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Perspective for Electro-Mobility in European Cities

Master of Science Thesis in Energy Engineering

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Abstract

The electric engine provides smooth acceleration and deceleration, and a quiet ride, which all leads to a better driving experience. Another benefit of EVs over gas powered vehicles is improved acceleration and more horsepower. Electric car motors don't have a transmission and deliver the power directly to the wheels. In the near future the focus on providing electric vehicles for transport will increase and that is why in this study the attentions have paid to perspective of electric mobility.

In this study in the first chapter policy and analysis of market for Electric Vehicles (EV) are investigated. In this chapter the catigorization for policies and legislations are prepared. Also the trend of market and car models in the market and also manufacturers contribution have been studied. Furthermore in this chapter private sector demand for zero-emission vehicles signals market to dvelop electric vehicles are dealt with. At the end of chapter 1 case of Italy is regarded.

Chapter 2 provides information about low-carbon logistics and EV applications. Green logistics is introduced which its ultimate goal is to minimize the impact of logistics activities on the environment and achieve sustainable development. Project FREVUE which involves 8 european cities including Amsterdam, Lisbon, London, Madrid, Oslo, Milan, Rotterdam and Stockholm is presented. Furthermore in this chapter technical, operational economical and policy insights from FREVUE project are provided. Also The Italian Plan on electric charging infrastructures (PNIRE) and their goals are presented to clear some ideas about power stations and their capacities.

Chapter 3 allocates to conclusion and future developments about this study.

Key-words: Electric Vehicles, low-carbon logistics, project FREVUE, PNIRE

Contents

Introduction

Ten million electric cars were on the world's roads in 2020. It was a pivotal year for the electrification of mass market transportation. Sales of electric cars were 4.6% of total car sales around the world. The availability of electric vehicle models expanded. New initiatives for critical battery technology were launched. And this progress advanced in the midst of the Covid-19 pandemic and its related economic downturn and lockdowns.

Over the last decade a variety of support policies for electric vehicles (EVs) were instituted in key markets which helped stimulate a major expansion of electric car models. But the challenge remains enormous. Reaching a trajectory consistent with the IEA Sustainable Development Scenario will require putting 230 million EVs on the world's roads by 2030. [1]

For EVs to unleash their full potential to combat climate change, the 2020s will need to be the decade of mass adoption of electric light-duty vehicles. In addition, specific policy support and model expansion for the medium- and heavy-duty vehicle segments will be crucial to mitigate emissions and make progress toward climate goals. Europe has an ambitious goal to become a climate-neutral continent by 2050. To achieve this target, the European Commission will announce a multitude of new legislative proposals in the coming years. Many of them target mobility.

The European Commission is seeking to have at least 30 million electric vehicles on the roads by the end of this decade – a massive increase from the current 1.4 million EVs on the European streets. Reaching this goal demands a set of regulations and targets to steer states, companies, and consumers in the right direction.

Currently, the European Union promotes the rise of electric mobility in multiple ways, from pushing the car manufacturers to produce low emission vehicles to supporting the development of comprehensive charging infrastructure. [2]

The EU's unique 750 billion euro stimulus package includes 20 billion euros to boost the sales of clean vehicles, and 1 million electric and hydrogen vehicle charging stations are to be installed by 2025. In addition, many countries are directing their own national economic recovery investments to the infrastructure of the future: electric vehicle charging.

1 Policy and market analysis for EV

In this chapter with more focus on EU countries, policy, and market for EVs are investigated.

Significant fiscal incentives spurred the initial uptake of electric light-duty vehicles (LDVs) and underpinned the scale up in EV manufacturing and battery industries. The measures – primarily purchase subsidies, and/or vehicle purchase and registration tax rebates – were designed to reduce the price gap with conventional vehicles. Such measures were implemented as early as the 1990s in Norway, in the United States in 2008 and in China in 2014. [3]

Gradual tightening of fuel economy and tailpipe CO_2 standards has augmented the role of EVs to meet the standards. Today, over 85% of car sales worldwide are subject to such standards. CO_2 emissions standards in the European Union played a significant role in promoting electric car sales, which in 2020 had the largest annual increase to reach 2.1 million. Some jurisdictions are employing mandatory targets for EV sales, for example for decades in California and in China since 2017.

Convenient and affordable publicly accessible chargers will be increasingly important as EVs scale up. To help address this, governments have provided support for EV charging infrastructure through measures such as direct investment to install publicly accessible chargers or incentives for EV owners to install charging points at home. In some places building codes may require new construction or substantial remodels to include charging points, for example in apartment blocks and retail establishments. [3]

Effort by cities to offer enhanced value for EVs has encouraged sales even outside of urban areas. Such measures include strategic deployment of charging infrastructure and putting in place preferential/prohibited circulation or access schemes such as low- and zero-emission zones or differentiated circulation fees. Such measures have had a major impact on EV sales in Oslo and a number of cities in China. [4]

Making the 2020s the decade of transition to EVs requires more ambition and action among both market leaders and followers. In markets that demonstrated significant progress in the 2010s, a primary direction in 2021 and beyond should be to continue to implement and tighten, as well as to broaden, regulatory instruments. Examples include the European Union CO_2 emissions regulations for cars and vans, China's New Energy Vehicles (NEV) mandate or California's Zero-Emission Vehicles (ZEV) mandate. [3]

Near-term efforts must focus on continuing to make EVs competitive and gradually phasing out purchase subsidies as sales expand. This can be done via differentiated taxation of vehicles and fuels, based on their environmental performance, and by reinforcing regulatory measures that will enable the clean vehicle industry to thrive.

In the long term, realizing the full potential for EVs to contribute to cut vehicle emissions requires integration of EVs in power systems, decarbonization of electricity generation, deployment of recharging infrastructure and manufacturing of sustainable batteries. [5]

Countries that currently deploy limited numbers of electric cars can profit from the lessons learned and advances already made in automotive and battery technology to support the production and uptake of EVs. Product innovation and the expertise developed in the charging services industry will also be beneficial for emerging economies. But they will also need to significantly tighten fuel economy and emissions standards. Emerging economies with large markets for second-hand imported cars can use policy levers to take advantage of electric car models at attractive prices, though they will need to place particular emphasis on implications for electricity grids. [6]

To date, more than 20 countries have announced the full phase-out of internal combustion engine (ICE) car sales over the next 10-30 years, including emerging economies such as Cabo Verde, Costa Rica and Sri Lanka. Moreover, more than 120 countries (accounting for around 85% of the global road vehicle fleet, excluding two/three-wheelers) have announced economy-wide net-zero emissions pledges that aim to reach net zero in the coming few decades. [3]

Policy attention and actions need to broaden to other transport modes, in particular commercial vehicles – light-commercial vehicles, medium- and heavy-duty trucks, and buses – as they have an increasing and disproportionate impact on energy use, air pollution and CO_2 emissions. Medium- and heavy-duty vehicles represent 5% of all four-wheeled road vehicles in circulation but almost 30% of CO_2 emissions. Progress in batteries has led to rapid commercialization in the past few years of more and more models in ever heavier weight segments and with increasing ranges.

In 2020, California was the first to propose a ZEV sales requirement for heavy-duty trucks. The Advanced Clean Truck Regulation is due to take effect from 2024. The Netherlands and a number of other countries are implementing zero-emission commercial vehicle zones and pioneering deployment efforts. Although this is a hard-to-abate sector and there are competing decarbonization pathways (including hydrogen and biofuels), the electrification of medium and heavy-duty vehicles is increasingly recognized as a promising pathway to reduce both local pollutant and CO_2 emissions. Electrification of HDVs requires policy support and commercial deployment similar to that which passenger cars enjoyed in the 2010s. Electric buses are already making a dent in key cities around the world, supported by national and local policies that target air pollution. Policy measures to promote electric buses are diverse; they may include competitive tenders, green public procurement programs, purchase subsidies and direct support to charging infrastructure deployment, as well as effective pollutant emissions standards. [7]

Given their enormous number and popularity, electrifying two/three-wheelers in emerging economies is central to decarbonizing transport in the near term. China is taking a lead with a ban of ICE versions of two/three-wheelers in a few cities.

Then there are two pictures showing light-duty and heavy-duty vehicle policies and incentives in different countries with more focus on the EU in the after explanations. In these two tables Canada, China, the EU, India, Japan, and the United States are compared. [8,9]

Current zero-emission light-duty vehicle policies and incentives in selected countries

		Canada	China	European Union	India	Japan	United States
Regulations vehicles	ZEV mandate	**British Columbia**: 10% ZEV sales by 2025, 30% by 2030 and 100% by 2040. **Québec**: 9.5% EV credits in 2020, 22% in 2025.	**New Energy Vehicle dual credit system**: 10-12% EV credits in 2019-2020 and 14-18% in 2021-2023.				**California:** 22% EV credits by 2025. **Other states:** Varied between ten states.
	Fuel economy standards (most recent for cars)	114 g CO_2/km or 5.4 L/100 km*** (2021, CAFE)	117 g CO_2/km or 5.0 L/100 km (2020, NEDC)	95 g CO_2/km or 4.1 L/100 km (2021, petrol, NEDC)	134 g CO_2/km or 5.2 L/100 km (2022, NEDC)	132 g CO_2/km or 5.7 L/100 km (2020, WLTP Japan)	114 g CO_2/km or 5.4 L/100 km*** (2021, CAFE)
Incentives vehicles	Fiscal incentives	✓	✓	✓	✓	✓	✓
Regulations chargers**	Hardware standards.	✓	✓	✓	✓	✓	✓
	Building regulations.	✓*	✓*	✓	✓		✓*
Incentives chargers	Fiscal incentives	✓	✓	✓	✓	✓	✓*

Figure 1.1: light duty (vehicle and chargers) regulations and incentives

Current zero-emission heavy-duty vehicle policies and incentives in selected countries

Policy Category	Policy	Canada	China	European Union	India	Japan	United States
Regulations vehicles	ZEV sales requirements			Voluntary to earn credits economy standards under fuel. Municipal vehicle purchase requirements.			**California:** new bus sales 100% ZEV by 2029. **California and New Jersey:** new truck sales up to 75% by 2035.
	Fuel economy standards	✓	✓	✓	✓	✓	✓
	Weight exemptions			2 tonnes over class.			**California:** 2 000 pounds over class.
Incentives vehicles	Direct incentives	✓*	✓*	✓*	✓	✓	✓*
Incentives fuels	Low-carbon fuel standards	✓*					✓*
Incentives EVSE	Direct investment	✓			✓	✓	✓*
	Utility investment						✓*

Figure 1.2: heavy duty (vehicle and charger) regulations and incentives

1.1. Legislation and Policies

1.1.1. The EU policies

As part of its pandemic-related response, the European Union accelerated the roll-out of electric mobility through its commitment to decarbonization in the EU Green Deal8 and the subsequent Next Generation EU and Recovery Plan. In December 2020, the EU Sustainable and Smart Mobility Strategy and Action Plan bolstered these plans for the transport sector with ambitious ZEV deployment goals. [3]

A number of EU directives and regulations are under review to adapt them to achieve stated ambitions. These include CO_2 emissions performance standards for cars and vans; Alternative Fuels Infrastructure Directive; European Energy Performance of Buildings Directive (which supports the deployment of charging infrastructure); Batteries Directive of 2006 which is being complemented by a proposed Batteries Regulation announced in December 2020 and the EURO pollutants emissions standard.

Corporate fleet average tailpipe emissions are targeted to go below 95 grammes of carbon dioxide per kilometer (g CO_2/km) in 2021 under the CO_2 emissions standards. EVs are increasingly important to meet the targets and a driving factor explaining why EV sales rose in 2020 despite Covid-19 and the automotive sector's overall downturn. The next targets push emissions to fall 15% in 2025 and 37.5% by 2030 from 2021 levels. These targets are being revised with a view to better support the EU Green Deal ambitions. Revisions are likely to include lower emissions targets, modifications in the role of zero and low emission vehicles (ZLEVs) (emissions under 50 g CO_2) and possibly a well-to-wheel approach rather than the current tailpipe (tank-to-wheel) approach. [3]

In early 2021, nine EU countries urged the European Commission to accelerate an EU-wide phase out of petrol and diesel cars. This could create legislation allowing member states to enforce national ICE bans.

In addition to EU policies and directives, many countries in Europe are continuing EV subsidy and incentive measures. In some, pandemic relief stimulus measures have favored alternative powertrains with supplemental purchase subsidies and cash-for-clunker schemes.

In the Europe Union, the Alternative Fuel Infrastructure Directive (AFID) is the main measure guiding the roll-out of publicly accessible EV charging stations. EU members are required to set deployment targets for publicly accessible EV chargers for the decade to 2030, with an indicative ratio of 1 charger per 10 electric cars. The EU Green Deal raised the bar with a target of one million publicly accessible chargers installed by 2025 and set out a roadmap of key actions to achieve it. This includes revisions to the AFID in 2021. Some proponents call for it to be converted to an enforced regulation which would allow the establishment of binding targets for member states, to revise the 1 charger per 10 electric cars ratio, to give EU citizens the right to request the installation of charging points right to plug regardless of location and to include provisions for HDVs. [3]

The AFID also sets targets for the deployment of chargers along the Trans-European Transport Network (TEN-T) core network, which has been reviewed in 2021. To inform the review three large industry associations signed a joint letter that proposes to formalize charging point targets to 2029 and an ultra-fast charging network along the TEN-T. Other have stated the importance of these revisions to ramp up charging infrastructure to meet increasingly ambitious OEM targets and the variety of available EV models.

EU member states are implementing the revised European Energy Performance of Building Directive (EPBD III), which sets requirements for residential and non-residential buildings to improve access to charging points. The Recovery and Resilience Facility, a EUR 672.5 billion fund, include support for charging stations.

An interconnected European EV charging network also depends on the ambitions of individual countries. Leading countries such as Germany, France, Netherlands, Sweden, and Italy have national policies and targets to encourage development that range from grants and fiscal incentives for installation of public and private chargers to free public charging in urban areas. [3]

1.1.2. Measures deployment by EU countries

The below tables highlight key policies and measures that support the deployment of electric vehicles (EVs) and zero-emission vehicles (ZEVs) for light-duty vehicle (LDV) and heavy-duty vehicle (HDV) models. It summarizes existing measures as well as announced targets and ambitions by region and country. These take a variety of forms, such as fuel economy standards, CO_2 emissions standards, deployment roadmaps, and EV sales or stock targets and ambitions. The table does not include fiscal policies such as subsidies, carbon taxes or similar policy instruments. [3]

The policies and measures are structured in four categories:

- Legislation: Legally binding commitments such as regulations and standards.
- Targets: Announced government targets that are part of legislation, budgetary commitments, Nationally Determined Contributions to the Paris Climate Agreement or national climate plans such as those submitted by member states to the European Union.
- Ambitions: Government goals or objectives as set out in a policy document such as a deployment roadmap or strategy.
- Proposals: Government goals released in public documents or embedded into legislation designed to stimulate discussion as to their feasibility. These often bring forward deadlines for phase out of gasoline or diesel vehicles, presented from one member country to a regional government body (e.g. by member states to the European Union), or they build upon current ambitions, targets, and/or legislation.

Table 1.1: Legislation measures in the EU [3]

Country/ region	Policy type	Key policy measures and targets	Year announced	Vehicle type	Source
European Union	Legislation	Revision of the Clean Vehicles Directive including minimum requirements for aggregate public	2019	Heavy-duty vehicles	European Parliament (2019)

		procurement for urban buses (24-45% in 2025 and 33-65% in 2030), and for trucks (6-10% in 2025 and 75% in 2030) with the share varying across member states.			
European Union	Legislation	CO_2 emissions standards for new heavy commercial vehicles to tighten by 15% by 2025 and by 30% by 2030 (reference period: 2019/2020)	2019	Heavy-duty vehicles	European Union (2019)
European Union	Legislation	CO_2 emissions standards in terms of g CO_2/km) for cars to tighten by 15% between 2021 and 2025 and 37.5% between 2021 and 2030 and for vans by 15% between 2021 and 2025 and 31% between 2021 and 2030.	2019	Light-duty vehicles	European Union (2019)
European Union	Legislation	CO_2 emissions standards for new cars: 95 g CO_2/km from 2020,	2019	Light-duty vehicles	European Union (2019)
The Netherlands	Legislation	Zero emission transport zones to be introduced in 14 cities by 2025 (number expected to increase to 30 by mid-2021).	2021	all	Government of Netherlands (2021

Table 1.2: Target measures in the EU [3]

Country/ region	Policy type	Key policy measures and targets	Year announced	Vehicle type	Source
Belgium	Target	Flanders region target: 20% ZEV sales by 2025 and 50% BEV or FCEV sales and 20% PHEV in 2030.	2020	Light-duty vehicles	Flemish Government (2019)
European Union	Target	Voluntary ZEV targets: 15% share of car sales by 2025 and 35% by 2030 and 15% share of van sales by 2025 and 30% by 2030 by vehicle manufacturers. If met, the CO_2 emissions target can be relaxed for that manufacturer	2019	Light-duty vehicles	European Commission (2019)
European Union	Target	Target: 13 million passenger ZEV stock by 2025 (based on CO_2 emissions standard for LDVS)	2019	Light-duty vehicles	European Green Deal(2019)
France	Target	Target: 500 000 passenger PHEV and 660 000 passenger BEV and FCEV stock and 170 000 light commercial BEV and FCEV stock by 2023. Target: 18 million passenger PHEV and 3 million passenger BEV and FCEV stock and 500	2020	Light-duty vehicles	Government of France (2020)

		000 light commercial BEV and FCEV stock by 2028			
Greece	Target	Target: at least 30% share of passenger electric LDV sales by 2030.	2019	Light-duty vehicles	Government of Greece (2019)
Hungary	Target	Target: 1 290 urban bus stock by 2029. From 2022 onwards, only electric buses will be funded.	2019	Heavy-duty vehicles	Government of Hungry(2019)
Iceland	Target	Target: ban sales of passenger petrol and diesel LOVs by 2030	2018	Light-duty vehicles	Government of Iceland 2018)
Ireland	Target	Target: ban sales of diesel-only urban buses from 2019.	2018	Heavy-duty vehicles	Government of Ireland (2018)
Ireland	Target	Target: 100% share of passenger LDV sales to be EVs by 2030.	2019	Light-duty vehicles	Government of Ireland (2019)
Ireland	Target	Target: 950 000 electric passenger LDV stock by 2030.	2019	Light-duty vehicles	Government of Ireland (2019)

Italy	Target	Target: 6% gross final energy consumption to come from electric cars in 2030.	2019	Light-duty vehicles	Government of Italy (2019)
Italy	Target	Torget: 6 million passenger electric LDV stock (including 4 million BEVs) by 2030.	2019	Light-duty vehicles	Government of Italy (2019)
Norway	Target	Target: 100% ZEV (or biogas) urban bus sales by 2025. Target: 75% ZEV inter-city bus sales and 50% truck sales by 2030.	2016	Heavy-duty vehicles	Government of Norway (2016)
Norway	Target	Target: 100% ZEV sales in passenger LDS by 2025	2016	Light-duty vehicles	Government of Norway (2016)
Portugal	Target	Target more than 30% EV sales in passenger LDVs by 2030 and 100% by 2050.	2019	Light-duty vehicles	Government of Portugal (2019)
Slovenia	Target	Target no new sales of passenger LDVs with CO_2 emissions above 50 g CO_2/km in 2030.	2017	Light-duty vehicles	Republic of Slovenia (2017)
Spain	Target	Target: 5 million electric LDVs, buses and	2020	Multiple	Government of

		two/three-wheelers in 2030.			Spain (2020)
The Netherlands	Target	Target: 100% of public urban bus sales to be ZEV by 2025 and 100% ZEV stock by 2030	2019	Heavy-duty vehicles	Government of the Netherlands (2019)
The Netherlands	Target	Target: 50% taxi stock to be ZEV by 2025	2019	Light-duty vehicles	Government of the Netherlands (2019)
The Netherlands	Target	Target: 3 000 heavy duty FCEV by 2025	2019	Heavy-duty vehicles	Government of the Netherlands (2019)
The Netherlands	Target	Target: 15 000 stock of passenger FCEVS by 2025 and 300 000 by 2030.	2019	Light-duty vehicles	Government of the Netherlands (2019)

Table 1.3: Ambition measures in the EU [3]

Country/ region	Policy type	Key policy measures and targets	Year announced	Vehicle type	Source
Denmark	Ambition	Ambition: 1 milion passenger LDV stock to be ZEV by 2030	2020	Light-duty vehicles	Government of Denmark (2020)
European Union	Ambition	Ambition: at least 30 million passenger ZEV stock by 2030 and nearly all passenger LDV and heavy commercial vehicle stock by 2050	2020	All	European Commission (2020)
Finland	Ambition	Ambition: 4 600 electric HDV stock by 2030.	2021	Heavy-duty vehicles	Government of Finland (2021)
Finland	Ambition	Ambition: 700 000 electric car and 45 000 electric van stock by 2030 (of which at least 50% are BEVS).	2021	Light-duty vehicles	Government of Finland (2021)
France	Ambition	Ambition: 5 000 passenger and commercial LDV FCEV stock by 2023 and 20 000-50 000 by 2028	2018	Light-duty vehicles	Government of France (2019)

France	Ambition	Ambition: 200 heavy commercial FCEV stock by 2023. Ambition: 800-2000 heavy commercial FCEV stock by 2028	2018	Heavy-duty vehicles	Government of France (2019)
Germany	Ambition	Ambition: 50% of urban buses to be electric by 2030.	2020	Heavy-duty vehicles	Hybrid and Electric Vehicle Technology Collaboration Program (2020)
Germany	Ambition	Ambition: all passenger LDV sales to be ZEV by 2050.	2015	Light-duty vehicles	ZEV Alliance (2015)
Germany	Ambition	Ambition: 7-10 million passengers electric LDV stock by 2030.	2019	Light-duty vehicles	Climate Action Program 2030 (2019)
Poland	Ambition	Ambition: 1 million electric passenger LDV stock by 2025	2016	Light-duty vehicles	Government of Polan

					d (2016)
Poland	Ambition	Ambition: ZEV public transport across all modes by 2030 in cities of over 100 000 residents.	2021	All	Government of Poland (2021)
Spain	Ambition	Ambition: 150-200 FCEV buses on the road by 3030.	2020	Heavy-duty vehicles	Government of Spain (2020)
Spain	Ambition	Ambition 5 000-7000 FCEV vehicles (multiple LDV and HDV categories) on the road by 2030.	2020	Multiple	Government of Spain (2020)
United Kingdom	Ambition	Phase out petrol and diesel passenger LDV sales by 2030. All sales of passenger LDV to be BEVO FCEVS by 2035.	2020	Light-duty vehicles	Government of the United Kingdom (2021)

Table 1.4: Proposal measures in the EU [3]

Country/ region	Policy type	Key policy measures and targets	Year announced	Vehicle type	Source
Denmark	Proposal	Proposal no sales of new diesel and petrol cars by 2030 (A joint Danish-Dutch inititive backed by 9 EU member states calls for the European Union to accelerate diesel and petrol car phase out to 2030).	2019	Light-duty vehicles	Government Denmark (2020)
European Union	Proposal	Nine member states have requested the European Commission to support a date for EU-wide phase-out of the sale of new petrol and diesel passenger LDVS. (Austria Belgium, Denmark, Greece, Ireland, Lithuania, Luxembourg, Malta, and Netherlands)	2021	Light-duty vehicles	Government Denmark (2021)
France	Proposal	Proposal no sales of the most polluting vehicles (emitting more than 123 g CO_2/km) by 2030	2021	Light-duty vehicles	Government of France (2021)
Italy	Proposal	Proposal: mandatory purchase of 30% alternative fuel vehicles (ZEV and methane vehicles) by 2022, SOK by	2019	All	Government of Italy (2019)

		2025 and 85% by 2030 by public bodies across all modes.			
Spain	Propos al	Proposal: no sales of passenger LDVs that emit CO_2 at the tailpipe by 2040	2020	Light-duty vehicle s	Gover nment of Spain (2020)
Sweden	Propos al	Proposal: ban on new petrol or diesel cars sales after 2030.	2019	Light-duty vehicle s	Gover nment of Swede n (2019)
The Netherla nds	Propos al	Proposal 100% passenger LDV sales to be ZEV by 2030. A joint Danish Dutch initiative backed by 9 EU member states calls for the European Union to accelerate diesel and petrol car phase out, to 2030).	2017	Light-duty vehicle s	Gover nment of Nether lands (2019)

1.2. Electric vehicles markets

After a decade of rapid growth, in 2020 the global electric car stock hit the 10 million marks, a 43% increase over 2019, and representing a 1% stock share. Battery electric vehicles (BEVs) accounted for two-thirds of new electric car registrations and two-thirds of the stock in 2020. China, with 4.5 million electric cars, has the largest fleet, though in 2020 Europe had the largest annual increase to reach 3.2 million. [10]

Overall, the global market for all types of cars was significantly affected by the economic repercussions of the Covid-19 pandemic. The first part of 2020 saw new car registrations drop about one-third from the preceding year. This was partially offset by stronger activity in the second-half, resulting in a 16% drop overall year-on-year. Notably, with conventional and overall new car registrations falling, global electric car sales share rose 70% to a record 4.6% in 2020.

About 3 million new electric cars were registered in 2020. For the first time, Europe led with 1.4 million new registrations. China followed with 1.2 million registrations and the United States registered 295 000 new electric cars. [11]

Numerous factors contributed to increased electric car registrations in 2020. Notably, electric cars are gradually becoming more competitive in some countries on a total cost of ownership basis. Several governments provided or extended fiscal incentives that buffered electric car purchases from the downturn in car markets.

1.2.1. Car models in the market

Worldwide about 370 electric car models were available in 2020, a 40% increase from 2019. China has the widest offering, reflecting its less consolidated automotive sector and that it is the world's largest EV market. But in 2020 the biggest increase in number of models was in Europe where it more than doubled.

BEV models are offered in most vehicle segments in all regions; PHEVs are skewed towards larger vehicle segments. Sport utility vehicle (SUV) models account for half of the available electric car models in all markets. China has nearly twice as many electric car models available as the European Union, which has more than twice as many electric models as the United States. This difference can partially be explained by the comparatively lower maturity of the US EV market, reflecting its weaker regulations and incentives at the national level. [12]

The average driving range of new BEVs has been steadily increasing. In 2020, the weighted average range for a new battery electric car was about 350 kilometres (km), up from 200 km in 2015.The weighted average range of electric cars in the United States tends to be higher than in China because of a bigger share of small urban electric cars in China. The average electric range of PHEVs has remained relatively constant about 50 km over the past few years.

The widest variety of models and the biggest expansion in 2020 was in the SUV segment. More than 55% of announced models worldwide are SUVs and pick-ups. Original equipment manufacturers (OEMs) may be moving to electrify this segment for the following reasons:

SUVs are the fastest growing market segment in Europe and China, and by far the largest market share in the United States. [12]

SUVs command higher prices and generally offer higher profit margins than smaller vehicles. This means OEMs find it easier to bear the extra costs of electrification for SUVs since the powertrain accounts for a smaller share of the total cost compared with a small car.

Electrifying the heaviest and most fuel consuming vehicles goes further toward meeting emissions targets than electrifying a small car. [13]

In Europe, the ZLEV credit scheme in the most recent CO_2 emissions standards offers strong incentives for selling electric SUVs from 2025, as it relaxes emissions standards in proportion to their potential to reduce specific CO_2 emissions. In fact, in Europe, the share of electric SUV models is higher than for the overall market.

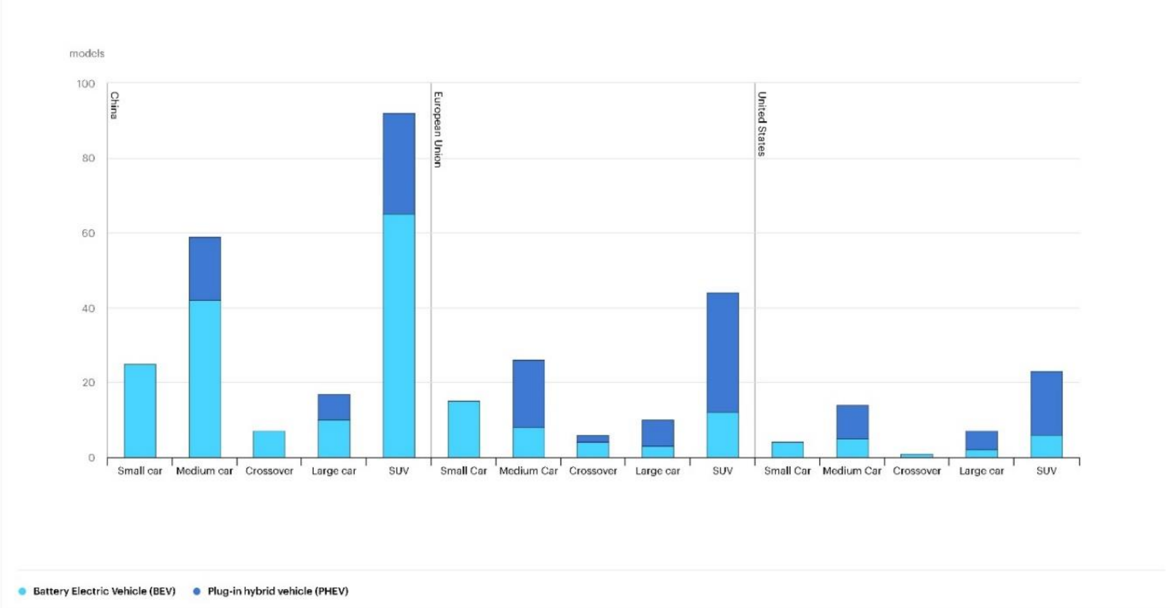

Figure 1.3: available electric cars in different regions [3]

1.2.2. Manufacturers' contribution

OEMs are expected to embrace electric mobility more widely in the 2020s. Notably 18 of the 20 largest OEMs (in terms of vehicles sold in 2020), which combined accounted for almost 90% of all worldwide new car registrations in 2020, have announced intentions to increase the number of available models and boost production of electric light-duty vehicles (LDVs). [12]

Several manufacturers have raised the bar to go beyond previous announcements related to EVs with an outlook beyond 2025. More than ten of the largest OEMs worldwide have declared electrification targets for 2030 and beyond.

Significantly, some OEMs plan to reconfigure their product lines to produce only electric vehicles. In the first-trimester of 2021 these announcements included: Volvo will only sell electric cars from 2030; Ford will only electric car sales in Europe from 2030; General motors plans to offer only electric LDVs by 2035; Volkswagen aims for 70% electric car sales in Europe and 50% in China and United States by 2030; and Stellantis aims for 70% electric cars sales in Europe and 35% in the United States.

Overall, the announcements by the OEMs translate to estimated cumulative sales of electric LDVs of 55-72 million by 2025. In the short term (2021-2022), the estimated cumulative sales align closely with the electric LDV Projections in the IEA's stated policies scenario. By 2025, the estimated cumulative sales based on the OEMs announcements are aligned with the trajectories of IEA Sustainable Development Scenario. [13]

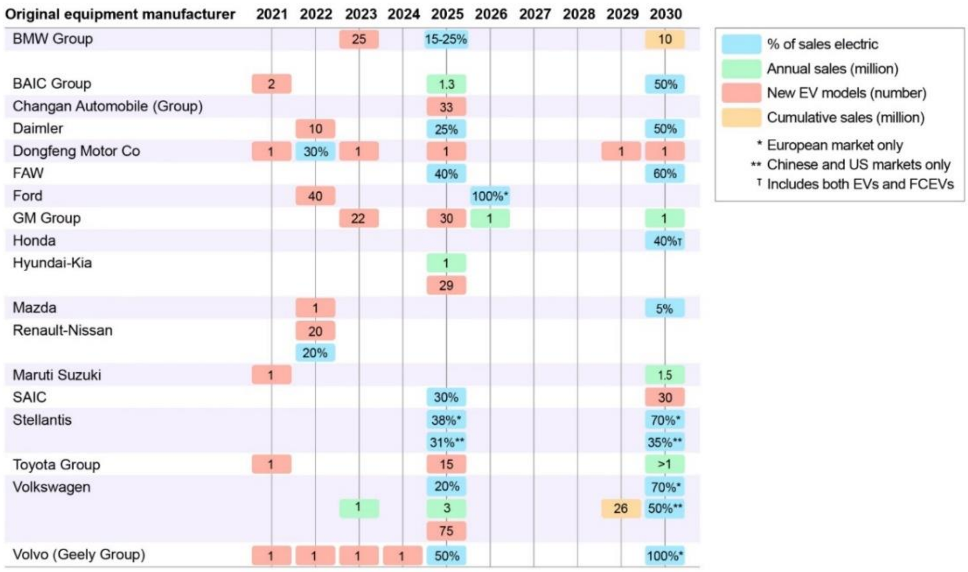

Figure 1.4: manufacturers' share for electric cars [3]

1.2.3. The EU market

Overall Europe's car market contracted 22% in 2020. Yet, new electric car registrations more than doubled to 1.4 million representing a sales share of 10%. In the large markets, Germany registered 395 000 new electric cars and France registered 185 000. The United Kingdom more than doubled registrations to reach 176 000. Electric cars in Norway reached a record high sales share of 75%, up about one-third from 2019. Sales shares of electric cars exceeded 50% in Iceland, 30% in Sweden and reached 25% in the Netherlands.

This surge in electric car registrations in Europe despite the economic slump reflect two policy measures. First, 2020 was the target year for the European Union's CO_2

emissions standards that limit the average carbon dioxide (CO_2) emissions per kilometre driven for new cars. Second, many European governments increased subsidy schemes for EVs as part of stimulus packages to counter the effects of the pandemic. [3]

In European countries, BEV registrations accounted for 54% of electric car registrations in 2020, continuing to exceed those of plug-in hybrid electric vehicles (PHEVs). However, the BEV registration level doubled from the previous year while the PHEV level thripled. The share of BEVs was particularly high in the Netherlands (82% of all electric car registrations), Norway (73%), United Kingdom (62%) and France (60%). [3]

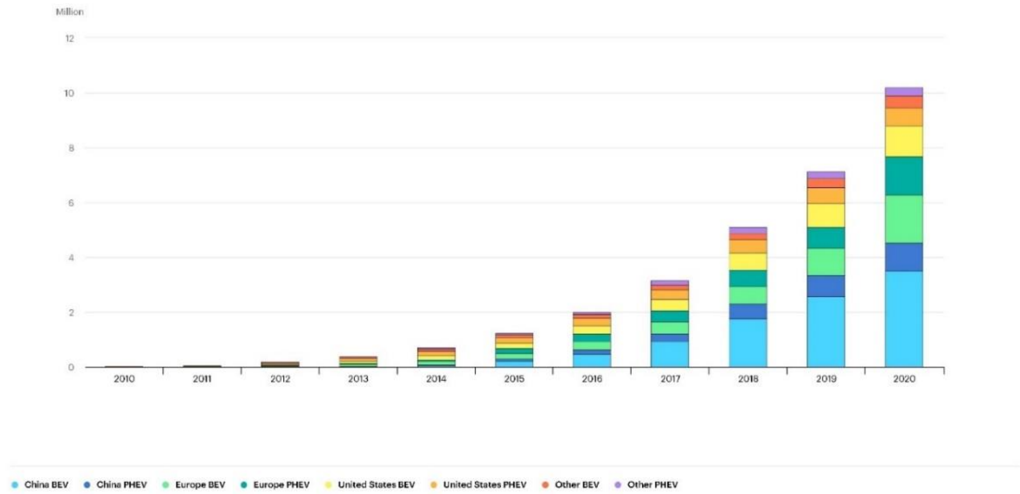

Figure 1.5: world electric car stock [3]

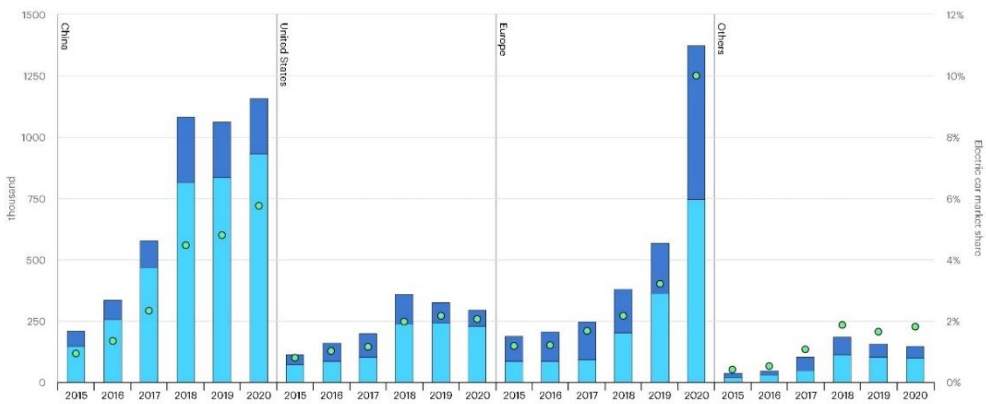

Figure 1.6: world market share for electric cars [3]

1.2.4. Electric heavy-duty vehicle models expansion

The availability of electric heavy-duty vehicles (HDVs) models is expanding in leading global markets. Buses were the earliest and most successful case of electrification in the HDV market, but the growing demand for electric trucks is pushing manufacturers to broaden product lines. Nevertheless, model availability is not the only indicator of a healthy market – fewer total models may reflect the reliability and broad applicability of existing designs, whereas more diversity of models may reflect the need to tailor products for specific needs and operations.

The growth in electric model availability from 2020 to 2023 across segments – bus, medium freight truck (MFT), heavy freight truck (HFT) and others – demonstrates manufacturers' commitments to electrification. Truck makers such as Daimler, MAN, Renault, Scania, and Volvo have indicated they see an all-electric future. The broadening range of available zero-emission HDVs, particularly in the HFT segment, demonstrates the commitment to provide fleets the flexibility to meet operational needs. [11, 13]

The HDV segment includes a wide variety of vehicle types, e.g. from long-haul freight to garbage collection trucks. China has the most variety in available electric bus models. The availability of MFT models is broadest in the United States. For HFTs – the segment where the EV model offer is expected to the grow the most – Europe offers the widest selection of models.

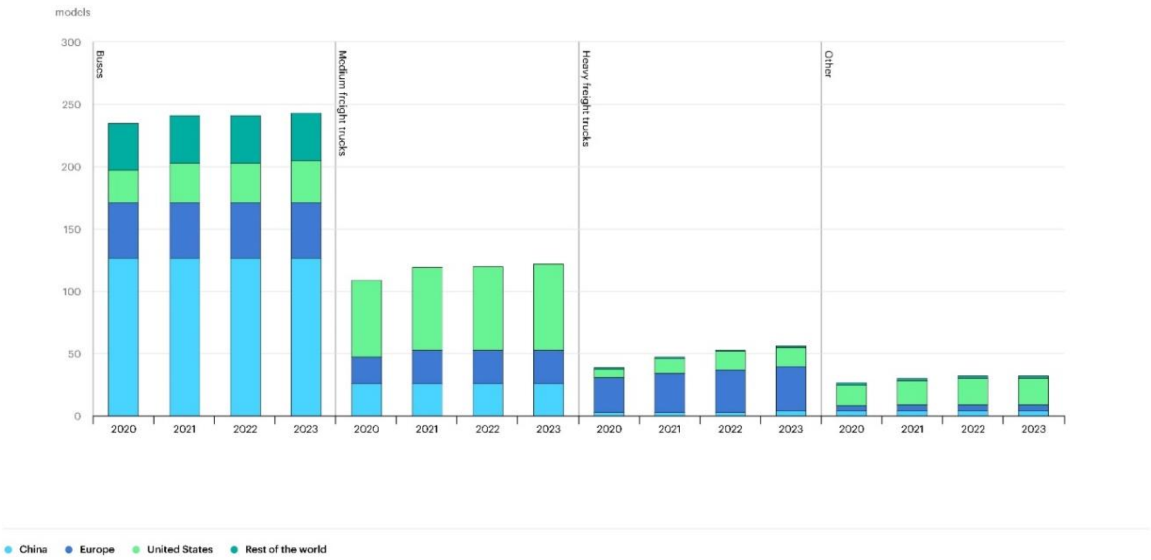

Figure 1.7: available heavy duty electric vehicle models in the market [3]

1.2.5. Publicly accessible chargers' expansion

While most charging of EVs is done at home and work, roll-out of publicly accessible charging will be critical as countries leading in EV deployment enter a stage where simpler and improved autonomy will be demanded by EV owners. Publicly accessible chargers reached 1.3 million units in 2020, of which 30% are fast chargers. Installation of publicly accessible chargers was up 45%, a slower pace than the 85% in 2019, likely because work was interrupted in key markets due to the pandemic. China leads the world in availability of both slow and fast publicly accessible chargers. [3]

1.2.5.1. Slow chargers

The pace of slow charger (charging power below 22 kW) installations in China in 2020 increased by 65% to about 500 000 publicly accessible slow chargers. This represents more than half of the world's stock of slow chargers.

Europe is second with around 250 000 slow chargers, with installations increasing one-third in 2020. The Netherlands leads in Europe with more than 63 000 slow chargers. Sweden, Finland and Iceland doubled their stock of slow chargers in 2020.

Installation of slow chargers in the United States increased 28% in 2020 from the prior year to total 82 000. The number of slow chargers installed in Korea rose 45% in 2020 to 54 000, putting it in second place. [3]

1.2.5.2. Fast chargers

The pace of fast charger (charging power more than 22 kW) installations in China in 2020 increased by 44% to almost 310 000 fast chargers, slower than the 93% pace of annual growth in 2019. The relatively high number of publicly available fast chargers in China is to compensate for a paucity of private charging options and to facilitate achievement of goals for rapid EV deployment.

In Europe, fast chargers are being rolled out at a higher rate than slow ones. There are now more than 38 000 public fast chargers, up 55% in 2020, including nearly 7 500 in Germany, 6 200 in the United Kingdom, 4 000 in France and 2 000 in the Netherlands. The United States counts 17 000 fast chargers, of which nearly 60% are Tesla superchargers. Korea has 9 800 fast chargers. [3]

Publicly accessible fast chargers facilitate longer journeys. As they are increasingly deployed, they will enable longer trips and encourage late adopters without access to private charging to purchase an electric vehicle.

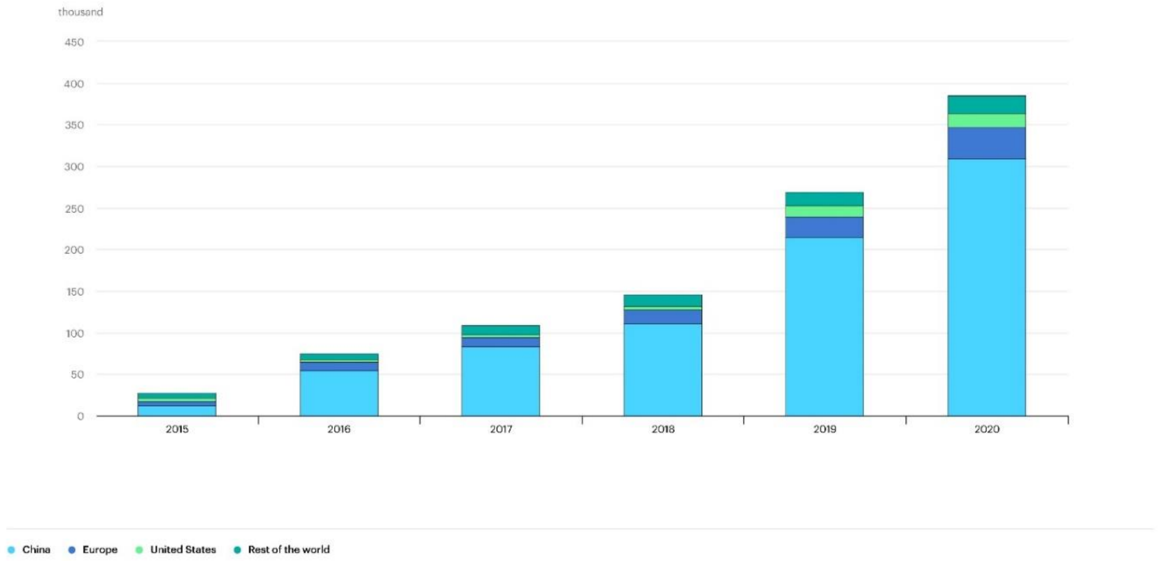

Figure 1.8: fast electric light duty vehicles chargers [3]

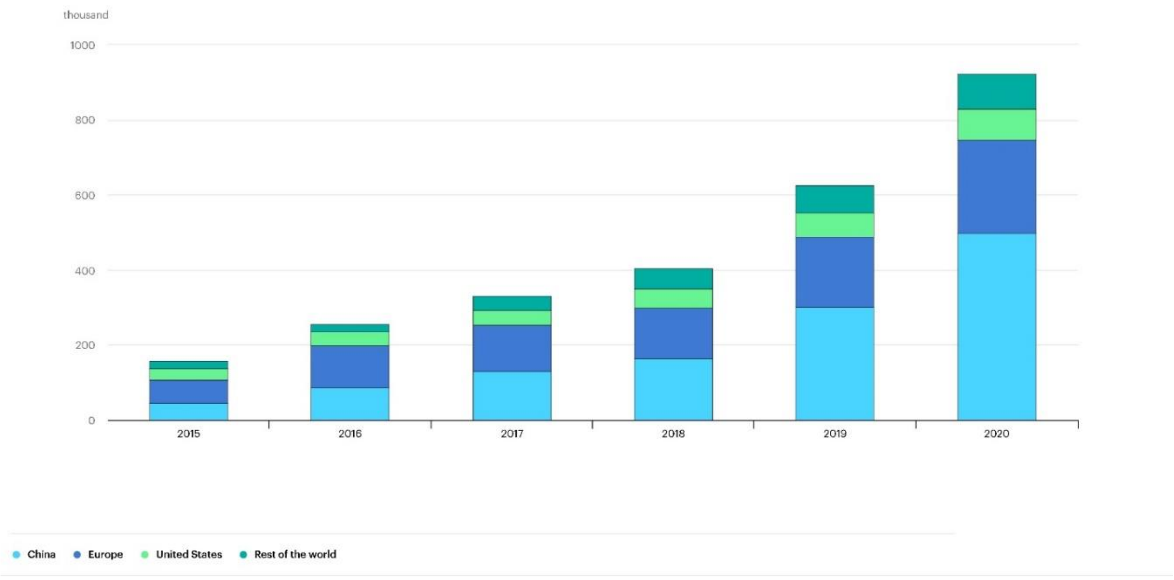

Figure 1.9: slow electric light duty vehicles chargers [3]

1.2.6. Private sector demand for zero-emission vehicles signals market to develop EVs

Table 1.5: private sector demand for EVs [3]

company	Operating area	Announced	Target/Actions
Amazon	Global	2020	Orders 100 000 BEVlight-commercial vehicles from start-up company Rivian. Amazon aims to be net-zero emissions by 2040
Anheuser Busch	United States	2019	Orders up to 800 hydrogen fuel cell Nikola heavy duty trucks.
DHL Group	Global	2019	Delivery of mail and parcels by EVs in the medium term and net-zero emissions logistics by 2050
FedEx	Global	2018	Transition to an all zero-emission vehicle fleet and carbon neutral operations by 2040.
H2 Mobility Association	Switzerland	2019	19 of Switzerland's largest retailers invest in Hyundai hydrogen trucking services that will deploy up to 1 600 heavy duty zero emission trucks.
Ingka Group (IKEA)	Global	2018	Zero-emission deliveries in leading cities by 2020 and in all cities by 2025.

Japan Post	Japan	2019	Electrify 1200 mail and parcel delivery vans by 2021 and net-zero emissions logistios by 2050. Replace entire vehicle fleet (>10000) with New Energy Vehicles by 2022 Launch nearly 10 000 BEV logistics vehicles.
JD	China	2017	Replace entire vehicle fleet(>10000) with new energy vehicles by 2022
SF Express	China	2018	Launch nearly 10000 BEV logistics vehicle
Suning	China	2018	Independent retailer's Qingcheng Plan will deploy 5 000 new energy logistics vehicles.
UPS	North America	2019	Order 10 000 BEV light-commercial vehicles with potential for a second order,
Various companies	Multinational	2018	Walmart, Pepsi, Anheuser Busch, FedEx, Sysco and other large multinational corporations pre-order 2000 Tesla Semi models within six months of truck's debut.
Walmart	United States	2020	Electrify the whole vehicle fleet by 2040.

1.2.7. Case of Italy

In this section, there will be a closer look to the data available for Italy with more focus on the chargers at the end.

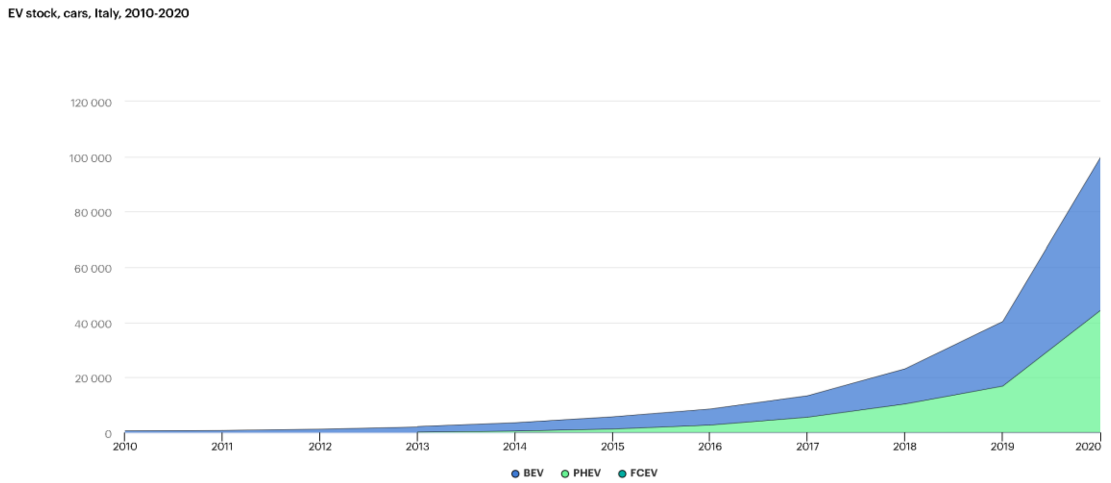

Figure 1.10: EV stock in Italy for cars [3]

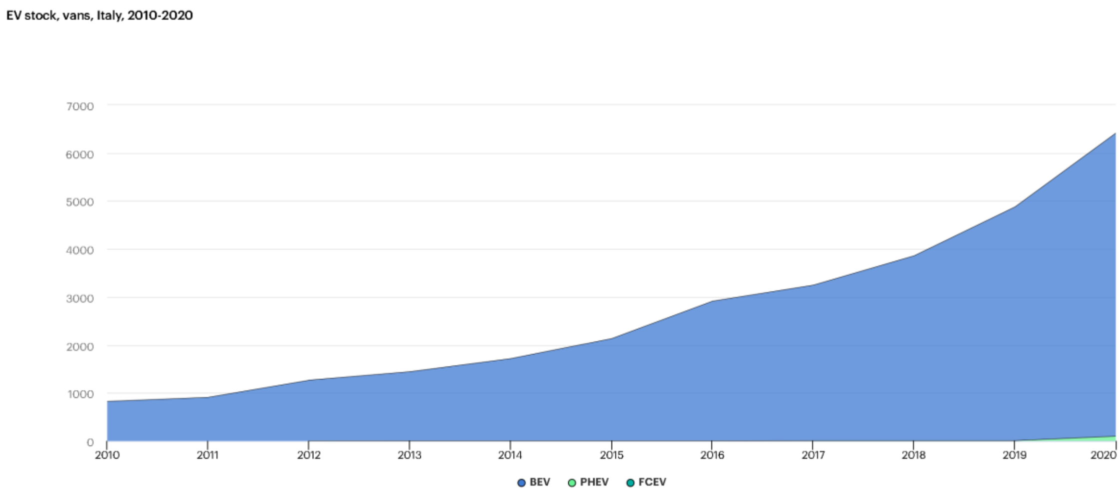

Figure 1.11: EV stock in Italy for vans [3]

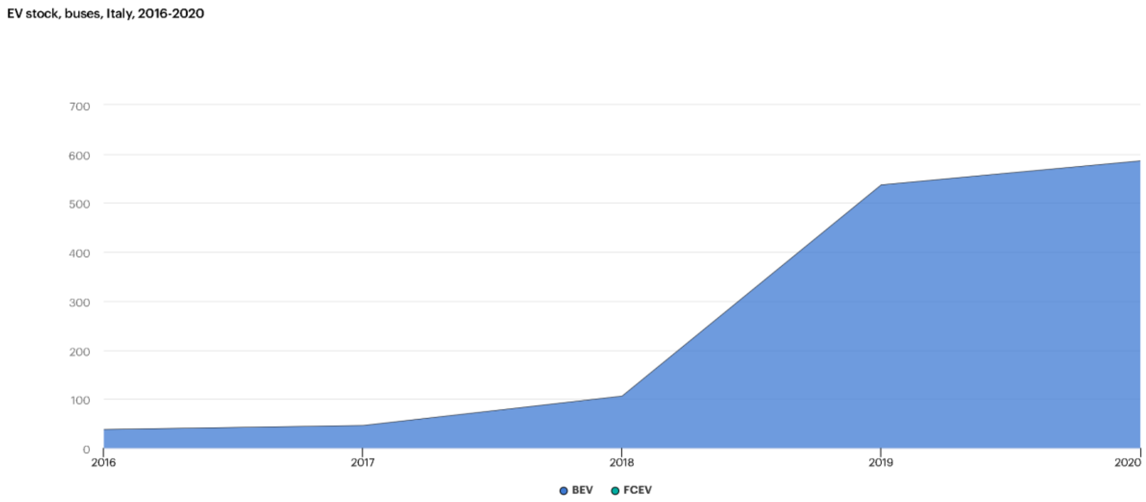

Figure 1.12: EV stock in Italy for buses [3]

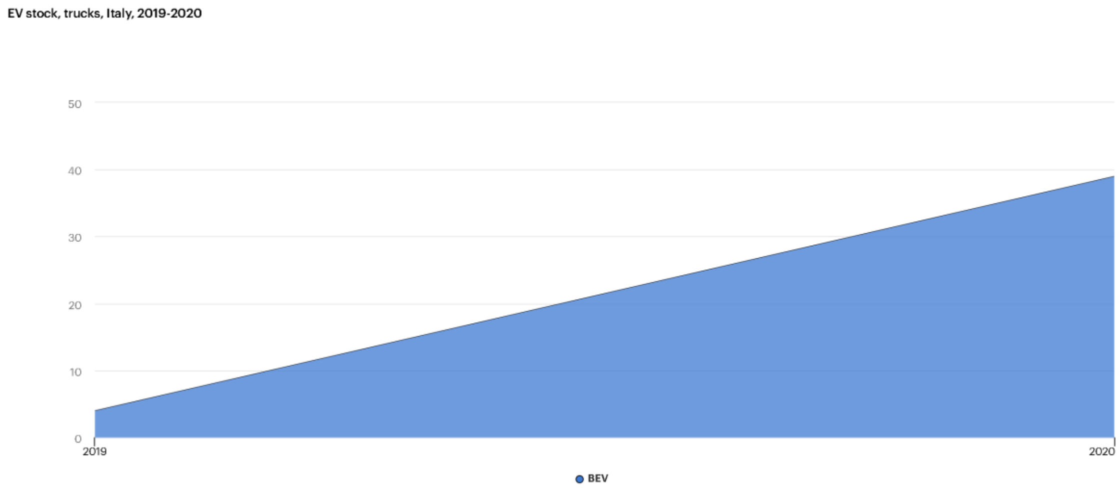

Figure 1.13: EV stock in Italy for trucks [3]

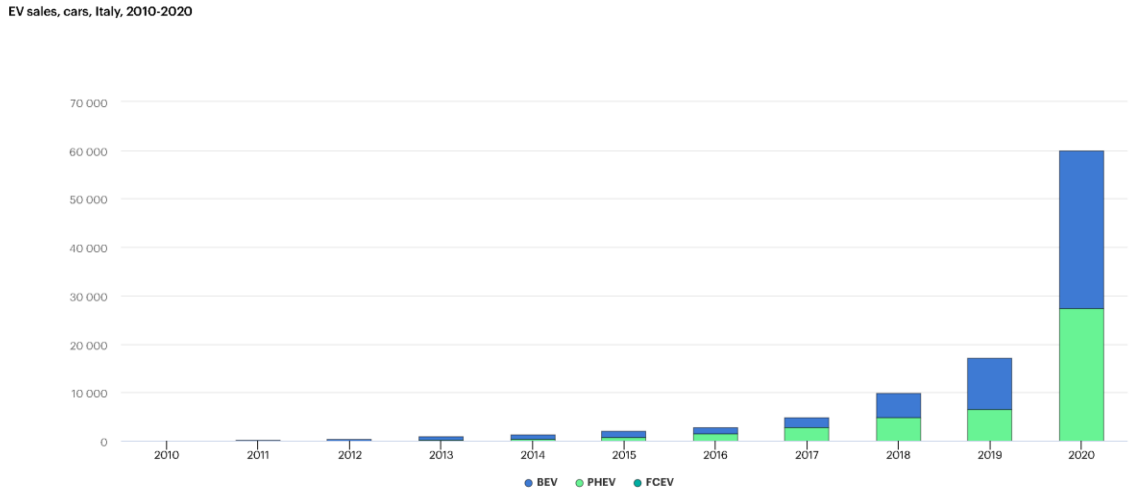

Figure 1.14: EV sales in Italy for cars [3]

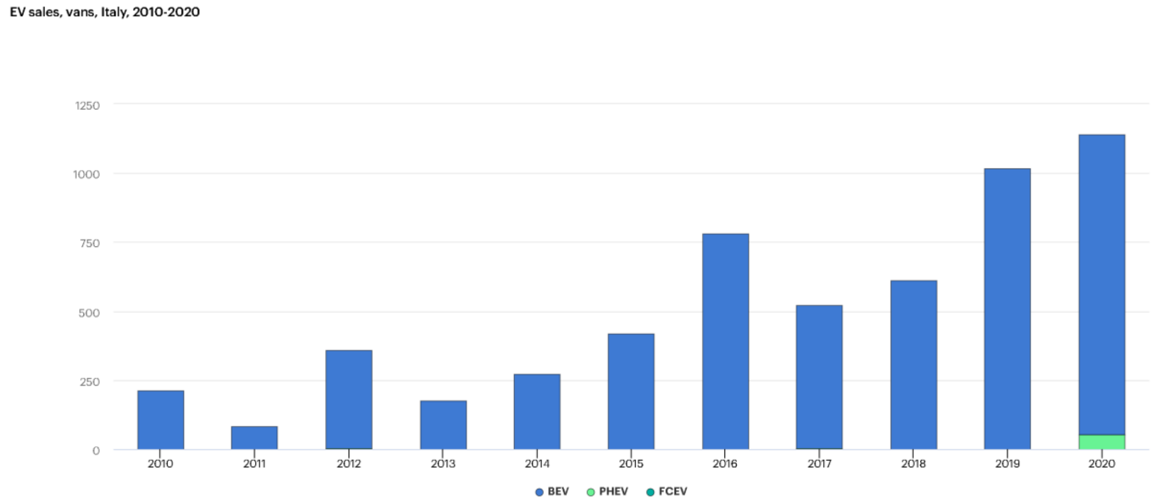

Figure 1.15: EV sales in Italy for vans [3]

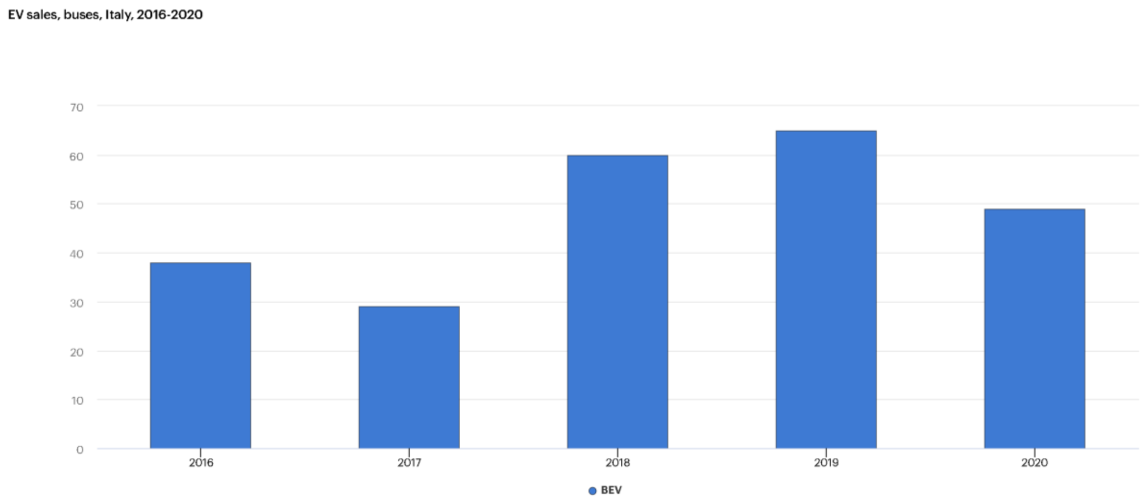

Figure 1.16: EV sales in Italy for buses [3]

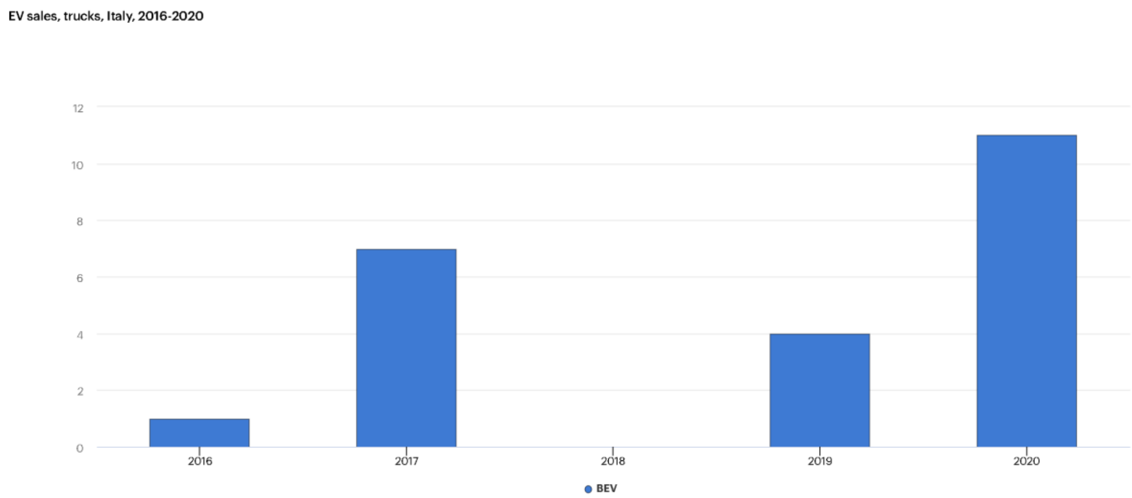

Figure 1.17: EV sales in Italy for trucks [3]

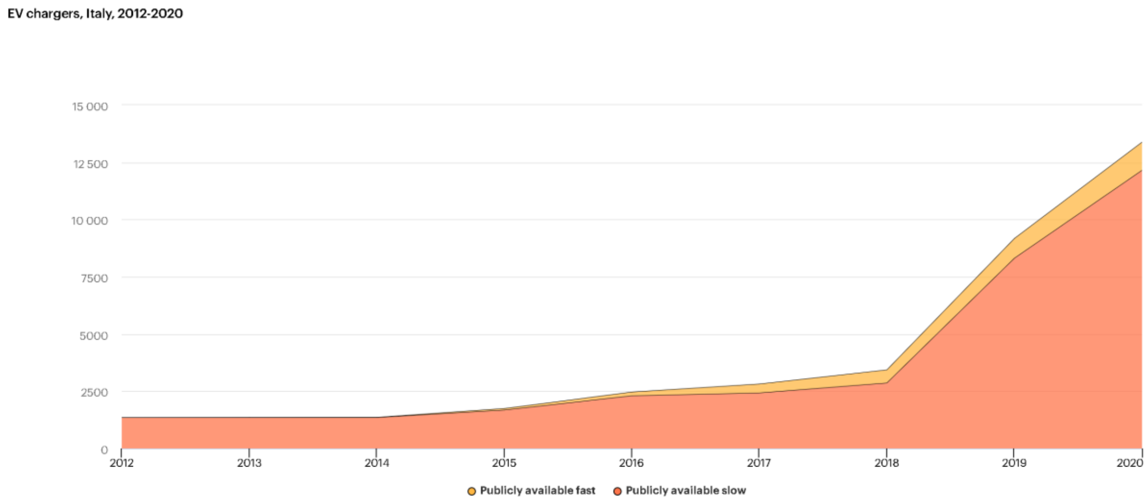

Figure 1.18: EV slow and fast chargers in Italy [3]

2 Low-carbon logistics and EV applications

In this chapter using of EVs in logistic and supply chain system will be investigated.

2.1. Green logistics

Green logistics refers to the use of advanced logistics technology to plan and implement logistics activities to restrain harm to environments and reduce resource consumption. The ultimate goal of green logistic is to minimize the impact of logistics activities on the environment and achieve sustainable development. [13]

The significance of developing green logistics is not only in energy saving and emission reduction, for logistics companies, it can also reduce logistics costs and improve economic and social benefits. The development of green logistics is not only to achieve greening through technical means and management in a certain part of logistics. Moreover, the operation is carried out through all links in the logistics to realize the greening of the entire logistics system. [13]

Green logistics is developed on the basis of traditional logistics, in term of operation process it is similar to traditional logistics. To realize a green logistics system, it is necessary to realize the greening of packaging, handling, transportation, storage, distribution, waste treatment, etc. Figure 18 shows the green logistics structure diagram and its related green distribution and transportation to the EVs. [14]

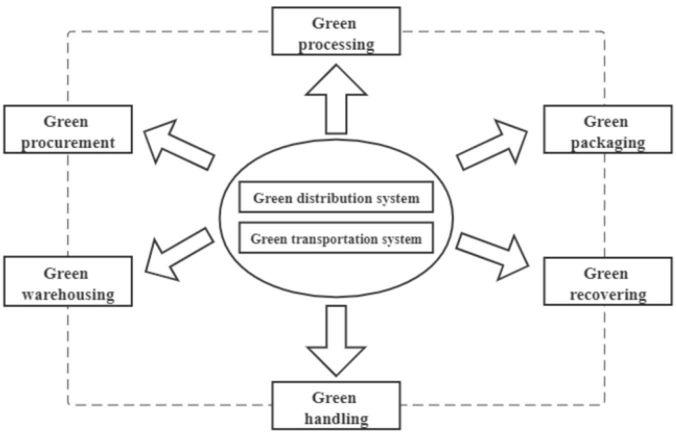

Figure 2.19: green logistics

Green logistics is a concept with deep meaning, all methods and processes aimed at reducing the ecological environment impact during logistics process belong to the category of green logistics. While, low-carbon logistics emphasizes environmental protection, which can reduce the carbon intensity (the ratio of greenhouse gas emissions produced to GDP) during logistics. In terms of scope, green logistics includes low-carbon logistics, green logistics is richer in connotation. [15,16]

The origin of low-carbon logistics is attributed to the low-carbon economy and the Copenhagen Environment Conference's advocacy of green issues. Low-carbon economy means that under the guidance of the concept of sustainable development, through technological innovation, institutional innovation, industrial transformation, new energy development and other means, as much as possible to reduce the consumption of high-carbon energy such as coal and petroleum, reduce greenhouse gas emissions, and achieve a win-win economic development pattern for social development and ecological environment protection.

Often most of the logistics cost lies in the transportation goods, and the carbon emissions caused by vehicle transportation also account for a large proportion of the carbon emissions of the entire logistics system. [16,17,18]

2.2. Electric vehicles applications in city logistics

In the urban last mile process, as the last link before the product reaches the customer, there are many customer points, complex distribution routes and congested road conditions that make traditional fuel vehicles run under uneconomical, high fuel consumption, low speed or idle conditions for a long time, namely causes a lot of carbon emissions, noise and vibration, and also increase the cost of vehicle. In today's low-carbon and environmental protection context, EVs have become the most promising alternative to current distribution vehicles with their zero-carbon emission, zero pollution and low noise characteristics, and are the main way to realize green logistics. [19,20]

This section defines the related concepts of EVs and analyzes the characteristics and application status of EVs distribution.

2.2.1. Applications of Electric Vehicles in Urban Logistics

Traffic generated by freight transport accounts for 20–30% of kilometers covered by vehicles in urban areas and for 16–50% of air pollution derived by all kinds of transport. It would seem that the optimal solution should be a switchover to electric propulsion and replacing the conventional fleet with electric vehicles. Alas, shippers and drivers have bad experience related to initial implementation of electric vehicles. They primarily point out the lesser performance of electric vehicles (in comparison to the conventional ones) in terms of travel range, speed, acceleration and unreliability. Many research studies in that respect date back at least 20 years, e.g., under projects financed by the EU, such as EVD-POST (Electric Vehicle Deliveries in Postal Services). [21]

The main conclusions highlighted the high costs of goods delivery, limited choice of vehicle models, lack of support with regard to vehicle sales and long lead time for spare parts, low capacity of batteries, limited travel range, relatively low speed and limited carrying capacity. In short, the authors of those studies indicated that the early versions of EFVs were far from perfect and they were not a serious alternative to conventional vehicles for the purposes of logistic operations in cities. One of the first successes in terms of EV implementation is described in Taniguchi paper. It pertained to using EFVs within a cooperative framework for the purposes of urban freight transport, wherein its main idea was to establish an EFVs depot in the center of Osaka and enable their use by multiple distribution companies. The project involved 28 electric freight vehicles, and 79 companies volunteered to participate in the undertaking. As a result of the system implementation, the number of kilometers covered was reduced, which led to a decrease in congestion. Another implementation involved a three-year project described in that was mainly aimed at long-term measurements of fuel and energy consumption, travel range when using an electric motor, drivability, lithium-ion battery capacity and durability. A van prototype was proposed, equipped with a parallel architecture of hybrid drive based on five-cylinder 2.7 L diesel engine. The electric drive system was based on a permanent magnet 90 kW motor and 15 kWh lithium-ion (Li-Ion) battery. Another attempt at developing a modular structure of electric light trucks or vans (ELTVs) was the OPTIBODY project. This time, the new architecture was to contribute to improve the passive vehicle safety, in order to reduce the number of fatal accidents and injuries. They provide a comparison of electric and fuel-powered urban freight vehicles in terms of life cycle, energy consumption, greenhouse gases (GHG) emissions and total cost of ownership (TCO). The authors engaged in studies using the New York City driving cycle that included frequent stopping and a low average speed, electric vehicles emitted 42–61% less greenhouse gas and consumed 32–54% less energy than freight vehicles equipped with diesel engines, depending on performance of individual vehicles. [22]

Research studies focused on comparing three-wheel electric freight vehicles of small carrying capacity in relation to freight vehicles equipped with diesel engine were performed by Tipagornwong and Figliozzi. The studies were undertaken in urban areas, and the vehicles in question were the so-called trikes, low-emission vehicles using a combination of human effort and an electric motor for propulsion. [22,23]

Other studies, described in, pertained to Amsterdam, a city that for many years has been striving to improve the air quality, road traffic safety and capacity, as well as to reduce noise levels by means of applying intelligent delivery methods and ecological transport. The research found that the current generation of electric vehicles is capable of operating urban freight transport quite efficiently, at the same reducing the distance covered by the vehicles by 19% (when applying consolidation), concurrently improving the air quality and reducing CO_2 emissions by 90%. [23]

Taefi features an extensive analysis regarding the existing EFV initiatives in Denmark, Germany, Holland, Sweden and Great Britain. It concluded that there is a need for such research, as urban freight transport is thought to be one of the most promising areas of electric vehicles application. [24]

2.2.1.1. Impediments to Application of Alternative Drive Vehicles in Urban Logistics Systems

Application of alternative drive vehicles—in particular electric vehicles—in urban logistics is related to fundamental advantages of using this type of drives. These involve the possibility to produce energy from any source, lack of gaseous or solid pollutant emissions into the atmosphere, lack of noise emissions, higher energy efficiency compared to traditional drives, cheaper production of drives, their maintenance and servicing, providing energy independence, low operation costs depending on the vehicle velocity and the price of 1 kWh. The existing electric power distribution network is the best developed part of the infrastructure. However, it is also important to stress the limitations and impediments which must be overcome in order to enable a significant increase in the interest in alternative drive vehicles. These may be broken down into three basic groups:

(a) economic difficulties including costs of purchasing such vehicles, costs of producing electric power for the vehicles, and costs of utilizing used-up batteries;

(b) safety-related problems regarding the aspect of hardly audible operation of electric motor compared to conventional engines, which may consequently lead to collisions or accidents; but also potential risk of battery self-ignition;

and (c) operational barriers, mainly connected with the fact that the full potential of alternative drives efficiency has not been fully achieved yet, long battery charging time, and limited cargo space in the case of electric vehicles.

What is important in terms of electric vehicles efficiency is the climate of the geographic area where such vehicles are used. It predominantly affects the vehicle's travel range: in winter months, more energy is needed for heating the interior, whereas, in summer months, air-conditioning increases the power demand. An important factor to limit the efficiency of urban freight transport using EFVs is city topography. Energy consumption was high when driving on motorways and uphill. On the other hand, EFVs did well in urban traffic. Undoubtedly, the greatest barrier is the still high price of purchasing electric vehicles. They are usually more expensive than their traditionally powered counterparts. On the other hand, we can expect that businesses will be able to use different forms of support in purchasing vehicles of this type. This may mean tax relief as well as subsidies from local governments. A good example in this respect is Norway experiencing a substantial increase, the highest in Europe, in the number of electric vehicles. In this context, it is worth noting the conclusion drawn from the studies shows that EFVs will not become competitive until savings derived from the operating costs reduction are sufficient to cover the substantially higher initial costs of purchase.

The most costly component of EFVs is usually batteries, the cost of which accounts for circa half of EFV retail price. Manufacturers focus on the technical capacity of batteries and increasing the operation range while decreasing their weight and charging time. Electric vehicle batteries must feature high Ah capacity; besides, they must be characterized by high power-to-weight and energy-to-weight ratios, as well as high energy density. Research and development in this regard is still underway.

Currently, economic efficiency of EFVs is characterized by high purchasing costs of batteries, and lower costs of maintenance and fuel purchase. Over a short and medium term, EV costs are considerable, however, their advantages make them more competitive in a long run. The latest research has shown that TCO may be lower for electric vehicles compared to conventional ones. It should be noted that EV purchases are currently most often financed with public funds. Private operators will be inclined to replace their fleets if: they notice benefits for their companies, an appropriate number of alternative fuel stations is provided, there are marketing benefits for the company, the given company is in any way connected with environmental protection, appropriate vehicles are available. [25]

Often, operators are forced to apply solutions of this kind by way of administrative decisions which prohibit in historic city centers or other specified areas vehicles other than those with alternative drives. The limited availability of information in model specifications and its operation is perceived as another factor to inhibit purchasing EFVs and using them in urban logistics. Source London reports that, "at the moment of purchase, there was not much information on basic elements i.e., screws and nuts or if the vehicle required water or oil". Additionally, the impediments that inhibit the use of electric and hybrid vehicles include: higher operating costs of applying electric vehicles, small capacity of batteries, lack of battery charging infrastructure, low reliability and a large number of defects during complicated operation of the vehicles. [26]

Over the recent years, considerable progress has been made with regard to improving the performance of electric vehicles, and many problems identified in earlier attempts at EFVs implementation in urban logistics have been resolved. Unfortunately, many problems entered a new dimension, and solutions have not yet been developed, even though the new EFVs feature longer travel ranges, more carrying capacity, better batteries and it takes less time to charge them completely or partially.

It should also be noted that it is not plausible to perform all freight operations by means of EFVs. This relates to particular situations calling for vehicles with a large carrying capacity or long time of effective operation, e.g., when the vehicle must be in continuous operation for more than 12 h. [23]

2.2.1.2. Key Factors Determining the Usability of Electric Drives in City Logistics

Although today's EFVs demonstrate better performance parameters: longer travel range and more capacious batteries and more carrying capacity, their actual usability in urban logistics remains limited. The challenges and factors that influence successful implementation of EFVs in everyday logistic operations in a city are:

(a) Technical performance: travel range of EFVs usually does not exceed 100–150 km, even though the values specified by manufacturers tend to be higher. Potential stakeholders declare a greater interest in EFVs if they see improvement of operational parameters such as travel range, operation time with a battery, increasing the number of charging points and charging stations.

(b) Operational performance: EFVs show both positive

and negative features in comparison to IC engine vehicles. The positive features include the limited impact on the natural environment and decrease in noise level, which translates into their usability in city centres and time windows. At the same time, the charging, carrying capacity, maintenance and the need to adjust the logistic concepts to EFV application are perceived by operators to be the major operational challenges.

(c) Economics: Purchase price and TCO still exceed corresponding

values related to conventional vehicles. This results mainly from high costs of batteries and EFV small production limits. In the long run, these costs are expected to diminish, which will be connected with improving the operational parameters and efficiency, cutting the purchase prices, e.g., as a result of mass production. Resale value is highly unknown, which stops investors from making purchase on

the primary market.

(d) Environmental performance: EFVs cause less CO_2 emissions compared to their conventional counterparts, however, their demand for energy as well as energy prices in a long run and energy capacities of individual countries require analyses and research studies.

(e) Social and attitudinal impact: EFVs are less noisy and more environmentally friendly than conventional ones, therefore most of the public show a positive view on this direction of development.

(f) Impact of local policy and governance structure: Governments of many European countries take up new directives aimed at increasing the use of EFVs while decreasing the use of conventional vehicles.

Technical performance of EFVs (within the scope discussed further on in this article, i.e., carrying capacity, maximum velocity, travel range, engine power, engine torque, battery charging time, batterycapacity) is improving with every new design and model. In addition, the economic factor, i.e., price, is changing. This considerably contributes to the growing interest from potential investors who also pay attention to additional aspects that are already implemented in conventional vehicles, e.g., telematics solutions and applications related to safety of drivers, passengers and cargo. [26]

The assumptions for the model introduced below are one of the results of the cooperation with city logistics stakeholders under the work of the Freight Quality Partnership in Szczecin. [27]

The partnership has been established as a major activity of international projects C-LIEGE. The activities have been continued under the next international project GRASS. The FQP in Szczecin was focused on identification of major problems and establishing of the proper actions to improve the functioning of urban freight transport in city. The utilization of electric vehicles was one of the most important

potential measures. The meetings with UFT stakeholders helped to establish among others the general expectations regarding implementation of electric vehicles in Szczecin city logistics system.

2.3. FREVUE 'Freight Electric Vehicles in Urban Europe'

The FREVUE project demonstrates the use of electric freight vehicles (EFV) in city logistics operations in eight European cities. The project is co-funded by the European Commission under the Seventh Framework Program, Theme 7 Sustainable Surface Transport. It answers the call "Demonstration of Urban freight Electric Vehicles for clean city logistics". Within the project the demonstration of 127 EFVs is organized, covering a variety of urban freight applications that are common across Europe. [28] This includes:

• Goods deliveries (including food, waste, pharmaceuticals, packages and construction);

• New logistics systems and associated ICT;

• Organization with a focus on consolidation centers to enable minimalization of trips in urban centers.

• Vehicle types (from small car-derived vans to large 18 ton goods vehicles);

• Climates (from Northern to Southern Europe);

• Diverse political and regulatory settings that exist within Europe.

Below we shortly present the eight cities and the demonstrations that take place there within the FREVUE project:

2.3.1. Amsterdam

In Amsterdam three companies and the municipality are involved in the FREVUE demonstration: i)Heineken's logistics service provider is using a 12 tons electric truck (Ginaf) to supply hotel, cafes and restaurant establishments in the city center, ii) UPS uses six retrofitted large electric vans (which looks like the typical UPS van form the outside), and iii) TNT recently started operating 5 large retrofitted electric vans (based on Fiat Ducato chassis) for their express deliveries. In addition to subsidies the municipality of Amsterdam has taken complementary policy measures to make EFVs use more attractive. Those privileges are exemptions on traffic codes / regulations / rules, such as parking on sidewalks to load / unload, driving into roads that are only for pedestrians, etc.

2.3.2. Lisbon

The Portuguese postal company CTT uses 10 small electric vans (type Renault Kangoo ZOE) for post and parcel operations in Lisbon. Next, EMEL uses five small electric vans for maintenance of the on street parking and charging point infrastructure. The Lisbon local authorities are the third FREVUE partner in this local demonstration. The municipality looks at supporting policies for EFVs and already uses some EFVs for waste collection and gardening and city maintenance.

2.3.3. London

For FREVUE UPS has 16 EFVs running in London. These are all retrofitted vehicles, this implies: a changed powertrain and refurbished old vehicle. These EFVs replaced existing roundtrips of diesel vehicles. The replaced roundtrips are less than 75 kilometers, so these do not exceed the daily range of the EFVs. In the other London demonstration Clipper uses two EFVs of ten tonnes for the operation of the consolidation centers in London. These EFVs make two roundtrips per day between the large consolidation center in Enfield 10 miles north of the London city center and the smaller one at Regent Street.

2.3.4. Madrid

The Madrid demonstration includes three operators and an UCC (Urban Consolidation Center). The operators active in the Madrid demonstration are: TNT Spain, SEUR (both parcel deliveries) and Pascual (dairy products). Currently four electric vehicles are running: two Renault Kangoos (TNT and SEUR) and two larger vans for Pascual (Iveco Daily and Mercedes Vito). The local authorities decided to use an UCC in the FREVUE demo. After a search for an available suitable location, they found an old market for fruit and vegetables that was empty. Part of this old market is reconditioned to make it suitable as UCC (in the southern part of Madrid), including charging infrastructure for the EFVs. The use of the UCC is offered for free to the operators in the FREVUE project, except for some really minor costs, e.g. the costs for cleaning, some maintenance issues, etc.

2.3.5. Milan

The Milan demonstration is slightly delayed due to several technical and legal barriers when trying to get a French-authorized electric freight vehicle with temperature controlled box vehicle to operate in Italy. A specialized logistics operator, i.e. Eurodifarm, specialist in the temperature controlled distribution of pharmaceutical, diagnostic and biomedical products to pharmacies, hospitals, third party distributors, nursing homes and patients, will operate two EVs in the demonstration.

2.3.6. Oslo

In Oslo Bring is the logistics company running the FREVUE demonstration. Bring uses subcontractors to deliver and pick up parcels. The company plans to operate 6 vehicles in the FREVUE demonstration, from which 4 are already operating. These EFVs are replacing existing conventional vehicles. The EFVs deployed are Peugeot Partners. The logistics concept is as follows: in the morning deliveries are made and in the afternoon pick-ups are done. Basically, the routes start at home, to the post office, to the Bring customers, doing pick-ups, to the post office and then back to home. Four different post offices are used to start 4 different EFVs operated routes.

2.3.7. Rotterdam

In Rotterdam the Binnenstadservice's (see Van Rooijen and Quak, 2010) local franchisee RoadRunner uses a Nissan eNV200 for its deliveries, TNT just started operating 4 large electric vans and UPS operates 4 large electric vans. Next, Heineken operates one large 19 ton electric truck (Hytruck). The city of Rotterdam is also active in FREVUE preparing a study in cooperation with the local grid operating company to: determine the spatial distribution of business vehicles (trucks and vans); derive the overnight charging requirement if all vehicles were electric; combine this spatial distribution of demand with the grid capacity; explore the possibilities of local energy production and storage in a pilot.

2.3.8. Stockholm

Originally, one demonstration was planned with a construction consolidation center (CCC) and EFVs carrying construction materials from the CCC to the construction sites. After one year the electric van (Mercedes Vito) that was used to move materials from the CCC to the construction sites accompanied by two conventional trucks (with hybrid cranes), as the capacity of the electric vehicle was too limited for all construction deliveries.

Now Stockholm is examining the possibility for an UCC to deliver goods in the city center using electric freight vehicles.

2.3.9. Technical insights from FREVUE project

So far the vehicles used in FREVUE do perform excellent from a technical point of view. No problems or issues were reported and all vehicles performed as was promised by the manufacturers. Obviously, the vehicles are running for only short periods now (between a few months to about two years), but based on these observations we can say that the EFVs are no longer ‘trial’ products (as these were in the early 2000s), but reliable vehicles. [28]

The FREVUE project showed that in some cases the existing power grid is not sufficient to charge the EFV fleet during the off hours at the depot. For example, the London demonstration showed that it was necessary to upgrade the power grid in order to charge the 16 UPS EFVs (and run the sorting machine) at the depot at the same time during the night. Grid upgrades are expensive for commercial vehicle fleets and are non-scalable. These upgrades (owned by the power-network company) have to be paid by the end user regardless of who is the owner.

This is contradictory, because it requires a logistics service provider to make an investment in a network it does not own. Next, the process of obtaining landlord permission for the necessary infrastructure upgrade works has proved to be more complicated than anticipated (in this case). That is largely because there are multiple levels of ownership involved. Most other cases show that some investments are necessary for charging infrastructure and sometimes in the grid (for example in Rotterdam), but these investments are limited in comparison to grid investments that we saw in the London-demonstration. [28,29]

2.3.10. Operational insights from FREVUE project

FREVUE demonstrations provide good examples of logistics (re)organization via direct replacement of internal combustion vehicles (ICEs) by EFVs. Simply replacing a conventional vehicle with an electric vehicle seems to be the easiest way to use electric freight vehicles in urban freight transport operations. Though, most of the times this is not an optimal solution, as the logistics organization was designed for ICEVs. However, some routes have the characteristics that perfectly fit EFVs, i.e. parcel or post deliveries. Usually, these trips cover short distances, have a high drop density and start from depots close to cities.

FREVUE examples of EMEL, UPS and CTT show that this is indeed the case. Replacing an ICEV can be done by operators if the roundtrips that were performed fit the limitations of EFVs, especially the limited range of an EFV compared to an ICEV. [30]

From the demonstrations we learned that in many cases replacement does not mean that there are no additional efforts. For example, the use of an EFV requires more intelligent planning. In the case of RoadRunner (Rotterdam) the EFV replaces a conventional vehicle on a route. However, during or after this fixed roundtrip planners used to plan pickups for the conventional vehicle, whereas for the replacing EFV this results in issues with the vehicle range. So in planning extra variable pickups after the fixed roundtrip to this vehicle, the EFV had an extra constraint.

Another FREVUE example where the EFVs also replaced existing ICEV roundtrips is for UPS. There, the challenge with EFVs is the following: at UPS the vehicles have very tight routine at the depot, such as washing and fueling, loading and unloading. With the ICEVs this routine is easy and fast. With an EFV there is less flexibility as these have to be planned at a charging location (where it should be for about 8 hours). All vehicles are running form e.g. 8 am to 6 pm vehicles, so then these are away from the depot. Then between 6-10 pm the vehicles are washed and fueled / charged. Next, the conventional vehicles are 4 hours idle and from 2 am these are off for inbound logistics operations again. These 4 hours are too short to charge the EFVs fully. So operations at the depot have to be planned around the charging of the vehicle. As a result the vehicles are charged at the time that most electricity is used (e.g. the sorting machines, as this process also takes place in the late evening / early night). [29]

Another way to use EFVs in city logistics operations, in cases where replacement of the vehicles is not possible due to e.g. range issues, is to make use of a hub. Several examples exists where hubs are used as a starting point for city logistics operations with EFVs. [29,31]

Madrid's Urban Consolidation Center (UCC) in FREVUE: the local authorities redeveloped an unused market place to an UCC with facilities for charging and cross-docking for the FREVUE demonstrators in Madrid. This facility enables the carriers to operate in Madrid with EFVs at low costs, as the use of this UCC is, except for some services, free for them. This UCC is used for cross-docking deliveries and pickups from EFVs to conventional vehicles (and the other way around) and charging the EFVs. There is no bundling of loads between the users of this facility.

Stockholm's Construction Consolidation Center (CCC) in FREVUE: the CCC has a temporary structure, it will be moved during the 15 years of construction development. The city of Stockholm owns the CCC and an operator, who won the tender, runs the operations. Since the city owns the land on which construction takes place, local authorities could require the use of the CCC in the building regulations (the city is also a developer itself, and from that role it can also require the use of the CCC by builders). All vehicles carrying limited volume (i.e. less than about 5 euro pallet places) that deliver to the building sites have to unload at the CCC. When construction started most deliveries from the CCC to the actual construction sites were transported by the EFV. However, in the beginning of 2014 the volume of goods at the CCC increased and the electric van was getting to small for delivering all the goods. The smaller parcels and packages were then fitted on the crane vehicle instead, as this vehicle was driving with larger volumes between CCC and construction sites anyway. A suitable electric powered crane vehicle was not found, so the remaining of this demonstration continues using conventional vehicles. The CCC still operates satisfactorily, but at this moment without EFVs. Stockholm local authorities examine the possibilities for an UCC to supply the city center to test EFVs there. [29,32]

2.3.11. Economical insights from FREVUE project

The procurement process of the demonstrations within FREVUE project has illustrated that that the availability of smaller electric vans is relatively good. Several large manufacturers produce EVs for this segment. For the larger vans comparable to e.g. the Iveco Daily, the availability of vehicles is limited. Most of the vehicles used in this category are retrofitted vehicles, for example UPS changes the powertrain and refurbishes the old vehicle, whereas TNT makes use of retrofitted vehicles on a new Fiat Ducato chassis. The Cargohopper 2 is an example of a vehicle in this category that has been completely developed for TransMission. Trucks are relatively scarce in electro mobility. In FREVUE two of Heineken's logistics service providers are using an electric truck at this moment (one 19 ton truck and one 12ton truck), which will be increased to seven trucks in total. . Articulated vehicles are not available at this moment at a feasible price (not as full EV, but also not as plug-in hybrid). The FREVUE demonstrators have confirmed that the availability of EFVs varies. [29]

In general the market for smaller vans is reasonably well developing, whereas larger vans or trucks are often tailor made or produced in smaller batches. This translates into the extra procurement costs: smaller vans are more expensive than conventional vans with an order of magnitude about twice the procurement price and (retrofitted) larger vans show an order of magnitude about twice to four time the procurement price of a comparable conventional vehicle. Trucks can be about four / five times (or more) as much in procurement. Demonstrators also confirm cost advantages of EFVs, such as the use of electricity instead of diesel, tax reductions, and subsidies.

Finding a feasible business case for use of EFVs in city logistics operations is still a challenging issue. Following the line of reasoning as described in Quak et al. (2014), we see that using an EFV in city logistics mainly affects the cost-side. On one hand investment costs increase due to higher vehicle prices, reorganisation of planning, use of extra locations, etc. Costs advantages also occur due to the use of electricity instead of diesel, which can be considerable sometimes up to 80% in cost savings due to using electricity instead of diesel and some other advantages that are discussed in the following sections. On the other hand, the use of EFV usually does not result in extra revenues as most customers do not want to pay more for zero emission deliveries. Therefore, it important to find ways to make the business case feasible. [29]

One of these examples where operational advantages were found is the case of the Cargohoppers in Amsterdam.

In the baseline scenario when all deliveries were made by conventional vehicles TransMission runned two networks in Amsterdam: one for parcels delivered by vans and one for pallet-loads (or bigger) delivered by trucks. These networks overlapped geographically. In the new situation all deliveries are brought to the micro hub where further sorting is done in the four Cargohoppers. The networks that were separated are combined in this new situation and as a result TransMission needs fewer kilometers (both in Amsterdam and in the trips from the depot in Almere toAmsterdam and back). An operational advantage! [29,32]

2.3.12. Policy insights from FREVUE project

Since the EFVs in all categories are more expensive in purchase, an active role of local authorities is often expected to make the business case more feasible. In FREVUE demonstrators three instruments are used cities to promote the uptake of EFVs:

- Subsidies/purchase – in FREVUE many of the vehicles are partly (i.e. a part of the extra costs compared to a conventional vehicle) funded from the project. Some local authorities have subsidies available for the

procurement of EVs example e.g. Amsterdam.

- Some of the FREVUE demonstrations use favorable taxation schemes like no congestion charge for EFVs, no parking fee, or no road tax are another financial instrument that local authorities use to make the business case more attractive for EFVs. Some of these instruments focus more general on electric vehicles rather than EFVs.

For example, carriers do often not pay parking fees when making their deliveries, so there is no actual operational advantage for EFVs if these vehicles do not have to pay a parking fee.

- Supportive policies such as entering (low) emission zones, use of bus lanes, parking at non loading areas, wider time access restrictions, and possibilities to enter pedestrian zones can result in operational advantages. At the same time some environmental zones do not apply to vans and as a result in these cities there is no operational advantage for electric vans at this moment (see for example Rotterdam, Madrid).

Certification is another issue where regulatory support is necessary. This is the case both for EFVs that aredeveloped in small batches, for example the Cargohoppers, but also the larger trucks as for Heineken. Therequirements are strict. All vehicles, as these are often tailor made or specifications slightly differ in batches, have to be tested to get a certificate. These extra certification costs add to the already high prices. No certifications based on standard components are yet allowed.

Another issue, following from the FREVUE demonstration in Milan, is that a vehicle that is approved for one country is not automatically allowed on the road in another European country. The partner who provided the vehicles for Milan is French and the vehicle has a special certification to circulate in France but, in Italy this is not legitimate. As a result, the already limited supply of these electric refrigerated vehicles in Italy is made even smaller. [29]

2.4. Focus on Charging Infrastructures in Italy and Milan

In regards to charging infrastructures, in 2018, 70.000 public and 400.000 private charge stations were installed in Europe, corresponding to a third of all installations worldwide. At the end of 2017, Italy is estimated to have around 2.750 public charge stations (16% of which are high powered) and 7.000 private charge stations.

New installations stopped between 2013 and 2014, but they have started again in recent years: public charge stations have increased by around 250 units in 2016 and 750 units in 2017. The global average ratio between charge stations and EVs equals 0,86 (China 1,05). Having a station/EV ratio of 0,66, Italy is the European country with the lowest relationship, which again confirms how far the country is from being an EV mature market. [33]

According to the Italian Plan on electric charging infrastructures (PNIRE), Italy aims at installing between 4.500-13.000 low-powered public charge stations and between

2.000-6.000 high-powered public charge stations. In order to reach these targets, the plan sets a minimum number of charge stations to be installed on a 2-year basis by 2020. [33]

On the topic of barriers to the development of such infrastructure, the PNIRE identifies the uncertainty of bureaucracy timing as the main challenge for operators. In particular, timing issues concern the delay of local authorities (mainly municipalities) in providing permits for public land use (by law the authorization should be issued within 30 days from the request, but given that this timing is not mandatory it is often not respected), as well as delays in providing the connection of stations to the electricity grid by the Distribution System Operators (DSO).

The e-charging infrastructure market in Italy appears still at an early stage, as companies are still figuring out the optimal solutions for operating in this sector. The majority of these infrastructures are commissioned either by local authorities or by a Point of Interest (PoI), i.e. big commercial activities (shopping centres, cinemas, supermarkets, etc.) who wish to attract customers by providing a free or flat-rate charging service. Points of Interest are quite a widespread buyer in Italy at the moment, however they are not expected to grow much more in the future.

Regardless of whether the client is public or private, in most cases all the aspects concerning infrastructure are managed by an E-Mobility Provider (EMP), who plays an "extended" role by dealing with all the technical and maintenance aspects, together with its usual e-service activity. This is by far the main business model occurring in Italy, and the EMP involved is very often a utility provider such as Enel, A2A and Hera. This model makes it, on one hand, easier for the buyer (especially for a local authority) to deal with just one counterpart; on the other hand, it also makes access and charge terms still highly fragmented, as each buyer can demand different terms, and this causes uniformity issues. [33, 34, 35]

Table 2.6: Public charge stations in Italy [33]

	2011	2012	2013	2014	2015	2016	2017
Public charge stations- Normal power (<22 kW)	614	1350	1350	1350	1679	1796	2298
Public charge stations- High power (>22 kW)	2	2	6	13	70	203	443
Total public charge stations	616	1352	1356	1363	1749	1999	2741

Despite the lack of official data, Motus-e4, a leading association for e-mobility in Italy, is confirming the increasing trend also for 2018 as they estimate that there are over 5.000 public charge stations today in Italy. [34]

These numbers are still much lower than what was planned in the Infrastructural Plan for charging Electric Vehicles [PNIRE, 2015], which contains targets and technical information for completing the Italian electric charging stations as required by the AFID. The plan was last updated in 2015.

2.4.1. What is PNIRE?

The Italian Plan on electric charging infrastructures (PNIRE) The PNIRE aims at installing between 4.500-13.000 low-powered public charge stations and between 2.000-6.000 high-powered public charge stations. In order to reach these targets, the plan sets a minimum number of charge stations to be installed on a 2-year basis by 2020:

- 2015-2016: at least 150 highways charge stations; 150 road stations (i.e. 1.5% of total

installations) starting from the most relevant and driven roads; 150 stations in the surroundings of crucial traffic spots such as big railway stations, underground parking lots, airports and ports).

- 2017-2018: 150 highways stations, 200 road stations (hence reaching 3.5% of total installations), 200 stations around crucial traffic spots.
- 2019-2020: 200 highways stations, 1.400 road stations (17.5% of total installations) and 1.400 stations around crucial traffic spots.

In order to reach these targets, a public fund has been established by the PNIRE to finance local charging infrastructure projects. The fund was brought into effect last year when the Ministry of Transport and the Regions/Autonomous Provinces signed an agreement to allocate 72 million euros across all but two Italian Regions to finance their regional programs for e-mobility infrastructure. Both public and private infrastructures must be included in these programs and financing applies to all stages of the infrastructure development, from strategical planning to the installation of the infrastructure and to the information given to the public. The fund is co-financed by the Minister of Transport (with a cap of 50%) and the Regions/Autonomous Provinces. [34]

2.4.2. Procurement and tender procedures for charging infrastructures

The Italian transposition law of the Legislative Decree implementing Directive 2014/94/EU (namely the AFID, Directive for Alternative Fuel Initiative), which regulates the measures to implement alternative fuels and electric vehicles charging [AFID, 2016], constitutes the main legislative reference for charging infrastructures in Italy. First, the law outlines (with further specifications than the AFID) definitions and categorizations of the charging infrastructures. Charging points can be either accessible or not accessible to the public; the latter case refers to charging points that are located within residential or business areas for their exclusive use. On the other hand, charging points that are accessible to the public can be built through public or private initiatives, with different terms for authentication, use and payment.

As set out by the AFID, charging points are distinguished between standard power – that transfer electricity to EVs whose power is up to 22 kW – and high power – that refuels EVs with a power higher than 22 kW. Besides, the Italian transposition further splits: standard power into slow and quick, and high power into fast or super-fast. Sometimes, as in the PNIRE, the distinction between fast and super-fast is omitted. Table below depicts different charging points technologies.

Table 2.7: Different charging points technologies [33]

Normal power charging points		High power charging points	
Slow	Quick	Fast	Superfast
kW<7.4	7.4< kW < 22	22<kW<50	kW>50

The PNIRE also sets out priorities and criteria for placing charging infrastructures that are accessible to the public. First, they should be placed at refueling stations, as they are located in demand-sensitive areas, they are already connected to the electricity grid and video-monitored. Second, charging points should be located near big attractive areas, such as shopping centers, cinemas and supermarkets; this is because not only they are highly attended, but also (and more importantly), because charging timing can easily match consumers' habits. For similar reasons, charging infrastructures should also be strategically located in big parking lots, requiring as well a required number of dedicated parking spots. Overall, charging points should allow at least for two EVs to charge simultaneously, so as to avoid excessive public land use. [35]

Regarding possible barriers to the development of charging points, the PNIRE identifies the uncertainty of bureaucratic time constraints as a main challenge for operators. In particular, timing issues may affect municipal protocols in providing permits for public land use, and for Distribution System Operators (DSO) to be able to connect to the electricity grid. For the former, the law suggests (but does not mandate) that authorizations from municipalities should not take more than 30 days to be issued. [33]

According to AFID requirements, charging infrastructures and services that are accessible to the public must be developed utilizing fair trade practices, which can be set either directly via the market or indirectly via public tenders held by both local and central governments. Requirements for tenders are also stipulated in the PNIRE. Firstly, tenders must require technological interoperability of the infrastructures (also when assigned to different producers) so as to steer the market towards open systems and to guarantee territorial continuity of the charging service. Secondly, the manufacturer must ensure an adequate management system is in place, which should provide the municipality with crucial information, such as their location and whether the system is correctly working, their degree of interoperability and their integration with ITS (Intelligent Transport Systems) for local traffic management. Besides, as mandated by the AFID, the infrastructure must also include the possibility for EV users to charge without having to enter into a contract with the electricity provider concerned. Last, but not least, tenders must follow the general regulation for public procurement as stipulated in the Legislative Decree n. 50 of April 18, 2016. [33]

In this frame, the Distribution System Operators (DSOs) have to deal with additional specific requirements. On one hand, they must guarantee a non-discriminatory cooperation with any charging operator, especially in terms of permits required with local electricity providers. On the other hand, when a DSO wishes to take part in the tender, national antitrust law applies, requiring that they can only do so through a vertically integrated firm – i.e. a separated firm that is part of the DSO group. The DSO is also expected to plan the development of the electricity provision in coherence with an increasing demand for fast and high-speed charging services. In general, a close working relationship between local authorities and DSOs is crucial for strategic charging infrastructure planning, also considering that, the infrastructure does not only include the sole charging activity, but also multiple charging services.

2.5. The current status of the transition to e-Mobility throughout Italy

The Electric Transport (ETI) is an innovative tool that enables to gage performances in relative terms of the 20 Italian Regions (ETI[R]) and the 14 Metropolitan Cities (ETI[M]). [33]

It is calculated based on the below graph:

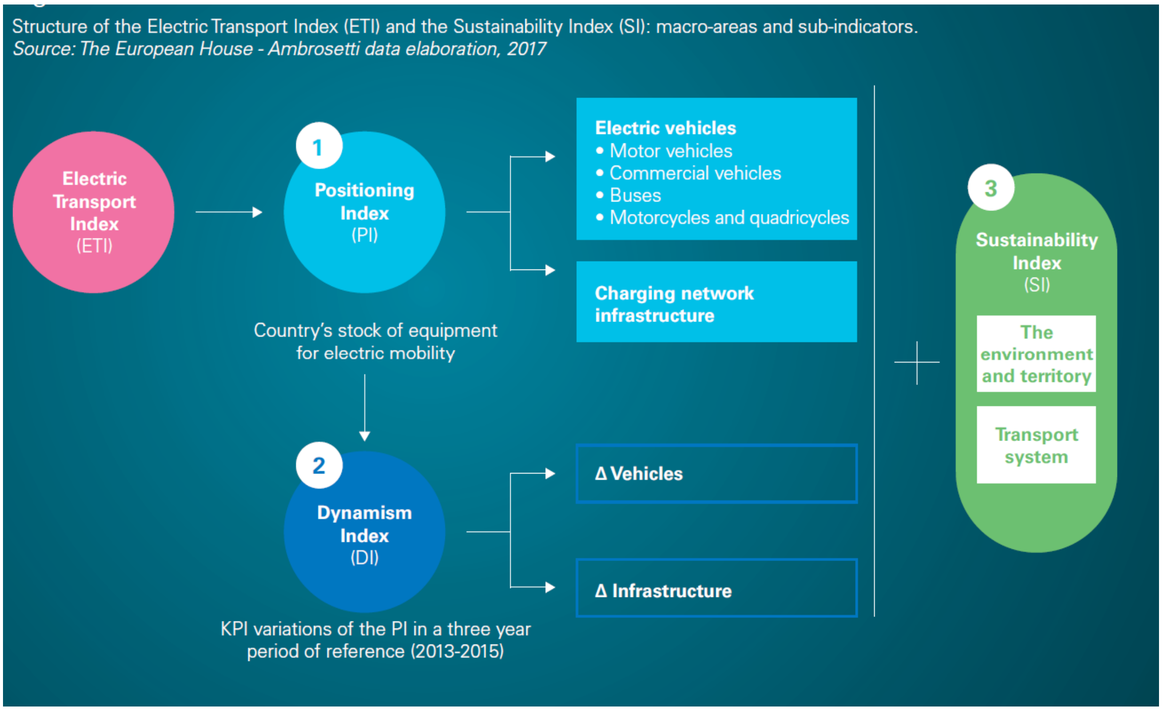

Figure 2.20: Structure of the Electric Transport Index (ETI) and the Sustainability Index (SI) [33]

To have a clearer idea of the current status of e-Mobility across Italy, The European House - Ambrosetti developed the Electric Transport Index (ETI) which makes it possible to compare in relative terms the performance of Italy's 20 Regions (ETI[R]) and 14 Metropolitan Cities (ETI[M]). The creation of the two synthetic indicators, ETI[R] and ETI[M], are based on the identification and selection of a series of Key Performance Indicators (KPIs) aimed at measuring the current level of development locally in Italy of road electric transport (motor vehicles, commercial vehicles, motorcycles and quadricycles) on the basis of two aspects:

- The extent of electric transport vehicles and the status of local infrastructure (stocks), measured using a Positioning Index (PI).

• Variation over time of vehicle and infrastructure stocks in the short-term (three-year reference period3), measured using a Dynamism Index (DI).

This information was combined with the Sustainability Index (SI) which provides a qualitative/quantitative indication of the extent to which a given area is sustainable both environmentally and in terms of its transport system.

For each sub-index (PI, DI and SI) the KPIs selected were grouped into macro-areas. Specifically:

• The Positioning Index is comprised of 14 KPIs for Italy's Regions and 12 KPIs for its Metropolitan Cities, which are sub-divided into two macro-areas "Electric vehicles" and "Charging infrastructural grid". The former provides a picture of electric vehicles in local areas, measured both in absolute terms and relatively in terms of the overall fleet of motor vehicles, (light and heavy) commercial vehicles, buses, motorcycles and quadricycles in circulation, while the latter refers to electric charging points in the area and number of charging stations for electric motor vehicles in circulation.

• The Sustainability Index is comprised of 7 KPIs for the regions and 6 KPIs for the Metropolitan Cities, sub-divided into the macro-areas of "Environment and Local Area" which monitors a number of negative external influences on the environment linked to transport (level of air, noise and water pollution) and "Transport System" which examines the primary risks connected to an inefficient road transport system with low sustainability (level of motorization, average age of vehicles in circulation, level of pollution of motor vehicles in circulation and risks from road transport). While the Positioning Index (PI) is given a numeric score in relative terms (on a rising scale from 1 to 10), the Dynamism and Sustainability Indices (ID and IS) are expressed in an overall range of the area's positioning ("high", "medium- high", "medium-low" or "low").

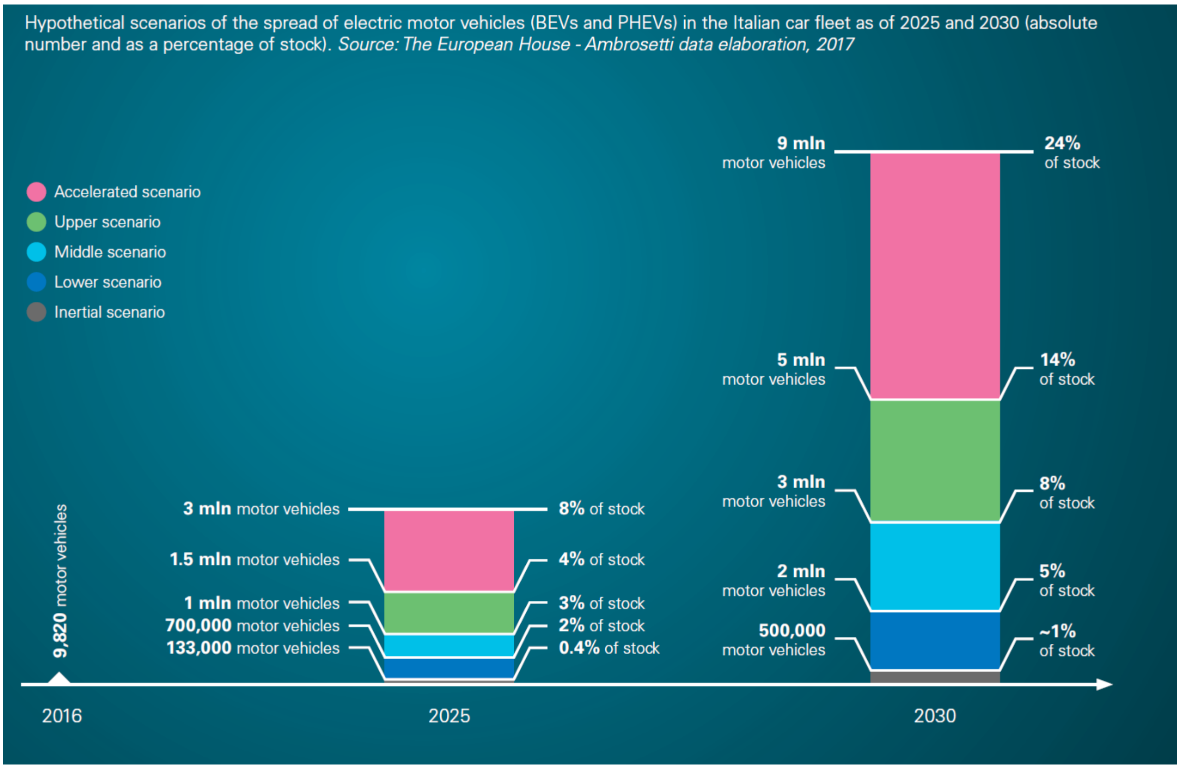

Figure 2.21: Hypothetical scenarios of the spread of electric motor vehicles (BEVs and PHEVs) in the Italian car fleet as of 2025 and 2030 [33]

Hypothetical scenarios of the spread of electric charging points (public charging stations and private wall-boxes) and the ratio of electric motor vehicles (EVs) and charging points in Italy as of 2025 and 2030. N.B.: the histograms refer to hypothetical growth in the number of electric motor vehicles (BEVs and PHEVs) on a national level in the various development scenarios for the years 2025 and 2030 (respectively 3 and 9 million electric motor vehicles in the accelerated scenario). *Source: The European House - Ambrosetti elaboration based on Enel estimates, 2017*

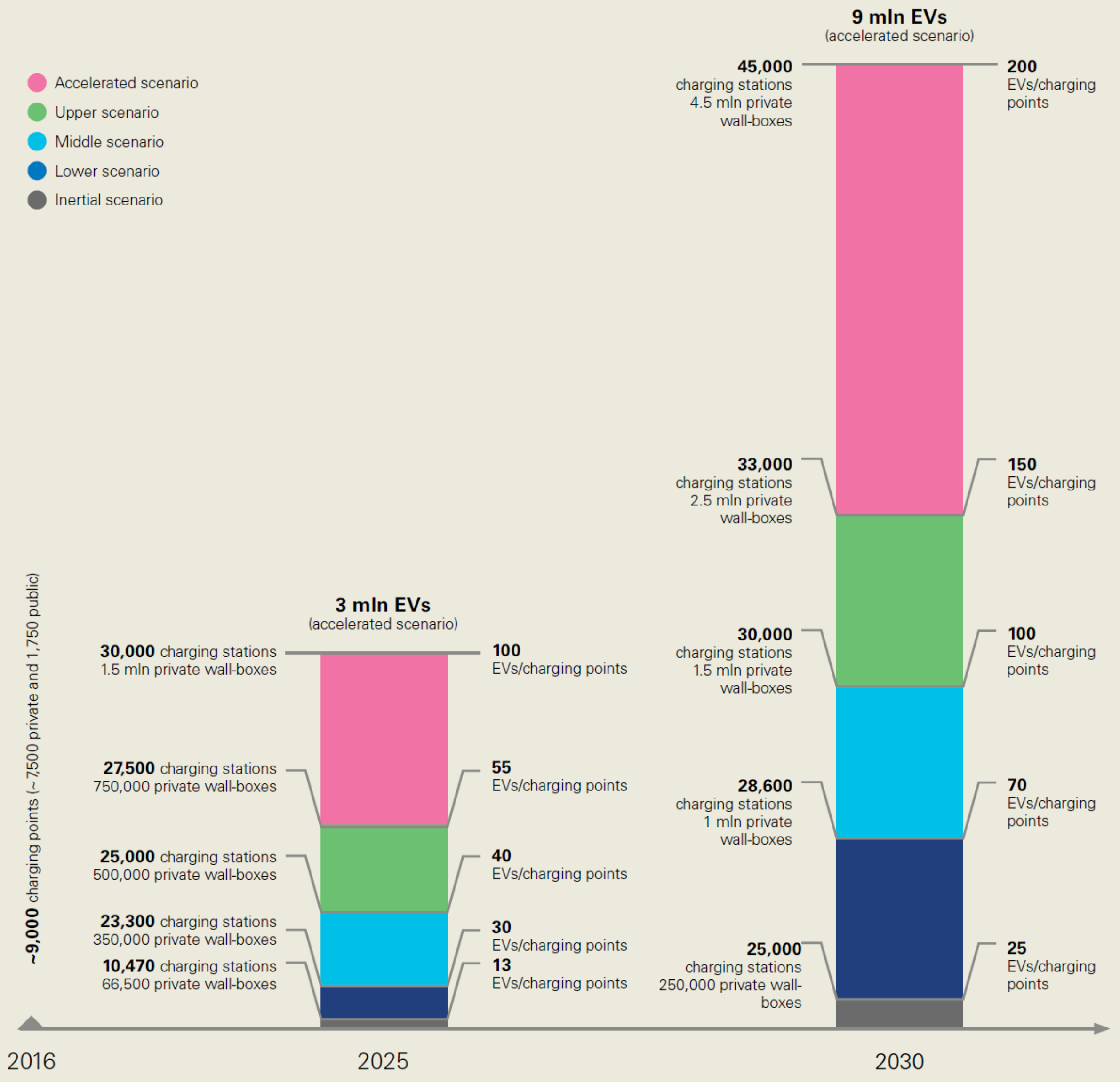

Figure 2.22: Hypothetical scenarios of the spread of electric charging points (public charging stations and private wall-boxes) and the ratio of electric motor vehicles (EVs) and charging points in Italy as of 2025 and 2030 [33]

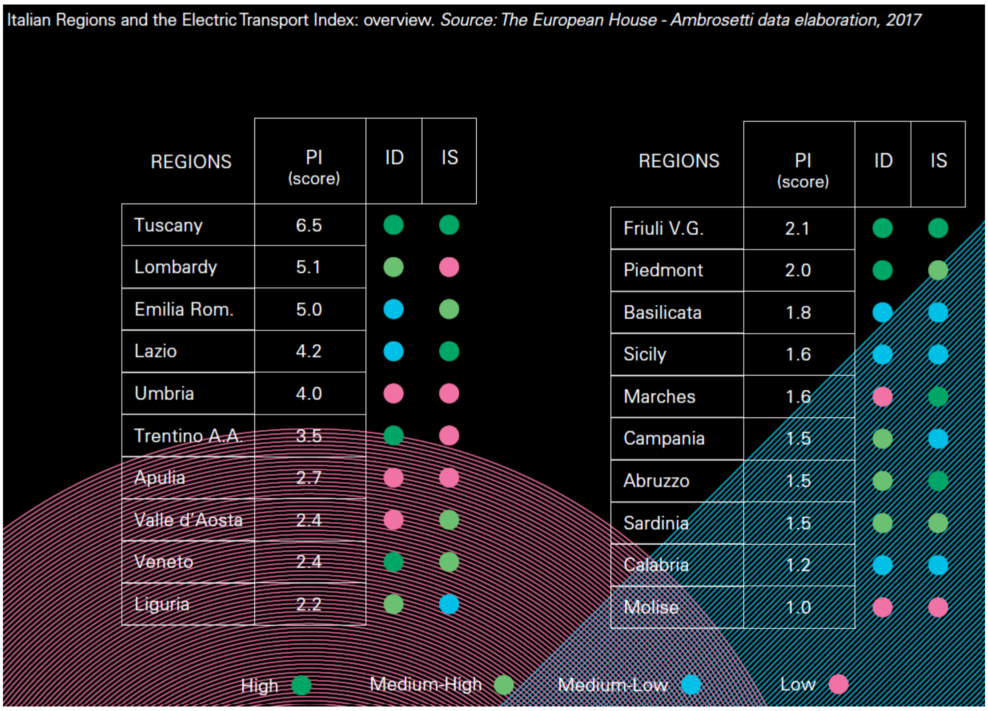

Figure 2.23: Italian Regions and the Electric Transport Index [33]

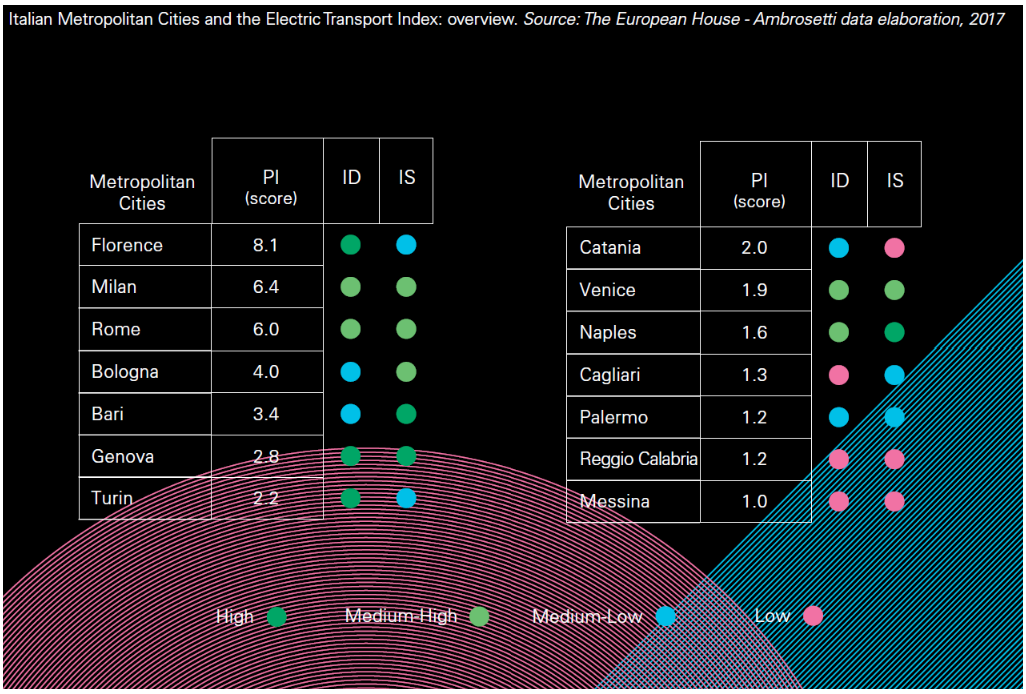

Figure 2.24: Italian Metropolitan Cities and the Electric Transport Index [33]

The Electric Transport Index reflects a highly-diversified situation within Italy, with a significant gap between the north and south of the country. Among Italian regions, Tuscany has the highest e-Mobility score in the Positioning Index (6.5 out of a maximum of 10), showing a high level of dynamism in the short-term and in the sustainability of its regional transport and environmental system. In second and third place are Lombardy and Emilia-Romagna with specific strong points in, respectively, the spread and level of electric cars and commercial vehicles. With the exception of Apulia, all the Regions in the south of Italy are positioned in the lower part of the ITER 2017 ranking, thus indicating ample potential for development of e-Mobility in these areas, including as a strategic driver in support of improvement in sustainability regarding the environment and local transport system. [33, 34]

Among the Italian Regions, Tuscany records the highest score of 6.5 out of a maximum value of 10. With the exception of Apulia, all the regions in Southern Italy are in the lower half of the ETIR 2017 rankings, highlighting the great potential that exists in these areas for the development of e-Mobility. The best performance in the ETIM 2017 rankings for electric transport was delivered by the Metropolitan City of Florence, with a total score of 8.1. It is followed by the metropolitan areas of Milan (6.4 points out of a maximum of 10) and Rome (6.0 points). [33]

Table 2.8: Comparison of Milan with other big EU cities regarding charging stations [33]

	City	Population (Million)	Charging points	Charging points per 10,000 inhabits	Average travel time (minute)
1	Paris	7.40	190.00	0.26	1.94
2	London	5.95	6508.00	10.94	0.01
3	Madrid	4.80	291.00	0.61	2.22
4	Barcelona	3.33	620.00	1.86	0.96
5	Berlin	3.06	1215.00	3.97	0.73
6	Milan	2.81	904.00	3.22	0.73

7	Rome	2.60	623.00	2.40	2.37
8	Naples	2.55	50.00	0.20	3.88
9	Budapest	2.06	596.00	2.90	1.55
10	Bucharest	2.04	57.00	0.28	7.73
11	Vienna	1.99	579.00	2.91	2.28
12	Warsaw	1.89	81.00	0.43	3.77
13	Munich	1.88	1063.00	5.67	0.80
14	Hamburg	1.7	2171.00	12.76	0.67
15	Turin	1.57	377.00	2.40	2.02
16	Cologne	1.54	529.00	3.43	1.09
17	Prague	1.44	232.00	1.61	1.77
18	Sofia	1.29	17.00	0.13	14.84
19	Stockholm	1.21	1607.00	13.32	2.08
20	Amsterdam	1.20	1020.00	8.50	0.76

A further dedicated assessment is carried out for the case of the 20 largest cities in the European countries that have been considered and compares Milan to other major EU cities. In particular, Table 13 describes and compares cities in terms of their population, charging points, and accessibility to charging stations. Since the listed cities differ substantially in terms of their urban sprawl, administrative boundaries, and morphology, we decided to calculate statistics within a 25 km radius buffer around each city core to improve the comparability of the reported metrics across cities. The city core is based on the coordinates reported in the World Cities Database. Population is calculated based on zonal statistic sum of GHS-POP gridded population within the buffer.

The results show that population within the 25 km radius buffer around each city core is not significantly correlated to the number of available EV charging points in the same area. This result suggest that a significant role is likely played by the different degrees of market maturity as well as the public policy support to the installation of EV infrastructure in similarly sized cities. This is summarized by the charging points per 10,000 inhabitants metric, which reveals that Stockholm, Hamburg, and London are the European metropolitan cities with the largest penetration of EV charging infrastructure. They are followed – albeit at significant distance – by Amsterdam, the German cities of Munich, Berlin, and Cologne, and by Milan. The average travel time column of Table 13 summarizes the travel time to the most accessible charging station at each pixel falling within the 25 km buffers considered. It must be remarked that these times refer to the nominal travel times. Namely, in dense urban areas a single station might lead to the consideration of thousands of people as at <1 min from the most accessible charging point. The metric is therefore more useful in comparative terms across cities, rather than for its absolute value. [33]

3 Conclusion and future developments

3.1. Conclusion

To cut a long story short, The EU have not achieved its targets for publicly accessible chargers until now.

European countries for the most part failed to meet the recommended electric vehicle supply equipment (EVSE) per EV 2020 targets for publicly accessible chargers set by the Alternative Fuel Infrastructure Directive (AFID). However, there are wide disparities between countries. AFID, the key policy regulating the deployment of public electric EVSE in the European Union, recommended that member states aim for 1 public charger per 10 EVs, a ratio of 0.1 in 2020.

In the European Union, the average public EVSE per EV ratio was 0.09 at the end of 2020. But that is not the whole story. The Netherlands and Italy are above the target at 0.22 and 0.13 respectively, with almost all being slow chargers, though fast chargers are 3% of the installations in the Netherlands and 9% in Italy.

Countries with the highest EV penetration tend to have the lowest EVSE per EV ratios, such as Norway (0.03), Iceland (0.03) and Denmark (0.05). In these sparsely populated countries with many detached houses and private parking spaces, most EV owners can largely use private home charging. To a lesser extent, it also reflects that the Nordic countries have a higher proportion of fast chargers, with shares of 40% in Iceland, 31% in Norway and 17% in Denmark.

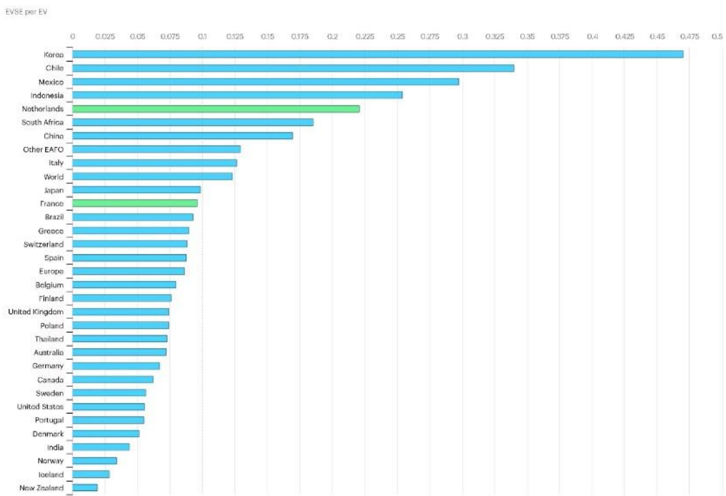

Figure 3.25: ratio of public chargers for EV by country [3]

3.2. Future Development

1. Developments are still required to obtain a robust charging infrastructure that is suitable for the demanding daily practice of the logistics sector. Remote diagnosis and configuration of the charging infrastructure, the vehicle and the combination thereof is a major wish-list item.
2. A sound strategy is required regarding the choices for on-board AC-DC converters versus external DC chargers. If the external charging infrastructure has a different design (e.g. aiming for cheaper 44 kWh AC charging stations) from that built into the cars by OEMs (e.g. aiming for external DC chargers), this causes lots of issues for carriers.
3. Collecting the actual practical consumption figures of BEV goods vehicles, especially the effect on consumption of:
• Outside temperature.
• Weight.
• Tyre pressure.
• Journey profile (speed, stops).
• Driving behaviour.
It is a known fact that these factors greatly affect the power consumption and range. Collecting this data from everyday practice will allow the following:
• Creating training programmes for drivers.
• Ensuring that software for journey planners takes these effects into account (predictability).
4. Supporting businesses in redesigning their logistics, modified for the combination of ZE zones and BEVs.
5. Collecting the data in other regions, performing the same calculations and using these results for the development of ZE zones in accordance with the Climate Agreement.
6. Assessing the assumptions and results with businesses in the logistical segments in order to refine the input data.
7. Paying specific attention to the target group that makes a living with relatively old delivery
vans within the city as independent entrepreneurs in retail, the construction sector or with parcel deliveries. This relatively vulnerable group has less access to funding for (new) electric delivery vans, but will have to deal with the effects of the ZE zones.
8. The method used to model the power demand during the day, constructed from journey profiles and charging strategies, appears to be very fruitful. The same approach for BEV public transport buses was immediately proposed as a useful exercise, if only to see whether that typical demand for charging coincides with the peaks in the demand for charging for logistics or not. Continuing this line of

reasoning, it would be advisable to set this up for all energy consumers (homes, offices, industry, data centers) per postcode area and in this way gain an insight into the local 'electric heartbeat' of the city.

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