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Department of Management and Production Engineering

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Master thesis

Future evolution of light commercial vehicles' market

Concept definition for 2025

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To my parents

1 Introduction

This work is focused on understanding the future evolution of light commercial vehicles' market; it contains the results of a number of specific analyses aimed at identifying actual and rising trends, customer needs and regulation development. In recent years internet, smartphones and connected services have been revolutionizing every aspect of our life, including the automotive sector. Moreover, the growing concern for sustainability and pollution is pushing governments worldwide to adopt stricter and stricter legislations to reduce vehicles' emissions and ban diesel and this, in turn, is forcing OEMs to focus on alternatives to traditional combustion engines. Connectivity and powertrain electrification are two phenomena already affirmed in passenger cars' market that are starting to influence also commercial vehicles' one. Many OEMs are considering adopting on their vans line-up the same infotainment as passenger vehicles, including, for example, connected navigation, digital clusters, vocal assistants with artificial intelligence, remote vehicle control and remote monitoring. Regarding electrification, in car market electrified vehicles such as Toyota Auris or Renault Zoe are gaining market share quarter by quarter and the same is happening for the few electric commercial vehicles available. Most manufacturers are making bold announcements that in the short term their line-up would be completely electrified, that they will drop diesel to offer only gasoline engines; they are presenting different concepts at every motor show, but the truth is that there is a multitude of different strategies that can be adopted to survive in an extremely competitive environment such as automotive, an industry that is expected to change profoundly in the next years for reducing pollutant emissions. For example, there are different possibilities to electrify a vehicle and none of them has emerged as a dominant design yet; every application has its own pros and cons and is suitable for a specific use case. Today every light commercial vehicle is offered by OEMs in many different heights and lengths either as a van or as a chassis cab that is converted by a specialized company afterwards, for example for refrigerated cargo spaces, ambulances and many other cases, but manufacturers do not offer directly on the market mission specific products. In a industry that has been based on diesel engines for many years, the paradigm shift in terms of powertrain creates an interesting opportunity for OEMs to propose something new, a differentiated product that can satisfy a specific use case and through which obtaining higher margins and market share.

2 Methodology and aim of the work

This work has been developed within Fiat Chrysler Automobiles and aims at supporting the process to define the next generation of light commercial vehicles for the European market. I worked in the team dedicated to electrified vehicles inside the "Product Planning and Institutional Relationship" area for eleven months during which I contributed to define an overview of the light commercial vehicles currently on the market, announced or rumoured, with particular attention to hybrid and electric ones. The main tasks I had were on one hand to continuously monitor and forecast market sales and, on the other, to define and monitor the implementation of features and contents specific for electrified vehicles. The first activity was mainly based on the critical evaluation and integration of periodical reports and databases provided by different external consulting companies such as Frost and Sullivan, McKinsey and Navigant Research; among them IHS Markit proved to be the most accurate in forecasting trends and volumes, therefore many figures and insights of this document are based on its data. The other part has been more complex involving activities like monitoring competitors' actual and announced vehicles contents, commissioning specific reports to consultants to investigate and foresee emerging trends, planning and organizing researches and surveys with customers. In such occasions were assessed both customer requirements and their evaluations about our ideas and contents. To support these two main activities, many other researches and studies had been necessary: to monitor the evolution of the legislative framework for vehicles' emissions, to observe powertrain technologies evolution, to consider local subsidies and tax incentives for green mobility solutions, to assess and forecast the development of the charging infrastructure.

All data present in this document, elaborated or not, are based either on reports commissioned to external consultants or on figures provided by FCA Competitive Intelligence and I was authorized to use them. Where a third party specific public accessible report was used, the reference is indicated in the dedicated chapter.

2.1 Structure

Starting with a quick list of definitions for terms that will be frequently used along this work, the focus than moves on the description of today's light commercial vehicle market, highlighting customer segmentation and the typical breakdown of the total cost of ownership for this type of vehicles. Following this, a whole chapter is dedicated to present the main trends that will influence the light commercial vehicle industry in the next years: smart cities, e-commerce, regulations and sustainability. Chapter six is about electrification alternatives and the development of the charging infrastructure, that is a fundamental requirement for the diffusion of rechargeable electric vehicles. Thereafter a section provides an overview about competitors' products followed by one analysing customers' perspective: interest in alternative fuels, habits, use cases and interest or suggestions for some specific features. The following chapter contains the definition of the concept for 2025: a differentiated product specifically designed for a selected mission profile. The last part quickly deals with the end of life of vehicles' batteries, that is one of the major concerns caused by the diffusion of electric vehicles.

3 Definitions

Here are provided some terms that will be frequently used along this document

3.1 Market segments

FCA classifies vehicles according to their size (A, B, C, D, E, G, H) and the body type they have (car, SUV, MPV, van), obtaining the following segmentation:

- **A** segment (A car): mini cars, city cars (Fiat Panda, Volkswagen Up)

  1A segment (A van): commercial vehicles derived from passenger car models (Fiat Panda Van). Usually they are not considered real commercial vehicles since they are not specifically designed for carrying materials.

- **B** segment (B car): small cars (Fiat Punto, Volkswagen Polo)

  I0 segment (B-SUV): small SUVs (Fiat 500X, Jeep Renegade)

  L0 segment (B-MPV): small multipurpose vehicles (Fiat 500L)

  1BS segment (B-van): small vans (Fiat Fiorino)

- **C** segment (C car): compact cars (Alfa Romeo Giulietta, Volkswagen Golf)

  I1 segment (C-SUV): compact SUV (Jeep Compass, Volkswagen Tiguan)

  L1 segment (C-MPV): compact MPV (BMW 2 series Active Tourer)

  1BL (C-van): compact vans (Fiat Doblò, Nissan NV-200)

- **D** segment (D-car): mid-size cars (Alfa Romeo Giulia, Audi A4)

  I2 segment (D-SUV): mid-size SUV (Alfa Romeo Stelvio, Jeep Cherokee)

  L2 segment (D-MPV): large MPVs (Ford S Max)

  2P segment (D-van): mid-size vans (Fiat Talento)

- **E** segment (E-car): large cars (Mercedes E-Class, Audi A6)

  I3 segment (E-SUV): large SUV (Audi Q7, Porsche Cayenne)

  2G segment (E-van): large vans/small light duty trucks (Fiat Ducato, Mercedes Sprinter)

- **G** segment (G-car): large luxury cars (Audi A8, Mercedes S-Class)
- **H** segment (H-car): high performance cars (Mercedes AMG GT, BMW Z4)

Due to the homogeneity of vehicles' dimensions and powertrains in 1BS and 1BL and the limited number of nameplates available, usually the four segments for light commercial vehicles are merged into three different ones: the “Compact” or 1B includes both 1BS and 1BL, the “Medium” segment represents the 2P and “Large” is another way to name 2G.

3.2 Technologies

An xEV is a vehicle with an electrified powertrain: in addition (or substitution) of the traditional internal combustion engines (ICE) and fuel tank they feature a lithium-ion battery and one or more electric motors. Today the main electrification technologies are the following:

BEV: battery electric vehicles. Pure electric cars and vans that are charged through a plug. No combustion engine on board.

REEV: range extender electric vehicles. The wheels are moved by an electric motor using the energy provided by a battery. There is also a traditional internal combustion engine that can only be used to charge the battery.

PHEV: plug-in hybrid electric vehicles. They have both a traditional engine and an electric motor that can move the vehicle, working separately or simultaneously. The battery can be charged through a plug.

HEV: hybrid electric vehicles. The combustion engine is paired with an electric motor that helps to reduce consumptions and increases power. According to the size of the electric motor and the battery, they can be classified as “Full-Hybrid” (HEV), “Mild-Hybrid” (MHEV) and “Micro-Hybrid” (mHEV), listed with decreasing electric power and battery capacity. For those vehicles, the battery can only be charged by the ICE or while braking.

FCEV: fuel cell electric vehicles. They use fuel cell technology to combine oxygen and hydrogen to create electricity that is stored in a battery and used to run an electric motor. This technology is still immature and has had only a few commercial applications. Its diffusion will require the development of a hydrogen infrastructure that is totally absent today and that will take a long time before being established. Therefore, this technology will not be taken into account for a 2025 concept.

Note that all the technologies listed above have the “regenerative braking”: the electric motor is set to work as a generator to slow down the vehicle and recover energy to recharge the battery while braking.

Figure 1 shows how the most common technologies differ according to the characteristics of the main electrification components: charging power, battery capacity and electric motor power and how those affect the driving experience.

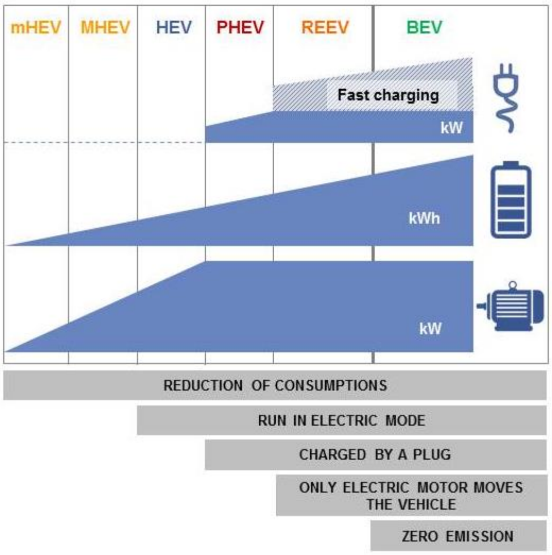

Figure 1 - Electrification Technologies

4 Light commercial vehicles market

Before launching a new vehicle, or in general a new product, it is crucial to understand its market by identifying customers' segments, understanding their expectations, defining typical use cases and analysing costs normally associated with that product. That is the aim of this chapter.

4.1 Definition of LCV

Light commercial vehicles, LCVs, are all those motor vehicles aimed at transporting goods or more than nine people, with body type "van" and a gross weight up until 3.5 ton. The first distinction we need to do is between vehicles aimed at transporting people (including recreational vehicles: campers) and these aimed at carrying goods. This work is focused on the second type. They range from the compact Volkswagen Caddy, developed on the same platform as Golf, to the large Iveco Daily that has its own dedicated one. Moreover, vans derived from passenger car models (1A segment) will not be taken into account for this work, because they are a re-adaptation of vehicles designed with a totally different scope.

4.2 Customer segmentation

LCVs' market can be segmented according to two main parameters: the type of ownership and the "mission" of vehicles.

4.2.1 By ownership

This criterion divides customers in two groups: fleets and private owners. The first category represents almost 70% [1] of sales every year and is characterized by the fact that in this case the customer is another company that purchases, usually, more than one vehicle to satisfy a specific need. For example, a construction company knows exactly the type of materials that have to be moved, the average daily mileage that must be covered, the number of passengers that will use the vehicle and the engine power needed to optimize the process. These parameters will be significantly different for a delivery company or for a business involved in maintenance of appliances. For medium and large fleets OEMs can provide dedicated service programs and specific vehicles' functions. Brand and model selection are based on how much a specific vehicle fits customer specific needs, reliability, safety and purchase and operational costs. Private owners pay attention to these parameters too, but, in addition, their decision process involves also other aspects: since usually they are directly involved with driving, design and comfort become important criteria to make the decision. These customers usually have a very limited number of vehicles that need to perform a range of different tasks, so flexibility is usually important.

4.2.2 By Mission

The mission of a vehicle is the specific role that it must fulfil. There are four main categories that can be identified for transporting goods, each characterized by peculiar needs and "routines". The main one is *"General haul"* and includes the transport of goods or tools as a non-core activity of an individual or a small enterprise; it represents almost

40% of large segment sales and even 65% of the compact one. The daily mileage is usually between 50 and 400 km a day and typical users are craftsmen, retail merchants, short term rentals and utilities, involving both services and municipalities. Another category, accounting for 25% of sales of the large segment and 16% of the compact one is "*Delivery*": professional freight logistics including post & urban delivery, food & beverage and thermo controlled or refrigerated vehicles. In this market segment the distance covered each working day ranges from 80 to 250 kilometres and daily routes are scheduled in advance. *"Construction"* represents up to 16% of large vans sales and around 10% of the compact one's. These vehicles are used to move construction materials and equipment from or to a jobsite and cover distances from 50 to 200 kilometres with heavy loads every working day. Finally, the last category is called *"Special equipment"* and includes all emergency, maintenance or special public vehicles that need to be specifically designed and adapted for their use. Those include, for example, ambulances, car recovery, waste collection and "autonomy" vehicles (such as the ones specifically adapted to carry a person in a wheelchair). Their weight on the market is very limited and the daily mileage per working day is usually up to 300 kilometres a day. An important point that needs to be stressed for all these groups is the high utilization rate they have: statistics say that the less used category is general haul, with an average of 200-250 working days a years, while the highest utilization rate is reached by delivery, with an average of 300 working days a year and peaks, for example for the food delivery sub segment, up to 360. Reliability is a critical aspect for an LCV. Figures 2 and 3 summarize respectively the market share of each mission in 2G and 1B segments (those represent the "extreme" cases, with 2P composition in between) and the range of daily distances usually covered.

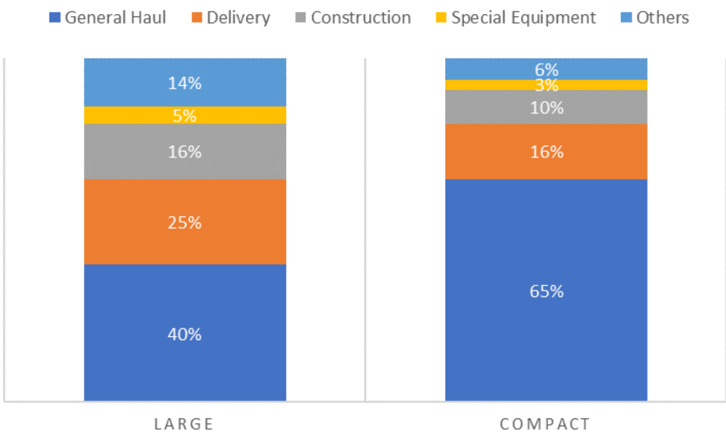

Figure 2 - Missions market share

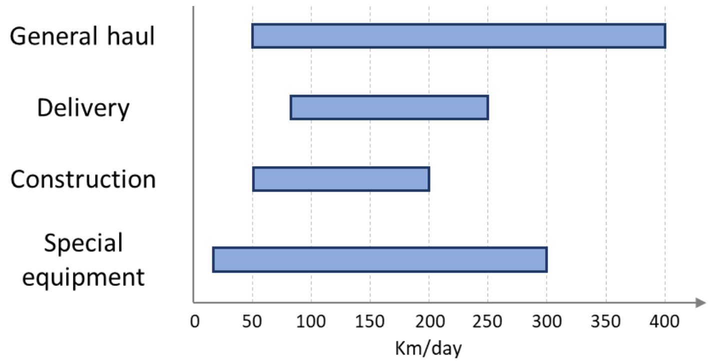

Figure 3 – Range of daily distances covered per mission

4.3 Operating costs

Usually a light commercial vehicle involves two different types of costs: the payroll for the driver and the total cost of ownership (TCO). The former one is more or less constant within each country since it depends on taxes and employment agreements. The other variety of cost includes all different costs and expenses sustained from the purchase to the re-sale or disposal of the vehicle; it may vary according to vans' daily mileage, their size, their expected useful life, their purchase price and their depreciation, their reliability and another long list of aspects. To simplify things, let's do two examples, one for the compact segment and one for the large one, using for the different parameters average real market values. We can consider a van that is purchased new, kept for four years and then sold. During this period, the vehicle is used 270 days a year and will cover 160,000 kilometres, around 150 each working day. TCO composition is shown in Figure 4; the components are depreciation, the loss due to the decrease of value of the van, utilization and acquisition taxes, cost of financing capital to buy and utilize the vehicle, insurance, fuel and maintenance expenses: service, wear and tyres.

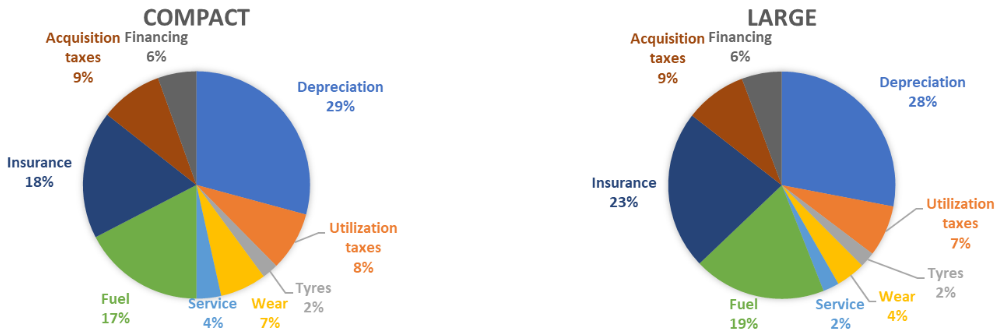

Figure 4 - TCO composition for a compact and a large LCV

As you can see, there is only a slight difference of composition between the two extreme segments, determined by the fact that 2G vans are considered more reliable than smaller ones. Increasing the mileage, fuel, service, wear, tyres and utilization taxes gain weight while the other components are industry and country dependant. Our researches show that not only large fleets owners, but also privates and small players are increasingly TCO-oriented when it comes to purchase one or more new vehicles; many OEMs provide online TCO calculator tools and the possibility to have detailed analysis reflecting the specific activity of their businesses. With reference to figure 4, the arch, moving clockwise, from depreciation to fuel includes all the voices on which OEMs should focus to reduce customers' costs and obtain a competitive advantage in a market where information about total costs of ownership is almost perfect.

5 Trends

Today everything changes much faster than it used to do. For example, it took around 60 months to sell, globally, the first million of BEVs (starting from 2011); the second million took 17 months and the third only 10; by 2019 is estimated that it will take only six months to sell a million of full electric vehicles worldwide [2]. Distances have been eliminated by internet, online services and logistics, making the world a single, huge market. Social media entered everyone's life influencing routines, allowing companies to better understand customers and spreading ideas. After a long period in which production rates have grown in many sectors without any limit, natural resources have been exploited without any foresight and environmental pollution has increased reaching dangerous harmful levels, concepts such as "sustainability" and "environmental friendly" are starting to spread, with national and local governments beginning to adopt specific regulations to reduce pollutants. Time to market is getting shorter and shorter in every industry, so new products are launched more frequently every year and, as a consequence, their useful life is getting shorter too. This fast-changing environment offers to companies both, opportunities and threats, it is up to them to create value from every new situation.

5.1 Macro Trends

Among all current global and local trends that are spreading worldwide shaping businesses, cultures and societies, three of them will profoundly influence light commercial vehicles' market: urbanisation, smart cities and e-commerce. They are described in the following paragraphs.

5.1.1 Urbanisation

According to the World Health Organization [3], in 2015 more than fifty-four percent of the global population lived in urban areas and the figure is projected to reach sixty percent by 2030 and sixty-eight in 2050. It was forty-seven percent in 2000. Growing global urbanisation has four main drivers [4]: developing-world industrialisation, environmental change, agricultural mechanisation and, the most important one, the growth of the global population. Today there are 7 billion people on our planet, but up to 11 billion are expected by 2050. Developed countries, searching for lower-cost production, increasingly source materials, products, components and services from the developing world. One industry attracts another, workers need products and services, thus building a virtuous cycle of development. The introduction of industrial agricultural techniques in emerging countries, requiring fewer but highly skilled workers, stimulates large numbers of rural people to seek livelihoods in towns and cities. This phenomenon is reinforced by environmental degradation in rural areas and societies with a direct dependency on local natural resources like forests, fisheries and freshwater. Currently urban areas generate around 80% of world gross domestic product, being responsible for 60% to 80% of energy usage and resource consumption and more than half of anthropogenic CO_2 emissions [4]. Urban areas with over ten million people are classified as "megacities"; today there are 33 worldwide and they will become 43 by 2030 [5]. The high concentration of people and economic activities in urban areas determines huge environmental pressures that need to be mitigated by planning, managing and governing cities in an increasingly efficient way.

5.1.2 Smart Cities

Traffic congestion, pollution and increasing social inequality are only some of the negative effects generated by the rapid growth faced by several cities [6]. In this context, a debate has emerged on the way new technology-based solutions, as well as new approaches to urban planning and living, can assure future viability and prosperity in metropolitan areas [7]. *"Urban metabolism"* refers to the flows necessary to satisfy the needs of those living in cities; *"Grey infrastructure"*, such as roads, metros, railways, buildings and utilities, determines a city's layout. Such infrastructures include energy and water supply, waste management, housing and transport systems and require constant maintenance, planning and developments to avoid overuse of resources and energy wastes; *"Green infrastructure"* idea involves parks, tree-line streets and green areas to provide social, ecological and economic benefits to the urban population such as air filtration, temperature regulation, flood protection, noise reduction and recreational areas [8]. In this context the most common, and often misused, term we hear nowadays is "Smart City". Such term indicates the concept of a healthier, greener, denser and more efficient urban environment that can be seen as the convergence of "technology" and "city"; the use of smart technologies and services, that often rely on information and communication technology, helps local governments and society to make a better use of their resources. For example, monitoring traffic and security cameras, parking spaces, sewers, schools' thermostats, public transportation utilization and energy requirements provides data for better planning and decision making. Despite that, the deployment of ICT should not be identified with the concept of Smart City itself, since smart initiatives do not only entail technology changes, but also investments in human capital and innovations in urban living practices and conditions [9]. One of the key aspects of this transformation is to redefine urban mobility: air pollution, noise, traffic congestion and availability of parking spaces are worsening with the growth of urban population; the idea that everyone should have his own car is no longer sustainable. The main trends influencing urban mobility are: shared mobility, for example car-sharing, car-pooling and free floating bike and moped sharing as a substitute of public transportation network and private vehicles; autonomous driving, it will increase safety and expand access to mobility to elder or impaired people; vehicles electrification will on one hand decrease noise and pollution, but, on the other, increase electricity consumption and require the implementation of a dedicated charging infrastructure; connectivity and the internet of things will generate data with a wide variety of uses: from facilitating trip planning and guide driverless vehicles based on real-time conditions to analyse flows of people and vehicles helping transport authorities to identify bottlenecks, adjust services, and make long-term transit plans.

Even though each city is a "per se" reality with specific needs, problems and opportunities, national and local governments must create incentives, define regulations and promote projects to guide the development of cities towards the smart-city concept, reducing their environmental impact and improving the life quality of their inhabitants.

5.1.3 e-commerce

Another challenge that cities have to face and consider while planning urban mobility is e-commerce. According to "Statista" [10], in 2017 it represented 10.2% of total retail sales worldwide and it is forecasted to grow until 17.5% by 2021. These figures would be much higher if considering only Europe, Nord America, China and Japan. Amazon, that currently accounts for 37% [11] of online sales, recently introduced the "same day delivery" service in more than 8,000 cities worldwide and even "2-hours delivery" and "1-hour delivery" services in dense metropolitan areas. This will foster sales of categories typically not sold online and expand the range of possible customers, furtherly boosting e-commerce growth. Therefore, in addition to cars, taxis, ubers, buses and motorcycles, also the number of delivery vans running around cities will grow higher and higher, worsening the already polluted and congested urban environment. To better understand the impact that LCV have on pollution (specifically, NO_X emissions), Figure 5 provides a snapshot on what happens in London today. If e-commerce really grows as it is expected to do and OEMs will not provide an alternative to ICE vans, the situation will soon become unbearable.

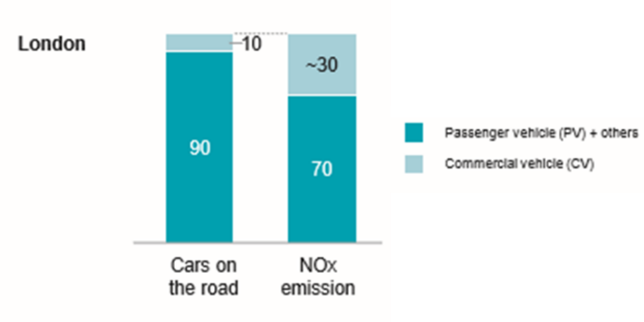

Figure 5 - Snapshot on LCVs pollution

E-commerce logistic process involves inefficiencies: products are no longer bundled in a freight vehicle and sent to a shop, but customers buy products (often only a single one) that are delivered at home by a delivery company. Every online retailer has its own courier service, so buying two different products from two different websites means two different vans delivering at your place, even if the same day or simultaneously. In addition to this, many times (more than 1 out of 10 in UK during 2016) the first delivery attempt fails because no one is at home and the courier needs to return to your home later or the following day. Yet another problem is reverse logistic: in most countries more than half of online shoppers have returned at least one online purchase [12]; for some categories return rates exceed 30% [13]. All these aspects will determine a significant growth of the average delivery fleet size with visible impacts forecasted for 2020 in Europe. Local governments need to incentive the transition towards efficient, economic and environmentally friendly ways of delivering in order to reduce pollution and traffic, allowing a sustainable development for urban environments.

5.2 Regulations

In every market, usually, technology evolves because of two opposite forces: customers' pull and regulatory push. If customers are willing to pay a higher price for a product featuring an innovative technology, then firms compete to bring it to the market and gain a competitive advantage over competitors. When the change involves significant investments in research and development and does not create additional value to customers, but increases society's welfare, as in the case of reducing vehicles' pollution, governments usually intervene establishing incentives, taxes and penalties to force the technology shift. To reduce urban pollution and greenhouse gases emissions, regulation is evolving under three distinct aspects: CO_2 fleet limits, closure of city centres to polluting vehicles and diesel bans. The aim of such initiatives is to incentive electrification.

5.2.1 CO_2 targets

Road transports contribute for about 23% to CO_2 global emissions. To reduce this impact, many countries are setting thresholds for OEMs limiting the average CO_2 value, considering also the mass, of the fleet they sell within a year. Exceeding this value means paying a penalty based on both, the excess CO_2 amount and the total number of vehicles sold during that year. To provide a simplified example that can give an idea about the magnitude of these fines, if in Europe an OEM selling one million vehicles a year has a yearly average of g CO_2/km for the fleet exceeding the threshold by 1,5 grams, the fine will be calculated as 95€/g x 1.5g x 1,000,000 vehicles, resulting in 142.5M€. The general trend for those limits in the main countries worldwide can be seen in Figure 6 and 7.

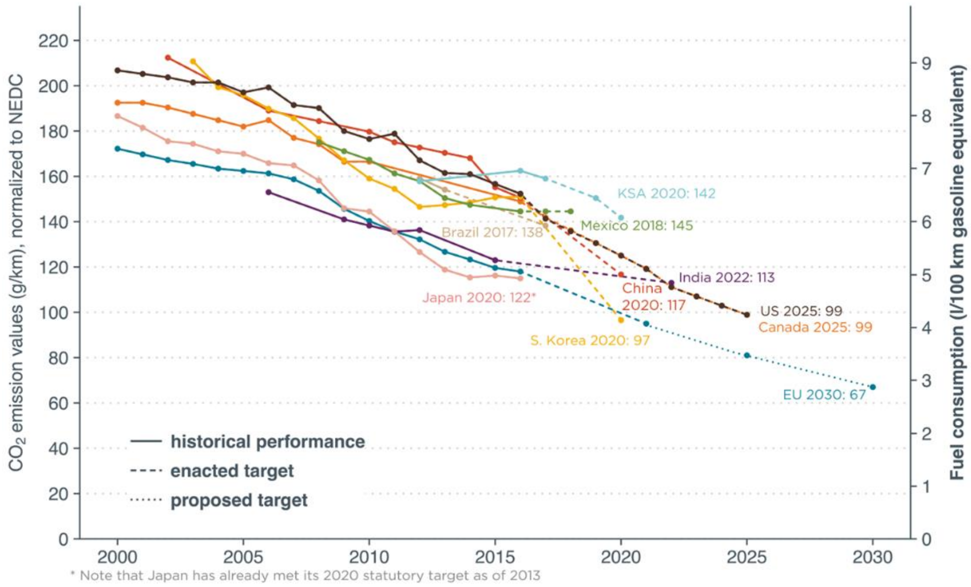

Figure 6 – Passenger car CO_2 fleet limits' trend by country

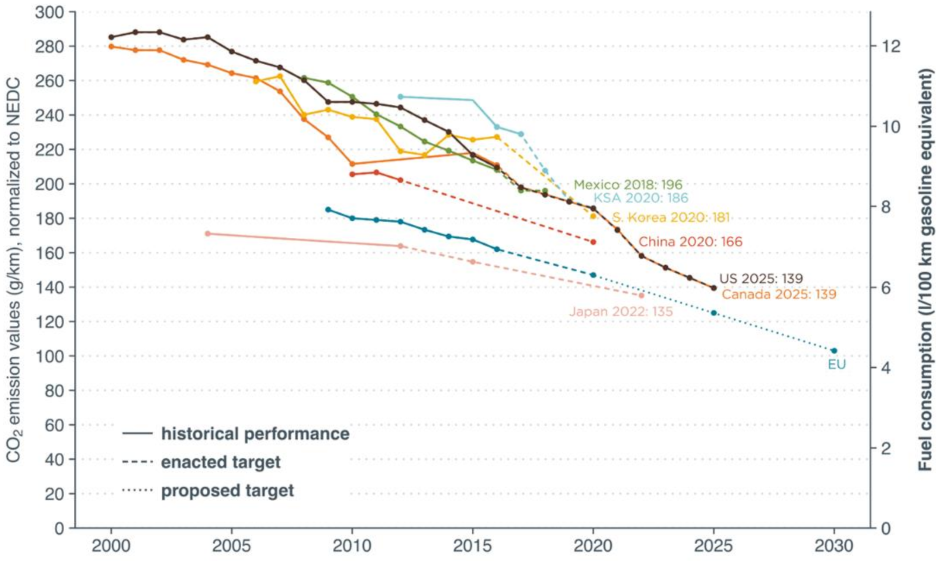

Figure 7 - LCV CO2 fleet limits' trend by country

Keeping the focus on Europe, the current target set for passenger cars' fleets is 130g CO_2 / km and will be reduced to 95g CO_2 / km from 2020. For light commercial vehicles, today the threshold is set to 175g CO_2 / km and will become 147g CO_2 / km from 2021. Moreover, EU government has defined new standards to be progressively introduced for engines to limit pollutants and a new homologation cycle to determine the emission level of a vehicle, the Worldwide harmonized Light vehicles Test Procedure or WLTP. This last one, if compared to the current procedure (the New European Driving Cycle, NEDC) provides more realistic results. A proposal from the European Parliament presented in November 2017 aims to set 2030 targets to be 30% lower compared to 2020/21 ones. If such legislation will be approved, for OEMs will not be enough to develop and commercialize hybrids as they are doing to achieve 2020-2021 targets anymore, the switch to BEVs will be inevitable.

5.2.2 *City centres*

Other initiatives to reduce traffic pollution in urban environments concerns the creation of access regulation schemes, low- and ultra low emission zones (LEZ/ULEZ): areas where circulation of most polluting vehicles is regulated with a mechanism based on their homologation emission category. Some classes, usually the oldest and most polluting ones, could be completely forbidden to access such areas permanently or during certain periods, while others may pay a fee, sometimes proportional to their emission level, to enter the zone for a given amount of time. In addition to this, a “congestion charge” can be asked: two examples are London and Milan. In both cases there are discounts or exemptions for hybrid, electric and alternative fuel vehicles. The number of such areas is becoming higher and higher throughout Europe and the trend is set to continue through 2020-2025, stimulating demand for city vans with hybrid or electric powertrain. These initiatives are promoted by the European government as an efficient instrument to reduce congestion and pollution and at the same time generating revenues for local budgets. In addition to that, many local administrations already announced the introduction of Zero Emission Zones (ZEZ) in city centres within the next few years: for example, private ICE cars will be forbidden in Oslo from 2019 and in Madrid from 2020 (see Figure 8 for a more exhaustive list). Other initiatives are being locally discussed and implemented: from windscreen stickers to easily identify vehicles’ emission category to higher parking fees for more polluting ones. Driving an xEV will be essential to access city centres, even in the short term.

5.2.3 Diesel bans

In addition to CO_2, combustion engines, especially diesel ones, produce also other substances such as nitrogen oxides (NO_X) and particulates that have been directly linked to human health issues. In recent years, many medical studies have been conducted and the awareness on this topic grew significantly, leading both local and national governments to announce diesel vehicles’ bans to start within a few years in many cities and countries worldwide. These initiatives have been rumoured and discussed for some years now and have determined a significant decrease in diesel’s market share for passenger cars and small vans belonging to 1B segment. While on the surface these prohibitions seem harsh (diesel is the dominant fuel in the European market), they provide the industry with enough time to plan the transition to EVs: with bans in the largest markets not starting before 2030 and some not until 2040, car manufacturers have been given enough time to switch over their current research and development budgets to electrification, retool their production plants for xEVs, and launch more electrified models. The transition will be particularly challenging in light commercial vehicles’ market, where diesel share on new sales was more than 95% in the first half of 2018, when gasoline powered vehicles accounted for the 2,8%

and electrified ones were only 1.1% of registrations; a disruptive change is needed. Figure 8 summarizes recent announcements about diesel and ICE bans.

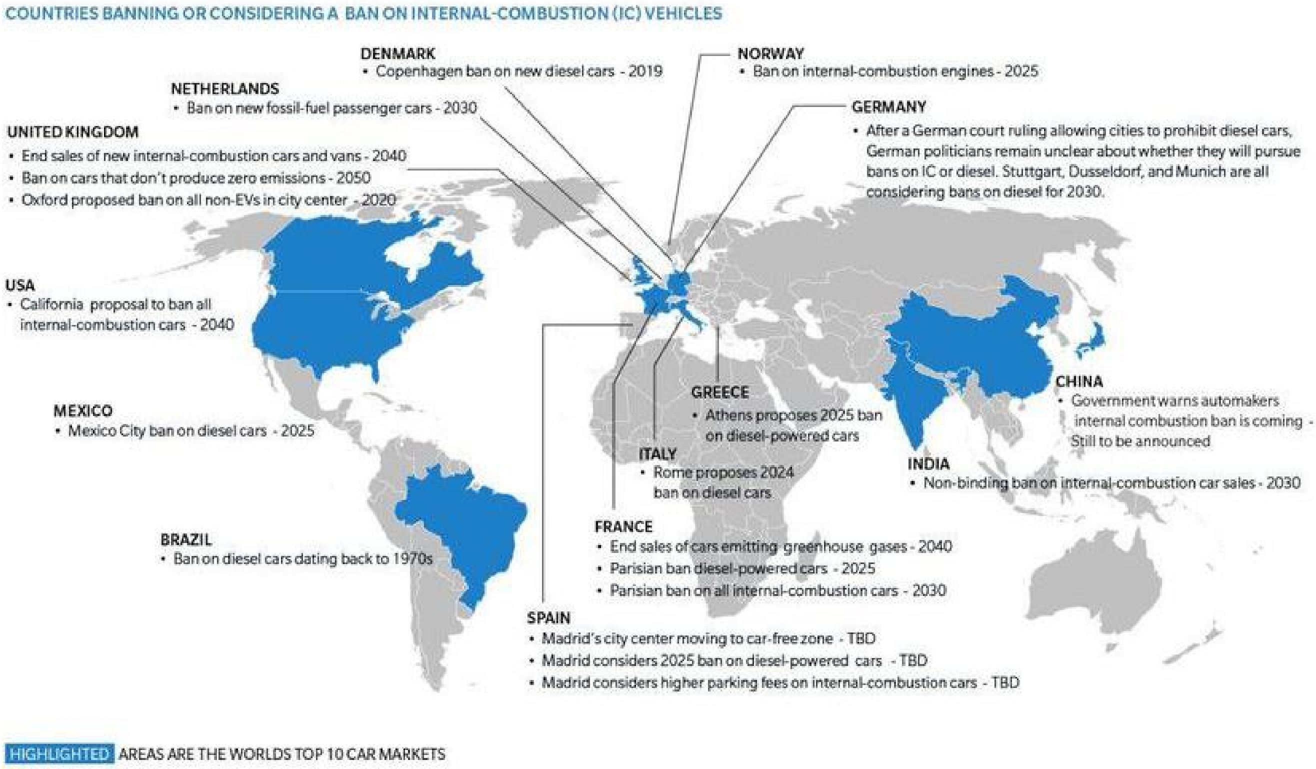

Figure 8 - Limitations announced for ICEs

5.3 Sustainability

In recent years sustainability is becoming increasingly important for customers. A study performed by Unilever in 2017 outlined that one third of customers are now buying from brands based on their social and environmental impact; this attitude is more relevant in emerging countries such as India, Brazil and Turkey; Keith Weed, Unilever's Chief Marketing and Communications Officer says [14]:

> "This research confirms that sustainability isn't a nice-to-have for businesses. In fact, it has become an imperative. To succeed globally, and especially in emerging economies across Asia, Africa and Latin America, brands should go beyond traditional focus areas like product performance and affordability. Instead, they must act quickly to prove their social and environmental credentials and show consumers they can

be trusted with the future of the planet and communities, as well as their own bottom lines."

Due to this growing environmental awareness, companies are starting sustainable initiatives in order to measure and reduce their ecological footprint and meet customers' demand. An article published by Bain & Company [15] highlights that 81% of the 297 global companies interviewed said that "sustainability is more important to their business today than it was five years ago, and 85% believe that it will be even more important in five years"; today over two-thirds of companies' core mission statements include sustainability. This approach represents an opportunity, especially for first movers: according to current estimates, meeting the UN's Sustainable Development Goals [16a] could generate $12 trillion in business savings and revenue, and create 380 million jobs, by 2030 [16b]. The automotive industry, having a profound impact on the human and natural environment, plays a significant role in social and environmental development in a sustainability context [17]. OEMs must introduce in their line-ups efficient and low emission vehicles, both to respond to customers' demand and to promote the green image of their brands.

6 Electrification

Until some years ago, in the automotive industry "The Core competence" was designing internal combustion engines. Some OEMs were able to do it and used this capability to create partnership, alliances and obtain a competitive advantage. Today the whole industry is facing a huge challenge in order to satisfy new emission standards, urban and local traffic limitations and customers' request for sustainability. Improving the efficiency of current traditional combustion engines will lead to very limited benefits: an optimistic estimate is a 2-3% emission reduction in the next five years or so. Note that gasoline engines emit more grams of CO_2 each kilometre than diesel ones, so diesel bans' impact will furtherly turn away OEMs from compliance's CO_2 emission targets. To overcome the physical limits of ICEs there is the need for a change in technology and, today, there are only two alternatives: FCEVs or xEVs. Fuel cell vehicles will produce zero emission but, nowadays there are still too many barriers to their adoption: the technology still needs to mature and costs for establishing a hydrogen infrastructure would be huge. In addition to the development of a completely new network of hydrogen stations to refuel, new plants to “create” and stock hydrogen must be designed and built too. Electrification can reduce, or completely eliminate, vehicles’ emissions with the application of mature technologies and the charging infrastructure can rely on the existing electricity network: this on one hand will speed up the diffusion of charging stations and on the other allow owners of rechargeable vehicles to recharge at home or at the workplace. So, the easiest and fastest way to meet all environmental, regulatory and customer requirements is electrification and, since the equation to determine the CO_2 level for every OEM’s fleet sold allows only “partially” heavier vehicles to pollute more, to start from large SUVs and light commercial vehicles is a must. In this chapter are presented all the different alternative electrification technologies and an overview about tax incentives and subsidies for xEVs in Europe. The last paragraph provides some figures about the development of a charging infrastructure and the related costs.

6.1 Available technologies

As we have seen in the definition section, the main xEVs’ technologies differ by the size of electric components and provide different driving experiences. Each application is particularly suitable for a specific use case and at this point strengths and weaknesses for each one must be discussed. BEV vehicles are the greener ones: they do not directly produce any pollutant and, considering that the average price is very high compared to traditional cars or vans, many European countries provide discounts and tax incentives for this kind of vehicles. The drawback here is that nowadays the range is still limited and, moreover, in many areas the charging infrastructure needed is not developed enough yet. Because of these reasons, full electric vehicles diffusion is still limited, both in terms of nameplates and sales volumes. To overcome the limitations, other alternatives have been developed. Range extenders (REEV) add to a BEV vehicle a small combustion engine that can only recharge the battery in case of emergency; it is not directly linked to the wheels or axles. This approach allows to overcome “range anxiety” and solves the problem of travelling across areas without a charging infrastructure. Compared to BEV vehicles, REEVs are way less efficient: they are heavier since they have also an ICE on board with all the related technology and the high number of energy conversions – from fuel to motion, from motion to electricity that is stored in the battery and then from electricity to motion again - determine many energy losses. For this type of vehicles, the daily use scenario should be the one of BEV vehicles, with the use of the combustion engine to charge the battery only occasionally. Hybrids provide a CO_2 advantage too, so in many countries, also this category is subject to tax discounts and local incentives. Let's start from plug in electric vehicles. These are mainly powered by a traditional engine but are also equipped with a battery, rechargeable through a plug, and one or more electric motors large enough to allow the vehicle to run in electric mode for up to 50 kilometres of range. This application could be particularly suitable for people that usually commute in the city where they can run with zero emissions, giving also the possibility to reduce consumptions in "hybrid mode" when running with the traditional engine during a long trip. The main drawback of this technology is the high cost and the weight of a full-size ICE, full size electric motors and a heavy battery. Full HEVs have smaller batteries and usually can run in electric mode only for a few kilometres and up to a very limited speed (usually from 30km/h to 60km/h). Compared to PHEVs, these vehicles are lighter and cheaper. The main purpose of this technology is the reduction of consumptions. The last two categories are mild hybrids (MHEV) and micro hybrids (mHEV). The first usually have a 48V battery while the second have a 12V battery; in both cases the additional technology is very light and easy to be developed: usually it can be installed on ICE even if they are not specifically designed. Therefore, even if these technologies do not allow to run without using the combustion engine and determine only a slight reduction of emission, their main advantage is that they can be embedded in vehicles customers already know. All these types of xEVs have the so called "regenerative braking" that allows the car or van to recharge the battery using the electric motor as a generator while coasting, simulating the combustion engines' brake; that's the only option that HEVs, MHEVs and mHEVs have to store electricity; as mentioned, BEVs, REEVs and PHEVs can be charged through a plug. The direct proportionality between benefits in term of CO_2 emission (that is directly linked to fuel consumption) and additional cost is shown in figure 9:

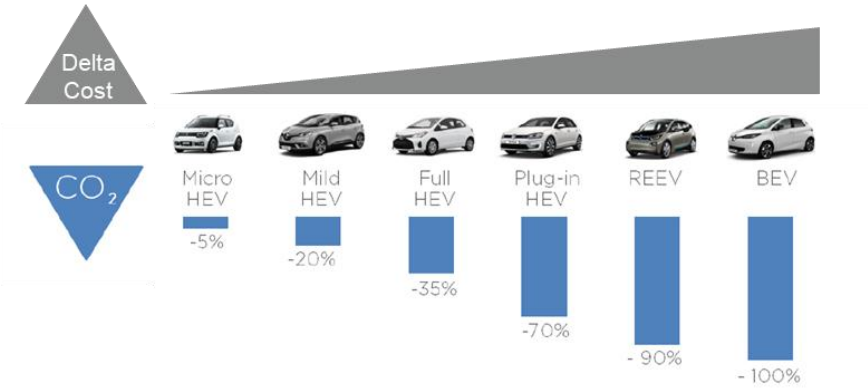

Figure 9 - Cost and CO2 for xEVs technologies

6.2 Tax incentives & TCO

Introducing regulatory constraints to force OEMs to electrify their vehicles is only one aspect of governments' intervention. When a new technology enters a market, usually it has higher costs than incumbent products so, to stimulate adoption, administrations can introduce benefits and tax breaks. For xEV adopters these incentives involve subsides for the initial purchase and tax reductions both on the initial expenditure and on annual ownership charges. Figure 10 provides some examples of such benefit available in Europe in 2017 both for passenger cars and for vans.

Purchase grant (one time)	Ownership tax (annual)	Company car tax (annual)
€4.000 grant	No tax at all	120% deductible
< €10.000 grant	50% or 100% discount	No tax at all
£4,500 grant	No tax at all	9% instead of 17%
€4,000 grant	No tax at all	< €8.000 discount
No VAT on purchase	NOK 455 instead of NOK 2.820	50% discount
No purchase tax	No tax at all	4% instead of 22%

Figure 10 - xEV subsidies and tax incentives

Additional monetary savings are determined by the exemption from parking fees, access tolls to city centres and Low- / Ultra low emission zones. Another aspect that must be considered while purchasing a new van is that electrification creates savings also in terms of operating cost: in Europe during the second half of 2017 the average price for diesel was 1.18€/l and for gasoline 1.27€/l, while in the same period the average cost of electricity was only 0.2€/kWh. Considering these figures, a numerical example has been made based on the NV200, that is a Compact van by Nissan that can be purchased with three different powertrains: BEV, diesel and gasoline, all featuring the same power (110hp) and the same dimensions. Results are presented in Figure 11: refuelling the diesel version after driving for 100km costs over 60% more than the electricity needed to charge the BEV and cover the same distance. The gap gets even wider for the gasoline powered engine: about 146% more. Unfortunately, there are not hybrid light commercial vehicles on the market up to date, so a direct comparison with those technologies is not possible; let's only remark that the decrease in CO_2 emission they provide is proportional to fuel savings.

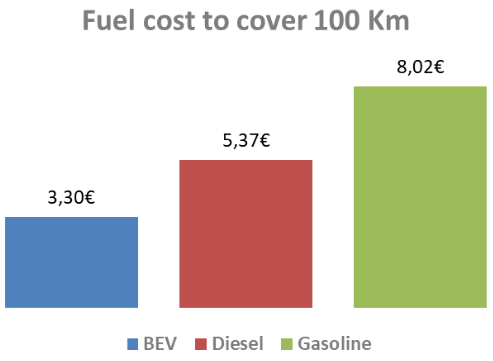

Figure 11 - Fuel costs based on NV200 (110hp) consumptions, average EU prices (2nd half 2017)

For BEVs, additional savings are determined by the high reliability of electric motors: they are simpler and involve significantly fewer moving parts than combustion engines, so require lower service and maintenance expenditures and reduce the probability of failures, increasing the uptime of the vehicle.

6.3 Charging infrastructure

One of the key aspects for the diffusion and the optimal use of BEVs, REEVs and PHEVs is the availability of a widespread charging infrastructure. The first action that comes to mind is the actual deployment of charging spots in parking places, private houses, shopping centres and along the highways, but this is not the only aspect that requires attention. Standards must be defined to avoid the need of a redundant infrastructure and reduce costs, determining a better extensiveness of the network at the same time. Another aspect to be taken into account is that, to allow the transition to rechargeable vehicles, the increase of the installed energy capacity is crucial and this, according to many people, should be satisfied with renewable sources not to frustrate the environmental advantages provided by electric vehicles. These are the topics for this paragraph.

6.3.1 Classification

Charging infrastructure can be classified according to two different principles and it is necessary to underline that the development of each category is equally important. The first criterion is the location of the charging station and the second is its power. According to the positional principle you can distinguish among public, semi-public and private charging spots. The first category includes all the ports that are located in places accessible 24/7 for free by anyone; a fee or a subscription may still be required to charge. Some examples are rest stations along the highways and parking spaces along the streets in the city. Semi-public areas are still accessible by anyone but are somehow restricted: they belong to shopping centres, hotels, restaurants, commercial activities or shops. These two main categories can be furtherly divided by the energy power they deliver: the first group, “Normal Chargers”, deliver up to 22kW with alternate current, while “Fast Chargers” range usually from 50 to 350kW with direct current. Domestic charging ports are located in homes, private areas or garages. They can be divided in two groups: specifically designed sockets that deliver up to 3,5kW of power and, compared to traditional sockets for appliances, feature some additional safety mechanisms and may include a load management software. The other group includes wallboxes, devices that usually can deliver up to 11kW of alternate current and include dedicated load management software and protection devices. Figure 12 provides an example and a recap of charging alternatives.

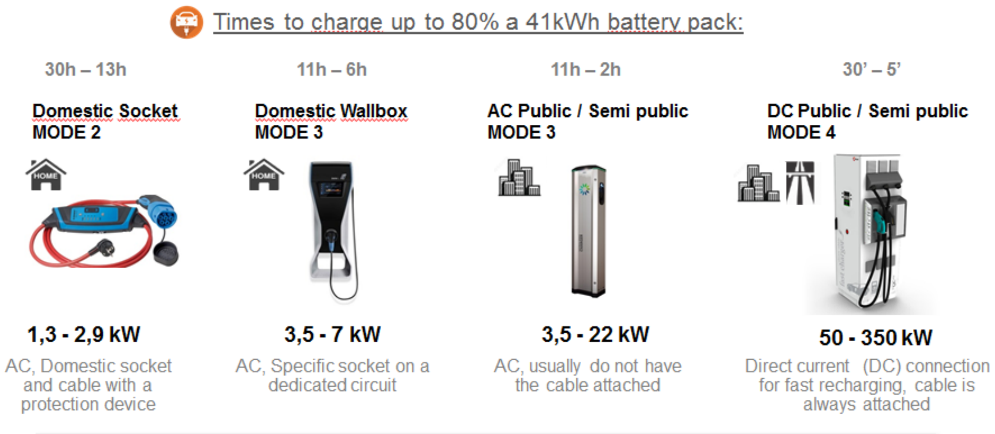

Figure 12 - Charging stations classification

To apply the charging times from the example to real life applications, both the Renault Zoe and the new Nissan eNV200 have a battery capacity close to the one cited in picture 12 and, for the passenger car, the declared range is 400km NEDC while for the van it is 275km NEDC. For PHEVs, that usually mount significantly smaller batteries, usually AC power up to 22kw (so mode 2 and 3) is enough to charge the vehicle quickly without sustaining the additional expenses related to fast charging. Among many varieties of available plugs to connect vehicles to the power grid, different standards have been set worldwide, usually one for each Region; for instance, Europe follows "type 2" standard for charging sockets while US and Japan adopted "type 1". If the proposed concept will be a rechargeable vehicle sold not only in Europe but also in other regions, it must be designed to be flexible and locally compatible with all different standards or an adapter must be provided. Figure 13 represents type 1 and type 2 sockets.

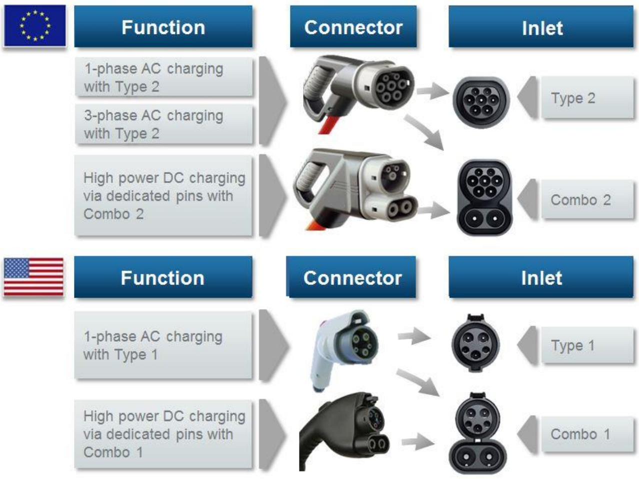

Figure 13 - Type 1 and 2 standards

6.3.2 *Deployment*

The European Alternative Fuel Observatory [18] counted, back in 2013, around 30,000 public charging station installed in Europe. This number grew up to over 130,000 by the end of 2017 and has overcome 150.000 by August 2018. An actual number for domestic and semi-public charging points installed is difficult to determine, but forecast foreseen a significant growth for each category. According to IHS, by 2024 there will be nearly 6.6 million of domestic charging ports, around 3.2 million of semi-public and over 2.1 million of public ones. This growth is pushed by local governments that dedicate specific budget amounts to fund the installation of private charging points: for example, up to 75% of the cost in United Kingdom and 60% in Germany. Considering that every company that will adopt rechargeable vehicles in its fleet will need to install some dedicated charging points, these subsides are particularly relevant. On the other hand, public and semi-public installations are supported with governments' direct funding or specific tax reductions: for instance, the French government grants tax credits on a number of energy efficiency and renewable energy measures, including the installation of charging equipment. Domestic and semi-public charging spots installations are boosted by European and local legislations:

- *Europe*: Procedure 2016/0381/COD: proposal for a Directive of the European Parliament and of the Council on the energy performance of buildings: new residential building, and those undergoing major renovation, with over 10 parking spaces will have to guarantee pre-cabling for electric vehicles recharging for every parking space by 2025. Non-residential buildings will need 10% of parking spaces equipped with recharging facilities by 2025

- *France*: 50-75% of parking bays in any new or renovated residential building must be pre-installed with conduits that allow the easy installation of EVSE* ranging between 7 kW and 22 kW
- *Italy*: from 2018 all new or refurbished non-residential buildings with at least 500 square meters and residential buildings with at least 10 units will have to be prepared to install EV charging stations in at least 20% of available spots.

In Figure 14 there is, where available, the comparison of IHS forecasts about cumulated charging stations in Europe with the ones provided by Frost & Sullivan and Navigant Research. Please note that, except for domestic ones, each charging station is considered to have two different charging spots.

Figure 14 - Charging infrastructure forecast (EU)

Such extensiveness of the infrastructure is fundamental to permit all the possible use cases that a light commercial vehicle can have: a quick refuel can be needed during the lunch break, many drivers use to bring the vehicle at home during the night and would need to charge it there, fast charging on the road can be necessary if night delivery shifts will be introduced in parallel with daily one. The presence of an extensive charging network has also been proved fundamental to overcome drivers' range anxiety.

6.3.3 Investments needed

According to the European Alternative Fuels Infrastructure Directive [19], a ratio of a maximum of 10 PEVs per public charging point is recommended to guarantee a good diffusion and a proper daily usage of plug-in vehicles. Considering IHS' forecast about xEVs' diffusion, the car parc that will need to be recharged at 2024 has been calculated as sum of BEVs, REEVs and PHEVs sales, both passenger cars and light commercial vehicles, for a timeframe of 7 years, starting 2018. This figure, together with the forecast about the availability of charging infrastructure means about 1.3 plug-in vehicles for each domestic charging port and around 8 for each public charging station. Therefore, we can say that the estimate provided for the charging infrastructure could be considered realistic and adequate. Charging infrastructure expansion is driven by tangible governments subsides and public investments, therefore its deployment is a highly competitive market with a number of start-ups, utility companies, automotive suppliers and OEMs, software and hi-tech players. Let's now consider the actual deployment cost. On average a domestic charging port costs 1,000€, a public or semi-public AC one costs around 3,000€ and a DC one 35,000€, this means that the total cost for deploying the forecasted infrastructure from 2018 until 2024 could be estimated in about 8 billion euros. Figure 15 provides the yearly detail of such expenditure.

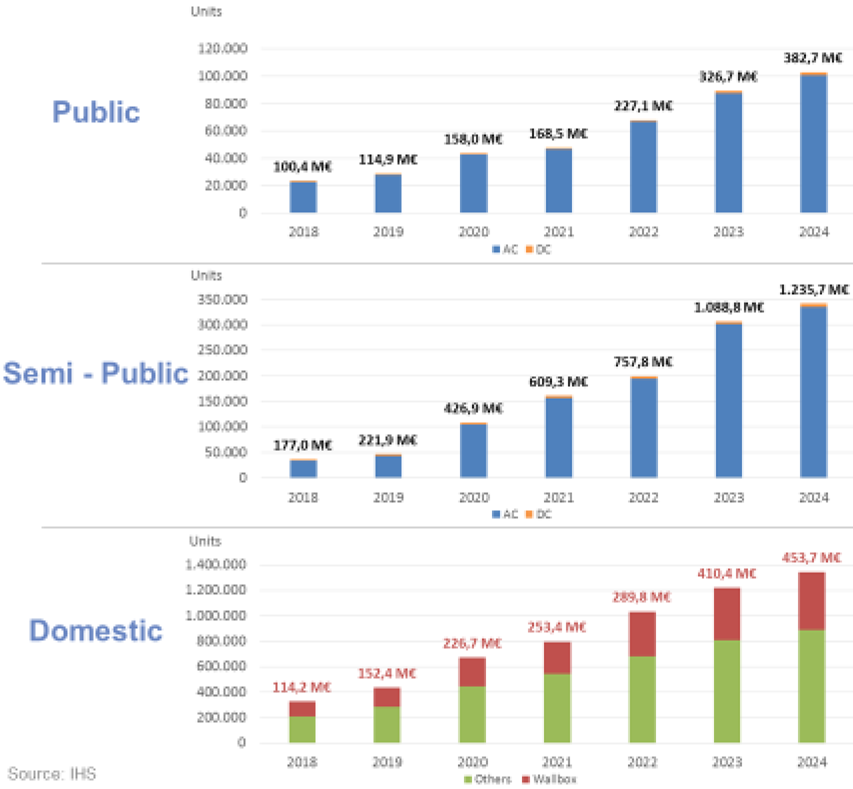

Figure 15 - Charging infrastructure's development cost

6.3.4 *Installed power & related costs*

Many consider switching from an ICE vehicle to a BEV like shifting emissions from an exhaust pipe to a power plant, but this is not exactly true: how green your electric car or van is, depends on where you are plugging it in: power grids use a variety of energy sources – fossil fuels, solar, hydroelectric, wind, nuclear, tidal – and the mix depends by the specific country or region. Figure 16 provides some examples for main countries worldwide.

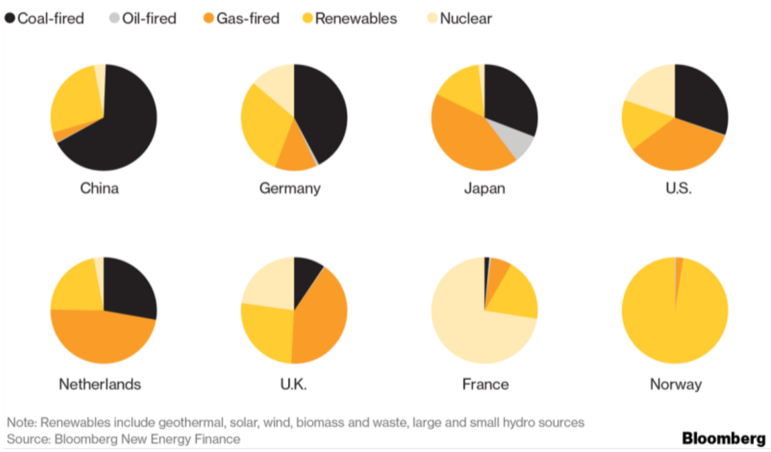

Figure 16 - Electricity production mix

Based on these mixes, Bloomberg has calculated the average CO_2 emission for an electric vehicle and compared it with the one of a conventional gasoline vehicle (Figure 17). The result is that, even in a market like China that relies for nearly two-thirds on emission intensive coal to produce electricity, a BEV vehicle produces less CO_2 per mile if compared to a traditional gasoline one.

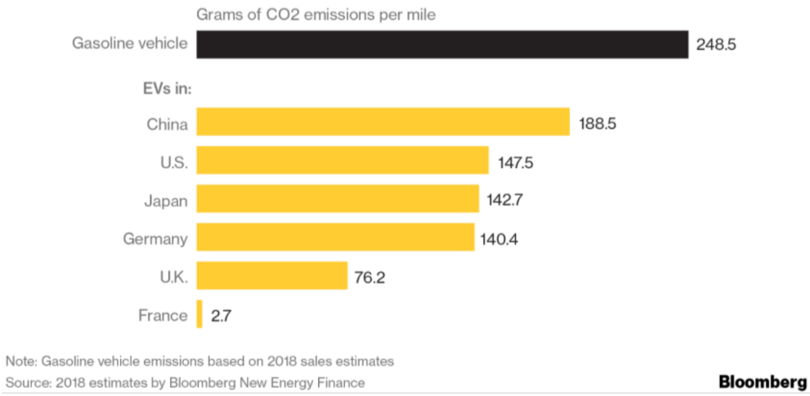

Figure 17 - Average CO_2 emission

Considering that wind and solar power keep taking a bigger and bigger share of the world's energy mix, electric vehicles will get cleaner and cleaner (Figure 18).

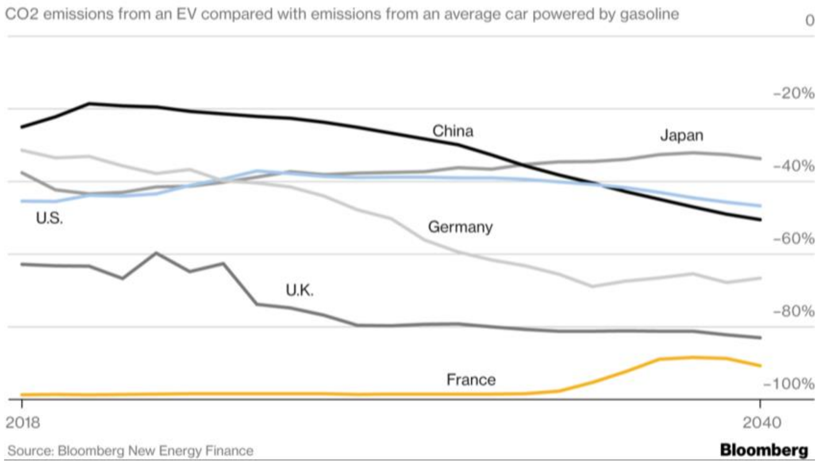

Figure 18 - Forecasted CO_2 emission trend for BEVs

Having cleared that, independently from the sources used to create electricity, not only hybrids' but also BEVs' CO_2 impact is lower than the one of conventional vehicles, let's analyse the investments needed to cover the additional energy request due to recharging BEVs, REEVs and PHEVs. Theoretically, in absence of storage systems and in the worst case, the installed capacity must equal the total maximum output that the grid can deliver. Considering infrastructure's forecast mentioned in the previous paragraphs, its deployment means an additional power capacity requirement of 55 GW in Europe by the end of 2024; the maximum increase of capacity is forecasted to be needed between 2023 and 2024, when it will be about 13.5 GW. To provide an idea of how much this 13.5 GW increase from 2023 to 2024 means, figure 19 explains how that amount can be produced:

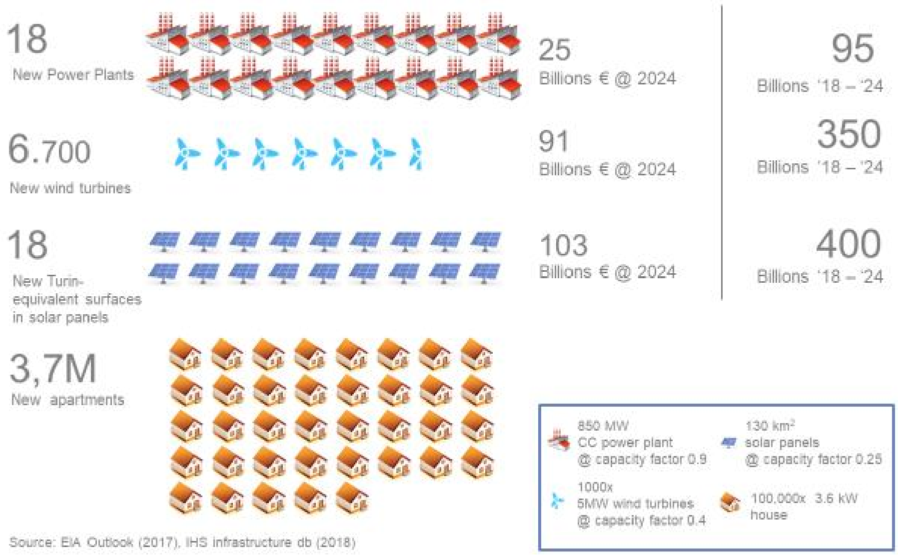

Figure 19 – Forecasted installed capacity increase

The estimates on the right express in euros the investments needed to install the additional power capacity for backing the deployment of the charging infrastructure, assuming to choose only one type of power source in each case. Even though investments needed are significant, much more than the cost of deploying the charging stations, it is important to underline that these can be considered upper limits. In fact, three main aspects must be taken into account: first, it is statistically unlikeable that the whole European charging infrastructure will work simultaneously at the maximum power; second, in recent years, according to BP [20], the trend in energy consumption in Europe is decreasing because of improving efficiency of light and appliances, meaning that some of today's excess capacity can already cover tomorrow's needs, without additional expenditures; third, the evolution and diffusion of storage systems in the power grid can significantly smooth requirement peaks.

7 Competition

If on one side OEMs are willing to sell electrified light commercial vehicles to reduce their CO_2 impact and be compliant with the regulation on emissions, on the other enterprises are willing to switch to xEVs to avoid traffic limitations, diesel bans and gain tax incentives and subsides. During the first half of this year the share of electrified vans was 1.1% of the total new vehicles registrations, but this figure is forecasted to grow significantly. “Fleet Barometer Europe 2018” [21], an annual fleet trend analysis published by the Corporate Vehicle Observatory, highlights that companies are getting more and more interested in adopting xEVs: in 2025 the share of electrified LCV fleet sales in the European market could reach 10%; this number can be seen as a minimum, since it does not consider privates’ interest in switching to electrified vans. This research is based on a survey answered by over 3,300 fleet managers across 11 countries. Because of these simultaneous technology push, by firms, and technology pull, by customers, we can expect that many car makers will propose on the LCV market at least one electrified model in the near future.

7.1 Current players

Some OEMs are already selling an electrified version of their light commercial vehicles and, until now, all of them are BEVs. Let’s analyse the market by Group.

7.1.1 Renault Nissan

Despite the alliance between these two brands was established back in 1999, each of them developed its own electric van starting from their experience in the passenger car sector with Leaf and Zoe, that have been leading the European BEV market for the last six years now. Renault Kangoo ZE is based on the ICE version, was first launched in 2011 and deeply renewed in mid-2017. This new version features a 33kWh battery and a 44kW electric motor allowing a declared NEDC range of 270km. the payload is slightly lower than the one of the traditional version: up to 650kg and the cargo volume is 4.6m^3. In the first half of 2018 it has been the top selling BEV in Europe with 3,300 units. Using the same battery and a slightly more powerful electric motor (57kW), a full electric version of Master (2G segment) had also been developed, with the first deliveries to customers started in mid-2018. The aim of the large van will be mainly last mile deliveries, with a declared range of 200km NEDC, a payload up to 1,130kg and a load volume up to 13m^3. Nowadays Renault is the only brand that offers the rental of the batteries, with prices that varies according to the yearly mileage and the time span of the rental. Nissan eNV200 is also a compact segment van (1B), with a payload of 770kg and a load volume of 4.2m^3; model year 2018 features an 80kW electric motor and introduced a 40kWh battery, almost two times the previous one. The homologated range is 275km NEDC. Since its launch it has been the van with the highest percentage of electric sales over yearly volumes: 15% in HY 2018. For all these three models, many components and the infotainment and connectivity system is the same used on the correspondent passenger cars. Common features include charging station locator, scheduling for conditioning and/or recharging the vehicle, an additional driving mode, called “Eco”, that optimizes energy consumptions to increase range. We will see a detailed description of these features in the chapter 9.

Figure 20 - Renault Kangoo ZE (a) and Master ZE (b), Nissan eNV200 (c)

7.1.2 PSA

PSA Group has had in its line-up full electric vans since 2013, year when Citroen Berlingo electric and Peugeot Partner electric were launched. These are exactly the same vehicle, with a 49kW powertrain, a 22.5 kWh battery and a declared range of 170km (NEDC). Load characteristics are in line with competitors in the compact segment: payload up to 620kg and volume of 4.1m^3. They both feature an “Eco” driving mode to reduce energy consumption. Even if both vehicles have not had any major update since the launch, overall the group sold nearly 1.400 BEVs in the first half of 2018. This year at Geneva motor show PSA presented the new version of conventional ICE Berlingo and Partner, but no announcements about the new full electric ones has been made; main analysts forecast the group will exit the electric van market for a few years in order to move production in a different Country and develop the new BEVs on its new platform.

Figure 21 - Citroen Berlingo electric (a), Peugeot Partner electric (b)

7.1.3 Iveco

It was the first brand to introduce a large electric van in Europe: it happened back in 2009. The latest version, the 2017's one, allows to cover a maximum range of 280km (NEDC) with a modular battery divided in 3 packs and alternative electric motors: 60 or 80kW. It has a maximum payload up to 1.600kg. An interesting characteristic of this vehicle are the driving modes: Normal, Eco to optimize energy usage and improve range and Power to maximize handling and torque when needed, for example in case of start with full load while going uphill. To show the driver all the necessary information, such as the power gauge, the selected driving mode and the instant energy consumption, a third-party HD display has been placed on the head unit, thus eliminating development costs for a new and more sophisticated infotainment system than the one usually required by an LCV. Despite the early enthusiasm the vehicle received from the press and customers, sales have been very limited up to now.

Figure 22 - Iveco Daily electric

7.1.4 StreetScooter

This brand entered the market as a start-up born within Aachen university in 2010 with the proposition of making even the smallest electric vehicle fleet an economically attractive option and finding a successful, forward-thinking balance between cost and climate in the process [22]. Free from conditioning due to previous experiences and from constraints coming from past decisions, they developed a cheap yet very flexible modular architecture to build vehicles dedicated to last mile deliveries. In 2014 StreetScooter was bought by Deutsche Post DHL Group and became Europe's leading manufacturer of electric commercial vehicles renewing the group's fleet. From 2017 started selling its models, the Work and Work L (both 1B segment) also to third parties and announced a partnership with Ford to develop the Work XL, based on Transit's chassis (2G segment). The idea beyond its vehicles is modularity: both compact vehicles feature a 48kW motor and battery options range from 20 to 40kWh, their payload ranges from 720 to 1,200kg and their load volume between 4 and 8m^3. The project under development with Ford will have a battery ranging from 30 to 90kWh, other specifications have not been disclosed for this large van yet. The interiors of the models actually on sale are very simple, providing almost nothing but the essential. The key success factor of the company is customization. For example, a cabin and a compartment in use on vans of postal services not only differ from the ones developed for a dairy company, but are different also among them, according to the specific needs of the company that purchases them. Out of the 7,500 BEV light commercial vehicles sold during the first six months of 2018, more than 1,700 were StreetScooter's. Recently the brand responsible announced the opening of a new plant that doubled the production capacity, now reaching 20 thousand units a year.

Figure 23 - SreetScooter Work (a), Work L (b) and Work XL (c)

7.1.5 SAIC

Another player trying to take advantage of the technology shift to enter the European market is SAIC, the largest vehicle manufacturer in the Chinese market. Since January 2018 the Chinese OEM started the deliveries of its Maxus EV80 to the first fleets. This product is a large van with a 100kW electric motor, a 56kWh battery, a payload of 950kg and a load volume of 10.2m^3; today it is available only in Germany and Austria but will be available on sale in all European countries from 2019. This vehicle features both normal and fast charging, allowing to recharge the battery in only two hours, allowing to easily overcome limitations due the 200km range, if needed. SAIC has had its electric commercial vehicles being produced for the Chinese market for several years now, so it can rely on its well proven technology; moreover, its production capacity that can fulfil any size of orders and has no rivals in Europe. Since September 2018, IKEA adopted EV80s as “shared vans” with which customers can bring purchases at home in some cities in Germany. The project will soon be implemented in other facilities, according to the Swedish company.

Figure 24 - Saic EV80

7.2 Announced vehicles

Apart from the models already available on the market, other main European players are developing electrified versions of their light commercial vehicles. As we have mentioned at the beginning, vans belonging to the compact segment often share their platform with passenger cars and, because of this, many OEMs may easily carryover hybrid technologies developed for cars. Even if the CO_2 benefit will be much lower for LCVs than for passenger cars, nonetheless such technologies could help to achieve the new strict emission targets and to avoid ICE vehicles' limitations. Despite this, no manufacturer announced any mild, full or plug-in hybrid van for the compact 1B yet. An overview of the announced models follows.

7.2.1 Daimler

The first electrified van of the group was the Vito E-Cell, whose production started in 2011 and was stopped a few years later (2015) due to poor results in the market. After that, Mercedes launched a new version of Vito based on a new platform and developed a BEV version on that: the eVito; pre-orders have been available from the beginning of this year and deliveries in Europe just started. The official specifications reveal an 84kW electric powertrain with a 42kWh battery allowing a range of 150km and a maximum load of 1,037kg and 6.6m^3. It will be the first electrified van in the medium segment (2P) available on the market. Daimler's electrification strategy will continue with the full electric eSprinter (2G segment) scheduled for 2019 followed by the smaller Citan for the 1B segment, always coming as a BEV. The larger van will have the same 84kW electric motor as eVito but will offer 2 different battery choices: a short range one – 42kWh for 115km range – and a long range one – 55kWh for 150km range. In this case the payload is up to 1,024kg and the cargo volume is 10.3m^3. According to a recent press release, eVito will introduce 3 different driving modes: C, E and E+. The first two allow the maximum power of the system, where C provides a faster handling than E. E+ limits the maximum power of the engine to 70kW to increase the residual range. Another technical feature that will be introduced in the LCV market by eVito and eSprinter are the e-coasting levels, already available on some passenger cars as Hyundai Ioniq and Mitsubishi Outlander. With e-coasting the driver can simulate different levels of the traditional "engine brake", using the electric motor to create electricity to be stored in the high voltage battery while slowing down the vehicle, for example when approaching an intersection or going downhill. On Mercedes' vans there will be 4 levels that can be set with two paddles behind the steering wheel; from D++ that completely eliminates engine resistance to D- where, while not accelerating nor braking, the regenerative effect is so strong that it almost stops the vehicle. eSprinter is also said to use the latest infotainment system the brand developed for passenger cars, the MBUX. This will allow drivers and fleet owners to remotely check the status of the vehicle, including battery levels and charging times, set some parameters and take advantage of both the connected navigation system and the AI assistant developed by the Mercedes. To help customers understand this new technology, Daimler developed a smartphone app able to monitor the use of the current vehicle and suggest pros and cons of switching to a battery electric vehicle.

Figure 25 - Mercedes eVito (a) and eSrinter (b)

7.2.2 Volkswagen Group

By the end of 2018 the group will start delivering the Volkswagen eCrafter and its alter ego, the Man eTGE; some early deliveries to selected European customers already happened in Hannover and in the United Kingdom. Both are full electric vehicles with a 100kW powertrain, a limited maximum speed of 90km/h and a 43kwh battery for the eCrafter and a 36kWh one for the version by Man. The ranges are respectively 176km NEDC and around 150km, making it a perfect vehicle for urban environment. Charging will be possible either with alternate current at 7.2kW or through a 40kW direct current proprietary system that in just 45 minutes can fill the battery up to 80%. eCrafter and eTGE will have a load volume of 10.7m^3 for a maximum payload of 1.700kg. Those vehicles feature the "Discover media" infotainment system developed for Golf, including the connectivity and "app connect" services, an advanced "Park Pilot" system and the emergency anti-collision technology. Thus, the gap with passenger cars in terms of comfort, connectivity and safety is getting tighter and tighter. The eCrafter won the "European Transport Award for Sustainability 2018" for its category [23]. During 2018 Hannover International Motor Show Volkswagen revealed the technical specifications of ID Buzz, a full electric compact van inspired by the classic Volkswagen Type 2 known as Microbus. It will be available from 2021 with two alternative battery pack: 48kWh or 111kWh that will allow a range respectively of 330km and 550km on WLTP; the electric motor will provide 150kW of power and the maximum payload will be 800kg. During the same event were shown also two other projects based on the Crafter, but with no information if they will be available on the market or not in the future. The first van had a hydrogen powertrain, while the second was a mild hybrid with the electric motor mounted on the rear axle in order to provide all wheel drive on demand [24].

Figure 26 - Volkswagen eCrafter (a) and ID Buzz (c), Man eTGE (b)

7.2.3 *Ford*

Ford has a different approach. Recently it has invested significant resources for the development of a new and super-efficient combustion engine: the 1.0 EcoBoost. Its applications will be both on ICE passenger cars and on light commercial vehicles as a range extender. A small fleet of Transit Custom (2P segment) REEV has been deployed in London for a 12-months trial that started at the beginning of 2018 and has been followed in May by a new fleet being deployed in Valencia for a similar "real usage" test. This vehicle will be able to cover more than 50 kilometres in pure electric mode and over 500 kilometres by charging the battery with the conventional engine. The aim of this technology is to guarantee the range of a conventional van while allowing the access to low and ultra-low emission zones and limiting emissions in polluted urban areas. Because of this last point, during the UK trial Ford implemented with some local governments and universities a feature called "Geofencing": according to the GPS location the vehicle is forced to run in pure electric mode. The aim of such system is to regulate LEZ/ULEZ/ZEZ accesses and, in the future, to force vans to run as BEVs when they are in areas where local sensors reveal high levels of air pollution in that precise moment. The beginning of commercial production for the Transit Custom REEV is scheduled for 2019.

Regarding the large segment, Ford announced in September that for the next generation of Transit, scheduled to be launched in mid-2019, a mild hybrid version will be available, making it the first light commercial vehicle in the market with such technology.

Figure 27 - Ford Transit (a) and Transit Custom (b)

7.2.4 *Geely*

Geely, one of the most important car manufacturers in the Chinese market, operates in Europe through two of the brands it owns: Volvo and "the London Electric Vehicles Company" (LEVC). The last one obtained by UK government the financing needed to develop and produce the new generation of London's taxis: the so called "TX". Equipped with a 33kWh battery, it is a REEV with a 110kW electric motor and a 60kW Volvo sourced 1.5-litre turbocharged three-cylinder petrol engine. Based on this project that has a dedicated platform and architecture, the company has recently announced that it is working on a medium size van featuring the same chassis as TX. The declared value-proposition of the company is to fill the gap that there will be between long haul deliveries, that will keep being powered by conventional fuels, and last mile deliveries that will be done using BEVs. Chris Gubby, LEVC CEO, revealed that the van will be able to take two euro pallets, one of which can be loaded through a side sliding door; it will feature all the driving assistance systems developed for the taxi and will have a total cost of ownership close to the one of diesel vans [25]. Some prototypes have already been spotted and the commercial launch is expected for the second half of 2019.

7.3 Concepts

Recently many companies have proposed innovative concepts describing their vision about light commercial vehicles' mobility in the next years.

Electric and hydrogen vehicles, autonomous driving and integrated drones are only a fragment of the possibilities and ideas for the future. Here is a list with the most relevant ones.

7.3.1 Volkswagen eT!

Back in 2011, Volkswagen provided Deutsche Post with a small fleet of Caddy specifically converted to BEVs that were used for three months in Postdam (Germany). After that trial, the manufacturer used the data gathered from the field experience to develop a concept of a delivery vehicle: the result was the "eT!", a full electric vehicle powered by a 70kW electric motor (no details were given concerning battery capacity and the range). It had a sliding door on the side and a two-part hinged door on the rear over which an extendable additional roof panel was installed to protect the driver and the packages during load/unload operations in bad weather. To reduce wastes of time determined by the repeated enter and exit of the driver to move the vehicle between a delivery and the following one, two interesting features were introduced. There was a joystick on the passenger side to drive the vehicle up to 6km/h, the usual walking pace, also from the sidewalk side. In addition to this, every operator was provided with a smartphone or a similar device that, in addition to manage deliveries, allowed the vehicle to follow him while he is walking door to door or to reach the driver when he left it parked nearby. These features were possible thanks to the semiautonomous driving system mounted on board: eT! was able to identify and follow lanes, recognize and avoid obstacles and stop in case of emergencies or when approaching an intersection. Despite the project had been dismissed, some of the solutions implemented and the data gathered can still be considered a relevant contribution for the development of new light commercial vehicles.

Figure 28 - Volkswagen eT!

7.3.2 Mercedes VisionVan

The VisionVan proposed by Mercedes was specifically studied for the urban environment and merges a number of innovative technologies for last-mile delivery operations. It was equipped with a 75kW electric motor and modular batteries so it could cover a range up to 270km. The core of this idea was a cloud-based management system which organizes the loading of packages and the automated cargo space; it calculates the more efficient delivery route and guides the two drones that the vehicle featured. Each of them had a payload of two kilograms and could autonomously deliver within a 10 kilometres radius. Interiors were highly innovative too. The steering wheel had been replaced by a joystick, by doing so it was possible to move forward the driver's seat and increase the load volume. The passenger seat was removed, leaving a free space where the operator can stand and, through an automated shutter, take the packages to be delivered and exit the vehicle from the sidewalk side, saving time and increasing safety. In addition to the digital displays where all the necessary data were shown, a new system was implemented as a communication mean between the worker and the vehicle: different led stripes in the cabin changed their colour when approaching a biker or a person crossing the road, for example. The same led panel were mounted on the van externally for safety purposes. The loading of the vehicle was based on removable racks: they were loaded with parcels and packages while in the storage facility and then placed on the van after removing the previous one. Each rack had an automated system to manage packages, allowing drones to operate autonomously. This concept was proposed as a full electric vehicle to reduce pollution and noise in urban areas.

Figure 29 - Mercedes VisionVan

7.3.3 Isuzu FD-SI

At Tokyo Motor Show in November 2017 Isuzu presented its concept for the future of light commercial vehicles: the FD-SI. Even though no specifications about the powertrain were released, it introduced some architectural innovations. A honeycomb structure for the external cargo space provided strength and simultaneously internal compartments where easily and quickly store or take items to be delivered. Another interesting aspect was the driving cabin: it was centred and had space for the driver only; externally appeared almost vertical, choice that maximized the loading volume. All the relevant information was provided with a head-up display at the base of the huge widescreen, while another digital display mounted on the rectangular shaped steering wheel provided a live view of the street behind the van. The latter solution was implemented to remove the external rear-view windows and use that space to make the vehicle as wide as possible in order to maximize onboard space.

7.3.4 Nuro

Two principal engineers at Waymo, Google’s self-driving cars project, quit their jobs and founded Nuro in 2016 [26]. The aim of this start-up is to use together robotics, artificial intelligence and autonomous driving to create a vehicle that will revolutionise urban mobility. After raising 92M$ on a crowdfunding platform, they developed their first vehicle, called R1: it is an electric self-driving van specifically designed for last mile deliveries. There is no place for a driver or any passenger, but it has two big compartments whose interiors’ design is flexible and can be customized according to what needs to be delivered: groceries, dinner or any other type of package. Last June Nuro announced a partnership with Kroger, the American grocery giant, and from August 2018 they started a trial of autonomous delivery service for Fry’s Food store in Scottsdale, Arizona.

Figure 30 - Nuro R1

7.3.5 Toyota ePalette

During CES (Consumer Electronic Show) 2018, one of the most important exhibitions for the sector, Toyota presented the e-Palette prototype. Born from a partnership with Amazon, Uber, Pizza Hut and Mazda, the idea is to have a driverless BEV with high modularity: thanks to a standard platform and an open source control interface that allows other companies to install their autonomous driving systems and technologies, the vehicle could be customized for each mission. The basic roles it would fulfil are ride sharing and logistics. The first one includes all the different typologies: from hospital shuttles to taxis or mini-buses that can also carry smaller autonomous vehicles for lunch deliveries; more futuristic applications include mobile hotel rooms, offices and shops. For the delivery sector the concept was designed in two different sizes, a larger one for sub-urban logistic and the other is smaller for last mile services. Both can be used to bring smaller autonomous vehicles to the delivery area. Every vehicle, while approaching the right address or delivery point, will send a notification to the customer, who can withdraw his items using facial recognition. Toyota's target is to make available some ePalette versions for the 2020 Olympic and Paralympic games in Tokyo [27].

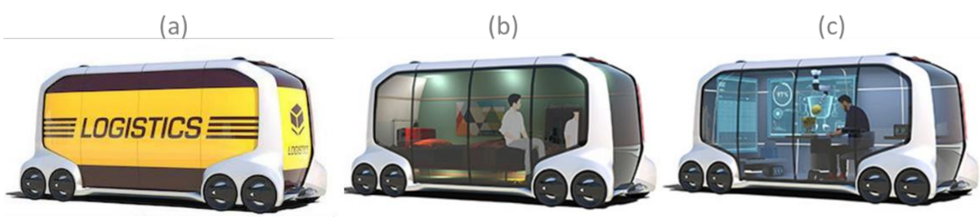

Figure 31 - Toyota e-Palette: van (a), hotel room (b), office (c)

7.3.6 Workhorse

Workhorse is an American company, based in Cincinnati, specialized in vehicle electrification. From its foundation back in 2007 (under the name of "AMP Electric Vehicles"), it presented many ideas and concepts: from its full electric van to a fuel cell one, passing through a fully electric helicopter for personal flights. "HorseFly" is one of its latest products and just started a trial period in Loveland, Ohio; it is a high efficiency octocopter-based delivery unmanned aerial vehicle for last mile deliveries that can be fully integrated with hybrids and electric vans. This custom-made drone can fly for 30 minutes with a top speed of over 70km/h (>45 mph) carrying packages of up to ~4.5 kilograms (10 lb) [28]. The most interesting aspect of this product is the guidance system: HorseFly features autonomous GPS and Compass to fly, an infrared camera for landing and can be remotely human controlled thanks to the 4G onboard connection. The specifically designed software notifies the van driver when an aerial delivery is available and, if he confirms it, he has to select the specific point of delivery on a satellite map and confirm the drone operation. All the process is fully automated except when the drone arrives right above the final destination: at this point a video feed is sent to a remote operator that can verify safety and, if needed, remotely manoeuvre the drop-off. With this method a single observer can control a whole fleet of HorseFlys and, at the same time, the highest possible safety is guaranteed during the most crucial phase of the delivery. In a press release to present this product, Jeff Bennet – Workhorse aerospace project manager – said that this technology provides significant savings: on one hand there is the possibility for the van driver and the drone to deliver simultaneously different packages, on the other HorseFly's operational costs are significantly lower than the ones of a truck: $0.34/mile to power an electric van versus $0.03/mile for the octocopter.

Figure 32 - Workhorse HorseFly

7.3.7 Renault EZ-Pro

EZ-Pro is the most recent concept van proposed by Renault: it consists of a small fleet of driverless robo-pods and an autonomous leader pod from where a person, freed from the need of driving, can supervise and manage the trip, delivery processes and each pod's tasks. All pods will be full electric and highly customizable to satisfy every possible customer: logistic companies, retailers and craftsman. To guarantee the maximum manoeuvrability all pods will feature four-wheel steering. Robo-pods will be able either to follow the leader one by platooning or can move independently; for last mile deliveries they can host self-service lockers and be accessible 24/7 through a smartphone app [29].

Figure 33 - Renault EZ-Pro: leader (a), robo pod (b)

8 Needs

After analysing the market, from electrified light commercial vehicles currently on sale to future concepts passing through products announced for the years to come, we need to identify customers' needs and market trends. Considering the very limited number of alternatives available on sale today and that the only technology applied is BEV, manufacturers can exploit their experience gained with electrified passenger cars as a starting point to define features to be implemented and needs to be satisfied.

8.1 Passenger cars' experience and LCV specificity

Historically light commercial vehicles had always been rougher than passenger cars: for instance, until a few years ago no van had a screen on the head unit or a digital cluster, none had led lights; automatic transmission were not always offered and automatic air conditioning was not available for most models. Today things are changing, and the trend is to implement on LCVs the same infotainment systems and optional available on passenger cars. Therefore, considering that diffusion of electrified passenger cars is slightly ahead of LCV's one, some insights can be derived from that market, always taking into account that these categories differ in many aspects. While light commercial vehicles are designed to haul goods for relatively short distances (heavy duty vehicles are more efficient for medium and long-range road transportation) and most often there is only one person on board, the driver, cars are designed to maximize comfort for passengers that can be up to 5 or 7, according to vehicle's segment. The target while designing a van must be to maximize the cargo space and the payload; many contents that enhance the driving experience such as the energy flow, the charging schedule and the preconditioning for xEVs, driving assistance systems and remote monitoring of the vehicle can be carried over from passenger cars. Commercial vehicle's routes generally are scheduled and planned in advance and usually there is not so much difference from one day to another: a construction company organizes in advance the handling of materials and usually work in a specific area; similarly, merchants and retailers schedule the movement of merchandise among stores up front. The situation is really diverse for a passenger car that can be used to cover short and repetitive distances during the week (to go to work, to bring children to school, to go to the supermarket are only a few examples), but on weekends or during holidays can be used to go to the mountains, to the seaside or to do any other long range trip; consultants and sellers use their cars to cover wide distances every day. Moreover, if a friend invites you over for dinner, an "unexpected" distance must be covered with the car. Considering this, fast charging must be available on BEV/REEV cars and suvs to reduce constraints due to the limited battery range, while for many LCVs' use cases it will not be necessary. Another important aspect that differentiates LCVs from passenger cars is sale channel: the first recorded a quite steady 70% of yearly sales made up by fleets in the last three years while, over the same period, this value was around 18% for passenger vehicles. Selling fleets is quite different than selling to privates: in the former case many times who is in charge of the purchase is not the same person who will drive the vehicles and, therefore, the parameters used to choose a brand and a model will be quite different from the ones of a private owner who needs to buy a van to drive it every day. Fleet owners can require live tracking or a management, monitoring and diagnostic software to easily check the status of their whole fleet at once, feature that can be useless for who owns only one or two vans. Companies could have a private parking lot where to locate vans and recharge them if necessary, while privates can have a garage, a garden or leave them on the street. Again, the experience gained with cars by some OEMs can be easily transferred to light commercial vehicles' market: for example, BMW developed its own wallbox that is sold as optional to PHEV/REEV/BEV owners and created an exclusive platform, "Charge Now", that allows BMW rechargeable vehicles' owners to access most of the European charging infrastructure with a unique ID card and single payment method. PSA, on the other hand, entered a partnership with New Motion, the largest charging network in Europe, and outsourced all the aspects related to charging xEVs: from providing and installing wallboxes, to provide the access to public infrastructure and manage payments methods. Next paragraph is aimed at better understanding light commercial vehicles usage, considering results coming from different surveys and events organized with customers, drivers and fleet owners.

8.2 Customers' voice

All data were collected between 2017 and 2018 involving professionals from different European countries; samples' composition was made including compact, medium and large segments' representatives, different fleet sizes and privates, owners and drivers, males and females. The first aspect that should be highlighted are the statistics about the answers to the question "Average kilometres per day": it emerged that 76% of compact vans and around the 57% of large vans cover less than 200km a day. These figures are even higher considering the percentages of vehicles driven for less than 300km a day: 94% of compact vans and 84% of large ones. Such surveys' results are aligned with data gathered from over eight thousand light commercial vehicles monitored 24/7 over the last two years. Regarding the "down-time", more than 70% of respondents answered that their vehicles remain parked more than 10 hours for the night; during this time, 58% of compact vehicles and over 68% of large vehicles are parked in a private area: a garage or a parking lot. Almost half of 1B vehicles and around 40% of 2G ones will be replaced within 4 years; for both segments over 80% of vehicles has a life span up to 6 years. Another important question that was asked for customer profiling was to rank the main parameters considered to purchase an LCV; starting from the most relevant, the top five are: load capacity, dimension, price/purchase conditions, performances & reliability and brand. As expected, data confirmed that the effort an OEM dedicates in support and relationship strengthening is a very important purchasing decision factor for big and medium fleet operators. It emerged that TCO is more important for large fleets and rental operators, as they have more accurate models for its estimation, while smaller operators expect greater transparency; residual value plays an important role for rental companies. Many interviewees, especially who already had a full electric vehicle, highlighted that they expect to charge BEV vans during the night and to use public charging infrastructure only exceptionally; as a consequence, providing a wallbox or selling it as optional would be crucial. Another interesting aspect that emerged is the importance of connectivity: a connected navigation system that shows the available range taking into account traffic, driving style and topography will enhance the efficiency and reduce the "range anxiety" of drivers. Telematics is relevant as it can benefit medium and large fleets in several ways: improving fleet productivity, generating fuel savings and lowering insurance costs. The availability of different driving modes has been highly appreciated, since allows to maximize the efficiency of vehicle's setting in every driving condition. Finally, a dedicated research highlighted that, for selling all categories of xEVs, a key element is to provide a warranty on both, the hybrid powertrain and the battery, the latter including also capacity besides defects.

8.3 Market trend

Back in 2012 in Europe diesel had over 97% of LCV registrations' share, in the first half of 2018 it was 95.3%. Gasoline grew from ~1% in 2010 to the current 2.8%, electrified vehicles accounted for 1.1% while they were 0.6% in 2012 and alternative fuels (LPG and Compressed Natural

Gas) remained steady around 0.8% (Figure 34 - 35). From these data it may seem that nothing is happening, that diesel is still the favourite choice for LCVs.

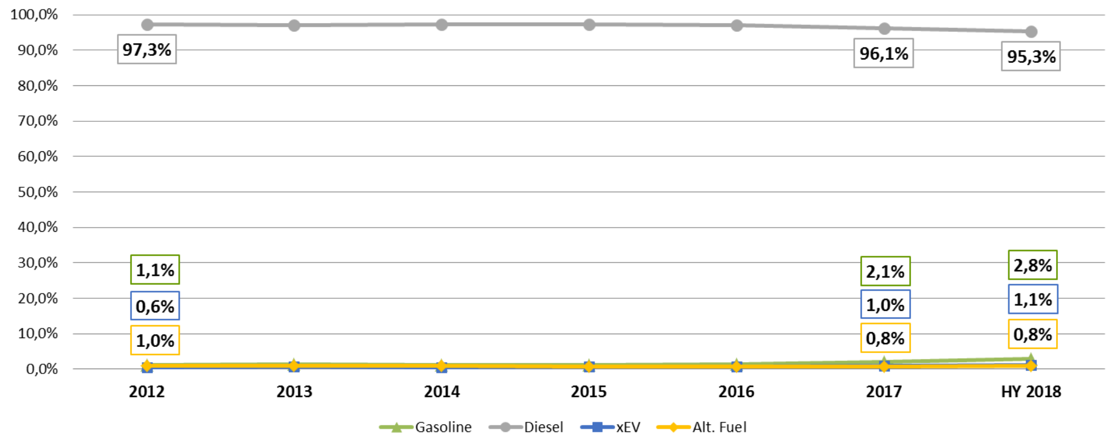

Figure 34 - Fuel trend: overview

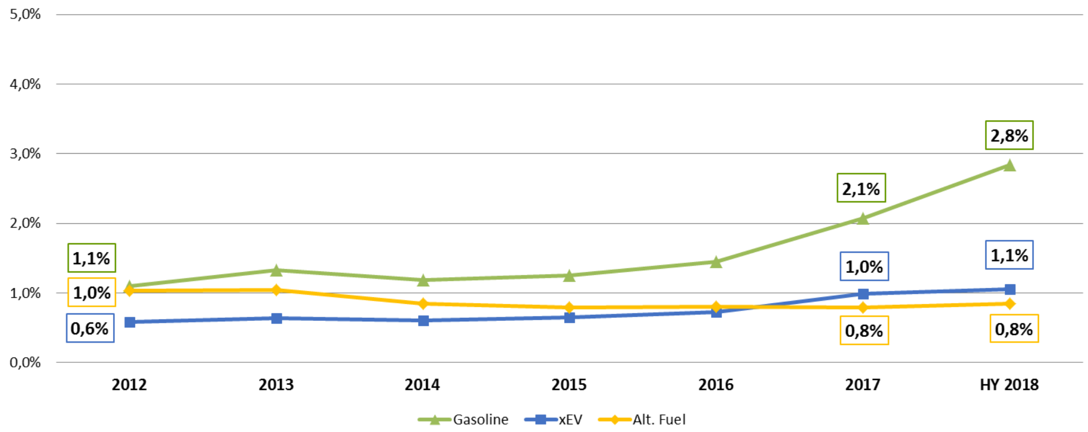

Figure 35 - Fuel trend: diesel alternatives' detail

If we consider the context, the takeout from the first half year results can be slightly different. Diesel is still the main fuel in every segment and, in the medium and large segment, it holds almost 100% of market share, true. But in these two segments there are no alternatives: there are no gasoline or electrified models currently available in the market. The only segment in which customers have a choice is the compact one, even if the number of diesel nameplates is still dominant compared to the other ones. Let's analyse the figures here (Figure 36): diesel lost 6.5% of market share from 2012, being replaced by gasoline, that went from a market share of 2.4% in 2012 to the current 7.7%, and electrified vehicles that accounted for 3.0% during the first six months of this year.

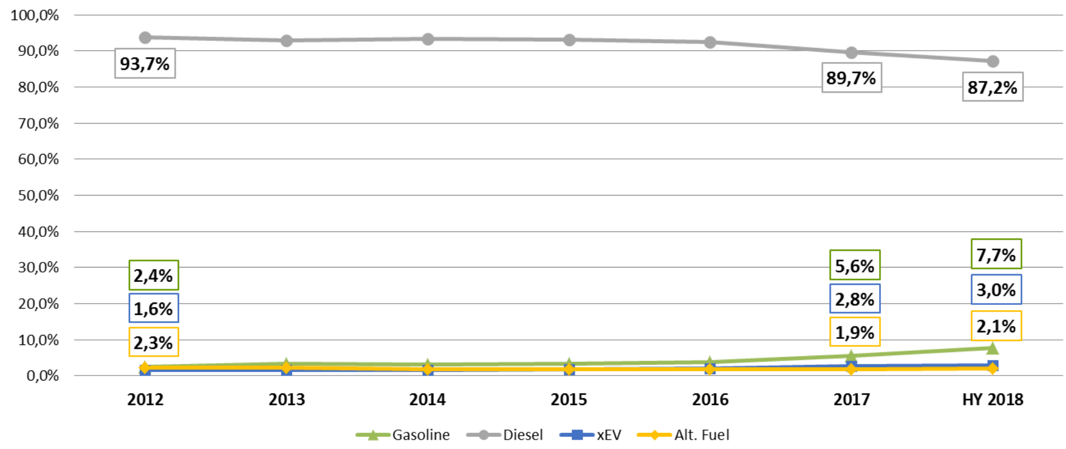

Figure 36 - Fuel trend: Compact segment

Considering that today the only electrified models available on sale are still the same BEVs there were in 2012, the growing trend of "diesel alternatives" and the presence of only a few gasoline ad electric models in the market can be seen as an opportunity for OEMs. In addition to the forecast that at least 10% of van sales will be electrified by 2025 because of fleets (see chapter 7), the estimate provided by IHS is that in 2025 xEVs will account for the 23.5% of new vans, while gasoline and alternative fuels will reach respectively 7% and 2.2% of market share with a significant decline of diesel. Besides analysts, also many logistic and fleet companies showed high interest in electrification, therefore having at least one electrified van in the line-up will be necessary to remain competitive in the market.

9 Concept proposal

Every day on radio, television, internet and social media we hear or see commercials about a new model of vehicle "X", equipped with all the latest features that appear futuristic, appealing and, sometimes, incredible. From a family car with driving assistance systems, wireless charging for your smartphone and adaptive lights to the new version of a van that should be able to revolutionise your business thanks to its high fuel efficiency, its larger load compartment and, also here, the new driving assistance systems. Everything seems to move quickly and constantly. What most people do not know is that the introduction of a totally new model, both for passenger cars and LCVs, can require four to five years while yearly updates are often minor changes that have been already planned in the last deep redesign. If we want to change tomorrow's mobility, we need to start working now.

9.1 Target segment definition

The first choice we have to make is about the customer segment we want to target with our product. Figure 37 provides a comprehensive view of the main characteristics of light commercial vehicles' missions that will help us in the selection process.

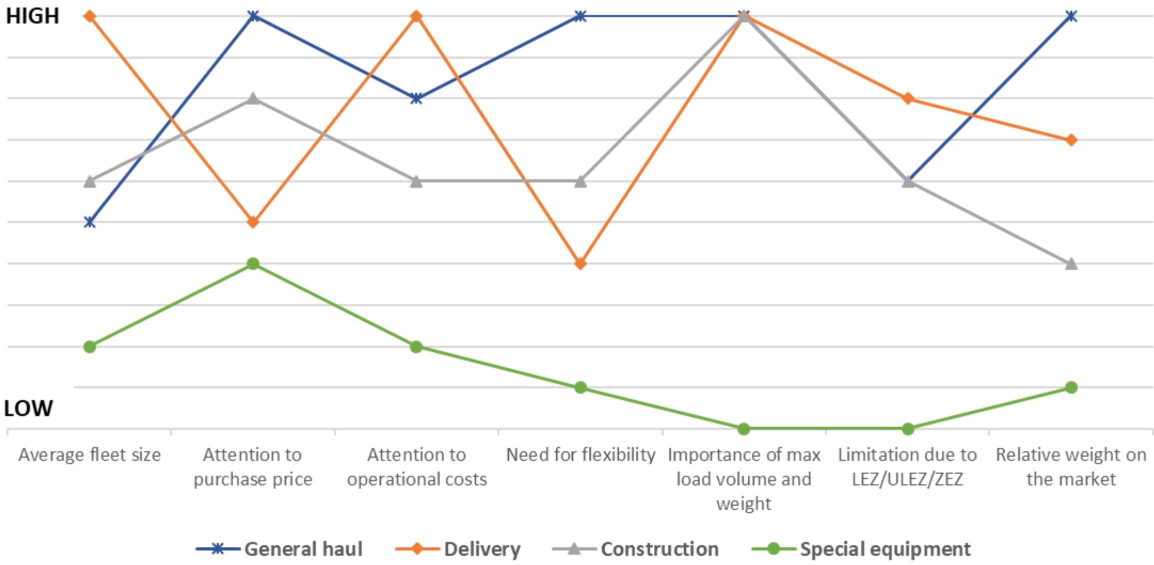

Figure 37 - Missions characteristics

Let's analyse it starting from the left. The delivery segment, generally, is composed by a few main players with large fleets for each subsegment: DHL, UPS for logistic, national postal services for parcel delivery, Bofrost and Tesco for food and beverage delivery, for example. In Special equipment segment usually fleets are relatively small, going from ambulances fleets to single vehicles for specifically adapted to carry wheelchairs. The remaining categories fall in the middle: construction companies usually have medium size fleets of light commercial vehicles while "general haul" is composed by retail stores', short term rentals' and companies' fleets and craftsmen's vehicles. This first parameter just analysed allows to better understand the next one: the relevance of purchase price. Since the main owner's category in general haul segment are craftsman that usually have a limited number of vehicles, this segment is the most sensitive to purchase prices. In the construction industry, on the other hand, the purchase prices for vans are relatively small if compared to other expenditures such as wages, materials and the cost of capital. For urban logistic and deliveries LCVs are the core of the business: drivers will spend many hours driving, utilization rates are very high and reliability is fundamental: if measured with the previous two segments, the attention to purchase price is lower in this case. Special equipment vehicles are necessary to ensure people welfare and safety, therefore price is pushed in the background. Similar motivations can be advanced regarding the attention to the operating costs for the construction, general haul and special equipment industries; the delivery segment is an exception: with e-commerce growing significantly and more and more online retailers offering same day delivery without any additional cost for the customer, logistic companies have to be extremely careful to the reduction of operational costs. Today most of light commercial vehicles sold are “standard”: having different heights, lengths and payloads but always featuring the same regularly shaped cargo space behind the cabin; a different approach to pursue differentiation can be to develop vehicles specifically designed for a certain mission. To analyse this possibility, an interesting parameter to consider is the flexibility required by their vehicles in term of variety of items to be loaded. The higher flexibility is required by general haul vehicles: customers use them to transport clothes, groceries, furniture, equipment and any other kind of items. Loads for vans in the construction industry are less diverse: materials and construction equipment that can vary a lot according to weight and dimensions. LCVs for deliveries usually carry packages that can differ greatly according to size and weight, but only within a limited range. Some deliverables need thermo controlled or refrigerated load compartments. The lowest need for flexibility, from the point of view of an OEM, is in the special equipment sector; here usually the manufacturer provides the basic chassis and the cabin of the vehicle and a third party will customize them to accomplish a specific mission (car recovery, ambulance, waste collection, for example). Moving to the next column, for all commercial applications of vans, maximizing payload and load volume is fundamental. The creation of Low-, Ultra low- and Zero emission zones will affect most the delivery segment that operates only in urban environments. For construction and general haul companies the impact of a periodic fee to access the restricted zones will have a lighter impact since transportation is a non-core activity. Special equipment vehicles are usually exempted from this kind of regulations. In the last column is represented the relative weight that each mission has on the market. After this overview, it could be clear that the best segment to target with a dedicated van is the delivery one. Having the second market share among missions, it guarantees a broad potential market made up mainly by large fleets and with the highest potential to grow thanks to the boom of e-commerce. The great attention to operational costs and the impact that the creation of restricted area to limit pollution will have on this market create an opportunity for a paradigm shift from diesel vehicles to xEVs, while the limited variability of parcels and packages allows the proposal of a solution specifically designed for deliveries. Pursuing differentiation in terms of both powertrain and functionality to focus on a single segment allows an OEM to reduce the competitive pressure and to gain higher margins, since its product will exactly fit customer needs.

9.1.1 Customer requirements

To better understand the evolution of this sector, some specific researches and surveys have been conducted by analysts about both, logistic companies and final customers. The report "Signed, sealed, delivered (and regularly returned)" by PWC synthetizes the data coming from the annual "Global customer insight survey 2018" [30], in which over 22 thousand people from 27 countries were interviewed and can help us to better understand which aspects are more important for final customers in this segment. The first data that emerged is that, when asked to select and rank the more attractive benefits that can be offered at no extra cost, the result was: free return shipping (selected by 65% of respondents), package tracking (54%), same day delivery (50%) and delivery at a specific time slot (50%). To further investigate the "quick delivery" aspect there were other dedicated questions and what came out is that about 72% of customers expect their goods to arrive within 2 days and that the vast majority of people is willing to pay to have a "same day" delivery. These two aspects, reverse logistic becoming a "must", and a risible short lead-time accepted by customers, make the diffusion of local logistic warehouses inevitable and last-mile delivery even more important than before. In the document are also mentioned two innovations: one coming from Dubai that can revolutionize deliveries and the other, an app called What3Words, that can furtherly boost e-commerce growth. The former one, introduced by the start-up Fetchr, is a system that uses the current GPS location of the customer instead of his address for deliveries. Such system can enhance customer experience as they do not need to wait at home or to reach a delivery locker anymore, but will also increase logistic complexity, since the approach to define daily delivery routes will have to be completely redefined. According to United Nations, around 4 billion people live in places and houses that do not have a clear address, involving problems for identification documents, bills and many other issues. What3Words, a company born in 2013, developed an algorithm to categorize each 3x3 squared meters of earth with a combination of three words. In this way every place is identified in a unique way. This mapping innovation, already adopted by Mercedes and Land Rover, has further increased the potential customers base of e-commerce and delivery services.

To sustain the substantial growth of daily deliveries and the increasing number of parcels and returns to be managed, last mile logistic companies are trying to optimize the delivery process as much as possible to reduce their operational costs. Today even small fleets' owners look for vans equipped with telematics and, if possible, a dedicated routing and management software; such tools already proved to create significant savings for many different players on the market. For instance, it is famous UPS case: by using telematics to monitor drivers' behaviour and driving habits the company discovered that turning left wastes a lot of time and gasoline money from idling, so it developed a routing algorithm that makes van turning only right, if possible. Another example is Tesco UK that has a fleet of 2,200 vans making on average 65.000 deliveries per day: it was able to achieve a 12% reduction in fuel costs and a five million drop in damage expenses by using telematics. Anyway, these technologies allow to optimize only one part of the delivery process; as of today, no improvement has been introduced to reduce wastes of time in the last part of the process: when the driver has to get out of the vehicle, look for the package in the cargo space, ring the bell and wait for the addressee to come to take it; this part of the process is the most time consuming nowadays. The next generation of light commercial vehicles should have advanced telematics and connectivity services, feature some contents able to optimize efficiency also in the last part of the delivery process and have extremely low operational costs in terms of fuel and maintenance.

9.2 Technology selection

Once identified the customer segment we want to serve and its needs, we have to define the technologies to adopt in order to enhance final customers' experience, reduce operating costs, satisfy regulations' requirements about pollution and reduce the impact of last mile deliveries on the environment.

9.2.1 Electrification technology

The main technology-based decision to be made is about the powertrain; as we have seen, today diesel vehicles represent over 95% of LCV sales, but this must change in the near future because of the upcoming diesel bans. Pure gasoline vehicles should be avoided too, since their CO_2 emissions are higher than diesel ones and from 2021 OEMs must be compliant with the new strict emission regulations whose target have been set as a 25% reduction of the average emission level allowed in 2015, a figure based on a market almost completely powered by diesel. The remaining alternatives are electrified powertrains; figure 38 provides a recap of what we have seen so far about xEVs technologies.

	Relative development cost	CO_2 reduction	Daily mileage	LEZ/ULEZ access	ZEZ access	Best use case	Relative market demand	Complementary goods needed
MHEV	LOW	LOW	as ICE	NO	NO	Mix of urban, extra urban and highway usage	LOW	NO
HEV	MEDIUM	MEDIUM	as ICE	YES	NO	Mainly urban usage, with chance of extra urban and highway trips	LOW	NO
PHEV	MEDIUM	HIGH	as ICE	YES	YES	Mainly urban usage, need to run in electric mode for short distances (<50km)	MEDIUM	YES
REEV	HIGH	VERY HIGH	as ICE	YES	YES	Urban usage and electric mode dominant (>50 km), possibility to run with an ICE	MEDIUM	YES
BEV	HIGH	COMPLETE	limited	YES	YES	Urban usage dominant, electric mode needed for the whole mission (< 300km)	HIGH	YES

Figure 38 - Electrification alternatives overview

Mild and full hybrid technologies can be easily used on vans belonging to the compact segment, where OEMs can re-apply systems and components developed for passenger cars. This solution can slightly improve vehicles' efficiency without penalising the weight of the van with heavy batteries and electric components and with no significant additional costs both for OEMs and for the customers. Market demand is low if compared with other electrification technologies because MHEVs and HEVs have usually no access to areas where emissions are regulated and tax benefits are usually very low or absent for this kind of vans. Plug-in and range extender vehicles can be seen as a good solution if there is the need to enter some areas accessible only to zero-/low emission vehicles or where a pollution fee is charged while keeping the daily mileage "unlimited" as it happens for vehicles with internal combustion engines. One of the main disadvantages of PHEVs are the limited range they can cover in pure electric mode. Range extender overcome this problem with a much larger battery capacity. The drawbacks in this case is a very low efficiency in energy transformation when using the ICE. Fuel is transformed through the combustion engine in mechanical energy (this transformation is 40% efficient, at best), the mechanical energy is then transformed through a generator in electrical energy and stored in the battery; from there electricity is taken and converted into mechanical energy again and sent to the wheels to move the vehicle. Both PHEVs and REEVs result to be heavier and complex because in addition to the battery and electric motors large enough to run the vehicle, they have a combustion engine and all the related technologies on board; this also reduces the available payload and cargo space and determines high development costs that cause a significant increase in the price that customers have to pay for purchasing the vehicle. The "Delivery" customer segment involves a daily mileage of up to 250 kilometres and an average utilization rate of 280 days a year with peaks of 360 for fresh food delivery, for example. Considering these parameters, the most appropriate technology for a van targeted at this segment is BEV. The constraint about the available range will not be a problem, since it will allow to cover the traditional daily routes that are also scheduled and planned in advance, detail that allows to maximize "fuel" efficiency and schedule charging periods in advance. Moreover, electric motors have much fewer moving parts than traditional engines and so require much less maintenance, assuring high reliability and allowing very high utilization rates. Full electric vans can completely eliminate pollutant emissions and noise, increasing the local quality of urban environments and providing an advantage in term of fleet CO_2 emissions; they can access any limited traffic zone and benefit of the highest tax discounts and subsides among xEVs. All these aspects make this technology particularly appreciated on the market. With rechargeable vehicles OEMs have also the opportunity to sell bundles of complementary goods: different of wallboxes to charge in companies' parking lots and services to access the public and semi-public charging infrastructure.

9.2.2 Autonomous driving

Recent advancement in monitoring and connectivity technologies, paired with their decrease in price, have already brought on the market the first vehicles with systems that inform and support drivers. Figure 39 summarises the 0 to 5 stage model introduced internationally to classify the different levels of automation, their use case and the preferred area of application.

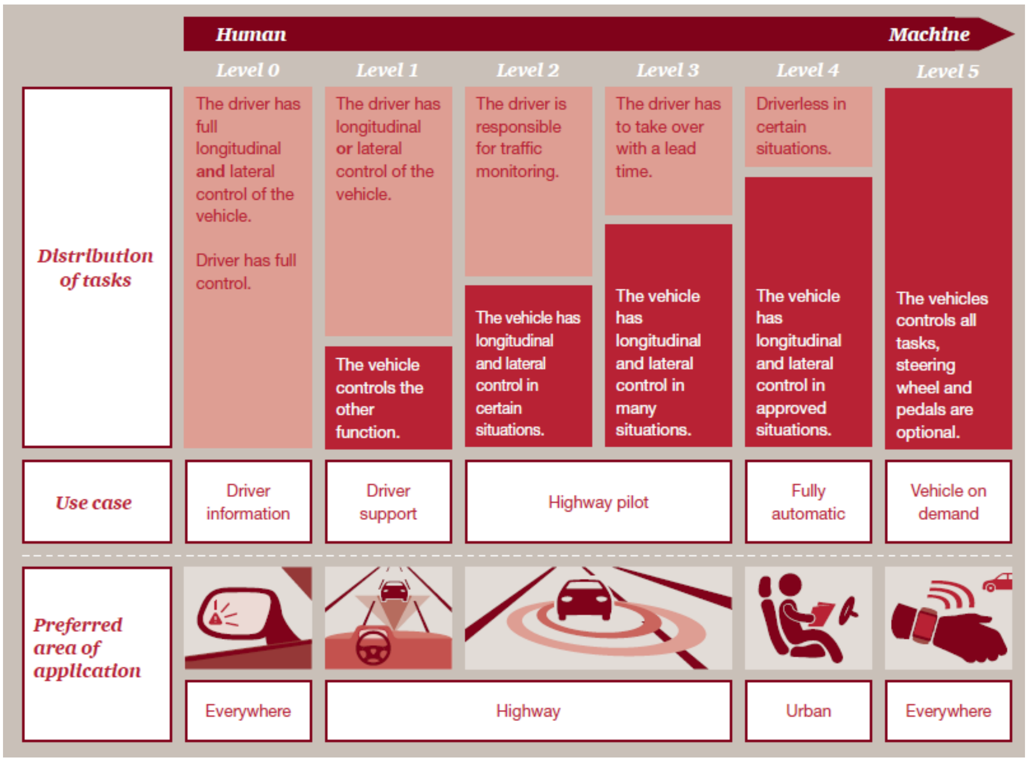

Figure 39 - Autonomous driving

Price Waterhouse Coopers forecasts that models featuring at least level 4 will appear on the market from around 2022, while technology will be available sooner. That is because in most of the countries worldwide the regulation framework is still unclear on this topic and lacks specific legal principles about the implementation of such systems and the assignation of responsibilities, but in Europe this situation will change soon. In France there has been over 50 autonomous vehicles projects since 2014 and, according to many newspapers, by the end of this year there will be the first legislation proposal to allow the usage of level 3 and 4 autonomous private cars, robotaxis and delivery vehicles. In June 2018 Germany became the first country worldwide to legalize the use of “highly autonomous” driving systems, setting some limitations: the constant presence of a licensed driver, the possibility for the driver to override the system at any moment and the presence of a data recorder on board [31]. The italian government approved at the beginning of 2018 a law that introduced the possibility to request the permit to test autonomous vehicles and, after that, to test them in a specifically designed area in Turin. This kind of tests will start by the end of the year. The main advantage of autonomous driving up to level 4 is the significant increase in safety: blind spot detection, emergency braking, lane departure warning, lane keeping, adaptive cruise control and automatic overtaking are all systems relying on cameras and radars constantly monitoring the situation much better than drivers that can lose focus, be distracted or accidentally fall asleep. With such technologies, a significant part of repair expenses due to small “city” collisions will be avoided and insurances’ fees will be reduced too, if the probability of accidents is decreased. In addition to this, for full autonomous vehicles there will be also other significant operating costs reductions: there would be no need to have a driver for each vehicle, but a supervisor for a group of 6-8 vans will be enough and the vehicle will always drive in the most efficient way maximizing fuel economy. The proposed concept will be made available with standard level 4 autonomous driving and level 5 as optional. In the first case the vehicle will be able to autonomously drive in certain situations freeing the driver so that he can focus on other tasks and, when he takes control, the van will be able to access the crowded and narrow streets that characterizes many European historical city centres, where a driverless vehicle will not be able to drive. The level 5 version will allow the maximum operational cost reduction for deliveries in suburban areas, during the night when the traffic is low or where the layout of the city is compatible with it. Being the delivery segment characterized by large fleets, such double solution allows logistic companies to maximize their savings with level 5 autonomous driving where possible and to increase van safety and productivity with level 4 in areas where the driver is still needed. Since in 2025 some markets could still not be ready for the shift towards driverless vehicles, offering these two versions allows OEMs to maximize their potential customer base and competitiveness. Price Waterhouse Cooper estimates that 40% of the mileage driven in Europe could be covered by autonomous vehicles in 2030.

9.2.3 Drones

Another important characteristic that will be a game changer for deliveries in the next years are drones: a recent study highlighted that around 90% of e-commerce packages weights less than 2.5 kilograms, making them perfectly suitable for aerial delivery. As we have seen, Workhorse already implemented a "real life" trial of this technology paired with delivery vans; such application has a huge potential both in terms of cost reduction and of productivity increase. While the driver, if there would be one, is delivering a package A, simultaneously a drone can bring package B to another customer and maybe a second drone could be picking up a returned item from another place and bringing it to the van. To avoid the creation of a bottleneck at the "sorting stage", when items have to be loaded on drones or stored in the van, an on-board automatic system for warehousing must be implemented in the cargo space of the vehicle, so that drones can work autonomously. Another advantage provided by this type of delivery is that drones require much less energy per kilometre than electric vans (the ration is around 1 to 10 [28]), thus can be used to deliver parcels that are outside of the main route of the truck, extending the range within which a single van can deliver. As in the case of driverless vehicles, also for delivery drones the highest barrier to adoption is determined by local legislations. Up to now, only in a few countries worldwide remotely controlled or autonomous drones' flight has been regulated or has been approved for some trials. Aerial safety and privacy are still major concerns, especially for urban areas. The first issue can be addressed by having a supervisor every 3-4 active drones that can monitor flights and take control in case of emergency; the latter needs a regulatory framework because to fly and guarantee safety drones must use cameras and many other devices to monitor the surrounding environment. Despite this, Price Waterhouse Cooper's report (mentioned in section 9.1.1) highlights that 38% of interviewed customers declared to be ready for receiving their packages by drones, a percentage that grew significantly with respect to the previous year's survey and that will keep growing in the next years, according to analysts. A light commercial vehicle that will be launched in 2025 should feature all the necessary technologies for aerial deliveries as optional, so that logistic companies will benefit from the productivity increase and cost reduction in areas where such technology will be allowed and, at the same time, customers operating in countries where unmanned aerial vehicles will still be forbidden will not have to pay for it.

9.2.4 Modular architecture

To overcome both drones' and autonomous vehicles' regulation delays and in order to increase customers' value, the next generation van should be modular. The idea is to have a single wheelbase chassis on which different modules can be assembled. Specifically, the wheelbase will be almost completely flat and house all the basic components of the vehicle such as the electric motors directly attached to front and rear axle, a modular battery, all devices needed to have level 4 autonomous driving, the 5G connectivity system and the main control unit. At the beginning there will be two main different modules. The first add-on, let's call it A, will have a cabin, and a cargo space equipped with a fully automatic and removable rack. In this way it can be loaded with packages and deliverables directly in the warehouse facility and only after placed inside the van. This system will guarantee a fast and careful sorting of deliverables and allows drones to operate independently from the driver. The cargo chassis will be accessible by two different shutters, one on the sidewalk side and the other on the roof. The side-opening will feature a control mechanism with a QR- (or bar-) code scanner and a facial recognition one allowing the vehicle to recognize the operator and provide him the package associated with that code. An additional module that can be placed on the roof will be the "hangar" for a couple of delivery drones, being a safe deposit that provides both access to the load compartment and to an on-board charging network. The second module (B) will provide a load compartment and all the additional technology needed for level 5 autonomous driving, without any cabin. The internal rack, drones' add-on and the two shutters will be the same as the previous module's ones. A modular solution allows a reduction of vehicles' depreciation cost for fleet owners and gives them the opportunity to update or change a certain technology at lower cost, by replacing only the single part and not the whole vehicle. OEMs could easily develop additional versions of modules and removable racks that can respond to specific needs, such as a refrigerated compartment for example, later on. Offering a product designed for deliveries that can be adapted to specific usages creates additional value for customers that would pay a higher price for such product; moreover, the purchase of both basic chassis and modules creates a lock-in effect that could stimulate re-purchase and customer loyalty.

9.2.5 Technology summary

Summarizing the technological choices up to now, the concept proposed for a vehicle to be launched in 2025 is a full electric van that aims at reducing the impact of mobility on the environment and at increasing final customers' satisfaction through product differentiation and operational costs reduction. The vehicle will be specifically designed for the delivery segment and based on a modular platform that at the beginning will allow four different combinations based on two main modules (A and B) and an add-on (for drones). The A module is a solution that eliminates air pollution and noise and can be adopted in countries or cities where regulations concerning drones and autonomous driving will be particularly delayed, where these practices will be forbidden or not suitable because of urban layout. Anyway, featuring level 4 autonomous driving systems, it will considerably increase drivers' safety. In the countryside or in areas where it is allowed, the A module can be equipped with drones managed by a specific add-on placed on the roof; this would increase the productivity of delivery and return processes. The second module, B, will be the real game changer. Together with the basic chassis, it will generate a self-driving vehicle that can be equipped with drones. The complete version (B plus drones), will considerably change the use case of this type of vehicles. In the door to door delivery process the driver ringing the bell will be substituted by a notification through an app that will provide customers with a QR- or bar code to open the shutter when the van is approaching. Some deliveries or returns can be performed simultaneously by the vehicle and one or two drones significantly reducing delivery times and battery usage. The vehicle can also be parked in strategic places where clients can go and withdraw their packages while drones deliver other items. This could also be done at the end of a traditional delivery route to decrease the rate of "second day" deliveries. Both main modules will have an automated removable rack in the cargo area that will increase productivity, permit drones to work autonomously and allow final customers to withdraw their packages from the driverless version of the van. Modularity represents an opportunity to expand as much as possible the potential customer base and to provide logistic companies with vehicles that fit their specific requirements.

9.3 Market positioning

After having identified the customer segment to focus on and the main technologies and innovations to be implemented in order to satisfy the specific mission requirements, let's consider now some more technical aspects that are key success factors in the light commercial vehicles' market: payload, load volume, dynamic performances and, since it's a BEV, range. For each of them will be set a target value to satisfy mission's requirements and to remain competitive on the market.

9.3.1 Range, payload and volume

Traditionally LCVs are designed to belong to a specific segment, Compact, Medium or Large, according to their dimensions determined by the platform on which they are based; usually for vehicles belonging to the same segment, there are only slight differences in terms of cargo volume and payload. Compared to traditional ICE vehicles, usually a full electric van has a slightly lower payload because of the weight of the battery. The integration of this last one into the chassis allows to maintain the volume at the same level of combustion LCVs. Speaking about the concept, the high delivery rate allowed by drones and the automatic onboard sorting system, that also need some dedicated space, require high capacity volumes that can be granted only by a 2G segment van. Figure 40 summarizes the positioning of all competitors in the European market of BEV light commercial vehicles and the target positioning of our concept.

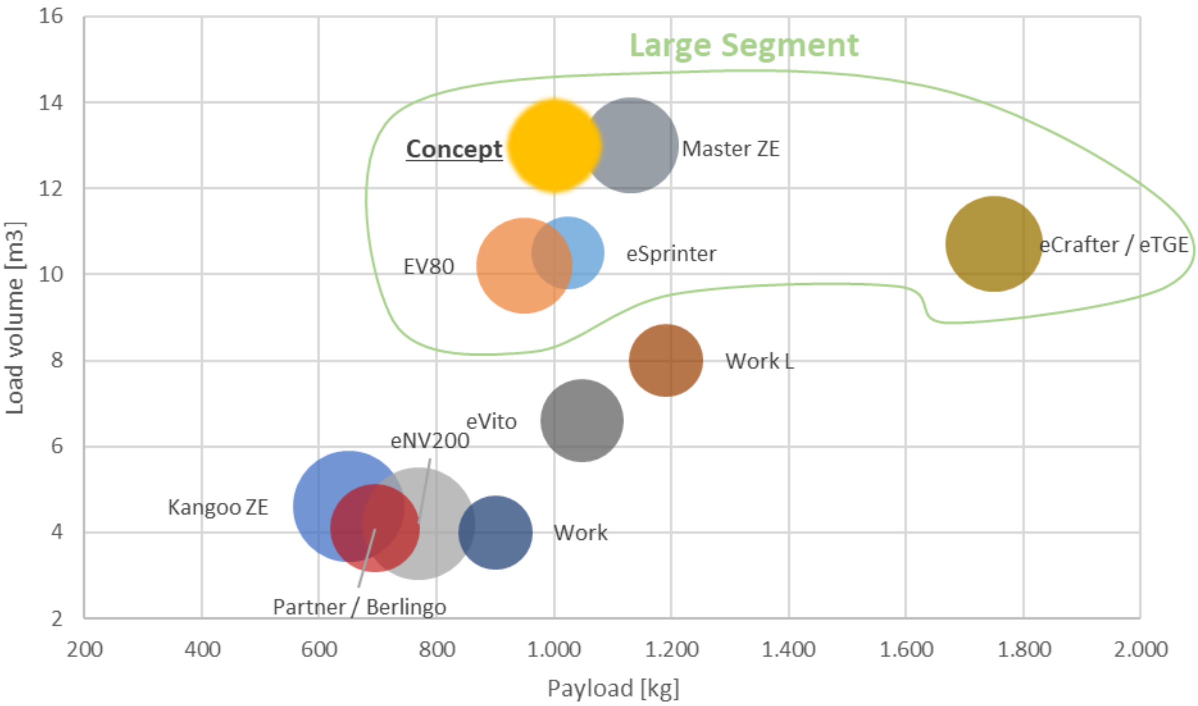

Figure 40 - Positioning of current and announced full electric LCVs

As you can see, large segment's vehicles are spread in the table, with a payload varying from 950kg to 1,750kg and a volume ranging from 10.5m^3 to 13m^3. Considering the nature of packages delivered with e-commerce (90% are below 2.5 kilograms, see paragraph 9.2.3) and, as we said, the high delivery rate of the vehicle, volume must be as high as possible while payload can be less than the admissible on vehicles for other types of missions such as moving construction materials or general haul usage. The best positioning will be having a 1,000kg payload to be in line with most of current and announced competitors and a 13m^3 load volume, aligned with the Renault Master that is currently the electric model offering more on-board space. Regarding the range, a target of 250km has been set; doing so, theoretically over 60% of large vans' users will be satisfied and this figure will reach the totality of costumers considering only the delivery segment and that drones can cover many consignments and are more energy efficient than an electric light commercial vehicle. In addition to this, the usage of the autonomous vehicle (base plus Module B) as a movable depot where customers can pick up their orders or return items will furtherly decrease the distance covered daily by each vehicle.

9.3.2 *Dynamic performances*

The last technical aspects that must be set to define the concept and that is taken into account by customers to select a van to be purchased are dynamic performances. Those include electric motor power, maximum speed and acceleration. Since the powertrain is fully integrated in the basic chassis of the modular van, these specifications will be the same for both, vehicles integrating the A module and vehicles equipped with the B one. Here is the mapping of actual and announced BEV competitors on 2G segment.

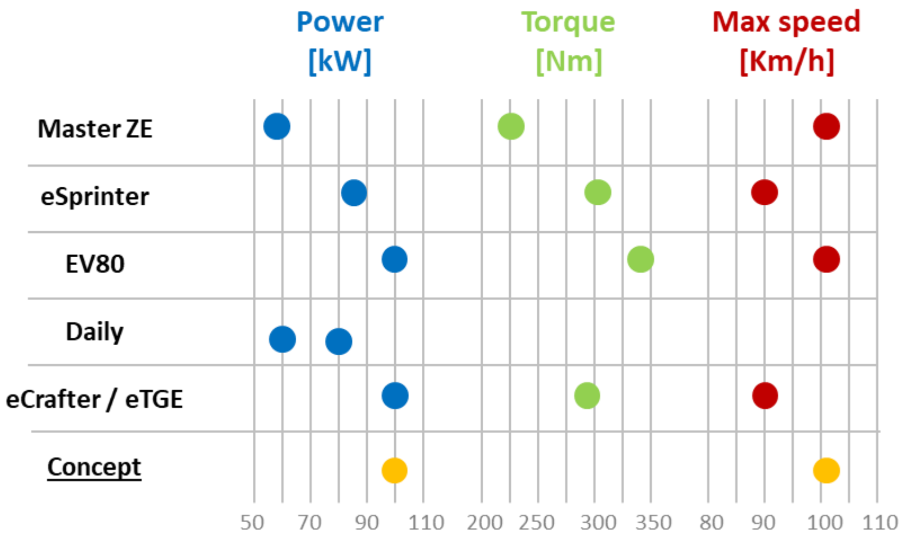

Figure 41 - Dynamic performances of large BEV vans

Considering the additional weight for the automated rack system, the drones' hub and the technologies for level 4 or 5 autonomous driving, the power should be 100kW with 280Nm of torque, aligned with Volkswagen models that can carry higher payloads than our concept. Regarding the maximum speed, it can be set to 100km/h to be in line with competitors for the version with the driver; in case of autonomous driving the speed can be limited via software according to the location of the vehicle: historical city centres, suburbs or highways. Considering the ICE vehicles currently available in the large segment, the 0-100km/h acceleration should take less than 15 seconds, while the 0-50km/h target is 6 seconds.

Such values represent only a starting point based on competitors and preliminary analysis, they must be evaluated and corrected after having defined precisely all the other specifications of the vehicle such as the gross weight, precise dimensions and design, aerodynamic coefficients and many others.

9.4 New customer needs and contents

The significant change in powertrain and on-board technologies involves not only legislative and technical challenges, but also generates completely new customer requirements and opens new business opportunities. Even if these arguments and the financial evaluation of new businesses will go beyond the scope of this work, in this section are presented many features and contents that are already being discussed and developed in the automotive sector and that will be implemented in the concept to enhance the driving experience, easily manage a fleet of electric vehicles and meet customer requirements.

9.4.1 Charging

The main concern when considering the adoption of a full electric vehicle is the charging process; in section 6.3.1 many different alternatives have been presented: charging from a traditional "domestic" socket, using wallboxes or charging stations with alternate current or fast charging (direct current). To select the most suitable option for a full electric van designed for last mile deliveries two key aspects should drive the decision: the target range of 250 kilometres, that would be more than enough to cover the required daily mileage, and the long time that this type of vehicles spend continuously parked at night, during which the battery can be charged. An alternate current system up to 22kW will be adopted on the vehicle, there is no need to install expensive fast charging technologies. If, from one side, charging on the road using the public infrastructure will be a waste of time for the operator in case of Module A configuration, this charging solution will be impossible for a driverless van. Therefore, the vehicles will be almost exclusively charged in customers' facilities and this creates new opportunities for OEMs that can sell complementary goods: wallboxes and charging services. They can make partnerships with local energy providers and electronic companies to sell and install wallboxes, bundle dedicated energy contracts with the purchase of the electric vehicle and provide pass to access the public and semi-public charging infrastructure in case of emergencies (A Module). Today many energy providers and some carmakers, Hyundai, Nissan and BMW for example, are already working on two main innovations of the charging process: scheduling and vehicle to grid. The first uses the connectivity of the vehicle and the local infrastructure to balance the power request to the grid and optimize costs: the driver (or the fleet manager or a specific software) can set, from the infotainment system or remotely, the departure time of a vehicle and the charging station or the vehicle itself will manage the charging process trying to smooth peaks of energy request to the grid - for example while charging simultaneously more than one vehicle – and taking advantage of two parts tariffs or similar cost advantages, anyway guaranteeing the percentage of charge the driver requested for a specific time. All this works within the company through a load management software installed locally on board or in the wallbox. "Vehicle to grid" (V2G) can be seen as the stage beyond the system just described: the vehicle is charged not only according to local power request conditions, but the process is managed by the energy provider at a national level. After the user sets some constraints such as "by 8:00am the battery must be 100%" or "minimum level of battery requested 30%" for a single day or a weekly schedule, the grid itself manages the charging procedure deciding when it will be the best moment to do it and optimizing continuously the level of power provided. Moreover, during demand peaks the grid can take the energy stored in vehicles' batteries to instantly increase supply. Doing so the need of temporarily activate additional powerplants when electricity request peaks is reduced, creating savings for energy providers that can reward customers for "offering" their vehicles for this practice. Another significant advantage of this system is that excess energy created through renewable sources can be temporarily stored in vehicles' batteries and used later, allowing to take advantage at full capacity of green power plants when the energy source (sun, wind or water) is available. V2G can also apply to a house or n apartment whose owner has a PHEV, REEV or BEV vehicle; in this case it is also called "Vehicle to home" (V2H). Such application was first introduced in Japan after Fukushima disaster that caused blackouts for many days in many areas. This system integrates the domestic electrical grid with the battery of a rechargeable vehicle when connected to a specifically designed charging station. Besides charging the battery, V2H can either use the energy stored in the battery to power the house or store in the vehicle the energy generated through domestic solar panels or wind turbines. Figure 42 synthetizes the V2G mechanism.

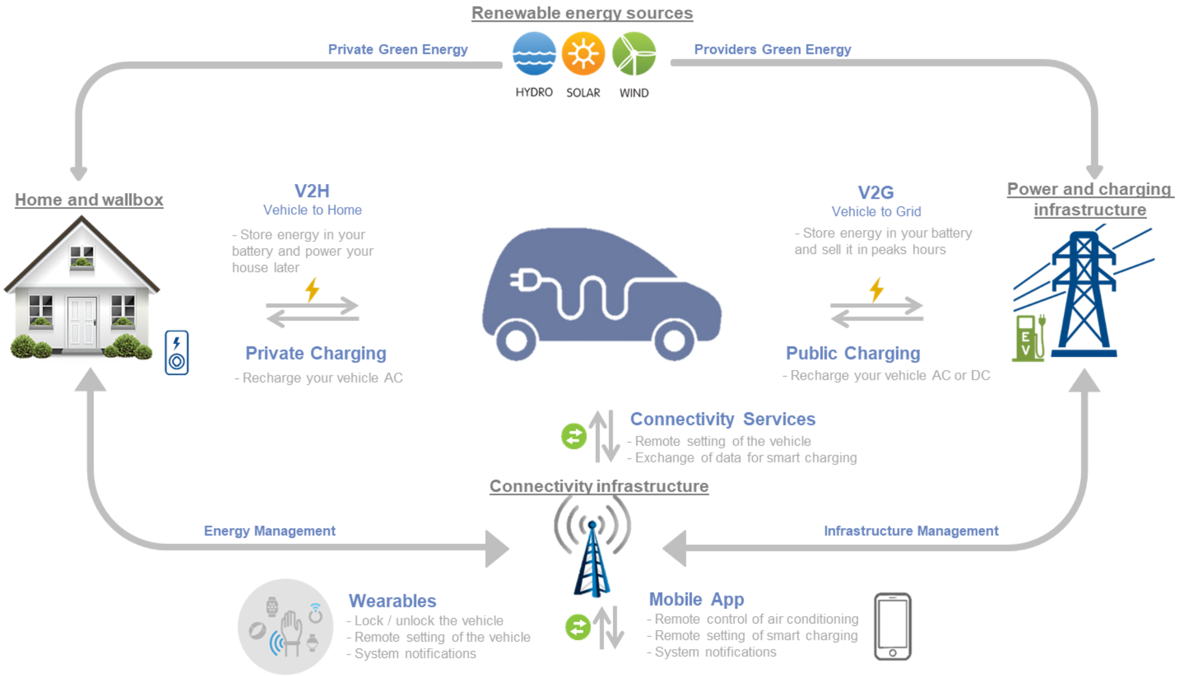

Figure 42 - Vehicle to grid

Even if a business model, standards and regulations still need to be defined for vehicle to grid, some trials are being made and some vehicles already feature this content: Mitsubishi Outlander, Nissan Leaf and Nissan eNV200 are, for example, already available in Europe. Mitsubishi did a test in the Netherlands using the over 25 thousand Outlander sold in the country, Enel and Nissan did a yearlong test using Leaf in Denmark, Edison did a trial in California in a military base [32] and a demonstration project will be implemented in different locations in Japan with Mitsubishi's hybrid vehicles [33]. These innovations will revolutionize the energy industry by making renewables sources more appealing and bringing us closer to a zero-emission society. Moreover, such systems can decrease the amount of additional energy capacity required to sustain the development of the charging infrastructure, allowing a faster deployment of this last one. Considering the great advantages of this technology and that today it is already available on some vehicles, V2G will be a standard feature in the future and, therefore, will be implemented on the 2025 model.

9.4.2 Module B

This unit aims at increasing productivity using a removable rack with an automatic distribution system placed inside the cargo space. Having the chance to load and order packages directly in the warehouse reduces the loading time for vans and increases flexibility: if the delivery schedule changes or a vehicle has a failure, it is only sufficient to substitute the rack of that specific van. A crucial recommendation for these racks is that must be compatible with the most common moving, handling and filling systems in use. To furtherly optimize time usage, it is important that these racks are sold separately from the module too, allowing to have some of them in delivering vehicles while others are been filled in the facility. Another service that must be provided to customers concerns software; an integrated program must control every aspect of the van: from monitoring of vehicle's status to scheduling the daily routes, to allow final customers to pick their packages with a QR code, supervise autonomous driving and organize drones' flights. These last two aspect must be developed guaranteeing the highest possible safety, for this reason a supervisor each 6-8 vehicles and another each 4 in-usage drones must be assigned. For this reason, OEMs need to provide periodical training courses to logistic companies' employees and need to define a structure for this service: assign this role to a specialized third party that organizes everything, from the location to the teaching, or to use dealers' network for this purpose, this last solution providing the opportunity that customers would have to periodically visit the showrooms.

9.4.3 Module A

Here, in addition to Module B requirements (except for the ones regarding autonomous driving) must be considered all contents needed in the cabin in order to maximize drivers' comfort and delivery efficiency. The trend in electrified light commercial vehicles is to adopt the same infotainment systems as passenger cars, two examples are the Nissan eNV200 that from 2018 uses the same user interface as Nissan Leaf and the new eSprinter by Mercedes that will carry over the MBUX, the new software platform developed and already in use on the passenger cars line-up. So, the cabin of the concept will feature a full digital cluster and a touchscreen head unit display where all trip information, energy usage, navigation system and driving settings are shown. The main features that will be available for drivers are different driving modes, preconditioning, eCoasting levels, turtle mode, drone management interface and, for extreme needs, charging station locator. Preconditioning allows the driver or the fleet owner to activate the heating or cooling system in the cabin remotely or according to the departure times scheduled while the vehicle is still connected to the power grid. This yields to battery savings while driving, extending the available range: a dedicated study highlighted that in winter heating a vehicle from a temperature of -14°C to 20°C can require up to 6kWh; to maximize efficiency the driver or the fleet owner must be able to schedule and easily update, if necessary, departure and charging times through an on board software and a smartphone app [34]. The availability of different driving modes allows the driver to select the best setting according to the situation. Most competitors in the market today have only two modes: normal and eco. This last one maximizes the range by reducing acceleration performances as well as top speed and the conditioning system's power. To be aligned with the market it is fundamental to implement an "Eco mode" also on our vehicle and, in order to offer something more, another setting can be carried over by passenger cars: the "Sport" mode. Obviously, the scope will be completely different in an LCV; it will be used to provide the maximum powertrain power and torque when particular situations occur: a restart at full load on a slope or in case of overtake, for example; the name could be changed to "Dynamic", "Force" or "Power" mode. The driving experience will be furtherly customized by setting the eCoasting: this permits to select the desired level of regeneration provided by the electric motor that working as a generator can simulate the engine brake of ICE vehicles. In passenger car's market the best example of this technology is Hyundai Ioniq: it has two paddles behind the steering wheel through which the driver can select among 4 levels of regenerative braking. Level 1 completely eliminates the electric motor resistance so that, once removed the foot from the accelerator, the vehicle will keep "sailing"; at the opposite side of the scale, level 4 provides the highest possible regeneration: once feet are not pushing any pedal, the van quickly slows down until almost complete stop. With such system drivers can drive using only regeneration instead of brakes to stop or slow down the vehicle, recharging the battery and increasing the range. The "Turtle Mode" has already been implemented on some vehicles and is kind of a "recovery mode" that automatically intervenes when the van battery is (almost) fully discharged: air conditioning, radio and displays are switched off to reduce energy consumption as much as possible and the driver can do one additional kilometre or some hundreds of meters at a very limited speed to park the vehicle in a safe place. The system will automatically use the cabin displays, cluster and head unit, to notify the driver when a drone delivery is available and the he can authorize the operation that, from that moment, will be supervised by a remote operator. Finally, if for any reason the level of the battery falls beyond the quantity of energy needed to return to the facility, the charging station locator function can show on the navigation map the position of chargers and some additional information such as the provider, energy prices, paying methods and the status: if it is free or someone is using it. Considering the feedback provided by customers (see section 8.2), the vehicle must come with a specific warranty for the battery covering both defects and capacity; this will reassure buyers about the reliability of electric vehicles and smooth the transition towards full electric vehicles.

9.5 Future developments

One main advantage of having a modular architecture is the ease of the update process. When the powertrain and the battery are worn or if there will be any major update in these technologies, the basic chassis can be substituted without changing the other modules, whose compatibility with next generation basis will always be guaranteed. In the next years different modules can be developed according to market trends or on customers' request: from customized load compartments to refrigerated ones or even adds-on to transport people or fluids. In addition to this, new usages for the current versions can be defined too. A fleet of vans with the driverless module can be used, after a quick rack adaptation, for a free floating "van sharing" service within cities: vehicles could be parked on streets and final customers can, through a smartphone app, request one of them for a certain amount of time; the van will autonomously reach the location the user communicated and here he can load the vehicle and enter the location where it must deliver the load. After finishing a job, the van will autonomously park in the nearby waiting for the next delivery. When the battery reaches a certain threshold, the van will autonomously drive to a dedicated facility where the basic chassis can be substituted with a fully charged one and the service can be immediately resumed. Another alternative for an OEM could be to focus on the basic chassis and a limited number of modules and open to third parties the possibility to develop additional ones with different functionalities to satisfy every market niche. The possibilities are limitless and being the first player on the market with such solution can provide a significant competitive advantage, especially if the proprietary design and interfaced become the standard in the market.

10 End of life

One of the most discussed topics nowadays is the end of life of products: production rates have grown so fast in recent year that availability of raw materials is becoming an issue and disposal of wastes is emerging as a very important aspect of each product's lifecycle. The European Union introduced over time many legislations to regulate products' disposal and this applies also to the automotive industry. Since 2000 a directive [35] specifically addresses vehicles' disposal defining recyclability thresholds, and standards to identify materials, it is made clear that manufacturers should bear costs of disposal and recycling and facilitate as much as possible the dismantle process. Since the main concern for a battery electric vehicle is about batteries' disposal and this represents also the main difference with respect to the end of life of a traditional ICE vehicle, next paragraph will briefly discuss this aspect.

10.1 Battery

Maybe it is not common knowledge, but a modern vehicle battery can be recycled up to 80% today [36] and before this, it can have had at least two different lives. Traction applications require high quality batteries providing a certain level of instant power and huge capacity; when they are no more suitable for automotive applications, they can still be perfect for other usages, having still 60% - 70% of their capacity. Some companies have already performed some experimental projects in the following are described the main ones. At the end of 2017 BMW started the construction of a pilot facility to be used as a battery farm in its factory in Leipzig. The idea behind this is to use the residual capacity of i3 and i8 batteries to balance energy consumption and production similarly to what happens with vehicle to grid. Supposing a constant level of electricity production, the excess quantity that will not be used immediately will be stored in batteries and used to cover demand peaks when request is higher than production. These systems can also be used to store electricity produced by renewable non-constant sources, such as sun, wind and tides when they are available and use it when needed. It is estimated that this "second life" for batteries can last from eight to ten years and does not require a dedicated technology on the battery itself, but this last one must be designed with a sufficiently regular shape, be easily removable from the vehicle and must be possible to connect it directly to the grid. Another interesting project to give vehicles' batteries a second life is called "E-STOR". The basic idea is to create fast charging stations using worn automotive batteries in locations where constructing a high-power connection to the power grid would be very costly. These batteries are recharged at low power, and the stored energy is then released at high power. The initiative is based on a partnership between Renault and the English Connected Energy and some stations have been already deployed in Germany and Belgium. Last summer has been announced that the system will be compatible also with Jaguar I-Pace batteries and Connected Energy received investments from both Engie, one of the largest energy providers worldwide, and Macquarie Group, an Australian investment fund [37]. After the completion of their second life, batteries can be recycled and provide new usable materials at a fraction of the cost needed to obtain them from raw natural resources.

11 Conclusion

All the information and data gathered during my internship in the Product Planning – Electrified Vehicles area of Fiat Chrysler Automobiles allowed to develop a comprehensive analysis to better understand the evolution of light commercial vehicles' market and to identify a target segment for a differentiated product that will be launched in the European market in 2025. A complete benchmark of competitors' products and many studies about customer needs and habits enabled the definition of a concept vehicle in terms of technologies, market positioning and contents.

BEVAD, that is the name of the proposed van, is a full electric vehicle with 250km of range specifically designed for deliveries and based on modularity that can be configurated in four different versions combining two main modules, A and B, and an add-on that manages two delivery drones.

The delivery segment is mainly composed by large fleets looking for vehicles with the lowest possible operational cost and will be heavily affected by the creation of low-, ultra-low- and zero emission zones and the charge of pollution fees in urban areas; considering the typical usage profile of this mission: the usual daily mileage goes from 80km up to 250km and down time in most cases is longer than 10 hours per day, the most suitable solution is a battery electric vehicle. This will help OEMs to achieve the strict CO_2 targets set by the European Parliament and provides them the opportunity to sell complementary goods such as wallboxes and charging services. Urbanization trend and the exponential growth of e-commerce are forecasted to increase, so the potential market will expand over time. The diffusion of fast and ultra-fast delivery services such as same day or even one-hour delivery determines a significant increase in complexity and costs for logistic companies that highlighted the need of a specific solution that would help them to achieve higher efficiencies and cost reductions in the logistic process. Modularity allows customers to have customized solutions for their businesses, reduced expenditures for technology updates and lower depreciation costs. Module A and B can be mounted and a common base with four wheels that hosts the electric motors, the battery, devices for level 4 autonomous driving, the connectivity system and the main control unit. Module A includes a cabin for the driver and an innovative cargo space featuring a removable automatic rack. Such configuration generates savings because of the lower cost of electricity compared to traditional fuels, allows greater productivity since the automatic rack decreases the time needed for each delivery and can be filled in the warehouse while the van is still in use; moreover, electric motors guarantee higher reliability than traditional ICE and level 4 autonomous driving can reduce repair and insurance expenses. The cabin will feature many innovative contents that will enhance the driving experience of a BEV and optimize its efficiency. Module B has the same cargo space as the previous one and integrates all the additional systems needed to upgrade the vehicle from level 4 to 5 of autonomous driving; there is no cabin in this case. This composition will allow the lowest possible operational costs in areas where urban layout and local legislation permits it. Both modules can be integrated with the drones' add-on that will furtherly increase productivity and the delivery range of a single vehicle, being more energy efficient. In the future additional modules can be offered to satisfy other specific needs and expand the potential customer base. Given the high delivery rates allowed by the technologies adopted, the vehicle is positioned in the large segment so that it can transport as many packages as possible within the same shift. A first approximation for dynamic performances has been proposed to be competitive in the market but further analysis when vehicle's specifications will be more detailed are needed. The following step for this concept is the construction and evaluation of the business case and, if it will be considered profitable, the beginning of the detailed design and engineering phase.

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Today is the beginning of a new adventure,

Thank you all,

Valerio

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