Outlook City Logistics 2017

Topsector Logistiek

Connekt

CE Delft

Hogeschool van Amsterdam

TNO innovation for life

Topsector Logistiek

Table of Contents

1 Management Summary 5

2 Introduction 10

3 Reading guide 12

4 City Logistics 13
Scope 13
Dutch perspective 15
Segments 15
GHG emissions estimate 16

5 The challenge of Factor 6 18
The carbon productivity challenge 18

6 The role of sustainable transport fuels and energy technologies 20

7 Current and future trends and drivers 23
Definition and development 23
Primary External Drivers 25

Society 25
A More demanding customers 25
B Increasing political and societal pressure to reduce GHG emissions 26
C Increased political and societal pressure for improved livability of cities 26
D Increased political and societal pressure to reduce footprints, by means of a circular economy 27

Technology 27
A Connecting the physical world 27
B Robotizing and automation 28
C Vehicle drive technology and energy source adoption driven by scale 28

Logistics 29
A Towards omnichannel 29
B Physical internet and universal labelling 30
Performance Based Regulation 31

8 Outlook per segment 33
Introduction 33
Assumptions used in all segment analyses 34
General cargo 36
Developments in general cargo 36
- Retail chains 37
- General cargo partial delivery 39
- Home delivery of large goods (2-person deliveries) 40
Temperature controlled city logistics 41
Developments in temperature controlled city logistics 41
- Large retail 42
- Wholesale food service specialists 43
- The small specialists 45
- Home delivery of fresh food and services 46
- Home delivery meals 47
Parcel and express 47
Developments in parcel and express 47
Facility Logistics 49
Developments in facility logistics 49
Construction Logistics 52
Developments in construction logistics 52
Waste collection 56
Developments in waste collection 56
Annex A Further clarification on city logistics segments & segment-specific developments 60
Introduction 60
General cargo in cities 60
Introduction to general cargo 60
Three different systems in general cargo 60
External drivers and developments in general cargo 62
Temperature controlled logistics 65
Introduction to temperature controlled logistics 65
Different logistics systems in temperature controlled logistics 65
External drivers and developments in temperature controlled logistics 67
Parcel and express mail 69
Introduction to parcel logistics 69
Different logistics systems/requirements in parcel 70
External drivers and developments in parcel deliveries 71
Facility logistics 73
Introduction to facility management & logistics 70
Logistic characteristics of facility management 70
External drivers and developments in facility management 74
Construction logistics 76
Introduction to construction logistics 73
Different construction segments and construction phases 77
External drivers and developments in construction logistics 79
Waste collection in cities 82
Introduction to waste collection 82
Different logistics systems in waste collection 83
External drivers and developments in waste collection 85
B Illustration on presented statistics 87

1 Management Summary

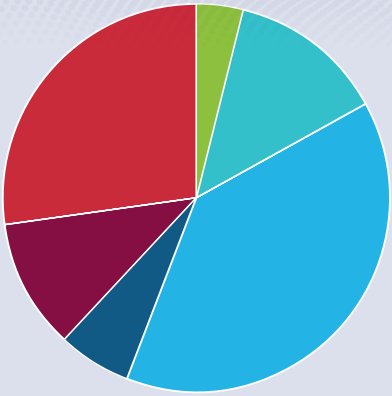
When it comes to City Logistics, the need to innovate comes from multiple directions. Greenhouse gas emissions must be drastically reduced while at the same time maintaining a vibrant and healthy economy, demanding robust action from each and every sector, including transport. At the same time, competition for scarce and precious common resources in a city (open and green space, an attractive and healthy environment, safety, clean air and low noise levels) puts political and societal pressure on supply networks to innovate in order to do more with less consumption of these scarce resources. This needs to be achieved not only by means of low-GHG-emission vehicles, but with less noise, less danger, less local pollution harmful to citizens, fewer transport movements and reduced need for roads and parking spaces.

Responding to these demands requires application of new low-/zero-emission technologies and energy sources and introduction of new supply-chain designs to reduce the number of movements, as well as innovative and specific policy regimes.

Solving that puzzle is in our view a joint effort which requires iterative refinements of a hypothesis: a solid and transparent reference view which can be challenged and improved upon.

Cities are growing ever more important as economic and population centres and City Logistics[1] is consequently growing in both scale and as an emissions source. The total GHG (Tank-to-Wheel, TTW) emissions of City Logistics in the Netherlands are estimated at 3.6 (+/- 0.9) Mtonne per year in 2015[2]. The following pie chart shows how these emissions are distributed over the relevant city logistics activities (segments). The choice of segments is based on competition: segments hardly compete with each other.

GHG Emissions per city logistics activity (segment), 2015/NL



City Logistics comprises of a vast variety of supply networks, each with its own service demands driven by the particular wishes of the end-customer. This heterogeneity is reflected in the wide variation in the means of transport used, from cargo bikes to 18-metre truck-trailer combinations. A multitude of independent external trends and drivers each bring about their own changes, now and in the future, but they create business opportunities, as well. With City Logistics being so heterogeneous, the route to meeting all the many challenges differs from segment to segment.

This Outlook combines data, assumptions and reasoning to elaborate likely paths forward per segment: a view, based on the Dutch situation, about how to achieve the various goals while taking all relevant factors into due account, including economic viability. The purpose of the Outlook is to help structure a complex issue that is currently being debated by numerous stakeholders.

The key in structuring a complex discussions is to make the assumptions explicit: if assumptions are changed, the likely paths will change, too. Different views on an outcome usually can be traced back to a few key assumptions. Tracking the developments of these key assumptions in more detail helps to determine the likelihood of a path.

The interesting and challenging task ahead is to refine and improve the assumptions and add new data as shared knowledge. After several iterations, the result will be a shared vision on how to accelerate innovations in City Logistics in the coming years.

Some external drivers are common to all.

Low/zero-emission drive technologies and fuels

For road transport, the current portfolio of options for efficient vehicles running on sustainably produced energy carriers includes:

- battery-electric vehicles (BEVs) running on renewable electricity
  - including Light Electric Vehicles (LEVs) and e-assisted cargo bikes
- fuel-cell electric vehicles (FCEVs) running on hydrogen produced from renewable sources
- hybrids, combining BEV and FCEV technology with ICE technology
- efficient internal combustion engine vehicles (ICEVs) running on low-carbon fuels; these include sustainably produced biofuels as well as synthetic fuels produced using renewable energy.

Availability at reasonable Total-Cost-of-Ownership (TCO) is driven by scale. A key role for regulators and governments is to accelerate scale and prevent fragmentation.

There is still significant potential for improving the energy efficiency of conventional vehicles. For long-haul trucks a 40% reduction of fuel consumption and TTW CO_2 emissions appears feasible[3] at net negative costs ($\Delta TCO < 0$).

(Battery) Electric vehicles and LEVs are the most likely option for transport in urban areas, at least in the near term.

Hydrogen is a significantly less efficient route for using renewable energy in transport, but is a relevant option for light-, medium- and certain heavy-duty applications, especially when range and power demands are high. Hydrogen seems the most likely contender for the next-generation zero-emission heavy truck, projected to become available around 2035.

Due to limited availability of sustainably produced biomass, use of biofuels will be limited to long-haul applications in road freight, shipping and aviation. It is very uncertain if and when synthetic ('solar') fuels will become widely available at acceptable cost. The role of natural gas, in the form of CNG or LNG, as a transition fuel for City Logistics should not therefore be overestimated, as biofuels will remain a scarce resource.

More demanding customers

Supply networks service a customer-dominated environment driven by timelines and customer convenience. Customer intimacy is key to understanding the fickle demands for transport and value-added services and establishing market dominance. Transporters and other companies applying mobile and web-based IT to create optimum customer intimacy will dominate their segment and dis-intermediate others.

Connecting the physical world (IoT)

Cheap computers-on-a-chip with very low power requirements are currently being combined with sensors and new forms of wireless connectivity, allowing them to be attached to physical objects and travel with them while staying connected (constantly or intermittently). Traceable physical objects (goods) mean transparency of the supply network to the final customer at every step and customer intimacy based on transparency instead of trust.

Traceable, connected vehicles are pivotal for many of the new possibilities in flexible and customized regulation of city access, which today is limited to relatively coarse measures such as environmental zones and time slots for access and loading and unloading zones.

Robotization and automation

Robotization and automation bring productivity to a new level, making solutions affordable that were previously seen as prohibitively expensive. The obvious target is to reduce handling costs at warehouses, cross-docks and delivery. Autonomous vehicles do away with the need for a driver.

Towards omnichannel

The difference between what is now called e-commerce and other supply networks is evaporating. The shift to omnichannel sales will lead to an increase of direct deliveries (B2C, B2SME, C2C) at the expense of volume through brick-and-mortar stores. While the decision to buy may still be made in the store, increasingly the goods are being delivered where and when the customer wants. 'Order everywhere, deliver anywhere and return anywhere' will be the motto of omnichannel sales, which will have a significant impact on logistics. This omnichannel strategy is also more important in B2B markets.

Physical Internet and universal labelling

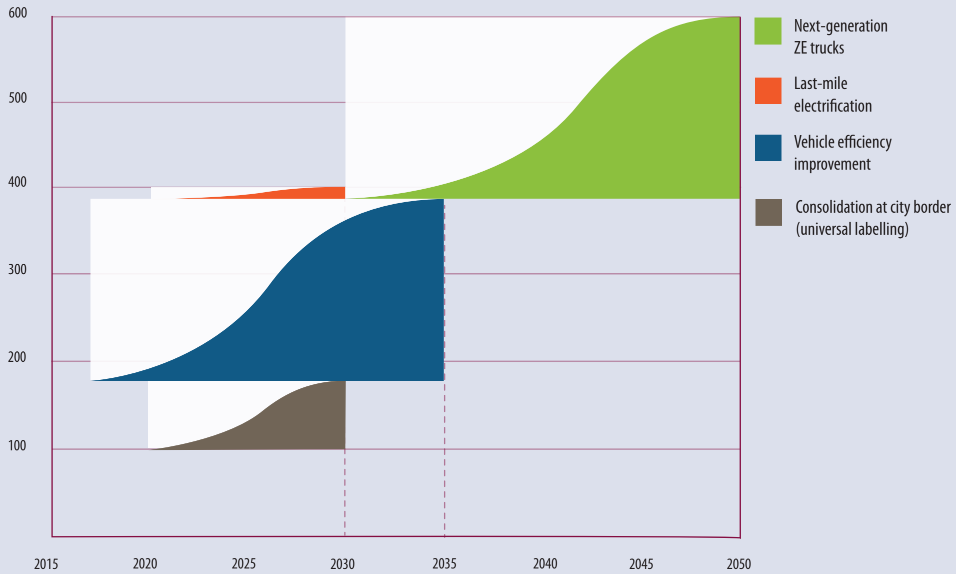
The concept of the Physical Internet uses some of the principles of the Internet to propose a new paradigm for supply networks, creating an Internet for Goods where goods find their own path from origin to destination. The proof of concept is already over 125 years old (Mumbai, India, Dabbawallah system) but requires universal labelling in combination with reduced handling costs to compete. The introduction of universal labeling in the EU based on SSCC labels[4] is a major step forward towards implementing a Physical Internet.

Backcasting

The prime assumption in developing a view for the future has been that achieving the desired six-fold increase in carbon productivity (known in the Netherlands as 'Factor 6') is non-negotiable. The most likely path responds to external drivers, takes into account the inertia of institutions and regulations, and considers the economic life-cycle of capital goods such as vehicles and infrastructure. Fairness to all stakeholders shouldering the burden is taken as a must.

Working from detailed assumptions, backcasting of Factor 6 pathways has been carried out for each segment specifically. The results are summarized in 'cascade graphs' that combine the timing and impact of each proposed measure in a single view. As an example, Figure 1 shows the cascade graph for general cargo partial delivery, the largest subsegment in general cargo.

Figure 1
Example of a cascade graph, for general cargo partial delivery



From these component visions for individual segments the following common areas of action for both government and the logistics sector can be identified. A shared view gives direction to vehicle manufacturers as to where the market will go.

Governments:

- Develop and introduce common IT and control systems facilitating easy-to-use customized and individualized access to sensitive city centres, based on connected vehicles that are traceable.
- Mandate and implement green tendering for construction projects.
- Mandate and implement bundled deliveries for facility logistics.
- Ensure efficiency improvements through implementation of policies at the national and international level.
- Create scale: incentivize supply and demand for large volumes of zero-emission vehicles and prevent fragmentation.
- Urban planning: separate the flow of traffic from areas where pedestrians and cyclists dominate

Logistics Sector:

- Increase IT sophistication, data transparency and data exchange for:
  - improved customer intimacy
  - cooperative networks (up to and including the Physical Internet)
  - transparency to government
  - measurement of relevant key performance indicators (e.g. emissions, number of movements etc.).
- Higher levels of automation and robotization.
- Adopt business models, geared towards:
  - the need to reduce transport movements into cities by joining up urban networks or creating new ones
  - exploiting all opportunities to increase carbon productivity and road safety and reduce noise/emissions to gain a competitive edge.

2 Introduction

Transport is one of the most difficult and complex sectors to decarbonize[5].

This complexity becomes especially visible in city logistics: the transport of goods in and out of cities, servicing the needs of those who live and work there[6].

The ever-increasing demand by city inhabitants for better, faster and more customized supply networks is at odds with the demand by the same city dwellers for more open space, peace and quiet, safety and clean air. On top of that, the Paris agreements require a decrease in the GHG emissions of transport[7].

Together, these facts create a conundrum: how to satisfy all demands?

Many stakeholders have expressed the need for a balanced path forward, a shared and acceptable vision as to how this long-term goal can be achieved, what intermediate steps need to be taken, and how milestones and intermediate goals should be timed. It has proven difficult to define such a path, as many factors are interdependent and city logistics is fairly heterogeneous in nature.

The heterogeneity of urban freight transport is reflected in the first place in the variety of means of transport, ranging from light commercial vehicles (LCV) used by one-man SMEs to deliver services or specialty goods to large tractor-trailer combinations servicing major retail networks and from light electric vehicles like cargo bikes to 20-tonne trucks. Or letter and parcel delivery versus heavy construction transport. Or temperature-controlled goods (food, perishables) versus general cargo. Or waste collection versus facility products and services for large offices.

Secondly, each type of supply network has different service demands, driven by the end-customer. Parcels and letters, temperature-controlled goods, (food) retail, general cargo, construction, facility/services, waste collection: these all set different demands on the service, resulting in different types of logistics organization and different service profiles. Supply networks go through life-cycles, as demands change, or as connected IT (such as mobile Internet and smartphones, Internet of Things) make new services possible that render classic supply networks obsolete.

Technological developments in drive technology and energy sources (battery electric vehicles (BEV), plug-in hybrid vehicles (PHEV), hydrogen, bio- or solar fuels) are not expected to deliver a 'silver-bullet': vehicle price and performance will remain largely the same as today, but emissions will drop to zero.

A new technology usually has different strong and weak points than the mature one it competes with. It is unclear which zero-emission technology will eventually dominate, or even if one particular technology will be able to service all demands. The availability of new technology (timing, price, energy infrastructure) will be partly driven by the scale of demand, creating a chicken-and-egg dependency and uncertainty about timing. Total-cost-ownership (TCO) for operating a zero-emission vehicle will most likely start above the TCO of the mature internal combustion engine product, creating a hurdle for introduction and scaling. City logistics requirements will differ widely from segment to segment, leading to a different sequence and timing for each.

LCVs and trucks are capital goods that follow investment cycles. Their useful life spans more than one decade, and requires second-hand markets for used equipment. Forced depreciation as a result of regulation can be a serious economic burden, creating uncertainty about investments in intermediate solutions. At the same time, accelerated technological depreciation is a risk for the front-runner: a new generation of vehicle technology could make an early investment obsolete before it is fully depreciated. The same applies to infrastructure investments and investments in intelligent transport systems.

The above makes the design and implementation of policies such as regulations problematical, especially given the need to tailor to specific subsegments and applications simultaneously.
At the same time, the competition for scarce and precious common resources in a city (space, peace and quiet, safety, clean air) will exert (political and social) pressure on supply networks to innovate: to do more with less consumption of these scarce resources. New vehicle technology will help, but the design of supply networks may very well need to change too, defining new requirements for means of transport. The rise of cargo bikes and Light Electric Cargo Vehicles (LECV) and the development of social delivery networks are indicators of this trend. This adds another element of uncertainty to the puzzle.
Solving that puzzle is in our view a collective effort which requires iterative refinements of a hypothesis, which should start with a solid and transparent vision that can be challenged and improved on.

This Outlook is the first of three editions, aiming to iteratively develop a vision per segment of city distribution on one or more feasible paths to de-carbonize the distribution of goods. A vision is not a prediction of the future, nor a prescription of actions and tasks. Its goal is to provide a baseline which can be shared and debated and improved on, to structure discussions among stakeholders, to allow anyone to test their own scenarios, to make it easier for all involved to check all dependencies, to facilitate identification of essential dependencies in actions. As such, this first version is an invitation to contribute, an invitation to add improvements and an invitation to share it widely.

The contributions will be collected between June 1 and November 1, 2017. After November 1 a new edition will be developed, to be published in the spring of 2018.

3 Reading guide

This Outlook starts, in **Chapter 4**, with a definition of city logistics: what is within its scope and what is not, and what are the logistic segments and their GHG emissions.

Chapter 5 demonstrates the challenge of 'Factor 6': the target derived from the Paris agreements on reducing GHG emissions.

Chapter 6 considers the role of sustainable transport fuels

Chapter 7 explains how the vision for each segment of City Logistics has been constructed on the basis of the relevant external drivers and common enablers.

In **Chapter 8** the visions are presented in greater detail.

CE Delft and TNO have analyzed each logistic segment with respect to characteristics of size, growth, emissions and so on.

Based on multiple focus group interviews, Connekt, CE Delft, TNO and the Amsterdam University of Applied Sciences have developed a view as to what trends and developments are most likely to influence supply network development in the future. Connekt and the Amsterdam University of Applied Sciences have integrated this information into the proposed visions, while TNO and CE Delft have calculated the effects shown in the cascade diagrams.

An analysis of the overall logistics ecosystem and the potential of current trends and developments is presented in **Chapter 9**.

4 City Logistics

Scope

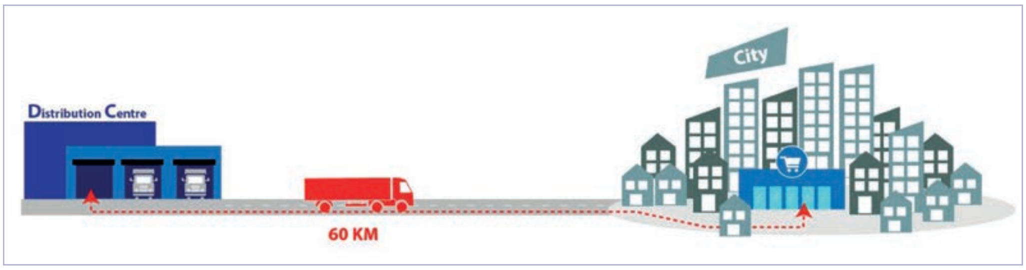
In this outlook the scope of City Logistics is defined as follows:

'the last leg in a supply chain to a customer location in a city, or the first leg from a customer location in a city back into the supply chain'

The last leg starts at the last warehouse before delivery and ends at the delivery point (office, company building, shop or home).

This means the last leg may very well cross the geographical border of a city. For instance, in large retail chain logistics, the last leg means shipping groceries from Distribution Centres (DC) to an inner-city retail outlet. In some cases this leg may be 80-100 km long.

Figure 2
Example of long last leg

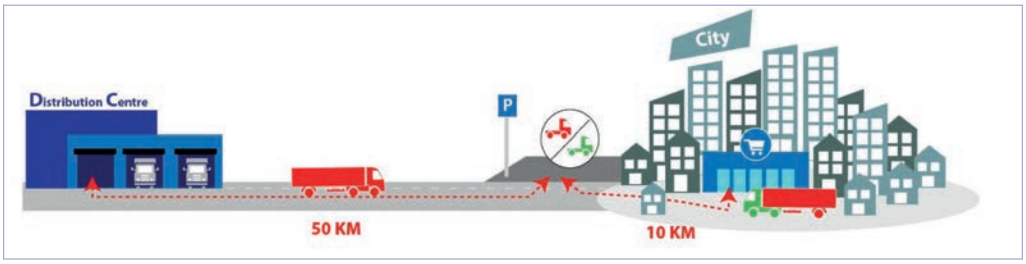


The last leg depends on city size: it may merely be a few km, when a hub or small DC for smaller items or parcels is located just outside a big city, or 20-40 km for delivery of goods to smaller, more rural cities.

Figure 3
Example of short last leg

When a tractor-trailer combination is split near a city, it does not break the last leg in our definition. The trailer is pulled from the splitting location to the final destination in the city by an electric truck, but the start of the leg is the remote warehouse.

Figure 4
Example of split in last leg



The focus in this report is on the logistics of the last leg.

This definition has several effects that need to be taken into due consideration:

- **The length of the leg defines the base level of CO_2 emissions in a segment.**
  The absolute level of CO_2 emissions in a segment is obviously dependent on the length of the last leg. Comparing emissions between segments needs to take this into account.
  Large retail chains that ship full truck loads (FTL) to their stores in cities tend to concentrate their distribution centres in fewer and fewer locations, as picking and handling in DCs is relatively expensive compared with transport over longer distances. These long distances (10 -100 km or more) cause substantial CO_2 emissions in the last leg. While only a minor percentage is emitted within the geographical city boundaries, the emissions of the whole leg is included in this definition of city logistics.
  Parcel transportation companies tend to have large inter-hub transportation trucks that deliver to hubs close to the boundary of a large city: the trip to a customer in the big city is short and therefore causes low CO_2 emissions. A trip to deliver a parcel to a customer located in a smaller city nearby may mean a greater travel distance. Only the CO_2 emissions of the last leg are taken into account.

- **Relationship with push for zero-emission logistics within city perimeters**
  In the Netherlands several large cities are actively pushing for predominantly zero-emission logistics ***within the city perimeter*** by 2025, in the cooperative effort called Green Deal Zero Emission City Logistics (GDZES). This push is driven as much, or even more, by a desire for more open space, peace and quiet, safety and clean air, as by a desire to reduce GHG emissions. This strong push is very important to kick-start the use and acceptance of zero-emission technology in logistics, to create the early adopters required to reach the next group and enable demand for zero-emission technology in logistics.

  In developing this Outlook it was first considered to use the same definition (the city perimeter as boundary of scope) to be consistent with the GDZES. However, this creates serious drawbacks in analysing the factors driving change and the options available in various segments. The definition of the scope employed in this Outlook was therefore changed, accepting the possible misunderstanding as a minor drawback.

The scope of this Outlook is thus much larger, including the part of the last legs beyond city limits and including all the cities in the Netherlands. A successful push in larger cities for zero-emission logistics within the city may, for instance, require the use of PHEV trucks that can run several dozen kilometres on battery power. This PHEV then runs on fuel in the rest of the leg from and back to the DC, achieving the zero emission in the city centre target for GDZES, whereas the overall reduction in GHG emissions is relatively small.

However, this major step in technology and acceptance is only a minor step in reducing the GHG emissions of the overall segment. Furthermore, the target of increasing transport performance per emitted kg of GHG by a factor 6 for all the logistics in the last leg to all cities (not only the few major ones) in the Netherlands requires far more than zero emission logistics in the large cities' centres only.

Dutch perspective

This Outlook is written from a Dutch perspective with the Dutch market in mind; not all segments are similar in other countries, nor is the way logistics is organized. The results and the vision presented cannot therefore be copied one-to-one to other countries. Distribution structures and distances between cities and distribution centres may vary from one country to another, for example. As a consequence, the path to decarbonize a certain segment might differ as well. While we do not claim to have developed universally applicable visions, though, the general approach to decarbonizing each segment of city logistics is anticipated to be fairly universal. Many of the decisions and actions, the interdependencies and possibilities, are similar in all (Western) European countries, and as such the paths proposed in this Outlook will most likely also be of interest to others.

Segments

City logistics is a heterogeneous collection of different transport and logistics activities that sometimes only have in common that they take place within the geographical area of a city. Therefore, this Outlook classifies different city logistics segments.

The definition of a segment is based mainly on the characteristics of the players in a supply chain and how the market is structured.

For instance, in waste collection logistics: collecting household waste seems very similar to collecting waste from SMEs, until one takes into account that household waste collection is a concession granted and paid for by a municipality. Waste collection from SMEs, in contrast, is a commercial service selected and purchased by each SME individually. This is therefore considered a separate segment.

Another example concerns perishables shipped to supermarkets in temperature-controlled trailers: the customer is the same as for normal, non-perishable groceries, yet the requirements (HACCP, time as in loss of sellable days) are such that combining these two supply chains is hardly[8] possible.

The segments we have identified are:

General Cargo
- large retail chains
- small and independent stores
- home deliveries

Temperature Controlled
- supermarkets
- wholesalers
- specialists
- home deliveries

Parcels and Express

Facility Logistics

Waste logistics
- Collective (concession)
- Business

Construction
- Large projects (with 4 phases from preparation of grounds to detailed finishing)
- Small contractors and independents

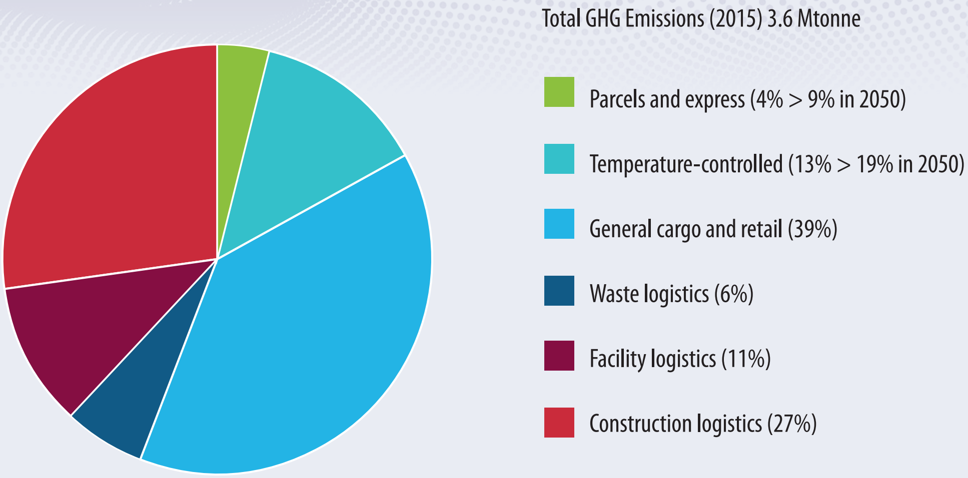
There are significant differences between the sub-segments in terms of logistics organization. The most striking differences are the stakeholder responsible for logistics organization and planning, the vehicles typically used and the trip types. Where large retail chains use mainly self-orchestrated tractor-semitrailers for point-to-point trips, independent stores are typically supplied by logistic service providers (LSP) with smaller vehicles in a milk-run. Being characterized by numerous consignments of limited size, this type of transport by definition has a relatively lower logistical efficiency.

GHG emissions estimate

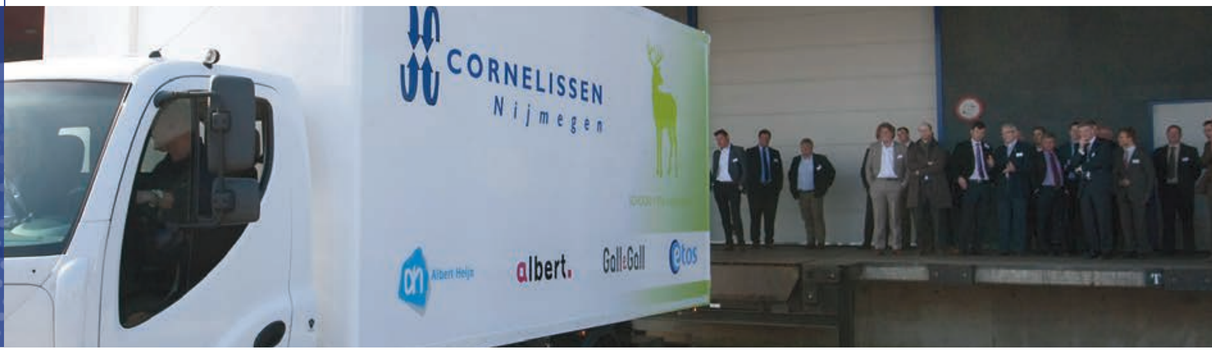
The total GHG (TTW[9]) emissions of city logistics, within the scope defined above, are estimated at 3.6 (+/- 0.9) Mtonne per year in 2015[10]. The variation is due largely to the difficulty of estimating the size of Construction Logistics and Facility Logistics, as there are few statistics available for this purpose. In some cases the estimate for a segment can vary by +/- 10% up to +/- 20% of the absolute value.

The estimated growth in GHG emissions over the coming decades (under the assumption of no intervention or action to reduce emissions) is mainly in Parcels and Express, and Temperature-Controlled. This growth will lead to a relative decrease in the share of the other segments.

Figure 5
GHG emissions per segment (2015)



5 The challenge of Factor 6



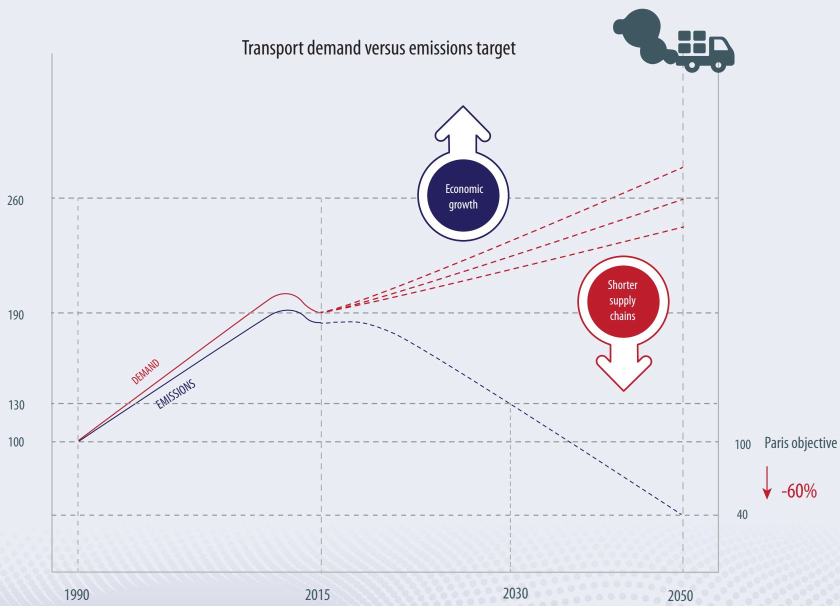
The carbon productivity challenge

The EU has set itself a long-term goal of limiting global warming to 1.5-2 degrees C. The 2 degrees target translates to reducing greenhouse gas emissions by 80-95% in 2050[11] compared with 1990 levels. To achieve the 80% goal, emissions from transport must be reduced to over 60% below 1990 levels by 2050, *all assuming a linear decline in emissions over time.*

The importance of this assumption is rooted in the difference between rapid versus late reduction of emissions. The basis is a total maximum budget of cumulative CO_2 emissions, calculated to limit atmospheric CO_2 concentrations to the required level: if we achieve a fast and early emissions cuts, there is less need to achieve the 60% reduction. On the other hand, if reduction is delayed, the target moves from a 60% reduction to 80% or more as more of the cumulative budget is consumed.

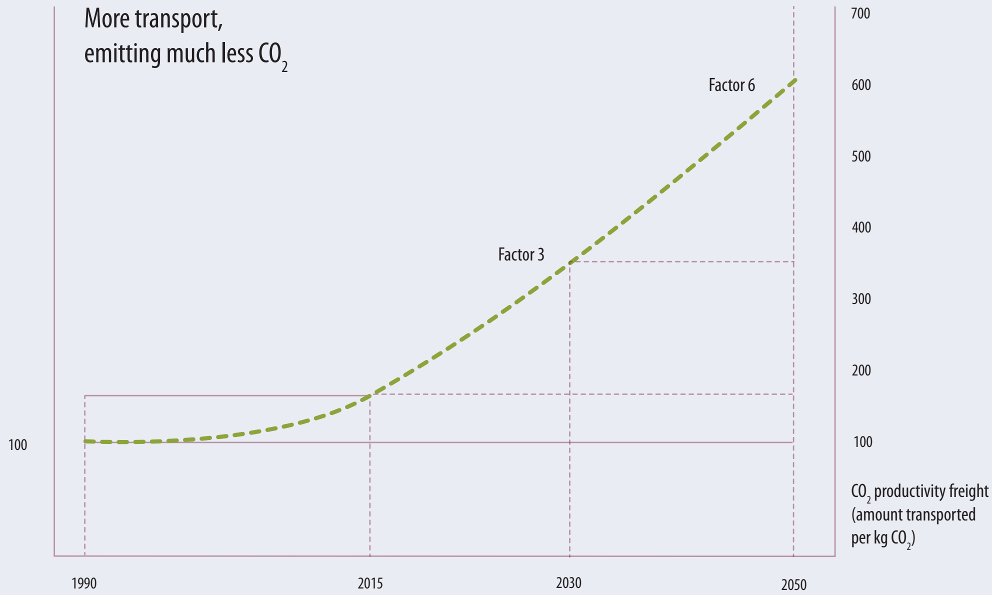
Any successful policy or action on climate change to secure this goal must support two objectives: reducing CO_2 emissions as soon as possible and maintaining economic growth.

Figure 6
Economic growth leading to transport growth and GHG emission reduction target



Continuous economic growth will lead to a continued increase in freight transport demand. In the Netherlands this assumption means that meeting the 2050 target for transport emissions requires an approximately sixfold increase in 'carbon productivity': the amount of freight and passenger transport per unit of carbon equivalents emitted, i.e. t-km/CO_2e (see Fig. 7), or **Factor 6** for short.

Figure 7
A sixfold increase in CO_2 productivity is required in the Netherlands to achieve CO_2 the reduction targets for the EU28.



To achieve this sixfold increase in carbon productivity requires an integrated approach, capturing available opportunities to increase energy efficiency in a cost-effective way, decarbonizing energy sources, accelerating the development and deployment of new low-carbon technologies and changing the logistics operations of businesses and consumer behaviour. CO_2 abatement options are needed at all system levels, i.e. energy carriers, powertrains, vehicles, fleets, logistics operations, behaviours and so on, and in all transport areas, i.e. passenger cars, buses, light commercial vehicles and medium/heavy-duty trucks.

Analysis of the Dutch transport sector shows that the required pathway towards the intermediate 2030 target and the 2050 target is very challenging. All existing and currently planned low-carbon policies and measures will only be able to accommodate emissions from projected growth in transport demand and stabilize emissions at current levels. Although achieving the full potential of existing and planned policies and measures will in itself be by no means straightforward, even more complex system innovations and coherent sets of abatement options are will be needed to achieve six times more efficient city logistics system.

For city logistics as a whole as well as component segments the same Factor 6 is assumed to be required by 2050. Although growth rates in transport demand may differ from segment to segment over time, the overall long-term challenge will still requires a Factor 6 emissions reduction. As the reference development of each segment in terms of absolute CO_2 emissions differs among segments and over time, all graphs in this report related to the Factor 6 challenge are indexed on a scale from 100 to 600 to make them easier to interpret and compare. In addition, the measures to achieve the Factor 6 challenge add up linearly[12] in the graphs: moving from level 100 to 200 requires the same amount of CO_2 reduction (or CO_2 productivity increase) as moving from level 500 to 600.

6 The role of sustainable transport fuels and energy technologies

Different scenario analyses show that the long-term CO_2 emission reduction targets for the transport sector can in theory be reached by a combination of more productive supply chains (curbing the growth and reducing the volume of vehicle-kilometres), the large-scale application of extremely efficient vehicles running on sustainably produced energy carriers (electricity in battery storage, H_2, solar/biofuel) and, where possible, a shift towards inherently more energy-efficient transport modes.

For road vehicles the current portfolio of options for efficient vehicles running on sustainably produced energy carriers includes:

- Battery-electric vehicles (BEVs) running on renewable electricity
  - including Light Electric Vehicles (LEVs) and e-assisted cargo bikes
- Fuel-cell electric vehicles (FCEVs) on hydrogen produced from renewable sources
- Hybrids, combining BEV and FCEV technology with ICE technology
- Efficient internal combustion engine vehicles (ICEVs) running on low-carbon fuels (including sustainably produced biofuels as well as synthetic fuels produced using renewable energy)

All options have their specific advantages, drawbacks and limitations, leading to the conclusion that it is likely that future road transport systems will contain a mix of all these technologies, with each being applied in specific (sub)sectors or niches where the benefits of the technology outweigh its drawbacks. At this stage it neither possible nor constructive for the transition to draw up a blueprint indicating which technology will 'win' in which application. Nevertheless, certain broad conclusions can be drawn based on current insights in the various technological routes[13].

There is still significant potential for improving the energy efficiency of conventional vehicles

Through improved engines, waste heat recovery, efficient gearboxes, increasing levels of hybridisation, improved aerodynamics, lower rolling resistance tyres and weight reduction, the fuel consumption and TTW CO_2 emissions of internal combustion engine vehicles can still be greatly reduced. Assessments in support of future CO_2 legislation for cars and vans show that reductions from the current fleet average of around 120 g/km to around 70 g/km in 2025 (NEDC)[14] are feasible at acceptable cost. Light commercial vehicles are expected to follow passenger car trends. feasible at acceptable costs. Light commercial vehicles are expected to follow the passenger car trends.

For long-haul trucks a 40% reduction of fuel consumption and TTW CO_2 emissions appears possible[15] at net negative cost (Δ Total Cost of Ownership (TCO) < 0). This improved efficiency will help reduce demand for biofuels in applications where other renewable energy sources cannot be applied.

(Battery) Electric vehicles and LEVs are the most likely option for transport in urban areas

Given that electric vehicles have zero tailpipe emissions and low noise emissions and that electric propulsion powered by the grid is the most energy-efficient route for converting renewable energy into kilometres driven, electric vehicles are the preferred option in cities. Until now, though, implementation has been held back by costs, range, charging times and charging infrastructure requirements. For full-scale adoption, the challenge of pushing the operational envelope further while reducing costs needs to cross a tipping point. This will occur first in the urban environment for a large proportion of passenger cars, vans, city distribution trucks, light electrical freight vehicles and city buses.

Conductive slow charging is currently the main option used for charging EVs, but is unlikely to suffice when EVs become the dominant vehicle technology in urban areas. In the coming decade gaining practical experience with alternative charging infrastructure options, including fast conductive charging, inductive charging and possibly in-motion charging with overhead wires for e.g. trucks ('electric motorway') or buses, is paramount for determining the dominant design of a future charging infrastructure that can support large-scale adoption of electric vehicles.

Hydrogen is a significantly less efficient route for using renewable energy in transport, but is a relevant option for light-, medium- and certain heavy-duty applications for more demanding applications

Fuel-cell vehicles running on hydrogen are nearing technical maturity. They combine some of the superior driving characteristics of electric vehicles with a longer range, a short refuelling time and an energy infrastructure that is superficially similar to the current system based on petrol stations. These are all important advantages from an end-user perspective. As technologies stand at the moment, though, the energy chain from renewable electricity production to mechanical energy at the wheels entails significant energy losses in electrolysis, compression or liquefaction and subsequent transport of hydrogen and in conversion back to electricity in the fuel cell on board the vehicle. Starting with a given amount of renewable electricity, e.g. from solar energy (photovoltaics) or wind turbines, a battery-electric vehicle can drive a factor 2 or more further than a hydrogen-powered vehicle. As long as renewable energy is not abundantly available at low cost, from an overall energy perspective hydrogen will mostly be used in applications where the drawbacks of battery electric vehicles are not acceptable.

Hydrogen may well play a role as a buffer for excess renewable energy, though. While the market price of excess renewable energy may be low (and at times even negative), this does not mean that hydrogen produced from excess electricity will be cheap. This will depend on the net capital costs of the electrolysis facilities that are only used part of the day. Furthermore, the future availability of excess electricity for hydrogen production should not be overestimated, as this will be reduced by effective demand management in smart grids or by storage in alternative stationary options with possibly lower costs.
Similar concerns apply to power-to-gas and power-to-liquid options where hydrogen produced from (excess) renewable electricity is combined with captured CO_2 to produce carbon-based fuels that could replace natural gas and fossil petrol and diesel in conventional vehicles.

Due to limited availability of sustainably produced biomass, the use of biofuels will be limited to long-haul applications in road freight, shipping and aviation

Despite a 'closed carbon cycle' the well-to-wheel (WTW) GHG emissions of biofuels are not zero. GHG emissions occur in agriculture, the production of fertilizer, and the production and distribution of the fuel. In addition, significant GHG emissions often result from so-called indirect land-use change (ILUC) as a consequence of the increased land demand for growing energy and food crops. In recent years it has become clear that for some widely used biofuel routes the WTW GHG emissions are actually higher than for the fossil fuels they replace. In addition, there are concerns about competition for land as global demand for food rises.

Given that other sectors will also generate increasing demand for sustainably produced biomass in the coming decades, it is wise to assume that the availability of sustainably produced biofuels for the transport sector will be limited and not suffice to replace more than a minor share of current fossil fuel consumption. As a consequence, the consensus is that biofuels for transport should be reserved for applications where electricity and hydrogen are not viable options. In road transport this may include long-haul applications rather than city logistics operations (as in this Outlook's focus). Within the transport sector as a whole, large-scale biofuel use is foreseen for shipping and aviation[16].

The role of natural gas, in the form of CNG or LNG, as a transition fuel should not be overestimated

Compared with Euro VI for heavy-duty vehicles and the future Euro 6 with RDE[17] requirements for light-duty vehicles, the air quality benefits of natural gas compared with diesel have proven to be very limited. Compared with petrol vehicles, the air quality benefits were already limited to lower emission levels for certain unregulated exhaust components. Direct emissions of CO_2 are somewhat lower than for petrol and diesel, but net WTW GHG emission reductions depend on the origin of the gas and on the energy use and possible leaks in long-distance transport of natural gas, as well as on the amount of methane slip in engines running on natural gas.
In spark ignition engines, gas leads to lower combustion efficiencies compared with diesel, although this might be partly overcome by higher compression ratios in dedicated engines. Dual-fuel compression ignition engines permit use of natural gas with diesel-like engine efficiencies. Using natural gas and diesel in RCCI[18] engines, currently under development, could lead to further improvements in engine efficiency combined with inherently low exhaust emissions.

The WTW emissions of methane-powered vehicles can be significantly reduced by using biogas or synthetic gas produced from renewable energy and captured CO_2. The availability for use in transport of biogas with favourable WTW emissions, e.g. from waste or manure, will always be limited owing to limited global feedstock availability and demand from other sectors. In addition, there is concern about creating a lock-in if natural gas were to be used on a large scale as a transition fuel to bridge the gap between current petrol and diesel vehicles and the future upscaling of alternatives such as electric and hydrogen vehicles. We have only 35 years to complete the transition to a low-carbon transport system, which is only 2 -3 investment cycles. Asking both vehicle owners and actors in fuel supply infrastructure to phase out investments in 15 or 20 years does not appear to be an attractive option.

7 Current and future trends and drivers

The main contribution envisaged for this Outlook lies in its developing a set of visions that sketch feasible paths to decarbonize specific city logistics segments. As mentioned in the introduction, a vision is not a prediction of the future, nor a prescription of actions and tasks. Its goal is to provide a baseline which can be shared and debated and improved, to structure discussions among stakeholders, to allow anyone to test their own scenarios and to make it easier to check dependencies.

Definition and development

In the following, the size (volume, emissions, etc.) and current system of each city logistics segment are first characterized. Next, based on an extrapolation of current developments, the potential for decarbonization is set off against the Factor 6 challenge.

The question then becomes:

- What measures and steps are required to secure the Factor 6 target?
- What actions need to be taken, in what sequence, when and by whom?
- How are the uncertainties in developments over the coming decades to be taken into account?
- Last but not least, what decisions need to be taken and by whom?

The number of factors and actors involved in city logistics and the interdependencies among them makes it very hard to use standard analytical frameworks to develop a view of one or more feasible paths. The complexity level is simply too high.

Any proposed step or measure beyond an extrapolation of current developments will affect the positions of the stakeholders in city logistics, and as such is contentious, especially if one of the stakeholders proposes it. At the same time, an integral view of a likely and reasonable path will accelerate the discussion between stakeholders: if a path and its dependencies can be properly formulated, it becomes possible to propose changes and improvements, to incorporate new data or new developments, to debate the trade-offs between values and considerations, all against an explicitly stated reference. The challenge then becomes to define a better, more sophisticated vision, proceeding from that reference.

The method used in this report to define a feasible path is based on combining these principles and assumptions:

- **Backcasting from factor 6**
  - Working back from a target to identify what is needed to secure it is the leading principle.
  - The target is to achieve a Factor 6 improvement in GHG efficiency (emissions per unit transported) for all city logistics segments in 2050 and, as a by-product, to drastically reduce emissions of other toxic gases and particles at the same time, especially within cities.
  - Everything required to achieve the target can be considered a necessary step, even if that step is contentious or not yet embodied in laws or regulations.

- **Following existing primary external drivers**
  - Supply networks (and the transport of goods) are a service to end-consumers and customers, and as such are subject to external trends, developments and driving forces that shape society and demand.

- **Observing internal consistency**
  - A 'silver bullet' solution that assumes a technological escape that leaves everything else unchanged is highly unlikely.
  - A systemic change that creates a new stable situation integrating multiple trends and demands is seen as a likely solution.
  - All stakeholders' perspectives must be considered, and the path should be acceptable or fair for all. Businesses must be able to be profitable, reasonable demands of city dwellers must be met, (de-)central governments must be able to balance the conflicting demands of society, etc.
  - Any path will disrupt the status quo. A path that appears to have the least resistance yet achieves the goal is more likely than others. Resistance may, for example, be in the form of:
    - going against external trends
    - betting heavily on 'silver bullets': solutions that are as yet only dreamt of
    - requiring a change of laws and customary practices that are disruptive and costly
    - leaving specific stakeholders in the cold, putting the burden of change in one corner instead of creating a collective burden
  - Interactions and 'water bed effects' should be taken into account as far as possible. If, for instance, a regulation on LCVs were to lead to parcel delivery in private cars, the desired effect on GHG emissions would not be achieved, unless private cars are zero-emission.

- **Taking inertia in account**
  - Change takes time.
    - The more stakeholders are involved, the longer it takes to innovate.
    - New methods and ways to organize a supply network start with early adopters in situations where there is a pressing need. It takes time to let this diffuse across the country and into new situations.
    - Gearing up production capacity for new means of transport by OEMs (Original Equipment Manufacturers) takes investment decisions, time to build it, and time to recoup the investments.
    - Replacing a large fleet of LCVs or trucks takes their normal replacement cycle of 15 to 20 years unless specific incentives are introduced.
  - It is therefore essential to start 'setting the stage' as soon as possible.

These principles and assumptions have been used to identify, develop and select the most plausible scenarios per subsegment through analysis of available data and existing reports, using expert judgement, interviews and focus groups to test and refine each vision.

In this Outlook the most plausible path per city logistics segment resulting from this exercise is quantified at an aggregate level to achieve 'cascade' graphs, showing the sequence of step changes, the timing to achieve full effect and the relative impact on achieving the Factor 6 goal. The combination of these is what we have termed a vision.

As comments, new or improved data, new information or new trends are incorporated, new versions of these visions will evolve. Indeed, we see this as the main purpose of their initial development in this Outlook.

Primary External Drivers

Logistics, and city logistics in particular, do not occur in isolation. Many external factors either affect city logistics or even define the boundaries in which its operations are organised. Based on interviews, literature and workshops, we have identified the primary external drivers in society, technology, logistics and policy that (can) most influence city logistics in the future. We have identified relevant trends and developments that have an overall impact as well as a specific (and sometimes different) effect on a specific segment:

- **Societal developments:** including more demanding customers and increasing political and societal pressure to reduce GHG emissions and improve the liveability of cities
- **Technical developments:** including connecting the physical world and the Internet of Things (IoT), robotization and automation, and vehicle technology.
- **Logistics developments:** including developments towards omnichannel, universal labelling and the Physical Internet (PI).
- **Policy:** and the development of performance-based regulations

In the following sections these various developments are briefly introduced.

Society

A - MORE DEMANDING CUSTOMERS

Supply networks service a customer-dominated environment, driven by timelines and customer convenience. Customer intimacy is key to understanding the fickle demands for transport and value added services. A supply network that significantly improves a perceived service level holds major appeal and consequently a monetary value.

The theory of service quality defines 6 service quality dimensions[19], as perceived by customers. In sequence of importance they are:

- Reliability (= predictability, compared to expectations, as to the expected time and place under any circumstances)
- Compliance (= meeting regulations)
- Responsiveness
- Customization
- Empathy
- Look and Feel

Recent ICT developments show that the use of mobile IT can improve on these quality dimensions, as it allows direct individual contact and enables customer control. The companies that apply this technology to create the best customer intimacy will dominate, and dis-intermediate others.
For logistics service providers or companies owning their own fleet catering to B2C (or B2SME) delivery this means stronger demand for:

- more delivery options at the latest possible stage in the delivery process[20]
- 24/7 city logistics
- a reduced drop size and drop value, (eventually) leading to higher frequency of movements for LSPs as more stops are needed for the same volume
- excellent transparency on where the delivery is, if expectations can be met, and correct customer service communication when changes occur
- the option to include additional services with a delivery
- the option to include return flows[21]
- non-intrusive means of transport (license to operate)

While these developments will first be visible in B2C and B2SME deliveries, eventually other B2B deliveries will also experience the effects of the increased customer intimacy.

B - INCREASING POLITICAL AND SOCIETAL PRESSURE TO REDUCE GHG EMISSIONS.
As shown extensively in Chapter 4, the GHG emission reduction challenge is sizeable and becoming increasingly important in the political agenda as voter concern grows. The trend assumes that this pressure will increase with time.

C - INCREASED POLITICAL AND SOCIETAL PRESSURE TO IMPROVE LIVEABILITY OF CITIES.
The success of the city as the place to live, work and relax is visible everywhere. Cities have become the dominant economic factor where the greatest share of national income is generated. More and more people either live and work in the city or commute daily to a city to work there.

The demand for personal transportation and transport of goods has subsequently grown, leading to competition for the limited available space. Large-scale utilization of urban space by road infrastructure for cars, vans and trucks to drive or park is no longer an unchallenged given. Increasingly, public space is being reserved for other purposes, including creating more room for cyclists and pedestrians, greening the city and other initiatives to make (or perceived to make) the city more attractive. People living and working in cities are tolerating less and less impact on these scarce and precious common city resources (space, a green and healthy environment, low noise levels, safety, clean air). This puts (political and social) pressure on supply networks to innovate and do more with less consumption of these scarce resources. This demand goes beyond low-carbon emissions; it also involves low noise, less congestion, high safety and less space for city logistics.

This demand for liveability coincides with the more societal demand for GHG emission reduction.

D - INCREASED POLITICAL AND SOCIETAL PRESSURE TO REDUCE FOOTPRINTS, BY MEANS OF A CIRCULAR ECONOMY

A more circular economy reduces demand for scarce materials and increases that for intelligent re-use of products after their economic/technical lifespan. This requires sophisticated logistics solutions which are currently in their infancy.

Technology

A - CONNECTING THE PHYSICAL WORLD

It is hard to underestimate the effects of (fixed and mobile) connectivity on society, continuously disrupting its organization. In the past 25 years it has become an ubiquitous utility for many of us, as well as for businesses, institutions and governments.

Connecting the physical world is the next wave of this (r)evolution. Embedded computers in products are connected to the internet. Cheap computers-on-a-chip with very low power requirements are combined with sensors and new forms of wireless connectivity, so they can be attached to physical objects and travel with them while staying connected (constant or intermittently). The term 'Internet of Things' (IoT) is used for this development.

The effect on supply networks is that it will become affordable to track objects in semi-real-time, including vital statistics such as current ambient and internal temperature. Tracking means transparency of the supply network to the final customers.

Transparency to the final customer creates customer intimacy, which is a differentiator already exploited by parcel delivery companies - and is in itself a trend already discussed under the heading 'more demanding customers'.

Transparency also reduces the need to trust that goods will be handled and transported with due care and as agreed upon by the logistic service provider. This will enable carrier-agnostic supply networks, where the actual carrier is not known beforehand (see also 'Physical Internet in logistics developments').

Besides connecting products, most commercial vehicles are already connected to their home base through dedicated onboard computers (Fleet Management Systems/FMS), connected to Transport Management Systems (TMS) and using real-time traffic data. Control Towers managed by and for shippers are on the rise.

This connectivity will be expanded and re-used for regulatory purposes such as traffic management, including access to city zones (see 'Performance-based regulation') and reserving special un-loading spaces, tax and customs, safety and statistics, as well as advanced traffic management in cities[22]. Enforcement of regulations will become based more and more on widely distributed IoT sensors in cities, as this allows highly customized regulation with low enforcement costs.

The obvious privacy issues will be solved by organizational measures, such as Trusted-Third-Parties. The example of Australia's 'Intelligent Access Program'[23] points to one possible solution. Another development can be seen in a demonstration in Amsterdam (among other places), viz. reserving unloading locations. Currently, delivery vans circling the streets, trying to find a parking spot, or lack thereof, decide to double park; it happens in every city. It is inefficient and a hassle for the driver as well as city residents. To tackle this problem Amsterdam has started trials with reserved parking spots for delivery vans, which can drive directly to this spot and no longer need to load and/or unload on the street. This will allow the logistic sector to work more efficiently and budget-friendly, while pressure to find a parking spot and traffic congestion will decrease.

B - ROBOTIZING AND AUTOMATION

Autonomous vehicle technology is one of the most obvious examples of automation that will impact city logistics. Its application may vary depending on the supply network: reducing the costs of a labour-intensive last mile delivery versus customer intimacy demands that dictate human-human interaction when delivering. Or autonomous bulk vehicles that use late and early hours to access the city quietly[24].

The general trend is that automation brings productivity to the next level, as solutions that were previously regarded as prohibitively expensive now become affordable.

One of the biggest costs in a supply network is handling. In sea-freight the success of the sea-container is based on the massively reduced handling costs of containers compared with individual cargo items. Standardized containers have enabled an ever-increasing level of automation of container handling . Intelligent robotization in city logistics holds the promise of automated handling of goods, regardless of size and packaging. This will reduce costs and make supply networks with more hand-over points affordable. Fully automated warehouses already exist in e-commerce sectors to reduce handling (i.e. manual picking) costs.

The latter trend dovetails with more specialized, high-frequency carriers within the city, who combine cargo in cross-dock/temporary storage facilities (urban consolidation centres) to full loads in specialized vehicles for custom delivery: zero-emission with less movements, while allowing for high frequency delivery. The same logic applies to parcel, food and groceries deliveries.

It is not only robotics that will play an important role in logistics. Other technological advances will reduce the need for control by manpower and for opening doors for autonomous driving vehicles on motorways and within built-up areas.

C - VEHICLE DRIVE TECHNOLOGY AND ENERGY SOURCE ADOPTION DRIVEN BY SCALE

The push for a low-carbon alternative to the internal combustion engine (ICE) running on fossil fuels leads to several competing technologies with associated energy sources. In practice, it is the scale of use of a technology (including its use in passenger cars and buses) that largely determines its successful application. Scale leads to:

- lower production costs, lower running costs
- availability of energy and energy distribution infrastructure
- experience that leads to both reliability, cost reductions and general acceptance
- a second hand market, lowering the TCO

The role of the government in creating scale and preventing fragmentation in requirements is vital, especially in a transition phase. A seemingly simple question like the (minimum) ZE-range of a PHEV vehicle becomes quite an issue if a European standard needs to be developed to obtain a sufficiently large scale of production by OEMs.

Logistics

A - TOWARDS OMNICHANNEL

The difference between what is now called e-commerce and other supply networks is evaporating. E-commerce is breaking new grounds and the lessons learned will be adopted by more traditional segments. This broadening of e-commerce is closely related to the increasing demand for value-added logistics, service logistics and fresh food, as already discussed under 'More demanding customers'. Current pure e-commerce players adopt bricks-and-mortar, while traditional bricks-and-mortar retailers adopt online ordering and home delivery, both leading to omnichannels that compete (among other things) on serving customers best (customer intimacy).

Specialized shops - stand-alone or part of a network - can reach customers in a much larger area through dedicated webstores and cooperation with a logistics service provider or by distributing their products themselves. Large retailers are using local shops for meeting demand (same-day delivery). Supermarkets are starting to supply customers through home deliveries and pick-up-points, and the same holds for building materials, fashion and consumer electronics. At the same, e-tailers are opening physical shops in the city centre as experience centres. All these examples illustrate the full mix of traditional and modern sales channels. Aggregators combine local-for-local producers in webstores, catering for local demand.

The shift to omnichannel sales will lead to an increase in direct deliveries (B2C, B2SME, C2C) at the expense of volume via a bricks-and-mortar store: the store may be the place where the purchasing decision is made, but increasingly the goods are delivered where and when the customer wants. The 'order everywhere, deliver everywhere and return everywhere' characteristic of omnichannel sales are having a significant impact on logistics:

- Increase of B2C and B2SME deliveries and longer shipping distances.
- Local specialist shops can reach and supply clients over a far larger geographical area.
- The rise of distribution of fresh meals (food) and cooled/temperature-controlled goods.
- Retailers and specialist shops distribute on own account to keep close contacts with clients.
- Many return deliveries and waste collection.
- Stock to be picked up and delivered can be anywhere, including in a store, (unmanned) pick-up-points or a restaurant.

These changes will eventually also be adopted (to some extent) as the standard for other products and deliveries.

B - PHYSICAL INTERNET AND UNIVERSAL LABELLING

The Internet we use daily is based on several principles that have led to an extremely successful system. The global Internet consists of over 25,000 individual networks (private, public, profit, non-profit) that cooperate in transmitting information from origin to destination, across networks if necessary. A global address space and basic rules on how to handle packets are combined with agreements on the cost of carrying a packet originating in someone else's network.

In practice this means that if you want to send a packet of information to a very remote webserver, requesting a page, your Internet Service Provider (ISP) will hand over (route) this packet to one of its (many) peer networks to forward it. This second network may be another ISP, or a backbone carrier connecting continents. Maybe a third or fourth handover is needed to reach the destination. The exact route is not known beforehand: at each router (junction) new decisions are made about what the likely optimum route. A second packet of information sent later with the same destination may therefore follow a different route.

Internet networks peer one-on-one if they have a lot of traffic to exchange, on the basis of private commercial arrangements. General exchange points connect a multitude of networks at the same time (as at the Amsterdam Internet Exchange, where over 700 networks exchange traffic). Backbone carriers make a business out of being the high-volume carrier in the background, doing business with your ISP.

The concept of the Physical Internet uses some of these principles to propose a new paradigm for supply networks, creating an Internet for Goods.

The first principle is a universal (preferably global) address space used by all, so all networks can handle any packets of goods correctly and route packets are handed over by a peer satisfying customer wishes (fast, cheap, exactly on time, best effort, low carbon footprint, etc.). The introduction of universal labeling in the EU based on SSCC labels[25] is a major step forward toward a Physical Internet.

The second principle is carrier-agnostic forwarding and routing. The packet/parcel can be forwarded to a peering network, which can hand it over to another peer to reach the destination. A second parcel for the same destination may (or may not) use a different route, depending on the options and load at that particular time.

A simple example is buying a second-hand washing machine on Marktplaats.nl[26] from someone living on the other side of the country. A local specialist collects the machine. It gets picked up by one of the 'peer' networks of the specialist who does regular backhaul runs between the area of origin and destination[27]. Another specialist delivers the machine locally. The difference from current practice is that the route and the (intermediate) carriers are not pre-determined, but selected as the parcel goes. The parcel selects its own route.

It has been shown that existing supply chains would be able to perform much better[28] in such a paradigm, at the expense of more handling. One of the oldest examples of a Physical Internet, the Dabbawallah system in Mumbai (India), shows that even without central planning or IT-systems a very high level of reliability and consistency can be achieved: universal labeling and local routing decisions are enough to manage a flow of over 200,000 meals a day from homes to individual destinations.

The rise of robotization holds the promise that handling costs can be reduced to a level whereby a Physical Internet competes on (integral) costs with the current supply chains.

The trend to create customer intimacy may limit the potential: for instance, if branded products that require a lot of trust are transported, such as fresh food. When specific requirements are set (security, time, etc.), a specific bespoke supply chain is necessary.

Performance Based Regulation

The further development of (local) policies to push for an increase in CO_2 productivity in city logistics and a shift to zero-emission city logistics in city centres is inevitable: growing political and societal pressure demands it.

This push can already be recognized in the existing variety of local regulations, customized to different local circumstances in different cities or parts of cities.

Policy regulations such as environmental zones (limiting access to vehicles better than a certain emission standard), limited access times for freight transport in city centres (for instance between 6 and 11 a.m.), axle-weight limitations or length limitations are all standard practice today. Some cities[29] now limit access entirely in certain districts.

These policy regulations are contentious as they are generic, impact supply chains directly and are feared by transporters to be subject to sudden changes after elections. Yet some form of regulation is seen as highly desirable.

As the path for each segment to achieve Factor 6 is different, there is a growing need for a more flexible and customizable method of regulating access. As connected vehicles with geolocation capabilities are becoming standard, the path to individualized regulation is opened, the next step going beyond current regulatory practice.

The term 'performance-based regulation' describes a highly flexible and individualized approach to regulating why, when and where a commercial vehicle can drive. The word 'performance' is used both for roads and the immediate environment (how sensitive is the situation, like children playing nearby, how much weight can a bridge carry, how sensitive is the environment to air pollution and noise) as well as for the vehicle (weight including cargo, size, emissions, noise, safety features, etc.). Performance-based regulation is about matching vehicle performance to the sensitivity of the environment. This may be time-of-day-dependent, as with noise emissions, for example. The assumption is that vehicles are GPS-enabled and connected and can therefore be transparent to regulators, allowing access to be customized.

The generic term 'city' is a container concept, describing a large variety of urban areas. The dense old city centre of Amsterdam, for example, poses quite different challenges to the more recent open structure of Rotterdam. A suburban area does not have the same frequency of delivery as a pedestrian area with shops. Size and therefore volume of deliveries make solutions possible that cannot be economically sustained in smaller cities.

This variety, combined with the difference in segments and their development, compounded further by the time lag between early adaptors and late followers adopting Factor 6 requires considerable flexibility in the realm of regulation.

In the visions presented in the next chapter it is assumed that this flexibility is created by combining a common framework for various levels of regulation (in geo-fenced zones) with local implementation at the levels required.

Such a framework would make it easier and more attractive for cities to implement regulations and ensure that these are more harmonized across cities. This well help create the scale required for low-cost implementation. The standardization created by adopting a common approach allows for scale, low costs and ease of use for supply networks servicing the entire country, with specific local circumstances driving how the framework of zones is applied locally (and changes over time).

A choice of zones and applicable regimes might be as follows (in rising order of regulation level):

1 **Public roads**
   a. no other regulations
2 **Geo-fencing**
   a. for instance based on emission class
   b. or with time windows
3 **Routed geo-fencing**
   a. as 2, but with addition of prescribed/limited routes to (un)loading zones
4 **Slotted and routed geofencing**
   a. as 3, with the addition of allocated timeslots for entry and (un-)loading-zones
   b. assumes advanced ITS systems that create 'green-flow' with priority, and managed unloading zones (reserved, with flexibility in trading slots between users)
5 **Restricted**
   a. for designated modes of transport and designated routes only

An example of level 5 would be the construction challenge posed by the large 'Marine' site in Amsterdam. The only acceptable mode here might be an (electric) flat barge commuting between the north of the IJ river, where the consolidation centre is, pre-fab components are constructed and heavy machinery is maintained, and the site itself where construction takes place.
Level 4 is quite well known in Distribution Centres for large retail organizations, where this is standard practice (except the possibility of trading slots between transporters). As such, this is not new or uncommon, it just has not been applied to dense city centres.

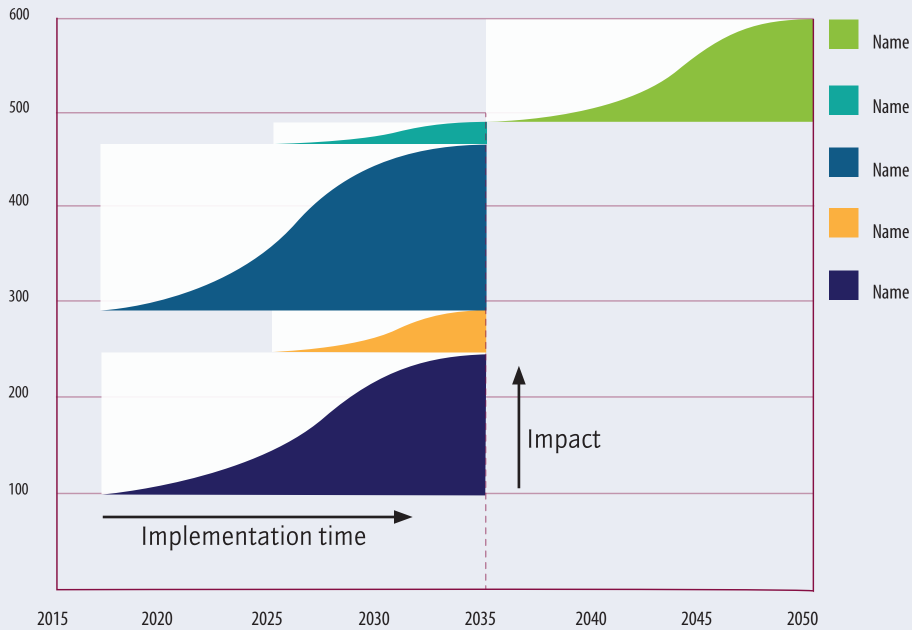
Connected commercial vehicles that are transparent on cargo and destination(s) allow for easy implementation of zones and cheap, flexible and easily fine-tuned individualized regulation. The choice of zones, where they are useful and if they should be used at all would be a local decision fitting the local circumstances.

8 Outlook per segment

Introduction

In this section the preliminary visions of this first Annual Outlook are presented per segment of city logistics. Each vision starts with some primary data and characteristics on which the backcasting calculations are based. The narrative of the assumed path is then elaborated and quantified, followed by a brief description of the key assumptions made in constructing the cascade graphs.

Figure 8
Example of cascade graph



The cascade graphs show cascading blocks of effects which add up to a Factor 6. The height of each block represents the maximum contribution towards achieving the Factor 6 goal, assuming maximum penetration of the effect in question in all the cities across the country. This will take time, with early adopters[30] starting at once and others following later. It will also take time to convert an existing fleet to a new technology following successful introduction, or roll out concepts successful in big cities to smaller ones, or modify business processes.

The width of the block represents the time it takes from early introduction to full coverage and penetration. A block starts on the x-axis in the year regular operational application is started and ends in the year full penetration in the specific zones or nationwide is achieved. The curve within the block is a stylized representation of a possible penetration curve, picking up speed after the early starters have proven the viability.

The impact of the various trends differs per subsegment. In some markets segments customer demand will be a major influencer (e.g. parcels), while in other segments this may play a minor role (e.g waste). In tables per subsegment the icons indicate the estimated size of the impact of a trend.

The study by CE Delft (2016) on the quantification of city logistics emissions has been used a starting point for generating subsegment statistics. As this study was undertaken for the purpose of making an initial estimate of aggregate emissions, however, it cannot be used directly for describing or quantifying the emissions of subsegments. In some cases, then, where this study provides insufficient detail, other studies have been used or estimates made on the basis of our own expert insight. In Annex A, deviations from CE Delft (2016) and our additions are summarized.

Assumptions used in all segment analysis

Implementation of performance-based regulation and zones

The different archetypes in general cargo, and consequently the logistics organization in these types changed over time, and will develop the coming years. The table below illustrates the trends that will be most influential in this market segment. The impact of drivers differs per sub segment.

Zones and performance-based regulation are among the most vital steps in the transition phase and beyond. There are major differences between segments in adoption paths and in the availability of new technologies, compounded by the fact that cities vary substantially in size and structure and by various significant challenges. It is assumed that this type of regulation will be introduced in the 2020-2025 time frame. The implication is that if it is not introduced within this period, the effects (i.e. the blocks in the cascade graphs) will shift to a later date (i.e. further to the right in the graphs).

To estimate effects and time paths, a number of assumptions were made with respect to zoning. The percentages in the table below indicate the share of kilometres in cities affected by implementing the zone regimes in the cascade figures showing the different effects in the vision.

Zone	LARGE CITIES (50%) >70.000 INHABITANTS kms coverage	SMALL CITIES (50%)<70.000 INHABITANTS kms coverage	TOTAL
1 **Public roads** a. no other regulation	100%	100%	100%
2 **Geo-fencing** a. For instance based on emission class b. Or with time windows	80%	40%	60%
3 **Routed geo-fencing** a. As 2, with the addition of prescribed/ limited routes to (un)loading-zones	60%	25%	43%
4 **Slotted** a. As 3, with the addition of allocated timeslots for entry and (un-)loading-zones b. Assumes advanced ITS systems that create 'green-flow' with priority, and managed un-loading zones (reserved, with flexibility in trading slots between users)	40%	10%	25%
5 **Restricted** a. Only with designated mode of transport and designated route	5%	0%	3%

Increased consolidation and rise of specialists

The pressure within cities for clean air, peace and quiet, safety and open space creates a push to reduce the number of vehicle movements, even if these are zero-emission. In addition, further rising demand for precision logistics (higher customer intimacy) results in faster and smaller deliveries. To satisfy these high service requirements a further shift towards highly specialized (local) urban freight service providers is anticipated. This is expected to result in decoupling at city perimeters and further urban consolidation, enabling use of larger vehicles for supplying the various hubs. Urban consolidation can occur at both newly developed sites - where local authorities have a role in facilitating for available space that is accessible, covering various market segments (e.g. general cargo and cooled goods) - but also at existing local hubs[31] (parcel or wholesaler), by expanding activities, such as those of specialized urban freight service providers.

Availability of low-emission technologies and energy carriers

Transitioning from a mature technology produced on a large scale to a new fuel and drive technology is an uphill battle until the required scale for the new option is reached. Delays in upscaling spawns an even bigger fleet of new ICE vehicles that will have an average economic life of 15 years of more, pushing back the goal of converting the entire fleet. An aggressive push to create volume whenever and wherever possible is essential to create the rate of fleet turnover needed to achieve the Factor 6 goal.

In this report the following aggressive schedules have been adopted:

- Incremental technological efficiency improvements to conventional ICE vehicles until 2035. The current conventional diesel trucks can be significantly improved. The technical potential for fuel consumption reduction is estimated between 35 and 40% for various types of trucks (CE Delft, 2012[32]; TNO, 2015[33]). Measures range from further optimization of the diesel engine, light weighting and improvement of aerodynamics and optimization of tyres and wheels.
  Once ZE vehicles in various segments such as passenger cars, vans, city trucks and at some point long-haul heavy-duty trucks start to become a viable, scalable and preferred option for the mass market, OEMs will probably scale down and eventually cease to invest in further efficiency improvement of ICE vehicles.
- Increasing availability of ZE LCVs and small- and medium-size ZE city distribution trucks between 2020 and 2025 and, subsequently, large-scale vehicle replacement in commercial city logistics by such ZE vehicles between 2025 and 2035.
- Increasing availability of PHEV HD trucks for long-haul transport between 2020 and 2025 and large-scale market adoption in the timeframe 2025-2035.
- Increasing availability of next-generation ZE heavy-duty trucks (either BEV or FCEV) for long-haul transport between 2030 and 2035 and large-scale market adoption in the timeframe 2035-2050.

For vehicles requiring additional power, such as electric cooling or power-take-off, slightly delayed introduction is assumed.

Next-generation ZE trucks after 2035

Up to 2035, the incremental technological vehicle improvements that are in the pipeline for mass-market introduction are relatively clear. In most segments the combination of logistics measures and technological developments up to that point are insufficient to achieve the Factor 6 objective. To bridge the gap, additional technological advances are therefore required, mainly to decarbonize large truck-trailer combinations and further upscale the use of smaller vehicles (rigid trucks and vans) for larger cargo weights and distances. It has been assumed that the first generation of electric trucks will be replaced by a next generation that can be more widely applied, using power storage, hydrogen or some other sustainable energy source.

General Cargo

Developments in general cargo

Societal pressure to improve the liveability of cities is especially felt in the segment of general-cargo partial deliveries, one of the largest segments in urban logistics. Frontrunners are currently experimenting with consolidation at the city border, leading to more outsourcing of last-mile transport and a broadening from segment specialist (e.g. fashion) to urban specialist. This trend is being accelerated by rising costs in the last mile and by developments in automation, connectivity and smart labelling.

The following table illustrates the trends that will be most influential in this market segment. The impact of drivers differs per subsegment.

DEVELOPMENT	LARGE RETAIL CHAIN	PARTIAL DELIVERY	HOME DELIVERY LARGE GOODS
More demanding customer	•••	•••	••
Towards Omni channel	•••	•••	•••
Connectivity and smart labelling	••	•••	•
Increasing political and societal pressure for sustainability	••	•••	•
Increased pressure for better liveability in cities	•••	•••	••
Vehicle development (from conventional fuels towards zero emission)	••	•••	•
Automization and robotization	•	•••	••

The most important trends have been used as inputs for developing the vision for a transition to a low-footprint urban logistics system.

Retail chains

Kilometers driven per year (2015)	1,000 Mio km
Distribution over vehicle types (2015)	Rigid trucks: 20% Tractor-semitrailer: 80%
CO_2 emissions (TTW/2015)	792 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.1

Grocery and general retail chains, being sensitive to retaining their 'license to operate' from society, are expected to lead the curve in experimenting with available technologies and alternative logistic concepts.

Grocery retail chains mainly use FTL tractor-trailer combinations or large rigid trucks, run by subcontracted transport companies[34] that service retail shops from regional or centralized Distribution Centres (DCs). In the near future the trend towards centralizing into fewer DCs (and therefore towards longer distances driven) will continue, as the cost savings of centralized DCs outweigh the extra distance driven.

Logistics optimization and CO_2 emission cuts will be achieved by adding **control towers** and using the return trips from retail shops for collecting goods from suppliers in **backhaul trips** to DCs. For general retail, the backhaul optimization possibilities are limited, as less of their volume is produced locally.

This already highly optimized logistic chain - characterized by large volumes and FTL - does not benefit from consolidation points near a city.

The exception may arise in the future, when groceries home delivery grows to such a level that it competes with the volume via retail outlets. If handling costs are simultaneously reduced through automation and robotics, the supply chain may change. The high demand for home delivery may lead to consolidation centres at city boundaries (or strategically located near a region with smaller cities) from which zero-emission deliveries are made to both homes and shops. In this scenario the traditional centralized DCs may well be eliminated and replaced by such decentralized consolidation centres. For calculating CO_2 emission cuts this scenario is not that different from the vision, even though it is operationally quite different.

Demand for local emission reduction in larger cities will lead to an early step to use Plugin-Hybrid **(PHEV)** tractor-trailer or rigid truck combinations with enough capacity to run on battery power within the city, with a conventional combustion engine being used elsewhere. These combinations are suitable for use in any city, big or small, and can be used for backhauling.

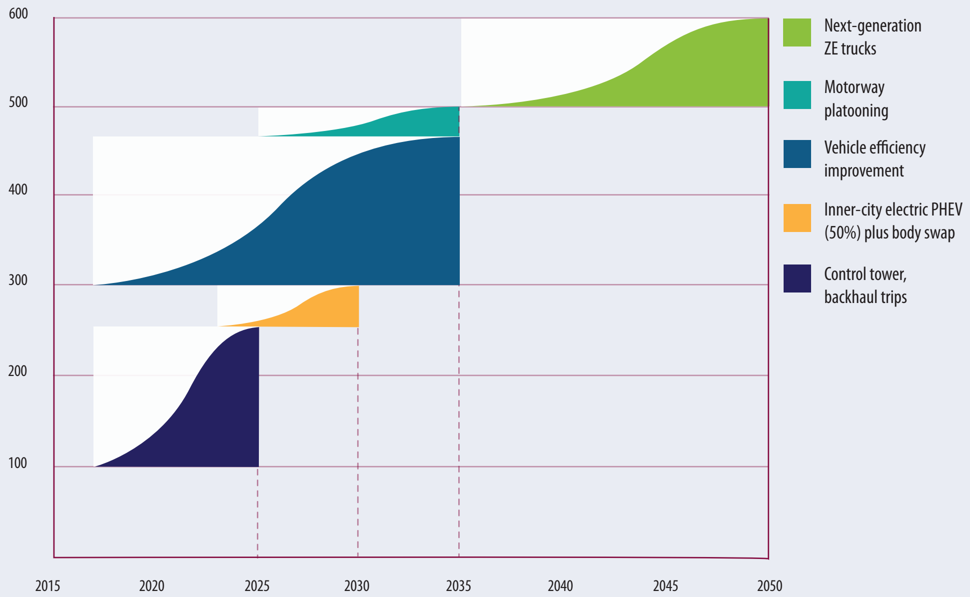
*In addition, a **swap of tractors** can be executed at the perimeter of large cities, from conventional to electric, to perform the last mile in zero-emission mode. This will be limited to larger cities where the volume is high enough to justify the extra handling and costs and the need to respond to societal pressure is high. Again, for calculating CO_2 emission cuts this scenario differs little from the vision, although operationally it is quite different.*

Vehicle efficiency improvement is a highly effective step, with emissions cuts greatest when longer distances are driven on motorways, such as between DCs and retail shops.

Roll-out of on-the-fly multi-brand **motorway platooning** can reduce the air resistance of the tractor/truck further and is expected in the post-2025 period, following development of the technology and early trials.

Next-generation ZE tractor-trailers or rigid trucks requiring no combustion engine and fitting the required emissions profile will appear in the 2030-2040 decade.

Figure 9
Towards zero-emissions logistics in grocery and general retail and large retail chains



This cascade graph is based on the following assumptions:

- For large retail the further use of control towers (already taking place) results in a 5% reduction in kilometers outside the city.
- Backhauling leads to a net 30% reduction in emissions (assuming losses to detours and mismatches) for groceries and 15 % for other retail, resulting in an overall reduction of 20%.
- For PHEV introduction, we assume that the last mile corresponds to 10% of the trip distance, reducing GHG emissions by 10% on each trip.
- On motorways, platooning will mainly reduce the fuel consumption of the trucks following the first truck in the platoon and to a lesser extent that of the first vehicle. Based on TNO (2015)[35] we assume a 10% reduction in fuel consumption on average.

General cargo partial delivery

Kilometers driven per year (2015)	1,356 Mio km
Distribution over vehicle types (2015)	LCV: 32% Rigid trucks: 64% Tractor-semitrailer: 4%
CO_2 emissions (TTW/2015)	750 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	0.8

General cargo partial delivery is a large, heterogeneous segment, servicing mostly generic business-to-business transport of goods that do not fill a truck or trailer (less than truck load, LTL) nor fit into a parcel network. Many small specialists and some cooperative networks[36] pick up and deliver a wide variety of goods on demand, from and to any location.

Especially over longer distances, the transport legs can be seen as point-to-point, even if the pickup run is a milk-run, as well as the delivery run. Cooperative networks use a hub-and-spoke design to optimize for regional specialization and nationwide coverage at the same time: cargo is collected regionally and exchanged with other regions at one or more hubs.

The long distances between origin and destination or hub make **vehicle efficiency improvement** effective, as the resultant emissions cuts are greatest when longer distances are driven on the motorway.

The push for less vehicles and ZE vehicles in dense city centres (operationalized by performance-based regulation focusing on ZE) and the increased demand for customer intimacy (small size, short lead time) will result in more **consolidation** of transport within the city perimeter. The 'long tail' of transport[37] will be incentivized to consolidate. This will start at the centre of the bigger cities and expand outward, as well as to smaller cities. These specialists will rapidly adopt **universal labeling** as this lowers thresholds for attracting business and exchange of cargo. The rise of specialists will be accelerated by performance-based regulation in sensitive zones and later on by automation and robotization that lower transshipment costs. The specialists will start to cooperate as a group and adopt principles of the Physical Internet to attract ever more business, as the advantages of more IT sophistication become apparent.

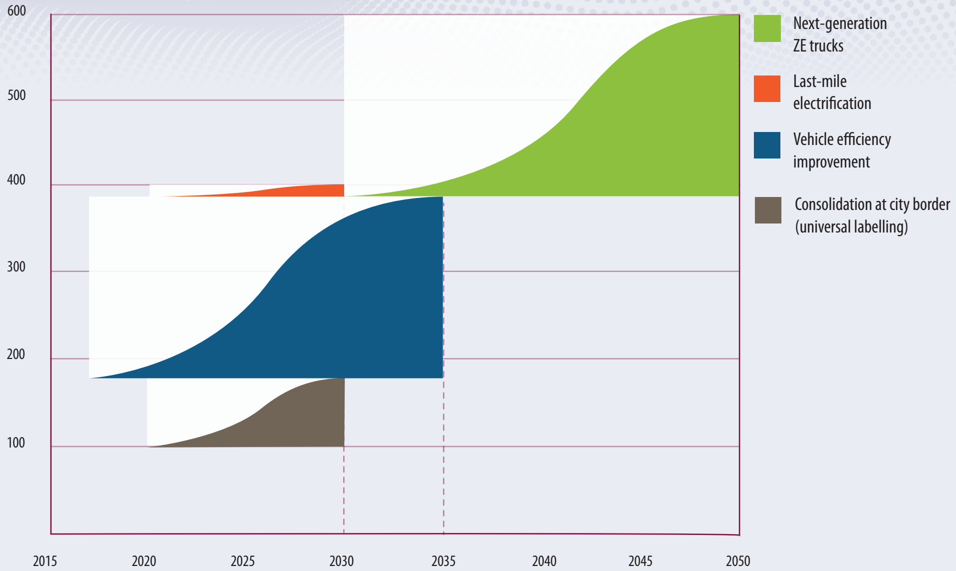
These specialists can support the IT systems and IT sophistication needed to attaint the (information) service levels so valued by customers and improve their competitive edge. Alternatively, IT platforms without assets[38] may be able to take on this role.

Changing the logistics network within cities facilitates network optimization outside them. A larger vehicle can be used to supply consolidation centres.

Investments in **last-mile electrification** vehicle technology will be such that these create advantages for specialists that can attract the volume needed to justify the investment for becoming the key player in the city centre.

The **next-generation** ZE tractor-trailers or rigid trucks requiring no combustion engine and fitting the required emissions profile will appear in the 2030-2040 decade.

Figure 10
Towards zero- emissions logistics in general cargo partial delivery



This cascade graph is based on the following assumptions:

- Consolidation of cargo at the city border is expected to lead to a reduction in the number of trips for final delivery through increased vehicle loading and bundling of stops for a smaller delivery area. At the same time, the vehicles that bring goods to the hubs can be larger and can support off-hour deliveries (as well as avoid congested urban areas), since more cities can be served within one working day. We assume an overall efficiency improvement of 50%, applying to zone 4/5.
- Last-mile electrification is applied in this zone as well, with the assumption that 20% of the distance driven is within cities, leaving 80% of the kilometres operated by conventional vehicles outside cities.
  The next-generation ZE truck for this segment closes the gap in performance and costs with conventional ICE vehicles.

Home delivery of large goods (2-person deliveries)

Home delivery of large goods is usually connected with a service: installing something, providing professional advice, taking away the old equipment or furniture, and/or removing packaging waste. Two persons are needed to deliver the complete service, typically using an LCV or smaller truck (< 7.5 t), direct from a central distribution centre. As this is a value-added service, separating out the service from the delivery is difficult without reducing customer satisfaction ('one-stop shopping').

As the volume is relatively low, there are very few instances where a handover and consolidation centre on the edge of a city is viable. The long distances between the DC and the customer make the **vehicle efficiency improvement** effective, as the resultant emissions cuts are greatest when longer distances are driven on the motorway.

Next-generation ZE LCVs or small trucks requiring no combustion engine and fitting the required emissions profile of driving long distances daily will appear in the 2030-2040 decade. Access to inner-city delivery has been made dependent on conformity to the performance-based regulatory framework, which is not a burden for specialized home-delivery companies.

Figure 11
Towards zero-emissions logistics in home delivery

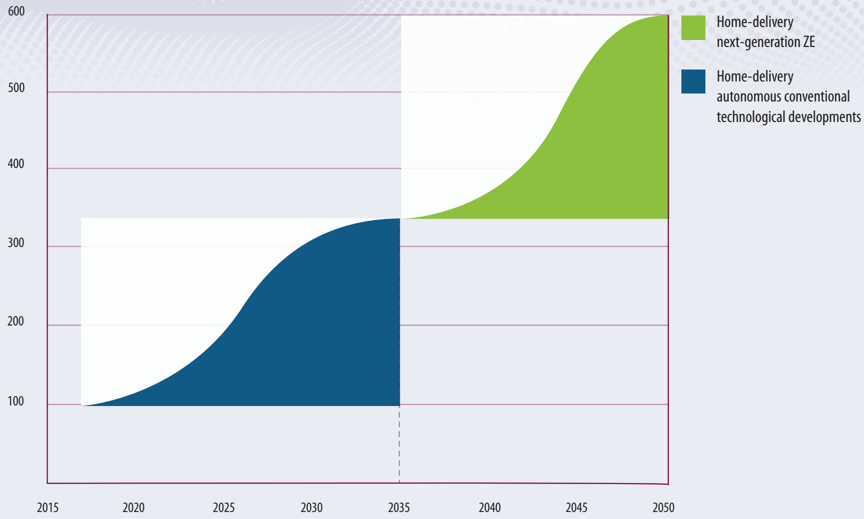


Figure 11 is based on the following assumptions:

- Consolidation of home delivery goods at the city border is expected to be implemented for only a limited range of addresses, in zone 4/5. Decoupling at these zones implies that the vehicles servicing hubs can be larger as they no longer need to access the inner city. On top of that, hub supply logistics can be organized more efficiently, since more cities can be served within one working day. In that case a 50% emissions cut is estimated, although the total volume is low.
- The next-generation ZE LCV or trucks for this segment will close the gap in performance and costs with conventional ICE vehicles earlier than for 20-40 tonne trucks, though the difference in years is not much.

Temperature controlled city logistics

Developments in temperature controlled city logistics

Temperature-controlled logistics is a diverse segment, covering the entire city. The pressure on liveability is most strongly felt in inner-city areas where wholesalers and specialists are active. Here, internet ordering will become the standard, increasing the number of orders while decreasing drop size and density. To compensate for these developments and maintain a high-quality and sustainable supply network up and running, connectivity, automation and robotization will be rapidly adopted. The table below illustrates the trends that will be most influential in this market segment.

DEVELOPMENT	SUPERMARKET	WHOLESALER	HOME DELIVERY	SPECIALISTS
More demanding customer	•••	•••	•••	•••
Towards Omni channel	•••	•••	•••	••
Connectivity and smart labelling	•	•••	•••	•••
Increasing political and societal pressure for sustainability	••	•••	•••	•••
Increased pressure for better liveability in cities	••	•••	•••	•••
Vehicle development (from conventional fuels towards zero emission)	••	•••	•••	••
Automization and robotization	••	•••	•••	••

The most important trends have been used as inputs for developing the vision for a transition to a low-footprint urban logistics system.

Large retail

Kilometers driven per year (2015)	449 Mio km
Distribution over vehicle types (2015)	Rigid trucks: 20% Tractor-semitrailer: 80%
CO_2 emissions (TTW/2015)	356 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.25

Temperature controlled delivery to large **food/grocery retail** shops requires cooling and/or conditioned equipment on the vehicle, an additional function requiring considerably extra energy. The perishable or temperature-sensitive goods set specific requirements on handling[39]. Being able to guarantee the environmental condition the goods require is vital for business, limiting the options for transshipment or increasing the cost thereof.

Logistics optimization and CO_2 emissions reduction are achieved by adding control towers and using the return trips from retail shops for collecting goods from suppliers in backhaul trips to DCs. This already highly optimized logistic chain, characterized by large volumes, FTL and specialized vehicles, does not benefit from consolidation points near the city.

The exception may arise in the future, when fresh food plus groceries home delivery grows to such a level that it competes with the volume via retail shops. If handling vosts are simultaneously reduced through automation and robotics, the supply chain may change. The high demand for home delivery may lead to consolidation centres at city boundaries (or strategically located near a region with smaller cities), from which zero-emission delivery are made to both homes and shops. In this scenario the traditional centralized DCs may well be eliminated and replaced by such decentralized consolidation centres. For calculating CO_2 emission cuts this scenario is not that different from the vision, as it will coincide with the rise of the next-generation ZE truck; operationally, though, it is quite different.

Demand for local emission reduction in larger cities will lead to a step to use Plugin-Hybrid **(PHEV)** tractor-trailer or rigid truck combinations with enough capacity to run on battery power within the city, with a conventional combustion engine being used elsewhere. This may require a trailer with its own battery for cooling. This combination is suited for use in any city, big or small, and can be used for backhauling.

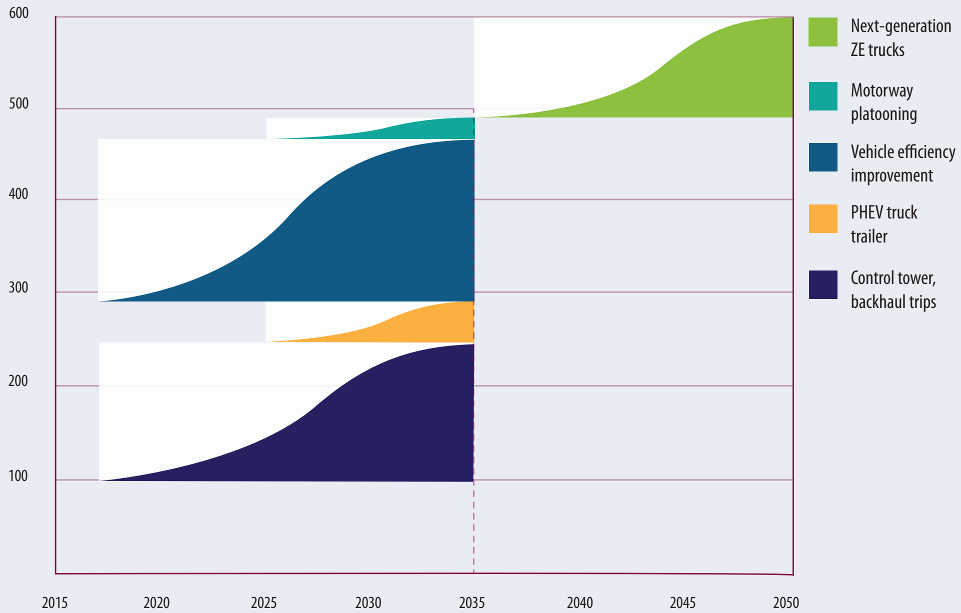
*In addition, a **swap of tractors** can be executed at the perimeter of large cities, from conventional to electric trucks, to perform the last mile in zero-emission mode. This will be limited to larger cities where the volume is high enough to justify the extra handling and costs and the need to respond to societal pressure is high. For calculation CO_2 emission cuts this scenario differs little from the vision, although operationally it is quite different.*

Vehicle efficiency improvement is a highly effective step, with emissions cuts greatest when longer distances are driven on motorway, such as between DCs and retail shops.

Roll-out of on-the-fly multi-brand **motorway platooning** can reduce the air resistance of the tractor/truck further and is expected in the post-2025 period, following development of the technology and early trials.

Next-generation ZE tractor-trailers or rigid trucks requiring no combustion engine and fitting the required mission profile will appear late in the 2030-2040 decade, as the energy requirements of cooling and conditioning place a severe burden on vehicles energy demand.

Figure 12
Towards zero-emissions logistics in temperature-controlled large retail



This cascade graph is based on the following assumptions:

- The various logistics optimization options result in a 10% reduction in the number of kilometers driven, mainly through less empty driving through exchanging trips. This increase in average loading can be achieved by optimizing the logistics at a more aggregated level, e.g. by using empty return trips for supplying distribution centres, or by developing a supply network for groups of retailers rather than single networks.
- On-the-fly motorway platooning will mainly reduce the fuel consumption of the trucks following the first truck in the platoon and to a lesser extent that of the first vehicle. Based on TNO (2015) we assume a 10% reduction in fuel consumption on average.
- As for general retail, the next-generation ZE technology is needed for this segment to decarbonize long-haul large trucks, a category that currently cannot be readily electrified owing to the large weight of the battery needed for full-day range as well as high costs.

Wholesale food service specialists

Kilometers driven per year (2015)	584 Mio km
Distribution over vehicle types (2015)	LCV: 18% Rigid trucks: 77% Tractor-semitrailer: 5%
CO_2 emissions (TTW/2015)	358 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.5

Wholesale food services specialize in delivering anything related to food and drink (non-perishable and perishable, temperature-controlled or frozen) in the business-to-business market.

The high service requirements of the customers and the perishable nature of the goods lead to relatively high-frequency roundtrips and therefore multiple distribution locations relatively close to cities or a region of cities. Still, the average distance between distribution locations and customers, and the need to make distribution runs (LTL loads, many drops) will mean **Vehicle efficiency improvement** leads to major emission cuts. 'Stop and Drop'[40] type solutions in the city reduce emissions and noise locally and provide lessons for the next step.

For dense cities, **last-mile electrification** of vehicles becomes possible as distances are lower. This will start with smaller vehicles (LCV) and expand from there as soon as the technology allows for the energy demands of both driving and temperature control. Municipalities will support this by providing more Stop and Drop locations and possibly power for charging vehicles at the same time. Performance-based regulation focusing on electrification will nudge this development forward as soon as it becomes feasible.

The combination of these trends will spur **network consolidation of high-frequency services** in temperature-controlled food transport. Either the wholesaler becomes more and more a logistics specialist, carrying temperature-controlled deliveries for others with little additional volume, or temperature-controlled delivery in cities becomes a specialty service, catering for both wholesalers and small-volume specialty shops. Easy booking, easy transhipment of goods, uniform labelling and, above all, good tracking and tracing on the basis of well-tagged packaging materials are key requirements for success. The advances in IoT will allow complete transparency on location, travel and environmental conditions of individual goods for original supplier and customers alike. Once consolidated networks are on the roll and have volume, they will likely be able to provide a high service level to clients with several predefined drop moments per day. The high utilization of the specialty service will mean fewer movements in sensitive areas, using electric vehicles; municipalities will incentivize the combination.

The adoption of electric cooling and ZE technology for delivery trucks is at the front of the technology curve, but since cooling requires substantial additional energy, adoption of **next-generation ZE trucks** is more complex, as the mission profile requires more of the technology.

Figure 13
Towards zero-emissions logistics for temperature-controlled wholesalers

This cascade graph is based on the following assumptions:

- Last-mile electrification, incentivized by implementation of zero-emission areas in zone 4/5 - representing a 25% share of kilometres - will be rolled out for the entire wholesaler network. As a result, network consolidation is expected, leading to a 30% reduction of kilometers through increased frequency of services by a limited number of players. This reduces the need for additional kilometres to meet clients' needs.
- As for general cargo, next-generation ZE truck implementation is geared mainly to reducing vehicle purchase costs, to benefit from the implementation of emission-free zones.

The small specialists

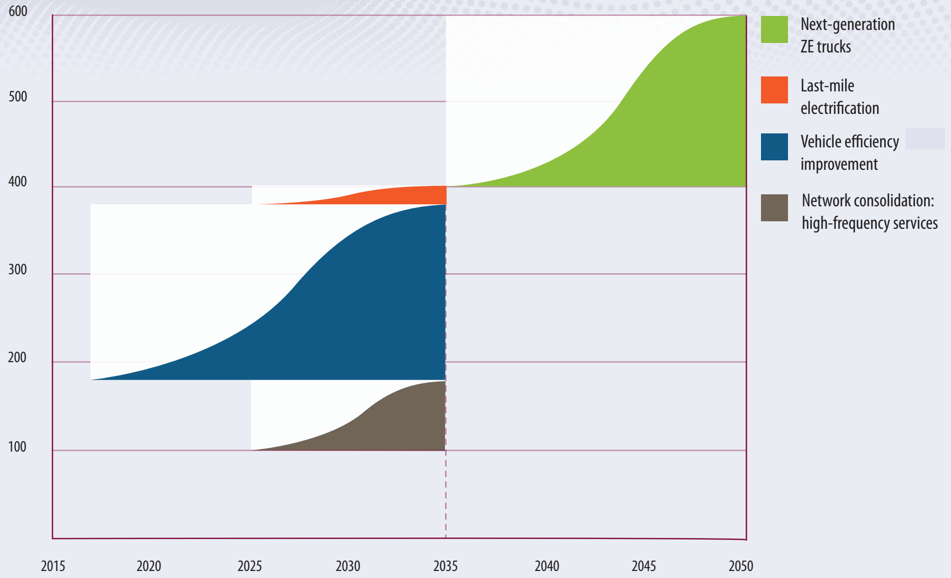
Kilometers driven per year (2015)	150 Mio km
Distribution over vehicle types (2015)	LCV's: 100%
CO_2 emissions (TTW/2015)	40 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	~1.5

Most small specialists in food have their own fleet of small- to medium-sized trucks or LCVs, servicing a sizable geographical area, with many small orders. To stay in business, customer intimacy, customer service and absolute reliability regarding the quality of the perishable goods are absolutely key. Some specialists service a single region, while others operate nationally. The long distances driven, even regionally, and the need for frequent distribution runs (LTL loads, numerous drops) mean **vehicle efficiency improvement** knocks on substantially in emissions reduction.

Network consolidation of high-frequency services in combination with the demand for **last-mile electrification** in dense cities will mean the specialist has to make choices. If the mission profile allows it, stepping up to electrification may be possible, although this will require investments. The alternative is to consider joining a consolidated network, either by cooperating with the wholesaler, who is becoming more and more of a logistics specialist, or by using a newly installed consolidated temperature-controlled logistics delivery service in cities, using a hub at the city border. As trust is key to the business, complete transparency as to location, travel and the environmental conditions of individual goods is mandatory via-à-vis both the original supplier and customers.

Changing the logistics network within the city allows it to be optimized outside, with larger vehicles being used to supply consolidation centres.
Adoption of electric cooling and ZE technology is at the front of the technology curve, but since cooling requires a lot of additional energy, adoption of the **next-generation ZE trucks** is more complex as the mission profile requires more of the technology.

Figure 14
Towards zero-emissions logistics for temperature-controlled specialists



This cascade graph is based on the following assumptions:

- Last-mile electrification, incentivized by implementation of zero-emission areas in zone 4/5 - representing a 25% share of kilometres - will be rolled out for the entire transport volume of specialists.
- For bundling at fresh hubs it is assumed that bundling applies to zone 4/5 in cities, reflecting all inner-city shopping and entertainment areas. It is assumed that bundling will cut emissions by 50% (Quak, 2009) owing to more consolidated trips into cities and the use of larger vehicles.
- Next-generation ZE vehicle development is focused mainly on the affordability of ZE vans and light trucks.

Home-delivery of fresh food and groceries

Kilometers driven per year (2015)	45 Mio km
Distribution over vehicle types (2015)	LCV's: 100%
CO_2 emissions (TTW/2015)	12 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	~10

Home delivery of the combination of groceries and fresh food is heavily branded, with customer intimacy the pre-eminent key to success. It is therefore foreseen that specialized networks will remain and compete in the coming decades, using state-of-the-art technology to keep customer acceptance high: ZE becomes a hygiene factor.

Home delivery of groceries is generally carried out from local hubs (supported by centralized home delivery distribution centres). The hubs themselves are serviced by tractor-trailer combinations from DCs or suppliers. Fresh food is combined with non-perishables.

With public pressure for livability high in residential areas, various home-delivery grocery outlets have already started using electric vehicles or have announced plans to do so. The only thing holding back their adoption is the availability of technology that fits the mission profile at reasonable extra cost.

As soon as **electric delivery** technology becomes available, adoption will be immediate, starting with dense cities and expanding outward.

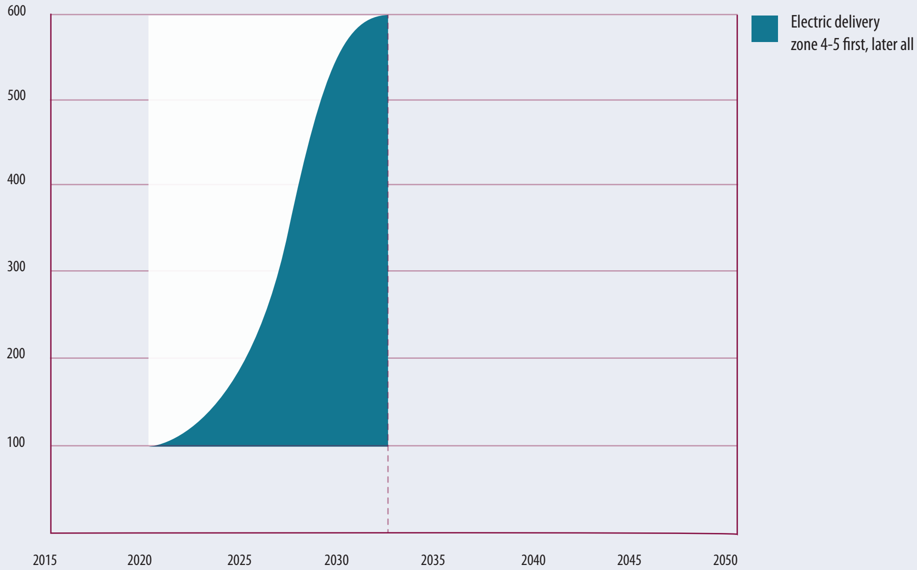


Figure 15
Towards zero-emissions logistics for home deliveries

This graph is based on the following assumptions:

- The ZE vehicles currently used on a small scale for home delivery of groceries will be used more and more, reaching full fleet penetration in 2030.

Home delivery of meals

The **Home delivery of meals** business has grown spectacularly in recent years. The service concept of letting the customer order online and picking up hot meals at any restaurant participating has proven to be successful. Hot meal delivery is by definition high-frequency, point-to-point and short-distance, as time is of the absolute essence. In the city two-wheelers dominate the sector, while small LCVs are used for longer distances to suburbs. The combustion-engine scooters for shorter distances are already being replaced by (e-assisted) bikes and cargo-bikes, which now often dominate the street scene. Battery technology for this purpose will reach maturity by 2020.

Parcel and express

Developments in parcel and express

Parcel and express deliveries have changed significantly over the last decade with the rise of B2C e-commerce and these trends will continue in the coming years. As the table below illustrates, this segment is extremely dynamic. Customer satisfaction and developments in vehicle automation and zero-emission drivetrains will be most influential.

Parcel and express primary external drivers score

DEVELOPMENT	B2C	B2B
More demanding customer	•••	••
Towards Omni channel	•••	••
Connectivity and smart labelling	•••	••
Increasing political and societal pressure for sustainability	•••	••
Increased pressure for better liveability in cities	•••	••
Vehicle development (from conventional fuels towards zero emission)	•••	••
Automization and robotization	•••	••

The most important trends have been used as inputs for developing the vision for a transition to a low-footprint urban logistics system.

Kilometers driven per year (2015)	106 Mio km
Distribution over vehicle types (2015)	LCV's: 86% Rigid truck + Tractor-semitrailer: 14%
CO_2 emissions (TTW/2015)	37 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	3.4

Parcel and express deliveries start at regional hubs, usually located near larger cities where the main business is. Although parcel and express delivery is a much smaller segment than construction, for instance, it is one of the most visible in the public eye. Customer intimacy leads to a **99% success rate** for B2C deliveries, mainly as a result of full use of all the IT services becoming available (cf. home delivery of groceries). **Electrification of inner-city** deliveries will follow the trend of increased societal pressure, incentivized by requirements of performance-based regulation by local governments. (E-assisted) cargo bikes and electric vehicles are already in use.

The trend to customize the delivery moment and location to the wishes of the customer[41] will accelerate, just as delivery options will grow. Customer intimacy will take over as a differentiating factor from response time, stimulating emergence of a range of last-mile delivery options, although eventually only a few large-scale models will survive. The result will be a higher success rate for delivery. As soon as the price/performance of technology is adequate for a more demanding mission profile, it will be adopted.

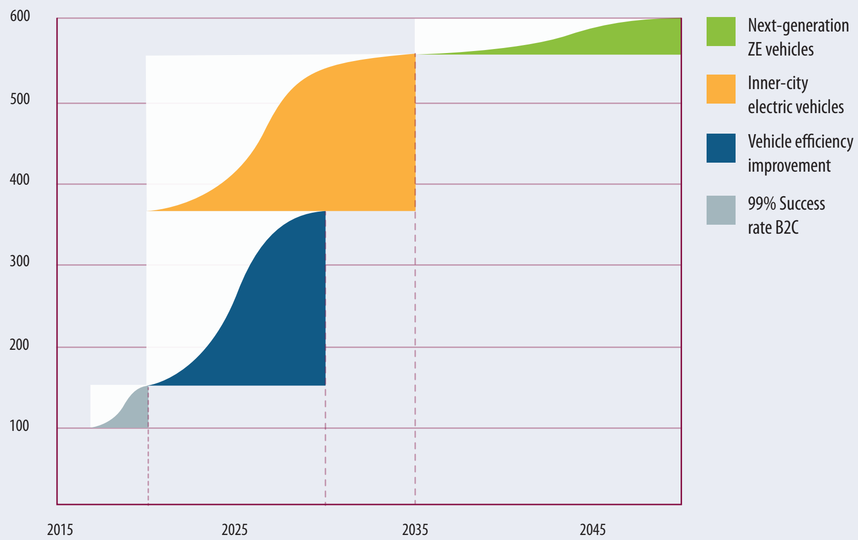
At the same time, cost reduction will drive automation, which may appear in the form of automated varieties of follow-me vehicles in order to reduce costs, which is a main differentiator in B2C deliveries.

Drones may form part of the mix. As they take some deliveries away from already electrified means of transport, this will not contribute as such to achieving Factor 6.

Deliveries outside the city, which are relatively small in volume but contribute a relatively high percentage of CO_2 emissions, will benefit from **vehicle efficiency improvement**.
The combination shows a fast reduction in emissions for a majority of addresses, with the rest having to wait for the **next-generation ZE truck/LCV**.

Universal labeling, robotization and autonomous vehicles are adopted early, positioning this segment well for the early stages of the Physical Internet. This may accelerate the growth of the sector, as other segments will exploit the advantages of volume, efficiency, low emissions, excellent IT and customer intimacy. Especially in facility logistics, service logistics[42] and construction[43] there are obvious business cases that will be explored.

Figure 16
Towards zero-emissions logistics in parcel and express delivery



This cascade graph is based on the following assumptions:

- The increase in the number of effective B2C deliveries (from 80% to 99%) will lead to a 10% volume reduction. In other words, this capacity can be used for absorbing part of the projected growth.
- Last-mile parcel distribution is projected to become both highly automated and electric. It is assumed that zone 2 and higher will become electric from 2020, starting in the busiest cities.
- Next-generation ZE is a further consequence of this trend towards less densely built areas, benefiting from increased competitiveness through scaling up in the 2020-2035 period.

Facility Logistics

Developments in facility logistics

Facility Logistics is the result of facility management of large offices[44]. Equipment has to be serviced, maintenance is needed, materials, furniture, parts and consumables and food must be delivered, services rendered, waste collected, and so on. The amount of logistics involved is much larger than many assume, compounded by the fact that equipment is usually sold with a service contract.

Overall, the number of public and commercial buildings is expected to remain stable and the demand for goods and services for these facilities is expected to increase only modestly. The trend to outsource more and more will continue. At the same time, a general shift towards buying services together with a product can be observed, leading to growth of service logistics. The following table shows which exogenous developments are expected to have the greatest impact in the facility segment.

Facility logistics: primary external drivers

DEVELOPMENT	FACILITY FLOWS IN CITIES
More demanding customer	••
Towards Omni channel	•
Connectivity and smart labelling	••
Increasing political and societal pressure for sustainability	••
Increased pressure for better liveability in cities	••
Vehicle development (from conventional fuels towards zero emission)	••
Automization and robotization	•
Circular economy	••

The most important trends have been used as inputs for developing the vision for a transition to a low-footprint urban logistics system.

Kilometers driven per year (2015)	1,363 Mio km
Distribution over vehicle types (2015)	LCV: 95% Rigid Truck: 5%
CO_2 emissions (TTW/2015)	47 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.4

The range of locations from which the last leg originates varies widely, which means CO_2 emissions reduction will be achieved through the **efficiency improvement of vehicles** driving from further away. This does not alleviate the pressure to reduce traffic and local emissions in cities. Large facilities are located in large cities and are consequently sensitive to societal pressure. The obvious solutions for reducing the local impact of facility logistics are to **consolidate goods at a bub and use a logistics partner** and use **inner-city electric vehicles**.

Consolidation at a hub requires not only that a multitude of suppliers change their delivery address to the hub, but also changes in operational processes and IT systems to support the administrative organization of acceptance, invoicing and payment of invoices. Stock-keeping patterns will change and procurement processes will become more centralized or coordinated. The final delivery address becomes a responsibility of the logistics partner. The Universal Label will make this organizational change slightly easier, yet it is a disruptive change with mostly external benefits.

The large organizational inertia that needs to be overcome to make this change will lead to a long adoption process. First movers will need to demonstrate the effects before others follow, while priorities will have to be shuffled. A strong top-down requirement to implement such a change will create the sense of urgency needed.

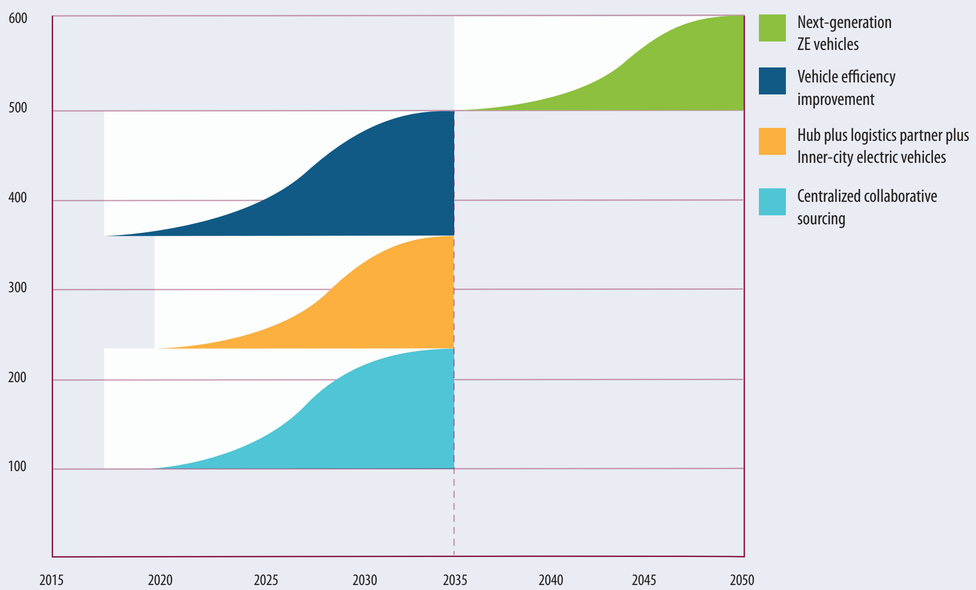
Governments and universities will act as early adopters, supported by logistic professionals from other segments[45] who see more business, can leverage their IT for customer intimacy and service, and are used to dealing with large organizations.

Large organizations with several locations within the same city can gain a lot from more **centralized collaborative sourcing**. Potential benefits include product standardization, economies of scale, reduction in supply chain complexity, strengthened negotiating power with suppliers and improved sourcing capabilities.

Service delivery requires human transport as well. The first step is changing the LCVs used for service transport (human, materials, tools) to **inner-city electric vehicles**. As that does not reduce the number of movements, experimentation will begin with separating these flows in city centres. Parts and materials can, for example, be transported by a parcel and express supply network as forecasted or upon demand to the right location. Reducing the inventory of parts is a well-received side-effect for service organizations. Suppliers, in collaboration with logistics service providers, will work on customer-specific delivery and servicing plans to optimize consolidation of shipments to locations.

For low-value goods, the Physical Internet solution may come into play as it matures. Smaller facilities may be serviced by parcel transport companies that expand the service they have on offer. Finally, the longer-distance transport leg to the city border can be decarbonized when the next-generation ZE trucks becomes available.

Figure 17
Towards zero-emissions logistics in facility logistics



This cascade graph is baed on the following assumptions:

- **Hub plus logistics partner:** One of the major improvements in facility logistics will be achieved through gradual introduction of city logistic hubs where goods for different facilities in the city are consolidated and from which one or several city distribution specialists will take care of last-mile delivery. It is assumed that this measure will be adopted in the performance-based zones 3 and higher.
  As a result, more collaborative sourcing and category management is expected. Consolidation in the hub(s) and last-mile distribution by city distribution specialists is assumed to gradually improve the logistics efficiency by up to 50% in 2035. The frequency of non-time critical deliveries and the type of vehicles used will change and result in higher vehicle utilization rates and fewer kilometres driven both for the long-haul leg as well as for the last mile.

- **Inner-city electric vehicle:** In addition to the logistic efficiency of delivery via hubs, more sustainable procurement policies and practices by organizations and procurement managers and the increasing availability of affordable ZE vans and city trucks will lead to a gradual transition to ZE inner-city distribution in zones 3 and higher.
- In parallel with the facility logistics hubs and electric last-mile transport, a large proportion of the CO_2 reduction up to 2035will result from **vehicle efficiency improvement**.
- By 2035 it should be feasible to achieve a Factor 4 emissions reduction in this narrative. The remaining gap to Factor 6 should result from the **next-generation ZE truck** after 2035. higher vehicle utilization rates and less kilometers driven both for the long-haul leg as well as for the last mile.

Construction Logistics

Developments in construction logistics

There are several external drivers that impact on the construction sector and construction logistics. These effects will vary across the typical construction project phases and among large, small and independent contractors. Because of the concentration of future construction works within larger cities, considerations of liveability are anticipated to mean major emphasis on - and rationalization of - construction logistics. Technology will increase the transparency of construction logistics and at the same time provide leverage for minimizing the negative impacts of construction works in cities.

DEVELOPMENTS	SMALL COMPANIES	LARGE COMPANIES
More demanding customer	•	•••
Towards omnichannel	••	•
Connectivity and smart labelling	•	•••
Increasing political and societal pressure for sustainability	••	•••
Increased pressure for better liveability in cities	•••	•••
Vehicle development (from conventional fuels towards zero emission)	••	••
Automization and robotization	•	••
Circular economy	••	••

New (large) construction projects in cities involves four logistical phases before maintenance starts:

1 Demolition and preparation
- bulk transport, heavy machinery

2 Construction of framework
- materials and large parts, special transport, cranes, bulk transport

3 Finishing (coarse)
- materials supplied by wholesalers
- equipment and installations

4 Finishing (fine)
- products supplied by wholesalers

Refurbishing existing offices and apartments/homes is similarly structured.

Construction traffic is one of the largest contributors to emissions, disruptions and incidents in the city. For large construction/infrastructure companies, the transition to reduce GHG emissions and reduce the number of movements and obstructions caused by construction is often driven primarily by the demands made by the local government (both as permit authority and as customer), which translate into tender requirements for contracts. The local government plays an important role in creating a level playing field for construction companies through regulations and permits (so called BLVC procedures: accessibility, liveability, safety and communication) and governments are the most important client of construction works taking place in cities. Whatever the customer asks for, the customer gets.

Tenders are competing on price as well as on emissions generated and number of movements in sensitive areas using the MEAT procedure (most economically advantageous tender). During the various construction phases, full transparency is demanded and generated to prove proposed targets are being met. Full transparency fits in well with performance-based regulation, zones and the transparency of connected commercial vehicles.

The organizational inertia to overcome is the lack of experience with tendering in this manner and the time it takes to prove that these procedures do not increase costs or delay construction. Proving they work in practice and showing convincing results are projected to take from 2018 to 2025, after which it all becomes standard procedure. The long lead times of construction work lead to full adoption by 2035.

Large companies

Large companies and large construction projects:

Kilometers driven per year (2015)	1,712 Mio km
Distribution over vehicle types (2015)	LCV: 88% Rigid truck: 12% Tractor-semitrailer: <1%
CO_2 emissions (TTW/2015)	544 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.12

As large construction companies have been preparing for this transition, the sector is very well prepared for a change in tendering and execution. Government plays in important regulatory role in construction and construction logistics. The construction sector is used to heavy regulation and (self-)monitoring.

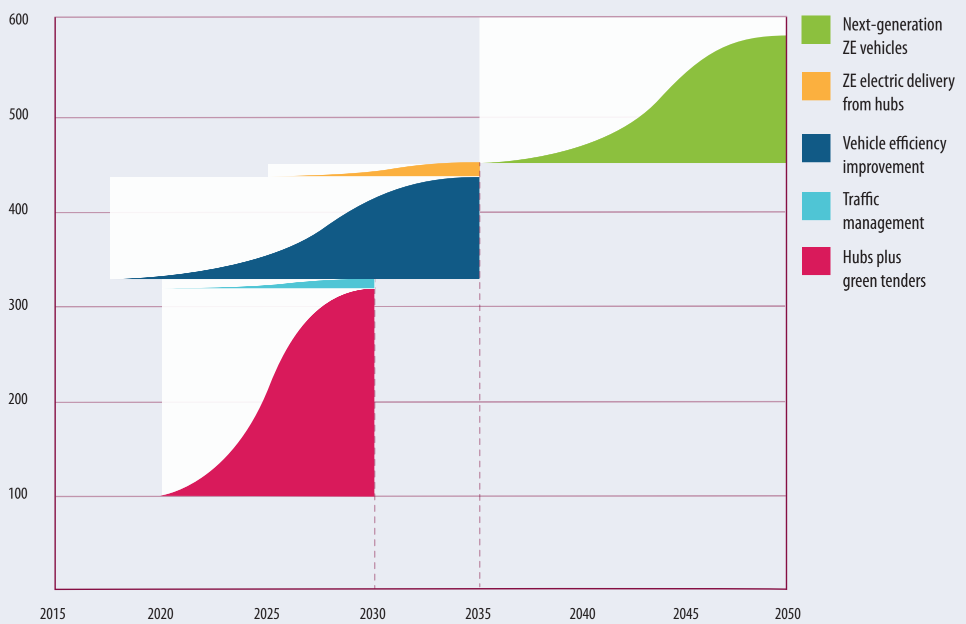
The increasing and continuous use of Building Information Management (BIM) systems improves the detailed management of products and materials required, allowing for just-in-time logistics and prefab construction support supply chain integration and a reduction of waste and failure costs. Logistic simulations, built upon BIM, show beforehand where improvements can be made and costs can be reduced. This allows companies to bid with confidence on tenders that also focus on logistics and the associated carbon footprint.

The first steps are based on construction **hubs and green tenders** and **traffic management** to improve the flow of construction traffic from the hub to the site. These green tenders explicitly focus on reducing traffic and emissions as a selection tool. In many cases a hub is needed, which local government facilitates using the available locations. Full transparency of connected vehicles proves conformity to the bid, including maximum weight and routes.

Large companies are used to integrating subcontractors in their management systems and mandate, for instance, that subcontractors park their vans outside the city and transport the staff of the subcontractors to and from the site daily. Construction companies and suppliers use inland and inner-city waterways where possible.

The connected vehicles and control towers communicate with traffic management systems to guide the flow of traffic between the hub and the site.
With time, **vehicle efficiency improvement** helps reduce CO_2 emissions. As drive technology improves, **zero-emission electric delivery from hubs** to construction sites becomes practical. Delivery to the hubs starts to change when **next-generation ZE trucks** becomes avajilable. Heavy equipment on the site follows the technology curve of heavy trucks, unless its use is stationary enough to warrant battery use and charging.

Figure 18
Towards zero-emissions logistics in construction: large companies



This cascade graph is based on the following assumptions:

- Large construction projects and large construction companies are assumed to cover about 50% of the construction volume in cities.
- Construction phases 1 and 2 are dominated by FTL with rigid trucks and tractor-trailers. As a result, efficiency improvement in construction logistics in these phases depends primarily on technological vehicle improvement (40% improvement in 2035) and to some extent on traffic management measures. Traffic management of fully-loaded heavy-duty vehicles into the city to the construction site and back is expected to result in a 10% reduction of CO_2 emissions and is assumed to be implemented by the performance-based zoning in zones 4 and 5. As a result, traffic management is only a minor improvement option in the bigger picture, but might play an important role in the most congested city centres.

- Construction phases 3 and 4 are dominated by LCVs and much less by rigid trucks. Logistics hubs have proven to have major reduction potential: up to 70%. It is assumed that once construction logistics are increasingly regulated using MEAT criteria, BLVC regulation and permits, as well as performance-based zoning and regulation, all large construction companies, including all subcontractors and suppliers or wholesalers, will increasingly adopt the concept of logistics hubs near city borders or prefab production outside cities between 2020 and 2030. It is assumed that the logistic efficiency improvement will gradually increase to 50% on average. In addition, consolidated goods and workers will increasingly be transported by smaller ZE vehicles from the hubs into the city to the construction site.
- It is assumed that ZE delivery hubs will be implemented in zones 4 and 5.

Small construction companies and independents

Kilometers driven per year (2015)	1,712 Mio km
Distribution over vehicle types (2015)	LCV: 88% Rigid truck: 12% Tractor-semitrailer: <1%
CO_2 emissions (TTW/2015)	544 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1.12

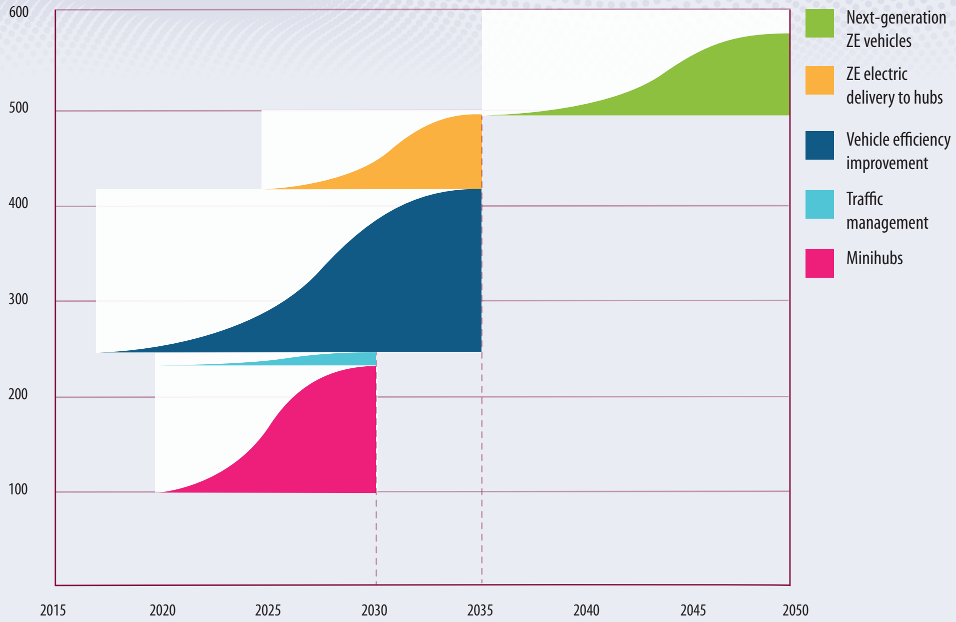
Besides large construction companies there are a multitude of smaller companies and independent individuals operating in this sector, sometimes working as a subcontractor for a large construction company. In that case they are required to follow the mandated procedures, and need to have vehicles meeting the imposed requirements.

For their own independent (smaller) jobs and contracts few customers are willing or able to tender including demands for emissions and/or movements. General **vehicle efficiency improvement** will reduce emissions to a certain extent. Zoning and **traffic management** in cities will induce greater efficiency, for instance by shifting materials transport and express deliveries to professionals specializing in construction logistics and site management who are more efficient.

To prevent overcrowding and nuisance in dense city areas of parked LCVs used for construction, building permits will stipulate no parking in these areas and assign space for a **minihub** for tools and materials. This hub will be serviced by construction material suppliers (with **ZE electric delivery to minihubs** as soon as it is feasible) or specialized logistic service providers and construction wholesalers, removing waste materials in the same run. Express deliveries will be done by couriers, or as part of an existing high-frequency parcel network.

In this segment the heavy-duty type of use in construction results in late adoption of ZE technology. In the long term, though, **next-generation ZE vehicles** (LCV/truck) will be able to meet the requirements.

Figure 19
Towards zero emissions logistics in construction - small companies



This cascade graph is based on the following assumptions:

- Smaller companies and construction projects are far more scattered around the city and include a wide variety of public and private clients. These small-scale projects are assumed to be regulated by performance-based zoning from zone 4 and higher. Minihubs will result in less kilometres transport by LCVs across the city. It is assumed that about 75% of the LCVs are used primarily for services and 25% for transport of goods. The CO_2 reduction potential is consequently much larger for services (70% CO_2 reduction) than for goods transport (30% CO_2 reduction). The necessary tooling and material supplies will be available at the minihubs. These minihubs will be supplied more efficiently and using ZE vehicles.
- The remaining reduction potential will result from vehicle improvement up to 2035 and from next-generation ZE vehicles as from 2035.

Waste collection

Developments in waste collection

Societal pressure and technological development will be dominant in changing patterns of waste collection. There is scope for efficiency improvement in both residential and business waste collection and the urban driving cycles allow for introduction of electric drivelines, driven by public and government pressure. The table below illustrates the trends that will be most influential in this market segment.

DEVELOPMENT	RESIDENTIAL	BUSINESSES
More demanding customer	•	•
Towards Omni channel	•	•
Connectivity and smart labelling	•••	•••
Increasing political and societal pressure for sustainability	•••	•••
Increased pressure for better liveability in cities	•••	•••
Vehicle development (from conventional fuels towards zero emission)	•••	•••
Automation and robotization	•	•
Circular economy	•••	•••

The most important trends have been used as inputs for developing the vision for a transition to a low-footprint urban logistics system.

Collective residential collection

Kilometers driven per year (2015)	101 Mio km
Distribution over vehicle types (2015)	Rigid truck (garbage type): 100%
CO_2 emissions (TTW/2015)	123 kton
Autonomous growth factor 2015-2050 (demand for goods transported)	1

Municipalities are responsible for organizing household waste collection and can cut CO_2 emissions through public procurement, as with public transport.

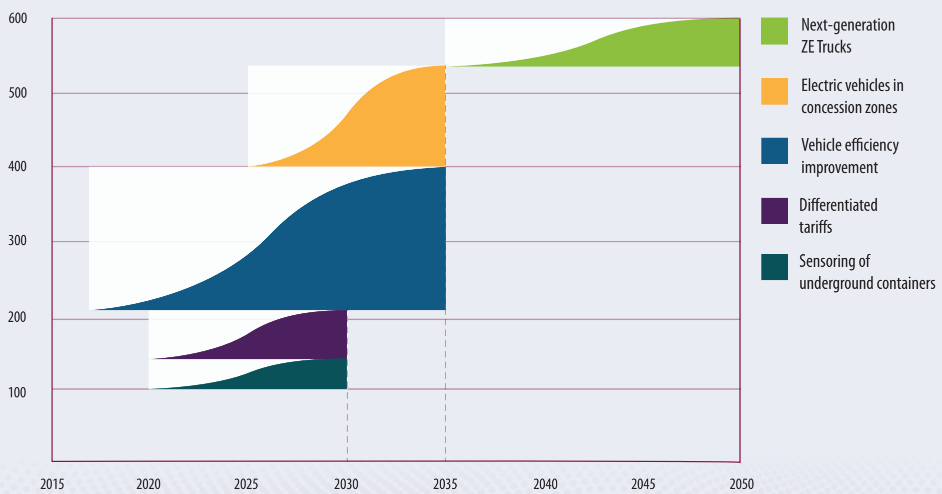
General **vehicle efficiency improvement** will reduce emissions up to a certain level. Implementation of **differentiated tariffs** (diftar[46]) in combination with smart sensoring and dynamic routing will lead to a reduction in the number of trips required for waste collection. Diftar combined with **sensoring** will lead to an optimized logistics systems with fuller bins and less frequent emptying, reducing both GHG emissions and logistics costs. Implementation of connected and sensored underground waste compactors or containers in existing and new residential areas instead of bags and bins will lead to a reduction in demand for emptying. Compactors will be implemented in the most densely populated areas, where demand for space and peace and quiet is greatest.

Adoption of ZE equipment will follow the experience gained by electric public-transport buses, in own fleets or in new concession tenders. Adoption of ZE zones and implementation of ZE waste collection will go hand in hand.

Adoption of electric vehicles starts within the own local fleet or as a requirement in the public procurement of a waste collection contractor. **Electric vehicle** usage starts in **zone 4/5** and is subsequently scaled up to **zone 3** later on.

The **next-generation ZE truck** makes waste collection feasible in all zones and cities.

Figure 20
Towards zero-emissions logistics in waste collection: households



This cascade graph is based on the following assumptions:

- Implementation of differentiated tariffs (diftar) in combination with smart sensoring and dynamic routing will lead to a 25% reduction in the number of trips required. Application of diftar is relevant for households with a private bin. It is estimated that diftar will lead to improved logistics for 50% of households.
- Another 25% of households are estimated to use underground bins for waste collection in the period after 2030, where sensoring will lead to 25% reduction in the number of km driven, in combination with dynamic routing. An increase in container loading will lead to less emptying.
- Electric refuse trucks are assumed to be introduced first in zone 4/5 and later in zone 3, corresponding with a 43% share of zero emission collection.

Business waste collection

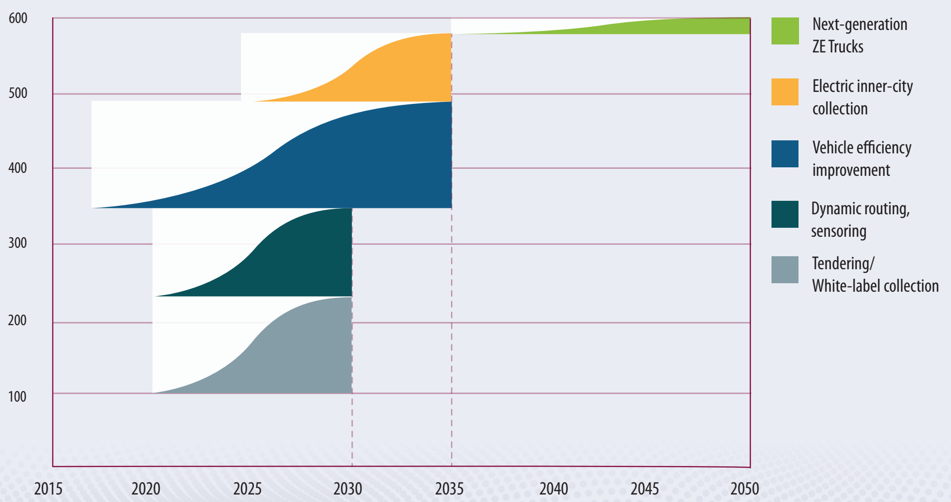
Kilometers driven per year (2015)	64 Mio km
Distribution over vehicle types (2015)	Rigid truck (garbage type): 100%
CO_2 emissions (TTW/2015)	78 kton
Autonomous growth factor 2015-2050 demand for goods transported)	1

Waste collection from businesses is a liberated market, leading to inefficiencies in collection compared with household waste collection, which is collected house-to-house on a well-organized basis by the municipality..

Dynamic routing with sensorized containers will improve collection schemes, resulting in a reduction in the number of trips required. Driven by public pressure and the introduction of performance-based regulation, waste collectors in inner cities will organize **white-label** waste collection runs servicing all customers in a specific area. A shared service collects the waste, measuring the exact type and weight per customer. Downstream, the various streams are administratively allocated to individual companies. Alternatively, waste collection will be **tendered** in areas with high public pressure to reduce vehicle movements.

As distances are short, electric inner-city collection becomes feasible.
The **next-generation ZE truck** makes waste collection in all zones and cities feasible.

Figure 21
Towards zero-emissions logistics in waste collection: businesses



This cascade graph is based on the following assumptions:

- Dynamic routing and smart sensoring leads to a 25% reduction in the number of collection trips, on the assumption that one in every four trips can be saved, since the average load in current fixed collection schemes is often around 50%.
- White-label collection or collaboration between companies is estimated to be implemented in zone 3 and higher. It is estimated that trips can be organized in such a way that the total distance driven can be halved through shorter routes.
- Electric inner-city collection is assumed to be implemented in zone 3 and higher.

Annex A

Further clarification on city logistics segments and segment-specific developments

Introduction

In this annex, the various city logistics segments and subsegments are discussed and clarified. The route towards the Factor 6 goal for each segment is defined by both the primary external drivers and developments within the specific segments. Subsegment description is important, since the options for optimization and reduction of GHG emissions are not the same across the entire segment. As an example, the route towards optimization for large retail shops is different from that for small retail shops.

General cargo in cities

Introduction to general cargo

Retail distribution is one of the most visible segments in urban freight transport. The products transported in this segment are non-perishable goods, including fashion, textiles, bikes, books, toys, electronics, furniture, home appliances and household items[47]. As general cargo is not perishable, different flows can be combined in one truck, as well as stored without losing its value through decay.

Three different systems in general cargo

The general cargo segment can be roughly divided into three different logistics archetypes: supply of large retail chains, supply of small and often independent stores and deliveries of large goods like washing machines and furniture to private homes. These three systems differ in their logistics organisation.

- **Large retail chains:** logistics is centrally organized from a retail chain, the shipper, although data from the stores (e.g. PoS (Point-of-Sale) data) is very often used. The distribution of goods starts from a centralized or regional DC and is controlled by the retail chain. This can be either on own account or by outsourcing the transport to a dedicated logistics service provider. The retail organisation determines the logistic planning and controls the supply chain.
  Vehicles are generally fully loaded and supply one or a few regional stores of the retail chain in roundtrips starting and finishing at the retail chain's depot. Usually, the return items as well as waste are collected and returned to the retail chain's depot by the same vehicle making the deliveries. The major stores of these retail chains are often located in the cities' major

shopping centres, where tight delivery time windows are in force. Sometimes also satellite shopping centres in suburban areas are part of the distribution loop. Nevertheless, the route planning is determined by delivery time window restrictions of the inner city and may result in inefficient routing and extra kilometres driven. These supply chains are adapted to high volumes, scale, low cost and efficiency in their logistics operations. Distribution is based on scheduled transport services with medium to large trucks from DC to the points of sale, high load factors and. in the Netherlands, a typical distance to stores of less than 150 kilometres. While the logistics organization of various retail chains is similar, drop sizes vary. Depending on the delivery frequency and rate of circulation, the drop size can vary from a few roll racks to a full truck load of dry groceries to a supermarket. In the Netherlands retail chains, which do not distribute on their own account, very often use only one or a limited number of dedicated LSPs for all their deliveries.

- **Partial delivery:** these are organized from the receiver side, not from the shipper side (as was the case for large retail chains, where the sender and receiver are both part of the same retail chain). In contrast to retail chain stores, this archetype is characterized by the fact that logistics are either organized by a logistics service provider, by private carriage of the supplier or by the retailer itself.

  Many smaller independent retail shops do not have the scale nor volumes for full truckload deliveries. As a consequence, a logistic service provider organises warehousing and distribution on behalf of multiple shippers. While the volume per drop is lower for the small/independent retailer than for the large retail chain, the amount of urban traffic to supply these stores is higher.

  The shipper - often a wholesaler - hires a logistics service provider with a supply chain network (e.g. cross-dock), in order to organise distribution as efficiently as possible. The volume level in this network is usually smaller. From the retailer's perspective it may also be possible to receive some deliveries from various LSPs, whereas for the retail chains the majority are supplied in a single consignment. To organize the deliveries in this archetype, efficient LSPs need to combine several clients in order to have a high drop density. General cargo distributors are often specialised in a certain market segment like drinks, white goods, fashion (e.g. Bleckmann), books (e.g. CB). LSPs may have a few (e.g. De Rooy, Van Opzeeland) or many (e.g. Transmission, Jan de Rijk) distribution centres in the country. This implies that the distances driven per day can differ significantly.

  In addition, there are many small independent retailers in cities using private vehicles to carry goods from various suppliers to their store. Owing to this inefficient type of distribution and the use of generally older and less environmentally friendly vehicles, this imposes a relatively large burden on the environment and liveeability in terms of emissions, nuisance and congestion. For various reasons these retailers are insufficiently incentivized to invest in more environmentally friendly vehicles or make use of more efficient LSPs. This type of distribution is less rationalised and these retailers are generally not readily convinced of alternative distribution approaches, owing to force of habit in doing it themselves, for example, or the fact that one's own time is not considered a cost factor. Apparently, the cost, effort or control of private distribution is attractive enough to continue on own account. This is also explained by the lack of a level playing field: private carriers are much less restricted by delivery time windows and environmental regulations.

- **Home delivery of large goods:** besides the many parcel deliveries and food deliveries that form the vast majority of all home deliveries, we identify an archetype of general cargo that also delivers goods (and collects returns) at home addresses. Although this archetype is limited in terms of volume and trips compared with the other two, logistics organization differs from other home deliveries as well as from other general cargo deliveries. A separate archetype is therefore described here. The home deliveries in this archetype are typically large and/or heavy goods and do not fit the normal parcel distribution networks due to their odd size. Typical goods in this archetype include furniture and white goods, which require a two-person distribution network. Delivery of these goods comes with specific requirements for logistics and is therefore often more expensive than the regular parcel network, since deliveries are expansive, the receiver needs to be (and very often is) at home and the goods cannot simply be dropped off at the neighbours. Delivery personnel need to have more expertise than driving, as they handle home installment of the goods as well as having to be client-friendly as they are working in customer homes (and therefore form the interface between supplier and customer). The trips in this archetype can be relatively long, as the inter-drop distance may be high.

External drivers and developments in general cargo

The various general-cargo archetypes and consequently their logistics organization have changed over time and will develop further in the coming years. The table below shows where we expect the biggest impacts on the logistics organisation in the three general-cargo archetypes.

DEVELOPMENT	LARGE RETAIL CHAIN	PARTIAL DELIVERY	HOME DELIVERY LARGE GOODS
More demanding customer	•••	•••	••
Towards Omni channel	•••	•••	•••
Connectivity and smart labelling	••	•••	•
Increasing political and societal pressure for sustainability	••	•••	•
Increased pressure for better liveability in cities	•••	•••	••
Vehicle development (from conventional fuels towards zero emission)	••	•••	•
Automization and robotization	•	•••	••

Based on these general developments we can estimate how these different archetypes are likely to evolve in the years ahead, how these developments will impact on emissions and wider footprint and identify opportunities and perspectives for action to change the projected future. Here we sketch the expected short-term autonomous development of logistics in the different subsegments, to serve as a springboard for the vision.

In general we observe an increase in agility and responsiveness of supply chains due to more demanding customers, with retailers in these segments starting to behave more and more like an e-commerce customer to be able to offer comparable services. The whole segment is becoming increasingly similar to the 'fresh' supply chain, since the shelf life of goods is declining rapidly. More frequent smaller-size deliveries require a more fine-meshed distribution network strategy with DCs closer to cities, which increases the need to consolidate expensive last-mile movements. At the same time, it is observed that flagship stores in city centres will function more and more as a showroom for customer experience.

Customers can order in the shop or back at home afterwards (cross-channel). What they buy is no longer dependent on stocks at the shop. More varieties are possible, e.g. more sizes and fabric colours. Some type of consolidation at the city border is likely in the coming decades, driven by increasing costs on the last mile and the trends in standardization and robotization. The most likely area of change is the partial-delivery segment. Actions by local governments (e.g. closure of 's-Gravendijkwal for trucks in Rotterdam) and growing congestion problems will accelerate this trend owing to more expensive last-mile transport.

Large retail chains

Already many stores, about 60%, in the Netherlands are part of (large) retail chains. Although a decrease in the amount of sales via traditional stores is expected in favour of more online sales in this segment, such as fashion and electronics, it is expected that large retail chain stores will continue to dominate city centres for the coming years. The current logistics system to supply these stores is already orchestrated by the retail chain and is usually quite efficient, within the service requirements, using large trucks that leave the retail chain's DC full every day.
Two developments are influencing the one-stop deliveries of some of these chains, however: the increase in omnichannel development (integrating online sales and returns in traditional logistics to and from stores) and the increase in shop-in-shop concepts within the large retail chains' stores. The first implies including small deliveries in the more volume-driven logistics operations. The second implies that large stores in the city centre are supplied by more suppliers than the large retail chain's trucks only, which means certain parts of the stores are supplied similarly to small and/or independent retail stores.

No major changes are expected in the logistics operations of these large retail chains. Most of the kilometres driven in this archetype, and with them the corresponding footprint, currently comes from the parts outside the city (i.e. the trip from the retail chain's DC and the city border and back), as most large retail chains distribute to all stores from one or a limited number of national/regional DCs. Since the logistics operations are already orchestrated by large chains, further rationalization can be expected, such as increased use of LHVs[48] for the longer-distance transport in the distribution rounds, where single tractor-semitrailer combinations handle final distribution, with the second trailer meanwhile being parked. Other efficiency gains can also be expected, especially in the outer-city parts of these distribution roundtrips, for example due to platooning. The further increase in availability of real-time data on store-stock, traffic and other circumstances make precision logistics feasible for retail chains.

Finally, as these retail chains are often very visible in the cities, as well as on the road - if the brands are showed on the trucks - the increasing societal pressure for sustainability can affect these chains relatively more than other segments, creating pressure to use the cleanest possible vehicles for distribution.

Small and/or independent retail stores

This category of stores, for example small fashion stores, are expected to be affected by more demanding customers. At the moment these stores are often not cost-competitive (as webstores and large retail chain stores can offer products at lower prices), but need to provide an experience, more exclusivity or better advice. Being able to serve the customers while they are in the stores is therefore essential. It is therefore expected that the number of small and just-in-time deliveries to these stores will only increase. One result of this will be to move store owners to behave more and more like online consumers, desiring last-minute delivery, the next (or even the same) day, from multiple suppliers in order to guarantee uninterrupted product availability and reduced stocks (and related risks) in the store.

It is anticipated that in this segment especially the number of stores will decrease and in the meantime the number of small coffee- and lunchrooms will increase in larger Dutch cities. These small specialized stores fit - if it is not fresh-delivery that is involved - perfectly into this segment and we therefore see a slight decrease (about 20% in the coming three decades) in the number of delivery points in this segment (at the expense of fresh-small retail and large retail chain stores that take over store locations after a small store owner retires, for example).
As this segment is characterized by partially filled trucks driving many kilometres (from a depot to the city and serving many different stores receiving deliveries from multiple suppliers using several service providers), the transition to a more sustainable system requires some form of consolidation.

There are several examples of transport companies that cooperate on particular loads (i.e. between 1 and 5 pallets/roll containers). Examples of such collaborative networks with local transport companies include TransMission, that even does zero-emission last-mile deliveries in Amsterdam via its own-developed Cargohoppers, Netwerk Benelux and Distri-XL. Cooperation leads to fewer trips with a higher load factor. Other initiatives are goederenhubs[49], Stadslogistiek Delft, Breytner and the recent announcement by CB logistics to leave last-mile distribution to a local partner. City hubs will perform the last mile with LEFVs in Roermond and Amsterdam. Some of the cited initiatives are zero-emission, implying the use of electric vehicles, using consolidation centres to increase drop density.

In general, it is currently very difficult to develop a feasible business case in terms of total cost of ownership for the adoption of zero-emission vehicles, owing to a lack of government incentives. Besides consolidation, further diversification of logistics service providers specialized in urban distribution can be observed. For example, CB Logistics delivers not only books (media) to city stores, but also fashion and healthcare products, to increase the drop density in a given city (saving the expensive last-mile). So, instead of being a specialized transport company for a specific product segment, it is developing towards a company specialized in city logistics. Similar diversification trends are also occurring in other segments (from specialized fashion logistics to broader city logistics services, etc.).

Home deliveries of large goods

Today, the home-delivery market for large goods is growing. While statistics on two-men delivery services may be lacking, based on developments that can be monitored a serious increase can be observed, one example being the increase in warehousing for these large goods (Coolblue, Dynalogic, 2015). However, home deliveries of 'ugly freight' (e.g. defined as out of gauge/oversize, very heavy, etc.) accounts for only a very small part of all vehicle trips in the general-cargo segment.

The major developments in this segment correspond to other developments in home deliveries (see Post and parcel segment). One major contrast to the relatively easy to handle home deliveries - i.e. parcels - in this segment is that the addressees are usually at home. This is the case for large white goods as well as for furniture, as time slots are usually agreed on at the time of ordering and these goods require someone at home to receive them. In the future we expect an improvement in communications between receiver and transporter (more precise slots, slot choice, etc.). Since the delivery men already install or carry these goods into the homes, this fits perfectly into the trend of an increase in value added services (installation and return of old goods).

This archetype will develop in the coming years; the integration of two-men distribution networks of service providers (for sales via online channels and via brick-and-mortar stores) can already be observed and is expected to continue to improve the drop density for these difficult goods. At the same time this will also reduce costs for this relatively expensive delivery service (last-mile delivery by two men). On the other hand, own delivery services - like Coolblue, which started experimenting with its own delivery service for these goods in 2016 - are currently proceeding from the idea that doing it yourself provides an opportunity to better serve the customer at his home. This segment is expected to grow considerably, reducing the footprint in the process. As many of these deliveries come from regional warehouses (for furniture as well as white goods), most of the delivery trips are along motorways between the warehouse and the city addresses. Different concepts are now aiming to make these regional kilometres as efficient as possible (e.g. using truck-semitrailer combinations), making final deliveries by rigid truck only. Breytner has started such a service, whereby (furniture) deliveries are first brought to the city perimeter in two swap-body containers by a combination, with two personnel only being required for the last mile; in this way only one man is needed on the truck for most the trip (in kilometres at least).

Temperature controlled logistics

Introduction to temperature controlled logistics

Fresh categories - fruits and vegetables, meat, fish, dairy and baked goods - typically account for up to 40 percent of grocery chains' turnover. Fresh food is often complex to manage: prices are volatile, suppliers are fragmented, the products are perishable and sometimes fragile, and replenishment and quality-control processes are labor-intensive. In addition, owing to rising consumer demand, retailers are carrying an ever-expanding range of fresh products, many of which have different temperature and handling requirements. In this section, fresh food logistics is divided into four categories, ranging from high-volume retail logistics of supermarket chains and wholesaler foodservice for HoReCa and office catering to low-volume specialist supplies to restaurants, specialist shops and home deliveries.

Different logistics systems in temperature controlled logistics

As an approximation, the temperature-controlled logistics segment breaks down into four logistics archetypes, which we identify as the supply of large retail shops, the supply of HoReCa by wholesalers and by specialists, and home shopping. These four systems differ in their logistics organization.

- **Retail logistics of large supermarket chains:** In the Netherlands, supermarket density is very high; most residents have access to a supermarket within one kilometre. Supermarkets are supplied from regional or national DCs. The grocery chains AH, Jumbo and Superunie are the market leaders (85%). Retailers typically have a handful of regional DCs and one fresh DC. Local shop deliveries are typically fulfilled via the regional DCs, which act as a cross-dock. About 50% of the supermarket's turnover consists of fresh food products. Products from many suppliers are consolidated in regional DC's or the fresh DC. For example, fresh food suppliers such as Campina (milk), Bakkersland (bread) and The Greenery (fruit and vegetables) deliver to the regional or fresh DCs of large chain retailers, where products are cross-docked and consequently supplied to supermarkets by large LSPs like Peter Appel Transport, Simon Loos and XPO. The supply chain is strongly controlled by the retailers and consequently LSPs have to meet the specific logistics requirements (e.g. time slots) of the retailers. Sometimes a shared DC is operated together with a logistics service providers to increase efficiency and shorten delivery times. Efficient handling of products is enabled by roll containers filled with boxes

of fast-moving consumer goods and packed fresh products. The supply chain is geared to high-volume, large-scale, low-cost and efficient operations. Transport from DCs to the supermarkets is characterized by scheduled transport services using large trucks or tractor-semitrailers and with high load factors. Typical distances to stores are about 75 km on average, up to a maximum of 150 km. The frequency of deliveries to the 4,500 supermarkets is between once and several times a day, depending on store size, and trucks often carry the products of only one store.
The turnover of specialist shops (bakeries, butchers) is currently under pressure because of customers' preference for one-stop shopping. The market share of specialist shops and markets is about 20% of supermarket sales (36 billion euro).

- **Wholesaler foodservice to HoReCa and office catering (B2B):** Wholesaler foodservice companies supply HoReCa locations as well as canteens in offices, hospitals and other health institutions and schools. Fresh food products make up less than 20% of wholesaler foodservice supplies. Many fresh food suppliers deliver to the regional or local DCs of wholesalers like HANOS, Sligro, DELI XL and Lekkerland. Transport from DCs to HoReCa and office catering in cities is characterized by medium volumes per customer, scheduled transport with medium-sized rigid trucks and high load factors. Trucks make a relatively large number of stops in the city, bringing in daily supplies of fresh products to around 5 to 10 customers. Wholesalers use a private fleet (HANOS) or have outsourced transport (Sligro, DELI XL, Lekkerland). Customers have a relatively dominant position in this market, as it is they who determine delivery time and frequency. Wholesalers typically have up to 10-15 DCs spread across the country, especially at the edge of large cities, thus about 100 DCs in all. Handling of the goods is moderately to highly efficient, using roll containers, pallets and boxes.
  Price competition in this market segment is significant, as the wholesalers have a similar product portfolio.

- **High-value specialist supplies to restaurants and SME specialist shops (B2B):** This segment is characterized by high-value products, low volumes and inefficient logistics with a very low drop density: often only a few stops in one city, while on the receivers' side a large number of up to 20 drops per week for high-end restaurants are reported. There are many direct point-to-point non-scheduled deliveries of often local products by local specialist suppliers, such as fresh fish for restaurants and other suppliers for fine-food shops, meat and poultry dealers, bakeries, etc. Depots or cross-docking are hardly ever used, with the delivery fleet preferring to depart from the supplier's site.
  Products are transported by a large variety of privately owned cars, vans and small trucks. Vehicles typically drive up to 350 km per day and make up to 20 stops. Price is not a distinctive criterion in this market, which is driven more by quality. Delivery time is the limiting factor, as all clients need to be supplied well before dinner time. Product handling efficiency is relatively low because of limited standardization. Products are carried in small boxes of various size as well as other types of packaging.

- **Home deliveries of fresh products and meals (B2C):** Home deliveries of online food (e.g. AH.nl, Picnic) and fresh products such as vegetables and fruits and meals (e.g. HelloFresh) is a strong growth market in this segment. The number of meal boxes ordered grew by 42% over the year 2015 and home delivery of groceries is projected to grow 30% annually. It is, however, still difficult to make money from home delivery of groceries. Mealboxes and vegetables and fruits are mainly delivered on own account. However, in some cases logistics service providers are responsible for distribution of these boxes. Experts expect that suppliers will need to share their networks to become cost-competitive.

Following the disappointing results of pick-up points, supermarkets are now investing heavily in development of a home-delivery network. They are using various models: Picnic only distributes if the network density is high enough at fixed moments, while AH offers flexibility in terms of timing and is experimenting with a fixed-price delivery contract. Supermarket Plus works with local entrepreneurs. Other shops work with LSPs for grocery delivery. Supermarkets generally use small-size cross-docks at city perimeters where (fresh) goods are distributed. Since the goods are already bundled per client at the main DC, the density of goods in a truck supplying these cross-docks is relatively low.
Picnic is one of the few supermarkets delivering at no additional cost; its model is the least flexible. Picnic uses light electric vehicles for last-mile distribution. To limit labour costs, order-picking is done centrally as far as possible. Complete orders are shipped to hubs, where last-mile vehicles are loaded. Sometimes inter-DC transport is used if certain low-volume product categories are order-picked at one location only.
In addition to home delivery of takeaway meals, common practice for many years already, delivery of high-quality meals (e.g. Foodora, Deliveroo) has recently been laucnhed in the Netherlands. Electric bikes and scooters are becoming the common method for home delivery of meals. As such, this segment can become zero-emission relatively easily.

External drivers and developments in temperature controlled logistics

The different archetypes in fresh food, and as a consequence the associated logistics organization, has changed over time and will continue to develop in the coming years. The table below shows where we expect the biggest impacts on logistics organization in the four archetypes.

DEVELOPMENT	SUPERMARKET	WHOLESALER	HOME DELIVERY	SPECIALISTS
More demanding customer	•••	•••	•••	•••
Towards Omni channel	•••	•••	•••	••
Connectivity and smart labelling	•	•••	•••	•••
Increasing political and societal pressure for sustainability	••	•••	•••	•••
Increased pressure for better liveability in cities	••	•••	•••	•••
Vehicle development (from conventional fuels towards zero emission)	••	•••	•••	••
Automization and robotization	••	•••	•••	••

Based on these general developments we can estimate how these different archetypes are likely to develop the coming years, estimating the impacts of these trends on emissions and footprint, as well as identifying opportunities and perspectives for action to change the projected future. Here we sketch the expected autonomous development of logistics in the different subsegments, while the following sections explore perspectives for action to enable a transition to a low-footprint urban logistics system.

Supermarkets and home delivery

Supermarkets are still increasing their market share, selling more fresh products, while there is growing interest in sustainable supermarkets offering local organic fresh food (e.g. Marqt). Although supermarkets will continue to grow, owing to an increasing market share, at the expense of specialists like butchers and greengrocers, there is strong growth in home delivery of weekly groceries and fresh meal boxes instead of shopping in stores. Further home delivery requires:

- An increasing need for local cross-docking for home deliveries.
- More sensing, tracking and tracing, more standardization due to e-commerce.
- High service level with shorter delivery times expected: within one or two hours.

No major changes are expected in the logistics operations of supermarkets, but rather incremental optimizations. Most of the kilometres driven in this archetype, and with them the corresponding footprint, currently comes from the parts outside the city (i.e. the trip from the supermarket's DC and the city border and back). Since the logistics operations are already orchestrated by large chains, further rationalization can be expected, such as increased use of LHVs for the longer-distance transport, where single tractor-semitrailer combinations handle final distribution, with the second trailer meanwhile being parked. Other efficiency gains can also be expected, especially in the outer-city parts of these distribution roundtrips, for example due to platooning and optimisation at network level (e.g. synple). The further increase in availability of real-time data on store-stock, traffic and other circumstances make precision logistics feasible for retail chains.

Finally, as supermarket supply is very visible in the cities, the increasing societal pressure for sustainability can affect these chains relatively more than other segments, creating pressure to use the cleanest possible vehicles for distribution.

Wholesalers

High-frequency, low-volume is typical for this segment, where time-sensitivity and perishability are key criteria. High-quality daily fresh product supply has become the standard for high-end restaurants, with suppliers offering delivery within the required time slots. The ease of Internet ordering has become the standard, increasing the number of suppliers, while decreasing drop density. This is not only a trend in restaurants and specialty shops; wholesalers, too, are having to cope with the strict time windows of their clients, requiring them to supply neighbouring organizations within other time slots. It is reported that up to 30% more kilometres are driven than strictly necessary because of clients' time-slot requirements.

More and more, people are tending to eat away from home (in major Dutch cities the share of HoReCa in food consumption has increased by 5% over the past few years) and consumer prepared meals, following a trend set in the United States. This implies that supermarkets will shift towards preparation of meals and that on-demand home delivery of prepared food from medium- and high-end restaurants (UberEATS, Foodora, Deliveroo) is likely to increase.
Deli XL operates one electric truck and recently started a cooperation with Bubble post in order to organize sustainable delivery in Amsterdam.

Specialists

Although still limited in size, this segment is expected to show strong growth in the years to come, because cities will attract yet more visitors, generating more restaurant visits. The rise of home delivery of high-end meals illustrates the interest in high-quality food and the market for high-quality specialist ingredients. Food specialists strongly benefit from the possibilities of Internet. Since price is not the main criterion, specialists can cover long distances to supply their clients. Because this market is dominated by small companies, focused more on customer satisfaction than logistics, it is expected that inefficient logistics will continue to dominate, with a limited number of stops per city, in the absence of incentives directing these players to partners with high-density networks.
There is generally very little interest from SME specialist suppliers in the greening their fleet, apart from a few frontrunners that use sustainability as a key discriminating factor (e.g. organic - fair-trade - electric). Greening of the fleet may also be difficult from a technical point of view with respect to full electric vehicles and vans. Vehicles in this segment may have rang limitations that do not fit the required daily-trip distances of specialist suppliers.

Parcel and express mail

Introduction to parcel logistics

Parcel and express delivery is the delivery of parcels or high-value express mail as single shipments. In this segment we do not consider regular mail. Parcel services are provided by most postal systems, express mail, private package delivery services and less-than-truckload shipping carriers. The products transported are (smaller) business goods and smaller consumer goods such as fashion and household items, electronics and books and typically have the following characteristics:

- Larger than a large letter (weighs no more than 750g)
- Weighs no more than 15-30 kg
- Can be lifted by a single average individual without mechanical aid.

Parcel logistics basically distinguishes between B2C (business to consumer; although this segment can also include C2C deliveries (consumer to consumer) using a parcel network) and B2B deliveries (business to business deliveries). Because of the rise of e-commerce, in particular, this segment has more or less exploded in size, with the B2C market now making up the bulk of transported volume. The market is dominated by a few large players that are trying to increase their drop density in this mainly cost-driven market (especially the B2C market), where many e-commerce receivers consider deliveries to be free.

The number of parcel deliverers active on the B2C market is relatively limited. The market is dominated by PostNL (+/-60%), DHL (+/-20%), GLS and DPD[50]. In the B2B market more players are active: TNT Express, UPS and FedEx should also be mentioned in this context. Parcel deliverers were traditionally focused on B2B packages. Over the past 10 years e-commerce has grown rapidly and now represents a significant volume in the parcels market.

Expressed in volume, about one-third of the market is international, crossing the Dutch border, the remainder national.

Different logistics systems/requirements for parcels

With parcel logistics, B2C and B2B parcel delivery are very similar. Some operators use only one network to serve both, while others use different networks - as requirements, times and locations differ, and drop density is high enough to have different networks. Note that, for example, two-men distribution is another network (see General cargo), as are deliveries of groceries and food (see Fresh goods segment), although these also concern home deliveries, often resulting from e-commerce activities. All parcel carriers make use of the hub-and-spoke system as a logistics model. This model allows the couriers to operate their networks as efficiently as possible at regional, national and international levels. A parcel can enter the network via a courier's collection milk-run, with dedicated (and often full-truckload) transport between, for example, a web shop's distribution centre and the (closest) courier's sorting centre, or via a parcel shop (postal office) where the parcel is brought. The parcels are collected from different companies and transported to a (regional) hub. This local distribution centre is referred to as a sub-hub. Through multiple sub-hubs (or directly), the parcels are finally brought together into a main hub where parcels are sorted and then shipped back to the regional hubs. The last-mile delivery starts from these regional hubs and therefore always start close to the final destination (with the exact distance depending on network density). Last-mile delivery is very important to (internet) retailers, as it comprises up to 50% of total delivery cost. A parcel deliverer delivers about 140-180 parcels per day, with trips often limited owing to available time, time slots or volume - but almost never because of the combined weight of the parcels. The number of stops can be slightly lower, when multiple parcels are being delivered to the same addresses. As thew average ride from a sub-hub is approximately 75 km, electrification is a feasible option. At PostNL about 80% of deliveries are carried out by subcontractors, mostly with their own vehicles. They use various sizes of van, up to a maximum payload of 3,500 kg, which they can oerpate with a standard driving licence.

Typically, the order value is larger in B2B, but the purchase frequency is mostly higher in B2C. Purchasing behaviour is not the same in the business and private market. Given that B2B customers buy larger amounts, the purchase process often takes longer and is more rational. Successful delivery is easier for B2B than B2C, because delivery during office hours is more successful at offices than at homes.

Typical difference between B2C and B2B are:

- **B2C deliveries:** Online shopping/e-commerce has changed the world of parcel delivery, with a sharp increase in B2C deliveries. The increase in B2C is expected to continue with increasing choice, convenience and competitive offerings. With the growth of B2C deliveries, the industry is facing a new set of challenges:
  - Significant levels of delivery failure due to 'not at home' (20%) in combination with 'no permission to leave behind?' and/or 'signature required'.
  - Inefficient delivery volumes, as B2C generally involves one package per stop compared with larger volumes in B2B (two packages per stop on average).
  - Focus on residential areas.
  - Relatively large time-windows, where the early evening is gaining in popularity (as there are more people at home).
  - Linked to the expanding time windows: the rise of same-day delivery. Although this is still a relatively small market, its market share is expected to increase. This service was introduced by TNT and DHL Parcel and is also offered by some start-ups.

- **B2B deliveries:** B2B parcel deliveries are different, as delivery can take place during office / opening hours and a delivery seldom fails. There is a high order value in combination with a higher number of packages per delivery. Delivery is thus relatively efficient compared with B2C. The focus is on industrial areas and commercial areas.

External drivers and developments in parcel deliveries

B2C parcel delivery has grown enormously because of the rise of e-commerce, and there are a limited number of large players. In terms of turnover the top 10 e-commerce webstores have the same market share as the remaining 90 e-commerce retailers in the top 100. Examples of large internet retailers are Bol.com, Wehkamp, Zalando, Coolblue and H&M. During the busy days before the Christmas period in 2016, the number of orders at Bol.com peaked at about 15 orders per second and resulted in a new record of 500,000 orders in one day. These records are about twice as high as those in 2014. PostNL has reported that the handling of parcels peaked at about 40 parcels per second just before Christmas in 2016. In 2015 the Dutch market for parcels was estimated at at least 208 million units and it is showing double-digit growth. Because of the rise of B2C parcel delivery, the number of vans driving in residential areas is on the increase and is expected to rise still further, as a result of more same-day deliveries, among other factors. Note that besides parcel delivery vans, other home deliveries (food, groceries, etc.) are also partly responsible for the increase in light-duty vehicles in residential areas. Although the combined numbers of these vans may be 15 to 20 per city and could increase to around 50 (see NOS, PvA), this number is still very small in comparison with that of passenger vehicles in these areas. The fact that these vehicles block traffic during the few minutes of loading and unloading and waiting for the receiver to accept the parcel (e.g. double, illegal parking due to a shortage in free loading / parking areas) makes these vans very noticeable in the streets, as well as resulting in more traffic problems than other road-users. LEFVs could offer a solution to these problems.

The number of B2C parcels will triple in the next ten years, while the large internet retail platforms like Bol.com, Coolblue and Zalando will become even more dominant. It is expected that e-commerce will have a 30% average share in retail sales in 2030.
The different archetypes in parcel distribution and, as a consequence, the associated forms of logistics organization have changed over time and will continue to develop in the coming years. The table below shows where we expect the biggest impacts on the logistics organisation in both archetypes.

DEVELOPMENT	B2C	B2B
More demanding customer	●●●	●●
Towards Omni channel	●●●	●●
Connectivity and smart labelling	●●●	●●
Increasing political and societal pressure for sustainability	●●●	●●
Increased pressure for better liveability in cities	●●●	●●
Vehicle development (from conventional fuels towards zero emission)	●●●	●●
Automization and robotization	●●●	●●

The parcel logistics segment is developing rapidly owing to the increase in e-commerce and the business model innovations taking place at webstores and other platforms. Many of the developments that - with time - will impact on urban freight transport in the other segments will first be visible in this segment. The above table shows that the B2C developments enabling the final receiver to steer (receiver-led deliveries) and developments enabling a carrier and/or webshop to better inform (and be in contact with) this final receiver will influence final-mile deliveries most.

Large e-commerce players, as well as various start-ups, have identified last-mile services as a key differentiator. The variety of delivery options and the perceived quality of the delivery service are major decision-making criteria for online customers and hence directly affect e-commerce players' success in the marketplace. Vendors are working hard to offer the best customer experience possible, especially by improving delivery times.

The last mile's share in total parcel delivery cost is quite high, often reaching or even exceeding 50 percent of total delivery costs. As a result, the main emphasis in this (often cost-driven) market is on finding new ways to make this final mile more cost-efficient, with further atomization of this now expensive and labour-intensive part of parcel deliveries the likely result. A similar development is already visible in the other handling-intensive parts, in particular the picking of products at the webstore's central distribution centre.

The most relevant developments for parcel distribution are the following:

- **Receiver-led final deliveries:** short delivery times, tighter time slots, high service: e-commerce customers have been pampered more and more the last few years, with increasingly shorter times between ordering and delivery; cut-off times at midnight are nowadays becoming the norm and same-day deliveries are gaining in popularity. There will be even more pressure on shortening the time between ordering goods and having them delivered (e.g. ordered at 12 p.m., delivery the next morning). Customers will also demand more flexibility on time slots (already having multiple options while ordering, also at night and during weekends) and tighter time slots (e.g. between 3 and 5 p.m. instead of between 9 and 5 p.m.); the options for final receivers to choose time slots, changing delivery preferences, are thus set to increase in the coming years. This may decrease efficiency for deliverers in some cases. Fast, reliable and efficient deliveries with seamless parcel transfer, matching more demanding customer requirements, is a competitive factor for e-commerce retailers. Currently, many parcels are delivered to neighbours when people are not at home. The market is continuously searching for a successful transfer of the package to the customer. Many different solutions have been tested in recent years and have proven viable. Centralized lockers and pick-up points are not showing growth, but are expected to retain a certain market share. Alternatively, some people that are often at home let their own premises function as a pick-up point for their neighbourhood (ViaTim and Homerr). At the same time, start-ups in high-service home delivery are entering the market (Buurtmus). Delivery at home at a predefined time or at an alternative location (work) are the most likely options to survive as a result of the quest to increase the 1st drop success rate and receivers' satisfaction. Eventually, same-day delivery is expected to achieve a limited market share, as some 25% of consumers are willing to pay an additional fee, but the vast majority of this group are unwilling to pay for the true costs. Younger consumers are more inclined (just over 30 percent) to choose same-day and instant delivery over regular delivery.

- **Competition on the last mile:** Fierce competition is observed between large parcel deliverers, in-house last mile transport by e-commerce retailers (Coolblue) and disruptive start-ups (Trunkrs, PickThisUp etc.). Companies like Bubble Post and others are working to set up bike messenger networks that enable local companies but also for e-commerce companies same-day delivery of parcels. Many subcontractors/freelancers works for parcel operators and retailers are starting to make contracts with platforms acquiring private persons for delivery. This development has taken place the last couple of years for cutting down costs on the last mile delivery; this is expected to continue and affect the final delivery most, as this part makes up for most of the parcel delivery costs.

- **Autonomous technology**: As part of the search for the most competitive form of home delivery and optimal customer experience, it is likely that autonomous technology will take over from couriers and that some form of new autonomous-delivery models will finally dominate the market. Mc Kinsey[51] recently projected autonomous vehicles with lockers to dominate the B2C market, but driverless autonomous follow me vehicles could also be used to increase efficiency and keep personal contact with customers. This projected change, however, provides an excellent proposition for large scale implementation of electric vehicles. In the B2B segment, where costs are less important, it is expected that today's personal delivery will remain the standard.

Facility logistics

Introduction to facility management & logistics

Facility flows in cities include the deliveries of goods and services concerned with maintenance and operations to ensure the functionality of public and commercial buildings in cities, such as offices, hospitals, schools, hotels and museums. Service logistics encompasses the delivery of goods and services that either support the main activity of the facility, such as general supplies, paper and printing, ICT systems, equipment, or support the smooth functioning of the organization, such as cleaning, catering, security, after-sale services (e.g. filling and cleaning of coffee machines) or maintenance of equipment, elevators, interior work, etc.. Although CE Delft (2016) estimates the total footprint of facility flows at about 10% of all urban freight transport, the flows in this segment are very heterogeneous and as a result it is complicated to address these different groups.

Logistic characteristics of facility management

Usually, suppliers can be divided into three groups: delivery of goods, delivery of services and delivery of goods and services. There are multiple service providers for one organization, building or facility, chosen on the basis of the specialization and quality/price ratio for the specific service provided. Service contracts typically run for 5 years or more, corresponding to the duration of the rental agreement of the building. Service contracts typically include service-level agreements (SLAs) with respect to the frequency, availability, functionality or quality of services, for example. Transport costs are typically included in the total price of the service contract (DDP) and are not separately visible to buyers. Recent research in the Netherlands shows that large facilities can be visited by up to 40 suppliers on one day. Facility managers or buyers of large organizations typically work with hundreds of suppliers. Suppliers include mail and parcel, service logistics, food-service (fresh food), waste collection, cleaning, office supplies, etc. Inbound logistics are mostly predictable transport flows. Dutch research also shows that 20% of suppliers account for about 85% of deliveries and over 50% of suppliers originate from within a 30 km range. Several of the largest suppliers may typically have a market share of about 50% of the total freight volume. Suppliers of goods have often outsourced transport to a dedicated LSP or to a LSP that combines the shipments of multiple shippers (e.g. parcel or general-cargo deliverers). Suppliers of services often arrive by car, van, public transport or bike, whereas suppliers of goods mainly use vans and trucks of various sizes.

Although the vast majority of suppliers' daily trip distances are feasible for electric vehicles, use of electric transport for facility logistics is currently very limited.
Facilities usually have a designated delivery / pick-up point with a loading bay and space for goods handling and storage. Stockkeeping patterns and frequency of deliveries determine the required handling and storage space in the building. Sometimes it is the other way round, though, when stock replenishments are determined by limited and fixed storage space. Services usually require a longer stop at the recipient than deliveries of goods. For goods delivery the stopping time is relatively short, determined mainly by unloading time and physical handover. Trucks and vans have various payloads when entering the city, depending on the type of logistics system employed by the supplier, ranging from highly efficient milk-runs for multiple customers to direct dedicated delivery with half-empty trucks or dedicated delivery with full truck-loads.

External drivers and developments in facility management

In the Netherlands the total amount of office space is expected to remain relatively stable owing to the decreasing amount of floor space required per employee due to teleworking. The utilization rates of office buildings is thus expected to improve. Due to the aging population, the number of hospitals is expected to increase slightly and the number of schools to decrease slightly. Overall, the number of public and commercial buildings is expected to remain stable, with demand for goods and services at these facilities anticipated to increase modestly. At the same time, a general shift towards buying services together with a product can be observed, leading to an increase of service logistics. The following table shows which exogenous developments are expected to have the greatest impact on facility flows.

DEVELOPMENT	FACILITY FLOWS IN CITIES
More demanding customer	••
Towards Omni channel	•
Connectivity and smart labelling	••
Increasing political and societal pressure for sustainability	••
Increased pressure for better liveability in cities	••
Vehicle development (from conventional fuels towards zero emission)	••
Automization and robotization	•
Circular economy	••

After-sales services are generally considered more profitable than merely supplying the goods or equipment. A variety of value-added services are therefore being provided by suppliers in this segment. Instead of just paying for the cost of spare parts or supplies, performance-based contracts are increasingly being used. Another closely linked development in this segment is the use of integrated DBFMO contracts for utility construction projects or renovation of obsolete buildings. Integration of the design, build, finance, maintain and operate stages into a single contract can bring about whole-life optimization. The contractor or consortium receives an availability fee or performance-based fee during the contract period of commonly 20 to 30 years.

Due to the IoT trend, inventory control and management is expected to become more efficient and procurement more centralized. A lower number of stockkeeping units and lower stock levels in more centralized locations will likely result in more frequent deliveries with smaller drop sizes. Consequently, smaller drop sizes are expected to shift transport partly from general-cargo deliveries (pallets) to the B2B segment of parcel deliveries.

IoT and sensors are also expected to result in more remote maintenance and control, preventive and proactive maintenance leading to less downtime and more efficient maintenance and logistics. Service logistics is expected to increase and result in more combined supply of goods and service. Better planning of the necessary tools, spare parts or supplies is also expected to improve maintenance efficiency.

Furthermore, there is growing attention to and awareness of organizations' and facilities' environmental footprint. As a result there is increasing consolidation of supplies, either at-source (e.g. a supplier like Staples) or at one or more smaller hub locations at the city border. The storage location of such micro-hubs is available near the delivery location, which may be also at the premises of one of the companies participating in the shared hub. As a result, the storage space per individual public or commercial building can be further reduced. From these micro-hubs, the consolidated goods are delivered to their final destination by a city distribution specialist. Examples are the Cargohopper service in the Netherlands and the Stadsleveransen system in Goteborg, Sweden. The Cargohopper service is operated by the Dutch LSP Transmission, using electric vehicles in Amsterdam. The Stadsleveransen[52] system pools deliveries for 500 shops and businesses, drastically reducing shopping-centre traffic and freeing up once congested streets for pedestrians and cyclists. A promising example is a project by the Dutch government in The Hague, where a micro-hub is currently being set up in Rijswijk and scope for more centralized category management and procurement is being investigated. A next step is to combine procurement with other organizations within the same city. In this case, procurement departments from different organizations need to cooperate, aligning procurement processes of specific goods and, possibly, creating a shared stock of general supplies. Collaborative sourcing and category management will lead to economies of scale and consequently more efficient logistics.

In general, many organizations tend to outsource anything that is not a core business for them. The number of companies that provide the whole range of facility services (cleaning, catering, maintenance, etc.) is expected to grow. Among office-goods suppliers more consolidation is expected not only in facility services but also by wholesalers (e.g. Staples for general office supplies, Hanos for fresh food-services, etc.). Higher volumes by fewer suppliers will improve the efficiency of goods and services deliveries, as professionals can bundle more deliveries to different clients within their networks. Collaborative sourcing and category management are expected to accelerate the market consolidation trend. Facility management experts indicate that it should be feasible to have about 90% of deliveries executed by a maximum of five suppliers. Large organizations with large facilities are expected to be able to implement these recommendations by themselves. However, for SMEs it will probably not be a high priority to improve facility logistics. For this category a push-oriented measure such as an environmental zone or city access charge would be a very effective way to rationalize facility logistics.

In general, procurement is a powerful tool to optimize the efficiency of deliveries. Currently, corporate social responsibility strategies are becoming an important driver for sustainable procurement and facility management practices. Governments are increasingly inclined to practice what they preach: zero-emission city distribution. Procurement departments and lead buyers play an important role here, by taking the logistics efficiency and possibilities for zero-emission delivery vehicles into full consideration. Tender requirements can be used to facilitate a better TCO and business case for e.g. electric vehicles. For example, contract periods of 10 years are more favourable to electric vehicles than contract periods of 5 years.

Construction logistics

Introduction to construction logistics

Managing urban areas has become one of the most important development challenges of the 21st century. Urban populations continue to grow and sustainable urbanization is key to successful development. Large construction projects increasingly involve large area development projects in the most intensely used urban environments, such as old historical city centres, shopping areas, primary public-transport transit hubs, central business districts and high-rise residential tower blocks. Area development or redevelopment projects in cities typically include many separate but interlinked construction projects managed by different consortium partners. Urban construction projects typically involve temporary full-road closures and traffic detouring. This imposes additional traffic and road loads on alternative routes and may result in congestion and infrastructure deterioration on detours. Passenger and freight transport are essential for the well-functioning of cities and the supply of their residents and businesses. Cities depend on an efficient and sustainable city logistics system to ensure their attractiveness, economic power and quality of life. Increasingly, construction-related traffic and traffic detouring within limited city space has negative effects in terms of emissions, traffic safety, congestion and nuisance (noise, stench, vibration etc.). As an illustration, last year 80% of traffic accidents in the city centre of Amsterdam were related to construction traffic.

The increasing importance of construction logistics

Remarkably, it is only recently that the logistics of construction projects has started to gain more attention, even though approximately one-third of the total mass of goods transported by road in the Netherlands is construction-related. After the general-cargo segment, construction logistics is the second-largest CO_2 emitter in city logistics. Clearly, logistics in urban areas is at the heart of construction activities and since 2010 is has received much more attention in the Netherlands. The increased focus on construction logistics has been driven by a number of pilot studies proving the potential in terms of both sustainability and productivity and profitability.

Innovation in urban construction logistics will be even more important in the near future. While construction industry turnover in the Netherlands is set to increase from € 62 billion in 2016 to € 73 billion in 2022 (EIB, 2017)[53] , the bulk of this growth will occur in urban projects.
Three main developments will drive the need for further innovation of logistics in urban construction projects:

1 **Urbanization and densification:** It is estimated that approx. 1 million additional houses will be needed and built in the period up to 2040. The majority of these will be built in cities, partly by transforming old offices and industrial buildings. Another challenge is the upgrade of aged utility systems like those for sewerage.

2 **Energy efficiency:** In order to achieve the Paris climate goals, a major part of the (often old) city housing stock needs to be upgraded into energy efficient or 'zero-consumption' houses.

3 **Circular economy:** If construction in cities is to be transformed based on the principles of the circular economy, this will have a major impact on design, construction modes and how buildings and materials are demolished, re-used and exchanged.

All in all, it is envisaged that the share of total construction turnover accounted for by the larger cities will increase form approx. 50% (2014-2020) to approx. 80% (2030-2040). Hence, innovation in urban construction logistics will have to cater for real new developments. The larger and mid-size contractors are expected to find their way, as can be seen in today's pilot projects. The main challenge lies in the market segment of small urban (renovation) projects, where thousands of small entrepreneurs with their mini-vans determine daily construction practice.

There are several factors complicating implementation of effective measures and agreements to improve construction logistics. First, the number and variety of stakeholders involved and split responsibilities often result in inefficiencies and failure costs. In a typical construction project the following stakeholders can be present: main contractor, sub-contractors, logistic service providers, transport companies, wholesale trade, suppliers, municipalities and residents. Failure costs are often a result of design changes having an impact on multiple stakeholders as well as on the construction logistics. Secondly, the construction segment is rather cost-driven, which complicates the implementation of innovations that can lead to benefits other than lower costs. As long as the cost-benefits are not proven, parties are generally hesitant to invest in such innovations. Another related factor is the fact that transport and logistics costs in construction contracts are never explicitly calculated. This makes it very difficult to demonstrate/calculate the cost-benefits of logistics innovations. A final example that makes the logistics of the construction segment rather complex is that transport orders are often received one day in advance. This short notice makes it harder to plan the transport efficiently, while the potential benefits of bundling are minimal.

Different construction segments and construction phases

The construction segment can be split into two different market segments: housing and utility, and infrastructure. In each of these segments projects have a planning and tendering phase, a project execution phase and finally an operating and maintenance phase. The construction execution process includes several phases, starting with site preparation, including any demolition and cleaning required, followed by the structural stage in which the building structure/shell is prepared, after which the building structure is finalized in the fit-out stage, including fitting-out work (both rough and final). Significant differences can be observed between the construction segments and phases. From a logistics perspective, an important distinction is between the highly frequent flow of bulk solid and raw materials with full truckloads by heavy-duty vehicles in the site-preparation and structural phases as compared with the delivery of semi-finished products, parts and services by less than full truckloads during the rough and final fitting-out stages. Another important distinction is between a limited number of large projects commissioned by a few large clients and executed by a few large contractors or consortia as compared with a large number of small projects commissioned by many small clients and executed by many small contractors.

Housing and utility

Most construction works involve numerous parties. Usually, a corporation or project developer sets out a tender for a construction project. This is closely coordinated with the municipality because of municipal land-use plans and land ownership. At this stage, all plans are already developed in cooperation with (a team of) architects. On such tenders it is the larger contractors that will be bidding. The main contractor himself will consequently hire several subcontractors to execute the tasks at hand. When choosing these subcontractors, price is always the leading criteria. This makes it harder for the sub-contractors to innovate in terms of quality or sustainability. The distance between suppliers and construction projects, the CO_2 footprint and the reliability of delivery times and risk and cost of potential delays are often not taken into account. Since every subcontractor will influence the construction process and thus the construction logistics, this practice leads to a rather complex and inflexible system. Traditionally, there is no overall coordination of logistics organization at the construction site: all subcontractors do their own job and organize their own logistics accordingly (cost-driven).

Because of changing consumer preferences in favour of inner cities, the locations of housing construction works have shifted. While in the last few decades much construction took place in the 'VINEX' residential development areas just outside the city border, demand for construction work in cities and city centres has recently been increasing. This is also due partly to the growing obsolescence of the housing stock, leading to a need for renovation and urban redevelopment. Although it is the large-scale construction projects that generate most nuisance and external effects, the sum total of numerous small-scale construction projects also results in very fine-meshed flows of construction-related traffic across the city by many independent subcontractors and suppliers. This may typically lead to a long queue of commercial vans parked near smaller construction sites in the fit-out stage. Most of these vans transport only a limited amount of own goods or tools and park near the construction site, generating considerable local traffic and nuisance. Most of the traffic to construction sites arrives between 7 a.m. and 11 a.m. (e.g. 80% in Amsterdam and 60% in other cities, according to research by HvA). The demolition and site-preparation stages typically involve both flows of bulk-material supplies and removal of construction waste, which may be recycled and reused. For bulk FTL flows, traffic circulation and planning of arrivals at the construction site is most important. Often there is very limited space for trucks, necessitating more frequent JIT deliveries. At large construction sites a new truck sometimes arrives every 5 minutes in the structural stage. For LTL flows, bundling of logistics flows saving empty kilometres driven is the most obvious route to improvement.

Infrastructure

Large infrastructure projects typically involve transport of large volumes of ground, asphalt and concrete. Sometimes pipelines are used for ground transport instead of heavy-duty vehicles. Groundplans sometimes require depots for temporary storage. However, groundplans and the use of depots are typically project-specific and not coordinated across different projects between different contractors in the same region. The client and procurement agency of infrastructure projects is often the road, waterway or rail asset manager, such as Rijkswaterstaat, Prorail or municipalities and provinces. Large asset managers such as Rijkswaterstaat have gained a lot of experience with large Dutch contractors or international consortia and have been developing innovative approaches, such as integrated contracts (DBFMO), public-private-partnerships (PPP), framework contracts and, MEAT criteria in tenders, to improve quality and minimize the external effects of projects. In some areas the infrastructure segment is some steps ahead of the housing and utility segment, with respect to transport or construction activities at night or in weekends, for instance, in order to minimize traffic disturbances during peak hours or with respect to measurement of the CO_2 footprint of the construction project.

When it comes to infrastructure-related construction projects in cities, traffic management and routing to the site are especially important. For instance, during construction of the North-South metro line in Amsterdam, the consortium made use of clever transport of materials underground. There were two points of entry to the metro tunnels: one in Sixhaven and one next to the A10motorway. From there, the required construction material was distributed with specially built tunnel-transport vehicles over the entire tunnel construction site without disturbing Amsterdam residents.

External drivers and developments in construction logistics

There are several external developments impacting the construction sector and construction logistics, as summarized in the following table.

DEVELOPMENTS	SMALL COMPANIES	LARGE COMPANIES
More demanding customer	•	•••
Towards omnichannel	••	•
Connectivity and smart labelling	•	•••
Increasing political and societal pressure for sustainability	••	•••
Increased pressure for better liveability in cities	•••	•••
Vehicle development (from conventional fuels towards zero emission)	••	••
Automization and robotization	•	••
Circular economy	••	••

Digitalization and information technology

One of the major developments is information technology and use of computer-aided designing and planning tools. Digital construction drawings and 3D-modelling are increasingly being used and include material-resource planning and logistic flows and costs as well. Building Information Modeling (BIM) enables virtual construction and real-time information sharing by all project partners and suppliers. Logistics data are also going to be included in the BIM. BIM information technology also permits creation of control towers for cross-chain logistics optimization. As a result, material flows and logistics costs are becoming more transparent and contractors are becoming more aware of these costs. In housing projects, logistics costs can make up around 15% of total costs. Material requirements are increasingly being planned far more in advance. Instead of planning and collecting the materials for the next day or even the same day, contractors already know exactly what materials are needed each day for the next few weeks. As a consequence, the construction site is becoming more lean and mean, with supplies being delivered more just-in-time.

Value-added services

As a result, wholesalers such as Technische Unie, RAAB Karcher or CRA are increasingly offering value-added services such as construction logistics, both towards the site as well as on-site. Instead of having subcontractors collect the materials at the wholesaler individually, the wholesaler provides one or multiple JIT deliveries across various construction sites within the same city or region. In addition, based on their in-depth knowledge of specific city logistics requirements, wholesalers are becoming more involved in the earlier stages of the tendering phase to provide construction logistics advice to contractors to improve their bids. As construction logistics and minimization of external effects for the stakeholders around the construction site becomes rewarded in tender scores, large contractors are looking for new partners who specialize in this area.

Besides wholesalers, LSPs such as DHL or Royal SAAN as well as facility service providers like GSA are also moving towards providing construction logistics services.

Sustainability

Owing to the increasing political and societal pressure for sustainability and for improved liveability in cities, another important development is the growing attention for quality and sustainability aspects in addition to the lowest price. Municipalities are increasingly adopting a BLVC framework indicating BLVC criteria (Bereikbaarheid, Leefbaarheid, Veiligheid, Communicatie) with respect to the accessibility, liveability, safety and communication aspects of new construction projects. BLVC requires contractors to provide a BLVC plan in which they must demonstrate their compliance with the BLVC-criteria. A BLVC plan can be up to 50-pages long and is a knock-out requirement in the tender specification. BLVC has not yet been implemented to its full potential in municipalities, currently being used most by the four largest cities, with Amsterdam leading in use and statement of BLVC requirements. However, the carbon footprint of construction logistics is still difficult to include in the BLVC criteria. Today, these criteria include, for instance, the maximum permissble number of waste containers, the number of queuing trucks and the number of commercial vans parked near the construction site. In the future though, it could also include routing requirements towards the site or the types of vehicles used. For instance, a BLVC could ban the use of less environmentally friendly tractors that also cause a lot of accidents in inner-city traffic. Tractors do not have to comply with environmental regulations and may be operated by people as young as 16 years of age without a driving license. As a result, tractors are much cheaper than regular heavy-duty vehicles and therefore often used by contractors to save costs. A BLVC could also disallow the use of heavy-duty trucks in inner cities. For example, in the inner city of Amsterdam trucks heavier than 7.5 tonnes are no longer allowed. Because of conflicting interests, the definition of the BLVC criteria is not always straightforward. For instance, there may be stakeholders, such as schools and offices, that oppose deliveries by heavy-duty trucks during office hours, while other stakeholders, such as residents, may not want trucks delivering during peak traffic hours. Enforcement of the BLVC plan is another important task for the municipality and is typically done by the project's stakeholder manager. Attention to enforcement often decreases during the construction execution phase. BLVC criteria should be defined as clearly and measurably as possible by using key performance indicators (KPIs).During execution the KPIs should subsequently be monitored, by using floating car data or a cordon of cameras to register licence plates entering the inner city, for example, and by having a complaint procedure for the stakeholders involved in the construction area. Currently, one of the barriers is the lack of a comprehensive methodology to measure the footprint of construction logistics and the fact that all subcontractors and suppliers must agree with either tracking and tracing or handing over the licence plate registrations of their vehicles or agree with other forms of measurement of their transport activity and corresponding CO_2 emissions.

Sustainable procurement by the client

In addition to BLVC, sustainability and quality aspects are also increasingly incorporated in the tender evaluation and scoring of the bids. Many projects today are tendered with using MEAT (Most economically advantageous tender). With MEAT, up to 60 or 70% is sometimes based on quality or sustainability aspects and only 30 to 40% on lowest price. However, the number of procurements with MEAT still varies and the percentage share of quality aspects in MEAT is on average about 40% according to industry experts. MEAT criteria could, for example, also include the lead time of the execution phase, accessibility, the amount of construction traffic and emissions, procedures and mitigation measures to minimize disturbances for the area surrounding the project site, etc.

Today, several supporting systems or methodologies are used in MEAT, such as the 'CO2-prestatieladder', 'DuboCalc', 'Bewuste bouwers' and 'BREEAM'. However, in practice no single methodology is yet able to comprehensively calculate the footprint of the construction logistics. The MEAT criteria are not sufficiently discriminating and consequently many bidders score at least 6 out of 10, with most bidders easily scoring an 8 or 9. MEAT has sometimes become more of a formality and, as a result, the lowest price often remains decisive. It should be noted that the bidder with the lowest price does not always have the lowest MEAT, too. Sometimes a bidder has the best price as well as the best MEAT because they have simply developed the smartest and most thoughtful project plan.

Another approach to minimize risks and improve the price-quality ratio and sustainability of large and complex construction projects, both in housing and utility and infrastructure, is the use of DBFMO contracts: Design, Build, Finance, Maintenance and Operate. With this type of integrated contract, the government is actually buying a service rather than a product, since the contractor - often a consortium - is required to keep a building or piece of infrastructure available and fit-for-purpose during a contract period of commonly 20 to 30 years. An advantage of this approach is that it encourages the contractor to align and optimize the different phases and processes of a project as much as possible, leading to lower prices and higher quality. This could therefore also facilitate alignment of the logistics of different parties, compared with a traditional contract in which different contractors are responsible for different parts of the project.

Sustainable sourcing by the contractor

One of the biggest challenges for the construction industry is that the buyers of large contractors still employ project-based sourcing practices based on the lowest price of materials and products. The increasing transparency of logistic flows, risks, costs and environmental impact is expected to shift the focus more towards supply chain management for multiple construction projects. As shown in Section 4 of this annex, such a mind shift will require additional action by higher management levels and the boards of large contractors.

Logistics efficiency

BIM, real-time information sharing, BLVC and MEAT have all encouraged the development of innovations in logistic efficiency, such as consolidation hubs near the city border and prefab production in an industrialized environment.
With the increasing demand for construction works in city centres where accessibility and storage space are limited, logistic optimization is essential. More and more construction projects are using a consolidation centre just outside the city (as with De Trip in Utrecht, for example[54]) or promoting carpooling by their employees to the construction site. At these logistic hubs, the required construction materials and people can be bundled and transported to the construction site with high load factors. Multiple housing and utility construction projects that have already used consolidation centres have reported reductions of up to 70% in CO_2 emissions and kilometres driven. Until now this development has been stimulated in part by municipalities and the Top Sector Logistics programmes, but it should be further adopted by large as well as smaller contractors. One factor complicating the use of consolidation centres is that agreements need to be made on the division of costs and benefits across the different subcontractors and actors in the logistics processes.

Another trend besides logistic hubs is to use JIT (Just In Time) deliveries. The advantages for the contractor are clear, such as the reduced need for storage and less risk of damaged or stolen material. For optimum alignment of JIT deliveries, geofencing can be used: a sensor in the truck that sends a message to the contractor when the truck is within a specified distance of the construction site. Intelligent time-slot management can then guide the truck to the construction site.

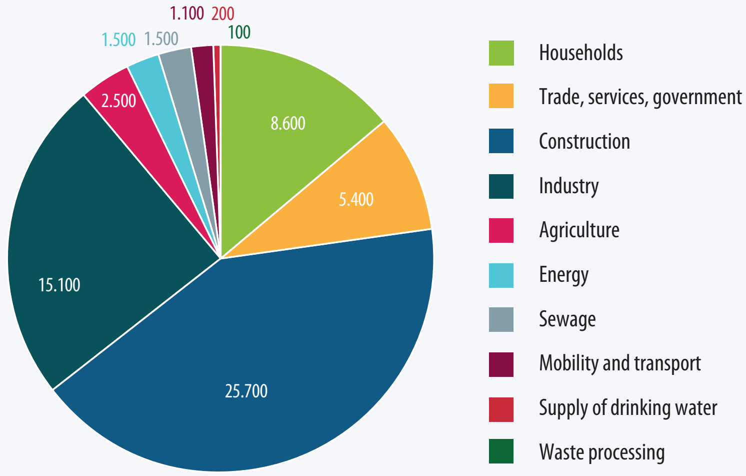
A different approach to bundling that is receiving increasing interest is use of prefab. VolkerWessels, for example, has a concept in which they can build a house in one day, by prefabricating all the different components at the factory and subsequently organizing the logistics such that all components are delivered in the right order and even at the exact spot where they will be used. This concept leads to a decrease in transport to just two truck rides per house. With this concept, houses are built one-by-one instead of block-by-block, resulting in a smaller construction site and less nuisance for the surrounding neighbourhood. Prefab can also decrease the amount of construction waste at the site and improve labour productivity.
For example, pilots with prefab elevator installations by TBI resulted in 35% higher labour productivity.
Furthermore, the scope for using different transport modalities is being explored. Examples include electric or low-emission vehicles that are given privileges by municipalities or transport by inland waterway. While inland shipping can lead to significant emission reductions, it is only cost-efficient for large-volume construction projects. A TNO study[55] showed that in the housing sector a minimum of three housing renovation projects should be built at the same time for use of inland waterways or Amsterdam canals to be cost-efficient.

Waste collection in cities

Introduction to waste collection

Waste companies collect and sometimes also process waste. Waste comes in many forms, such as swill, other organic waste, paper, glass, plastic, metal, oil/grease, dangerous goods and construction waste. The largest sources of waste by weight are construction waste and industrial waste. However, the focus[56] of this section is on the collection of sorted and residual waste from households and businesses (trade, services, government) in urban areas.

Figure 22
Amount of waste produced in the Netherlands in 2012 in ktonne (adapted from (2015, Vereniging Afvalbedrijven))



Household easte collection is usually associated with the lowest number of kilometres (5 km) per tonne of collected waste. For business waste this figure is 16 km, since businesses are spread farther apart than households. However, since there is a lot of lifting and compacting involved in household waste collection, CO2 emissions are not necessarily lower than for business waste. After collecting the waste, waste companies own the waste and gain revenue from processing it. The collection vehicles transport the waste to a local or regional transfer facility, from where tractor-trailers bring the waste to a processing facility. A company generally has one processing facility in the Netherlands for each form of waste, or brings the waste to another company's processing facility. Sometimes the processing facility is very close (<25-30 km) to the collection area. In this case no transfer facility is used and the waste is transported to the processing facility directly.

The mixing of waste from households and businesses during collection is legally prohibited. Households are obliged to pay a standard municipal waste tax called 'Afvalstoffenheffing', which is used by the municipality to organize household waste collection. For companies it is legally mandatory to contract a commercial waste collector.
Waste reduction and waste sorting are important policy goals because sorted waste is easier to recycle and re-use. Dutch households currently generate about 500 kg of waste per year, of which about 50% is separated waste and the other 50% residual waste. National and local governments[57] in the Netherlands aim to increase the share of separated waste to 75% and to reduce the amount of residual waste per resident to less than 100 kg by 2020.

Different logistics systems in waste collection

Due to the legal and physical boundaries between business and household waste collection, we make the following distinctions:

- **Waste collection for households:** In the Netherlands, municipalities are legally responsible for collecting waste from households. About 50% of municipalities have an in-house waste collection service (ROVA, Roteb or Avalex) with their own fleet of refuse trucks. The other 50% of municipalities have outsourced their household waste collection to commercial waste collectors such as Shanks/van Gansewinkel or SITA/SUEZ. The duration of contracts between a municipality and commercial waste collector is typically more than four years, but can be as long as 10-20 years. The programme of requirements of the tendered services are fully specified by the municipality. The primary criteria are price, service level, type of refuse truck, etc.

  In 2009 there were 3200 waste collection vehicles in the Netherlands (CBS), most of them compactor (compressing) trucks. Most of the waste collected by refuse trucks is in mini-containers or bags, on average 8-10 tonnes from 1200 households in a daily trip. Depending on the density of households and the distance from collection area to transfer facility, a daily trip is approximately 40 km. Daily trips for collecting waste from underground bins can be longer, owing to a more efficient collection process. They may make two collection trips instead of one.

Through their Power Take-Off (PTO), waste trucks also use diesel for other operations than movement, the most important being lifting containers and compressing waste. Depending on distance between stops, the percentage of energy used for auxiliary processes can vary significantly.

Municipalities employ two main types of waste collection service:

- **At-source separation:** municipalities separately collect waste sources such as paper, organic waste, etc.
- **Post-separation:** separation is carried out at central sites. Only one waste stream is collected and transported to local or regional transshipment sites.

At-source separation causes most transport movement within cities, owing to the collection of multiple streams. Outside cities, both collection systems generate additional transport in comparison to traditional waste incineration. Both separated and mixed waste streams need a sorting step[58] before being transported to large central processing sites in the Netherlands or abroad.

One-quarter of Dutch municipalities have introduced a variable tax (differentiated tariffs or diftar) for waste generation according to the 'polluter pays' principle in order to reduce the overall amount of waste and increase separation. The fixed tax ('afvalstoffenheffing') is reduced, but in addition households must pay a small price per residual bag or emptying of a mini-container. This is designed to increase awareness of waste generation. Diftar requires an advanced tracing system. As a recent alternative, municipalities are now also employing 'counterwise collection', whereby separated streams are collected at home level, but residual waste only at a more generic level.

Refuse trucks drive according to a pre-fixed route (a so-called milk-run). Households cannot currently determine when their garbage is collected; the milk-run is organized according to a fixed schedule. As many cities must deal with large fluctuations in waste volume, fixed waste collection schedules are based on peak waste levels and are therefore highly suboptimal. Through use of online apps and sensors, waste collection could become more on-demand in the future, providing greater system flexibility, with underground storage making for optimum utilization, as waste can then be deposited when households choose to and be collected when the container is full.

Depending on the type of collection (bags, bins, underground containers or compactors), routes can be once every two weeks or more frequently, as needs dictate. In the case of collection of waste from underground storage, the number of stops will be far lower. Underground containers for residual waste are typically shared by about 20 to 30 households and have a volume capacity of about 3-5 m^3. Currently, less than 10% of households in the Netherlands use underground containers for residual waste. Underground containers can be fitted with a sensor that signals when storage is 80% full. This can be either based on counting of the number of lid openings or by weighing the waste. Using GPS, a signal can be supplied to the waste company to empty the underground storage bin. Currently less than 10% of underground containers have sensors. Since underground containers are currently 40-100% full when emptied, sensors can lead to a significant increase in logistics efficiency.

By using underground compactors, the frequency of waste collection could dramatically decrease. The waste in underground storage can be compressed by a factor of five to allow more waste in the same volume, and in the case of plastic a factor of 60-70. Underground storage bins with compression use pressure to determine how full they are. Since the price of underground compactors is much higher than a standard underground container, compactors are currently not widely used.

- **Waste collection for businesses:** Since every waste-producing business needs to contract a commercial waste collector, there is a competitive market with multiple commercial waste collectors to choose from. SMEs are located predominantly in cities, while large companies are also located outside or at the edge of cities. Most business waste, about 70-80%, is collected by the two largest waste collectors (Shanks/van Gansewinkel and SITA/Suez), the emainder by smaller local and national parties. Collected waste becomes the property of the waste collector, which hampers collaboration and consolidation. Information about type of waste volumes and waste weight is regarded as highly sensitive and competitive. Waste collectors are focused primarily on the value of their waste and to a lesser extent on logistics efficiency. Different waste collectors are contracted for different waste categories, resulting in suboptimal utilization of assets owing to multiple competing waste collectors for many waste categories in the same geographical area. A waste collection contract typically runs for five years.

- Different types of waste are collected separately and with various frequencies by various collectors. Services are based mainly on fixed milk-run-like schedules rather than on dynamic on-demand scheduling. Incidental requests from customers to collect their waste outside the schedule are usually met to preserve a good relationship with the client, although this decreases logistics efficiency. The distance between stops is higher than for residential waste collection; trucks collecting waste from businesses drive fewer than 100 kilometers in urban areas, but over 200 kilometers outside cities.

External drivers and developments in waste collection

The waste collection systems in use for households and businesses are changing. The following table summarizes the impact of eight selected trends on the respective systems.

DEVELOPMENT	RESIDENTIAL	BUSINESSES
More demanding customer	•	•
Towards Omni channel	•	•
Connectivity and smart labelling	•••	•••
Increasing political and societal pressure for sustainability	•••	•••
Increased pressure for better liveability in cities	•••	•••
Vehicle development (from conventional fuels towards zero emission)	•••	•••
Automation and robotization	•	•
Circular economy	•••	•••

Waste separation remains important to governments and residents alike and there is growing attention to the circular economy. More at-source separation of waste is expected as local governments are currently not on track for achieving the goals of 75% separated waste and a maximum of 100 kg residual waste per resident. Post-collection waste separation is expected to be used more in densely populated cities, where residents have little space to store multiple types of waste for longer periods. Waste separation generally results in more kilometres: separation at-source entails more sources of waste and therefore more kilometres, while separation post-collection currently requires more trips to distant processing facilities. However, with the growth of the circular economy, more processing facilities will arise, reducing the required trip distance.

With reverse collection[59], residents are encouraged to separate their waste and reduce the total volume. In some cases, residents (e.g. those serviced by ROVA in some municipalities) must bring their residual waste to a storage bin, while separated waste is collected at home. In other cases, they must pay for their residual waste, while separated waste is free of charge.
In addition, a further shift from bags and bins from individual households to underground containers for street blocks is expected. These underground containers can be compactors, compressing the waste to decrease volume and requiring less frequent collection. They are anticipated mainly in densely populated and new-build areas where competition for space is severest.

The physical world of waste is increasingly connected. More and more waste containers for households and businesses are expected to be equipped with sensors and connected to the internet as ‘smart’ waste containers will become cheaper. Smart underground containers and compactors will enable on-demand collection and dynamic scheduling, thereby reducing the number of trips necessary and allowing route optimization.

The political pressure in the waste segment is increasing. On the one hand, there is major political momentum towards achieving a circular economy, with waste companies at the centre. On the other hand, residents of heavily populated areas are becoming more vocal about the number of waste trucks passing their street every day and entering inner cities.

A few zero-emission waste trucks are currently used by several companies to demonstrate their sustainability to the public. The total number of electric waste trucks is less than 1%, however. Although electric waste trucks have been proven technically feasible, waste companies regard them as too expensive to use in large numbers and their use is not required by law. Without additional measures and action electric refuse trucks are not expected to capture a large market share over the next ten years.

Annex B
Illustration on presented statistics

General
In this report, the study by CE Delft (2016) on quantification of emissions has been taken as a starting point. As that study was produced for the purpose of making an initial aggregate emission estimate, however, it cannot be used directly for describing or quantifying the emissions of subsegments. In some cases, where that study provides insufficient detail, other studies have been used, or estimates made on the basis of own expert insight. Below, deviations from and additions to CE Delft (2016) are summarized.
The figures cited correspond with the bottom-up figures from CE Delft (2016) and are therefore at the lower end of the figures cited in Chapter 4, except for facilities and construction, where an average of top-down and bottom-up figures have been used.

Fresh logistics
For large retail, the distribution over vehicle classes has been estimated on the basis of own expert insight. Home delivery has been estimated on the basis of a vehicle fleet of 2000 vehicles driving 75 km for 6 days a week. The transport volume of specialists has been estimated on the basis of 10,000 high-end restaurants and 10,000 specialty shops. Specialists were not identified in CE Delft (2016) and have been subtracted from wholesalers.

General cargo
The distribution of transport volume over large retail and partial retail has been estimated, as well as the distribution over vehicle classes. Growth factors have been estimated on the basis of KPMG (2016), own estimates and the ultimate share of 30% online in non-food retail sales (ING, 2015). Distribution over vehicle classes for large retail is an own estimate.

Parcel and express
Distribution over B2B and B2C is respectively 1/3 and 2/3[60]. Growth of transport volume is 75% of growth in the number of parcels, owing to operational efficiencies. Growth in the B2B segment is estimated at 1.5% annually, corresponding with the real growth of GDP. Growth for B2C is estimated at factor 3 for 2025 (ING, 2015) and subsequently 1.5% annually.

Waste
Future growth figures have been based on ING (2014). The emission factor for refuse trucks has been adapted to 1,220 g/km. Building waste is not included.

Building

With respect to the primary data, it should be noted that the number of kilometres driven by LCVs is highly uncertain. In CE Delft (2016) it was shown that the bottom-up and top-down analyses ranged from 1,000 to 5,000 Mio kilometres by LCVs. Based on expert judgment and the fact that by 2030-2040 it is expected that about 80% of construction turnover will be within larger cities, the lower bottom-up figure might be an underestimate. For the purpose of this study the average value of the bottom-up and top-down analyses has therefore been used. Furthermore, the distribution of vehicle types and mileage across large and small construction projects and different construction phases is not available.

Facilities

With respect to the primary data, it should be noted that facility logistics is one of the segments for which data about mileage driven and vehicles used is very limited. In particular, data on LCVs used in facility logistics are limited and vary widely depending on the methodology used (e.g. bottom-up or top-down). It is recommended to do more in-depth research into this segment for the next Annual Outlook. Data from several pilots (e.g. the facilities hub for the HvA Amsterdam and the facilities hub for the government buildings in The Hague) that are currently running might be promising to partly fill this gap.

References

ING, 2015
Stedelijke distributie in het winkellandschap van de toekomst, ING, 2015

CE Delft, 2016
De omvang van stadslogistiek, CE Delft, 2016

KPMG, 2016
Retail 2025, KPMG, 2016
https://assets.kpmg.com/content/dam/kpmg/pdf/2016/03/Retail-2025-19-1-2016.pdf

ING, 2014
Afval 2020 – Meer waarde uit minder afval, Assetvisie Afval, ING, 2014
www.ing.nl/media/ING_afval-2020-meer-waarde-uit-minder-afval-feb-14_tcm162-70205.pdf

Footnotes

1 City Logistics is defined as the last/first leg in a supply chain, between a warehouse/ distribution centre (DC) and an inner-city destination, including the transport within cities.

2 'De omvang van stadslogistiek', CE Delft, 2016. The variation is due largely to the difficulty of estimating the size of Construction logistics and Facility logistics.The estimated growth in GHG emissions over the coming decades (assuming no intervention or action to reduce emissions) is mainly in Parcels and express and Temperature-controlled.

3 The IRU report confirms the expectation of the potential of improved energy efficiency.

4 Serial Shipping Container Code, implemented in the GS1 standard.

5 ITF Transport Outlook 2017

6 The scope of City Logistics in this document is the last leg in a supply chain, for instance from a warehouse or distribution centre to the end-customer. The last leg may cross the geographical border of a city, as is currently the case for large retail. This last leg is not be taken literally but conceptually, as a literal definition would lead to artificial constructs.

7 More precisely, a factor 6 increase in the amount of goods transported per emitted kg of GHG by 2050: a drastic de-carbonization of transport. This Factor 6 is the average in the Netherlands for all logistic transport; in other countries the factor may be different.

8 There are exceptions where a transporter does mix them, but this is rare.

9 Tank-to-wheel (TTW): Direct emissions or tailpipe emissions from fuel combustion.

10 De omvang van stadslogistiek, CE Delft, 2016

11 The GHG reduction target for the transport sector is expected to be tightened to perhaps 80% or more by 2050.

12 Not to be confused with an exponential interpretation: reaching Factor 2 or level 200 in the graphs does not refer to 200% more efficient logistics or to a 50% reduction in the total CO2 emissions cuts to be achieved

13 Based on TNO (2017) 'Towards zero emission commercial road transport in urban areas'.

14 NEDC values, real-world values are measured as higher.

15 The IRU report http://www.citylogistics.info/strategy/iru-the-commercial-vehicle-of-the-future/ confirms the expectation of the potential of improved energy efficiency.

16 Although the business cases for the use of biofuel in aviation and shipping are not currently viable, the push for emissions reduction is expected to change this condition.

17 Real Driving Emissions.

18 Reactivity-controlled compression ignition.

19 V. Zeithaml et al., 1990, Delivering quality service, balancing customer perceptions and expectations, Free Press.

20 Companies are already testing new solutions, ranging from individual parcel boxes, click-and-collect offers, same-day delivery options, and even evening delivery services.

21 Customers expect generous return policies, as a large share of consumers (66%) reviews a retailer's return policy before ordering, and return a significant proportion of goods purchased (typically 30%), inducing significant return flows and accompanying vehicle movements (UPS, 2015).

22 www.nhvr.gov.au/road-access/access-management/intelligent-access-program Performance-based regulation by onboard systems, including real-time load weighing, is already being successfully applied in Australia.

23 See footnote 15.

24 The role of drones is seen as one of the zero-emission last-mile delivery systems. It remains to be seen if the total volume of goods transported by drones will become sizable.

25 Serial Shipping Container Code implemented in the GS1 standard.

26 Dutch version of Craigslist and Ebay.

27 Or to a hub where exchanges take place, as currently already practised in closed transport networks.

28 TVA consultants 'Precision Logistics': 50% reduction in travel, faster flow.

29 For instance Paris, London, Oslo, Barcelona

30 Most likely in GDZES cities.

31 Resulting in an approx. 50% reduction of GHG emissions (Besparingen voor vervoerders - de effecten van een nationale uitrol van het concept Binnenstadservice, TNO, 2009).

32 Marginal abatement cost curves for Heavy Duty Vehicles, CE Delft, 2012.

33 Options for competitive and sustainable logistics, TNO, 2014.

34 Some retailers have their own fleet.

35 Truck platooning: driving the future of transportation, TNO, February 2015.

36 Examples are Transmission or Netwerk Benelux and Distri-XL.

37 Large volume of movements with relatively little cargo.

38 'Überization' of transport: one example is the startup Quicargo.

39 Like HAACP requirements.

40 Electrical power for cooling supplied at specialized unloading locations in city centres, allowing for cooling without ICE engines running.

41 As opposed to pushing a time window that serves delivery efficiency.

42 Decoupling goods (parts and consumables) from the service person.

43 Government, education, large companies, etc.

44 Express delivery of parts and materials is cheaper than man-hours wasted.

45 Parcel and building-materials logistic networks, for instance

46 Payment per emptying of residual waste bin/container.

47 Note that there are no fresh and food goods in this category, nor parcel home deliveries. Home deliveries in this segment are usually characterized by their requiring a two-person distribution network, enabling heavy goods to be carried into homes.

48 Longer and / or heavier vehicles.

49 http://goederenhubs.nl/home

50 Autoriteit Consument & Markt (2016), Marktscan Pakketten - Eindrapport, p. 22.

51 The future of the last mile, Mc Kinsey, 2016.

52 www.innerstadengbg.se/innerstaden-goteborg/projekt/stadsleveransen/

53 EIB, 2017, Verwachtingen bouwproductie en werkgelegenheid 2017.

54 www.tno.nl/nl/over-tno/nieuws/2017/1/tno-laat-zien-dat-slimme-bouwlogistiek-in-de-praktijk-loont/

55 DBA Amsterdam, TNO 2014 R10228

56 Construction waste is considered in the chapter 'Construction'. Industrial waste is considered not to be within the scope of city logistics.

57 VANG-HHA programme.

58 E.g. for separation of plastics and metal.

59 In Dutch, 'omgekeerd ophalen'.

60 http://twinklemagazine.nl/achtergronden/2013/06/hoe-krijgen-we-de-last-mile-volledig-op-de-rails/index.xml

Colofon

Authors
Eelco den Boer (CE)
Rober Kok (TNO)
Walther Ploos van Amstel (Amsterdam University of Applied Sciences)
Hans Quak (TNO)
Herman Wagter (Connekt)

Disclaimer