ELECTRIC MOBILITY

Contents:

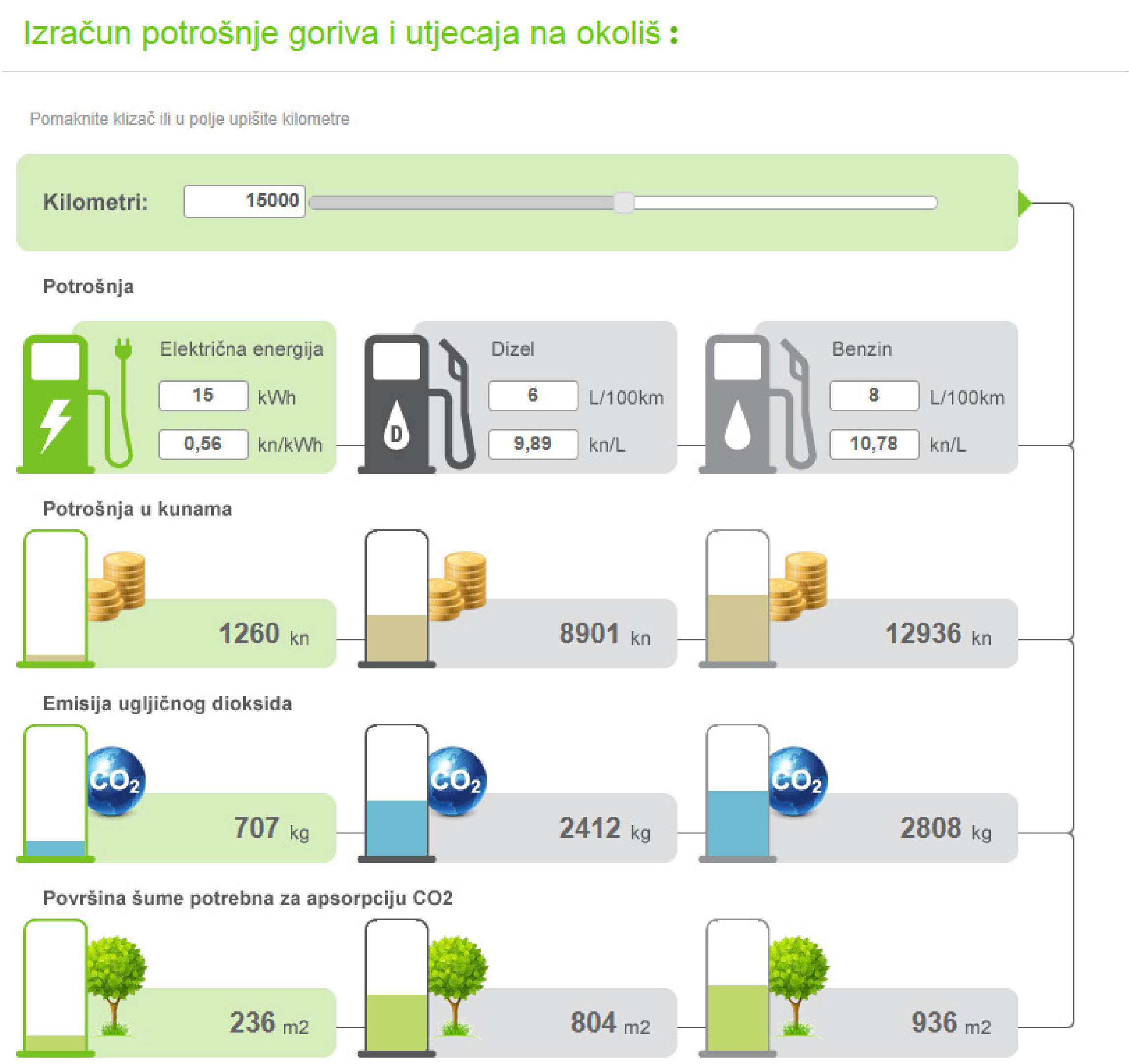
1. Basics of electric mobility

Electric car is a car that is propelled by one or more electric motors, using electricity stored in batteries / accumulator. It can be considered that cars with internal combustion have an unlimited range because they can be refuelled quickly and almost everywhere. Electric cars, because of the duration of charge and the lack of charging infrastructure in public places, in the beginning have a maximum range less than cars that run on fossil fuels. Therefore, many manufacturers initially labelled electric car as a "city car" suitable for daily urban routes. However, electric cars have several advantages compared to cars with conventional internal combustion engines. They do not emit CO_2 and other harmful particles because they have no exhaust and do not depend on oil as a motor fuel, whose price is increasing every day. Ride comfort is greater due to their linear acceleration and silent running of the electric motor. Also, the driving comfort is significantly greater due to the lack of a gearbox. However, electric cars are currently significantly more expensive than cars with conventional engines due to immediate higher cost of their lithium-ion batteries. However, the price of the battery is expected to fall due to their mass production. Fear among customers that the limited driving range could be too small for their needs is definitely a major limiting factor.

The objective of electro mobility is to find a sustainable balance between people, cars and the environment. Electro mobility provides a positive impact for reducing emissions. Studies show that the overall calculation of greenhouse gas emissions for electric cars is much lower than emissions of conventional vehicles. CO_2 reduction is 11 to 100% if the electricity used to charge the car comes from renewable energy sources.

Manufacturers have started to produce batteries that last longer and are easier to recycle. After use the batteries can be recycled for future use, can be sold and used in another industry or simply recycled when they reach the end of their useful life.

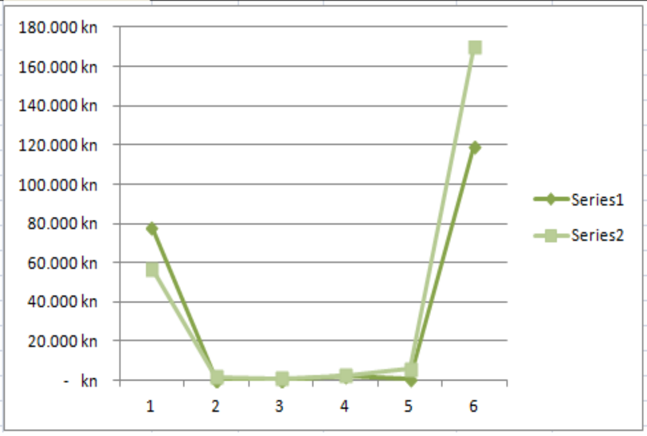
Electric cars have the potential to transform the way the world is moving. They can increase energy security by diversifying the mix of fuels and reduce dependence on oil, and also reduce emissions of greenhouse gas and other pollutants. However, the mass introduction of electric cars will require a transport system capable of integrating and encouraging this new technology.

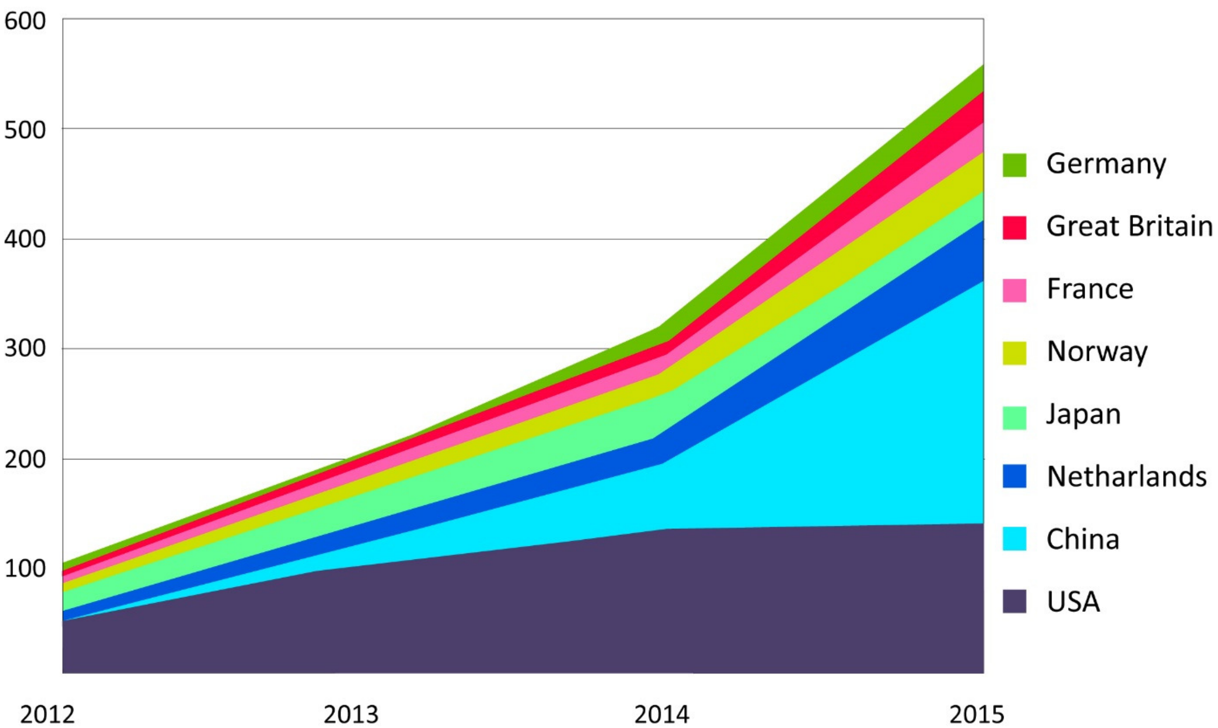


Source: www.elen.hep.hr

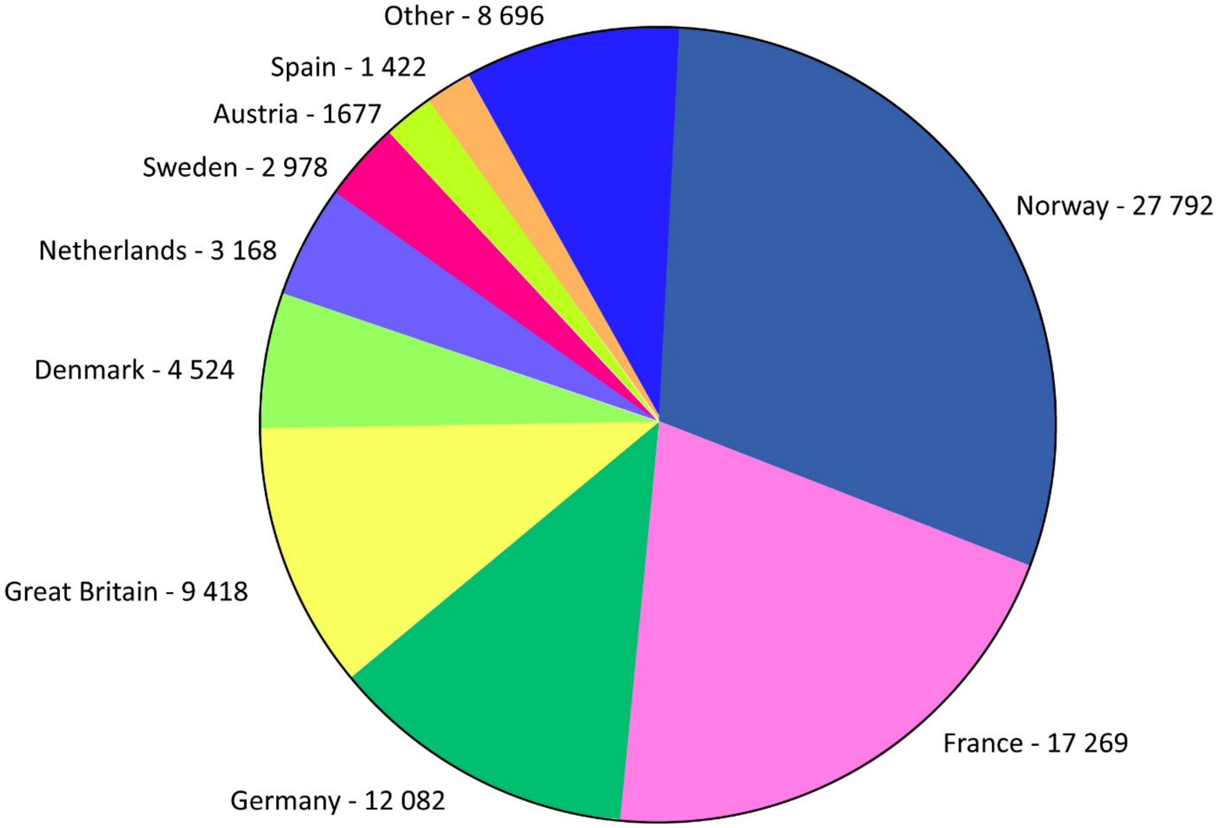
Usporedba VW UP i ELECTRA NEVO električnog vozila

	god. Star	km/god.	km/dnevno	Neto cijena vozila	os. Osig.	reg.	održavanje i amortizacija za bateriju	gorivo	TROŠKOVI Sveukupno	UŠTEDA
ELECTA NEVO	10	10.000	28	78.500 kn	485 kn	180 kn	2.600 kn	800 kn	119.150 kn	50.650 kn
VW UP	10	10.000	28	57.000 kn	1.800 kn	980 kn	2.500 kn	6.000 kn	169.800 kn	





- Globally billion cars, 1.2 million PEV - 0.12%
- 2014 sold 88 million cars, 300 000 PEH - 0.34%
- Europe 2015 to 1.27%



Picture: Sales of electric cars in Europe in 2015: 89,026, market share: 0.60%

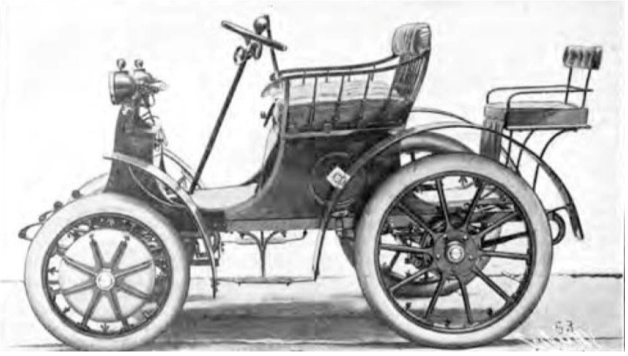
The history of electric cars

The history of electric cars began in the mid 19th century, and the invention of the electric car is attributed to various inventors. In 1828, Ányos Jedlik, a Hungarian who invented an early type of electric motor, created a small car model powered by the then new type of engine. In 1834 in Vermont, Thomas Davenport invented the first American DC electric motor. Rechargeable batteries that provide a viable way to store electricity in the car did not exist until 1840.

The invention of the improved battery technology in France in 1881, with the efforts of Gaston Plante and his countryman Camille Faure, finally opened the way for electric cars and their expansion in Europe. France and Great Britain were the first countries to support the development of electric cars.

Before improvement of the internal combustion engine, electric cars held many records regarding speed and range. Among the most important is breaking the record of 100 km/h on 29th April 1899. Although Thomas Davenport was among the first to install an electric motor into a vehicle, the electric car in the conventional sense was not developed until sometime around 1891.

Picture: Lohner-Porsche Electric Coupe, year 1899



Source: Electric and Hybrid Cars, Curtis D. Anderson and Judy Anderson

Picture: Woods' Victoria Hansom Cab, year 1899

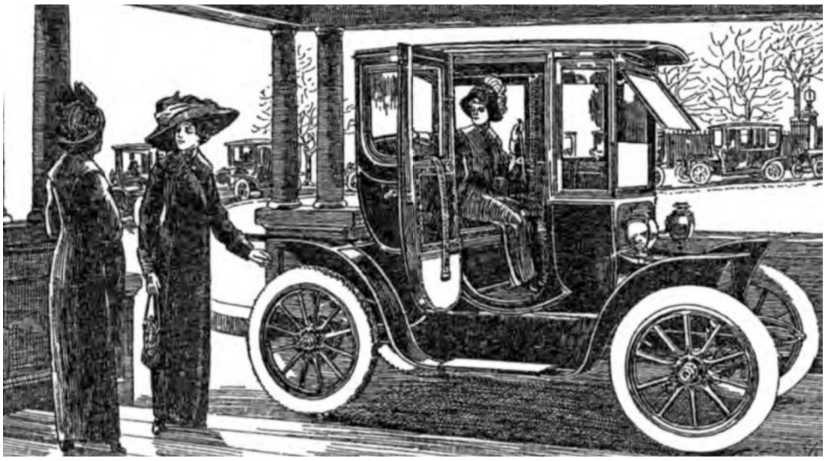
Source: Electric and Hybrid Cars, Curtis D. Anderson and Judy Anderson

Picture: german electric car, year 1904

Source: The German Federal Archive, www.wikipedia.org

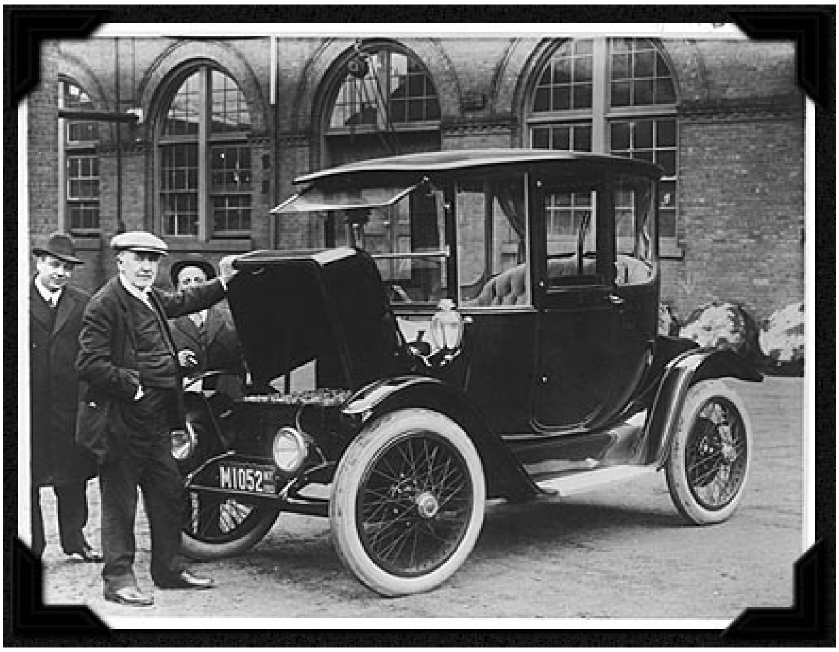
Due to technical limitations, the maximum speed of these earliest electric cars was approximately 32 km/h. At the beginning of 1900, despite their relatively low speed, electric cars had a number of advantages over their competition. They produced no vibrations, odours and noise associated with petrol-powered cars. Changing gears in petrol-powered cars was the hardest part of the driving, and electric cars did not require gear changes. Electric cars were popular among wealthy customers who used them exclusively in city traffic, so their limited range was not relevant. Electric cars also had the advantage because they did not require manual effort to start driving. Petrol-powered cars had handles for starting the engine on the front side which required the starting force. Electric cars were often sold as vehicles suitable for women drivers due to their easier operation. Early electric cars were even labelled as "women's cars".

Picture: Columbus Electric Coupe, year 1912



Source: Electric and Hybrid Cars, Curtis D. Anderson and Judy Anderson

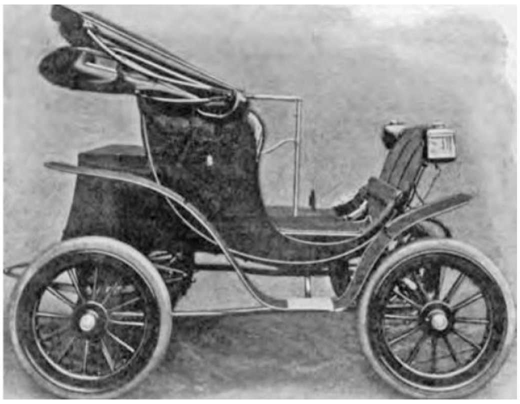
Picture: Thomas Edison with his electric car, year 1913



Source: http://upload.wikimedia.org/wikipedia/commons/8/8a/EdisonElectricCar1913.jpg

At the turn of the century, 40 percent of American cars were powered by steam, 38 percent by electricity and 22 percent by petrol. Most of the early electric car were massive and with extravagantly designed wagons with luxurious interior full of expensive materials. These cars were produced for the upper class of very wealthy customers that stood out by owning such a car. Basic models of electric cars cost around $ 1,000 (approximately $ 28,000 today), and on average they cost about $ 3,000 (about $ 84,000 today). The sale of electric cars had its peak in 1912.

Picture: Electric Victoria, year 1902; Detroit Electric Roadster Model 46, year 1915



Source: Electric and Hybrid Cars, Curtis D. Anderson and Judy Anderson

Picture: Milburn Coupe, year 1915; Detroit Electric Coupe, year 1917

Source: Electric and Hybrid Cars, Curtis D. Anderson and Judy Anderson

Picture: Charging of electric car in Detroit, year 1919

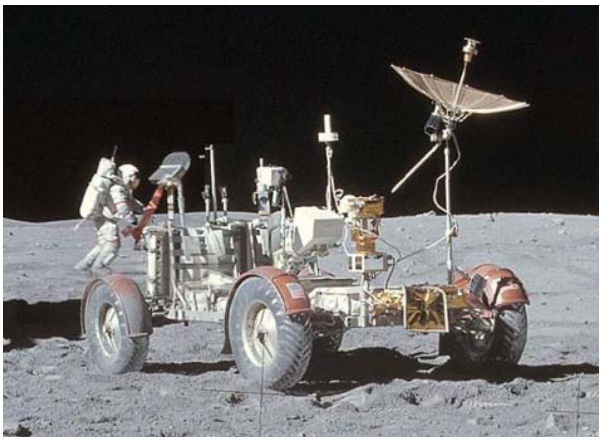
Source: Library of Congress, http://www.loc.gov/pictures/resource/cph.3b16781/

The First World War created a huge demand for electric vehicles in Great Britain and Europe. It is estimated that in 1914 the whole of Europe had approximately 3,200 electric vehicles (cars, buses...). Commercial electric vehicles were produced primarily in Europe. The safety of electric vehicles, their simple design and easy driving made them vehicles that even inexperienced and new, young drivers were able to drive. Norway and Sweden had on the market a large fleet of commercial electric vehicles and large energy hydropotential and were very promising markets after the war. Italy also generated electricity from hydropower, also representing a promising market for electric cars. Australia, Japan, Mexico and France were exporting electric vehicles in large quantities so their future looked bright because the demand was high.

After success at the beginning of the century, electric cars began to lose their position in the car market. This was a result of a series of events. In the 20's of the 19th century, road infrastructure was improved and the way between American cities was opened. To use these roads, a vehicle with a greater range than that offered by electric cars was needed. The discovery of large oil reserves in Texas, Oklahoma and California led to the wide availability and affordability of fuel. The use of electric cars was limited to urban environments because of their low speed (not more than 24-32 km/h) and very limited range (50-65 km). Petrol-powered cars were now able to travel further and faster than equivalent electric cars. In 1912, petrol-powered cars became easier to drive due to the invention of Charles Kettering and his electric "starter", which eliminated the need for a handle to start the petrol engine. Noise also became bearable due to the silencer, invented by Hiram Percy Maxim in 1897. Finally, the start of mass production of vehicles with petrol drive was initiated by Henry Ford. In 1915, the price of his car was $ 440 (today this is about $ 10,000), and a year later it even fell to only $ 360 (today this is about $ 7,700). In contrast, the price of similar electric cars was still increasing. In 1912, the price of an electric car was approximately $ 1,750 (today this is about $ 42,000). How did Henry Ford turn the then inferior car into the market leader? Not using technology, but using a better business policy. He understood the nature of the market and assumed that if people saw more Ford cars on the street they would want to buy the Ford brand. Low cost of car production and their availability launched an avalanche of demand.

On 31st July 1971, electric car became the first vehicle the man drove on the moon and so it got became distinctive from all other cars. It was the Lunar Roving Vehicle, first deployed during the Apollo 15 mission. "Moon Buggy" was developed by the companies *Boeing* and *Delco Electronics*.

Picture: Lunar Roving Vehicle



Source: http://en.wikipedia.org/wiki/Lunar_Roving_Vehicle

Although several years passed without public attention, the energy crises of the seventies and eighties led to renewed interest in electric cars.

The *Green movement* in the 90's and at the beginning of the 21st century made driving an environmentally-friendly car the political and fashion statement. Protection and conservation of the world's natural resources have value, and pollution is harming all of us. Environmentally responsible consumers overwhelmed the market. The construction of infrastructure for charging cars, increasing incentives for the purchase and encouraging the green concept in public life could restore the electric cars their popularity of the 19th century.

At the time of launching their *EV1* model on the market, GM did not adequately promote the car so they were accused of pandering to the wishes of *CARB* (Californian Air Resources Board), but only to still be allowed to sell all other environmentally inefficient cars, i.e. that they produced an environmentally friendly car only because of the imposed legal provisions.

Consumers were not allowed to buy EV1 cars, but they could only rent them for a fixed period, which means that all cars had to be returned to GM at the end of the lease term, without the option of purchase. After public protests of a group of GM's EV1 drivers agitated because of the impossibility of buying their cars, GM transported the entire fleet of electric cars to a remote location and destroyed them! A group of activists recorded the whole action, and it is all documented in the film "Who Killed the Electric Car?".

Picture: 15th of March 2005, the last EV1 was destroyed

Source: Pictures from documentary film: "Who killed the electric car?"

Instead of encouraging consumers to buy EV1, GM decided to promote Hummer and convince people that this is what they really want and need. They also lobbied for state tax benefits ranging from $ 25,000 to a whopping $ 100,000 per car (or rather a mini-tank) which is the biggest "oil consumer" and also the largest car on the road weighing 3 tons! (the maximum tax benefits in 2002 for an electric car amounted to $ 4,000, and for a car of 3 tons in 2003 $ 100,000!)

Almost all manufacturers withdrew their electric vehicles from the market. Toyota offered its last RAV4-EVS on 22nd November 2002. However, they continued to support several hundreds of their customers and users of Toyota RAV4-EV. EV1 can now only be seen in two museums where they are exposed without engines.

One of the conclusions made in the documentary "Who Killed the Electric Car?" was that in the same way as it was necessary to pass the law on wearing seatbelts, putting airbags in cars, catalysts, etc., so the "clean cars" are too important for the "clean environment" to be left to the automotive industry to decide on their fate.

The energy crisis of 2000 brought renewed interest in hybrid and electric cars. In response to the lack of large manufacturers for the production of electric cars, a lot of small companies started to design and advertise electric cars to the public. In 1994, *REVA Electric Car Company* was established in Bangalore - India, as a joint venture of the *Maini Group India* and *AEV of California*. In many countries REVA does not fulfil the conditions of a motor vehicle eligible to drive on highways, and it is categorised in other classes, such as in the USA the so-called *Neighbourhood electric vehicles* (NEV) and heavy *quadricycles* in Europe. Until March 2011, REVA sold more than 4,000 vehicles around the world and it is available in 26 countries.

Pike Research estimate that in 2011 there were almost 479 000 NEV vehicles in the world. The top selling NEVs are *Global Electric motorcars* (GEM) vehicles, with more than 45,000 vehicles sold as at December 2010. The production of the *Th!nk City* all-electric car, with a maximum speed of 110 km/h and a range of 160 km, was launched in 2008 by the

Norwegian manufacturer Think Global, but due to financial difficulties the production was terminated. Over 1000 *Th!nk* vehicles were sold in several European countries and the USA. In June 2011, the company declared bankruptcy and the production was terminated. The new owner scheduled to restart the production in early 2012 with a slightly altered concept of *Th!nk City.*

Picture: Th!nk City

Source: http://en.wikipedia.org/wiki/Think_City

Californian manufacturer of electric cars, *Tesla Motors*, in 2004 started the development of the *Tesla Roadster* model, which was first delivered to customers in 2008. *Tesla Roadster* is the first electric car adapted for American highways and available in serial production in the USA. From 2008 to December 2011, more than 2,100 vehicles were sold in 31 countries. Tesla was also the first to introduce lithium-ion batteries in its car production, and *Roadster* is the first car that has a range greater than 320 km on a single charge and can reach the speed of over 200 km/h.

Picture: Tesla Roadster

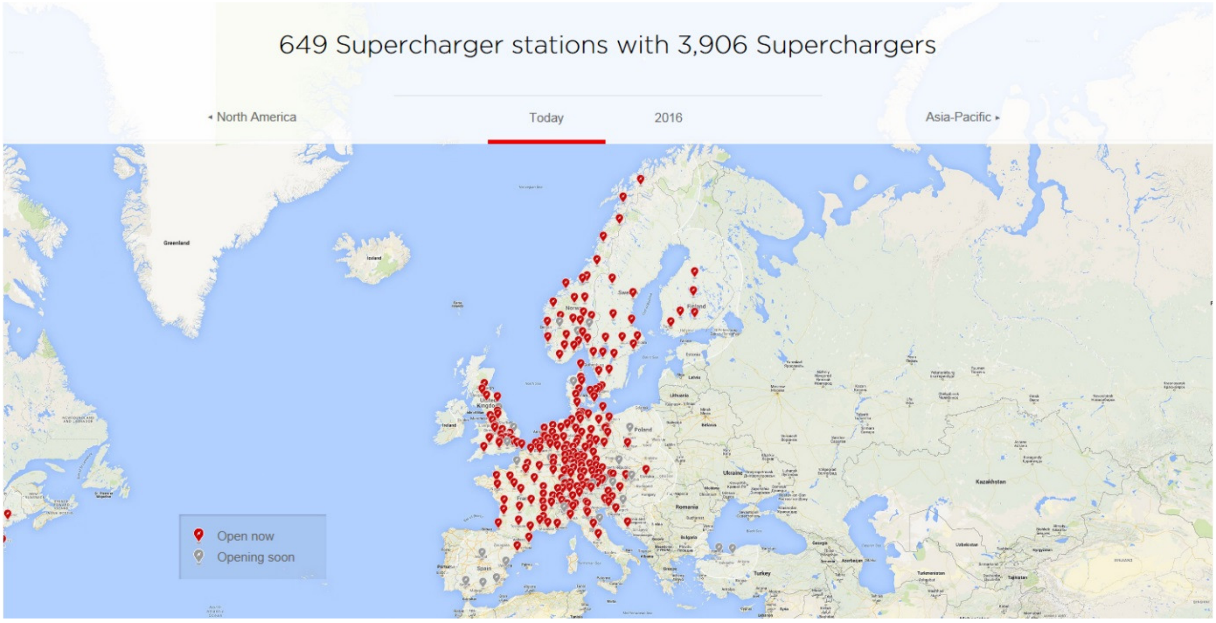
Source: www.teslamotors.com

In June 2012, the company *Tesla Motors* began delivering *Tesla S* model (sedan). This model saved the company, which was on the verge of collapse. Unlike *Roadster*, which is a sporty two-seater, *Model S* is a luxurious car for the whole family. The basic price of the *Model S* in the US market is about 60 thousand dollars, and this year they plan to deliver five thousand cars.

The basic model comes with batteries that allow a range of up to 258 kilometres, but *Tesla Motors* also offers batteries of greater capacity that allow this model to have a range of up to 370 and even up to 483 kilometres.

Tesla Superchargers are fast-charging stations placed on traffic routes in North America. Currently, only six stations are active, but the plan is to have about a hundred of them by 2015. They are designed to fill about a half of the battery capacity in half an hour. This is additional 240 kilometres. These rapid charging stations are located in places where you would otherwise want to stop: near restaurants, cafes and shopping centres. In many places, solar cells are put on the roof of the charging stations so the electricity is produced from renewable energy sources.

Picture: Infrastructure of quick Tesla Superchargers, map of todays situation in Europe, 2016



Picture: Tesla Superchargers

Picture: Tesla Model S

Source: www.teslamotors.com

Picture: Tesla Model X

Source: www.teslamotors.com

Mitsubishi i-MiEV was launched in July 2009 for fleets of customers in Japan, and for other consumers in April 2010, followed by sales in Hong Kong and Australia through a leasing model. I-MiEV was launched in Europe in December 2010, including the same versions under other brands - Peugeot Ion and Citroën C-Zero.

Picture: i-MiEV

Source: Mitsubishi Hrvatska

Picture: Citroën C-Zero

Source: Citroën Hrvatska

Nissan *Leaf*, presented on the Japanese and American market in December 2010, became the first modern all-electric car with zero tailpipe emissions that will be in mass production. According to Nissan, *Leaf* has a range of 160 kilometres. By December 2011, *Leaf* was delivered to France, Ireland, the Netherlands, Norway, Portugal, Spain, Switzerland and Great Britain. Since its launch on the markets in December 2010 by the end of 2012 more than 30,000 Leafs were sold worldwide. Nissan *Leaf* has thus become the best-selling electric car in the world.

Picture: Nissan Leaf

Source: www.nissanusa.com

Renault has turned its focus exclusively on the new generation of electric cars, skipping any intermediate step with possible hybrid models. This may be a risky move considering that the future of electric cars is still uncertain, and the number of sold hybrid cars is still increasing every day. But the way chosen by Renault is good as it does not distort the image created, and the concentration and coordination of the group that leads to a single goal in the future may mean the car market leader, in front of all who experimented with both hybrids and electric cars in their fleets. In 2011 the commercialization of serial electric vehicles Kangoo Z.E., Fluence Z.E., Twizy Z.E., and in 2012 also of the Zoe Z.E. model started.

Picture: Renault electric cars fleet (Kangoo, Fluence, Twizy i Zoe)

Source: www.renault-ze.com

Croatian electric cars manufacturers

RIMAC AUTOMOBILI

Young Croatian inventor Mate Rimac and his team who developed the electric car Concept One proved that anything is possible with a lot of talent, knowledge and effort. It should be noted that the car is almost entirely made up of parts manufactured in Croatia, and mainly experts from Croatia, but also global experts, participated in the development of Concept One.

Picture: Electric car Concept One – Rimac Automobili

Source: www.facebook.com/RimacAutomobili/

DOK-ING

DOK-ING is a company from Zagreb, primarily engaged in the production of military machines and robots, and the US army is also a user of their products. Four years ago, they entered the project of “the first Croatian electric car” and presented the first XD concept in 2010 in Geneva. XD is a 2.9 meter long electric three-seater. It is powered by two electric motors with a joint power of 120 hp. It reaches 100km/h in 7.7 seconds, and with a single battery charge it can drive up to 200 km.

Picture: Elektro automobil XD tvrtke DOK-ING

Source: www.doking-automotiv.hr

Hybrid cars (HEV - hybrid electric vehicle)

Hybrid cars are vehicles that use a standard internal combustion engine and an electric motor. *Hybrids* obtain most of the power from the internal combustion engine. If needed, the electric motor can bring extra power. Energy for the electric motor is generated while the car is driving, and is then stored in batteries. Hybrid vehicles do not need charging from an external source of electricity to operate the electric motor. The electric motor also functions as a generator that converts the energy from regenerative braking and stores it in the batteries.

Toyota Prius already dominates the global market as “the most eco-friendly” car since 2000. Prius has been sold in more than 70 countries, and its biggest markets are Japan and the USA. By February 2012, a total of 2.5 million Prius cars were sold in the world. Prius has opened the door to all new technologies and proved that interest in *environmentally clean cars* is real.

The latest generation of Toyota's hybrid car Prius hybrid draws power from the hybrid assembly made up of the 1.5-liter petrol engine of 74 hp and an electric motor of 61 hp, with a combined power of 100 hp. The average fuel consumption is around 3 l/100 km. The nickel-metal-hydride battery allows driving over short distances (less than 1.6 km) at the maximum speed up to 40 km/h in purely electric mode. If the speed is greater than 40 km/h the petrol engine automatically turns on.

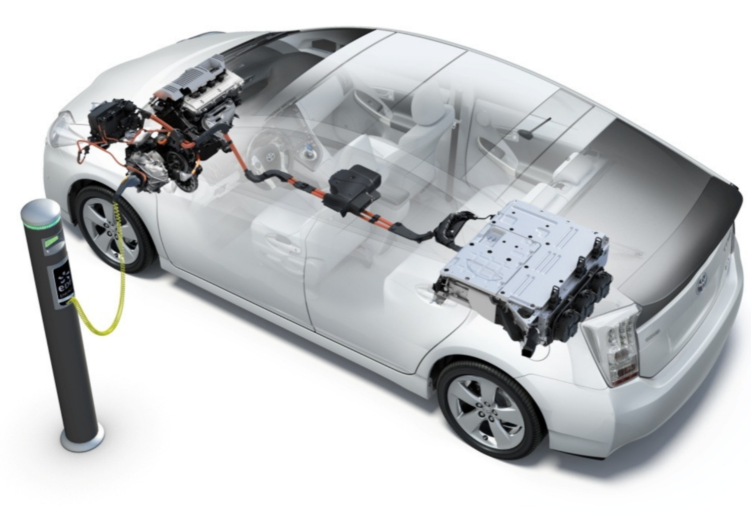
Technical knowledge and image that Toyota already has in connection with hybrid technology allows them to sell their knowledge related to the technology to companies like Ford and Mazda.

Plug-In hybrid cars (PHEV - plug-in hybrid electric vehicle)

Plug-in hybrids work in a similar way as hybrid vehicles. They also use the internal combustion engine and one or more electric motors for drive. Unlike hybrids, plug-in hybrid draws most power from the electric motor, which has the primary role. As the name suggests, to charge the battery plug-in hybrids must use an external power source via the outlet to fully charge the battery. However, as the battery discharges, the internal combustion engine comes in and takes over, and the battery is additionally recharged. When the battery fully discharges, a plug-in hybrid behaves like a standard hybrid, more precisely, the conventional engine takes on the role of the primary energy source. PHEV cars have very small battery capacity and thus also the range in all-electric mode (10-60 km). However, this does not mean that they are limited to such a small range. The internal combustion engine is a backup system and thus there is no fear of too short range with such vehicles.

In HEV's, an electric motor assists the work of a conventional engine, while in PHEV's it is the other way round. PHEV variant is more environmentally friendly while all-electric vehicles are closest to achieving the objective of environmentally clean vehicles. While offering lower environmental contribution in relation to all-electric cars, PHEV cars have a very important role in bridging the technology from the car with the internal combustion engine to electric cars.

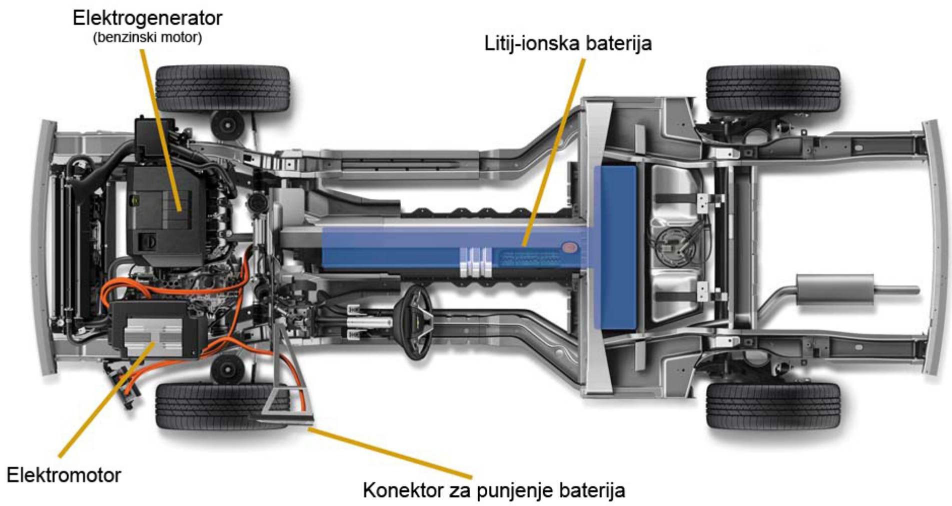
Picture: The main components of the drive system of Plug-In Prius



Source: Toyota Hrvatska

Extended range electric vehicle (E-REV) / Voltec technology

Picture: The main components of the drive system Opel Ampera and Chevrolet Volt (Voltec tehnology)



Source: www.opel.com

In conventional hybrids the wheels are powered by a petrol engine, electric motor, or both. In practice, the extended range electric vehicle (E-REV) is different from hybrids and plug-in hybrids as its wheels are always driven by the electric motor.

Voltec powertrain technology is used by Opel Ampera and Chevrolet Volt. The two twin cars. They can therefore be charged by plugging into any outlet of 230V in the household. Energy is stored in a T-shape lithium-ion battery of 16 kWh. The battery powers the electric generator that realises complete performance in terms of speed and acceleration of the vehicle to travel 40 to 80 kilometres. For longer distances the built-in petrol engine for extended range is used to drive the electric generator. The petrol engine is able to generate additional electricity to power the car and drive to a distance greater than 500 km.

Picture: Opel Ampera

Source: www.opel.com

100% electric cars (EV - electric vehicle)

Electric cars are different from conventional cars with internal combustion engines in the part related to the drive system. Instead of the internal combustion engine and the classic tank, electric cars are equipped with an electric motor and batteries.

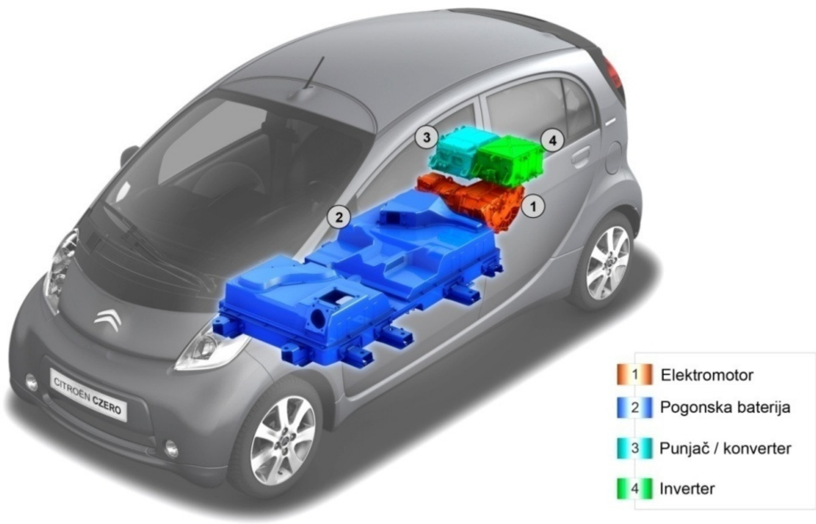
The electric motor provides better acceleration compared to the petrol engine (it has linear acceleration). This means that most of the electric cars will accelerate from 0-100 faster than petrol-powered cars. The induction motor (AC asynchronous motor) is the most common model of electric motors. This is mainly due to its simple design and low production costs.

The braking system of electric vehicles is designed so that the deceleration energy released during slowing down is stored back into the battery (so-called regenerative braking). This feature of electric vehicles is especially important in urban areas, where the driving mode consists of a stop-go principle.

Electric cars need to be recharged more often than we are used to fill the classic cars, but they can be recharged anywhere where there is an electrical outlet. The duration of charging varies depending on the current battery charge and options of the charging station. At a rapid charging station a car can be full already after 20-30 minutes, and at a slow charging system (slow charging stations or home charging) the charging time is 6-8 hours.

Compared to conventional vehicles, engines in electric cars, vans and trucks have only a few mobile parts and maintenance costs are minimized. Other benefits of electric vehicles are: reduced driving fatigue (due to the automatic transmission, low vibration and a smoother and faster acceleration) and the lack of engine noise (very useful for delivery vehicles that make deliveries early in the morning in residential areas).

Picture: The main components of the drive system - 100% electric car



Izvor: CITROËN Croatia

Picture: Comparison of electric cars and the car with the internal combustion engine

Source: CITROËN Croatia, Shutterstock and http://www.hybridcars.com/electric-car

Battery system

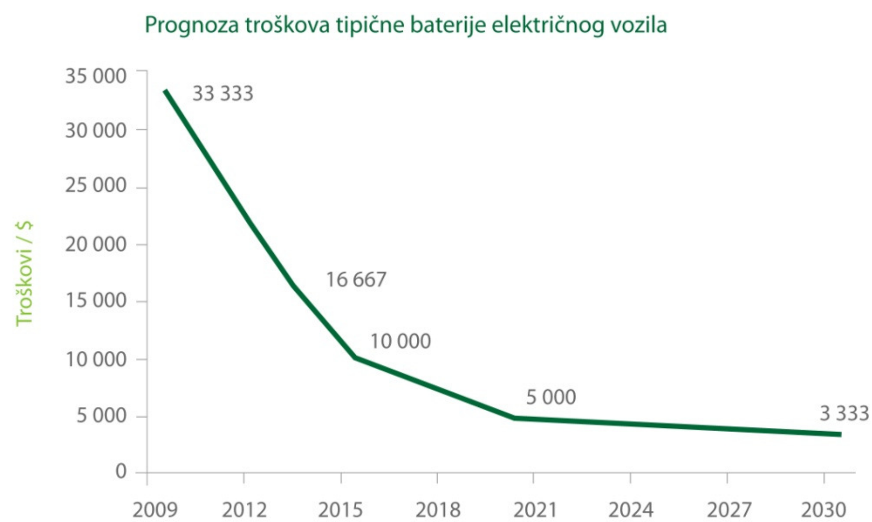
The successful introduction of electric vehicles on the market is highly dependent on the availability of battery technology, which enables reliable storage of electricity in the vehicle and thus directly affects its driving range. Even today, the battery capacities are large enough to cover the daily needs of the use of a car for most consumers. Global battery manufacturers announce an intensive increase in capacity in the near future and the autonomy of driving up to 350 km on a single charge is expected. Battery life is typically warranted for a period of at least 8-10 years.

Batteries should offer a substantial driving autonomy, as well as the proper performance of the vehicle. High security standards must also be ensured, taking into account the large amount of electricity stored in them. The risk of a sudden uncontrolled discharge, in case of a short circuit, overload and overheating, should be minimised. Generally, the original battery capacity decreases over the useful life, regardless of the type of use, and depending on the number and type of discharge cycles.

Safety issues regarding electrical, electrochemical, thermal and mechanical effects are considered to be surmountable, but require the use of a battery management system that regulates the voltage and temperature of cells at all times. High production costs of lithium-ion batteries are responsible for the slower market entry and remain the major area for research and development. Nevertheless, it is assumed that lithium-ion technology has the potential to reduce production costs, as a result of the optimisation of manufacturing processes, due to economy of scale and due to the transition to alternative and cheaper materials. The most significant limiting factor for the production of batteries could be global reserves of lithium.

In electric cars, batteries are the component with the highest added value and they represent the most expensive part of the electric car and thus the impact of battery manufacturers on car manufacturers may be such that in the future battery manufacturers may become manufacturers of the entire car. Noting the major impact of battery manufacturers on further progress of the production process, major car manufacturers have entered into cooperation agreements with battery manufacturers. Not only to ensure the commission on sales but also to able to impact the development of the batteries.

Picture: The expected batteries price trend in the near future



Source: U.S. Department of Energy

Electric cars contribute to cleaner air in cities as they do not emit harmful substances into the environment, such as particles (soot), volatile organic compounds, hydrocarbons, carbon monoxide, ozone, lead, and various nitrogen oxides. The benefits of clean air are most often of local nature since, depending on the source of the electricity used to charge the battery, emissions of harmful substances into the air are moved to the location where electricity is produced. If all the electricity used for charging electric cars were obtained from renewable energy sources (such a scenario is possible) then the electric cars would be completely without harmful gas emissions.

The average greenhouse gas emissions per kWh of electricity generated in 2006 in the EU amounted to 443 gCO_2/kWh, while in Croatia in 2008 the same emissions were 550 gCO_2/kWh of the electricity generated. Taking into account the average consumption of final energy by electric cars in the amount of 12.5 kWh/100km and the average CO_2 emissions per kWh of electricity generated in some EU member states, specific CO_2 emissions per kilometre were obtained.

Table: Comparison of energy consumption and CO2 emissions for electric cars

Model vozila	Finalna energija (Tank-to-Wheel) kWh/100km	Primarna energija (Well-to-Wheel) kWh/100km	CO_2 emisije (Well-to-Wheel) gCO_2/km
Toyota Prius (hibrid)	44	55	122
REVAi	11	30	50
QUICC!	14	39	63
TESLA Roadster	13	34	56
Nissan LEAF	15	41	67
Mitsubishi i MiEV	10	27	45
Th!nk	16	43	71
Smart Fortwo EV	12	33	53
Citroën C-Zero	13	35	58

Source: http://www.going-electric.org

Therefore, electric cars are completely free of local emissions (no exhaust) and the total emissions, if we take into account the production of electricity, are approximately 69 g CO_2/km on average. Compared to conventional vehicles equipped with internal combustion engines, with an average CO_2 emissions per kilometre of around 165 gCO_2/km (IEA estimate of actual emissions), the fact that electric cars burden the environment two or more times less than conventional cars is evident.

Recycling and disposal of batteries

Ensuring proper disposal of batteries and their recycling at the end of their life cycle is currently the greatest challenge for electric car manufacturers. For lead-based batteries a system of disposal and recycling has been developed and is commercially available. Recently, the recycling technology for advanced battery systems, such as lithium-ion is also commercially available. Disposal of batteries for hybrid cars is already included in the European Directive 2006/66/EC on batteries.

In the Republic of Croatia, the Ordinance on the management of batteries and accumulators ("Official Gazette", no. 133/2006, 31/2009, 156/2009) is currently in force. This Ordinance prescribes the method of labelling batteries and accumulators, the method of collecting waste batteries and accumulators, obligations and responsibilities of manufacturers of batteries and accumulators and manufacturers of devices whose integral parts are batteries and accumulators, types and amounts of fees payable by persons liable to pay fees, the method and time schedule for calculation and payment of the fees, the amount of fees paid to persons authorised for collecting, processing and recycling of waste batteries and accumulators.

The Sony's report (the study was conducted as part of the Japanese centre for recycling batteries) indicates that 56-61% of the lithium from batteries can be re-used in non-battery products. It is assumed that only the most valuable materials (e.g. cobalt) will be recycled in the beginning. Due to the large size of car batteries compared to small batteries used in mobile devices, the increase in recycling could become an economically attractive activity in the near future.

Contribution to noise reduction in urban areas

Electric cars are the only form of transport that provides almost zero noise during use at maximum speed prescribed for urban areas. The introduction of electric cars will significantly contribute to reducing the environmental burden of noise, and therefore a higher quality of life for citizens. Zero rate noise of electric vehicles has a negative security feature: when driving electric cars on city roads, there is a relative security problem for blind and visually impaired citizens and cyclists.

FIRST CITIES EXAMPLES OF GOOD PRACTICE

Norway - the city of Oslo

In June 2012, a total of 7,000 electric vehicles were registered in Norway. This puts Norway on the first position in the use of electric vehicles. Thus, Oslo is the world electric vehicle city with the highest density of electric cars.

Benefits for the users of electric cars are as follows:

- they do not pay charges when purchasing the car (for classic cars they are very high)
- exemption from paying 25% VAT on the purchase
- they do not pay the toll
- public parking free of charge
- allowed to drive within *yellow lanes*

In addition, in Norway there are around 3,500 charging stations, and in 2012 about 70 rapid charging stations will be installed. Locations and other information about all public charging stations in Norway are available in the open database NOBIL, developed and maintained by the company for electric vehicles in collaboration with *Transnova*.

These advantages make the electric car competitive with conventional cars. The goal of the Norwegian Parliament is to reach a figure of around 50,000 zero-emission vehicles until 2018. Norwegian association for electric vehicles set itself the target figure of 100,000 electric cars by 2020. This number is required to obtain a sustainable market for electric cars and charging infrastructure in Norway. Today, electric cars represent 2.5 percent of new cars sold in Norway every month. Electric cars are seen in Oslo on every corner, from mini-vehicles *Buddy* to sports car Tesla *Roadster*.

Since the beginning of its sale, Nissan Leaf sold 2,000 vehicles in Norway in 9 months, which makes it the second best-selling Nissan model. Thereby, it is also among the 15 best-selling models in 2012.

Picture: Tesla Roadster, Reva and Ford Th!nk electric cars parked in the free car park in front of charging stations in Oslo

Source: http://en.wikipedia.org/wiki/Electric_car

The USA - the city of New York

As early as 2007, New York City Mayor Michael Bloomberg announced *PlaNYC* - the initiative for creating a vision of the city by 2030 and put on the agenda the preparation for the population increase, stimulating economic growth and reducing CO_2 emissions.

The study *Exploring Electric Vehicle Adoption in New York City* shows that the quality of air in New York currently does not meet state standards for emissions of CO_2 and other particles. Given that only 44% of the population of New York owns a car (at the national level this is high 90%), urban priority of reducing emissions is focused on public transport. Electric vehicles will play a significant role in reducing these emissions.

Despite the density of traffic and conditions in the city, New York is suitable for integrating the charging infrastructure. 50% of drivers from Manhattan and 80% from Staten Island have ensured parking places, which could alleviate the problems of home charging.

PlaNYC represents a sustainable plan that determined an aggressive strategy to reduce greenhouse gas emissions by 2030 by 30% compared to 2005 figures.

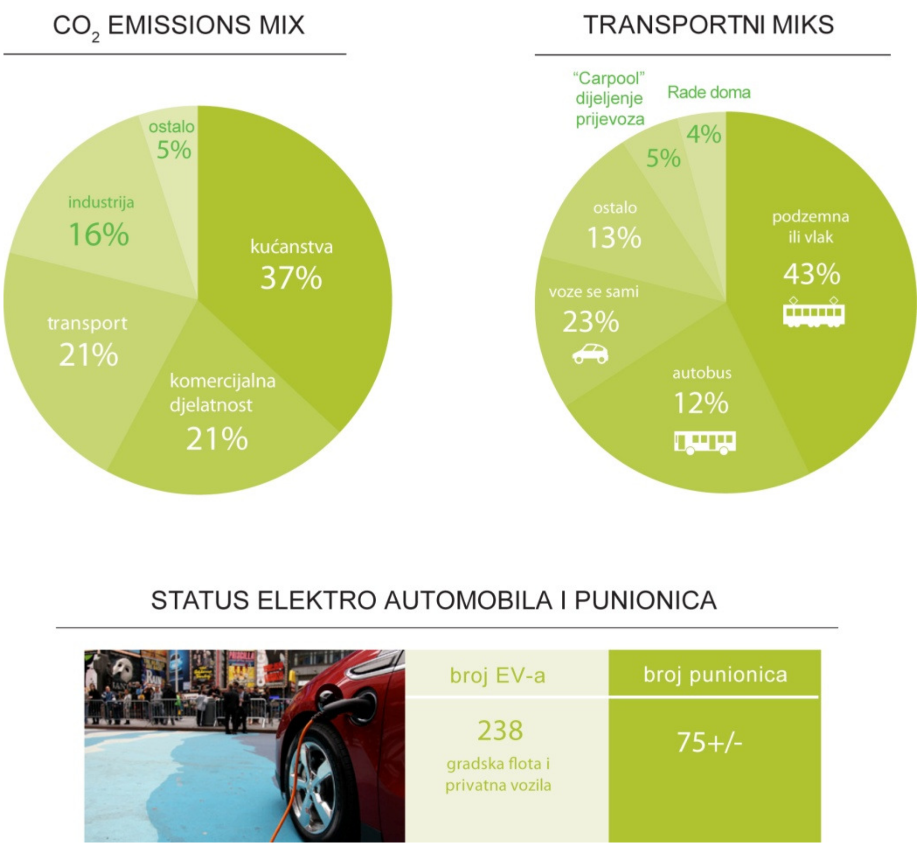
As part of the overall goal, emissions from transport (currently representing 22% of total emissions of the city) would be thus reduced by 44% by 2030. The plan also set the target for reducing particulate emissions to enhance air quality.

Obama’s administration aggressively supports electric car and battery manufacturers as well as customers to whom they subsidise the purchase of a car.

More than 4 billion dollars were spent on the design, production and purchase of electric cars. The federal government approved tax benefits of up to 7,500 dollars per vehicle in order to reduce the high initial price for the purchase of electric cars.

New York is progressing towards the integration of electrification. In 2011, the City bought 50 *Chevrolet Volts*, 10 *Ford Transit Connects* and 10 electro *eStar* trucks. A new purchase rounded the number of the fleet to 430 vehicles, which also include the so-called *neighbourhood vehicles* and scooters. The City, the company Con Edison, Nissan and a private cab company are currently testing 6 Nissan Leafs to determine the feasibility of introducing electric cars in city taxi fleets.

Picture: Situation in New Yorku in 2011



Source: EV City Casebook

France - the city of Paris

French billionaire Vincent Bolloré has invested 200 million euros in the car sharing project Autolib in Paris. Through this project, it is possible to rent electric cars in the city, and every driver who wants to drive the vehicle should, in addition to presenting the valid driver's license, pay a membership fee from 10 to 144 euros, depending on whether they rent the car for a day or a whole year. To this amount, the cost of using vehicles of eight euros for half an hour drive should be added.

Autolib car sharing project plans to introduce for rent in Paris and surroundings 3,000 Bluecar electric cars. It is assumed that this would reduce the number of private vehicles (currently there are about 22,500 vehicles, which is an equivalent of 164 500 000 km travelled kilometres of polluting vehicles). The reach of a Bluecar on a single charge is 250 kilometres at a maximum speed of 130 km/h, and each car is equipped with a GPS system in order to know their location.

Not only will there be less pollution, but there will also be less traffic congestion and less stress.

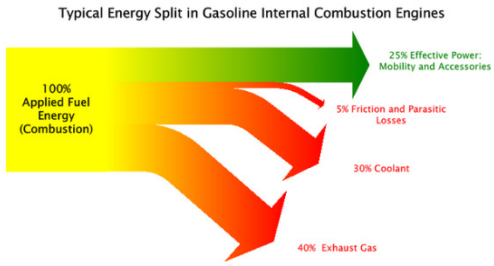
This is the first short-term rental of self-service cars that are all-electric, and can be returned to a different location, not necessarily the location where they were taken.

In June 2012, in Paris there were already 1,749 Bluecar electric cars, 1,100 stations and almost 5,000 charging stations and parking places. The aim is to continue the gradual implementation until the figure of 3,000 cars and 6,000 charging stations is reached.

Picture: Bolloré Bluecar cars on the charging stations of Autolib' carsharinga

Source: http://green.autoblog.com/2012/01/13/parisian-autolib-car-sharing-service-suffers-setbacks-sells-6-0/

2. Electric vehicles



Picture 1: Otto engine efficiency

First of all, we must understand what electric vehicle is. It is a vehicle propelled by electric motor, using electrical energy stored in some kind of batteries or another storage device. If we compare electric propulsion to internal combustion propulsion we see, that E-motor give vehicle instant torque from 0 Rpm, creating strong and smooth acceleration.
Another comparison is very important, that is energy efficiency.
While internal combustion engine has about 25-30% efficiency, EV on the other side transfers over 90% of energy in to effective power. Electric vehicles are also significantly quieter than conventional internal combustion engines. They do not emit tailpipe pollutants, so they contribute to a large local air pollution reduction, and, in many cases a large greenhouse gas and other emissions reduction. But that depends on the method used for electricity generation.
Electric vehicles provide independence from foreign oil, which in several countries is cause for concern about vulnerability to oil price and supply disruption.
Widespread of electric vehicles adoption faces several hurdles and limitations, including their purchase cost, lack of charging infrastructure (fast charging stations) and range anxiety (drivers fear that EV energy storage is not enough for their needs – due to limited range of most EV-s). Recharging can take a long time; however, for long distance driving, many cars support fast charging that can give around 80% charge in half an hour, using public fast chargers.

2.1. Electric vehicles type

The term "electric vehicle" refers to any vehicle that uses electric motors for propulsion, while "electric car" generally refers to highway-capable automobiles powered by electricity. Low-speed electric vehicles, classified as neighborhood electric vehicles (NEVs) in the United States, and as electric motorized quadricycles in Europe, are plug-in electric-powered microcars or city cars with limitations in terms of weight, power and maximum speed that are allowed to travel on public roads and city streets up to a certain posted speed limit, which varies by country.
While an electric car's power source is not explicitly an on-board battery, electric cars with motors powered by other energy sources are generally referred to by a different name: an electric car carrying solar panels to power it is a solar powered vehicle, and an electric car powered by a gasoline generator is a form of hybrid vehicle. Thus, an electric car that derives its power from an on-board battery pack is a form of battery electric vehicle (BEV). Most often, the term "electric car" is used to refer to battery electric vehicles

Types of EV`s (refers to size):

- Electric cars
- Quadricycles
- Electric wheel chair
- Electric scooters
- Electric bikes, other

Picture 3: Electric quadricycle

Picture 2:Electric bike

2.2. Electric propulsion – components

Electric propulsion consists of components:

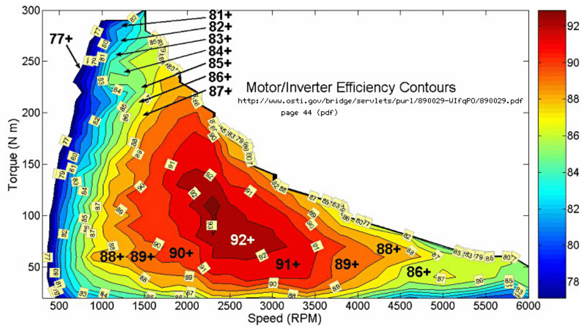
- Electric motor
- Control unit
- Batteries

Each of the component characteristic should be considered, when deciding for purchasing electric vehicle. If we pay attention to those crucial data, we are on good way to purchase an EV (electric vehicle) that will suit our needs.

2.3. Electric motor

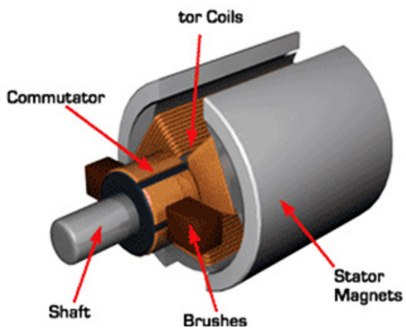
There are some key characteristic that define electric motors:

- Torque (continuous, peak)
- Rpm (at which voltage)
- Energy efficiency (different operating points)
- Power (continuous, peak)
- Operating voltage
- Compatibility with control unit



DC BRUSHED MOTOR-DIRECT CURRENT

DC electric motors and suitable control units are currently being used only with scooters and lighter E-vehicles. There is still quite a number of outdated high power (10-30 kW) brushed DC electric motors located mostly in the United states. New vehicles with brushed motors are not produced in EU. On the used vehicle market there are some PSA vehicles with brushed motors.



ıshed motor

This type of motors are not installed in new vehicles mostly because of their energy efficiency, which is around 75-80%. Brushes need to be replaced every 50kkm.

Brushed motor Advantages:

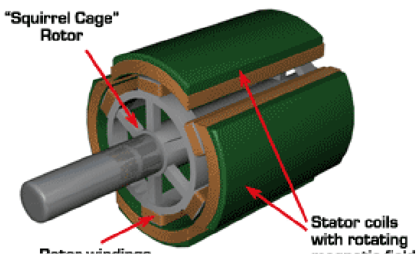
- Simplified wiring: Brush motors can be wired directly to DC power and control can be a simple as a switch.
- Low cost

Brushed Motor Disadvantages:

- Less efficient
- Electrically noisy: The switching action of the commutators constantly creating and breaking inductive circuits creates a great deal of electrical and electromagnetic noise.
- Lifespan: As they are in perpetual physical contact with the shaft, brushes and commutators wear out.

THREE-PHASE ASYNCHRONOUS AC MOTORS

Three-phase asynchronous AC motors are currently dominating the electric vehicle market, primarily due to the fact, that they are being used in industry for over 100 years and that fact makes the technology highly



motor

developed. Though their efficiency is lower than at synchronous PM motors, their cost is much lower and reliability much better.

Brushless Motor Advantages:

- Long lifespan: No brushes to wear out
- low maintenance: No brushes to replace
- High efficiency (85-90%)

Brushless Motor disadvantages:

- High initial cost: Need for commutating device like an encoder and a drive or controller

MOTORS WITH PERMANENT MAGNETS

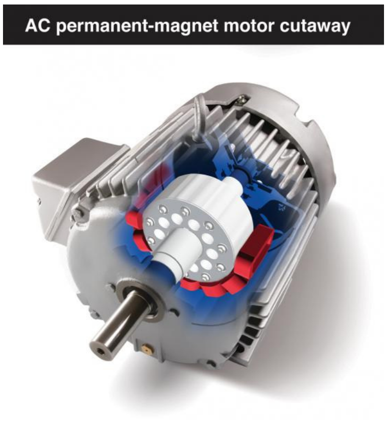
The synchronous motors with permanent magnets are establishing establishing themselves more and more, due to their superior energy efficiency, but their regulation is considerably more demanding. BMW i3, Opel AMPERA, Nissan Leaf…. Are current vehicles that are using this kind of electric motors.

Advantages:

- High energy efficiency (over 90%)
- Lightweight

Disadvantages:

- Price



Picture 7: AC permanent magnet motor

2.4. Bateries

The battery is the main and the most expensive part of electric vehicle. It`s voltage and capacity define all other components of EV propulsion.

Type of batteries used in EV:

- Lead batteries
- Lithium batteries
- Lithium polymer batteries

Battery Technology Comparison

Specifications	Lead-Acid	NiCd	NiMH	Li-Ion Cobalt	Li-Ion Manganese	Li-Ion Phosphate
Specific energy density (Wh/kg)	30 – 50	45 – 80	60 – 120	150 – 190	100 – 135	90 – 120
Internal resistance (mΩ/V)	<8.3	17 – 33	33 – 50	21 – 42	6.6 – 20	7.6 – 15.0
Cycle life (80% discharge)	200 – 300	1,000	300 – 500	500 – 1,000	500 – 1,000	1,000 – 2,000
Fast-charge time (hrs.)	8 – 16	1 typical	2 – 4	2 – 4	1 or less	1 or less
Overcharge tolerance	High	Moderate	Low	Low	Low	Low
Self-discharge/month (room temp.)	5 – 15%	20%	30%	<5%	<5%	<5%
Cell voltage	2.0	1.2	1.2	3.6	3.8	3.3
Charge cutoff voltage (V/cell)	2.40 (2.25 float)	Full charge indicated by voltage signature	Full charge indicated by voltage signature	4.2	4.2	3.6
Discharge cutoff volts (V/cell, 1C*)	1.75	1	1	2.5 – 3.0	2.5 – 3.0	2.8
Peak load current**	5C	20C	5C	> 3C	> 30C	> 30C
Peak load current* (best result)	0.2C	1C	0.5C	<1C	< 10C	< 10C
Charge temperature	-20 – 50°C	0 – 45°C	0 – 45°C	0 – 45°C	0 – 45°C	0 – 45°C
Discharge temperature	-20 – 50°C	-20 – 65°C	-20 – 65°C	-20 – 60°C	-20 – 60°C	-20 – 60°C
Maintenance requirement	3 – 6 months (equalization)	30 – 60 days (discharge)	60 – 90 days (discharge)	None	None	None
Safety requirements	Thermally stable	Thermally stable, fuses common		Protection circuit mandatory		
Time durability				>10 years	>10 years	>10 years
In use since	1881	1950	1990	1991	1996	1999
Toxicity	High	High	Low	Low	Low	Low

Source: batteryuniversity.com. The table values are generic, specific batteries may differ.
*"C" refers to battery capacity, and this unit is used when specifying charge or discharge rates. For example: 0.5C for a 100 Ah battery = 50 A.
**Peak load current = maximum possible momentary discharge current, which could permanently damage a battery.

Picture 8:Battery comparison

If we look at battery types used for different kind of application, we see, that lead batteries are usable only for light and slow vehicles with top speed of 25km/h, in which case the best choice are traction batteries like **Trojan**, witch have deep cycle for discharging.

10:Trojan battery

The market is currently dominated by **Lithium Iron Phosphate** ($LiFePo_4$) and **Lithium Polymer** (LiPo) batteries, which come in various shapes and sizes. **LiPo** batteries have higher specific energy (170-240 Wh/kg) and they are more compact (smaller voltage drop at load) than **$LiFePo_4$** (100-120 Wh/kg). However they are about 40% more expensive, very hard to assemble into battery pack and they are more sensitive to low temperatures (need to heat them when charging below freezing point). For those reasons they are rarely found in serial manufactured vehicles. From current EV on the market, only Renault Twizzy and Nissan Leaf are using this type of energy storage.

BATTERY TYPE (comparison)	LEAD	$LiFePo_4$	LiPo
Capacity(kWh)	25	10	10
Weight(kg)	480	100	60
Range(km)	40-60	50-120	60-140
Km(total)	20000	360000	350000
Price(€)	2600	4000	6000


9:LiPo cell

Sources:
http://img.tradeindia.com/fp/1/001/350/302.jpg
https://en.wikipedia.org/wiki/Electric_car#cite_note-Roth_2.E2.80.933-1
https://quantumdevices.wordpress.com/2010/08/27/brushless-motors-vs-brush-motors-whats-the-difference/
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http://machinedesign.com/site-files/machinedesign.com/files/uploads/2014/02/FIG12-PlatinumE-cutaway.jpg
https://en.wikipedia.org/wiki/Electric_car#cite_note-Roth_2.E2.80.933-1
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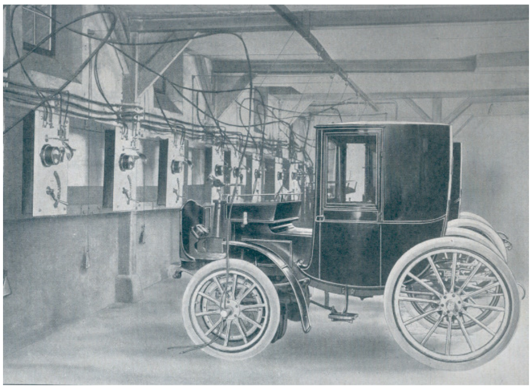
http://gas2.org/wp-content/uploads/2013/09/l-50-620x350.jpg

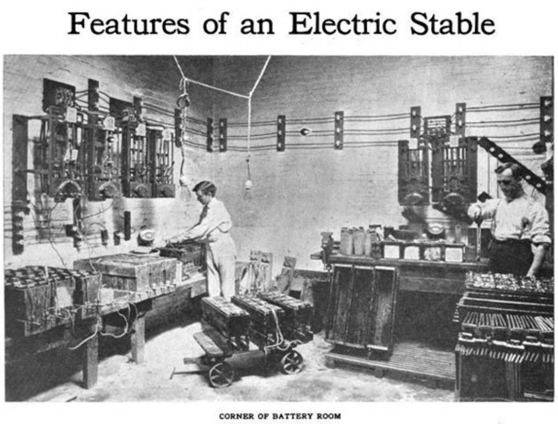
3. EV charging technology

3.1. History of EV charging technology

Since the first appearance of electric vehicles (EV) in mid-19th century, there has been a need for EV charging technology. The first EVs had disposable batteries and technology for „charging“ was replacing „dead“ batteries. Invention of rechargeable batteries meant that new models of EVs had the possibility to use the same batteries without replacement. All this early models of EVs were not mass made, thus, there was no need for commercial charging stations. Also, main problem was that until early 20th century, many homes were without electricity, and that meant that it was impossible to charge the vehicle in homes. Electrification of homes meant that EVs would be more accessible to public. This would mean that more and more people would buy and use EVs. At the beginning of 20th century, 38% of automobiles in USA were powered by electricity[1]. These cars would charge either with batteries on vehicle, or battery was removed from the vehicle, charged at another place, and then mounted back on vehicle.



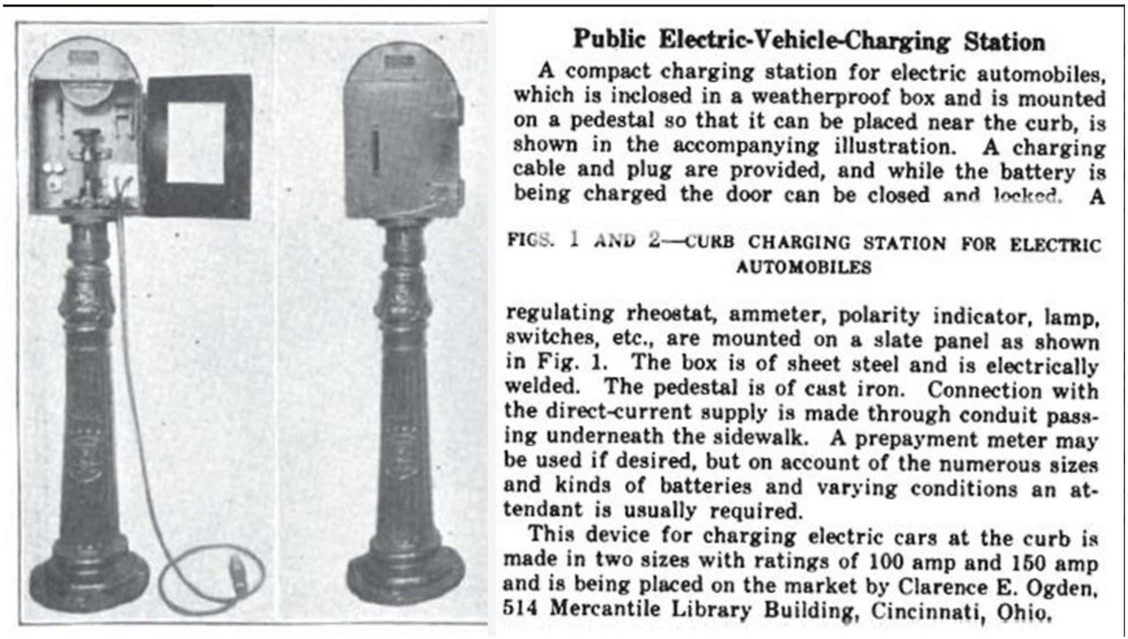
Picture 11 - Recharging center (http://www.ruralroads.org/en/electricity.shtml)



Picture 12 - Battery room (http://www.theatlantic.com/technology/archive/2011/03/batteries-arent-the-key-to-cleaner-transportation/72534/)

During these early EV days, a company called General Electric introduced first charging stations called „Electrant“. They were like phone boxes set up around major US cities, and EV users could use them to recharge the vehicle [2].

[1] http://www.britannica.com/technology/automobile/History-of-the-automobile#toc259061
[2] http://jalopnik.com/what-old-automotive-technology-is-new-again-531105802


Public Electric-Vehicle-Charging Station

A compact charging station for electric automobiles, which is inclosed in a weatherproof box and is mounted on a pedestal so that it can be placed near the curb, is shown in the accompanying illustration. A charging cable and plug are provided, and while the battery is being charged the door can be closed and locked. A regulating rheostat, ammeter, polarity indicator, lamp, switches, etc., are mounted on a slate panel as shown in Fig. 1. The box is of sheet steel and is electrically welded. The pedestal is of cast iron. Connection with the direct-current supply is made through conduit passing underneath the sidewalk. A prepayment meter may be used if desired, but on account of the numerous sizes and kinds of batteries and varying conditions an attendant is usually required.

This device for charging electric cars at the curb is made in two sizes with ratings of 100 amp and 150 amp and is being placed on the market by Clarence E. Ogden, 514 Mercantile Library Building, Cincinnati, Ohio.

FIGS. 1 AND 2—CURB CHARGING STATION FOR ELECTRIC AUTOMOBILES

Picture 13 - "Electrant" (http://jalopnik.com/what-old-automotive-technology-is-new-again-531105802)

Due to evolution of automotive industry in 1920's, improved road quality and quantity, EVs with their limited range were not more suitable for journeys, and this meant that their purpose was limited. Cheaper gasoline price during this period surely had even more influence on usage of internal combustion engine vehicles. This meant that until late 20th century, EVs were merely a quirk in automotive industry.

In late 20th century, public became more and more aware of air pollution, and idea of producing EVs started to rise again. Automotive companies started to make models of EVs, and question of charging infrastructure followed. First models of these EVs were able to charge at home, using a normal socket. At first, hybrid cars were considered some kind of compromise between ICE vehicles and EV, and home charging was enough to recharge. As soon as companies started to make plug in EVs, need for a proper public charging infrastructure grew.

This brings us to 21th century and evolution of EVs and charging technology.

Basic information on EV charging

Due to rise of EVs sold in last few years, EV charging infrastructure has become a big talking point in e-mobility. As EV do not have same benefits as ICE vehicle owners in “refueling” (no unique standard), need for spreading charger network is even bigger. Because EVs do not have same range as ICE vehicles do, this expansion is even more important.

Number of EV charging stations in the world is changing daily, so it is difficult to get correct information about correct number. Some studies say that in year 2015 there were around 55.000 charging stations across the Europe. This number is much larger than approx. 11.000 stations in 2012 (Source: AVERE France), and is growing rapidly. Rise of EVs sales during this last few years has a big influence in this growth.

Also, lots of countries now offer some kind of government incentives for EV purchase and EV charger installations.

To fully understand EV charging technology, we must mention some terms used in EV charging infrastructure.

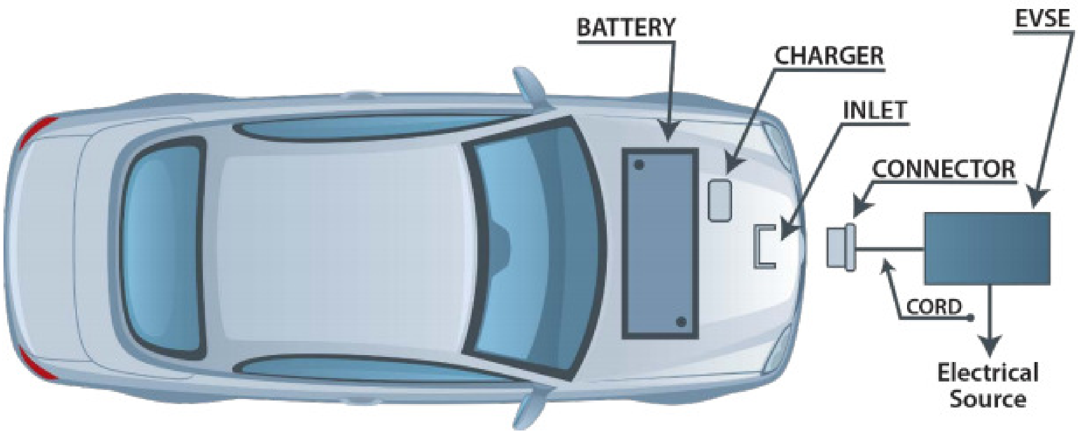
Energy supply unit – Device that provides electric power for charging. As you will read later, there are two types of these devices – Home and Public. These units are called Electric Vehicle Supply Equipment (EVSE)

Vehicle connector - Device which provides physical connection between vehicle and EVSE. Currently there is no standard connector type, and EV producers use few standard connector types.

EV inlet – Mounted on EV, it provides connection between connector and EV. Same as connector, there is no standard inlet type. As there is no standard type, there is no standard mounting location of inlet on vehicle. Most EVs use the location of gas tank plug on ICE vehicles, but inlets can be found on front part of EV, or in the back.

Battery charger – On board device which converts alternating current (AC) to direct current (DC) needed to to charge the EV batteries. Battery charger is not needed when DC is applied directly to batteries, but its use is to monitor the charging process.

EV batteries – Known also as “traction” batteries as they provide propulsion to EV. Same as connectors and inlets, lots of different battery types currently exist, and they differ in their power capacity. Larger power capacity means more driving range. Most of EV today use rechargeable lithium-ion batteries.



Picture 14 - EV charging system (www.http://www.fsec.ucf.edu/)

3.2. EV charging modes

In year 2001, International Electrotechnical Commission (IEC), published an international standard charging modes in publication IEC 61851 (Electric vehicle conductive charging system) where they defined modes of charging EVs according to power and speed. Today, new publication ICE 62196-2 divides charging modes:
MODE 1 – Slow charging from regular socket. Direct, passive connection, maximum 16A – 3,7 kW single phase / 16A – 11 kW 3 phase, without earthing, prohibited in some countries. It uses standard home inlets, is very slow, but does not use a lot of electricity.
MODE 2 – Slow / fast charging from regular socket, but equipped with some specific protection (in cable). Direct, semi-active connection, maximum 32A – 7,4 kW single phase / 32A – 22 kW 3 phase. Provides earthing, over-current and over-temperature protection. It is typically used in households which buy EVSE to use faster charging, or in commercial areas for adding range to EV.
MODE 3 – Fast charging using specific multi-pin socket with control and protection function. Active connection, maximum 63A - 14,5 kW single phase / 63A – 43,5 kW 3 phase. Communication between EV and grid allows integration of system in smart grid. Mostly used in commercial, public, chargers, where recharging of vehicle is needed in short time.
MODE 4 – Fast charging using DC connection using specific chargers with built-in control and protection functions. Maximum 400A – 240 kW. IEC 62196-3 has approved additional specifications for mode 4, which include maximum of 400A – 400 kW. This mode is used only for commercial purposes, as installation of technology needed is very expensive.
Communication method used is Pulse-width modulation (PWM).

EV charging stations according to mounting locations.

Home station

Vast majority of EVs are charged in homes of owners. This means that EV owners can charge vehicles using slow charger directly from regular socket, or by installing mode 2 home charging stations.
Using regular socket is the slowest type of charging. This is mostly used for overnight charging, but with big capacity batteries, even an overnight charging cannot ensure 100% battery charge for some car models. For example, 8 hours of charging using 3,3 kW power (230V/16A) can charge maximum of 26,4 kW using single phase, and that is not enough for a full charge of Tesla model S.
This is why EV owners can use mode 2 home chargers which can use more power and less time to fully charge the EV. Most models of this charging stations can easily be installed on garage or house walls, and they are equipped with protections.

Picture 15 - Ducati komponenti home charger

Picture 16 - BOSCH home charger

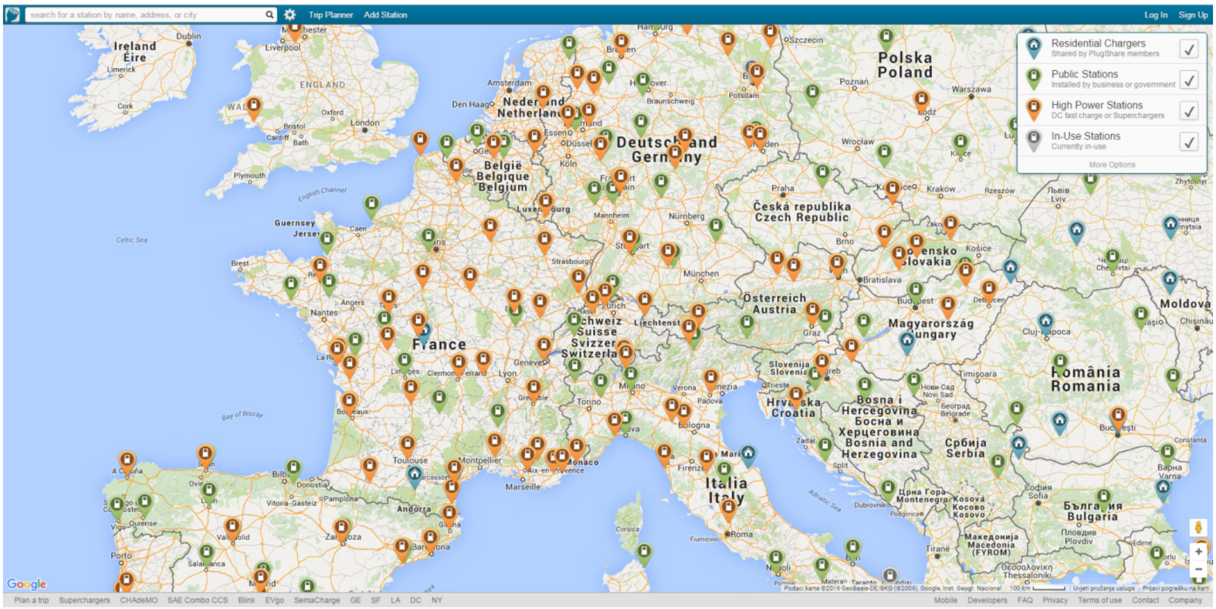
Using 22 kW power, this type of home stations ensure full battery capacity charge in matter of couple of hours.

Public stations

While home charging is available for every EV owner, this changes when we travel. As charging vehicle could become a big issue if you are low on battery and not close to home, public stations are getting a lot buzz these days. Parking lots, gas stations, shopping centers etc., are nowadays getting more and more covered with these public charging stations.

Picture 17 - Types of public stations

Time spent on these locations is not a big number, so public chargers are mostly mode 2 or 3. Some locations have installed mode 4 chargers, but as this is not a cheap option, these types of public stations are rare.
Problem for EV owners can be that public stations are not easily noticeable, that is why there are a lot of web sites and smartphone apps that can be used for finding the nearest charging station, or travel plans with EV (http://www.plugshare.com/, https://chargejuice.com/ etc.).
Most of these websites contain information about chargers ant their availability. As more and more public stations are equipped with communication modules and have some kind of managing software installed, one can easily see which charger is available, and even reserve a place for charging.
With daily increasing number of charging stations and EVs, other business branches include EV chargers as their point of interest for customers. So it is not really uncommon to find hotels, shopping centers or other organizations to advertise their place using EV chargers. Also, some booking websites include option to search a place to stay or visit using a filter with “EV charger available”.



Picture 18 - EV charging station map - www.plugshare.com

Picture 19 - Charging stations "field" at Portland airport

Using a public station is more or less the same with every producer, but identification and payment differ. There is no single solution that is used for every station. For user identification some use RFID cards, some use smartphone app, and a lot of charging stations do not require identification, but only payment by credit/debit card, mobile phone, or coins. Using user identification with RFID card or an app can allow more flexibility in terms of payment to charging service provider (pre-paid, post-paid).

Best selling EV producer in USA, Tesla, has developed its own “Supercharger” for superfast charging of their models S and X. These superchargers deliver up to 120 kW DC current directly to the battery. This makes Tesla supercharger currently fastest EV charger available, but it is limited only to Tesla models S and X. Other EVs cannot use this technology for battery charging.

As all superchargers are same, Tesla model S and X owners can use them worldwide, and interestingly, free of charge for life. Added to this, Tesla model S and X have installed software for trip planning according to existing superchargers. With this option, Tesla model S and X owners can be sure that they will not run out of “juice” on their trips.

Picture 20 - European Tesla Supercharger map - https://www.teslamotors.com/supercharger

Picture 21 - Tesla Supercharger - https://www.teslamotors.com

3.3. EV charger connector types

As mentioned before, there is no standard connector type for all EV producers to install on EVs. This does not mean that every producer has its own type, rather that they use some existing ones.
Most common type, and almost all EV producers include this connector type to its EV, is standard domestic plug used for AC slow charging. This connector is used in mode 1 and mode 2 charging.

Picture 22 - Schuko Mode 1

Picture 23 - Schuko Mode 2

SAE J1772 (or Type 1) is a North American AC standard for EV chargers with mode 3 charging. Companies which use this standard are mostly North American or Japan Based (Chrysler, GM, Ford, Toyota, Honda).

Picture 24 - SAE J1772 connector

For mode 3 AC charging, most of European EV producers, use **Type 2** (or Mennekes) connector on their vehicles. Originally proposed as standard by a German company Mennekes (thus the common name), now is recommended by European Automobile Manufacturers Association (ACEA) as a standard for AC charging, replacing the SAE J1772 . Most public stations are equipped with this type of plug.

Picture 25 - Type 2 connector

Charging stations across France and Italy use **Type 3C** connector for AC mode 3 charging. As ACEA recommends Type 2 for wide usage, this connector type is slowly disappearing, but is still present.

Picture 26 - Type 3C connector

For fast DC charging, mostly used connector type is **CHAdeMO.** This connector was developed by CHAdeMO association (Nissan, Mitsubishi, Subaru, Toyota), and is largely promoted by Nissan-Renault.

Picture 27 - CHAdeMO connector

Type 2 connectors can also be used for fast DC charging, but in **Combo** design. Two additional pins for DC are added to existing Type 2 plug, and they allow fast charging. Audi, BMW, Daimler, Ford, General Motors, Porsche and Volkswagen have agreed to use this type of connector for DC charging in their vehicles. As this two pins add the possibility for DC implementation, SAE J1772 Combo connectors can also be found on some charging stations.

Picture 28 - SAE J1772 Combo sonnector

Picture29 - Compo Type 2 connector

Fact that all these connectors use same electricity (AC or DC), allow that lots of cable combinations are possible, so EV owners can purchase different cables for different charging stations.
For example, it is possible to purchase cable with Type 2 connector on one side for car inlet, and SAE J1772 on other side for charging station.

3.4. Charging technology

Tapering

One important thing to understand when we talk about EV charging is that speed of charging is not the same during the charging process. As the battery is closer to its 0% level, charging is faster, but as the battery gets more charged, to top up the cells current reduces, and more time is needed to fully charge the battery. This event is called "tapering", and it can be noticed at approx. 80%, and most noticeable at last 5%. Some charging stations even cut off your charging process as soon as you battery reaches 80%.

Supercharge times for each 5%	
This applies to 60,70, 85 and 90 kWh batteries. They all supercharge to same percentage at the same time.	
0%-5%	02 min 48 sec
5%-10%	02 min 00 sec
10%-15%	02 min 06 sec
15%-20%	02 min 18 sec
20%-25%	02 min 24 sec
25%-30%	02 min 36 sec
30%-35%	02 min 42 sec
35%-40%	03 min 00 sec
40%-45%	03 min 06 sec
45%-50%	03 min 18 sec
50%-55%	03 min 36 sec
55%-60%	03 min 54 sec
60%-65%	04 min 06 sec
65%-70%	04 min 30 sec
70%-75%	04 min 54 sec
75%-80%	05 min 24 sec
80%-85%	06 min 12 sec
85%-90%	07 min 18 sec
90%-95%	09 min 54 sec
95%-100%	32 min 54 sec

Picture 30 - Tesla Supercharger - % over time – user measured (https://docs.google.com/spreadsheets/d/19khEGozqREIoAN6hd440o4qrzS2ADMVokv8G5FWmWSk/edit)

In picture 11, we can see how this works in practical use. One Tesla Model S owner measured the time required to charge his EV. Increase in time required to charge 5% is visible as the battery gets closer to 100%, and the last 5% needs 16 times longer than first 5%.

Charging duration.

Duration of battery charge is affected by these factors:

1. **Battery capacity;** The bigger the battery capacity, longer it takes to charge it. Different EVs use batteries with different capacity. This ranges from 10 kWh up to 90 kWh.

2. **Charging mode;** As explained before, there are 4 modes of charging, each having different charging duration. Slowest mode is mode 1, using maximum of 16 A - 3,7 kW, and the fastest is DC charging in mode 4, using a maximum of 400A – 400 kW.

3. **State of charge (SOC);** SOC is information of battery charge level at the begging of charging cycle. Lower the SOC, longer it will take to charge the battery to 100%.

4. **Battery charger;** As explained earlier, EV is equipped with on-board charger which converts AC to DC, and this way charges the battery. These chargers regulate the power capacity used to power the charging process, and they are rated accordingly. Mostly used is 3,3 kW battery charger.

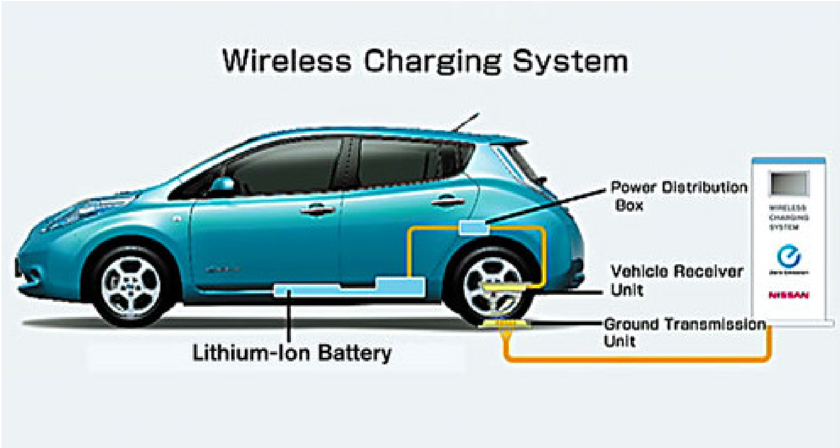
Directly related to duration of charge is charge frequency. Driver cannot influence the charging duration, but frequency is entirely related to EV owner. Same as in ICE vehicles, aggressive driving, rapid accelerations and strong braking use more “juice” from the battery, and thus discharge it faster.

Charging expense

When talking about charging expense, there are few points that must be noticed.
First of all, there are two types of expenses that appear. First one appears only once, and is not required for EV owners. This is the cost of purchasing and installing an EVSE. This is one time only expense, and can range from 100€ up to 10 000€. As stated, this is not an obligatory expense because EV owners can use home electricity for charging EVs.
Second cost is one of energy usage. For home charging, most basic calculation to use is to calculate how many kWh you use to travel 100 km, and then multiply it with cost of 1 kWh. This means if EV has battery of 30 kWh with 150 km range, 20 kWh is needed to travel 100 km. Cost of 100 km travel is cost of 20 kWh in household usage.
For public charging, this is a little bit different. Every commercial company installing EV chargers for public use can decide their own type of payment system. This means that public chargers can have coin, paper money or credit card slots for payments, or they can use mobile phone payment, RFID identification etc. Charging rates can be determined by kWh used per hour, amount of time used per charge or flat rate with pre or post payment. Also, charging can be free in some cases. This specially refers to EV chargers owned by energy supplying companies which include this charge in their monthly fees.
Special case of charging cost is Tesla Supercharger. As mentioned before, owners of Tesla Models S and X can use these Superchargers free for life.

Future

The future of charging technology is hard to predict. Today, wireless charging is available for Nissan Leaf, and few years ago, it was a science fiction. Electric busses with fast chargers on bus stations, wireless charging lanes for non-stop EV charging, and lots of other inventions are implemented, or near implementation today. With such rapid evolution of EV infrastructure it is very difficult and ungrateful to predict what the future will be.



Picture 31 - Nissan Leaf Wireless Charging

Picture 32 - BusBaar - bus station fast charging.

Picture 33 - EV re-charging lane proposal

One step closer to energy efficient charging in future are smart charging grids. These grids include solar collectors, smart home batteries and smart EVSEs.

For example, EV owner can use smart grid in a way that energy collected from the sun is stored in home battery, and this power is later used to charge the EV. Also, there is a possibility to charge the home battery with low cost energy rate (at night), and use it to charge the EV during the high cost energy rate.

Endless possibilities lay in evolution of EV charging technology, and we must look forward to this.

4. Economic efficiency of e-mobility (Costs)

4.1. Economic efficiency of e-mobility in the Republic of Croatia

Electric cars are much more expensive than conventional vehicles with internal combustion engines and hybrid vehicles because of the additional costs of their lithium-ion batteries. However, the price of the batteries falls because of the mass production and is expected to continue to fall.

Electric cars are driven by an electric energy which , if it is given from the renewable energy sources, causes minimal environmental pollution.
Efficiency of electric car is about 80% while the efficiency of conventional car is about 36%.
Not using oil as a means of getting more mobility but electric energy, greatly reduces a dependence on oil of foreign countries.
Taking into account losses from the charge/discharge, the consumption is 15-20 kWh per 100 km. If you pay for electricity at a daily rate, it is 15-20 kn. Night tariff is 7.5-10 kn per 100 km. But if you for charging use electricity from your own sources, for example windmills or solar panels, then the price is even lower.
Example of calculating the costs of the vehicle VW Golf:

Vehicle	E – golf	Golf 1.6 TDI	Golf 1.4 TSI
Engine power	85 kW / 115 KS	81 kW /110 KS	81 kW/110 KS
Price of the vehicle	283 000 kn (- 70 000 kn subvention)	190 000 kn	150 000 kn
Consumption	12.7 kWh/100 km	3.9 l/100 km	4.9 l/100 km
Fuel costs	0.529 kn/kWh	7.39 kn/l	8.65 kn/l
Vehicle tax	-	600 kn	600 kn
Additional costs	-	1500 kn (maintenance)	1500 kn (maintenance)
Costs at 15 000 km	1007,75 kn	6423,15	8457,75 kn

Data source: www.autozubak.hr (8th February, 2016.), fuel costs on 8th February, 2016.

If we consider the average traveled annual mileage, the costs of using electric vehicles are much lower than in conventional vehicles.
Maintenance costs are totally minimal and it is also important to note that with the goverment incentive, for an electric vehicle there are no additional costs for taxes on vehicle.

Prices of the electric vehicles in the Republic of Croatia in 2015.:

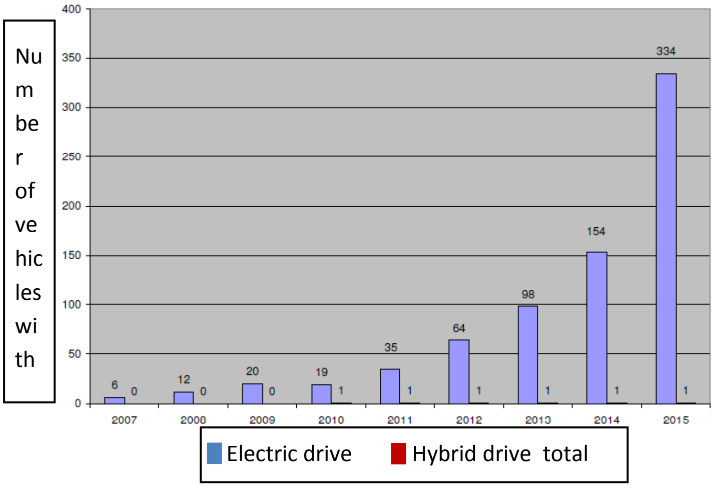
	POWER kW/KP	REACH	TYP OF BATTERY	CHARGING TIME	PRICE OF VEHICLE
TYPE OF VEHICLE					
Citroen C-Zero	49 / 65	150 km	Li-Ion	6 sati	230.000 kn
Mitsubishi i-Miev	49 / 65	160 km	Li-Ion	8 sati	202.000 kn
BMW i3	125 / 170	160 km	Li-Ion	5,5 sati	29.400 €
KIA Soul	81 / 110	212 km	Li-Ion Polymer	14 sati	25.880 €
Nissan Leaf	85 / 109	199 km	Li-Ion	10 sati	29.690 €
VW e-Golf	85 / 115	190 km	Li-Ion	13 sati	283.000 kn
VW e-Up	60 / 82	190 km	Li-Ion	9 sati	191.000 kn
Tesla Model S	225 / 306	390 km	Li-Ion	10 sati	65.000 €
Ford Focus Electric	107 / 145	162 km	Li-Ion	11 sati	33.605 €
Renault Zoe	65 / 88	210 km	Li-Ion	16,5 sati	21.700 €
Smart Fortwo ED	55 / 75	145 km	Li-Ion	7 sati	19.000 €

Although the starting price of electric vehicles is greater than the other, what we can see from the previous table, when we add up the costs of maintaining and charging, or refueling, using an electric car saves between 5000 – 8000 kn.

Therefore, with the incentive of 70 000 kn, to the buyer, on the average, already after 5 years it pays the difference in the price when he bought the car. Fund for Environmental Protection and Energy Efficiency in the period from 2014. to 2015. spent 29.7 million kn of incentives for the purchase of hybrid, plug-in and electric vehicles.

Demand for electric vehicles is increasing year by year. The trend is subject to various factors such as: economic growth, the demographic composition of the population, the availability of eco-incentives, the purchasing power of citizens, the supply of electric cars, the infrastructure of electric filling station,...

It is also necessary to note that the trend will, at the moment, increase when the fleet sales start; high profitability of electric cars as vans, vehicles for short distances in cities, rent a car and commercial vehicles (cars utilities).



Picture: Trend of demand of electric cars in the Republic of Croatia

One of the biggest weaknesses of application electric vehicles in Croatia is a small bottlers offer. With the increasing demand for electric vehicles, appears the increasing supply of electric filling stations. Zagreb County has in 2015. awarded 630.000 kn (80.000 euros) to the cities in its areas for the construction of electric filling stations.

The grants are awarded as part of a pilot program of the Zagreb County to urge the construction of filling stations, which are co-financed by national and EU funds, in the cities of Zagreb County. The same trend of increasing offer e-filling stations is also present in the rest of the country.

HEP (Hrvatska elektroprivreda – Croatian Electricity Company), the main distributor of electricity in the Republic of Croatia, will build public infrastructure in line with its Strategy 2020., which established 345 locations which are covered highways, towns and villages which are located on state and county roads.

The plan is to place ultra-fast DC bottling plants, which fill the battery for 15 to 30 min., on the highway which would provide the necessary link between the major Croatian cities, especially between Zagreb and Split, and the goal is to set up filling stations for electric vehicles at service stations on the motorway. In this way, by the construction of the AC filling stations in the cities, HEP

would networked Croatia and anyone with a pure electric vehicle or plug-in hybrid electric vehicles will be able to use them.
By implementing a public access network bottler for electric vehicles, Croatia becomes one of the members of the European Energy Highways and HEP will, in accordance with Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014., the branch office infrastructure for alternative fuels allow access fee and other service providers e-mobility to use this infrastructure.
We will be able to find bottling plant for our new cars within the public garage, shopping centers, office buildings and so on.
Unlike conventional vehicles, electric vehicles can be recharged at home while the public infrastructure will serve for recharging batteries, filling in an emergency when the customer forgot to charge his vehicle.

With the regard to projects and campaigns of the Ministry of Environment and the Fund for Environmental Protection and Energy Efficieny, which is co-financed purchase of electric, plug-in and hybrid vehicles, electric vehicles will soon become everyday on our roads, and the electricity that is available ih households, workplaces, shopping malls and other places will become the main driver of such cars.
Growing demand for electric vehicles the production of the same will also be increased, and thus the price of electric vehicles will decrease.
Electric cars are our future!

4.1. Economic efficiency of e-mobility in the Slovenia

Between 2011 and 2014 ,Eco fund has offered 500.000 € of nonrefundable money for purchase of electric vehicles to initiate energy efficient traffic program. 200.000 € were meant for private people and 300.000 for companies.
This amount has increased in 2015 and even more in 2016. There was 2 million € for companies and 500.000 € for private owners. Nonrefundable financial incentive can be approved for purchase of the new electric vehicles of M1, N1, L7e and L6e category without CO2 emissions from the exhaust. This incentive can also be approved for reworking an existing vehicle into an electric one State money can also be approved for plug in hybrid vehicles or for electric vehicles with range extender technology, but those must not exceed 50 g CO2/km exhaust emissions. In 2015 the amount of state incentive depended on the vehicle category and ranged from 2.000 € to 5.000 €.
Those amounts increased in 2016. Eco fund has arranged more money to achieve state goal for energy efficient and less pollutant traffic. The nonrefundable incentive money for electric vehicles and plug in hybrid vehicles in 2016 varies between 3.500 € and 7.500€.
Citizen with approved state incentive is also allowed to ask for a loan for environmental investments.
The amount of predicted money for energy efficient vehicles was not completely used in years from 2011 to 2013, yet in 2014 the amount did not suffice the needs.
Renault-Nissan alliance sold the highest number of electric vehicles in Slovenia thanks to Renault Zoe. They say that people decide for an electric vehicle over the conventional one only if it is more friendly for their budget. They say that the biggest problem regarding electric vehicles is the battery price, which is currently still high.
Besides ecological aspects of electric mobility, state of Slovenia sees in it a huge impact on a Slovenian economy. There are many producers of various electric vehicles parts and there is also a well developed Slovenian car cluster. Bills that increase electric vehicle sales numbers and well developed charging infrastructure will definitely influence those companies affected by electric mobility and enable them to be competitive on a global marketplace.

4.2. Economic efficiency of e-mobility in the Finland

The purchase price is currently the largest single electric vehicle cost items. Purchase price include car tax of 5%, on top of this will become an annual tax on "fuel/energy", which is 1,5cnt / day / 100kg. In addition to these contributions, will also be paid an annual tax based on a vehicle, which is the smallest possible and amounts to 43.07 € / year.
Currently, the electricity price of energy is an average of approx. 4cnt / kWh, when we add to this energy transfer price, which is approx. 3cnt / kWh, and electricity tax which is equal to n. 3cnt / kWh provides a simple charging energy price without any other charges of 10cnt / kWh. Electric vehicle consumption is typically approx. 10 - 15 kWh / 100 km so this calculation is obtained for one hundred kilometers energy costs € 1-1.5.
Other fixed expenses accounted / 100 km will change, of course, in relation to the kilometers driven. One of the most significant operating costs by lowering electric cars is that their need for maintenance is significantly less than comparable diesel or petrol driven into.

4.3. Economic efficiency of e-mobility in the Spain

The implementation of the electric vehicle in Spain and in a specific way in the city of Barcelona has been possible so far because different actions and incentives promoted at a governmental level: tax break and subsidies/funding.

SPAIN

The financial incentives actually active at national level that helps to increase the acceptance of the electric vehicle by citizens, at least at the economic side, are described next:

- Tax Break
    - At the time a vehicle is purchased, the registration taxes disappear if it is an electric vehicle or its emissions are lower than 120g/km.
    - At operational level, companies have a reduction on its economic activities taxes when they develop a transport plan which includes the electric vehicle as its principal transport mode.
    - Also, there is an economic aid for private owners over the IVTM tax that can be up to 75% of the total (it depends of each city).
    - A reduction of the electricity tax is enable when you install a charging station at home or work.

- Subsidies/Funding
    - There are actually actives some subsidies or funding that helps to increase the uptake of the electric vehicle in Spain, such as the MOVELE Plan for cars, PIVE 8 Plan for efficient cars and the PIMA Air Plan for electric commercial vehicles and electric bikes. Next, we can see an example of the subsidies of the MOVELE Plan for 2014 according to the range of the vehicle:

Electric Vehicle Range	Subsidy (€)	
	Vehicles	Stations
< 40 km	2.700	1.000
40 – 90 km	3.700	
90 km	5.500	

BARCELONA

The financial incentives implemented in Barcelona city are mostly the same as the ones mentioned for Spain. Nevertheless, there are some other regional incentives that help with the uptake of the electric vehicle:

- Additional incentives
    - Free circulation on HOV lanes managed by the city.
    - Free or advantageous discounts in parking spaces at regulated areas on the street and in public parking managed by the city.
    - Free use of the toll highways (no payment) after non mandatory subscription to the service EcoviaT.

5. Electric vehicles and environment

5.1. Air pollution in the cities

State of the environment and air pollution in major urban European centers

Through the history of the development of the cities, people have always had to adapt to living conditions that deviate from the natural to enjoy the benefits offered by life in the urban environment. At the same time they tried to a minimalize all the negatives that come with living in the densely populated community in a small space. By development of the cities gradually were solved all main problems of their inhabitants; such as water supply and drainage. With the beginning of industrialization, urban areas are simultaneously faced with two challenges – the rapid increase in population and large pollution which has produced an increasing number of industrial plants, as well as a growing number of households. In the 20th century to the causes of pollution in the cities can be added the development of transport, which is to this day became so widespread that in addition to industrial facilities has become one of the main causes of environmental pollution. Roads take up a significant portion of the space in cities and thus directly affecting the scanty surface for other purposes, such as parks and other green spaces. Except that occupies considerable areas, the traffic pollutes soil and water. Transport is also a significant source of noise pollution, light and vibration that further diminish the quality of life in urban areas. Traffic has become one of the major air pollutants. Studies have shown that the total share of air pollution caused by traffic pollution is 25%; road transport caused the most of it.

Air pollution has become one of the biggest problems of the modern world because it directly affects on the state of the environment and human health. Since the most traffic activities takes place just in urban areas, these are precisely the areas where air quality is the worst. At the same time in these regions live the largest number of inhabitants, so poor air quality affects on the health of the majority of the population. The study of the European Environment Agency from 2015., conducted in 40 European countries, estimated that air pollution in 2012. caused 430.000 premature deaths in Europe (Croatia – 4800, Slovenia – 1830, Finland – 1960, Italy – 84 400, ...)

Although in the past few decades systematically is working to reduce emissions from burning fossil fuels in road transport, due to the constant increase in the number of vehicles, the final result in the reduction of air pollution is not much better. Today the majority of urban areas in Europe and in the world does not have adequate air quality. As soon as you hang up a few parameters, we are witnesses of scenes of cataclysmic proportions (Beijig, Paris). Today more and more often we can hear the mention of sustainable developmnent which applies to traffic. The long-term goal of the EU is to improve air quality by introducing more stringent legislation, research and introduction of new sustainable technologies. European Environment Agency as an main institution that coordinates the activities of all EU member states, is responsible for making long-term strategy for improving air quality in Europe. In road traffic, as part of the solution in reducing air pollution, perfectly fits the concept of electromobility, which promotes energy efficiency and use of renewable energy in transport. This concept has evolved thanks to the commercialization of electric vehicles to which we have witnessed in recent years, and its goal is to approach to the citizens all opportunities and advantages of electromobility that it can as soon as possible come to life with as many users.

In this way, in the road traffic will be finally stopped the negative trends that affect to the environment, and air pollution in urban areas could be reduced to a level that will not undermine the quality of life of the majority of European citizens.

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http://www.azo.hr/BrojSmrtnihDlucajeva

http://www.azo.hr/EmisijaOneciscujucihTvari-

www.unizd.hr/portals/4/nastavni.../zastita_okolisa_01_01102006.ppt

http://www.mzoip.hr/hr/okolis/zrak.html

http://www.eea.europa.eu/hr/themes/air/intro

5.2. The impact of traffic on air pollution in urban areas

With the level of development of transport (constructon of infrastructure, means of transport and traffic) exponencially grew the adverse effects of traffic to all aspects of the environment (air, soil, water,...). Many of these pollutants directly threaten human health as well as animal and plant life.
Also,the pollution caused by traffic contribute to global pressures.
It is believed that the traffic is responsible for at least a quarter of global anthropogenic CO2 emissions, so that at least one quarter contributes to the greenhouse effect, global warming and change, for the time being, still relatively stabile climatic conditions on the planet.
The road traffic due to its volume (mileage), spent fuel and the space for road infrastructure, is the transport industry which mostly contaminates the environment, with direct negative affect on air, water, soil, flora and fauna, and with other influences on environment.
The influence on air:
By combustion of liquid oil (and gas) fuel, in the air are discharged: greenhouse gas emissions, pollutant emissions (different harmful polluting or toxic gases,etc., emissions of heavy and other metals (lead, copper, zinc, cadmium, chromium,...) and affects on global concentration of greenhouse gases in the troposphere, the local pollution (dry and wet deposition), cross-border pollution (mainly acid rain), ozone layer wasting, etc.

The influence on water:

The water runoff from roads, containing products of fuel, salt (mainly anti-icing pavement), solvents, heavy metals, etc., affects on the contamination of surface and groundwater and changes, the increase of acidity, in the hydrological systems.

The influence on soil:

Rinse water from roads and the wind carried dust which contains fuel products, salt (mainly anti-icing pavement), solvents, heavy metals, etc. affect on the soil pollution.

Construction of roads and other traffic infrastructure occupies on the one hand, the immediate areas for roads and related infrastructure, and on the other hand at least as much area which is no longer usable or it changes its purpose.
The road infrastructure cuts the certain agricultural land and diminish their value and often prevents previously free access to these areas.

The influence on flora and fauna:

The landscape is destroyed using a road construction materials (quarries), by construction of roads (quarries, landfill, cuttings, embankments, retaining walls, bridges, viaducts) and carry over of materials.
The habitats of certain animal species are intersected by road construction; their living space is chopped up, their seasonal migration routes are interrupted.

The other negative influences:

The noise of road vehicles is a component that weights heavily on the environment; it strong effects on human health; it causes insomnia, affects on fetal development, etc.
The waste from vehicles (waste tires, waste oil, waste batteries, heavy and precious metals, plastics and other parts of vehicles) are pollutants of air, water and soil, flora and fauna, and of the landscape especially because of illegal dumping.
Road transport of dangerous goods affects on all components of the environment.

Without fossil fuels today s industry and transport is difficult to imagine, but pollution because of their combustion act disastrously to health. The substances that pollute the environment cause serious harm to people and other living beings, and pollution due to burning of fossil fuels leads. The largest contribution to air pollution in cities gives burning of fuels for transport where again dominates road transport. Exhaust gases from motor vehicles are the main culprits among the various sources of air pollution because they contain many toxic substances. When we breathe them, they from lungs passinto the bloodstream and thus spread through the whole organism. Many diseases and deaths may be prescribed just to air pollution due to the use of fossil fuels in road transport. Some experts considere that for the inhabitants of the cities, polluted air is more harmful than tobacco smoke - the worst pass the people who smoke or are exposed to passive smoking. State authorities are exposed to criticism that too much attention is paid to the problem of smoking, and at the same time because of fear of resentment to industrial complex do not dare to bring the laws that would reduce the level of pollution of air, water and soil. Polluted air has proven to be the cause of many diseases and premature death in many surveys conducted in the Europe.
In France, Austria and Switzerland 6% of deaths are associated with the effects of inhaling the polluted air. Long-term exposure to air pollution is associated with undesirable changes in the airways, impaired lung function, increased risk of illness that require hospitalization, including intensive care and increased mortality.
The most toxic substance produced by motor vehicles, while fossil fuels are burning, is carbon monoxide. Entering in the blood, this compound reduces the ability of red blood cells that transmit and deliver oxygen to organs and tissues. Other toxic substances, such as lead, obstruct the production of red blood cells, and thus potentially lead to anemia. Lead can damage the nervous system and harm mental functions such as concentration and memory. Benzene, nitrogen dioxide and small toxic particles can cause damage to the bone marrow and the immune system. Thus, for example, is found a link between benzene and leukemia, especially after prolonged exposure to this combination. Hydrocarbons, which develop by combustion of fossil fuels in internal combustion engines, have potentially carcinogenic effect on children, infants and pregnant women. Pregnant women who breathe air contaminated with these toxins are exposed to an increased risk of preterm

birth, birth of children with low birth weight, mental disabilities and the subsequent preferences to developing asthma.
The pollution produced by motor vehicles is more dangerous to life and health than traffic accidents and treatment costs associated with the consequences of pollution to human health only of motor vehicle take of 1.7 percent of gross national income in the countries in which the estimations are done.

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Članak: U raljama globalnog onečišćenja

5.3 Electric cars and environment

A sharp increase in the number of cars in the world, and large amounts of exhaust gas led to the problem of environmantal pollution. Around the world motor traffic becomes enlarged. The transport sector is one of the fastest growing economic sectors in Croatia. The growth of total number of registered cars in the last 10 years was almost constant 5% per year. Data on average 439 passenger cars per 1000 inhabitants in Croatia compared to an average of 480 in the EU, indicate the great potential for further growth of the market (in the Republic of Croatia, until 2020., is expected over 2 million passenger cars compared to today s 1,8 million). The transport sector is also the most

important consumer of energy (over 30% in the structure of final consumption) and in the future we expect even faster growth in consumption than in other sectors.

Picture 1 and 2 – Trend of growth the number of cars in the world

City traffic, especially the use of cars in city traffic is one of the largest sources of air pollution in major cities. Bringing the quality of air in the first category for larger cities wil not be feasible without major interventions in urban transport system. The solution will have to be sought into: strengthening of urban public transport, the introduction of environmentally acceptable vehicles and fuels for public transport, intensive promotion/education on how to use environmentally acceptable vehicles – eco-driving, and promoting new concepts of urban mobility, for example „car sharing“.

To actualize this goal, Europe has adopted Directive 2009/33/EC promoting the establishment of a system of road traffic based on clean and energy efficient vehicles and on their intelligent way to use, while most countries committed to encouraging the use of alternative fuels and the production of energy from renewable sources. In the uses of the car in Europe are visible signs of the beginning of the electric revolution. EU provides very clear limits of emissions of CO2 of the cars that will by 2020. have to fall below 95 g/km. As an example we can take the emissions of a hybrid car Toyota Prius that produces one of the lowest emissions, and those amount 105 g/km. But this value depends on the overall energy production of a country, the energy used more from renewable sources will reduce the value of CO2 emitted by electric vehicles.

The main issue today is: Are electric vehicles completely ecologic or they pollute the environment?

Electric cars during the operation do not emit harmful gases and can be considered ecologically while hybrid vehicles emit significantly lower emissions than vehicles with conventional drive, but overall these vehicles significantly less pollute than cars powered by gasoline or diesel engine, these represent only technological solutions which can achieve the intended goals of reducing air pollution and the environment.
Unfortunately, it should be noted that current electric cars in a large percentage are not vehicles with zero emissions. First of all, the components of these cars have been created in factories that are most likely powered by fossil fuels. Electric cars use electricity which is still largely derived from coal or natural gas, therefore fossil fuels, which do not fall within the renewable energy and for electricity consumed during the drive electric car power plants emit a considerable amount of harmful gases in the environment. It should be noted that just increased production of electric cars requires greater production of electricity, which is in a high percentage got from coal and natural gas, which contributes to greater environmental pollution. Ecologically, coal is the most dangerous source of energy and currently 38% of electricity generated in the world is obtained from coal.


Pictures 3 and 4: Thermo-electric power plant

Experts warn that today one of the greatest problems in the manufacture of electric car are the batteries that store the electricity and for the development of which shuld be a lot of energy, while the biggest problem at the end-of-life that is taken care of, since it contains dangerous elements and substances for whose safe disposal again waste energy and release certain harmful gases.
When we speak about electric cars, the problem is the energy source. If the source is coal power plant, then these cars affect the production of 3,6 time more soot than those on petrol, and for that value increase mortality caused by air pollution.

However, if electric cars use electricity from renewable energy sources (wind, water, sun, biomass), it can reduce mortality caused by air pollution no less than 70%.

Picture 5: Electric cars and renewable energy sources

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5.4. The procedures and measures to reduce air pollution and environmental pollution caused by the action of road transport

The effect of pollutants to the environment is reflected in climate change at global level, at the regional level in the emergence of acid rain, and locally, in the appearance of smog. Exhaust gases contain large amounts of carbon oxides, nitrogen oxides, sulfur oxides, a certain amount of solid particles, soot and heavy metals. Their composition depends on the fuel used, the degree of combustion and mode of operation. The emission of harmful substances also depends on the size and structure of traffic, driving dynamics (free flow, congestion), the strength of the source and duration of the emission, age and general condition of the vehicle.
Environment protection measures are often in conflict with the other goals such as mobility, freedom or reduce costs.The reducing emissions of pollutants into the environment is a complex procedure that is carried out through legislative, institutional and governance frameworks.

Environmental protection measures include a variety of measures such as:

1. Traffic planning that consists of keeping traffic out of the city center, discouraging the use of private vehicles for daily travel, encouraging the use of public transport, replacing road transport with railway, improving the organization of transport,…
2. Obligation to use vehicles with catalytic converters because it reduces emissions of harmful substances
3. The use of clean energy and alternative fuels which involves the replacement of conventional fuel into biodiesel fuel produced from plants. Electromobility also offers a possible solution to the problem of greenhouse gas emissions caused by traffic
4. The development of vehicles that save energy

5. Exemptions for the import of new vehicles and the proper disposal of old vehicles,because part of the old vehicles leaves at inadequate place, and only a certain number goes to landfills for disposal of solid waste
6. Testing exhaust emissions of petrol and diesel engine, which means subjecting vehicles eco test during regular technical inspection
7. Systematic speed limit car
8. Education that includes awareness campaigns, everyday shooting and recording data on air quality and communication to the public
9. The possibility of introducing fees for air pollution where states must ensure that their actions will not cause damage to the environment outside their borders

The main environmental issues are noise, dust, local air pollution and ground water pollution, global warming caused by the emission of gases, the aesthetic aspect of the roads or interfere with the natural and cultural goods. As the number of vehicles increases, fuel consumption and the amount of air pollutants also grow up. All this imposes the need to take appropriate protective measures that improve air quality. Clean air and unpolluted water are becoming every day more and more important goods, we feel their deficiency. All this has led to a situation that to the issue of environmantal protection today, is approached much more serious and systematic and it is necessary to organize traffic flow efficiently in order to reduce environmental pollution.

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6. New opportunities

6.1. Electric mobility: Innovative pratcitec and business models

Business model innovation is one kind of disruptive innovations that will bring new effect on the market and bring challenges to the incumbent firm. It will enlarges the existing economic pie by attracting new customers or by encouraging existing customers to consume more.

Electric vehicle technology is a product and experience that is new and unfamiliar to most consumers. This technology is more expensive to build than conventional automobile technology but is less expensive to manitain and operate. New ways of mobility occupy different utility and performance envelope relative to conventional automobiles. This includes range and refueling characteristics which displace the demand for gasoline and diesel for powering a transportation services and place it on electricity. This change the sources and levels of air emissions and environmental pollutions in transportation sector. Electric vehicle technology is a technology distinct from conventional automobiles with a potentially wider range of utility to a broader array of stake holders.

The electric vehicles (EVs) have long been under emerging stage. It has a history of more than 100 years, with significant efforts in the early 20th century, followed by sequences of stops and starts and now new enthusiasm in the last decade. The new enthusiasm comes with high oil prices, climate protection policies, battery technology and recharging infrastructure development, and the rise of organized car sharing and intermodality.

EVs are believed to play an important part in the near future according to policy makers, car companies and other stakeholders. Ambitious regional and national goals have stimulated the progress of EV penetration by subsidizes for the vehicle and corresponding infrastructure deployment.
Meanwhile, most car manufacturers have added EVs in their portfolios and prepared to make mass production with different level of strategies and expectations. However, commercialization has been ineffective thus far, and dominant design is still dormant.

Sales of EV are far from satisfaction and lag behind from national goals. Accordingly, EV industry is still in the introduction stage in product life cycle, and struggling to take advantage of economies of scale in small niche markets. EV enterprises, including incumbent and entrepreneurial companies, have long taken numerous endeavors to promote EV in the niche markets by providing innovative business models, to promote EVs and overcome technological shortcomings like range anxiety.

Tesla Motor, viewed as a black horse to the auto industry, is an entrepreneurial firm dedicated for Electric vehicle scenario. Founded in 2003, Tesla Motor obtains a success as a Company dedicated for EV, and changed people's idea of EV as well as re-initiated the enthusiasm for pure Evs. Comparing to incumbent firm, entrepreneurial firms are generally less constrained in the evaluation of alternative models and more flexible in pursuing radical business models.

While most companies still take 'business as usual' approach for developing their EV production and offers, Tesla Motors stands out by providing disruptive innovation solutions.

An accepted business model approach in research and practice involve a fundamental reconsideration of the value proposition (product/services), the customer interface (channel, relationship and customer segment), infrastructure management (capability, partnership and value configuration) and the financial aspects (revenue model, profit and cost).

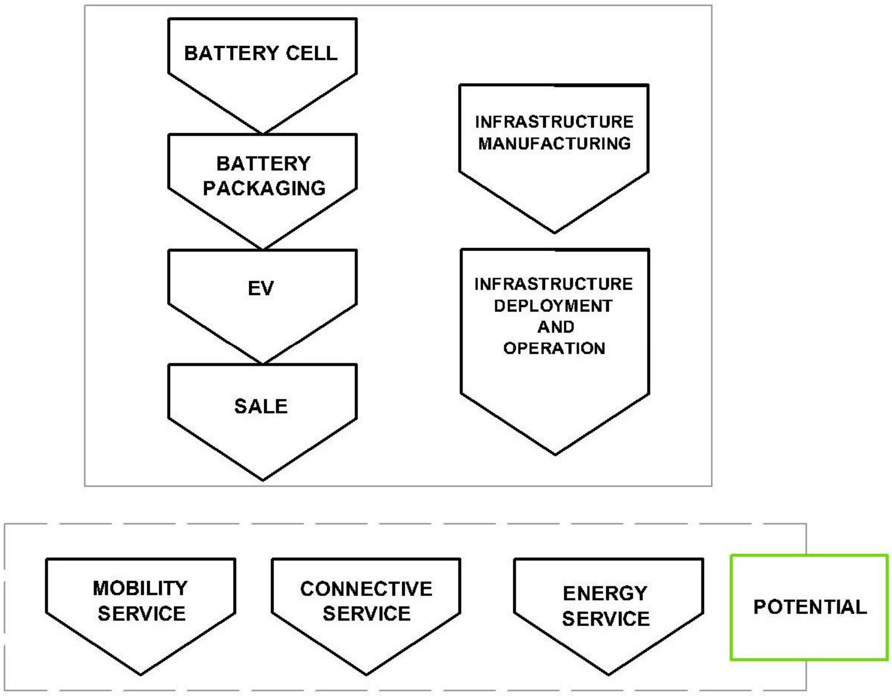
As EVs are in the emerging stage and paradigmatic design is still dormant, the elements on value creation and value capture design will have more influence in deciding the success of an disruptive technology.

The transition into an electric mobility trajectory will lead to fundamental changes in the value chain of the automobile which basically involving components from supplier, core components and assembling from companies, the energy utilities.

First of all, some modules such as internal combustion engine will become less important in the long-term. While modules such as battery, charging infrastructure will enter the value chain and act as critical roles as a result of high cost and changing peoples' driving behavior.
Secondly, new services enabled by EVs such as energy services or those enlarged by Evs such as car-sharing services and connective services will have numerous influences in the auto value chain.

At the moment, customer facing services such as energy services and mobility services still wait for EV penetration and changes in electricity grid regulation and people's behavior. As a result, the current EV value chain is emphasizing on battery (battery cell manufacturing and battery packing), vehicle (EV design, assembling and sales), and infrastructure enabling grid connection (infrastructure manufacturing and infrastructure network deployment) as it is showed below.

Figure 1: Example of EV value chain



Source: Tesla Motors: A Silicon Valley Version of the Automotive Business Model

Furthermore, the EV industry involves new modules and components as a result of battery-based electric mobility concepts such as recharging infrastructure and related services.

It is necessary to identify the different dimensions of the product and service from an EV firm in order to analysis its business model design. Three dimensions have been classified in a holistic study of EV, which are the vehicle together with battery; the infrastructure system; the system services which integrate electric vehicles into the energy system. At the moment, energy system service such as vehicle to grid services still wait for EV penetration and changes in electricity grid regulation and people's behavior.

6.2. Electrice vehicles

Tesla motor has thus far released three vehicle models into market: a two doors sport car Tesla Roadster and a sedan Tesla Model S., SUV Tesla Model X. Two other prototypes are waiting for commercialization: a family car Tesla Model 3 and another yet unknown model, most likely SUV version of Tesla Model 3. Tesla gained high reputation for its high performance of the vehicle, which is corresponding to its high-end customer segment.

Besides the fancy appearance and strong vehicle performance, Tesla innovatively increased the connectivity between users and the environment (eg. recharging station navigation, charging control and autopilot) enabled by IT based hardware and software applications. It innovatively offers data network in the car with telecommunication partners, and connect the car with maintenance centre, infotainment centre and so on.

Tesla Motors entered the market by targeting on the high-end niche market, by offering luxury specific purpose vehicle Roadster. Model S target on luxury multi-purpose car market as a result the selling number is magnificently larger than the Roadster. Furthermore, according to the planning map of Tesla Motor, it will continue to offer an SUV version luxury multi-purpose car, followed by a more economically multi-purpose car. It is corresponding to the strategy goal to create an affordable mass market EV. The customer segments of battery and recharging system need to match the customer segment of vehicle.

As a new comer to auto industry, Tesla Motor did not use the conventional dealership network for vehicle distribution. In contrast, it created a new multi-channel model for purchasing vehicles, which involved online stores and apple-like retail outlets. The online stores offer potential customer the chance to purchase the car directly online. Furthermore, the retail outlets are usually located in high traffic space, enhanced with technology with high integration of IT in order to better present Tesla vehicle and its company culture. Tesla applies a vertical integration on selling, which means the price of vehicle is non-negotiable. This caused some disputes in the conventional dealership network.

Even BMW, the company that is offering electric vehicles to the market in the most conventional way, recognized our fast changing society as a key ingredient for developing new products and services. After identifying the key external trends and challenges, e.g. urbanization, smaller households and climate change, in 2007 BMW started to create new and comprehensive concept for sustainable mobility: project i. They are selling urban mobility rather than a car. The concept for the BMW i3 appeals to two customer segments: urbanites and young couples who work and/or live in the city. The BMW i3 is 100% emission-free and characterized by the use of high-quality and sustainable materials. In addition an i3 car can be recycled for 95%. Regardless of the new BMW brand, sustainability in every step of production and urban mobility offer, the company is still selling electric vehicles within established model. From production line, through dealers to customers.

Slightly different approach at offering of electric vehicles to the market took Renault-Nissan alliance. Both companies already have many stores, services and dealers across the globe and they didn't have to start from the scratch. Electric vehicles are higher initial investment than conventional vehicles of the same size. Battery pack in each electric vehicle carries approximately 1/3 of the automobile price. Besides, batteries are constantly evolving and are the center of development and research lately.

Companies would like to improve energy management, capacity and extend vehicle overall range. Because of those reasons, Renault-Nissan alliance decided to decrease the overall purchase price of an electric vehicle to make them more accessible and are offering battery lease for a monthly fee which is much less than petrol price for the same mileage. This lease is also a guarantee for the battery and EV owners get their battery packs replaced when the company introduces a new battery technology. Tesla applied an ownership-as-usual model for revenue. Customers purchase the EV in order to possess the full ownership of the car including expensive batteries.
Battery is a critical module in electric vehicle since it carries high cost and value. The choice of battery will largely define the range anxiety that customers will face. Tesla applied an ambitious plan on the battery strategy, with expecting movements on battery factory and enters also the stationary battery market. It draws a lot of attention for its high range, and innovative battery pack technology.

6.3. Performance

All three models Tesla Roadster, Model S and Model X show a large capability for the range due to the high energy stored in battery. Tesla Model S equipped with very large 70 or 85 kWh battery. This pack is able to run for 335 km under standard condition, while most other companies choose a 16-24 kWh battery pack allowing a small range from 100 km to 160 km. Tesla motor has a good knowledge on battery pack and management system. It innovatively equipped Tesla Roaster with thousands of laptop Lithium-ion cells and assembles them into a performance and cost optimized battery pack. During the delivery of Tesla Model S, it developed a closer relationship with its battery cell supplier Panasonic, on both battery technology and scale of production.

6.4. Connectivity

As it is enabled by the connective service inside vehicle, Tesla user can have some control on battery system. For example, user can control the temperature of battery system before enter the car when the environment temperature is too low. The battery is generally sold to customers along with the vehicle, with possibility for extra purchase when the old one is at the end of life and need to be replaced.

6.5. Infrastructure

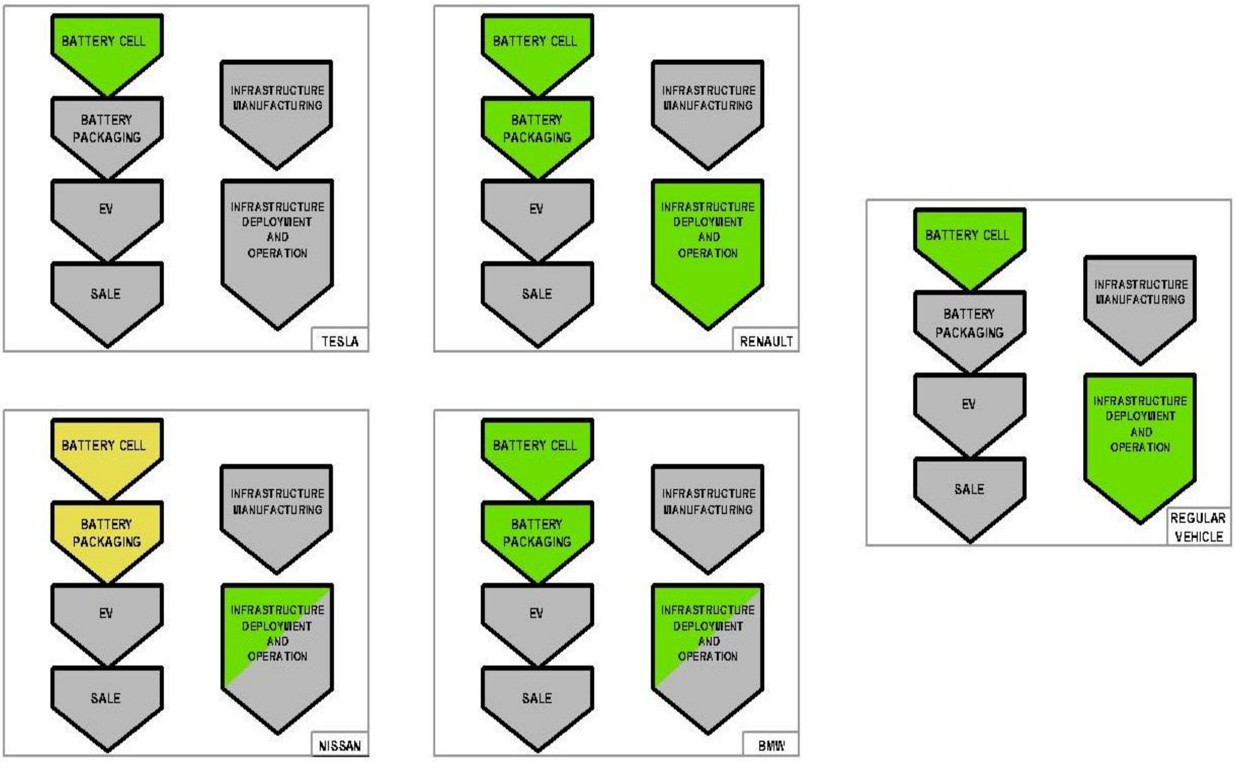
Another ambitious plan of Tesla Motors is the expansion of supercharger network. It is famous for its high performance in charging ability, well established network and free to Tesla user strategy. In alignment to the large capacity of battery adapted by Tesla, the supercharger station offers fast charging in order to satisfy the charging need for customers. It can deliver direct current up to 120kW and capable of charging to 80% of an 85kWh Tesla Model S within 40min. Beside the premium function of supercharger station, Tesla is enduring an ambitious expansion plan to establish superchargers network along well-traveled highways and in congested city centers. As a substitute to charging station, a pilot battery swap program is also launch in California to meet the charging need for customer and reduce range anxiety. As it is enabled by the connective service inside vehicle, Tesla user can find the nearest supercharging station and control the charging when connected.

The public network is solely deployed by Tesla Motor Company. This is mainly due to the different charging technology and standard adapted by the companies, and the different cable designed and adapted. But in order to foster the adoption of these in-house technologies, Tesla allow the use of the patent for free if other companies want to use its new high performance charging system. Tesla goes open source.

Tesla Motor shows a very original value configuration compare to other companies. During the delivery time of the Tesla Roadster, most components as well as battery cell manufacturing and vehicle design are outsourcing to the suppliers mainly due to the initial stage of the company and immaturity of the EV market; however, the packing and assembling of the battery cells and the energy management are conducted by Tesla. When the commercial delivery of Tesla Model S began, Tesla motor began to show a high level of vertical integration along its value chain. According to the value proposition of Tesla motor, it shows an integrated value configuration from battery packing, EV design, retail distribution to an intensively emphasized supercharger network.

In contrast in the conventional auto industry, the value chain constitutes of the pyramid relationship between supplier and company relationship - which supplier provides the fringe modules to companies such as gearbox and auxiliary battery and company produces the core component such as motor design and assemble the vehicle. On the other hand, energy utility will fill the car with fuel during the car lifetime.

Figure 2: OEM's and value chain accents



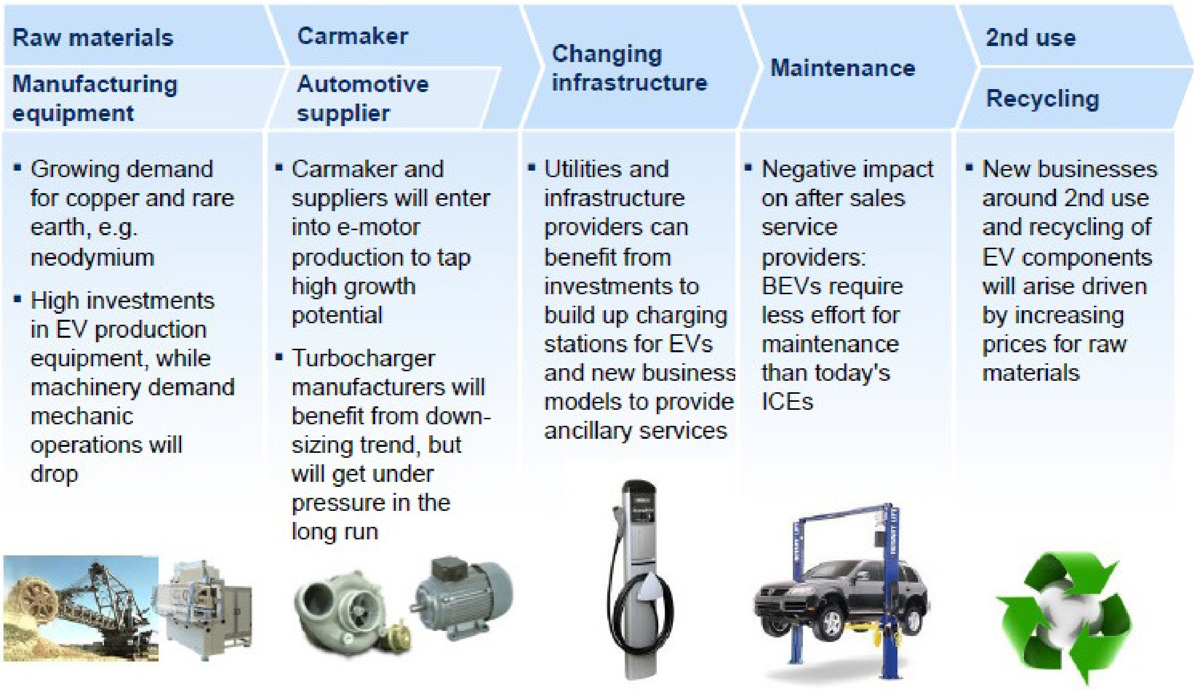
Source: Tesla Motors: A Silicon Valley Version of the Automotive Business Model

In EV industry, most companies who are greatly engaging in the EV market choose to follow their old routine of value configuration, which refers to integration-as-usual. In this type of value chain, companies treat battery as a module for outsource as before, it could be because of the limitation on technology knowledge or transaction cost concern. BMW and Renault are examples as showed above. A more involved choice could be the company and battery supplier form an joint venture company, as it is the case for Nissan.

On the other hand, as for the recharging network deployment, most companies wait for the action from recharging operation company or other stakeholder such as national or local government. Renault, BMW and Nissan followed this strategy. Furthermore, BMW and Nissan started to invest in the recharging infrastructure network with partners from 2015.

The shift towards electric mobility introduces a novel end-to-end value chain. For every challenge and new consideration that arises from this technology there is an opportunity for the creation of new or enhancement of existing business models along this new value chain.

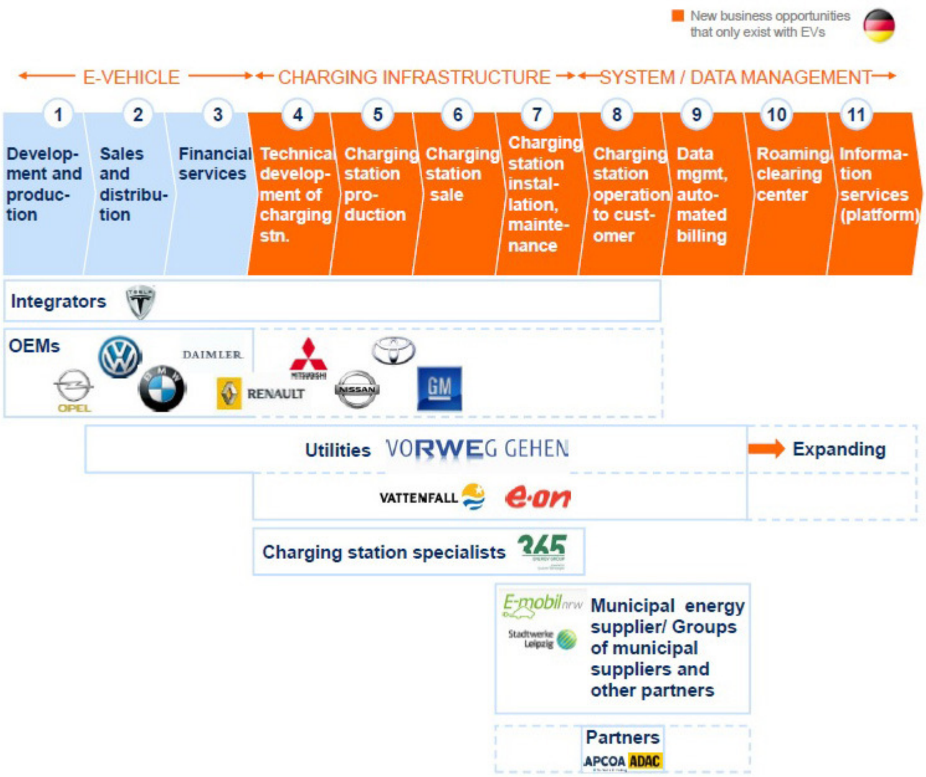
Figure 3: Impact of powertrain transformation on value chain



Source: McKinsey – Boost! Powertrain KIP

Incumbents of the traditional automotive value chain as well as new entrants are testing new approaches and models to meet the needs of the new value chain and take advantage of the emerging markets for new applications and services.

Figure 4: Incumbents and new entrants are trying to capture new opportunities along the EV value chain that did not exist with internal combustion engines



Source: McKinsey

This evolving electric mobility ecosystem is spawning a number of innovative business models. Emerging markets for products and services on the one hand are a result of EV adoption, and on the other hand enable and facilitate further EV scale-up.

6.6. Gigafactory

Tesla made an important step towards the mission to expand the role of EVs in the global marketplace. In cooperating with Japanese industrial giant Panasonic Tesla is developing a new, US-based battery production facility The facility will be able to produce batteries for as many as 500,000 EVs per year by the year 2020. The scale of the production is projected to be so large, in fact, that by 2020 the Gigafactory alone would produce as much battery capacity as the entire world produced in 2013.

The Gigafactory will produce cells for Tesla Motors and Tesla Powerwall (Energy Storage for a Sustainable Home) battery pack. To be sure, the impact of the Gigafactory will positively affect electric auto sales. The Gigafactory's scale and capacity may be felt across the technology and energy sectors as well. By eschewing the creation of their own proprietary battery technology. Tesla was able to cut significant costs from the most expensive part of any high-performance electric vehicle: the battery. The planned Gigafactory is a key strategic step in carrying out Tesla's long-term mission to deliver lower-cost EVs to consumers around the world.

While battery production and capacity has grown worldwide over the last decade, Tesla notes that nearly all of that growth has been in Asia. In contrast to that trend, the joint collaboration between Panasonic and Tesla will take place at a facility in the American West, close to Fermont where Tesla assembles their automobiles. Without having to ship batteries from Asia, this close proximity will lead to additional cost savings through considerably lower Model S and Model X production times.

The specifications for the Gigafactory are published. In keeping with Elon Musk's environmentally sustainable reputation, the facility, will not only recycle older battery packs but will also be powered by new local renewable energy sources, namely wind turbines and photovoltaic.

6.7. Car sharing

Electric vehicles are an important part of sustainable passenger transportation of the future. But unfortunately many people still associate electric vehicles with high prices, uncertainties about life-span of batteries and a concern that the electric vehicle will not be able to fulfill the needs of a regular car user. This makes it hard for the electric vehicle, despite its low running cost and potential environmental advantage, to compete with traditional cars when it is time for the family to buy a new car. But is private car ownership really the solution for future personal transportation needs?

Privately owned cars are mostly parked, up to 90 % of the time, and if all costs of ownership are summed up the cost per driven kilometer is very high. In urban regions car ownership also becomes more and more troublesome as the availability of parking space for privately owned cars is steadily decreasing. Maybe it is time to rethink and try to find alternatives to the traditional business models way to provide personal mobility with cars?

Mobility as a service (MaaS) is changing the traditional model of car ownership with an objective of meeting consumer mobility needs in the most efficient way. Getting from Point A to Point B can be done in a multitude of ways and may mean using a privately owned vehicle for only part of the journey or not owning a car at all - especially in dense urban areas.

Just one example is DriveNow which is the car sharing service in cooperation with BMW i, MINI and Sixt that enables users to rent cars independent of time and place with its core promise: "Pick up anywhere, drop off anywhere."

Daimler and its Car2Go car-sharing service is another example of car sharing, an important and potentially disruptive business model that is already seeing rapid growth in Europe. Despite currently low usage rates, a market survey by McKinsey found that a third of Germany's urban population is a prospective user of car-sharing services. Nearly 40% of young Germans (18- to 39-year olds) living in cities with more than 100,000 inhabitants indicated that ten years from now they "will use car sharing more." This data support supports industry analyst forecasts that the number of car-sharing customers in Europe might increase to 15 million by 2020, up from 1 million today.

To the degree that mobility as a service, and specifically car-sharing as an important new model, can integrate the usage of electric vehicles, it offers new opportunities for EV adoption by removing some of the barriers. First, on the user side, these models eliminate the hurdle of high initial purchase price, because users do not have to buy the cars they are driving. Mobility as a service can also alleviate the "range anxiety" that makes some consumers reluctant to purchase an EV by allowing them to opt for BEV usage only for driving distances that they're comfortable with. Car-sharing fleet operators could possibly benefit from lower fuel and maintenance costs, because they should be able to realize higher utilization rates (especially in dense, urban areas) as compared to private car use.

Mobility tends to be more complicated than just getting from Point A to Point B. When you consider all of the intermediary steps involved in getting from your home to your final destination (e.g., the bus to the train station, the taxi from the train station, or the endless search for an empty parking space) the overall journey ends up using a few more letters of the alphabet. Full mobility describes the set of solutions either focused on the complete journey – from start to finish – or on the parts of the journey not addressed by the first wave of mobility-as-a-service solutions.

6.8. Smart grid

Diverse and innovative business models are being adopted globally to enable the commercialisation of electric vehicles. The introduction of information and communication technology in electricity networks is the primary enabler of these new business models at the interface of energy and private transport sectors.

Here are four innovative applications of electric vehicles that can only be achieved in the context of an “intelligent” energy network:

- the value of controlled EV charging;
- the integration of electric vehicles in “smart home” energy systems;
- renewable electricity storage in vehicle batteries;
- electric vehicles as providers for secondary energy markets.

Digital technologies enable communications between vehicles, charging infrastructure, grid operator, and home energy management systems. With controlled vehicle charging, customers can reduce their fuel bills and utilities can optimize the utilization of power system capacity. Integrated into intelligent” power networks, EV batteries can be used to store intermittent renewable production from new technologies such as wind and solar power.

6.9. State incentives

With many new regulations regarding air and environmental pollution and European Union plan to reduce fossil fuels and raise the renewable energy sources in every aspect of economy, infrastructure, transportation and production, the only possible way to achieve those goals is the help from states. Incentives for electric vehicles are now applied in many European countries. The incentives mainly consist of tax reductions and bonus payments and premiums for the buyers.

The European car industry supports the further introduction of fiscal incentives for fuel efficiency. Tax measures are an important tool in shaping consumer demand toward fuel-efficient cars and help create a market for breakthrough technologies, notably during the introduction phase.

Innovations generally first enter the market in low volumes and at a significant cost premium and this needs to be offset by a positive policy framework. Electric mobility will make an important contribution towards ensuring sustainable mobility. However, advanced conventional technologies, engines and fuels will play a predominant role for years to come. Governments must continue to include these CO2 efficient technologies and solutions in their overall sustainable mobility policy approach.

An example of a successful support of a transition to electric mobility in Europe is Norway. They have highest percentage of electric car owners per capita in Europe. They set the goal to reach 50.000 zero emission vehicles by 2018. All electric vehicles are exempt from all non-recurring vehicle fees, including purchase taxes which are extremely high for ordinary cars, and 25% VAT on purchase, together making electric car purchase price competitive with conventional cars. Electric vehicles are also exempt from the annual road tax, all public parking fees and toll payments, as well as being able to use bus lanes. These incentives are in effect until 2018 or until 50.000 zero emission vehicles target is achieved.

Another successful example of European country that is also part of the European Union is Netherlands. The Dutch government set a target of 15.000 – 20.000 electric vehicles on the road in

2015, 200.000 vehicles in 2020 and 1.000.000 vehicles in 2025. First goal was achieved in 2013, two years earlier than expected. Initially, government set incentives such as the total exemption of the registration fee and road taxes. This incentive ended in 2014. In addition, the national government offers 3.000 € subsidy on the purchase of an electric taxi or delivery van, this subsidy is increased to 5.000€ in some cities. Electric car owners also enjoy free parking spots inside the cities.

Rapid adoption of electric vehicles in Netherlands is also due to the small size of the country, which reduces range anxiety, a long tradition of environmental awareness and high gasoline prices.

One more example of a country that greatly supports transition to electric mobility is Slovenia. Again, it benefits from being a small country, which eliminates a lot of range anxiety. Besides, country was fully covered with DC charging stations at the end of 2015. Slovenia is also offering 5.000 € incentives for an electric vehicle purchase and is lately debating about increasing the incentive to 7.500 €. City centers offer free charging options and free parking spots for electric vehicles further making this mobility appealing to a general customer.

6.10. Formula E

The second season of the FIA Formula E Championship was launched in Beijing. Off-track, DHL, the world's leading logistics provider and Official Logistics Partner of Formula E, concluded the inaugural season looking at real progress in the development of environment-friendly solutions and is continuing the race towards sustainable mobility during the second season.

As part of a business programme that DHL is leading on behalf of Formula E and its partners, called Formula E eStory, the logistics service provider introduced in Beijing a compendium, *"The eStory: Undertaking the Mobility Challenge",* covering mobility innovations, green technology solutions and community initiatives that were facilitated by Formula E, which are expected to have a positive effect on the consumer market and society in the coming years. The eStory business program aims to unlock the potential for boosting innovation and sustainable mobility. With the strong support of Formula E and partners the eStory will facilitate mass market adoption of sustainable mobility solutions, by accelerating technological developments, bringing these to the attention of major market players, and by increasing acceptance through educating people about e-mobility.

The success of electric mobility is influenced by multiple external trends, but also requires other pillars to be activated, including technological progress, having the right infrastructure and business models in place, and communication. Formula E is a powerful unifying platform for players of the various industries to explore and innovate, and thus jointly shape the future of sustainable mobility. The innovations generated and tested during the first season are only the first steps towards this common goal, with much more to be inspired by Formula E.

Formula E acts as a catalyst for technological innovation in the automotive industry. It brings together major global corporations that recognize the benefits of developing cross-industry collaborations and of jointly building innovative and sustainable solutions. Formula E's partners, demonstrate the ability to foster innovation and showcase how the outcomes have far outreached the scope of a racing championship.

One of the innovations in the area of producing clean electricity comes from the British company Aquafuel Research that provides mobile generators which run on glycerine instead of diesel. This fuel is clean on carbon emissions and produces very low particulate and NOx emissions. It is expected that in the next three to five years production of glycerine from salt water algae is commercially viable, thus creating a fully sustainable production. Further progress was made also in the field of charging systems for electric vehicles by Qualcomm Incorporated - Qualcomm's Halo Wireless Electric Vehicle Charging (WEVC). The course cars for the inaugural season were fitted with wireless charging technology that uses resonant magnetic induction to transfer energy wirelessly from a ground based pad to a pad integrated into the vehicle.

In its first season Formula E has proven to be an exciting platform. Not just for spectators, but first and foremost for the automotive industry to exchange ideas and innovate.

6.11. Conclusion

This text looked through the business model innovations that involve electric mobility. Several lessons can be drawn and new approaches learned regarding vehicles, infrastructure system, popularization of new mobility and education of more and more urbanised world.

Reduction of range anxiety, top down, flexible product integration, integration of informational technologies, changed mentality about car ownership and mobility can be seen as a major trends regarding inovative business models.

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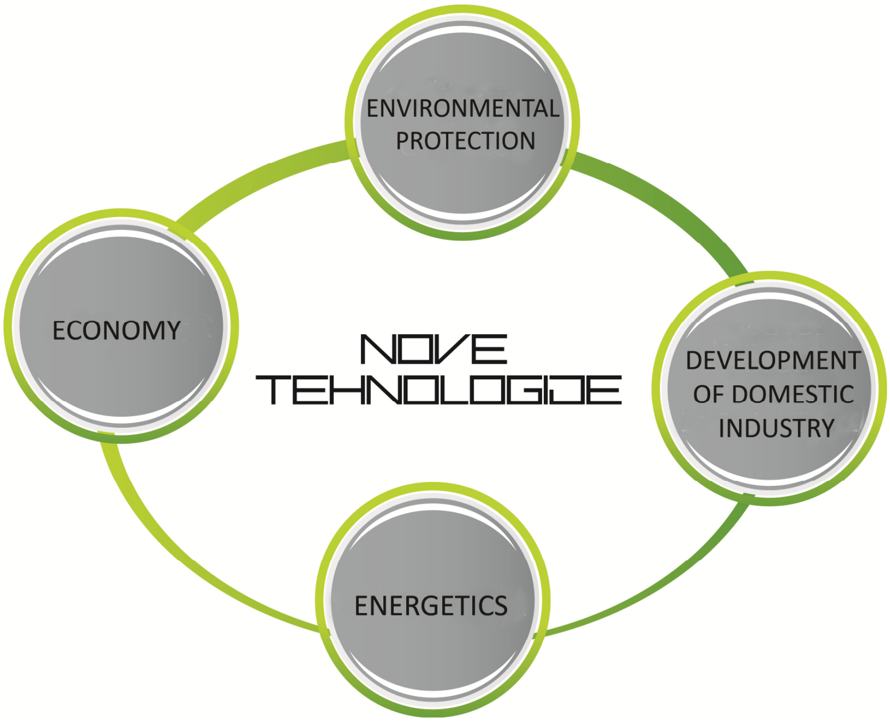
7. Electric mobility Case study

7.1. Electric mobility case study for Croatia

In mid 2010, Energy Institute Hrvoje Požar launched the *E-mobilnost.hr* initiative before the gathered partners and representatives from the Croatian industry.



E-mobilnost.hr is the first initiative in Croatia whose primary role was to provide an interactive communication platform and the basis for establishing partnerships between all relevant stakeholders, such as politicians, entrepreneurs, decision-makers and citizens who are inspired by electric vehicles, as well as those who are about to become ones.

In order to familiarize the citizens with the concept of e-mobility, its benefits, opportunities and challenges soon to be faced, the www.e-mobilnost.hr portal was launched aiming to affirm the development of the electric vehicles market and the supporting infrastructure in Croatia.

In 2010, the Energy Institute Hrvoje Požar prepared for the City of Zagreb the *Strategy for the development of electric vehicles charging infrastructure in the City of Zagreb.*

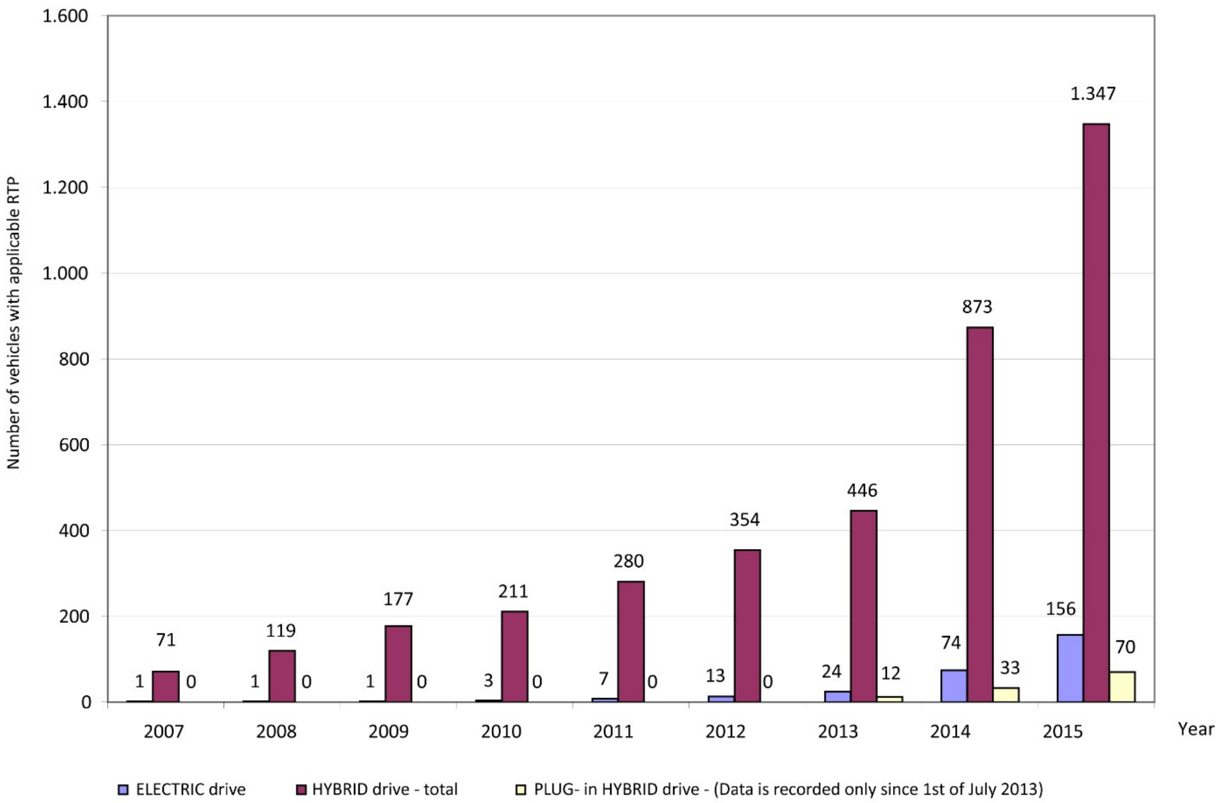
Since then, we have been continuously working on the promotion of e-mobility as well as on EU projects which encourage the development of infrastructure for electric vehicles and new business and transport models (MOBINCITY, PRO-E-BIKE, etc.). Also, the Institute prepared the technical basis for defining the draft national policy framework for implementing the Directive of the European Parliament and of the Council on the deployment of alternative fuels infrastructure.

The first charging station in front of the Energy Institute Hrvoje Požar, Savska cesta 163, Zagreb

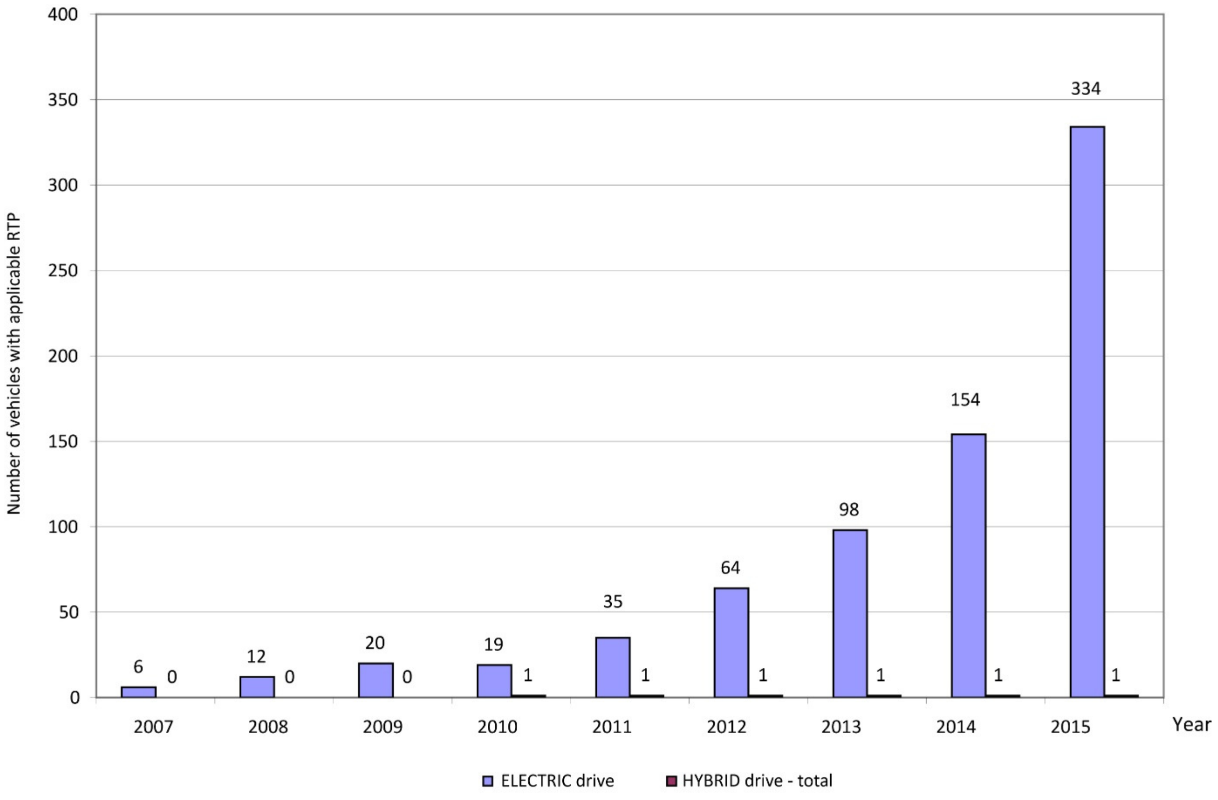
The first registered car in the Croatian market, Citroen C-Zero owned by the Energy Institute Hrvoje Požar

The infrastructure of charging stations is expanding, and currently in Croatia we have a total of 54 active charging stations, 14 of which are located in Zagreb. Exact locations you can find on ChargeJuice application or on www.puni.hr web site.

Previous two rounds of incentives from the *Environmental Protection and Energy Efficiency Fund* amounting to HRK 70,000 per electric vehicle, HRK 50,000 for PHEV / PHV and HRK 30,000 per hybrid vehicle, increased the number of cars on roads, but the current number is still very small.



Registered M1 vehicles with electric and hybrid power in Croatia, Source: Croatian Centre for Vehicles



Registered L-category vehicles with electric and hybrid power in Croatia, Source: Croatian Centre for Vehicles

Example company (implementation/use of e-bikes) - *Croatian Post*

The Croatian Post is the national post company. The Croatian Post continuously follows logistics trends and tests new vehicles with delivery potential. Accordingly, the Croatian Post was a testing company for electric bikes within the PRO-E-BIKE project (promoting-e-bike-delivery) conducted by the Energy Institute *Hrvoje Požar*. Even before the completion of the project, considering that they were satisfied with the results, they submitted an application in response to the Call for Proposals by the Fund for Environmental Protection and Energy Efficiency with their project *Improvement of energy efficiency by introducing e-bikes into postal service*. The project was recognized by the Fund, and co-financing of the purchase of 180 electric bikes was approved. The estimated annual savings (one e-bike replaces one petrol-powered moped) is around HRK 7,000. After replacing 180 mopeds with 180 electric bicycles, the total estimated cost savings amounts to 86.52%. The environmental advantage is that the replacement will reduce CO_2 emissions by 100.31 tons annually.

Electric bicycles FreeDuck 2 are a result of cooperation between the company Ducati komponenti d.o.o. from Ludbreg and the Slovenian bicycle manufacturer Krpan. FreeDuck 2 has a 250 W Ducati engine and reaches a maximum speed of 25 km/h. The lithium-ion battery enables a driving range of 60 kilometres on a single charge. It takes three hours to charge the battery, and bicycles are charged in post offices across Croatia where they are deployed. The bike’s load-bearing capacity (rider and cargo) is 200 kilograms.


Hrvatska pošta


Hrvatska pošta


www.krpan-bikes.si


Pošta
Hrvatska pošta
Hrvatska pošta
S voljom i na vrijeme.

Example town (implementation/use of e-bikes) - *Čakovec*

In May 2015, the project *Cleaner transportation in the Town of Čakovec* was implemented. The project established and organized a sustainable and environmentally-friendly public transport by introducing e-bikes, and the use began in June 2015. Using cars for routes up to 60 km was replaced with e-bikes, and thus the consumption of fossil fuels as the most common source of energy for cars was replaced in favour of electricity consumption, which is ecologically a more acceptable energy source. In the first phase of the project, 30 parking stands/racks for 20 electric bikes were installed, 2 charging stations and 500 user cards were made. In 2016, the town of Čakovec is moving into the second phase of the project implementation, which includes the purchase and installation of additional 10 e-bikes, 15 electrical parking rack units and two charging stations, in view of increasing the efficiency of e-bikes from the current average 4.5 hours to 12 hours per day. The upgrade of the existing system will increase the number of users from 100 to 400. The assumption regarding the number of users is based on the fact that citizens will no longer use electric bikes as an attraction, but as a regular public transport, and by installing two new terminals in the eastern and western part of the town, bicycles will be accessible to the residents of these areas. The increase in the number of hours of daily e-bike use will further reduce the consumption of petrol as fuel and emissions of CO_2 into the atmosphere, it will increase energy efficiency in traffic and reduce noise levels in the town. The system of using public e-bikes is a contribution to the community, as it provides citizens with a fast, simple and flexible system of personal transportation to distances up to 60 km. It also contributes to the overall mobility and connecting the town to the suburbs, it enriches the tourism potential, improves the image of the town.

Further information about the project: www.stromcek.hr

Example town - *Koprivnica*

In 2014, in order to stimulate electric mobility and for the purpose of regular activities of the town administration and employees of town companies, the town of Koprivnica purchased five electric vehicles, a plug-in hybrid vehicle and a hybrid vehicle. The vehicles were purchased as a part of the CIVITAS DYN@MO project, the primary aim of which was to reduce the operating expenses of town vehicles by 24% and to reduce CO2 emissions relating to transport of employees of the town administration and town companies by 27 %.
For easy use and charging of electric cars, five *fast* HEP ELEN charging stations were installed in central locations in the town. The energy used for charging in these stations is produced exclusively from renewable energy sources.

In addition to electric cars, two electric mini buses were bought with a capacity of 13 seats. We currently plan to introduce other lines of public transport with electric mini-buses (currently one line is operational). The planned final implementation is in 2020.

Also, a terminal with 10 electric bikes was installed at the Campus (there are 7 other BicKo system terminals with a total of 70 regular bicycles in the town (10 per terminal)).

Public e-bikes are an optimal way to connect those parts of the town of Koprivnica to which the distance is over five kilometres. Accordingly, the public bikes terminals system is planned to extend to the area of nearby settlements, and an increase in the number of public e-bikes is predicted according to demand until 2017.

In addition to public transport by electric mini-buses and e-bikes, the Plan also provides for establishing a car sharing system related to electric cars owned by the Town.
By purchasing five electric and two hybrid vehicles, the town of Koprivnica significantly contributed to the promotion of sustainable transport and economic savings in the town administration. In order to continue the positive trend, it is necessary to encourage further investment regarding the purchase of electric vehicles for other companies in the town of Koprivnica.
In addition to the use of electric vehicles for the purpose of field technical interventions, performing field activities and travelling for the purpose of business meetings and various town events, the use of these vehicles can be much broader, such as the procurement of electric vehicles for the purpose of delivery, waste collection, for the needs of fairs etc. is also planned.
The purchase of electric vehicles for the town administration and town companies, and encouraging the electric car purchase for private companies, is anticipated throughout the planning period of the Plan, according to the demand and the implementation of other measures of electric mobility provided within this Plan.

For the purpose of the existing number of electric vehicles in the town of Koprivnica, there is a sufficient number of fast-charging stations.
In accordance with the development of electric mobility, it is also necessary to develop the network of fast-charging stations for electric vehicles. Under the condition that companies in the Town purchase electric vehicles, the construction of *fast*-charging stations on the

premises of the companies is proposed to allow an unobstructed access of citizens to public *fast*-charging stations. After the implementation of all the electric mobility measures set out in the Plan, the construction of a network of charging stations is planned in accordance with the results of the monitoring plan.

Case study production company – electric bicycles designed and anufactured by Rimac Automobili

Greyp G12 was the first electric bicycle designed and manufactured by Rimac Automobili, an model built around the vast knowledge and experience gathered from in-house development and production of the Concept_One supercar. After the extremely successful firstborn Greyp G12 which was delivered to 26 countries on 5 continents, its successor, the new and fresh Greyp G12S, with its stunning performance takes the whole experience even further.

Many unique and intuitive features are developed from the ground up in order to make the everyday usage of Greyp even more pleasing and fun. Sophisticated biometric sensor is used to activate the bike, which can be programmed to deploy different riding modes for different riders or even for a specific finger. With quick recharging abilities you will never be left high and dry and 3 pre-set riding modes will provide you with a desirable bike setup for every situation, weather you just feel like cruising down the streets or you're in the mood to win the traffic-light grand prix.

The one of a kind user interface helps you plan your rides more efficiently and keeps you up to date with all of the bike's parameters.

Specification:

• 70 km/h top speed (electronically limited)

• 80 minutes recharging time

• range up to 120 km

• 12kW peak power

• battery capacity 1,5 kWh

• Li-ion battery

• 4,3" colour touch display

Till now Greyp sold over 100 bikes in 22 countries all over the World (Croatia, Italy, Switzerland, Netherlands, Czech Republic, Luxembourg, Estonia, United Kingdom, Sweden, Germany, Russia, China, USA, Colombia, Ecuador, South Africa, Austria, UAE, Luxembourg, Peru, Monaco, France).

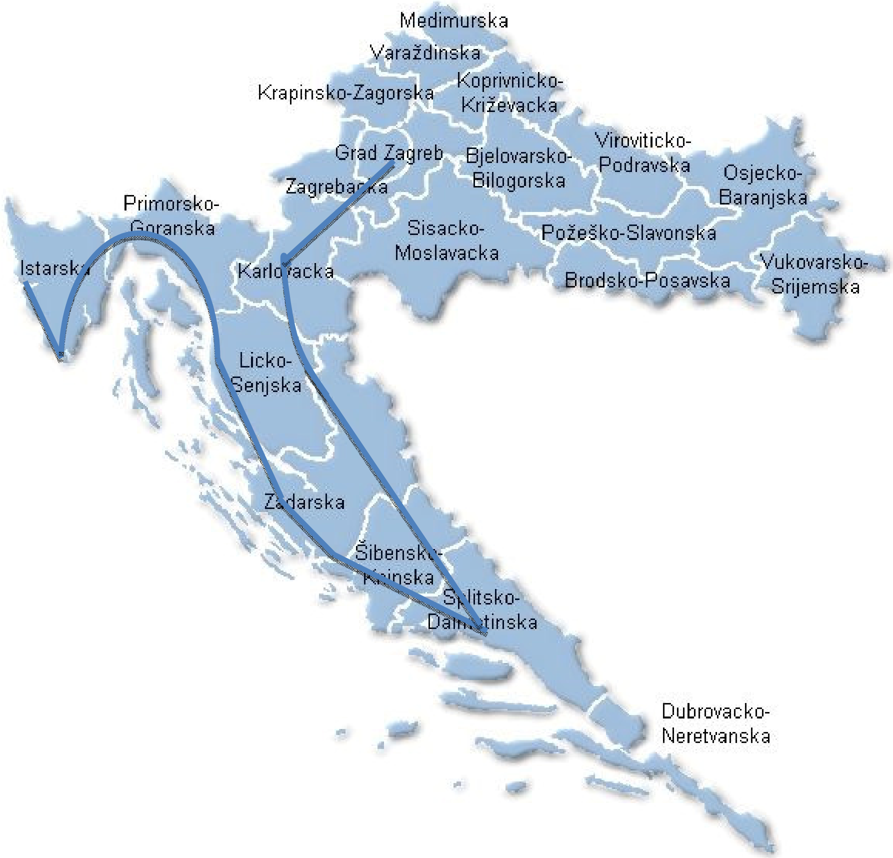
If you want to know more: http://www.greyp.com/

https://www.youtube.com/watch?v=4XK3xFfxs-c

Nikola Tesla EV Rally Croatia

"Nikola Tesla EV Rally Croatia" is the first rally for electric vehicles only held in this part of Europe. The rally has been held since 2014. The participants are local and foreign electric vehicle drivers, entrepreneurs, tourists and adventurers. The idea of the rally is a joint cooperation and integration of partners, towns and villages, tourist offices and related institutions in order to establish the infrastructure for electric vehicles. On the rally route, charging stations for electric vehicles are placed in the most attractive tourist sites as well as the start of the planned "Green Tourist Electric Highway" (Rovinj, NP Paklenica, Smiljan - MC Nikola Tesla, Poreč, and 7 in the city of Zagreb on private premises). Until the end of 2016, 10 more charging stations are planned to be installed.

As part of the rally, vehicles and charging stations will be presented and panel discussions on e-mobility and green technologies will be held, and those companies which already actively participate in reducing pollution and CO_2 emissions as well as reducing noise in urban centres through their activities and business will be presented.

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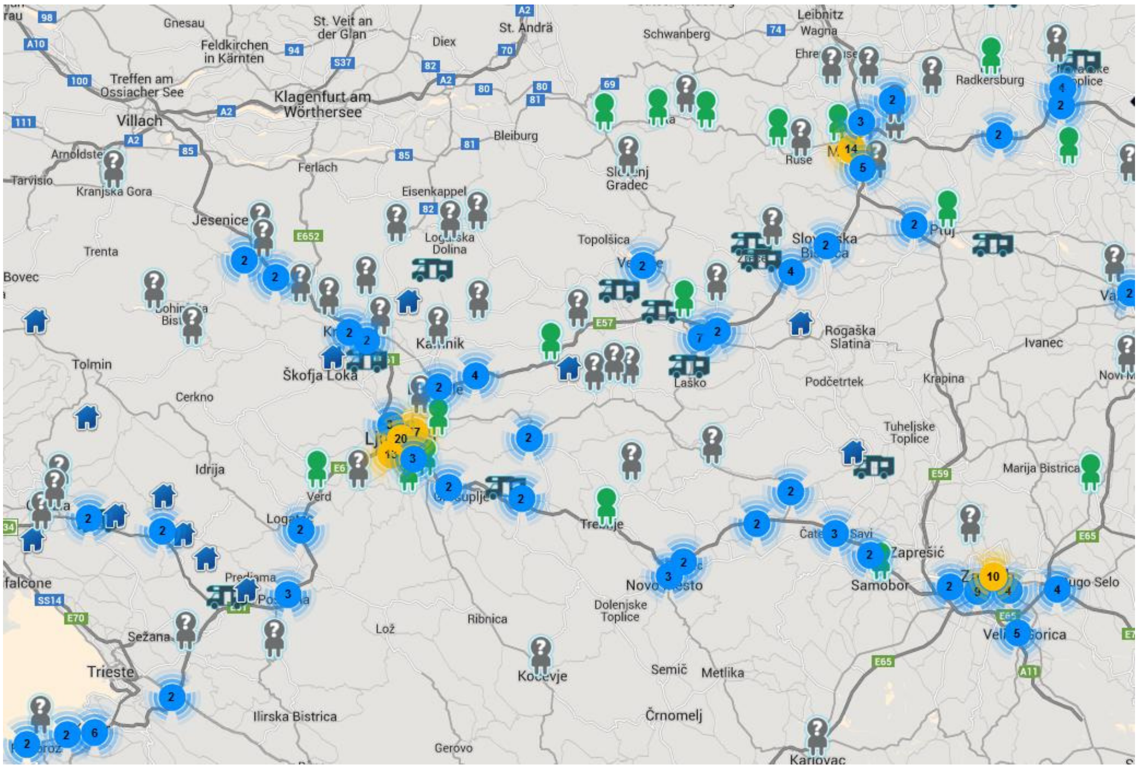
7.2. Electric mobility case study for Slovenia

Developing electric mobility plays an important role for Slovenia since the country wants to become no carbon emission environment in the future. Electric mobility is in consensus with state goals to decrease harmful effects of transportation to the environment. Slovenia has proven through diverse projects that it is an electric vehicles (and mobility) friendly country.
Electricity is an energy source that is produced in Slovenia and also used in transportation, especially in personal transportation, where it would mean that Slovenia would not need to import other energy sources. The country therefore has a chance to get rid of a global dependence on fossil fuels and become locally self-sufficient.
Slovenia could be energetically self-sufficient as far as personal transportation goes if vehicles would run on electricity. Electric vehicle spends ¾ less energy for the same distance as internal combustion vehicle.

CHARGING INFRASTRUCTURE

Green corridors of Slovenia is a project that helps expanding charging stations network for electric vehicles.
More active promotion of electric vehicles started in spring of 2015. Fast charging station network was established throughout entire Slovenian highway cross at the end of 2015. 26 DC charging stations were build. This is a part of the international project Central European Green Corridors where 115 fast charging stations were build in participating countries like Austria, Germany, Slovak Republic, Slovenia and Croatia. Nearly all electric vehicles have the option for fast charging and can be charged up to 80% in 30 minutes, which means that people can travel from Ljubljana to Maribor or from Ljubljana to Koper without major delays caused by charging.
Establishing fast charging station network was a major step towards electrified mobility in Slovenia. This step would be impossible without many AC charging stations that are already placed around the country.
We must also know that around 250.000 residents drive less kilometers per day than the average range of more accessible electric vehicles. This means that using only over night home charging would suffice their needs. Or on the other hand, majority of daily migrants use their vehicles to go to work where cars stay on parking lot for more than 8 hours, which is enough to fully charge an electric vehicle on an inexpensive charging station. Those charging station do not require many expensive infrastructure changes.
Council that is leading international project has established the guidelines for charging stations. Since none of Slovenian fast charging station developers and producers satisfied the criteria are charging stations imported.
Slovenian government has passed energy bill that concluded the debate: What should be first? Charging stations network or high number of electric vehicles on the roads? Research showed that charging infrastructure has to be developed on Slovenian highway cross. Now there are 26 DC charging stations which connects Slovenia into European electric highway network.
Company SODO d.o.o. did everything that was required to build those 26 fast charging stations for electric vehicles. Those charging stations are capable of 50 kW DC and 43 kW AC charging with Combo 2, Type 2 and CHAdeMO protocols. With those three connectors, charging station can be used by vast array of electric vehicles that are driving on Slovenian roads.
With this newly build network, Slovenia landed at the European top as far as the density of fast charging stations is concerned.

Figure 1: Fast growing number of charging stations for electric vehicles in Slovenia



ELECTRIC VEHICLES: NUMBERS

With established charging station network, car sales helix has moved upwards. Slovenian car market is offering almost all of established global brands of electric vehicles with theirs support system of services and salons. This includes BMW i program, VW e-vehicles, Renault-Nissan alliance Zero Emission vehicles, Mitsubishi, Citroen, Peugeot and their take on electric car, as well as Daimler group electric drive cars. Besides those, Tesla models are also holding quite a share in Slovenian EV numbers.

Real sales of electric vehicles began in April 2015. Before that, electric car sales were spars.

Information from infrastructure ministerial says that there are around 300 electric vehicles and around 70 plug in hybrid cars (end of the year 2015).

In previous years, Eco fund for electric vehicles was depleted quite fast and many were unable to purchase their own electric vehicle. This has changed in 2015 and is valid also in 2016. There will be enough nonrefundable fund for electric vehicle mass. It is expected that electric vehicle sales will increase for huge portions. Infrastructure ministerial and many communes are doing everything in their power to increase number of electric vehicles on Slovenian roads.

It is predicted that in 2050 or even sooner there will be only electric vehicles in Slovenia.

DEVELOPMENT BY COMMUNES

Involvement of communes in electric mobility development is the key for success. They contribute towards charging station network and are taking the lead with and example and are adopting electric vehicles for their needs. They incorporate them in public transport and are a good example to other companies to encourage them to include electric vehicles in their fleet. Communes are also very important in educational process.

Energy agency of Podravje has started consortium of Slovenian communes that are contributing to the fields of electric mobility. 40 communes are already taking a part in it.

Ljubljana

City commune of Ljubljana has developed much further than the rest of the country in regards of electric mobility. Until the end of 2020, 400 charging stations are planed to be build in and around Ljubljana. 4% parking spots will be equipped with charging stations and designated only for electric vehicles. In 2020,15% of parking spots will have proper infrastructure for possible future charging stations.
There is a debate going on if the yellow track designed only for buses and taxis should also be allowed for electric vehicles and another debate, weather or not electric vehicles should be allowed at Slovenska cesta which is currently open only for public transport.
City commune of Ljubljana is also planning to decrease the price for parking for electric vehicles in garage.
Ljubljana is 2016 green capital of Europe and further increased educational projects about sustainable mobility and is one of the few cities that are offering free rides around city center with a small electric vehicle – Kavalir.
Taxi drivers are encouraged to use electric vehicles. In 2015, City commune of Ljubljana organized few days of free taxi rides with Renault Zoe.

Maribor

City commune of Maribor is the second biggest city in Slovenia and is taking part in consortium of communes that develop electric mobility. They plan to restructure the whole mobility city concept in the next ten years. This plan includes many new charging stations for electric vehicles as well as for compressed gas and one for hydrogen cars. They will open mobility center, enable more eco friendly public transport and encourage companies to use electric vehicles or vehicles on compressed gas in their fleet.
City commune of Maribor is in the process of acquiring 30 electric buses for public transport.
Other smaller communes are following the state and few big leaders and are developing their own concepts of sustainable and electric mobility. For an example communes Izola and Novo Mesto started using electric vehicles for their needs. Both decided to acquire vehicles from Renault-Nissan alliance.

STATE INCENTIVES

Between 2011 and 2014 ,Eco fund has offered 500.000 € of nonrefundable money for purchase of electric vehicles to initiate energy efficient traffic program. 200.000 € were meant for private people and 300.000 for companies.
This amount has increased in 2015 and even more in 2016. There was 2 million € for companies and 500.000 € for private owners. Nonrefundable financial incentive can be approved for purchase of the new electric vehicles of M1, N1, L7e and L6e category without CO_2 emissions from the exhaust. This

incentive can also be approved for reworking an existing vehicle into an electric one State money can also be approved for plug in hybrid vehicles or for electric vehicles with range extender technology, but those must not exceed 50 g CO_2/km exhaust emissions. In 2015 the amount of state incentive depended on the vehicle category and ranged from 2.000 € to 5.000 €.

Those amounts increased in 2016. Eco fund has arranged more money to achieve state goal for energy efficient and less pollutant traffic. The nonrefundable incentive money for electric vehicles and plug in hybrid vehicles in 2016 varies between 3.500 € and 7.500€.

Citizen with approved state incentive is also allowed to ask for a loan for environmental investments.

The amount of predicted money for energy efficient vehicles was not completely used in years from 2011 to 2013, yet in 2014 the amount did not suffice the needs.

Renault-Nissan alliance sold the highest number of electric vehicles in Slovenia thanks to Renault Zoe. They say that people decide for an electric vehicle over the conventional one only if it is more friendly for their budget. They say that the biggest problem regarding electric vehicles is the battery price, which is currently still high.

Besides ecological aspects of electric mobility, state of Slovenia sees in it a huge impact on a Slovenian economy. There are many producers of various electric vehicles parts and there is also a well developed Slovenian car cluster. Bills that increase electric vehicle sales numbers and well developed charging infrastructure will definitely influence those companies affected by electric mobility and enable them to be competitive on a global marketplace.

PRIVATE INCENTIVES

Association of electric vehicle enthusiasts of Slovenia

This is an organization that unites electric vehicle enthusiast and early adopters. They are trying to popularize electric cars, are publishing a guidebook for new electric vehicle owners and attend as well as organize events connected to electric mobility. They are also more than willing to help with electric vehicle import.

Avant car

Avant car is a technology mobility provider that is offering innovative and affordable solutions, co-creating new mobility trends. The company is the first in region to commit to comprehensive development of electric mobility with the mission of accelerating the shift towards e-mobility paradigm. They own the largest electric vehicle fleet in region and are offering them through innovative business models. Their R&D department explores 5 main pillars on the e-mobility field: education (raising awareness), charging infrastructure, electric fleet availability, business models and renewable resources for energy creation/storage. With its fleet the company already covered more than 1 million zero emission kilometres in 2015.

Andrej Pečjak and Metron institute

Andrej is an innovative privateer that redesigns conventional vehicles into electric ones. He is raising awareness of electric mobility in Slovenia and has also achieved some noticeable results on diverse e-mobility competitions.

INDUSTRY

Slovenia is playing an important part in electric vehicle component production. From basic development, to research, development and production of components, production of electric vehicles as well as in sales and maintenance of such technologically advanced vehicles. Slovenian industry has also infrastructure capabilities and good support for this new mobility. State excels at electricity production. More than sole electricity production capabilities is important electricity from renewable energy sources in Slovenia.

Chemical institute made diverse important advances towards different and better battery technology. They are working on lithium-sulfide battery project as a part of two European industrial research projects. Apart from this, they were also approved by Honda for their visionary project for magnesium batteries.
For a further example, companies like Estrel and Avantcar are manufacturing charging stations. Petrol is developing an efficient system to control and supervise charging infrastructure.
Cimos has developed and is producing electric motor carrier for BMW i3. Hella Saturnus is producing front lights for Renault Zoe. Mahle Letrika is producing electric motor for Renault Twizy and so on.
In 2016, there will be first electric car produced in Slovenia company Revoz which is part of Renault.
As we can see, Slovenia plays an important part in electric vehicle development in the worldwide view.

LONG AND SHORT TERM GOALS

Slovenian energy policy is names charging station network expanding and electric mobility development, as a high importance.
Green book for national energy program of Slovenia is stating: »Electric energy that would be needed to power expected electric vehicles in 2030 is only 2% of current spend electrical energy in Slovenia or 6% of energy spent only from low amperage grid.
In 2055 Slovenian energy concept envisions only electric vehicles on Slovenian roads.
National energy program of Slovenia until 2030 for strategic plans for sustainable mobility and energy usage is stating:

- Introducing of electric and hydrogen vehicles in car parks
- Building charging infrastructure for electric vehicles
- Developing charging station network for transit and internal traffic.
- Expanding measurements and requirements for charging stations in projects.
- Development of intelligent and smart traffic networks that enable technical grounds for building proper charging infrastructure for sustainable mobility.

National energy program is also covering supply and demand of energy for traffic. It points out improvement in energy efficiency of vehicles as well as in driving, introducing new energy sources in traffic with establishing of proper charging infrastructure. It envisions incorporation of electric vehicles and vehicles on other alternative fuels into traffic. All this would decrease local and global environmental pollution.
Goals of the program that regards energy usage in traffic are:
- ensuring 50% of renewable energy sources for charging electric vehicles and hydrogen vehicles until 2015, which was not entirely met and it also plans to reach 100% until 2020 on public charging stations.
- developing energy and charging infrastructure for efficient use of environmental friendly vehicles and building more than 3.000 public charging station till 2020.

The majority of energy needed for electric vehicles for everyday driving can be supplied from domestic charging at home socket or home charging station which is easy and handy.
Green book for national energy program is following foreign studies and bills and is forecasting that in 2030 there will be 400.000 hybrid vehicles, 200.000 plug-in hybrid vehicles and 100.000 electric battery vehicles, 100.000 electric vehicles on hydrogen with a battery pack and 100.000 hydrogen vehicles.
In general, traffic policy is executing incentives for energy efficient and environmental friendly transportation.

ECONOMICAL EFFECTIVENESS OF ELECTRIC MOBILITY

Higher starting investment in electric vehicle bring along many economical effectiveness like low cost maintenance and low ownership expenses. Battery is the most expensive part of any electric vehicle, yet the technology is advancing. Battery capacity is increasing, price is decreasing, resulting in cheaper electric vehicles in the future.

The main economical benefits of electric vehicles are:

- Low maintenance cost (services)
- No tax for highways at registration
- Possibility of free charging at many locations
- Free parking in city centers and at other places
- Less to none environmental pollution taxes

With current electricity price rate and with all the taxes, driving an electric vehicle and charging it at home, costs from app. 1,5 EUR per 100 km driven. Yet, charging it at almost all charging locations around the state is still free of charge.

Electric vehicle insurance and registration are the same as at internal combustion engine and is based on engine kilowatts, but EVs are exempt from the road tax. In the case of plug in hybrid vehicles, electric engine and internal combustion engine kilowatts are summed up together.

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7.3. Electric mobility case study for Finland

Electric vehicles in Finland

In Finland the first electric vehicle was a train. Then electric busses took places in local public transportation. Pure e-cars are a slowly rising trend of decade 2010. Hybrid cars based on petrol and electric have been much more popular in private use in Finland than pure e-cars. These days combined use of diesel and electric in hybrid cars are getting popular in general and also among heavy duty vehicles.

According statistics in Finland have been registered 614pure electric cars until the end of 2015. Year before the number was 461 so raise over 60 percent. Among vans corresponding numbers were 129 and 96 so raise almost 35 percent. The number of hybrid cars raised more than e-cars from 492 to 937 so raise up to 90 percent during 2015.

In Finland winter season is cold and distances are long what makes difference between Nordic countries and especially southern Europe. Also charging points have been located mostly nearby growth centers because of greater population thus it's still inconvenient to commit road trips from city to city. This headache is reliefing due to gas stations which have started to involve e-car charging also and have charging points in addition of fuel pumps. A coverage of charging points is improved slowly.

Also e-motorbikes can be found in Finland and number of those has raised from 12 to 22 so over 80 percent up. But amount of E-scooters and e-mopeds have been decreased from 853 to 753 so down almost 12 percent.

Electric assisted e-bicycles have been used in Finland for several years but specific number of e-bikes isn't known because e-bikes aren't required to register. But offering of e-bikes is better now than few years ago and e-bikes can be seen in daily traffic. It's obvious that the number of e-bikes have raised recent years.

Regulation

Pure e-cars and hybrid cars are regulated similar way like ordinary cars are. Taxation class is the lowest one 5 percent of a price of a brand new hybrid or e-car. Also, electric and hybrid vehicles will have to pay tax on energy just like diesel or gas-powered vehicles. Electric cars, the amount of the tax is 1,5cnt / day / 100 kg when it is in diesel powered 5,5cnt / day / 100kg. Instead, the emission of the basic you don´t have to pay fees as because deferred emission of carbon dioxide / 100 km is 0g, and thus the basic tax to the electric cars are only 43.07 € / year.

Only motorcycles and mopeds, as well as other light electric vehicles are outside these taxes.

The beginning of 2016, the Finnish State to amend its legislation so that the light electric vehicles were allowed among public transport, under certain conditions.

The beginning of 2016, the Finnish State to amend the legislation so that the light electric vehicles were allowed among public transport, under certain conditions. These preconditions include, obligation to use the helmet and traffic insuring when a certain power threshold is exceeded.

The geographical conditions and its effects

Finland is a large and sparsely populated country, and thus the distances are very long. Finland is also a climatic region where the weather and temperature variations are very large. Long distances, together with the cold winter, causing all-electric car a very unfavorable conditions for part of the year.

Cold air and adverse factors together will bring the electric car operating range will be halved at worst, in winter. When to this combined with the time being sparse charging point network, cause this that to the electric motoring will focus more on growth centers than to sparsely populated areas. On the other hand, on electric vehicles the greatest benefit is achieved just in city traffic, where the braking energy can be utilized to the maximum. In addition, when the car is stationary eg. in traffic lights, the electric motor does not spin and energy is saved.

Charging Point Network

Earlier, the charging stations have been private and mostly owned by operators who charging their own vehicles. When the electronic traffic have increased also in private transport, also the public charging points have increased. Most of the Finnish charging points are just in the major cities and their centers. Beside the main road network, charging points have less, and the distances between these points are long.

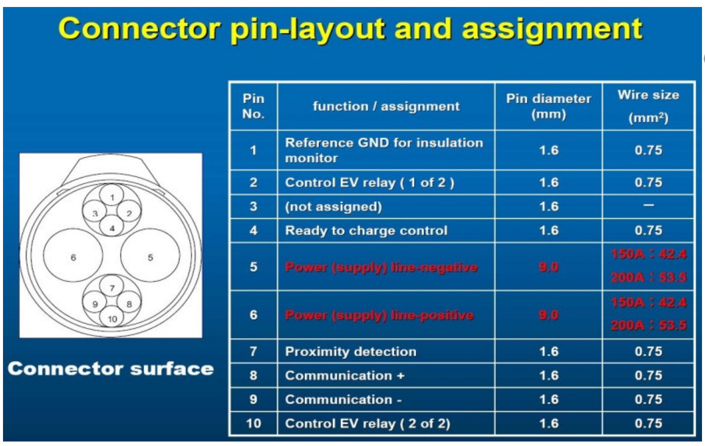
Finnish traffic offices (TRAFI) statistic were dated 31.12.2015 According we have 383 public charging points. These points are located at 193 different addresses. The southernmost of these points in Hanko, and the northernmost village of Inari. The westernmost point in Vaasa and the easternmost in Joensuu. While charging point network appears to Finland to coverage the whole land, have to remember that the points are located mainly in growth centers and the distances are long, especially in northern Finland.

Finnish public charging points by far the most common type of charging is Mennekes (type 2). Mennekes type of charging the maximum load capacity is up to 43kW, the most of 22kW. This type is a standard agreed in Finland. Mennekes name comes from the German manufacturer. The plug is seven-pole and the image shows the meaning of the connectors. As you can see from the image, charging on alternating current.

Charging by the Mennekes- type the electric vehicle battery pack charging approx. 1-2 hours. Charging by the Mennekes-type the charging electric vehicle battery pack charging approx. 1-2 hours. Restrictions to the charging current can cause the car's own control system and the different situations in the power system.

Another to Finnish standard approved type is CHAdeMO. This type of charging is a high-power quick charger. Output can reach up to 62,5kW. In practice, the charging efficiency is slightly lower, normally approx. 50 kW. In this way, when charging the battery, charger supply the current through a rectifier. A battery pack is charged directly to the direct current, and the car's own charging system is not used. When charging this charger type the charger and the vehicle are connected to the charging time via the CAN bus.

In Finland, to the standard is approved for use in the third type which is Combo2 style charging. In this type DC and AC is connected to the same outlet. In this case, need only one plug, depending from the charger can be fed either by a slower charging by via terminals AC or fast charging via DC terminals.



Pin No.	function / assignment	Pin diameter (mm)	Wire size (mm²)
1	Reference GND for insulation monitor	1.6	0.75
2	Control EV relay (1 of 2)	1.6	0.75
3	(not assigned)	1.6	–
4	Ready to charge control	1.6	0.75
5	Power (supply) line-negative	9.0	150A : 42.4 200A : 53.5
6	Power (supply) line-positive	9.0	150A : 42.4 200A : 53.5
7	Proximity detection	1.6	0.75
8	Communication +	1.6	0.75
9	Communication -	1.6	0.75
10	Control EV relay (2 of 2)	1.6	0.75

Schuko charging can be carried out everywhere, where you can find a normal outlet. Schuko download is intended only for temporary use and thereby obtain electric power is also so small that charging electric car battery takes 8-12 hours. This type charging cables has usually in own control unit, which limits the charging current of 6-10 amps. This is not recommended for continuous use.

Electric Vehicles

Electric vehicles can be classified according to size easily.
All vehicles regardless of the size, the basic technical implementation is still similar, just the size of components is changed.
In machinery, heavy equipment and passenger cars, it is possible to choose from including the so-called hybrid drive. This means that to diesel engine was added to the electric motor / generator to collect energy and to reduce the actual load on the motor and to reduce emissions and consumption. The hybrid powered vehicles still can be found in the very same electronic structure as pure electric vehicles.
Below vehicles sorted according to size

- Heavy equipment, which includes all machinery and trucks and buses.
- Lightweight construction equipment, which includes vans
- Cars
- Motorcycles
- Mopeds
- Electrically assisted bicycles
- Light electric vehicles

Heavy equipment and in non-road sector development has gone hybrid direction of full power. Hybrid use is achieved very good results, as well as the usability and consumption. At the moment there are also a lot of research in the use of hybrid use of non-road sector.
Fully electric light transportation vehicles has increased during the past year, from 96 to 129. The majority of the full electric vans located in growth centers and these cars using in delivery transport. Electronic vans operating range in a city moves between 100 and 150 km.
Passenger cars side TESLA's entry into the market of large audience by significant electric cars (Tesla S) was refreshing. The operating range is also different from the traditional 400 kilometers. Tesla's entry to market is certainly a positive impact on other brands electric car sales.
Nissan brand is still the number one of the sales in statistics and TESLA in a good second. As has already been processed, the Finnish conditions and long distances causes that electric vehicles cannot be the family's only car, because the most of electric cars operating range moves between 120 - 190 km and in optimal circumstances.

However, Toyota's pioneer working in hybrid technology will certainly appear in the future increasingly also in Finland. Even now, several brands has brought to the worldwide market of hybrid or plug-in hybrids, and it has been clearly seems also in Finnish statistics.
Hybrid can be divided into two categories PHEV and HEV. Rechargeable hybrid called PHEV is a hybrid, which can be used in very small operating range like the electric vehicle. HEV is a traditional hybrid without a separate battery charging possibilities and the electric motor mainly work with a combustion engine.
Moped and motorcycle market has come some interesting names. The largest manufacturers like Peugeot and KTM has brought to market their own models. Growth in the motorcycle market has still been limited and mopeds growth is even smaller.
Electrically-assisted bicycles have been in the market for a long time and they have their own well-established user base. Because the bicycles do not need to register their statistics is too hard to say the exact number and direction of development is difficult to specify. Into the market has come new models, and sales of these can be said that these are more popularity day by day. Electrically-assisted bikes have been to the present day made from basic bikes, and they have not offered any extra features. Lately, the market has been really stylish and versatile useful in the electrically-assisted bikes that anyone could possess.

These electrically assisted bikes engine powers are moving typically 250W- 500W and the operating range of 30 to 80 kilometers.
This year the beginning of 2016 the Finnish government eased its light electric vehicles law and to allow them access to the traffic. Remains to be seen how much this will affect the general level of awareness coming of e-mobility and the growth of electronic passing popularity.

Technology

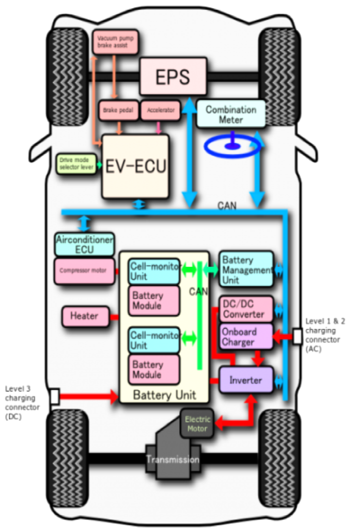
Electric or hybrid vehicles contain the same basic components, although on a different scale. Roughly speaking vehicles can be found in three basic components.
- Battery
- Electric
- Engine Controller

Each of these basic components requires to function perfectly lot of other drivers, components, and often also for communication data bus.
The battery or battery bank is most often LiFePO4 or LiIon cells, which are connected in series with each other to achieve a sufficient voltage level. In order to obtain sufficient battery capacity are those of series-connected cells are also connected to sufficiently parallel. TESLA mm S: approx. 85kWh battery pack contains more than 7,000 individual battery cells.

Lithium-based batteries are the accurate level of charge and discharge, as well as the charging currents. This is why batteries are equipped with BMS (Battery Management System) control, which makes sure that all the cells are discharged and recharged as much from the battery and is always available for the maximum amount of energy safely use.
Since the batteries perform direct current cars has its own charging system for those situations when using the Mennekes or Combo2 AC charging. Charging system rectifies the voltage and adjusts the charge current.
The electric motor is often a three-phase AC induction motor. The engine has advantages of high efficiency motor operation, as well as the collection of the braking energy is recovered from the generator. Good engine feature is its maximum torque at the right from the 0- rounds, as well as a wide speed range of the engine. Also, structurally engines are optimal for use in vehicles.

The engine requires a controller for controlling the motor speed and power. This driver is called an inverter. The inverter converts the DC voltage obtained from the battery to AC. The inverter requires external control devices, which are given control signals like motor speed, direction of rotation etc. These control devices as one example of an electronic accelerator pedal. Below is an outline diagram Mitsubishi's electric vehicle based components.

Costs



The purchase price is currently the largest single electric vehicle cost items. Purchase price include car tax of 5%, on top of this will become an annual tax on "fuel/energy", which is 1,5cnt / day / 100kg. In addition to these contributions, will also be paid an annual tax based on a vehicle, which is the smallest possible and amounts to 43.07 € / year.
Currently, the electricity price of energy is an average of approx. 4cnt / kWh, when we add to this energy transfer price, which is approx. 3cnt / kWh, and electricity tax which is equal to n. 3cnt / kWh provides a simple charging energy price without any other charges of 10cnt / kWh. Electric vehicle

consumption is typically approx. 10 - 15 kWh / 100 km so this calculation is obtained for one hundred kilometers energy costs € 1-1.5.

Other fixed expenses accounted / 100 km will change, of course, in relation to the kilometers driven. One of the most significant operating costs by lowering electric cars is that their need for maintenance is significantly less than comparable diesel or petrol driven into.

The future

The future of electric vehicles in Finland will depend very largely on energy policy orientations, as well as government attitudes towards taxation and the use of electric vehicles. Developing a network of charging also plays a key role in the development of electronic mobility. Own chapter is intelligent tools that are not yet in Finland not managed to fully take advantage of.

7.4. Electric mobility case study for Spain

The *Smart City* is a new concept defining a city that works to improve the quality of its citizens' lives by guaranteeing sustainable social, economic and urban development. A *smart city* is based on the use and modernisation of new information and communication technologies (ICT) to provide more efficient management of the city's services and resources.

In practice, a *smart city* has the capacity to meet the needs of its citizens (in terms of the environment, mobility, businesses, communications, energy and housing) and it thereby improves their daily lives.
It is a city that facilitates the interaction of its citizens with its administration; where open information is available in real time; and where it is possible to be enterprising. A city that is definitively a place that supports and fosters personal and business development.
A city that wishes to aspire to being a truly Smart city must develop all of its key areas (transport, energy, education, health, waste management, security, economy…) simultaneously and transversally.

Essentially the following three ideas establish the criteria that differentiate a Smart City:

- Efficient management of services and resources
- New tools and places for people, groups and institutions to interact with each other
- Use and integration of new technologies (ICT)

SNAPSHOT WITH FOCUS ON BARCELONA

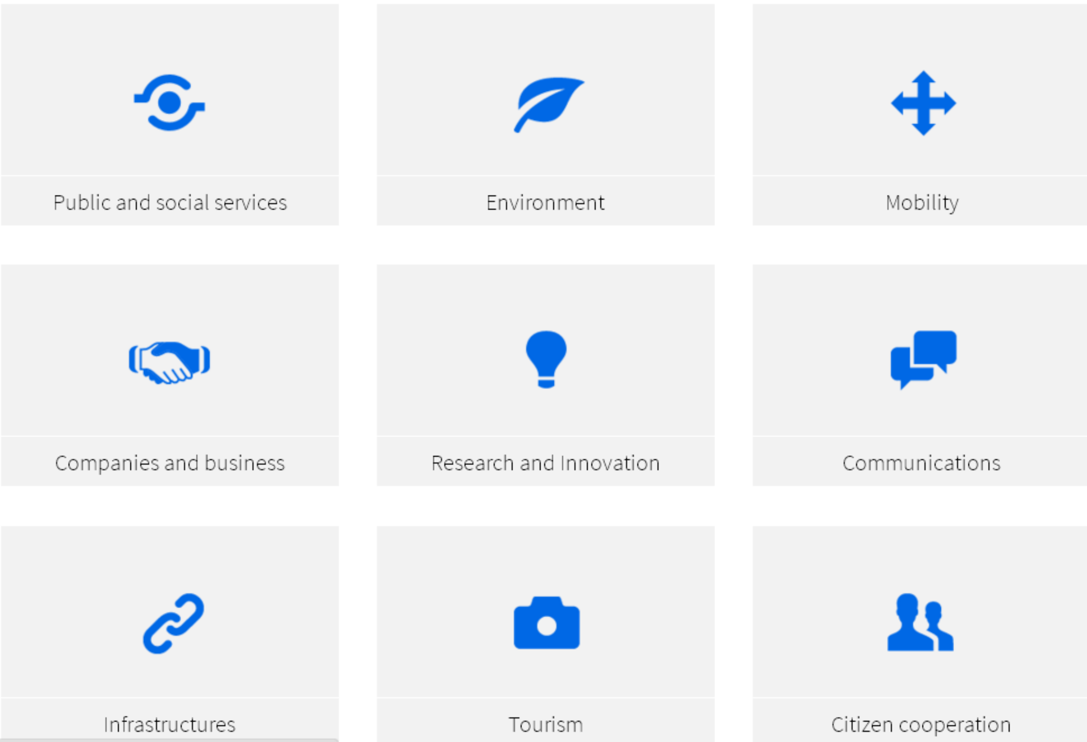
With more than 2,000 years of history and a singular identity, Barcelona has always been characterised by its spirit of innovation, enterprise and nonconformity. A characteristic that has led it to become a pioneer in terms of putting into practice the idea of the Smart City.

Thanks to a transversal strategy based on a long-term projection of urban transformation, Barcelona is considered to be the top smart city in Spain and the fourth in Europe.

Barcelona has a vision of the city it wants to become: self-sufficient, with productive neighbourhoods, living at a human speed and producing zero emissions. A productive, open, inclusive and innovative city; a living city with entrepreneurship people and organised communities.

This vision includes projects from a wide range of areas, which by working together and integrating technology and innovation aim to ensure that the city's residents benefit from a better quality of life and economic growth: this is achieved through more efficient management of the city's services and resources.

The different areas of action that are covered by Smart Cities are:



For the purpose of this document, we are going to focus on the Environment area and in a special way in the Smart mobility (Smart mobility endeavours to achieve safe, sustainable, fair and efficient mobility. It reduces environmental impact, but also ensures that the general public is able to move around more easily and with greater fluidity) and all what it is related to the electric vehicle.

Next, we are going to show interesting data related the electric vehicle for Spain and Barcelona city (2014):

Population	
Spain	**Barcelona city**
46,77 Million	1,6 Million

Registered Vehicles (total)	
Spain	**Barcelona city**
30.976.047	916.522

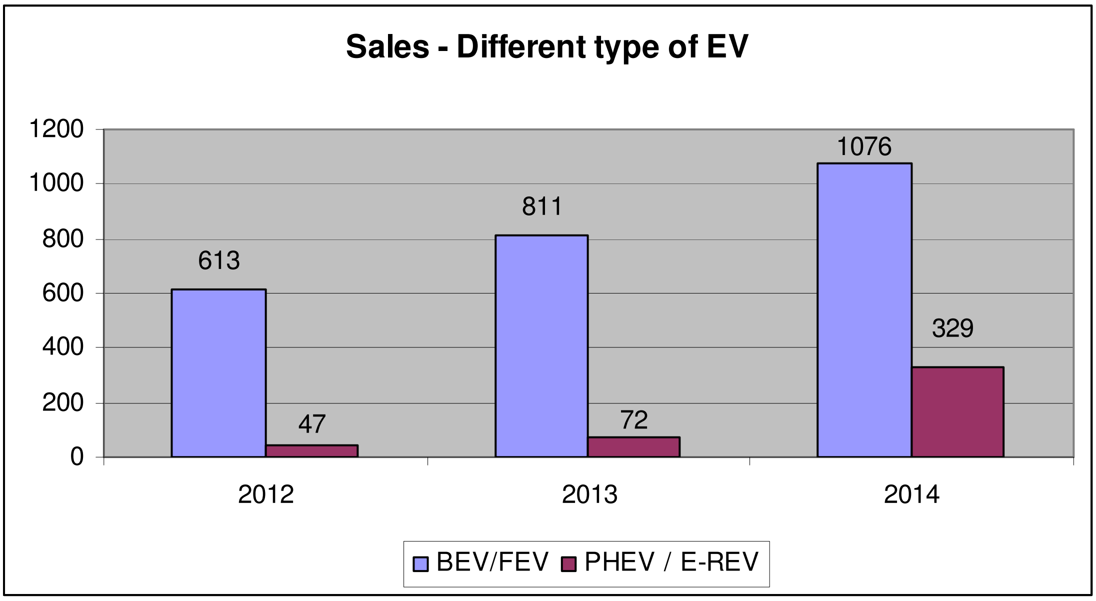
Transportation Mix and Daily trips	
Spain	**Barcelona city**
n/a	Public transport: 39,7% Passenger vehicle: 26,2% Walk or bike: 34,1%
n/a	6.557.935 daily trips

<table>
<tr><th colspan="2">POPULATION</th></tr>
<tr><th>Spain</th><th>Barcelona city</th></tr>
<tr><td>
</td>
<td>
</td></tr>
<tr><td>504.645 km²</td><td>101 km²</td></tr>
</table>

SPAIN

Actually in Spain there are registered, by the end of 2014, a total of 4.096 BEV/FEV (100% electric vehicle) and 717 PHEV/E-REV (Plug-in Hybrid EV / Range Extended EV). If we consider the total car park for Spain (approximately 31 millions) we can see the uptake of the electric car is still incipient (0,02%).

Next, we can have a look to the evolution of the sales (2012-2014) for the Electric Vehicle in Spain. The increase of the sales for the last 3 year period is around 61% for the total by the end of 2014.



About the charging infrastructure in Spain, we have the next figures. As a note, we are counting the charging stations but not the charging point or plugs. With this, in Spain we have around 1126 charging stations and we can classify them as next:

By Speed of charging:

Type of charger	Power	Stations
Standard	- 3kW	787
Accelerated	4kW - 22kW	384
Rapid	23kW -	88

By Socket types:

Type of socket	Stations
Mennekes type 2 socket	371
CCS	11
Schuko	726
SAE j1772	13
ChaDeMo	77
Other	61

BARCELONA

The uptake of the electric vehicle in Barcelona is higher than other Spanish cities then, for the year 2014, in the city of Barcelona were sold around 30% (425 BEV/FEV and PHEV/E-REV) of the total for that year.

Now, regarding the charging infrastructure in Barcelona city and surroundings we have the next figures that correspond to charging stations, but not the charging points or plugs. Considering this, we have for the Metropolitan area of Barcelona a total of 145 charging station and we can classify them as next:

By Speed of charging:

Type of charger	Power	Stations
Standard	- 3kW	100
Accelerated	4kW - 22kW	39
Rapid	23kW -	10

By Socket types:

Type of socket	Stations
Mennekes type 2 socket	52
CCS	10
Schuko	64
SAE j1772	8
ChaDeMo	10
Other	5

INCENTIVES TO HELP UPTAKE THE EV

The implementation of the electric vehicle in Spain and in a specific way in the city of Barcelona has been possible so far because different actions and incentives promoted at a governmental level: tax break and subsidies/funding.

<u>SPAIN</u>

The financial incentives actually active at national level that helps to increase the acceptance of the electric vehicle by citizens, at least at the economic side, are described next:

- <u>Tax Break</u>
    - At the time a vehicle is purchased, the registration taxes disappear if it is an electric vehicle or its emissions are lower than 120g/km.
    - At operational level, companies have a reduction on its economic activities taxes when they develop a transport plan which includes the electric vehicle as its principal transport mode.
    - Also, there is an economic aid for private owners over the IVTM tax that can be up to 75% of the total (it depends of each city).
    - A reduction of the electricity tax is enable when you install a charging station at home or work.

- Subsidies/Funding
    - There are actually actives some subsidies or funding that helps to increase the uptake of the electric vehicle in Spain, such as the MOVELE Plan for cars, PIVE 8 Plan for efficient cars and the PIMA Air Plan for electric commercial vehicles and electric bikes. Next, we can see an example of the subsidies of the MOVELE Plan for 2014 according to the range of the vehicle:

Electric Vehicle Range	**Subsidy (€)**	
	Vehicles	**Stations**
< 40 km	2.700	
40 – 90 km	3.700	1.000
90 km	5.500	

BARCELONA

The financial incentives implemented in Barcelona city are mostly the same as the ones mentioned for Spain. Nevertheless, there are some other regional incentives that help with the uptake of the electric vehicle:

- Additional incentives
    - Free circulation on HOV lanes managed by the city.
    - Free or advantageous discounts in parking spaces at regulated areas on the street and in public parking managed by the city.
    - Free use of the toll highways (no payment) after non mandatory subscription to the service EcoviaT.

EV SPOTLIGHT

Next, we will include some of the most interesting study cases already implemented in the city of Barcelona. Most of this developments or commitments by the government or private companies have as an end, the uptake of the electric vehicle in daily life inside the city of Barcelona.

Promotion and development of the Electric Vehicle

LIVE platform

LIVE Barcelona (Logistics for the Implementation of the Electric Vehicle) is an open public-private platform that seeks to position Barcelona as a centre of innovation in electric mobility. It is promoted by the Government of Catalonia, Barcelona city council, the Spanish government, OEM's, Utilities' company, etc.

LIVE set up the first citizens' office in Europe to provide information regarding electric mobility in Barcelona. As well as providing information for the general public, LIVE issues electric vehicle users cards required for using the municipal network of recharging points. Through its website and social networks, LIVE provides practical information for users. It is also a useful tool for the promotion of Barcelona and its electro-mobility initiatives. Today the city has more than 145 charging stations. This public network of recharging points is creating new business opportunities for innovators to implement new technologies. Many of these projects have been classified as pilot projects (Urban Labs) so as to position Barcelona as a city leader in innovation of public sanitation fleets, e-bike sharing programs and electric public bus services.

Electric Sharing Services

Electric scooter sharing service

The electric scooter sharing service named "MOTIT" as a pilot study in Barcelona city under the EC project SMARTCEM, helps to see how an innovate open sharing service with electric scooters that combines several SMARTCEM services can deliver a flexible and convenient option for urban mobility. Objectives related to increase user acceptance of EV's, increase transport efficiency, develop services for EV's, identify deployment barriers and enablers and support pan-european interoperability.

BICING Sharing service (Clearchannel)

After real non electric bike sharing service implementation experience, Clearchannel shows with this new development how the new electric bike sharing service, running right now as a pilot test, is implemented in Barcelona in order to supply needs not covered yet as well as it helps to uptake the electric mobility as an usual. The service stations where you can leave the bike and charge it are being implemented together with old stations, allowing a complete cover of the network. This service stands and promotes that the electric bikes are not anymore a leisure vehicle, it is also another option to move diary. A total of 46 stations and more than 300 electric bikes are now deployed in the city of Barcelona.

Companies' fleet transformation

<u>Electric motorcycle business (eCooltra)</u>

A company that approaches to the electric motorcycle business providing comprehensive mobility solutions for professionals, developing the B2C and B2B channels.

Cooltra helps to increase the uptake of the electric vehicle at the same time they have been developing the business of rentals using the electric motorcycles (different models) in different kind of companies such as courier services, food delivery and others. Important fact is how they developed their own workshop in order to do the maintenance of its fleet of electric vehicles.

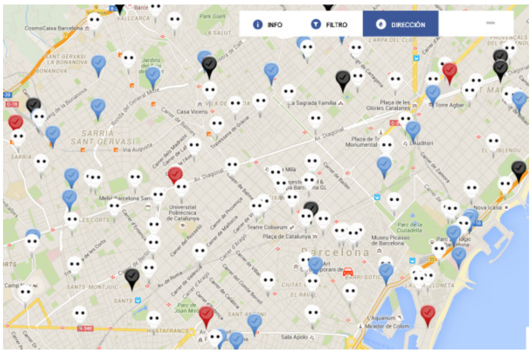
<u>URBASER</u>

A private company that uses EV's in its fleet in order to reduce harmful emissions while services are being done inside the Barcelona city (Garbage collection). On it's a daily agenda; they collect best practices about its fleet of electric vehicles in order to develop further strategies on this area. As an example, they are implementing/developing right now on their vehicles an electric engine for manage the garbage cans pick-up. Also, they have their own workshop in their facilities to repair and do maintenance to the electric fleet of the company. It is a company that actually invests and believes that the future is electric.

Charging Stations

<u>Charging stations (CIRCONTROL)</u>

A company leader in innovation and technology to deliver market mobility and e-mobility solutions and competitive products. Focussed in development of intelligent recharging solutions for electric vehicles. Circontrol offers range of electric vehicle charging products is the widest in the market and it features from home charging units to state-of-the-art ultra-fast charging systems that can charge any commercial electric vehicle in only 15 minutes. It also develops a powerful software that can control and monitor charging systems.



<u>Chargelocator</u>

The city of Barcelona, through its LIVE platform, has partnered with Chergelocator to enable users of its mobile app to: Find the cheapest/nearing available charging stations in the city, get information such as phone numbers, rates, location access descriptions and comments from other users and get complete information about vehicle's charging history and billing, etc

<u>Mobecpoints</u>

Barcelona is second after Rome in the use of motorbikes for personal mobility. In 2011 Barcelona launched its first electric Mobecpoint motorcycle charging stations in the city and hotels (where e-bikes are available to guest for rental) and on university campuses. The stations are available free of charge or even at a very low cost to encourage e-bike ridership.

Electric Vehicle education and training

<u>Electric vehicle education module in La Salle Barceloneta</u>

This high professional training school has been implementing a course related to the maintenance and the technology of electric cars and complemented with practical training in companies that already have electric cars in their fleet, such as URBASER or Cooltra.

<u>Electric vehicle education for professionals</u>

AEDIVE works with more than **1.200** companies, technological centres, universities and public bodies to enhance competitiveness of the most innovative Spanish Business Association for the Boosting and Development of the Electric Vehicle Market. Represent all the value chain of EV industrial sector and promote electric mobility and the implementation of an efficient, reliable and safe EV charging infrastructure.

<u>Electric vehicle competition (CREVE)</u>

The ELECTROCAT competition was created with the idea to set up teaching related the electric vehicle in high professional training school. The objectives covered are: 1. To generate electro-mobility knowledge among professional training school. 2. To work with a team and to overcome challenges. 3. Acknowledgments of the effort. 4. To prepare the future professional repairers for electric vehicles in the country. 5. To promote the participation to the enterprises of the area “Eix Riera de Caldes” and the companies of the rest of Catalonia.

Manufacturers

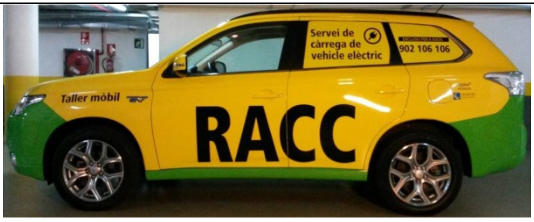
<u>Electric motorcycles manufacturers</u>

Volta motorbikes company is an electric manufacturer created with the mission of providing new solutions for the pollution problems of big cities. The firm's first model, Volta BCN, bears the name of the city because it shares a number of different values that are associated with the Catalan capital: design, environmental respect and quality.

I+D related Electric Vehicle

<u>Electric driving schools (RACC)</u>

A good example about how the electric and alternative energies have been implemented in the strategy of the company (to promote, to teach and to learn) in order to raise awareness about this topic in young drivers and fleet companies. Special attention to the pilot project (in partnership with the Directorate General of Traffic) related the use of the 100% electric vehicle (Renault Zoe) to obtain the driving license. Also, the way in which fleet drivers must behave in order to get the most of the electric vehicle's performance, adapting previous ecodriving techniques used in EU projects such as ECOWILL, but for electric cars.



<u>Electric vehicle assistance on the road (RACC)</u>

A new patrol vehicle with an onboard EV charging system capable to provide some additional range to reach the nearest charging point. Good example on how companies are integrating new technologies in its core business units in order to ensure company is prepared for EV and to help to uptake the EV acceptation in citizens. In other words, To place the company in a competitive and innovative position towards the challenging new assistance requirements of the EVs. Also, explanation about how this kind of projects helps to build new business opportunities in the field of B2B EV's fleets.

<u>Electric fleet of buses (TMB)</u>

The EC- project Zero Emission Urban Bus System (ZeEUS), implemented by the Barcelona Metropoplitan Transport (TMB), aims to be the main EU activity to extend the fully-electric solution to the core part of the urban bus network. It fits within the context to create a competitive and sustainable transport system.

Extend fully-electric solution to the core part of the urban bus network composed of high capacity buses. **Evaluate** the economic, environmental and societal feasibility of electric urban bus systems through live operational scenarios across Europe. **Facilitate** the market uptake of electric buses in Europe with dedicated support tools and actions. **Support** decision-makers with guidelines and tools on "if", "how" and "when" to introduce electric buses

Fleet transformation from ICE to EV

Companies such as Bureau Veritas, Metropolitan Transport of Barcelona, Regional Police, etc are uptaking the Electric Vehicle in their fleets considering both purchased and leased vehicles thanks to the assessment proposed under the EC project iCVUE. The purpose is to establish an assessment in which considering local boundary conditions, company requirements and other important variables, we can manage a whole life cost (TCO) in order to detect opportunities for EV's in their fleet and force the change in order to fullfil with the Profit and Loss account of the company. At the end, it is pretended to reduce harmful emissions in urban environments.