savings, better use of loading/unloading facilities, less congestion and pollution	Not available	Win-Win, communication and cooperation	User acceptance	IT-Tool for reservation of delivery slots	High (for freight intensive facilities)
Green Link (Paris, France)	IT based management of deliveries and use of clean vehicles via 3 depots	Less pollution, less noise	Profitability reached	Efficient management of the transport chain, Good mix of flows, Availability of space at central location	Availability of land, land prices at central locations	Business model and intelligent management of deliveries	High
Newcastle University	UCC + Delivery and Servicing Plan + electric truck	Less traffic in the University	N a	Consultation	UCC location	Linking UCC and DSP	High for large institutions

Tableau 2 : Overview on selected best practices regarding delivery management

In the following one best practice case is shown more in detail.

3.1 Logistics tool for delivery management (Basel, Switzerland)

The fairgrounds in Basel are located in a central part of the city. Access roads are narrow and do not allow for shunting with trucks. Space for parking and idling is very limited since the campus is also integrated in a residential and public area. The limitation of space led the fairground operator to develop a new management system for all logistics on their grounds. It is intended to limit conflicts between trucks manoeuvring, loading/unloading or waiting and parking in the vicinity. The ever increasing demand for transports to the fairgrounds also with higher requests for just-in-time deliveries peaking on the day right before and just after fairs being held led to further increasing traffic problems.

Solution

On the Basel fair facilities area, exhibitors, stand builders and other suppliers have to register online and in advance for all deliveries, pick-ups and transports to the fair grounds. The domestic logistics operator exclusively handles all logistics processes on the grounds. Confirmed and registered vehicles receive a delivery pass, which contains a date and fixed time slot for delivery, information about the loading, company and vehicle information. This information is also coded in a bar code for faster checking at the stations.

At the designated time the vehicle has to check in at the fair ground checkpoint, where all delivery information and cargo is verified and a parking space is assigned. Upon verification an access pass is handed to the driver including directions to the optimum delivery zone, where the loading is transhipped. The time allotment for a vehicle in the delivery zone depends on vehicle type and loading. After transhipment, the truck has to be removed from the fair grounds and takes a new trip.

The registration for deliveries or pick-ups is generally free of charge if performed regularly 7 days in advance. On shorter notice, up to 24h ahead, it incurs a small charge; the scale depends on the specific event and ranges between €80 and €420.

The developed online tool is available in 5 languages (German, English, Spanish, French, and Italian) and needs to be used for booking of timeslots for deliveries. The needed login for the tool is send to exhibitors upon registration for a trade fair. An access pass has to be printed from a PDF format and be presented upon delivery.

The case is technically feasible. The basic functionalities of the tool are already providing clear benefits and are easily implemented. In addition the case helps to increase efficiency in all logistics related processes and will eventually support monitoring.

Figure 4 : Elements of the logistics tool

Source: BESTFACT 2016

Experiences and Impact

The resulting benefits of the implementation are:

Reduction of traffic congestion on major national and transnational routes (inner city roads and Autobahn). For peak delivery and pick-up days related to major fairs 15km of congestion were measured due to trucks blocking the highway exits in order to reach the checkpoint. This congestion is now effectively avoided for each event.

The use of automated IT supported processes at the check point allows the handling of 95% of all arriving transports within less than 3 minutes. The aim is to reduce this requirement below one minute from handing in the documents until receiving a designated loading position.

Automation of billing and invoicing related to all logistics activities

Efficiency gains are reflected in time gains within the occupancy schedule on the fair grounds. Through consolidation eventually additional events can be held at the fairgrounds: increased capacity utilisation and increased revenues

High acceptance upon implementation, for the first fair event where the tool was in use almost 90% of the about 7’000 trips were pre-registered.

The fairground operator gains full control over the steering of all logistics activities. The provision of the logistics services was tendered to include all new and adapted processes.

For the fairground logisticians the situation improved vastly with introduction of time slots due to better planning of capacities. The efficiency of all logistic processes at the fairgrounds improved according to feedback. Congestion on the grounds was reduced due to better scheduling of delivery and pick-up of materials and goods at the stands, leading to less time needed before and after a fair to build and deconstruct the entire setup. Through this efficiency gain new fairs can be added to the schedule in the future.

Success factors and barriers

The following success factors have been identified:

- Optimal operative processes dictated functions and development of the logistics tool (not the other way around)
- Open and early communication strategy towards all involved actors and intuitive manuals and documentation
- Thorough and stepwise testing before implementation
- Close cooperation of involved actors (operators, city’s urban planning department, IT department, project developers, marketing, customers)

The main problem to overcome was the acceptance and support of the customers (stand builders, exhibiting companies, fair event agencies) since a major part of planning ahead was required by them that was before dealt with on a more short-notice and operational basis by the trade fair logisticians. An early and open communication strategy helped to overcome these problems and allowed to demonstrate benefits for all users of the tool.

Innovation and transferability

The innovation is the development of a dedicated tool for demand management. The solution can be easily transferred to other freight intensive facilities with high demand peaks and limited space an capacity for loading and unloading (e.g. intermodal terminals, freight villages, distribution platforms).

Synthesis of results in context of decarbonisation

The case delivers a relatively simple solution for the specific problem of the Basel fair grounds while also being a transferable solution that can be adapted by many similar urban facilities or freight intensive facilities. The shift of planning ahead from the fair operator to the exhibitors and their logistics service provider was achieved right from the start. The increased complexity for the delivery planning was accepted while benefits resulted for all involved actors.
At the end, the impact of this solution, like the other presented above, was a very substantial decarbonisation of transport, due to the high efficiency gains.

3.2 Delivery servicing plan + UCC and electric truck in Newcastle University

In Newcastle, a Delivery and Servicing Plan for deliveries to the University was set-up, including the change that non-urgent deliveries to the premises in city centre should be transferred first to an Urban Consolidation Centre, then transported to the final destination with an electric truck of 7.5t (Smartfusion 2015).
The Figure below shows the quantified impacts.

Impacts in Newcastle

CO_2 per parcel = -100%

	Energy		CO_2 equivalent			
	Litres diesel/ day	kWh/ day	$kgCO_2e$/ day	kg CO_2e/ parcel	Index $kgCO_2e$/ parcel	Reduction in CO_2
Before	24.7	0	77	1.278	100	0
After	0	73.4	0	0	0	-100%

Costs = -7%

	Staff		Costs						
	No. staff	Index no staff	Parcels delivered per staff per day	Total costs per staff/day in €	Total costs energy/ day in €	Other fixed & variable costs / day in €	All vehicles costs/ day in €	Total costs per parcel in €	Index total costs per parcel
Before	1.2	100	50	108	32	148	289	4.81	100
After	1.2	100	50	108	11	148	267	4.46	93

Figure 5: Impacts of the Smartfusion trial in Newcastle

Source: Smartfusion 2016
One impact of this solution assessed by the Smartfusion project was a 100% reduction in CO_2 per parcel, explained by the fact that the electric truck used in this experiment was functioning with a 'zero carbon electricity'.

4 Low-Emissions Zones (LEZ)

Short description of the solution

In a low emissions zone (LEZ), access to a certain area (e.g. the city centre) is denied to vehicles which do not meet certain criteria – typically pollutant emissions levels. The LEZs can be very different by their dimension (size), by the type of forbidden vehicles and by the means of control and enforcement. This measure may improve air quality in the exclusion zone, but may also bring with it undesired consequences, for example increased energy consumption and greenhouse gas emissions resulting from longer trips as a consequence of vehicles driving around the zone, and an accompanying (re)concentration of air pollutant emissions outside the zone. The typically poorer residents of these areas are thus potentially negatively affected by this measure.

Objectives and implementation

The main objective is environmental: mitigation of pollutant emissions. The main environmental result is a the decrease in particulate matters. On the economical impact, the operational costs of LEZ are highly variables according to the type of control. Another cost of a LEZ is the cost of the changes in the transport market (services and companies), a phenomenon which is rather unknown. These results are very dependent on the efficiency of control and enforcement. The main types of control are video surveillance (London) and 'visual' control by local police (Germany). In Europe, many implementations of LEZs are attributable to violations of the air quality standards prescribed in the EU's Air Quality Directive (96/62/EG). Their effectiveness is, however, for the most part unproven (scoping study), partly due to the difficulty in attributing air-quality changes to the LEZs alone. A social issue of this solution is that the forbidden vehicles are generally the old ones, mainly belonging to the poor people (cars) or small enterprises (duty vehicles): Implementing a LEZ can exclude the poor class and craftsmen (artisans) and to reserve local transport to upper classes and reach companies. When implemented alone, a LEZ have generally less impact on the traffic volume than on the fleet composition.

Examples and case studies

LEZs have been widely implemented in Europe (>250 cities/regions), a good overview of which is available at www.lowemissionzones.eu.

Opportunities and transferability

Access restrictions have also been implemented in many developing and emerging countries. The starting conditions are particularly favourable in Asian cities, as they consistently demonstrate a high interest in reducing local emissions and in environmentally friendly transportation systems. However, as access restrictions have been implemented in many developing and emerging countries already, future activities in this area could indeed focus on the transfer of experience from Asia to Europe or on the integration of already existing schemes into a wider sustainable freight transport policy package.

5. Pick-up Points

Short description of the solution

Pick up points are secured places where customers can take the parcels they have bought, mainly on the Internet. This approach avoids many truck-kilometers all the way to final customers by reducing the delivery round distances and by suppressing the need of rescheduling failed deliveries to home addresses. Therefore, the advantages of pick up points are for retailers and delivery operators, as well as for e-commerce final customers ; furthermore, they contribute to reduce freight traffic. There are different kinds of Pick up points (parcel lockers, proximity warehouses, convenience stores and local shops serving as networks, etc.). From the pick-up point, the customers can take their parcels; in the case of the stores' replenishment in the proximity area, final deliveries can be done by mean of small vehicles or even with wheelbarrows. The cost of pick up points varies depending on their typology: When referring to convenience stores, local shops serving as networks, etc., the cost of this measure is relatively low. When referring to parcel lockers some initial investment is needed, as well as the maintenance in the street and the corresponding technological development. For example, when the delivery is done, the courier needs to automatically send an SMS, email, etc. to the final user, to announce that the parcel is already on the locker. The customer also needs a password to access to the locker and when the parcel has been picked up, the system automatically sends a message to the transport company.

Objectives and implementation

The main motivation is the reduction of the number of movements and unnecessary deliveries to Internet users, which contributes to the reduction of pollution in cities. In the daily operative, the pick-up points also have other benefits: they make more flexible the supply chain and increase efficiency and reliability; The timing is lower since there is no need of finding the final user, they make it easier the deliveries routes planning since the delivery points are fixed, and finally the parcels can be picked up at every time of the day. Pick-up points also have some inconvenient : investment required when constructing a parcel lock is high, for infrastructure and information system ; loss of direct contact with the customer ; the fact that the Internet consumer needs to shift to the pick-up point can be a barrier.

Examples and case studies

In the Packstation of DHL in Germany, parcels can be received in line with the customers' needs : Packstation system allows the customers to receive and send parcels day and night without the need of waiting for the delivery in person. There are 2,500 Packstation available throughtout Germany. Walmart stores in North America have the possibility of working with pick up points : when buying by Internet, the customer has to introduce the zip code, as well as the Store pick-up; some additional information is needed as for example the email for informing when the parcel is ready for pick-up.

Opportunities and transferability

There are examples of leading cities in Asia (Japan), Europe (France, Germany, UK, Netherlands) and also North America. This solution is mainly interesting for cities or regions where e-commerce is developing fast.

6 Vehicle and Operation Regulations on Time, Weight and Size

Weight and size regulations can be enforced by public authorities preventing vehicles of a particular size and weight to operate on certain roads. In certain cases the load factor of a vehicle can be used as a measure for preventing goods vehicles operating in city centres well below their capacity, leading in that way to the reduction of traffic, but the control, for this last type of regulation is very difficult.

Objectives and implementation

Time regulations can be imposed on goods vehicles in a particular road or urban area, either on vehicle access or on operations (loading and unloading) with two main objectives: to protect residents or to reduce congestion associated with urban freight. These two objectives can be contradictory. Time windows can be implemented to avoid conflicts between residents or tourists on the one hand and freight deliveries on the other. These time windows can lead to traffic congestion in peak hours and to a poor utilization of vehicles. On the contrary, night deliveries and off-peak hours (combined with low noise delivery equipment) can be an efficient strategy to reduce vehicle-miles and congestion associated with urban freight. Typical times for night deliveries are 22:00 – 06:00. Two types of night regulations may be introduced: (i) time regulations on deliveries and collections to and from a particular building (e.g. retail outlet, office or factory) and (ii) regulations on goods vehicle movement in a part or the whole of an urban area.

Examples and case studies

This solution of night deliveries has been chosen by the city of Hanoï to avoid congestion; In Europe, Dutch cities, a few other cities (Dublin, Barcelona, Paris) in a more limited scale have also experimented this concept. One specific example is the multi-use lane of Barcelona, Spain, which has been transferred to Bilbao. The major avenues in city centre have been equipped with variable message signs for one lane out of the four-lane, one-direction avenue. This lane is allowed for deliveries during the day except during peak traffic hours, and allowed for residential parking during the night, from 21.00 to 08.00. This solution has reduced congestion, search for parking and delivery time, and is very well accepted among residents and shopkeepers in the area.

No in-depth assessment of the CO_2 impact of these experiments has been published to our knowledge.

7. Rail and Waterways for Freight Deliveries

A larger use of rail and waterways can reduce the number of trucks and vans on the roads in and around urban areas. It generally has to be combined with the use of road vehicles for the final delivery to the end consignee. Two types of rail infrastructure can be distinguished: heavy rail and 'mainly passenger rail' (subways and tramways). For heavy rail, the scheme is the same as for waterways: goods are consolidated in a terminal located outside of the urban area, and transported on shuttle trains or barges to an urban distribution terminal. From this urban terminal, goods are transhipped to motor vehicles, preferably low emission ones, for final delivery. Road traffic is reduced according to the distances and to the freight volume involved. The use of light rail, is quite a different option. Tramways offer a large capacity, allowing for a decongestion of road infrastructure, without local emissions. But the tram network is rarely suited for freight origins and destinations and the equipment is not (not yet?) adapted for loading and unloading freight. Underground freight distribution, though sometimes considered as a potential sustainable solution, has never succeeded in Europe: various studies have been undertaken but projects never reached the demonstration phase, mainly because of track maintenance issues, operational costs and of the low volumes potentially involved.

Objectives and implementation
The main objective of public authorities when trying to boost these non road modes is to reduce congestion, atmospheric pollution and noise resulting from trucks. Costs may be high, according to the existing infrastructure but even when no infrastructure investment is necessary, the use of non road-based means generally implies additional transhipments and a lack of flexibility which is costly. In the case of rail, noise emissions can result from freight activities in adjacent communities because of vibrations and also the overlap between the time in which the delivery is done and the maintenance of the tracks.

Examples and case studies
- Waterways : In Utrecht (NL), many hotels and restaurants are immediately adjacent to the city's canals and an electrically powered "Beer-boat" delivers beverages and catering products directly from a distribution centre. In Paris, Franprix a large French grocery retailer, is supplying 80 stores since September 2012 by use of a multi-modal transport chain combining trucks and barges.
- Heavy rail: Monoprix, another large French retailer, is supplying 90 supermarkets in Paris by train, from an intermodal terminal located 35 km south of Paris to a rail terminal located within Paris (Bercy station in the East) and the final deliveries to the supermarkets are made by trucks. Other evaluations carried out for another such project in the city of Rome show an environmental benefit due to the combined use of rail and clean vehicles for final deliveries.
- Light rail: In Zurich, since 2003, a "Cargotram" provides waste disposal service for bulky refuse around the city. In 2006, an E-tram has been introduced to provide a waste disposal service for electrical and electronic goods; In Dresden, a specific light train using the tramway network of the city connects a Volkswagen logistics centre to a manufacturing/assemblage car factory located within the city limits. In Paris, France, the ongoing project "Tramfret" looks at using the planned tramway network infrastructure, mostly in dense suburban areas, for freight trains.

The potential gains of implementing a non-road transport solution for urban freight are potentially high if infrastructure (railway, waterway, urban terminals) is available. But, in general these solutions are costly and some sort of public subsidies are required to cover for additional costs, except for niches markets.

8. Pricing Measures

Imposing or modifying taxes, providing subsidies or incentives may have a significant impact on urban freight transport services : Road pricing or fuel taxes will increase the price of urban freight, forcing transport operators to seek solutions like better consolidation of shipments, for saving costs, thus addressing major inefficiencies and negative externalities. Subsidies and incentives, provided by local authorities, can also encourage the development of sustainable urban freight distribution operations. Various forms of taxation policies have been introduced in an attempt to force companies to pay a price close to the marginal social cost. Road pricing is the most indicative example of such policies. They are direct charges levied for the use of roads including road tolls, distance or time based fees, congestion charges and charges designed to discourage the use of certain classes of vehicle, fuel sources or more polluting vehicles. Road infrastructure financing and transport demand management are the main objectives governing the implementation of these charges with the range of approaches including single road pricing (e.g. Norway, France), cordon pricing (e.g. Norway, Italy), network pricing (e.g. Germany) and area pricing (e.g. United Kingdom, Switzerland). While each approach presents advantages and disadvantages, they tend to be selected on the basis of local conditions and political reality rather than economic theories.
Direct subsidies have been provided by the European Union through the CIVITAS programme allowing city authorities to plan, implement and monitor innovative measures to promote sustainable urban freight distribution across Europe. However, the direct provision of subsidies by local authorities is not widely used in the context of urban freight transport because it is likely to be anti-competitive, may lead to state aid issues and is likely to be very expensive for city authorities. For these reasons indirect incentives, which provide cost advantages for the relevant private sector operators, are used to provide exemptions from regulatory provisions for behaviour that leads to sustainable urban distribution.

Road pricing schemes are primarily used as a mean for generating revenue, usually for road infrastructure financing (e.g. Norway, France, Germany), or as a transport demand management tool (e.g. United Kingdom, Switzerland) with the objective to reduce peak hour travel and ease traffic congestion. In most countries toll roads, toll bridges and toll tunnels are used for revenue generation to repay the long-term debt issued to finance the toll facility or to finance capacity expansion, operations or simply as general tax funds. Road congestion pricing for entering an urban area or pollution charges levied on vehicles with higher tailpipe emissions are typical schemes implemented to price externalities with their application being currently limited to a small number of cities and urban roads. Suitable pricing schemes can improve the overall efficiency of urban freight movements and foster the development of more sustainable logistics and distribution strategies. However, in some cases, urban road pricing schemes have proved to be controversial. A number of high profile schemes in the US and UK have been cancelled, delayed or scaled back in response to opposition and protest. Critics maintain that congestion pricing is not equitable, places an economic burden on neighbouring communities, has a negative effect on retail businesses and on economic activity in general, and is just another tax.
The opposite of taxation and tolls is the use of subsidies to encourage the development of sustainable urban distribution. As indicated before, direct subsidies by local authorities to transport operators are not widely used in the context of urban freight transport mainly due to budget constraints : the use of indirect subsidies is likely to be the most cost effective way of incentivising transport operators and their customers to adopt sustainable distribution strategies. Such policies as allowing low or zero emission vehicles, or vehicles operating from Urban Consolidation Centres,

to be exempt from time window restrictions or congestion charges (a policy differentiation) is likely to be a more effective policy for city authorities than becoming involved in investing in urban freight transport operations or infrastructure.

Examples and case studies

- The Norwegian cordon pricing schemes being implemented in the cities of Bergen (1986), Oslo (1990) and Trondheim (1991). All schemes were created for generating revenue but other indirect benefits were also reported: traffic was reduced by 5% in Oslo while the implementation of the Trondheim Toll Scheme resulted in a 10% decrease in traffic passing the ring in both peak and non-peak hours,
- The London congestion charge is operated, on behalf of the urban authority, by a private company. Its main objective is to reduce congestion and the related environmental impacts. Since its implementation in 2003, traffic volumes entering the zone have decreased by 18%, delays by 30% and there has been a broadly neutral impact on overall business performance in the zone.
- Following the example of London, the Stockholm congestion charge was adopted in 2007 with the objective to reduce traffic to and from the city by 10-15% during peak hours, increase the level of service in Stockholm city traffic and reduce the emission of carbon dioxide, nitric oxide and particulate matters. Since its implementation, light goods vehicles were reduced by 22%, heavy goods vehicles declined by slightly more than 10% while emissions of particles and nitrogen oxides are estimated to have fallen by between 8 to 12%. GHGs have also fallen by 40% in the inner-city and by 2 to 3% in Stockholm County. Today there are 20% less traffic in and out of inner city during peak hours, 10-14% less emissions and 30% less travelling times.
- The Milan Area C was introduced in 2012 replacing the former pollution charge called Ecopass. The objective of this new program is to drastically reduce the chronic traffic jams that take place in the city of Milan, promote sustainable mobility and public transport and decrease the existing levels of smog that have become unsustainable from the public health point of view. The first results that were reported indicated a decrease of 32.8% in vehicles entering the area compared to 2011.
- Mileage based usage fees or distance based charging have been implemented for heavy vehicles based on truck weight and distance travelled in New Zealand (called RUC), Switzerland (LSVA), Germany (LKW-Maut), Austria (Go-Maut), Czech Republic, Slovakia, Poland and in 4 U.S. States i.e. Oregon, New York, Kentucky and New Mexico.
- The CIVITAS programme (http://www.civitas.eu/) provides a good overview of subsidies that have been provided by the European Union allowing city authorities to plan, implement and monitor innovative urban freight distribution measures. However, as indicated earlier, indirect subsidies prove to be the most cost-effective way of incentivising transport operators and their customers to adopt behaviours that lead to sustainable urban distribution. Examples include exemption from or discounted congestion charges for low and zero emission vehicles in London, allowing vehicles operating from Urban Consolidation Centres to use priority lanes in Norwich and enjoy wider time windows in Bristol and La Rochelle. In Utrecht, low and zero emission vehicles are exempt from time windows and are allowed to use priority lanes.

Both taxes and subsidies, either direct or indirect, can impose a significant impact on existing urban freight transport operations encouraging operators to adopt sustainable urban freight distribution strategies. In nearly all large agglomerations, suitable pricing schemes for urban freight transport may yield reliability and travel time benefits that exceed the cost and foster more sustainable freight services

The Berlin Trial: A 27t. Diesel HGV used for urban coffee beans delivery has been replaced by a hybrid-electric truck, leading to carbon emission reductions of 25%..

Impacts of Berlin trials

Distance per parcel = identical

Units		t	km	tkm	l	l/100km	l/t	l/tkm
	mode	load	distance	performance	fuel use	Fuel efficiency	fuel per load	fuel intensity
After	H ON	12	6,7	80	2,8	41,8	0,23	0,035
Before	D	11,5	6,6	76	3,5	52,6	0,30	0,046

CO_2 per parcel = -24%

Units		kg CO_2e	g CO_2e /km	g CO_2e /t	g CO_2e /tkm	index
	Mode	Average CO_2 emissions	CO_2 efficiency	CO_2 per load unit	CO_2 intensity	CO_2 intensity
After	H ON	8,7	1296	723	108	100
Before	D	10,9	1632	943	142	131

Lifetime fuel costs = -21%

Indicator	l/100km	km	litres	€	€	index	%
Scenarios	Average fuel efficiency	Lifetime distance	Lifetime fuel use	Lifetime fuel costs	Difference in fuel costs	Fuel costs	Lifetime fuel costs reduction
Average Hybrid truck fuel use	42	500000	208955	250746	65061	79	21
Average Diesel truck fuel use	53	500000	263173	315807		100	0

Figure 6: Impacts of the Smartfusion trial in Berlin

Source: Smartfusion 2016

9. Conclusion and recommendations for future decarbonisation of urban freight transport and logistics

Regarding urban freight solutions there is a wide variety of approaches including infrastructure, technology, organisation and cooperation, operation and services, regulation and policy and methods and tools as well. Successful Best Practices often combine different approaches, offering the proof of concept and demonstrating the operative feasibility of decarbonisation.

The investigated cases have shown positive impacts and are in most of the cases transferable.

For a successful implementation, the local framework conditions, relevant success factors and barriers to overcome have to be taken into account.

Urban areas are at the origin of approximately half of the CO_2 freight transport emissions and cities can contribute to the mitigation of this CO_2. But for Cities, to take an active role and integrate better CO_2 and freight transport in urban transport and land-use, planning tools are needed to monitor and evaluate implemented measures. A wider application of these solutions and tools will also provide support for optimisation of strategies and for future decision-making.

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