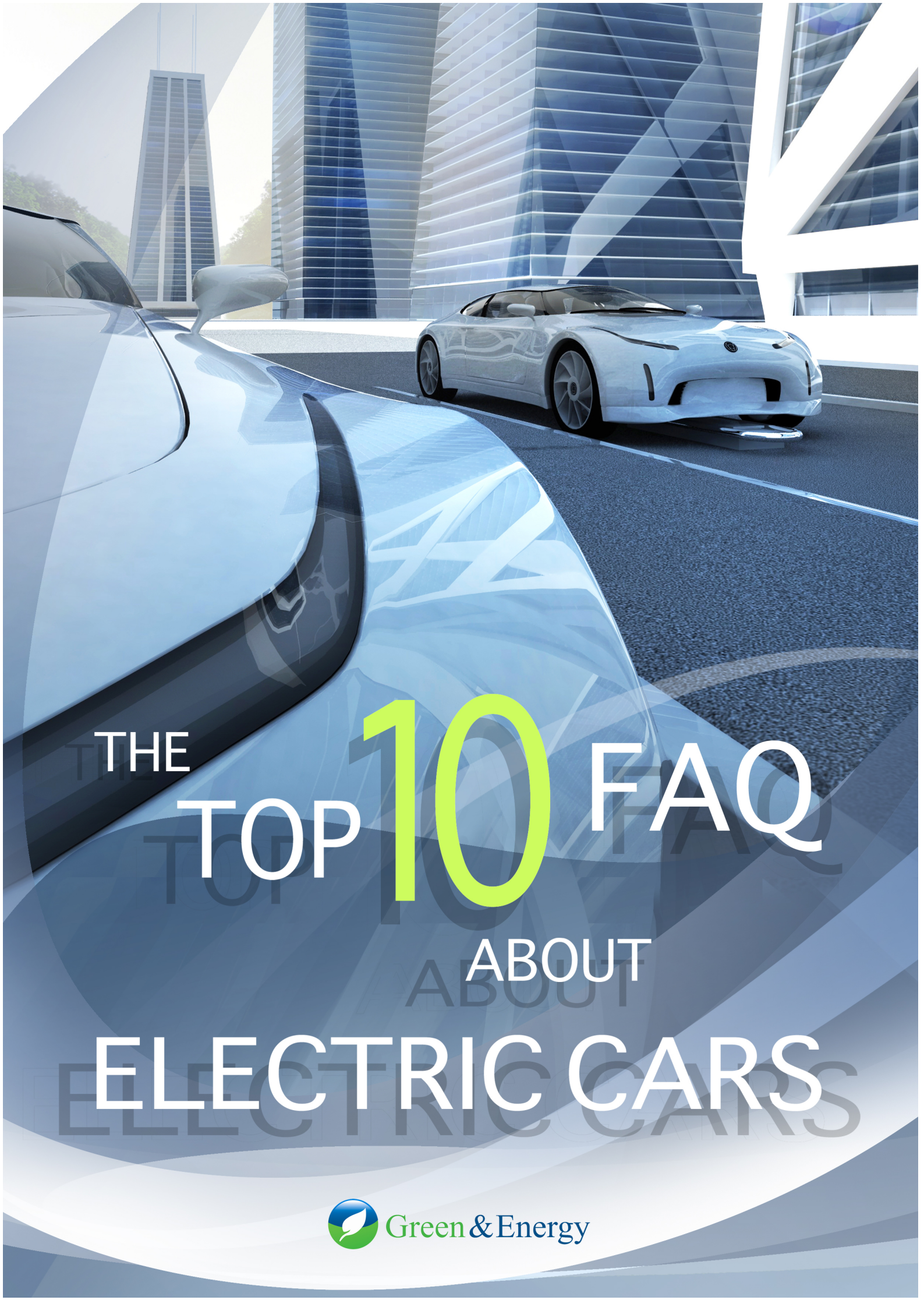

THE TOP 10 FAQ ABOUT ELECTRIC CARS

Green & Energy

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Prologue

Today, the issue of electric mobility is more current than ever. After conducting many conversations with people who are not experts in the field and having analyzed their needs, we realized that the general public lacks fundamental information about electric mobility and its modern use. This book was motivated by the desire to remove this deficit in basic information, or at the very least, reduce it. It is not aimed at the scientific community and specialized public but rather for general readers who are interested in learning more about the subject.

The authors are three scientists who have dedicated themselves to the issue both during and after their studies. They collectively decided to explain and share their knowledge on electric mobility, explaining it in a way that is simple to understand, removing any existing prejudices and refuting any misconceptions.

This has been accomplished by avoiding the excessive use of puzzling technical vocabulary or the excessive use of data. A thorough reading of this book will provide you with a basic knowledge of electric mobility and give you the opportunity to learn about the advantages and current disadvantages and the possible solutions to these issues.

This book is designed to give an independent view of the electrical performance of the cars and their various uses as well as to provide the reader with an informed understanding of the topic.

Introduction

„What interests you about electric mobility?" - A survey.

Before we started working on this guide it was important for us to know what questions were most important for the public. With this objective, we published a survey on the internet on various platforms. We eventually managed to encourage 4,000 people from different areas, countries and ages to participate in a survey. They were provided with a questionnaire consisting of 20 questions on electric mobility and, taking into account their interests and prior knowledge, were asked to prioritize their answers according to relevance and importance. The results of the survey are shown in the chart below.

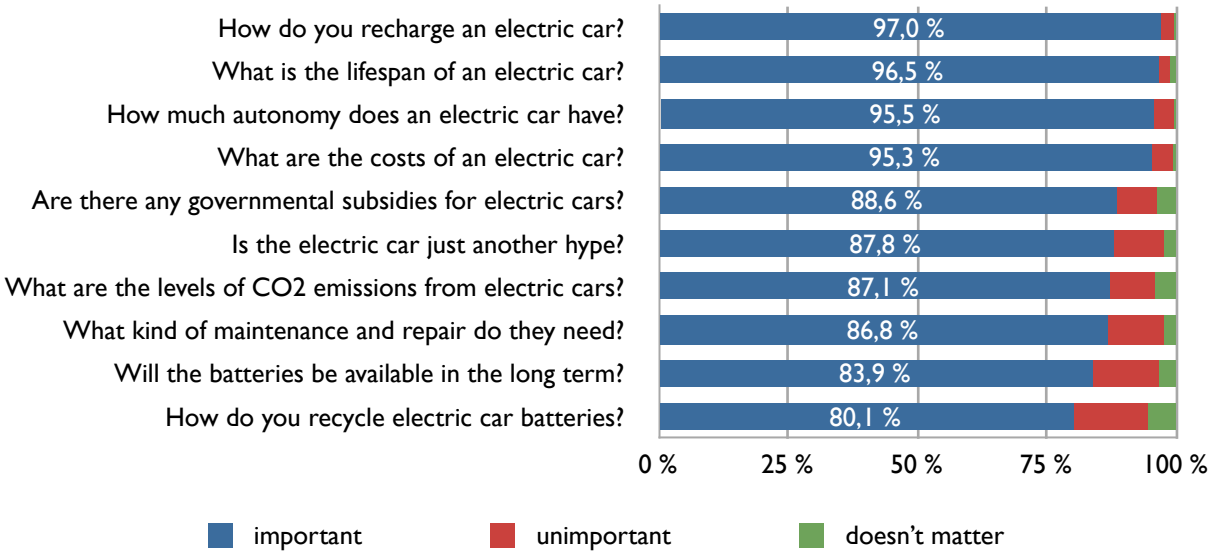


Figure 1: The ten most important questions about electric mobility

Number one on the list and therefore the question that generates the most interest is the question about how to recharge an electric car. The demand for information is also largely focussed around the life and autonomy of operating an electric vehicle. In turn, the survey frequently threw up questions about the price of the vehicles and the promotion of them in different countries. The participation of almost 4,000 respondents demonstrates the great interest in electric mobility and the number of people interested in learning more about the topic.

The survey helped us to discover the ten most common questions about electric mobility.

A brief overview

Currently, car dealers mainly feature cars with a conventional combustion engine. However, as this book will attempt to explain, they are beginning to understand that in the future, sales of hybrid and electric cars will grow. In this context, modern and alternative technology frequently appears as a series of concepts, parameters and names that you may have heard of but whose correct definition is not fully known. To prevent possible confusion and to provide clarity from the beginning, this chapter is an introduction to the subject and provides a concise perspective on these technologies, as well as explaining some of the new concepts.

Did you know that the first electric car was built in 1834 by Thomas Davenport? The vehicle was a prototype and did not have rechargeable batteries. When Carl Friedrich Benz introduced the first petrol automobile in 1885, the electric car was already known, but the low cost of fuel at the time meant that the combustion engine prevailed.

Source: http://de.wikipedia.org/wiki/ Thomas_Davenport

Even the manufacturers themselves have problems using the correct technical vocabulary. This is demonstrated in the official description of a product written by a British subsidiary of a US car manufacturer. It indicates an electric car battery with a capacity of 111 kWh (kilowatt hours), a fact which simply cannot be true. The car has 111 kW, a measurement that is used to indicate the electrical power more than to refer to the capacity of the electric car's battery. (see http://www.green-and-energy.com/blog/the-need-forclarification-around-evs/).

The main difference between cars with a combustion engine and an electric motor lies in the energy source used to enable locomotion. In combustion engines the energy sources are liquid or gaseous fuels derived mostly from fossils. Both oil and natural gas are accessible and finite resources. Additionally, access to these materials is restricted to certain regions which has generated a significant dependence on imports from the countries where the fuels are found. The need for these deposits has often resulted in political tension and even war.

For decades the increasing global demand and limited supply of these resources has led to a continuous increase in the price of petrol and diesel. Another basic argument against the use of fossil fuels is the environmental impact caused by their burning. For example, it is from carbon dioxide emissions that we get the so-called "Greenhouse Effect" that has been proven to cause climate change, resulting in many countries committing to reduce their emissions. Therefore, despite the claims that liquid and gaseous fuels can be obtained through Biomass, these methods have certain disadvantages. For example, to obtain the necessary amounts of Biogas and other Biofuels it would be necessary to turn to agricultural areas that are otherwise needed for food production. This is particularly problematic in those countries where food production and supply of goods for the general population is already difficult.

The facts outlined above demonstrate that the internal combustion engine alone does not represent the technology of the future, although at the present time it satisfies almost all consumer mobility needs. Unlike conventional vehicles, electric cars store the energy they need for their operation in chemical form in a battery. Cars with combustion engines also use batteries to store energy, not for traction but primarily for starting the engine. In this context they are described as "starter batteries". If the accumulated energy is used for the motion (traction) of the vehicle they are called "traction batteries". Traction batteries can store a much higher quantity of energy than the starter battery. An ordinary lead-acid battery is adequate for a starter battery, while the traction battery requires more advanced technologies such as lithium-ion or nickel-metal hydride (Ni-MH).

> Did you know that the CO_2 produced during the combustion of biofuels is almost the same as the amount a plant captures during its growth? For that reason, biofuels are CO_2 neutral.

The energy for the electric traction can be obtained through local and renewable energy sources. Thus, through electric mobility emission free mobility can be ensured. Another advantage is that the dependency on oil or gas producing countries is no longer existing. Therefore, the vehicle owner is not subjected to the costs dictated by the oil companies. If the electricity is not produced emission free, electric cars are responsible for CO_2 emissions which are not emitted into the environment from the vehicle, like conventional cars, but from the production process.

Along with the extensive number of utility companies there are also numerous methods of producing energy through both fossil and renewable sources, meaning that supply problems or dependence can be virtually eliminated. CO_2 emissions per kilowatt hours vary from country to country depending on the used power plants respectively used methods for the generation of electricity. The current emissions of different countries are shown in the figure below. France, with about 102 g of CO_2/kWh, is amongst the countries with the lowest specific emissions worldwide. This is because over 75 %[1] of the electricity is generated by nuclear plants which have relatively low CO_2 emissions when compared to plants fueled by coal, gas or oil.

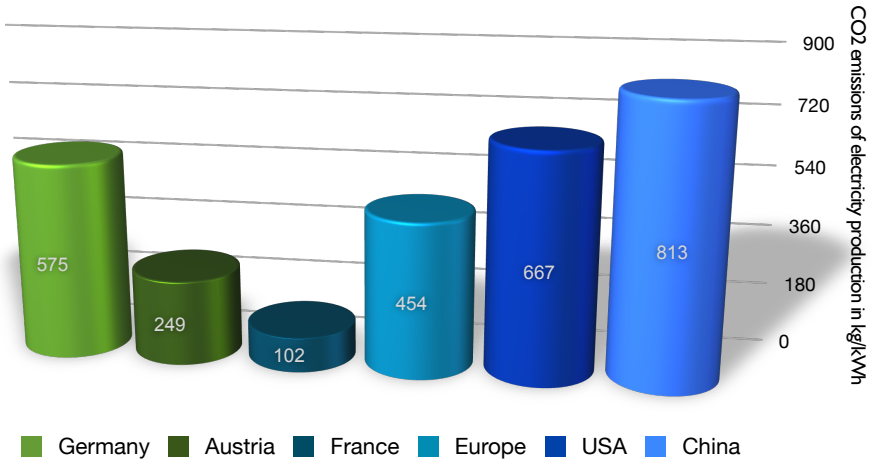


Figure 2: Specific emissions for electricity production in different countries[2,3]

1 http://www.world-nuclear.org/info/inf40.html

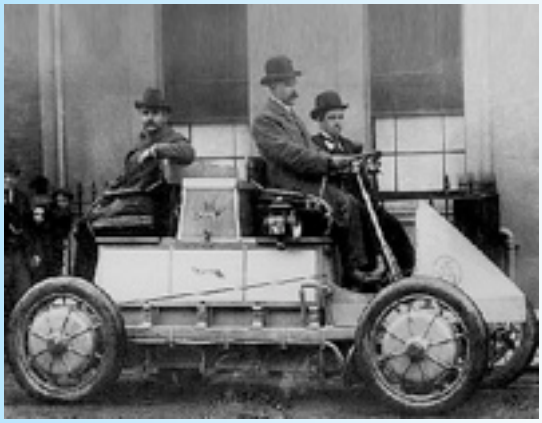
2 http://www.zukunft-elektroauto.de/pageID_8368817.html [GEMIS (2009)]

3 http://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0303.pdf

Due to technological advances and the growth of renewable systems, the average carbon dioxide emissions from power plants are continuously decreasing. Thus, the levels of CO_2 per kilowatt hour produced will also continue to decrease. Even if the electric cars are not recharged by electricity generated solely through renewable energies the emissions will still decline. The CO_2 emissions will be separately reviewed in Chapter 7.

Along with the pure electric cars that are slowly arriving on the market there are also hybrid cars that are already growing in popularity. The term "hybrid" generally refers to vehicle systems in which two or more technologies are combined. They have an internal combustion engine and an electric motor which make them a very attractive option, as apart from the lower energy consumption and therefore lower emissions of gases that cause pollution, they can be propelled purely through electricity even if only for relatively few kilometers. In this way you get the advantage of both technologies and compensation for the disadvantages of each.

Did you know that the vehicle known as the Lohner-Porsche was displayed at the Universal Exhibition in Paris in 1900? It was an electric car with the motor on the wheel hub. The image shows the racing version with the electric wheel hubs on all four wheels!



Source: http://de.wikipedia.org/wiki/Ferdinand_Porsche#Elektroauto_Lohner-Porsche

Did you know that the Greenhouse Effect is caused by greenhouse gases like CO_2 or methane. The greenhouse gases constrain the transmission of the suns rays reflected by the earths surface, which leads to rising global temperatures. Scientists as well as politicians came to a worldwide agreement that the extreme characteristics of the current greenhouse effect and therefore global warming is caused by the emissions created by humanity.

The electric motor is, in terms of efficiency, superior to the combustion engine. An electric motor has an efficiency factor of circa 95 % or more whereas a modern diesel powered engine only has a maximum efficiency of about 35 %. Depending on the driving characteristic and the route profile (for example driving in city traffic), this value is further reduced by a couple of percentage points and most of the fuel is used to heat the atmosphere rather than to propel the vehicle.

Another advantage of the electric car is the ability to recover the kinetic energy during braking. Braking, which has been a purely mechanical process up to now, can be also accomplished through electromagnetic forces that generate electricity and recharge the battery. This is known as "recuperation" and is particularly effective when driving in city traffic.

Currently there are many different configurations in the world of hybrids. They differ according to the various traction components as well as the degree of electrification of the vehicle. The variety reaches from Micro-Hybrid electric cars with only a "Start and Stop" function to electric cars with a so called Range Extender, which could be a small engine or fuel cell. The Range Extender generates electric energy while driving in order to recharge the battery or to directly drive the electric engine.

In a pure electric vehicle (EV) the engine is omitted. The car is equipped exclusively with an electric motor powered only by the battery.

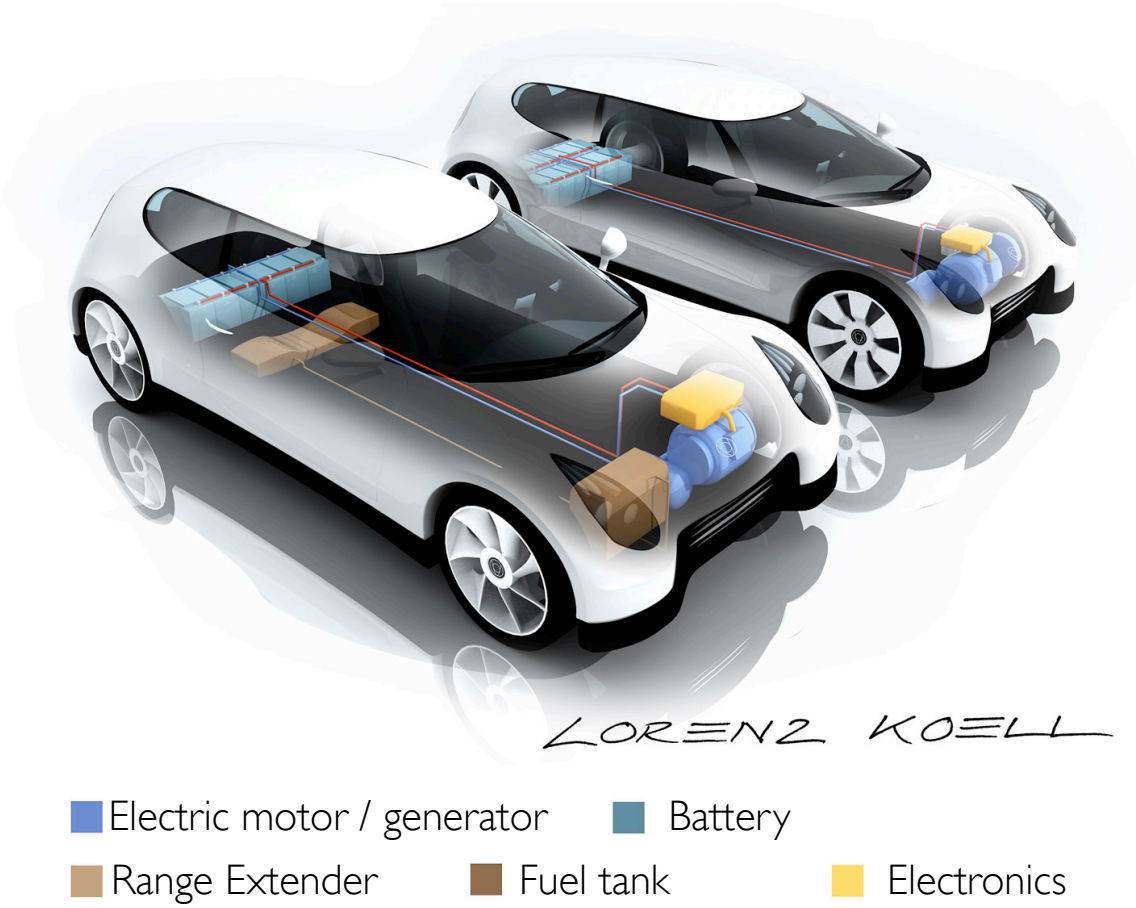


Figure 2: Hybrid car (left) and a pure electric car (right)

1-How do you charge an electric car?

What are the different ways to recharge an electric car?

Currently there are no standardized methods for charging electric cars, but we assume this will change soon. Generally there are three main ways: conductive charging, inductive charging and by changing the battery.

Using the conductive method the car (battery) is connected by a cable and plugged directly into an electricity provider. The inductive method, in contrast, works through electromagnetic transmission without any contact between the EV and the charging infrastructure. The charging spot is equipped with wires which carry an alternating current as soon as the EV is at the right place. The alternating current creates an electromagnetic field, which affects the receiver (also consisting of wires) in the EV in a way that a current is induced and charges the battery. This method is the same as that used to charge electric toothbrushes.

Currently, both the automotive industry and operators of charging stations prefer conductive charging because it is much cheaper and more efficient. Yet there are several R&D projects which focus on the further improvement of inductive charging, because it offers a way better user comfort and could be a key feature for electric mobility.

The third possibility takes into consideration the swapping of discharged batteries with fresh ones in a swapping station. This concept is being developed today by, amongst others, an Israeli company. However for this to be possible the dimensions and internal connections for the batteries must be standardized. Each electric car from each manufacturer would have to have virtually the same size, shape and type of battery. As this reduces the OEM's freedom of design and given that the choice of placement of the battery would be severely reduced, most of the manufacturers reject this method.

How long does it take to charge the batteries?

The time required to recharge the batteries depends on several factors. Firstly- the available power from the grid and the state of charge of the battery. Secondly, there are the specific characteristic values of both the car and the battery such as the battery type, the cooling system and the maximum permissible current.

For example, a conventional household outlet in Europe can achieve an output close to 3.5 kilowatt (kW) (Analog to Level 1 charging in USA, with 2 kW). Therefore, a battery with a capacity of 3.5 kilowatt hours (kWh) can be charged in one hour, regardless of any energy losses and other effects during the charge. This means that the procedure for charging a 20 kWh traction battery takes around 6 hours (in USA with Level 1 10 hours). However, a high voltage power port supplies around 22 kW (Level 2 charging) so the same battery would be fully charged in around 50 minutes. This fast load can only be guaranteed in facilities that have been technically upgraded for this purpose which

represents a considerable expense. Furthermore, the current battery types still react sensitively to variable charging methods and therefore these methods of fast charging are not yet standard.

It could be that the implementation of fast charging infrastructure would be a result of simply putting it in the public's consciousness, to demonstrate to the users that fast charging is possible and that additional unscheduled trips could be fulfilled. Vehicles are generally used every day and owing to the average distances travelled and the time the vehicle is parked etc., a level 1 charging installation should suffice in a majority of cases.

As for the amount of energy recharged there are two reasonable possibilities: A complete charge to 100 % or an 80 % charge. An 80 % charge is recommended when the process needs to be finished in a hurry and if you are not going to make long journeys afterwards. The problem with charging the batteries is that the charging of the last 10 or 20 % is slower and produces more losses in the form of heat. The following figure can help to explain the influence of load power during the process of recharging car batteries.

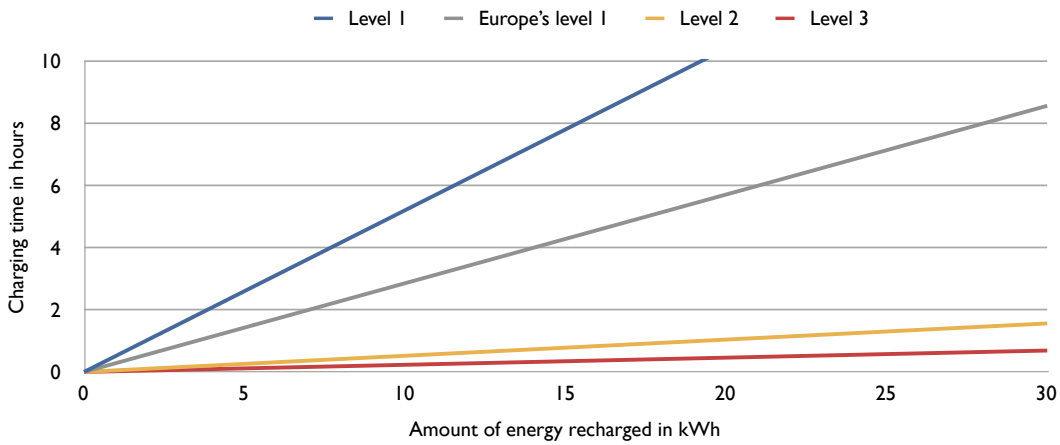


Figure 3: Time necessary for the charging process depending on the charging power and the amount of energy required.

Battery swapping would be, in terms of time demand, probably the best way to provide a full battery. With the technologies available today it would just take around a minute to get a fresh one. The downside of this technology is it's high cost. It would involve not only a new and expensive infrastructure (the swapping stations) but you would also need a certain amount of costly batteries for the exchange. It would also be necessary to standardize batteries to be compatible with all car models and because of this the removable battery system is rejected by many OEMs as well as many investors in this sector.

Did you know that you would have to pay about 10,50 € for a 100 km drive with a conventional car (for an average fuel consumption of 7 l/ 100km and a fuel price of 1,50 €/l)? With an EV the cost would just be around 4 € (for an energy demand of 20 kWh/ 100km and a price of 0,2 €/kWh).

The recharging time is one of the most important aspects in the discussions about electric mobility. A look at the average use of the car[4] demonstrates that a large part of the vehicle's lifetime is spent off the road so in most cases fast charging is not necessary. Furthermore, most of the every day journeys in Germany and Europe are below 50 km and could easily be fulfilled by electric vehicles despite the range limitation.

4 Grau, A.: Pendler: Die Mehrheit nimmt weiter das Auto, Statistisches Bundesamt, Wiesbaden, 2009