REPORT ON STATE-OF-THE-ART OF ELECTRIC AND AUTONOMOUS MOBILITY POLICIES AND BUSINESS MODELS

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About ERA-Net Smart Energy Systems

ERA-Net Smart Energy Systems (ERA-Net SES) is a transnational joint programming platform of 30 national and regional funding partners for initiating co-creation and promoting energy system innovation. The network of owners and managers of national and regional public funding programs along the innovation chain provides a sustainable and service oriented joint programming platform to finance projects in thematic areas like Smart Power Grids, Regional and Local Energy Systems, Heating and Cooling Networks, Digital Energy and Smart Services, etc.

Co-creating with partners that help to understand the needs of relevant stakeholders, we team up with intermediaries to provide an innovation eco-system supporting consortia for research, innovation, technical development, piloting and demonstration activities. These co-operations pave the way towards implementation in real-life environments and market introduction.

Beyond that, ERA-Net SES provides a Knowledge Community, involving key demo projects and experts from all over Europe, to facilitate learning between projects and programs from the local level up to the European level.

www.eranet-smartenergysystems.eu

About EVA project

The EVA project aims to support urban and regional institutions to steer the transition towards electric, connected and autonomous vehicles, and at identifying innovative territorial infrastructures capable of effectively supporting such a transition. The project started in September 2019 and the project consortium involves the following partners: SUPSI from Switzerland, EURAC from Italy, AICO from Austria, and MINES ParisTech from France. More detailed information is available on the project website www.evaproject.eu

About this deliverable

This deliverable is one output of Work Package 2 – Pilot regions. Such a Work Package is the starting point of the research work of the EVA project and aims to provide a detailed picture of the current mobility system in the two pilot regions of the project (Canton Ticino in Switzerland and South Tyrol in Italy). The collected insight will be the baseline for the co-creation of future mobility scenarios in Work Package 3 and for the simulations to be performed in Work Package 4.

This deliverable reports the state-of-the-art of electric and autonomous mobility policies and business models at the European, Swiss, Italian and, in particular, Ticino and South Tyrol levels. The evolution of electric passenger cars market share in Europe and in particular in Ticino and South Tyrol is reported. For both pilot sites the policies and incentives put in place to increase the number of electric vehicles are also analysed. Furthermore, an overview of the autonomous vehicles state of play is presented.
GLOSSARY

EU – European Union

EC – European Commission

EU28 – Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Sweden, United Kingdom;

EU/EFTA/Turkey – All EU28 countries more EFTA countries (Iceland, Liechtenstein, Norway and Switzerland) and Turkey;

EU27 – All EU28 countries except United Kingdom;

EAFO – European Alternative Fuels Observatory

FSO – Swiss Federal Statistical Office

FSOE - Swiss Federal Office of Energy

ICE – Internal Combustion Engine

BEV – Battery Electric Vehicles

PHEV – Plug-in Hybrid Electric Vehicles

PEV – Plug-in Electric Vehicles (BEV more PHEV)

FCEV – Fuel Cell Electric Vehicles

FEDRO – Swiss Federal Roads Office

AV – Autonomous Vehicles

SEA – Society of Automotive Engineers

UK – United Kingdom

CO2 – Carbon dioxide

NOx – Nitrogen oxides

GDP – Gross Domestic Product

OEM – Original Equipment Manufacture
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1 INTRODUCTION

In 2017, total passenger transport activities in the EU28 by any motorized means of transport were estimated to amount to 6 913.3 billion km or on average to around 13 505 km per person. This figure includes intra-EU air and sea transport but does not include transport activities between the EU and the rest of the world. Passenger cars accounted for 70.9% of this total, two-wheelers for 1.8%, buses and coaches for 7.4%, railways for 6.8% and tram and metro for 1.6% (European Commission, 2019). The main downsides of this intensive road transport are well-known:

- Climate change: the transport sector in the EU28 was responsible for 1249.6 Mtons of CO₂ equivalent (27% of the total CO₂ emissions); of those, 895.8 Mtons of CO₂ equivalent (19% of the total CO₂ emissions) were emitted by the road transport (European Commission, 2019) (Figure 1);

![GHG Emissions EU-28 (2017)](image)

- Air pollution: within the whole EU, road transport has a major share in other negative environmental effects, such as NOx emissions, fine dust and noise (EEA, 2019);
- Productivity: road congestion costs on average 1 % of Gross domestic product (GDP) in the EU (Christidis & Rivas, 2012);
- Road fatalities: in 2017, road accidents were responsible for 25'300 fatalities and 135’000 seriously injured people (European Parliament, 2019);
- International dependency: the transport sector is the biggest driver of oil demand at EU level – two-thirds of final demand for oil come from transport. In 2014, road transport accounted for 54% of final demand for petroleum products. Over 80% of the imported crude oil in 2014 was supplied by non-European companies (Transport & Environment, 2016).

In the recent years, mobility has been experiencing numerous and disruptive innovations and upheavals: the demand for mobility is becoming more and more pressing, not only more user friendly and tailored to people's individual needs but also more sustainable from an environmental, social and economic point of view. The elements that influence and increasingly will influence the market linked to mobility soon are schematically listed below.

**Growth of the impact of digitalization**

Rather than representing a mere technical evolution, digitalization embodies a real social and industrial revolution that has radically impacted and modified our daily life. Digitization does not mean, or at least not only, the simple shift of traditionally offline activities to online, ranging from work to shopping, but also an increasing incidence of connectivity and automation of everyday
objects, from cars to refrigerators (IoT), and an intensification and speeding up of communication between people. Other innovations, currently not yet present in our routine, such as virtual reality and augmented reality, are further elements that soon could be part of our everyday life.

**Urbanization**

The population increasingly tends to leave rural areas in favour of more densely populated centres to enjoy services and a wider choice in the workplace. The trend is even more evident in more recently developed countries such as Asia where, also by virtue of faster population growth, the projections to 2050 show that more than 3 billion people will be urbanized. The European numbers, although less impressive than the Asian ones, are nevertheless not negligible, since over the course of a century, between 1950 and 2050, the population could register an increase of 105%. In combination with the trend of digitization, this obviously makes measures aimed at making cities smarter and more desirable, lest they lose their liveability.

![Urbanization Graph](image)

**Development of environmental awareness**

The awareness of the limited resources has increasingly arose since the 1970s, bringing to the fore issues related to sustainability, savings and protection of the environmental heritage. This awareness has translated not only into regulations and measures - both internationally and cascading, nationally - aimed at reducing CO₂ emissions and increasing energy efficiency (Paris Agreement, n.d.), but also at a more marked environmental awareness, which translates into a greater commitment disseminated by individuals to contribute as much as possible to reduce their impact on the environment.

**Shift of the middle class**

The middle class in Europe is experiencing a decline in numerical terms, while it is increasing in Asia, where it is projected that it could increase by 38% by 2030, while it could decrease by 11% in northern America and by 22% in Europe. In these latter markets, the gap is widening between those with high purchasing power and those who are gradually losing it.

Contextualised and dependent on the diminished purchasing power of a segment of the population, on a more marked attention to sustainability issues, lack of space in the city due to the growing urbanization, a propensity to share resources rather than their possession. Ownership of an asset is also made less attractive by the fact that technological progress has never been as rapid as it is now, which increases the perception that an asset may quickly become obsolete and consequently devalued.
Significant growth in tourism and leisure activities

Over the twenty years period 1996-2016 the number of international arrivals more than doubled (with a growth of 219.4%) passing from 563 to 1235 million global arrivals (source: Statista, Tourism Worldwide 2017). The greater mobility of people has been facilitated by multiple factors ranging from the advent of low-cost airlines to the greater economic availability of new tourists, for example from the Asian and South American markets. The other numbers of people moving globally naturally have a significant impact on the transport sector, both long-haul and, once at destination, short haul. In places with a high tourist intensity, the high number of visitors makes it even more urgent to implement strategies aimed at making mobility more sustainable, not only for environmental and economic considerations, but also for the quality of life of local inhabitants and the guests themselves.

The growing importance of leisure in individual travel patterns has been observed across all Western countries over the past few decades. This type of mobility is unique in several ways: it is primarily based on choice and preference, spatially dispersed across a territory, and non-routine in nature (Nessi, 2017). For example, in Switzerland leisure is the main reason why people take trips: it was estimated that 44% of the average daily distance within Switzerland was covered in connection with leisure activities while work-related traffic accounted for 24%, and shopping trips for 13% (FSO, 2015).

Starting from the considerations briefly outlined above, it is possible to identify how these trends are affecting the mobility sector, which we have tried to categorize in a short list below. Although the trends are listed separately, it is appropriate to keep in mind that they are closely intertwined and independent.

Decarbonisation

Transport is the only sector in the EU, which did not record any important decline in greenhouse gas emissions in the last decades. Its emissions started to decrease slightly only after 2007 but are still higher than in 1990. In the framework of fighting climate change, the EU has set several targets on limiting greenhouse gas emissions from transport and making it less dependent on oil. The 2009 EU renewable energy directive required that 10% of transport fuels should come from renewable energy by 2020. The most recent data show that in 2018, 8.1% of the energy consumed in transport was renewable (EEA, 2019).
Fuel quality is also regulated at EU level, with a reduction target of 6% of the greenhouse gas intensity of the fuels used in vehicles by 2020. The Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, the so-called White Paper on Transport published by the Commission in March 2011, set an objective of lowering transport CO₂ emissions by 60% in 2050 compared to their 1990 level. The EU has adopted several measures to reduce emissions from road vehicles for example: the binding emission targets for new car and van fleets are already set since 2013 and the Commission set reduced targets at the beginning of 2020; and, EU consumers are also provided with information on fuel consumption of cars and their CO₂ emissions, which is also regulated at EU level (European Parliament, 2020).

Still, according to EEA (2017) recent data Europe relies on conventional vehicles while more sustainable technologies are being developed and slowly penetrating in the market (Figure 3).
Renewable alternative fuels (biofuels) would be an effective way to cut emissions, since they would require limited changes in the fuel distribution infrastructure and in internal combustion engines of vehicles, therefore the EU is supporting their deployment. However, use of bio-fuels raises critical issues about fairness of crop use for transport reasons, when world hunger has not been eradicated yet. Therefore, the electrification of transport appears as the best short- and medium-term solution. It is a way of reducing not only CO₂ emissions, but also particle emissions and noise pollution in urban areas. The deployment of electric cars, vans and buses used in urban transport is certainly closer than the electrification of trucks, coaches, ships and planes, as these remain a matter of further research. The Commission’s low-emission mobility proposal has introduced ways to scale up the use of renewable electricity for transport. It stresses the need for better infrastructure for charging, interoperability and EU-wide standardisation for electro-mobility (Virkkunen, 2017).

**Intelligent transport systems**

The term Intelligent Transport Systems (ITS) refers to information and communication technology applied to transport infrastructure and vehicles, to improve transport outcomes such as transport safety, transport productivity, travel reliability, informed travel choices, social equity, environmental performance and network operation resilience (World Road Association, 2002).

In many aspects, today’s vehicles are already connected devices. However, in the very near future they will also interact directly with each other and with the road infrastructure. This interaction is the domain of Cooperative Intelligent Transport Systems (C-ITS), which will allow road users and traffic managers to share information and use it to coordinate their actions. This cooperative element – enabled by digital connectivity between vehicles and between vehicles and transport infrastructure – is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation. Communication between vehicles, infrastructure and other road users is also crucial to increase the safety of future automated vehicles and their full integration in the overall transport system. Cooperation, connectivity, and automation are not only complementary technologies; they reinforce each other and will over time merge completely (European Comission, 2020).

**Automation**

Artificial intelligence is changing the transport sector. From helping cars, trains, ships and aeroplanes to function autonomously, to making traffic flows smoother, it is already applied in numerous transport fields. Beyond making our lives easier, it can help to make all transport modes safer, cleaner, smarter and more efficient. Artificial intelligence-led autonomous transport could for instance help to reduce the human errors that are involved in many traffic accidents. However, with these opportunities come real challenges, including unintended consequences and misuse such as cyber-attacks and biased decisions about transport. There are also ramifications for employment, and ethical questions regarding liability for the decisions taken by artificial intelligence in the place of humans (European Parliament, 2019).

**Shared mobility**

Mobility is increasingly seen as a service rather than an asset, that is, for users it is no longer the possession of a vehicle that is attractive, but rather the benefits and services connected to it. This translates into an increasing popularity of the models of individual mobility "on demand", especially with regard to car sharing and leasing, which have the additional advantage of reducing city traffic and congestion, also in consideration of the increasing crowding of urban centres. This change can in all respects be defined as "disruptive", since traditional business models, such as the production of vehicles for example, can be deeply challenged by players coming from areas unthinkable until a few years ago, as in the case of Google and Apple, which can leverage a vast know-how in the cloud, digital and social fields.
Finally, it should be stressed that it would be an understatement to think that sharing in the field of mobility is limited to the mere sharing of a vehicle, an e-bike or other means of transport, since it can extend to multiple aspects, from car-pooling to the energy stored in the EV batteries (e.g. Sion- Sono Motors power sharing).

Furthermore, in the recent years the idea of the Mobility as a Service (MaaS) has been flourishing. It consists in the integration of various forms of transport services into a single mobility service accessible on demand. To meet a customer’s request, a MaaS operator offers a diverse menu of transport options, be they public transport, ride-, car- or bike-sharing, taxi or car rental/lease, or a combination thereof.

The trends relating to mobility electrification and automation will be further discussed in this document, starting from a brief description of the technologies, and then reporting the penetration tendencies, first at the pan-European level and then at the test site level.
2 WHAT ELECTRIC VEHICLES ARE

The passenger cars market is dominated by internal combustion engines (ICE). These engines burn fossil fuels (petrol, diesel or LPG) to give motion to the vehicle. Electric engines use electrical energy to give motion to the vehicles. Today there are different forms of electric engines, in particular:

- BEV (Battery Electric Vehicle) - the chemical energy stored in one or more rechargeable batteries powers an electric motor. The batteries are recharged by plugging-in the vehicle to the electric grid;

- A Plug-in Hybrid - PHEV (Plug-in Hybrid Electric Vehicle) - can be seen as a mix between an electric and an ICE car, since its batteries can be recharged directly from the grid like a BEV, but it can switch to the ICE engine in case the batteries runs out;

- In the Extended Autonomy Electric - REEV (Range-Extended Electric Vehicle) - the internal combustion engine is used only as an electricity generator to recharge the traction battery, when the charge level is low. Due to the additional engine, REEVs are more expensive than BEVs;

- In a Hybrid Vehicle - HEV (Hybrid Electric Vehicle) - one or more electric motors are flanked to the thermal engine (petrol or diesel). The battery of the HEV is sufficient to support energy recovery braking and to travel a few kilometres in electric mode, but in return, by appealing to the thermal engine, the fuel supply allows good autonomy;

- In the fuel cell car - FCV (Fuel Cell Vehicle) - the fuel (hydrogen) contained in high pressure tanks feeds fuel cells where it reacts electro-chemically with atmospheric oxygen generating water and electric energy.

![Figure 3 – Types of EV available today](https://thedriven.io)

This report will look with particular interest to the Plug-in Electric Vehicles (PEV) since these type of electric vehicles can run with zero tank-to-wheel emissions and need electrical power from the grid to recharge the batteries.
3 WHAT AUTONOMOUS VEHICLES ARE

Autonomous driving is considered as one of the key innovations of the first decades of the 21st century, capable of revolutionizing the urban and extra-urban mobility system and transforming people's daily lifestyle. In fact, if electric vehicles are expected to solve three of the five downsides of the current road mobility mentioned in the introduction of this document (reduce greenhouse gases, air pollution and international dependency), autonomous vehicles (if electric) are expected to tackle all five downsides, since they could also positively impact road safety for both drivers and weak road users and contribute to improve traffic management (TA-Swiss, 2020).

Thanks to the introduction of Artificial Intelligence in driving systems, vehicles are becoming increasingly 'intelligent', capable of parking, changing the speed or direction of travel. SAE International (Society of Automotive Engineers), an American body responsible for developing and defining engineering standards in the field of the aerospace, automotive and vehicle industries, has defined the Automated Driving system (ADS), as "the set of hardware and software that are collectively capable of performing the entire DDT (dynamic driving task) on a sustained basis, regardless of whether it is limited to a specific operational design domain (ODD); this term is used specifically to describe a level 3, 4, or 5 driving automation system (SAE International, 2018). This technological evolution is increasingly relieving the driver from normal driving operations, transmitting an increasing number of responsibilities to the vehicle. The automation of the driving system varies according to technological progress and has been classified by SAE International in 6 different levels, taking into account the role of the driver and the context in which the vehicle moves (Figure 4).

![SAE J3016™ LEVELS OF DRIVING AUTOMATION](image)

**Level 0** - No Driving Automation: the driver has full responsibility for the driving operations (DDT). Safety systems may be present, such as electronic stability control or automatic emergency braking, which however are not considered automation systems because they do not change the role of the driver but intervene in emergency situations.
**Level 1** - Driver Assistance: the driver must constantly keep control of the vehicle and the surrounding environment. There are automation systems that allow the vehicle to move laterally (for example, parking assistance systems), or longitudinally (for example, adaptive cruise control systems), but do not allow any kind of distraction to the driver.

**Level 2** - Partial Driving Automation: the vehicle is equipped with partially autonomous driving systems that allow it to move independently both laterally and longitudinally in specific contexts (ODD) such as the highway, while the driver must maintain constant supervision on the driving system and the external environment.

**Level 3** - Conditional Driving Automation: the vehicle is completely managed by autonomous driving systems in a specific context (ODD), but requires that the driver is able to take control at the time of a system request for intervention (DDT fallback, e.g. mechanical failure or exit from ODD). From this level we can speak of Autonomous Driving System (ADS).

**Level 4** - High Driving Automation: the vehicle is completely managed by autonomous driving systems within a specific context (ODD). Furthermore, the system is able to manage even the critical moments (DDT fallback) to ensure the minimum risk condition.

**Level 5** - Full Driving Automation: the vehicle is completely managed by autonomous driving systems; is capable of moving in any context (ODD), operating in all road, weather, traffic conditions and respond independently to critical moments (DDT fallback). The presence of the driver on board is no longer necessary.

The technological development of AV has already been outlined but still the timing with which these levels of autonomy will be reached is much more uncertain. To the date, only some cars on the market reached level 2 of autonomy, and there are still no reliable forecasts regarding the launch of autonomous vehicles of level 3, 4 or 5 (Litman, 2019). Today due to the high technological, regulatory and legal uncertainty, it is impossible to define a reasonable time horizon for the market penetration of the different levels of autonomous vehicles, but there is no question that sooner or later there will be autonomous fleets on the European road (Scudellari, Staricco, & Brovarone, 2020).
4 TRENDS OF ELECTRIC VEHICLES IN EUROPE

The data present in this chapter was collected and structured by the European Alternative Fuels Observatory (EAFO) that is a project to monitor the penetration of alternative fuels are relative infrastructures in Europe. The data is shown at national level and where possible the data is collected directly from ministries and national statistic institutes (EAFO, 2020).

Starting from 2012, BEVs and PHEVs have gained increasing popularity among European consumers, mainly thanks to an increase of vehicles ranges and the governmental incentives that encourage ownership of EVs. In 2012 there were just 40’814 PEVs in the EU/EFTA/Turkey roads. Since that year, the number of units sold has sharply increased year by year, reaching almost 1.8 million units in the EU/EFTA/Turkey roads in 2019 (1.1 million units in EU28 only). Just in 2019 561’451 PEVs were sold, almost 31% of all PEVs passenger cars on the EU/EFTA/Turkey roads (EAFO, 2020).

Between 2015 and 2017, the PHEV sales rate was higher than BEV, in fact PHEVs presented greater autonomy and were considered more reliable. Nevertheless, PHEVs were already considered to be a transition technology and in the last two years the number of BEV sales were again higher than PHEV sales. This is due to several factors, among which we mention the number of new BEV models available, the extended autonomy of these new BEV models and the increase in the number of road electric chargers. The continued development of the BEV technology leads to a predicted increase in BEV sales over the long term (EAFO, 2020). Despite of the continued growth in sales, BEVs and PHEVs represented only 3.7% total newly registered cars in the EU/EFTA/Turkey in 2019. Figure 5 depicts in more detail the European evolution of the PEV market in the last decade.

The number of FCEVs is still small and mainly used for tests and technology demonstrations. In 2019, there were 1’334 passenger vehicles registered in the EU/EFTA/Turkey as FCEV (EAFO, 2020).

According to Transport&Environment Base scenario, respecting the 2025/30 EU CO₂ emission standards would require at least 2.3 million PEVs sold in the EU in 2025 (1.4 million BEVs and 0.9 million PHEVs) and at least 5 million in 2030 (3.2 million BEVs and million PHEVs) (Transport&Environment, 2019). This means there should be roughly a 2-fold increase of PEVs in the EU28 roads within the next 5 years and roughly a 5-fold increase in the next 10 years.

Today’s market development of plug-in electric cars (PHEV) in EU/EFTA/Turkey space is heterogeneous and fragmented: the fleet is mainly concentrated in 5 countries (Norway, France,
Germany, Netherlands and United Kingdom), that account for 73% of all PEV fleet. Tailights are Croatia, Cyprus, Greece and Latvia, where less than 1’000 passenger cars were registered BEV or PHEV until the end of 2019. In fact, ACEA (2019) has found that there is a correlation between uptake of electric cars and GDP in the EU plus Norway and Switzerland. They state “All countries with a PEV market share of less than 1% have a GDP below €29’000, including new EU member states in Central and Eastern Europe but also Spain, Italy and Greece. By contrast, a PEV market share of above 3.5% only occurs in countries with a GDP per capita of more than €42’000” (ACEA, 2019).

In this context is no surprise that Norway has the biggest fleet of PEV passenger cars in Europe, with 328’331 vehicles. There, in 2019 60.6% of all newly registered cars were BEV or PHEV. Germany has the second largest fleet of EV passenger cars (289’331 vehicles); in 2019, however, only 3.1% of all newly registered cars were BEV or PHEV.

![EU/EFTA/Turkey top countries PEV fleet](image)

The impressively high Norwegian EV market penetration level is first and foremost due to a substantial package of incentives promoting zero-emission vehicles into the market. The incentives have been gradually introduced by different governments and broad coalitions of parties since the early 1990s to speed up the transition (Norsk ElbilForening, 2020).

Norwegian authorities point out three major reasons for the success of the EV market penetration:

- **The 50% rule:** the Norwegian Parliament has agreed on implementing a 50% rule, which means that counties and municipalities cannot charge more than 50 % of the price for ICE cars on ferries, public parking and toll roads. A rule of maximum 50 % parking fee at public parking for zero-emission cars has been implemented by many municipalities from 2019.

- **Charging infrastructure:** today there are more than 10’000 publicly available charging points and more than 1’500 cars can fast-charge at the same time. Even if EV owners are charging at home and do not need daily fast charging, they think it is essential to have the option to fast charge when needed. By 2017 the Norwegian Government launched a program to fund the establishment of at least two multi-standard fast charging stations every 50 km on all main roads in Norway.

- **The Norwegian car tax system:** The overall signal from the majority of political parties is that it should always be economically beneficial to choose zero and low emission cars over high emission cars. This is obtained with «the polluter pays principle» in the car tax system. High taxes for high emission cars and lower taxes for low and zero-emission cars. Introducing taxes on polluting cars can finance incentives for zero-emission cars without any loss in revenues. The Norwegian Parliament has decided on a goal that all new cars sold by 2025 should be zero emission (BEV or FCEV) vehicles. The Norwegian Parliament believes that to reach this goal, the green tax system needs to be strengthened, instead of putting a ban
on ICE vehicles. The purchase tax for all new cars is calculated by a combination of weight, CO₂ and NOx emissions. The tax is progressive, making big cars with high emissions very expensive. For the last years, the purchase tax has been gradually adjusted, to have more emphasis on emissions and less on weight. Figure 7 compares an EV model with a similar ICE model to illustrate how the Norwegian tax system makes EVs competitive in the market.

![Table 1 – Top10 PEV models sold in EU/EFTA/Turkey 2019 (EAFO, 2020)](image)

Concerning the EU/EFTA/Turkey consumer purchase incentives to own a PEV, the current situation can be summarized as follows (ACEA, 2019):

- Purchase incentives for PEVs and especially their monetary value differ greatly across the EU/EFTA/Turkey;
- Only 16 out of the 33 EU/EFTA/Turkey countries offer bonus payments or premiums to buyers of PEVs;
- The majority of countries grant tax reductions or exemptions (related to acquisition and ownership) for PEVs; Some countries merely offer an exemption from the annual circulation tax for electric vehicles, for example.

The PEV market has been dominated by small and medium-sized BEV models and medium and large-sized PHEV models (EAFO, 2020). In 2019, it was observed a tendency shift, where medium and large-sized BEV represented a large slice of the PEV units sold, mainly due to the new Tesla and Audi eTron models.

![Figure 7 – Volkswagen Golf VS Volkswagen e-golf in the Norwegian market 2019 (Norsk ElbilForening, 2020)](image)
5 STATUS OF ELECTRIC CHARGING INFRASTRUCTURE

The wider development of the EV market in Europe depends on several factors, including the effectiveness of emission regulations for leading manufacturers to reduce CO₂ emissions of new car models, the financial incentives that countries offer to acquire an EV, the fuel prices, the battery costs, the general travel behaviour and, in particular, the charging infrastructure. Precisely with reference to this last point, crucial for the diffusion of electric mobility following the adoption of the directive on infrastructures for alternative fuels (2014/94/EU), in 2014 the European Union has published four specific objectives related to the development of an effective charging infrastructure for EV:

1. Member States were expected to make their national targets and policy frameworks public by the end of 2016;

2. The directive requires Member States to set targets for an adequate number of publicly accessible charging points to be built by the end of 2020, to ensure that EVs can circulate at least in urban and suburban areas. Ideally the target should expect a minimum. Ideally the target should have a minimum of one charging point for every 10 PEV;

3. Furthermore, the directive makes the use of a common plug across the EU mandatory, establishes technical standards for plugs and sockets in order to guarantee interoperability, which will enable e-mobility on a European scale

4. Member States must ensure that information on the geographical location of publicly available charging and refuelling points is made available in an open and non-discriminatory way

Member states (EU28) and EFTA countries, for whom the four above goals are not legally binding, are working to achieve these four goals of the directive:

1. Member States national targets and policy frameworks, for example, by establishing the 100% ZEV targets and bans on ICE vehicle sales. Denmark, Ireland, Netherlands and Slovenia put 2030 as a year for such targets, while France and Spain aim at 2040 (IEA, 2019).

2. Adequate number of publicly accessible charging points

In 2019, EAFO accounted for a total of 214'640 public charging points in the EU/EFTA/Turkey space. From those the large majority are normal charge type (≤22kW, 190'452 charging points) and only a small portion are fast charge type (>22kW, 24'188 charging points) (EAFO, 2020). According to conservative estimates by the European Commission, at least 2.8 million PEV charging points will be needed by 2030. This means there should be roughly a 13-fold increase within the next 10 years. The number of charging points has however been constantly growing, as depicted in Figure 8.
As for the market development of the PEV in EU/EFTA/Turkey space, it is heterogeneous and fragmented. Netherlands proves to be at the forefront, with a network with 50,466 public charging stations. Other countries with a high number of public charging points include Germany (38'625), France (29'648), the United Kingdom (26'476) and Norway (12'473). These five countries have 73% of all public charging points in the EU/EFTA/Turkey space. On the other end are countries as Cyprus (38), Greece (58), Malta (102) and Bulgaria (122), that do not arrive to 150 charging points.

ACEA (2019) looking to 2018 data made an interesting analysis, correlating the number of charging points and the surface of the EU28 countries. They found that four countries covering 27% of the EU’s total surface area – the Netherlands, Germany, France and the UK – account for 76% of all charging points in the EU. On the other end of the spectrum, a vast country like Romania – roughly six times bigger than the Netherlands – only counts 125 charging points, or 0.1% of the total EU number of charging points. Almost all EU member states with less than 1 charging point per 100 km of road have a PEV market share of under 1% (ACEA, 2019).

The target of one charging point for every 10 PEV was not yet reached, but year by year the rate is growing and, in 2019, there was one charging point for every 8 PEV (Figure 9).
Again, these values are highly heterogeneous throughout the EU/EFTA/Turkey space, where countries as Iceland, Norway and Sweden (62, 24 and 23 PEV per public charging point respectively) have more than doubled the target, while others, as Latvia, Slovakia and Croatia (3, 3 and 1 PEV per public charging point respectively), are far away from the target.

3. Common plug across the EU

In January 2013, the IEC 62196 Type 2 connector was selected by the European Commission as official charging plug for charging within the European Union. Mennekes originally proposed this connector system in 2009, leading to the colloquial name of Mennekes.

From November 2017, following the directive on infrastructures for alternative fuels, public charging points can have multiple connector types, but must always provide a Mennekes connector for Level 2 charging for fast AC charging, and a CCS connector for DC rapid charging where any rapid charging is provided. This directive makes CCS the standard for rapid charging in the EU (Miles, 2019) (Figure 10).

![Figure 10 – From left to right: Mennekes connector and CCS connector (Zajkowski, 2018)](image)

4. Information on the geographical location of publicly available charging and refuelling points is made available in an open and non-discriminatory way

Information of public charging station present in Europe is shown with geographic location, type of charge and provider information in the directory of charging stations for electric vehicles named Lemnet and available at the following link [https://www.lemnet.org/](https://www.lemnet.org/).

Even though information is available about the geographical location of charging stations, still PEV owners face charging network lock-in, software and costs associated with using out-of-network charging station. In fact, a PEV owner cannot pull up to any electric charging station and recharge regardless of the brand name on the station. To date, the market’s approach for solving EV-roaming (seamlessly charging EV across a range of networks) has been insufficient to overcome the problem. So far, charge network operators have tackled this dilemma in two primary ways: a) through bilateral agreements between operators and b) through centralized intermediaries that handle the e-roaming issue.

In a few words, the European public charging infrastructure network is currently undersized and fragmented. In the next years, significant investments for charging points and renovations of the grid would be required to meet the increased electricity demand. The peaks in energy demand for the growing PEV fleet rechargers could coincide with the peaks in demand for other appliances, which could have a negative impact on the stability of the electricity grid.
6 CURRENT AUTONOMOUS VEHICLE TESTS

Bloomberg created an atlas that aggregates information related to urban governments that have hosted tests, developed their own autonomous vehicle (AV) pilots, made plans and policies, and monitored developments in AV technologies, uses, and markets during the 2017-2019 period. This Atlas has identified 136 cities ranging from the very large (Tokyo, Japan, with a population of 35,385,804 inhabitants) to the very small (Cossonay, Switzerland, with population of 3,813 inhabitants). The overwhelming majority of cities that took part in AV policymaking, planning and pilots were in the developed world. The largest concentrations were found in North America, Europe, and East Asia. The Netherlands, Scandinavia, the United Kingdom, and the United States are particularly active. In the eastern hemisphere, Singapore, Australia, and China led the way. Just a handful of cities across the Global South began exploring the potential of AVs (Figure 11).

![Number of cities with AV projects per geographic area](image)

Figure 11 – Number of cities with AV projects per geographic area (Bloomberg, 2019)

Nearly every city in the atlas worked to identify locations for safe and effective testing of AVs. These efforts were almost universally guided by existing mobility goals and exploring how automated vehicles could fill gaps in transit networks was an almost universal priority (Bloomberg, 2019).

Cities included in this Atlas envisioned a variety of AV-based solutions, from transit to taxis to freight. AVs are widely anticipated to help provide new solutions in the stubborn gaps at the edges of transit systems, a crucial link that planners call the “last mile.” Since the launch of the Atlas in 2017, on average more than half of the pilots tracked focused on last-mile applications as for example connectors between rail stations and employment centres and shuttles circulating within large campuses. AV pilot zones took many forms but were limited in scope. Cities partnered on tests of a variety of AV products, including retrofitted autos and brand-new types of vehicles like conveyors (small, cart-sized AVs that travel on sidewalks). Test sites included technology parks, college campuses, urban renewal districts, and former Olympic park sites — places that made it easier to isolate AVs from the rest of the city. So, while trials were increasingly happening in cities, they did not tackle yet the full challenge of navigating complex urban environments (Bloomberg, 2019).

While cities took the lead in setting goals, none had the technical or financial resources to deliver AV pilots alone. All relied extensively on partners, including other levels of government, large corporations, start-ups, non-governmental organizations, and university-based researchers. State and provincial governments were the most important partners for cities. Typically, they supplied seed funding and the regulatory authority changed rules to permit AV tests on public lands and roads. However, large technology corporations and automakers, as well as a vast array of start-ups were also essential to supply AV technology. NGOs and universities primarily provided a source of expertise in public outreach, oversight on issues of impact and governance, and evaluation of test results (Bloomberg, 2019).
7 DEVELOPMENT OF ELECTRIC AND AUTONOMOUS VEHICLES IN ITALY

There are several actors involved in the definition and in the implementation of the Italian strategies dedicated to electric mobility in the public sector; among them the Ministry of Infrastructure and Transport and the Authority of Regulation for Energy Networks and Environment (ARERA). For what concerns the private sector, among the main stakeholders engaged in the development of the electric mobility in the private sector are the operators of the charging stations A2A, Enel Energia, Duerco, Alperia and Repower (all also energy suppliers electricity), Route 220, Gardauno (service provider of electric mobility) and charging station suppliers (SCAME, ABB, S&H, Tecno-Lario, Ducati Energia et al.). Italy does not currently have a platform for national roaming, but the major networks of stations charging and electric mobility service providers have signed agreements with the German Hubject, one of the biggest roaming platforms in the world.

7.1 Electric charging infrastructure development

In 2015 the Italian government updated its national strategy for infrastructures dedicated to recharging EVs (PNire, or the national infrastructure plan for recharging vehicles powered by electricity) which foresees the evolution of the EV market until 2020 and sets the roadmap for public authorities

- Among the targets of PNire, the installation of 4,500 charging points is expected for 2020 among the targets of PNire, the installation of 4,500 slow / accelerated charging points is expected for 2020 and between 2000 and 6000 fast charging stations (> 22 kW). See the table below (figure 11) for the growth in the numbers of current columns, both normal and rapid. The first ones cautioned at the end of 2017 at 2298 while the rapids at 443.

- In terms of purchases of electric vehicles, by 2020 the government plans to register between 18000 and 54000 EV in total, which represent between 1% and 3% of total vehicle sales in the country.

The latest version of the PNire roadmap, published in 2016, contains explicit references to Directive 2014/94 / EU and also provides for the development of a regional register of PUN (Piattaforma Unica Nazionale) charging points managed by the Ministry of Infrastructure and Transport to guarantee throughout the national territory managed by the Ministry of Infrastructure and Transport to ensure uniform and homogeneous information throughout the national territory for citizens and operators in the sector (on location, technology used, availability of access, cost of the service, status of the charging point, infrastructure manager, etc.) to be in line with the European DG Move and HyER.

A significant contribution is made up of Legislative Decree no. 257 of 16/12/2016, which implements the European DAFI Directive. The decree concerns the construction and management of an alternative fuel infrastructure and also identifies the fuels for which the introduction measures are a priority. In particular, in addition to establishing the objectives mentioned above for the installation of the charging station and the registration of electric vehicles, it also introduces obligations for newly constructed residential buildings to facilitate domestic charging.
7.2 Regulation and legislation for electric and autonomous vehicles

Vehicles are mainly regulated by the state by the legislative decree n. 285/1992 and subsequent amendments ("Traffic Code"). Legislative Decree No. 422/1997 provides that Italian regions and provinces can identify specific rules in relation to public transport.

Electric vehicles

The Ministry of Economic Development has published the text Integrated National Plan for Energy and Climate, prepared with the Ministry of the Environment, Territory Protection and Sea and the Ministry of Infrastructure and Transport, which incorporates the innovations contained in the Decree Law on Climate as well as those on investments for the Green New Deal envisaged in the Budget Law 2020. The PNIEC was sent to the European Commission in implementation of Regulation (EU) 2018/1999, thus completing the path started in December 2018, during which the Plan was the subject of a fruitful comparison between the institutions involved, citizens and all stakeholders, the national targets for 2030 on energy efficiency, renewable sources and the reduction of CO2 emissions are established, as well as the targets for energy security, interconnections, the single energy market and competitiveness, sustainable development and mobility, outlining for each of these the measures that will be implemented to ensure their achievement. Implementation of the Plan will be ensured by legislative decrees transposing European directives on energy efficiency, renewable sources and electricity and gas markets, which will be issued during 2020.

As regards mobility, with the introduction of environmental criteria in traffic in the suburban area, limited to the sections of motorways adjacent to urban centres and in the control of restricted traffic areas and with a disincentive to the use of more polluting vehicles.

In particular, they are expected:
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- adoption of guidelines for the classification of hybrid electric vehicles in order to allow national and regional administrations, as part of the incentive programs, to direct these incentives towards hybrid electric technologies with a lower environmental impact

- adoption of a decree to authorize the testing of the circulation on the road of vehicles for personal mobility with mainly electric propulsion, such as segways, hoverboards and scooters;

- proposal for modification of Legislative Decree 30/4/1992, n.285, aimed at introducing the environmental criterion for the adoption of measures to limit circulation, limited to the motorway sections adjacent to urban centers, with particular reference to the reduction of speed limits;

- introduction of the bonus / malus criterion that allows to discourage the use of vehicles with high polluting emissions;

- publication on the institutional website of guidelines and good practices to promote active mobility, especially on the home-school and home-work itineraries, also by the Regions.

This translates as the following:

Speed up the provisions of article 18, paragraph 10, of legislative decree 257/2016 (transposition of the DAFI directive) by providing that public administrations, entities and institutions dependent on or controlled by them, regions, local authorities and the service of public utility operators for the activities carried out in the provinces with high pollution of PM10 particles, replacing the respective fleet of cars, buses and public utility vehicles, including those for the collection of municipal waste, are required to purchase at least 30% by 2022, 50% by 2025 and 85% by 2030 of electric and hybrid vehicles with external recharge, natural gas and hydrogen, as well as electric or natural gas in the case of buses.

**Autonomous vehicles**

As described in the previous paragraphs, autonomous vehicles can be divided into several levels, based on the degree of independence of the machine. Self-driving vehicle is defined as a vehicle with a maximum autonomy level of 5, completely autonomous. Currently no means with these characteristics are available on the market but it is from this concept that observations on safety-related legislative aspects can be deduced. Autonomous driving takes place thanks to an artificial intelligence system, which allows you to mechanically reproduce what happens at the brain level. Starting from the latter, learning systems have been created that are gradually more sophisticated and closer to the way of learning of the human being, such as Machine Learning or neural networks that have allowed greater precision in the learning phase and in the calculation.

The fact that the vehicle is able to learn poses problems in terms of civil liability as the driver is equipped with an intelligent vehicle capable of making decisions with respect to particular scenarios. These decisions derive from signals deriving from sensors arranged inside and outside the vehicle. In particular, images can be processed and the presence of objects near the vehicle can be evaluated. In addition, the presence of a system for processing calculations means that the decision-making speed is high. All this means that compared to a human being, an autonomous car has a higher decision spectrum than a human mind.

Consider the following case: a car with a driver is about to collide with an autonomous car with five people inside. The autonomous car quickly calculates the future collision thanks to the signals deriving from the position sensors and can opt for two roads: stand still with the consequent death of the passengers or deviate to the left towards a sidewalk, where an elderly person is passing...
with the consequent the latter. This makes it clear that compared to such a scenario, a traditional driver would not even have had time to recognize this situation.

ITALIAN REGULATORY AND INSURANCE CONTEXT


The sectors of intervention and the priority objectives for the dissemination and use of intelligent transport systems on the national territory are thus identified:

a) optimal use of data relating to roads, traffic and mobility;
b) continuity of ITS traffic and freight management services;
c) ITS applications for road safety and transport safety;
d) telematic connection between vehicles and transport infrastructure

Based on this, the National Action Plan defines the principles to which the design and implementation of such systems must underlie.

On January 31, 2017, the Chamber of Deputies published the document "Mobility of the future: self-driving cars", in which new challenges and issues on which institutions are called to pay attention are defined.

On 28 February 2018, the Ministry of Infrastructure and Transport adopted the Decree relating to the implementation methods and tools for the testing of Smart Road solutions and connected and automatic driving on the road, relating to the testing of self-driving cars and the adaptation of the infrastructure. In the decree, although no mention is made of the SAE automation levels, it can be understood that the term autonomous driving should be traced back only to vehicles equipped with SAE 5 level technologies; they are therefore totally autonomous vehicles. The test authorization is issued by the Ministry of Infrastructure and Transport and lasts for one year.

In Italy there are insurance models that can be applied to the world of autonomous driving. It could identify which civil liability paradigm can be applied in the event of damage caused by the vehicle.

We now quote some laws that refer to robot, which in some respects can be considered close to the autonomous driving sector:

- The robot is considered as a consumer good: It is applied the art. 114 of the Consumer Code, Legislative Decree 206/2005. "The manufacturer is responsible for the damage caused by defects in his product"

- The damage does not derive from a defect in the robot, but from its behavior. One solution would be to apply art. 2051 of the civil code (Damage caused by things in custody: "Everyone is responsible for the damage caused by things in custody, unless it proves by chance" and impute responsibility for damages to the person who has custody on the property. This rule is applied in cases where the damage is caused by the thing independently of the man and the latter is liable for the mere fact of being its custodian and, therefore, having the power to control and supervise the asset, unless don't try the accident

Another legislative discipline that approaches that of the autonomous vehicle is that of the conduction of animals:
• According to art. 2052 of the Civil Code - Damage caused by animals: “The owner of an animal or who uses it for the time in which it is in use, is responsible for the damage caused by the animal, whether it was in its custody, whether it was was lost or fled, unless he proves by chance"

By making a comparison between the rules of robots and that of animals, it is possible to identify the possibility of the animal to move freely in the surrounding environment, an activity that many robots equipped with artificial intelligence are able to do today; in particular the driverless cars that are able to perform driving operations that are not entirely predictable a priori.

7.3 Focus on South Tyrol

The Province of Bolzano is known for its positioning as the "Green Region" of Italy for its being at the forefront in its sustainable approach to multiple sectors, ranging from that of renewable energies, to that of energy efficiency (e.g. Climate House). About the 56% of energy consumption in South Tyrol is satisfied through the use of energy from renewable sources (if traffic is not taken into account), a percentage almost quadruple compared to the European average she is Italian. By 2020 this share is expected to reach 75% and even 90% by 2050, thanks to a widespread presence of hydroelectric and power plants in the area biomass district heating, biogas plants, but also of wind and geothermal plants.

But it is above all in the context of mobility that the South Tyrol aspires to its most ambitious targets, given that it does is prefixed, with the approval in 2015 of a provincial law, to become a model region for one sustainable Alpine mobility by 2030. The strategy provincial aims to achieve this goal through development, with the participation of politics, of the economy, science and the entire population, of public transport, electric mobility, on the two wheels and inter-mode. Among the most relevant initiatives in this context, extension should be mentioned of the cycle path network, the introduction of South Tyrol Pass to encourage the use of public transport, the introduction bus or hybrid or electric, modernization of the Val Pusteria railway line and the project of the Brenner base tunnel to transfer the rail traffic currently on wheels.

7.3.1 Incentives

South Tyrol aims at becoming a model for sustainable mobility and for this reason it has activated incentive measures for the purchase of EV and charging stations. Individuals and private companies can take advantage of these incentives (Mobilità elettrica (#greenmobilitybz), 2020).

Incentives are regulated by:

1. Article 19 of the Provincial Law of 19 July 2013, n. 11

2. Provincial Council Resolution 28 January 2020, n. 49

Individuals can receive contributions up to an electric vehicle every two years for each of the following categories: cars, mopeds / motorcycles and cargo bikes.

The following types of electric vehicles, "new from the factory" are eligible:

a) the purchase of BEV, H2 fuel cell vehicles and BEV with range extender for the transport of people and goods;

b) the purchase of PHEV for the transport of people and goods;

c) the purchase of two, three- or four-wheel electric vehicles belonging to classes L1e-B, L2e, L3e, L5e and L6e or heavy four-wheel electric vehicles of class L7e;
d) the purchase of cargo bicycles with an auxiliary electric motor (L1e-A) with a minimum total capacity of 150 kg.

The contribution is granted in the case of purchase and also for long-term leasing or rental contracts lasting at least two years.

Individuals must not have obtained any provincial incentives for at least two years for the purchase, leasing or long-term rental of an electric vehicle for the same category:

a) motor vehicles for the transport of persons and for the transport of goods;

b) mopeds and electric motorcycles with two, three or four wheels;

c) cargo bicycles with a minimum total capacity of 150 kg.

These are the measures for contributions:

a) € 2,000 for the purchase of battery, H2 and fuel cell electric vehicles with range extender with batteries with a capacity of at least 15 kWh and which do not produce more than 70 g of CO2 emissions per km;

b) € 1,000 for the purchase of "plug-in hybrid" vehicles that do not produce more than 70 g of CO2 emissions per km;

   (For the purchase of motor vehicles referred to in letters a) and b) the contribution is granted on condition that the dealer grants a reduction in the price of at least the same amount).

c) 30 per cent of the eligible expenditure, for a maximum amount of € 1,000, for the purchase of two, three- or four-wheel electric vehicles;

d) 30 percent of the eligible expenditure, for a maximum amount of € 1,500, for the purchase of cargo bicycles.

The Province of South Tyrol grants contributions in terms of charging systems.

Contributions are:

1. The purchase and installation of charging systems for EV, including PHEV, and any costs for a specific electrical connection

2. To make available charging systems for electric vehicles, including plug-in hybrids, by means of a service contract, including any specific electrical connection; the contracts must have a duration of at least three years and provide for the purchase of ownership of the subsidized asset upon their expiry

3. the connection and installation of one or more charging stations if the latter are made available free of charge

Charging systems are those which are not used for commercial purposes and which are used exclusively for charging electric vehicles.

The beneficiaries of the contributions must have their residence or their headquarters in the province of Bolzano and have the availability of a parking space for the installation of a charging system in the province of Bolzano respectively.

A contribution of eighty percent of the eligible expenditure is granted, for a maximum amount of 1,000.00 euros for each top-up system

Contributions can be made to individuals for up to three top-up systems.
Professional installation must be certified by means of a declaration of conformity in accordance with the law.

The Autonomous Province of South Tyrol provides for the granting of incentives to private companies for the development of electric mobility.

The submission of one application per year per company is allowed. The following investments are allowed, to be made as part of the business activity carried out in South Tyrol and which have a direct impact on the same:

1. The purchase or rental of the following vehicles of category M1 for the transport of people, as well as categories N1 and N2 for the transport of goods:
   a) BEV battery electric vehicles, H2 FCEV fuel cell vehicles and battery electric vehicles with range extender (BEV with REX) with batteries of at least 15 kWh capacity; these latter vehicles cannot produce more than 70 g of CO₂ emissions per km;
   b) the purchase of "plug-in hybrids" for the transport of people and goods; these vehicles cannot produce more than 70 g of CO₂ emissions per km;

2) The purchase or rental of two, three or four-wheel electric vehicles belonging to classes L1e-B, L2e, L3e, L5e and L6e or heavy four-wheel electric vehicles of class L7e;

3) The purchase of cargo bicycles with or without an auxiliary electric motor (L1e-A) with a minimum total capacity of 150 kg and designed exclusively for the transport of materials and goods.

4) The purchase and installation of charging stations for electric vehicles or the signing of sales contracts with retention of ownership. These contracts have a maximum duration of nine years.

Vehicles and equipment must be "factory new". Investments that are traded or intended for rental are excluded. The concessions are granted in the form of a non-refundable contribution in compliance with the de minimis rule. The payment of the grant granted takes place after the investment has been made and only if the completed project corresponds to that envisaged in the grant application. Small, medium and large enterprises in the craft, industry, trade, services and tourism sectors, as well as freelancers and self-employed workers, can apply.

The activities of the agriculture, forestry, fishing, accommodation activities related to farms and activities relating to lotteries, betting and gambling houses are excluded.

These are the measures of the contribution:

a) € 2,000 for the purchase of battery electric vehicles, H2 fuel cell vehicles and battery electric vehicles with range extender;

b) € 1,000 for the purchase of "plug-in hybrid" vehicles;

In the case of acquisition of the above-mentioned vehicles, the envisaged contribution is granted on condition that the dealer grants a reduction in the price of at least the same amount.

The contribution referred to in letters a) and b) is doubled if the vehicles are purchased from "driving schools" or "taxi transport" companies.

c) 30 per cent of the eligible expenditure, for a maximum amount of € 1,000, for the purchase of two, three or four wheel electric vehicles;
d) 30 percent of the eligible expenditure, for a maximum amount of € 1,500, for the purchase of cargo bicycles;

e) 70 percent of the eligible expenditure, for a maximum amount of € 1,000, for the purchase and installation of charging stations for electric vehicles or the signing of sales contracts with retention of ownership.

7.3.2 Market and forecast for electric vehicles in South Tyrol

South Tyrol has a positioning as a "green region", also pursued in the sector of mobility due to a specific governance system with the following characteristics:

- Well-structured and rooted in the territory
- Integrated framework of a wider provincial strategy, whose ultimate goal is to make South Tyrol one model region for sustainable alpine mobility.

The analysis of the South Tyrolean status quo made it possible to ascertain that:

- Up to 2018 the number of EVs circulating in South Tyrol cannot be said to be really significant, however their diffusion is spreading regularly (EV registrations are doubled in 2017 compared to 2016) and this growth is accompanied and supported by an installation plan of about 5,000 columns on the territory by 2021.

- The current owners of an EV in South Tyrol are satisfied with their purchase, however they feel the need for further expansion of the infrastructure network and to be able to optimize times when their vehicle is parked to recharge it (e.g. at bars / restaurants)

- Local population: potentially the electricity in South Tyrol constitutes a model of mobility attractive to people who live the most diverse lifestyles. Faced with the hypothetical choice of purchasing a EV compared to a traditional one the local population was more inclined to choose a EV if they had information about savings at their disposal future associated with the use of the EV and regard to the diffusion of EVs in South Tyrol

- Tourists visiting the destination, though 91.3% of cases reach South Tyrol in car, wish more on-site mobility sustainable, both through making available on site of EV which, above all, of e-bikes, preference also confirmed by the counterparty of hoteliers

In addition to private buyers, first you can find businesses that are gradually in line renewing its vehicle fleet with electric vehicles - in part through the purchase of new cars, in part through the conversion of the existing ones. Even the Carsharing South Tyrol has already included an electric offer in his vehicle fleet. Alongside the increased diffusion of the EV in South Tyrol, it should also be mentioned that there was a significant expansion of electric bicycles, facilitated by the wide offer of cycle paths both in the main urban centres and in much of the provincial territory.

From the data collected by ISTAT it can be inferred that from 2011 until 2018, there has been an increase in the number of released cars in South Tyrol. This is due to tax relief in South Tyrol for companies dealing with vehicle registrations.
As can be seen from the graph, in fact, it has gone from around 2000 vehicles in 2011 to 180000 vehicles in 2018.

According to a study carried out by Eurac and following a BAU (business as usual) model, the predictions in 2030 on the type of vehicles are as follows:

- 20% of the vehicles will be BEV
- 60% of the vehicles will be HEV (10% PHEV)
• 20% of the vehicles will be ICE

![New registered passenger vehicle forecast. (Source EURAC, 2020)](image)

From this graph it can be understood how ICE vehicles gradually decrease over time going from 90% to 20%. It can also be seen that HEV vehicles will play an important role in these ten years. In particular, PHEV vehicles will grow slowly over time, digesting all the other hybrid vehicles.
8 DEVELOPMENT OF ELECTRIC AND AUTONOMOUS VEHICLES IN SWITZERLAND

Between 2000 and 2019, the Swiss road motor vehicle stock (excluding mopeds) increased by 34%, to achieve the global number of 6.2 million of vehicles. Passenger cars account for around three quarters of this stock, with 4’623’952 passenger cars registered in Switzerland - on average, 541 passenger cars per 1000 inhabitants. Looking more closely to the last decade (2009-2019), the number of passenger cars registered in Switzerland has grown by 15.3%. However, since 2015 the rate of growth is decreasing, registering the minimum growth of 0.5% in 2019 (Figure 16).

The average age of passenger cars in Switzerland is 8.7 years, which is two years less than the average car age in the European Union (Autoalan Tiedotuskeskus, 2020).

Figure 17 shows that the large majority of passenger cars registered in Switzerland until 2019 run on fossil fuels (Petrol, Diesel or LPG).

In fact, more than 97% of all passenger cars on the Swiss roads run on fossil fuels. Only 28’716 of them are registered as BEV passenger cars, representing 0.62% of the total passenger cars, and 98’339 are registered as hybrids (PHEV and HEV), meaning 2.13% of the total passenger cars (FSO, 2020). Of such hybrids, 18’435 were registered as PHEV (EAFO, 2020). Considering as plug-in electric vehicles (PEV) the sum of BEV and PHEV, in 2019 were registered a total of 47’151 passenger cars, corresponding to the 1.02% of the total passenger cars on the Swiss roads.
It was estimated that the transport sector in Switzerland is responsible for the emission of 15 million tons of CO$_2$ each year, and that passenger cars are responsible for 75% of them (VöV UTP, 2018). The emissions of the transport sector in Switzerland represent 31.7% of the GHG emissions of the whole country - and transport is the only sector for which emissions have been stable since 1990 (OFEV, 2016).

To decrease the climate impact of the transport sector, from the beginning of 2020 and just like in the EU, Switzerland introduced a more restrictive threshold on the average level of CO$_2$ emissions of newly registered cars imported by each car company over a year, equal to 95 grams of CO$_2$ per kilometre (previously 130 grams of CO$_2$ per kilometre). At the same time, additional CO$_2$ emission regulations were introduced as well for light commercial vehicles and light articulated vehicles, which will have to comply with a target level of 147 grams of CO$_2$ per kilometre (SFOE, 2019).

Swiss stakeholders envision that electric propulsion engines will play a central role in achieving these values, thanks to high energy efficiency and very low local emissions (DATEC, 2018). In Switzerland viewed from the perspective of the entire lifecycle, the carbon footprint of conventional combustion engine cars is approximately 70 percent higher than the electric cars powered by electricity generated at home. This is due to the fact that Swiss electricity mix is significantly generated by hydropower and nuclear energy, with only a small proportion being derived from fossil fuel (de Haan & Zah, 2013).

8.1 Electric vehicles regulation and market

Swiss governmental policy is hesitant to promote electric vehicles actively as a result of the mixed results of the country’s previous forays into vehicle electrification during the 1990s, which did not take root beyond selling niche electric transport products (HEV TCP, 2019).

Therefore, today at the Federal level there is not any direct regulation concerning the market share of the electric cars. Nevertheless, in 2018 the federal authorities together with 50 e-mobility stakeholders (e.g Federal, Cantonal and Municipal authorities, car manufacture companies, non-governmental organizations, and research institutions) have drawn and published a roadmap for the electric mobility. The objective of the roadmap is to increase the share of PEV (BEV and PHEV) in new car registrations to 15 percent by 2022 (DATEC, 2018). In order to reach this goal, the roadmap provides 65 measures, divided in three priority areas: growing the electric car market, rolling out charging stations, as well as incentives for use.

Some of the measures at federal level included in the roadmap are on the regulatory side and can have an effect on the market penetration of electric vehicles:

1- Setting the 95 grams of CO$_2$ per kilometre threshold on the average level of emissions of CO$_2$ of cars imported in Switzerland;

2- Increasing the maximum allowed weight of electric vehicles compared with ICE vehicles: for example, electric light duty vehicles can weight 4,25 tons instead of the 3,5 tons and not be considered in a higher taxation category;

3- Identifying parking spaces for electric vehicle exclusive use: green demarcations to indicate parking and charging areas reserved specifically for electric vehicles;

4- Removing the mention ‘automatic gearbox’ on the driving license when the driving lessons are done using an automatic gearbox vehicle, therefore driving schools can use electric cars in the context of driver training;

5- Exempting electric vehicles from the taxes related to cover infrastructure costs. However, when the penetration of the electric car market has increased significantly, this exemption should be withdrawn.
As previously stated, the Swiss penetration of BEVs is still low: 0.62% of passenger cars in the Swiss roads. The total penetration of electric vehicles is asymmetrically distributed among the cantons: the economically strong canton of Zug has already passed the 1% mark in 2019 (1.4% of its total vehicle stock were electric cars) and Zurich is not far behind, with a share of 0.9%. On the other end, the cantons Jura and Neuchatel present the lowest numbers, with 0.3% and 0.4% respectively (FSO, 2020).

Figure 18 shows that the year selling of BEV and hybrid (HEV and PEV) passenger cars have been growing in the last decade and in 2019 the market share of full-ellectrics and hybrids vehicles reached the maximum ever registered: BEV 4.2% and hybrids 8.4% (FSO, 2020). The official federal statistics do not disaggregate the PHEV from the overall hybrid data. The EAFO database has the number of PHEV and BEV sold each year, but the number of BEVs does not match with the Federal official database, maybe due to the harmonization process that the EAFO makes. Therefore, it is reported the number of PHEV from the EAFO database to have an indicative value. In this sense, we can consider that roughly 5.6% of the passenger cars sold in 2019 in Switzerland were PEV.

According to FSO and EAFO, in 2019, 17’605 PEVs (13’197 BEVs and 4’408 PHEVs) were sold, almost doubling (1.8 times) the number of vehicles sold in 2018. This means that more than one third of all PEVs matriculated in Switzerland were sold only in 2019. These numbers go in line with the EU/EFTA/Turkey data, were in 2019 31% of the PEV fleet was sold.

In the Swiss market, the number of PHEVs sold has never been higher than the number of BEVs sold. In fact, the Swiss market seems to prefer the full electrics (BEVs). Looking exclusively at the number of BEV sales in 2019, Switzerland is in the top 5 EU/EFTA/Turkey countries with highest sales, but still far away from the top 5 countries in terms of BEV fleet (in the fifth position UK with a fleet of 99’437 BEVs, Switzerland 28’716 BEVs).

According to the recent trend, the market share objective of 15% of PEVs (BEVs and PHEVs) of the roadmap 2022 is feasible and could even been surpassed (Figure 19). For this forecasting exercise, it was considered a 0.6% vehicle sales growth (the mean of the last two years (0.7% in 2018 and 0.5% in 2019) and a 1.47-fold increase in the sales of PEV (the average increase of the last 2 years), for each year for the next 3 years. Taking further into account that a recent study ran by TCS estimated that 48% of Swiss people intend to buy an electric car in the next 3 years (TCS, 2020), it is possible to state that the roadmap objective is likely to be achieved and surpassed.
The 10 most sold in Switzerland EV models are listed in table 2 (Swiss Mobility, 2020), which shows that among the top 10 models, just one is PHEV. The last year the Swiss market was dominated by medium and large size BEVs and the top 10 PEVs sold in 2019 cost more than 35’000 CHF (official Swiss list price with battery, including VAT).

<table>
<thead>
<tr>
<th>OEM</th>
<th>Model</th>
<th>EV Type</th>
<th>Number of units sold in 2019</th>
<th>Market share 2019 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesla</td>
<td>Model 3</td>
<td>BEV</td>
<td>5’024</td>
<td>29%</td>
</tr>
<tr>
<td>Renault</td>
<td>Zoe</td>
<td>BEV</td>
<td>1’799</td>
<td>10%</td>
</tr>
<tr>
<td>BMW</td>
<td>I3</td>
<td>BEV</td>
<td>1’063</td>
<td>6%</td>
</tr>
<tr>
<td>Hyundai</td>
<td>Kona EV</td>
<td>BEV</td>
<td>850</td>
<td>5%</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>Outlander</td>
<td>PHEV</td>
<td>741</td>
<td>4%</td>
</tr>
<tr>
<td>Audi</td>
<td>e-tron</td>
<td>BEV</td>
<td>681</td>
<td>4%</td>
</tr>
<tr>
<td>VW</td>
<td>e-Golf</td>
<td>BEV</td>
<td>616</td>
<td>3%</td>
</tr>
<tr>
<td>Nissan</td>
<td>Leaf</td>
<td>BEV</td>
<td>530</td>
<td>3%</td>
</tr>
<tr>
<td>Tesla</td>
<td>Model X</td>
<td>BEV</td>
<td>526</td>
<td>3%</td>
</tr>
<tr>
<td>Tesla</td>
<td>Model S</td>
<td>BEV</td>
<td>505</td>
<td>3%</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>BEV/PHEV</td>
<td>5’270</td>
<td>30%</td>
</tr>
</tbody>
</table>

Piana, et al. (2019) refer that in 2019 the Swiss EV customers should not be considered as isolated pioneers anymore and, considering the green learning curve, the Swiss EV market is in the second phase of “early adopters” (Figure 20).
Figure 21 shows the e-mobility scenarios drawn by EBP for Switzerland (EBP, 2018). These scenarios were generated in 2018 and estimated the PEV market share up to 2035, in the following three conditions:

- **Scenario BAU (Business As Usual):** Electric mobility is not specifically promoted, the charging infrastructure develops without central coordination or minimum requirements;
- **EFF (Efficiency):** Additional funding and incentive instruments are being introduced for efficient vehicles. The development of the charging infrastructure is coordinated and its introduction in the public street area is facilitated, while immediate requirements are introduced for the fast charging infrastructure. The technical progress is fully demonstrated in the new cars;
- **COM (Connected Mobility):** Electric cars and fast charging infrastructure are specifically promoted. The vision is that longer distances are covered by the combination of car and train, therefore smaller battery cars are promoted.

All the scenarios predict a yearly increase of the market penetration of PEV vehicles but with different pace. Looking at the graph, the 2022 objective (15% of PEV market share) seems only achievable in the COM scenario.
Furthermore, considering the COM scenarios, the EBP estimates that in 2035 PEVs will represent 35% of the passenger car fleet in the Swiss roads and the market share of PEVs in the same year will be 60% (EBP, 2018). Figure 22 depicts the estimations for the COM scenario.

**Figure 22 – Forecasting COM scenario for e-mobility Switzerland (EBP, 2018)**

### 8.2 Electric charging infrastructure development

Expansion of the public charging infrastructure in Switzerland is predominantly in the hands of the private sector (HEV TCP, 2019). The federal government takes on a supportive role with respect to coordination and planning of this expansion. In the recent years, three federal projects were launched:

1. Acknowledging that charging at the workplace is important to accelerate the market penetration of electric mobility, with the support of SwissEnergy, the Swiss eMobility Association launched the project “charge4work” aimed at providing information and consulting services for the installation of charging stations at the workplace and at business premises;

2. The information about charging stations run by different operating companies has been harmonized and aggregated in the national electromobility infrastructure data collection (DIEMO), in order to give an overall picture of the network of charging stations in Switzerland. The data are updated in real time and are available via multiple interfaces. The Federal map visualization can be assessed using the following link [http://www.pierno-di-elettricità.ch/](http://www.pierno-di-elettricità.ch/) and data to be used by third-party users is available using this link [https://opendata.swiss/en/dataset/ladestationen-fuer-elektroautos/resource/e33957be-180a-422b-90a5-fbfe9774927a](https://opendata.swiss/en/dataset/ladestationen-fuer-elektroautos/resource/e33957be-180a-422b-90a5-fbfe9774927a)

3. A fast charging network along national roads has been created. The FEDRO (Swiss Federal Roads Office) is financing the needed infrastructure for the creation of fast charging stations in the service areas and rest areas of the country to be managed by private institutions. It is planned to build approximately 160 stations, and, in the beginning of 2020, 39 were in operation (FEDRO, 2020).
The installation of recharging infrastructure has to follow the SIA’2060 “Infrastructure for Electric Vehicles in Buildings’ norm, that standardises the construction of recharging stations. This norm contains standard recommendations and provides procedures for all concerned stakeholders (engineers, architects, investors, clients and administrators) (SIA, 2017). The norm has been last updated in 2019 with the aim to improve the situation of electromobility in the building sector, by ensuring that electric mobility is adequately taken into account in new and renovated buildings.

By the end of 2019, there were 6’200 public charging points in Switzerland. The majority of them, as in the rest of EU/EFTA/Turkey, are normal charging points ≤22 kW (5’414 charging point), and a small portion are fast charging points (786 charging point). The installation of charging points has started in 2012 and since that year it started to grow - even though between 2015 and 2017, the installation growth was almost null, restarting again in the last 2 years (figure 23).

![Swiss public charging points](image)

*Figure 23 – Accumulative number of public charging points in Switzerland (EAFO, 2020)*

The recharge stations are diffused in all country, being mainly available in densely populated zones (figure 24).

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1 The SIA’s widely-applied body of standards provides recognized and indispensable regulations for planning and construction in Switzerland.
EAFO estimates that there are 8 PEVs per each public charging point in Switzerland and that this number has been growing since 2016 (figure 25). This figure is in line with the European average (8 electric vehicles per charging infrastructure), but lower than the reference value indicated by the EU directive (10 electric vehicles per charging infrastructure).

There are 25 public charging network operators in Switzerland (OpenChargeMap, 2020). With 1’586 charging stations in all 26 Swiss cantons, EV Pass is Switzerland’s largest public charging network operator (EV Pass, 2020).
8.3 Autonomous vehicle tests

At the moment, in Switzerland, AVs are only running as tests and each test has to be authorized by the Swiss federal roads office (FEDRO). The authorizations have a fixed location and term (normally the test can run for a period of about two years). All AV tests running in public roads are required to have a person on board able to monitor the vehicle and to stop it in case of an emergency. Project managers are required to submit half-yearly progress reports and, six months after the test conclusion, a final report containing data collected and experiences. The documentation is published on the FEDRO website\(^2\).

The first authorized test of autonomous vehicles in Switzerland was organized by Swisscom in 2015, in the city of Zurich, where a car equipped with additional sensors circulated in automated mode for about fourteen days (FEDRO, 2019). This test has been followed by other tests in Switzerland as synthesized in Table 3.

<table>
<thead>
<tr>
<th>Years</th>
<th>Company</th>
<th>Test city</th>
<th>Test Type</th>
<th>Comments</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-2015</td>
<td>Swisscom AG</td>
<td>Zurich</td>
<td>Passenger car</td>
<td>Effective duration of trial: approx. 14 days</td>
<td>Finished</td>
</tr>
<tr>
<td>2016-2016</td>
<td>Swiss Post AG</td>
<td>Bern / Solothurn</td>
<td>Delivery robot</td>
<td>First delivery robots in Switzerland</td>
<td>Finished</td>
</tr>
<tr>
<td>2016-2017</td>
<td>Swiss AutoPost AG</td>
<td>Sion</td>
<td>Shuttle Bus</td>
<td>Sion 1.0: two shuttle buses on public roads in the city of Sion</td>
<td>Finished</td>
</tr>
<tr>
<td>2017-2018</td>
<td>Swiss Post AG</td>
<td>All Switzerland</td>
<td>Delivery robot</td>
<td>Permit for delivery robot trials throughout Switzerland</td>
<td>Finished</td>
</tr>
<tr>
<td>2017-2020</td>
<td>Swiss AutoPost AG</td>
<td>Sion</td>
<td>Shuttle Bus</td>
<td>Sion 2.0: two shuttle buses on public roads in the city of Sion. Connection to Sion railway station.</td>
<td>Active</td>
</tr>
<tr>
<td>2017-2020</td>
<td>TPF (Fribourg public transport)</td>
<td>Fribourg-Marly</td>
<td>Shuttle Bus</td>
<td>Two shuttle buses on public roads in Fribourg-Marly</td>
<td>Active</td>
</tr>
<tr>
<td>2018-2020</td>
<td>VBSH (Schaffhausen public transport)</td>
<td>Neuhausen am Rheinfall</td>
<td>Shuttle Bus</td>
<td>Two shuttle buses on public roads in Neuhausen am Rheinfall.</td>
<td>Active</td>
</tr>
<tr>
<td>2018-2019</td>
<td>FFS (Swiss railways)</td>
<td>Zug</td>
<td>Shuttle Bus</td>
<td>One shuttle bus on public roads in the city of Zug / mostly within the 50 km/h speed-limit zone</td>
<td>Finished</td>
</tr>
<tr>
<td>2018-2020</td>
<td>TPG (Geneve public transport)</td>
<td>Geneve-Meyrin</td>
<td>Shuttle Bus</td>
<td>Two shuttle buses on public roads in Fribourg-Marly</td>
<td>Active</td>
</tr>
<tr>
<td>2019-2021</td>
<td>BernMobil</td>
<td>Bern</td>
<td>Shuttle Bus</td>
<td>One shuttle bus on public roads in the city of Bern</td>
<td>Active</td>
</tr>
<tr>
<td>2020-2022</td>
<td>TPG (Geneve public transport)</td>
<td>Geneve-Meyrin</td>
<td>Shuttle Bus</td>
<td>Marly 2.0: Two shuttle buses on public roads in Fribourg-Marly. Higher frequencies during peak periods / supplemented with simulations / analysis of parallelism with automated trains</td>
<td>Just started</td>
</tr>
</tbody>
</table>

\(^2\) https://www.astra.admin.ch/astra/en/home/topics/intelligente-mobilitaet.html
In summary, the AV tests ran and running in Switzerland mainly use shuttles buses, small buses with the capacity of 6 to 12 people on board, that supplement the already available public transport service. They are being tested in densely populated areas as a first/last mile solution, therefore making short distances trips.

The Swiss federal roads office (FEDRO) has summarized the AV situation by stating that the “vehicles tested are still far from being able to move independently from a point A to a point B: they are like students in the first driving lessons and still have a hard time juggling traffic and managing a whole series of complex situations” (FEDRO, 2019, pp. 16). In this report it is stated, as well, that at this moment the presence on board of a "safety" driver, to monitor traffic conditions and the behaviour of the vehicle, as well as being able to stop him in an emergency, is still indispensable.

8.4 Regulation and legislation for electric and autonomous vehicles

In summary, the Swiss government believes the introduction of electric vehicles should be driven by market forces. It views its role as a facilitator of information for a network of stakeholders and as the guarantor of a legal and fiscal system that favours ecologically sustainable applications (HEV TCP, 2019).

In the Federal Transport Outlook 2040, it is planned that transport demand will continue to increase, albeit at a slower pace compared to the post-2000 period. In particular, vehicle-kilometres travelled in 2040 by passenger road transport will increase by 18% compared to 2010 data (ARE, 2016). On the other hand, the Swiss Energy Strategy for 2050 states that by 2035 the energy consumption has to decrease by 43% compared to 2000 energy consumption level (SFOE, 2018). Therefore, to fulfil the strategical objective to reduce energy consumption while increasing the vehicle-kilometre travelled, there is a need to make private mobility more efficient and less energy demanding. Today electric vehicles are positioned as the technology that can help Switzerland to reach this goal.

Swiss EV owners tend to be richer and pay more for the vehicle than Swiss ICE owners (Piana, Weber, Bektas, & Schumann, 2019). Therefore, financial incentives to support purchase of EVs would rather go to the upper class and may not be decisive in their decision-making process. Therefore, the federal policy of investing in making EVs more appealing and more socially approved, showing them as a status symbol that produces environmental benefits, seems a right move at the moment. However, to extend use of EVs to wider social groups, new car models at lower price would probably be necessary (Piana, Weber, Bektas, & Schumann, 2019).

There is not a special piece of legislation related to autonomous vehicles. In practice, if the driver is fully responsible for the operation of the vehicle (level 0, non-automated; level 1, assisted; level 2, partial automation), the vehicle can be approved in the normal manner and does not require an authorization for a pilot test. Based on Article 106, paragraph 5 of the Federal Road Traffic Law (SVG), the Federal Council is empowered to issue special authorizations for conducting pilot tests with automated vehicles that are deemed necessary until the introduction of relevant legal provisions. This is the case of vehicles in levels 3 (conditional automation), 4 (high automation) and 5 (full automation) (FEDRO, 2020).
8.5 Focus on Canton Ticino

The canton of Ticino is the southernmost canton of Switzerland, being the only Swiss canton totally at the south of the Alps. This canton makes international border with the Italian provinces of Lombardy and Piedmont. The Canton Ticino is a relative small canton with 353’343 permanent residents in 2018 (FSO, 2020). In 2014, the Canton Ticino was elected the most ecologic canton of Switzerland (Isetti, Corradini, Gruber, Della Valle, & Zubaryeva, 2018). In 2018, 53% of energy consumption in Ticino was satisfied using energy from renewable sources (if traffic is not taken into account) (OASI, 2019). In 2020, the Canton Ticino won the Swiss prize “Goldenen Stecker 2019” (Golden plug) that recognize the active commitment of canton in favour of electromobility (SwissEMobility, 2020).

In 2019, 223’373 passenger cars were registered in Ticino: the canton has the third higher ratio of cars per inhabitant of Switzerland (632 passenger cars per 1000 inhabitants) (FSO, 2020). Looking more closely to the last decade (2009-2019), the number of passenger cars registered in Ticino has grown by 10.5%, but since 2014 the yearly rate of growth is decreasing, even registering a negative growth for 2018 and 2019 (Figure 26).

![Ticino passenger car market](image)

There are 1’060 passenger cars registered as BEV in Ticino, representing 0.48% of the total passenger cars (FSO, 2020).

The relationship between Ticino and electric vehicles started in 1995, when VEL1 program was launched. The VEL (“veicoli elettrici leggeri” – light electric vehicles, in Italian) program aimed to run EV cars tests in the Ticino area and create the right conditions for the penetration of EVs in the local car market. One of the results of the VEL program was the foundation of Infovel, a competence centre for sustainable mobility. The VEL program continuously ran until its fourth version, VEL4 (Isetti, Corradini, Gruber, Della Valle, & Zubaryeva, 2018). In 2015, the VEL program and initiative ended, due to the lack of political and financial support. Today initiatives and projects to help the penetration of EVs are active in the territory, led by private companies or associations.

At the best of our knowledge it was never tested an autonomous vehicle, level 3 or upper, in the public roads of the canton Ticino.
8.5.1 Incentives

In 2019 a cantonal incentive program specifically dedicated to electric mobility has been approved\(^3\). In summary, the canton Ticino has allocated 3’000’000 Swiss francs in this incentive program that aims to promote the purchase of full electric cars and the installation of charging stations for electric cars at home and workplaces. The incentives are subdivided in:

- **Incentive of 2’000 Swiss francs for the purchase of a BEV.** This incentive is a onetime flat-rate grant to physical person or legal entities that are registered in Ticino that buy a new full electric car (BEV or FCEV). To access to the incentive the selling automaker has to give the same amount in discount. In this measure is allocated the majority of the budget (2’500’000 Swiss Francs). Until April 1\(^{st}\), 2020, this incentive has been granted 278 times summing a total of 556’000 Swiss Francs spent.

- **Incentive of 500 Swiss francs to install a charging stations for electric cars at home and workplace.** To this measure is allocated 500’000 Swiss francs. Until April 1\(^{st}\), 2020, this incentive has been granted 32 times summing a total of 64’000 Swiss Francs spent.

If all the budget for incentives for the purchase of BEV is spent, it will result in 1’250 new EVs, which represents less than 1% of the total passenger cars sold in Ticino in 2019.

Despite of the cantonal incentive, buying a new ICE model today in Ticino tends to be cheaper than buying a similar BEV model. For example, table 4 compares the costs related to the purchase of a Volkswagen Golf 1.0 ICE model and a Volkswagen e-Golf (TCS, 2020).

| Table 4 – Volkswagen Golf 1.0 VS Volkswagen e-golf in the Ticino market 2020 (SUPSI elaboration) |
|---------------------------------------------------|------------------|------------------|
| **Volkswagen Golf 1.0**                             | **Volkswagen e-Golf** |
| Tabled price (excl. VAT)                           | 26’259            | 32’490           |
| VAT (7.7%)                                         | 2’191             | 2’710            |
| Retailer discount                                  | 0                 | -2’000           |
| Retailer price (CHF)                               | 28’450            | 33’200           |
| Cantonal incentive                                 | 0                 | -2’000           |
| Final price (CHF)                                  | 28’450            | 30’836           |
| **Annual circulation fee (CHF)**                   | 418               | 470              |
| From 2021 Annual circulation fee (CHF)             | 359               | 178              |

Finally, some local municipalities have their own incentive programs that can be accumulated with the cantonal incentive. Here we report two examples:

- The Municipality of Alto Malcantone (1’414 inhabitants) gives an incentive of 10% of the cost to acquire a fully electric car, to a maximum of 3’000 Swiss francs for each resident, that can be requested every 4 years (Comune di Alto Malcantone, 2017);

- The Municipality of Vernate (582 inhabitants) gives an incentive equal to the cantonal ones, that can be requested every 3 years (Comune di Vernate, 2019).

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\(^3\) The Ticino incentive program is composed of two pieces of legislation:  
8.5.2 Current market and forecast

As previously stated, the penetration of BEVs in Ticino among registered passenger cars registered is one of the lowest in Switzerland (0.48%). Figure 27 shows the same tendency seen for Switzerland: the yearly selling of BEV and hybrid (PHEV and HEV) passenger cars grew in the last decade in Ticino. In 2019, again in line with the rest of Switzerland, the market share of BEV and hybrids vehicles in Ticino reached the maximum ever registered: BEV were 2.7% and hybrids were 8.9% of the new registered passenger cars (FSO, 2020). The hybrids in these figures include all type of hybrid technologies because it was not possible to obtain the data disaggregated data by type of hybrid.

![Year market share by type of fuel](image)

*Figure 27 – Ticino year market share by type of fuel (2009-2019) (FSO, 2020)*

In 2019, 496 BEV passenger cars were sold, almost the triple (2.82 times) the number of vehicles sold in 2018 (176 vehicles).

Canton Ticino has estimated, that by 2020, 2’500 vehicles passenger cars registered in Ticino will have zero emissions from well-to-wheels (Canton Ticino, 2013).

There are no specific scenarios for the development of electric vehicles in Ticino. Nevertheless making the same forecast projection as for Switzerland, it was considered that the vehicles sales growth is the average of the last two years -0.45% (-0.3% in 2018 and -0.6% in 2019) and that the sales of BEV (only BEV since the data about PHEV is not available) will have a 2.033-fold increase (the average increase of the last 2 years) for each year for the next 3 years.

The Cantonal objective seems not likely to be achieved since there were only 1’060 BEV registered by the end of 2019, meaning that in 2020, 1’440 new BEVs should be sold. Our projections point that the number of BEV to be sold in 2020 is around 1’000 passenger cars. On the other end, if it is considered the 15% market share of the Swiss roadmap for 2022 for the Ticino market, the 2022 objective is likely to be achieved and even surpassed.
Also in Ticino there are several public charging stations providers. The larger network of public charging stations in Ticino, with 199 charging points, is called Emoti and is managed by Enerti, a company founded by Ticino’s electricity companies. This network has a widespread diffusion over the territory, which is not the result of a cantonal planning, but the result of the individual actions of the municipalities or some private individuals (MOBSTER, 2020).

8.5.3 Main initiatives and actors in Ticino

Today there are three active projects promoting the electro mobility in the Canton Ticino:

- Emoti – is the Ticino’s’ public access charging network that is constantly growing and is distributed throughout the territory, in particular in public car parks and places of public interest.

- MOBSTER project – electric mobility for a sustainable tourism. This project involves Italian partner from the provinces of Alto Adige and Verbano-Cusio-Ossola and Swiss partner from the Ticino Canton, with the goal to favor the creation and consolidation of cross-border networks between companies and other actors operating in the electric mobility sector in order to improve tourist use and encourage the adoption of more sustainable lifestyles (MOBSTER, 2020).

- MERA project - Autonomous Renewable Electric Mobility. The project aims to model and test the bi-directional charging technologies. Furthermore, the project wants to define new
business models in anticipation of autonomous electric mobility in the context of decentralized high renewable production in Ticino.

In Ticino there are three main actors actively promoting the electric mobility:

- Canton Ticino Government by giving incentives to buy electric vehicles and to install charging station, as previously mentioned;

- Enerti, that is the association of Ticino electric utility companies, that has implemented the Emoti initiative that promotes and installs charging station in private and public spaces: https://www.emoti.swiss/

- Protoscar, a privately owned Swiss company, works in the sector of electric mobility offering services that range from the elaboration of charging infrastructure concepts, vehicles architecture and prototyping, fleets electrification and optimization analysis, charging infrastructure planning and deployment and energy and CO₂ emissions studies.
9 FINAL CONSIDERATIONS

In Europe, the penetration of PEV is heterogeneous among countries and even inside countries, where richer northern countries tend to have the biggest PEV fleets. In the last decade PEV are continuously increasing their market share but still represent a small portion of the overall passenger car market. In addition, the European public charging infrastructure network is currently undersized and fragmented. Table 5 summarizes the main key numbers related to PEV in the EU-EFTA-Turkey, Norway (as the country leading the PEV market penetration in Europe), Italy, and Switzerland countries, as well in the EVA test sites regions (South Tyrol and Ticino).

<table>
<thead>
<tr>
<th>Country / region</th>
<th>EU-EFTA-Turkey</th>
<th>Norway</th>
<th>Italy</th>
<th>South Tyrol</th>
<th>Switzerland</th>
<th>Ticino*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (in thousands)</td>
<td>600'000</td>
<td>5'328</td>
<td>60'360</td>
<td>533</td>
<td>8'570</td>
<td>353</td>
</tr>
<tr>
<td>Total car fleet (in thousands)</td>
<td>288'343</td>
<td>2'700</td>
<td>39'018</td>
<td>497</td>
<td>4'624</td>
<td>223</td>
</tr>
<tr>
<td>Number of car per thousand inhabitant</td>
<td>481</td>
<td>507</td>
<td>646</td>
<td>931</td>
<td>541</td>
<td>632</td>
</tr>
<tr>
<td>Total PEV fleet (in thousands)</td>
<td>1'809</td>
<td>328</td>
<td>40</td>
<td>1</td>
<td>47</td>
<td>1</td>
</tr>
<tr>
<td>% PEV</td>
<td>0.6%</td>
<td>12.2%</td>
<td>0.1%</td>
<td>0.2%</td>
<td>1.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Number of charging points</td>
<td>211'438</td>
<td>13'763</td>
<td>9'176</td>
<td>273</td>
<td>6'200</td>
<td>199</td>
</tr>
<tr>
<td>Number of PEV per charging point</td>
<td>8.6</td>
<td>23.9</td>
<td>4.3</td>
<td>3.8</td>
<td>7.6</td>
<td>5.3</td>
</tr>
<tr>
<td>PEV sold in 2019 (in thousands)</td>
<td>561.5</td>
<td>79.4</td>
<td>17.2</td>
<td>0.51</td>
<td>17.6</td>
<td>0.49</td>
</tr>
<tr>
<td>PEV 2019 Market share (%)</td>
<td>0.6%</td>
<td>60.6%</td>
<td>1.0%</td>
<td>0.3%</td>
<td>5.6%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Market share objective [in thousands or %] (year)</td>
<td>100% (2025)</td>
<td>4'000 (2030)</td>
<td>15% (2022)</td>
<td>2.5 BEV (2020)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For Ticino the numbers presented are only BEV instead of PEV

Italy and Switzerland are not in the leading group in terms of PEV fleet dimension but the last years are observing an increase of PEV penetration in their markets but with two different strategies. While Swiss Federal and Cantonal governments do not have a national wide strategy leaving the initiative predominantly in the hands of the private sector (giving some punctual incentives and roadmaps without binding objectives for full-electric vehicles), Italy’s government has set a national strategy to push forwards the development of the infrastructures dedicated to recharging EVs and consequently increase the PEV market share.

The regions in analysis (South Tyrol and Ticino) are experiencing an increase of their PEV fleet. In South Tyrol the regional government has incentivized EV purchases through direct incentives; moreover, it has committed to improving the charging infrastructure, and to offering test drives and tax reductions to the citizens and companies (Nives Della Valle, 2019). Ticino cantonal government in 2019 has approved an incentive program for the purchase of full-electric vehicles but still the purchase price of these vehicles compared with their ICE equivalent model is higher. This inventive programme will probably have a limited impact, since it will only subsidize 1'250 vehicles, which is equivalent to less than 1% of the passenger cars sold in Ticino in 2019. Therefore, even though in Ticino an increase of BEV in the last two years has been observed, the Cantonal objective of 2'500 of zero emission vehicles by 2020 seems not to be achievable. On the other hand, if this tendency of BEV growth is kept in Ticino, in the next 3 years, the not binding Federal PEV market share objective of 15% for 2022 may be achieved. Reaching this...
objective however does not mean that the PEV fleet by 2022 will be dominant, in fact it will still represent a small portion of the passenger vehicles matriculated in Ticino.

This EV and infrastructure outlook allows to state that these two regions (South Tyrol and Ticino) are interesting test sites since the PEV fleet will tend to grow in the next years but still the public infrastructures are lagging behind, which will allow the adoption the EVA guidelines and avoid infrastructural sunk costs. Since in both regions autonomous vehicles are now leaving the research realm and, through pilot test activities, are starting to enter real-life, the EVA guidelines will support the shared and integrated development of electric and autonomous vehicles and the related infrastructures.
BIBLIOGRAPHY


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