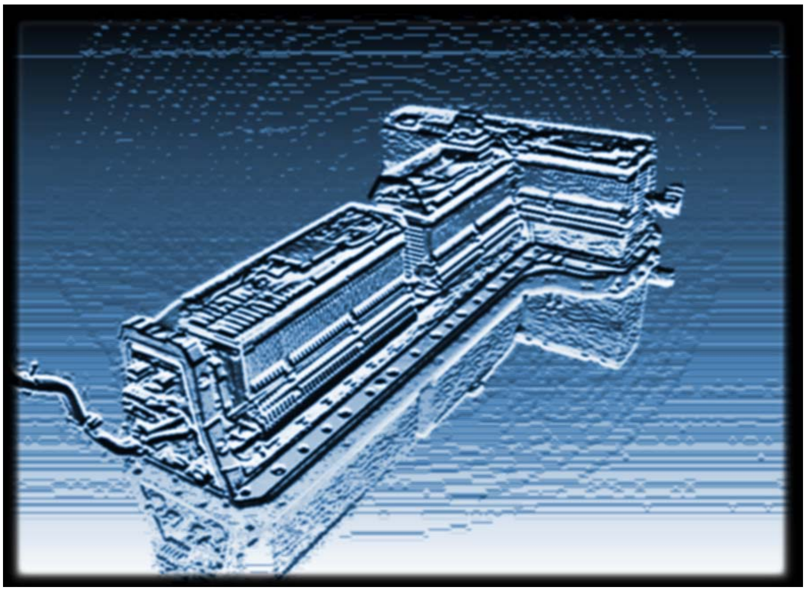
SUSTAINABILITY IN ELECTRICAL TRANSPORTATION



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PREFACE

I would like to thank all the people that contributed to this project. I am especially thankful to Javier Palacio, Iván Lozano and María Antón from Spain. Your help in the good, bad and even worse moments, and the provided information contributed a lot to the accomplishing of the project.

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Finally I want to thank my supervisor, Mr. Bauke W. Kuiper, and Mr. Roeland Waterlander, for the feedback that helped me finish the project. It was a really positive experience to work in a foreign country.

SUMMARY

The interest in electric vehicles is growing all over the world because of fuel price variations, uncertainties in the future oil availability and increased attention for environmental issues.

The dependence on fuel is a reality that can be observed anytime, anywhere. Nearly every product we use is related to this energy source and, as it is limited, it is wise to think of alternatives to it.

Electric cars offer a reduced dependency on fuel, less CO2 and PM10 emissions and last but not least lower powering costs because of their higher efficiency.

The Netherlands offer cost advantages over the construction of some kind of energy infrastructure because it is a very densely populated country, so it is interesting to consider some kind of transition to electric cars.

However, the electricity used to power the electric cars can be obtained from a lot of different ways. This study will show some light over the question of whether the electrical vehicles are such a sustainable mean of transportation as they are commonly thought to be.

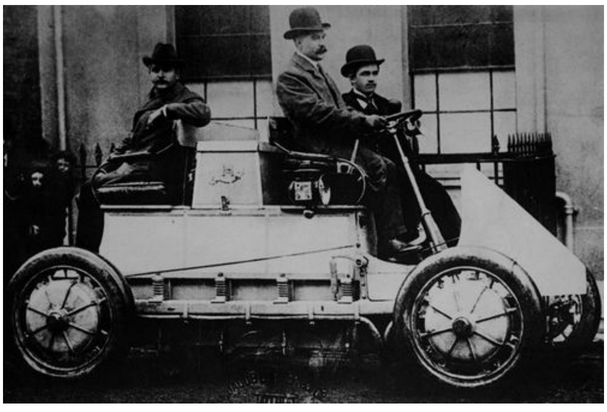
Generating electricity is usually polluting, but the main question is: Is it better or worse? The study is going to be done at three levels. The first level will compare the environmental impact that both fuel powered and electric vehicles have. The second level will be focused in terms of efficiency and the third one will study the economical aspects of the comparison.

1- TABLE OF CONTENTS

2- HISTORICAL REVIEW OF ELECTRIC CARS

Electrical vehicles are not a new concept in history as a mean of transport. Just after the use of the steam machines and with the creation of the electric battery by Alessandro Volta in 1800, some curiosity for running vehicles on this new energy source arose. Around 1830, Joseph Henry, a mathematics professor in Albany, NY invented the first rudimentary DC motor based on the studies from Oersted and Ampère some years before. Some years after that, Thomas Davenport used the concept from Henry and made it spin, seeing it as a possible replacement for steam to drive locomotives. Some scale models were made at that time in other parts of the world (Professor Sibrandus Stratingh and Christopher Becker, Holland, 1835). Moses Farmer created the first electric vehicle for two passengers in 1847, powered by Grove cell batteries. Over the 1850s the electrical vehicle (EV) reached a speed of 20 mph and in the following decade, a rechargeable battery was also added.

Going back to Europe, in 1881, Charles Geantaud and Camille Fallure (France), and Thomas Parker (Britain), in 1884, built their own electric vehicles (EVs). Other important names at this time would be J.K. Starley (Britain), founder of the Rover Company, who also experimented with an electric powered three-wheeled car, and Ferdinand Porsche (Germany), who invented a battery powered hybrid car with four motors, one on each wheel.



Lohner-Porsche, the 4-motor hybrid vehicle made by Porsche.

By the late 1800s and the early 1900s, commercial electric powered cars had the majority of the motor car market, outselling petrol and steam powered vehicles. For instance in 1899, 90% of the taxi-cabs in New York City were electric, and by 1904 one third of all the cars in Chicago, New York City and Boston were electrically powered.

1919 electric car at a "re-charging station."

However, the popularization of petroleum and its different uses changed the perspectives of using the electrical cars. At that time the crude oil was at a really low price, it and has to be mentioned that the batteries were very expensive because of the materials they were made of. These batteries had a much shorter lifetime than the mechanical components. That is why around 1908, Henry Ford, knowing about the growing popularization of oil, started the building of the internal combustion engine vehicles (ICE). From that point on, it was launched at a price of $850, the famous model T by Ford, which covered longer distances than electric vehicles, using a source of energy which was really cheap at that moment.

General Motors would be the last manufacturer of electric vehicles, which stopped building them by 1916. Actually, the peak of the production of electric vehicles was reached in 1912.

The use of ICE vehicles would increase even more just after the World War II. At that time, in the 1950s, gasoline was even cheaper than water, and much easier to get. That is why EVs were left aside and the use of ICE vehicles increased rapidly.

But the extensive use of petroleum products caused the price to rise dramatically in this period. By the 1973 oil crisis the idea of EVs arose again, as an alternative to the use of oil. Even at that decade the ecological problems caused by fuel burning were foreseen. That is why some countries such as England and Japan see EVs as an alternative to the use of ICEVs.

However, some years later, in the beginning of the 1980s, the price of oil stabilized so the interest on EVs was lost again. In the early 1990s users were aware of the environmental damage produced by the CO_2 and there was evidence of the near future shortage of oil in certain regions of the planet. For the third time arose the figure of the EV, but now with advanced electronic components, being much more efficient than the former ones. Despite being the laggard in the first run of these vehicles by 1900, GM was the one who presented the first new prototypes of these vehicles with the approval of legislation for the development of EVs. It has to be mentioned that there was no law to control the development of these vehicles so they could not be produced for use on U.S. soil in spite of having sent a vehicle of this type on the lunar space mission Apollo 17 in 1970.

Thus, GM began the commercial sale of these vehicles trough environmental conservation campaigns. In 1990 the GM Impact electric vehicle was created, but its price was only accessible to the government, which bought all the 50 units that were built for internal use. During this decade, BMW ends up taking over the sale of these cars in Europe, so does Nissan in Japan.

GM EV1, built in the late 1990s

In the late 1990s the next generation of vehicles was developed. Those were the hybrid vehicles, which combined different aspects from the previous vehicles- i.e. the ICEVs. and the BEVs- and have been developed until now. They have some clear advantages that have to be remarked:

Hybrid vehicles have a longer range than the electric vehicles, due to the fact that they can run on batteries and fuel and therefore their efficiency is bigger.

As they can run on electricity for short distances (the range of the batteries is very limited) they save a lot of fuel in city trips, compared to internal combustion engine vehicles (ICEVs).

As they are not full electric, they usually do not need a special infrastructure to be powered (The BEVs do need it).

But as well as the hybrid vehicles have some good aspects from the ICEVs and BEVs, they have some noticeable disadvantages caused by the fact of being dually-powered:

The hybrid vehicles are heavier, not only because they have both electric motor and combustion engine, but also because of the weight of the energy sources.

They also need more maintenance than the electric vehicles (which have more endurable motors than fuel powered cars).

Having 2 types of machinery in a single vehicle raises the powertrain costs and complexity to a great extent.

3- COMPARATIVE STUDY

3.1- ENVIRONMENTAL IMPACT-LCA DISCUSSION

In order to compare both types of vehicles it is mandatory to establish all the parameters so that a comparison is possible. Thus, it is necessary to choose a reliable method of study in order to make realistic conclusions.

Only in that case a clear answer can be given to the question of whether the electrical vehicles are more efficient or not. And in case they were, if the need for batteries would overcompensate their bigger efficiency.

3.1.1- METHODOLOGY

LIFE CYCLE ASSESSMENT

The life cycle assessment (LCA) studies the environmental aspects and the potential impact along the life cycle of a product or an activity.

The life cycle considers the whole 'history' of the product, from its origin as a raw material until its end as a residue, including the recycling possibilities. All the intermediate steps like the transportation and preparation of raw materials, manufacturing, transportation to markets, delivery, use, etc. are taken into account.

In a full LCA, all the environmental effects caused by consumption of raw materials, usage of energy for manufacturing, emissions and waste generated in the production process, are assigned to the products, as well as the environmental effects when the product is consumed or can not be used anymore.

Therefore the LCA is a kind of environmental accountancy in which the products are charged with the adverse environmental effects that have been generated along their life cycle

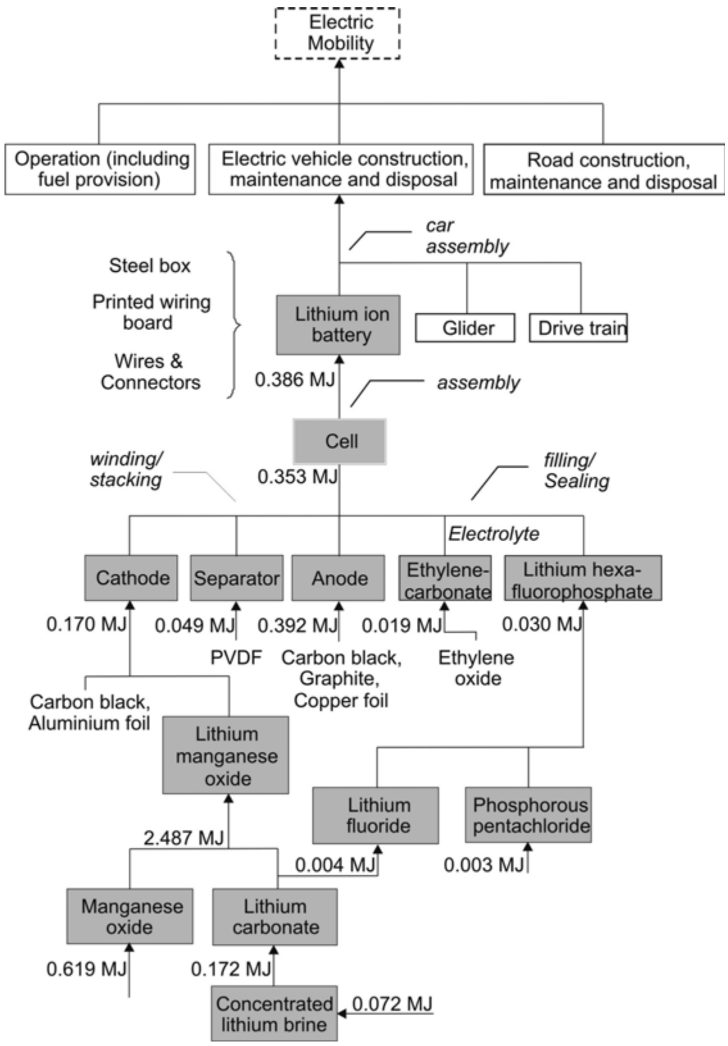
3.1.2- DETAILS OF THE MODEL

In the following lines the model and the manufacturing processes of the batteries will be described and discussed. Most of the specifications and parameters have been extracted from "Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles" (Ref 5).

BATTERIES

The type of battery modeled for this study is a $LiMn_2O_4$ battery. It has been done this way assuming that nickel and cobalt - which are commonly used in many of today's batteries – are scarce materials in the earth's crust. This makes them more expensive, so they will be substituted in a near future by manganese, which has a better availability and is consequently cheaper.

The following figure shows all the production steps needed to manufacture an electric vehicle, focusing in the Li-ion battery and its different parts. It covers the extraction of lithium and the electrode production to the battery pack, the components of the electric vehicle, and the mobility with the electric vehicle. For all production steps, the required thermal and electrical energy to produce a 1 kg Li-ion battery has been calculated. The mass parameters used for the calculation are based on a battery manufactured by the firm Kokam (Ref 10) and the cathode is made of $LiMn_2O_4$.



Scheme of the manufacturing steps of an electric vehicle, focusing on the batteries and its parts.

ELECTRIC VEHICLE

The electric car represented in this LCI (Life Cycle Inventory) was derived from the existing Golf LCI. The glider (chassis, car body parts, wheels, interiors, safety devices, acclimatization devices) remained unaltered, but the drivetrain was replaced by an electric drivetrain (composed of the electric power control, an electric motor and the transmission) and by a Li-ion battery. It had the following specifications:

- Range of around 200 km/charge.
- Battery weight, 300 kg.
- Battery capacity, 0.114kWh/kg·battery.
- Lifetime of 150.000 km.

Furthermore, some assumptions had to be made in order to have the cars in the same conditions:

- Extension of vehicle life to 240.000 km. This implies a battery replacement.
- Energy consumption is assumed to be 14.1 kWh/100km. This energy consumption refers to a combination of the urban (12.8 kWh/100km) and extra-urban (16.8 kWh/100km) Data based on existing vehicles with similar specifications.
- Overall efficiency of 80%. This includes charging losses and recuperation gains.
- The reference driving cycle is the NEDC (New European Driving Cycle, see Appendix 1).

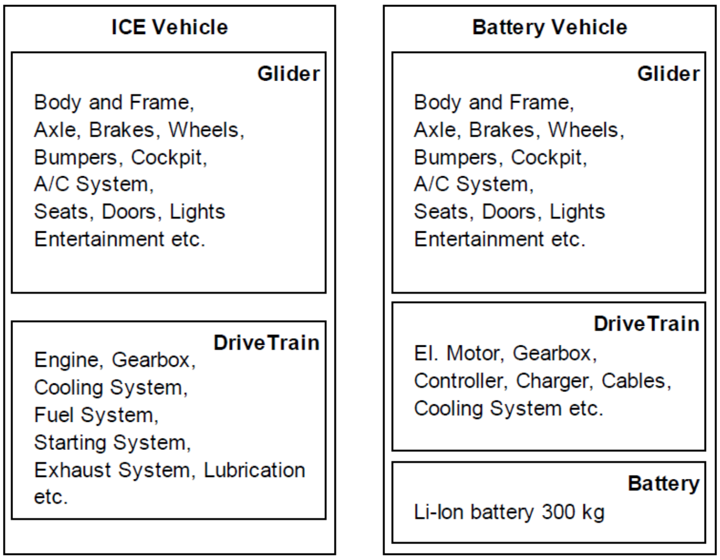
- Heating, cooling, and electronic devices consume in average 2.9 kWh/100 km.
    - Auxiliary energy consumption for heating accounts for 2 kWh/100km. assuming that there is a heating demand of four months within a year.
    - It is assumed to need 0.5 kWh/100 km electric energy for air conditioning.
    - Other electricity consumer need 0.5 kWh/100km based on the assumption that each of these consumers is utilized during 50% of the time the BEV is in use.
- The BEV thus requires in total 17 kWh/100 km.
- In order to fully understand the importance of the fuel consumption and to take into account possible deviations (e.g. aggressive driving style, etc.) the energy demand was varied in a ±20% range.
- The environmental burden caused by the use of the car in the diagram (p. 13) will consider both the infrastructures needed and the electricity consumption.

REFERENCE VEHICLE

A new efficient gasoline car (Euro 5 standard) was chosen as a reference ICE vehicle for comparison. It consumes 5.2 L of gasoline per 100 km in the NEDC, which leads in a direct emission of 0.12 kg CO_2 per km. It did not represent either the European fleet or the fleet of new cars sold in Europe in 2009, but it was chosen to represent a technological level similar to that of the BEV.

ADDITIONAL GENERALITIES

The following figure represents the main parts in which the car has been divided in order to get a fair comparison in terms of space, comfort and top speed.



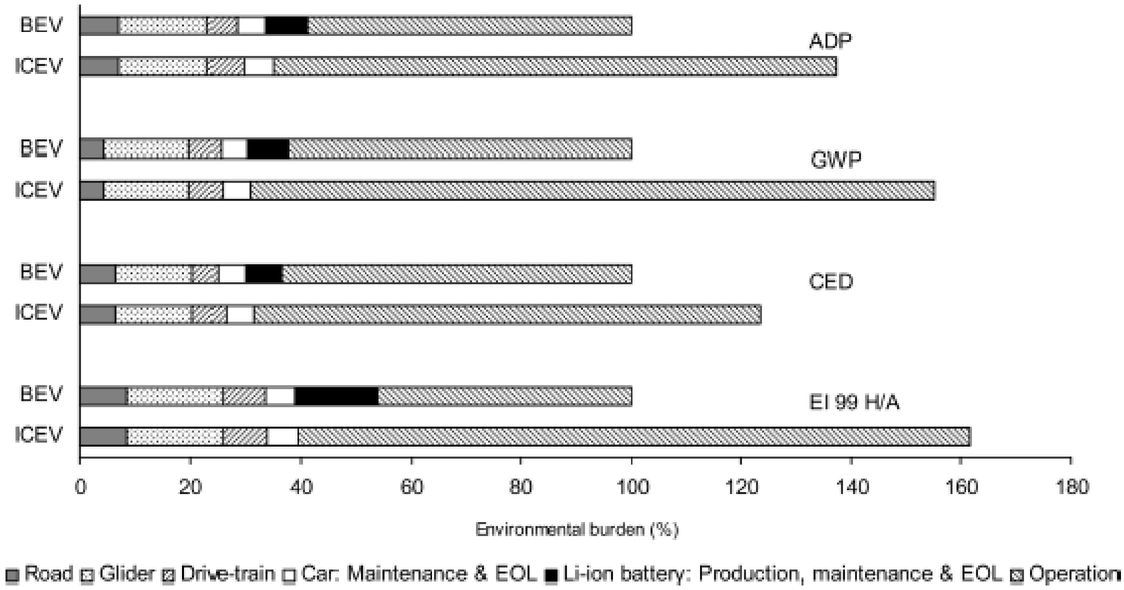
Different parts of the cars modeled in the LCA

All of the data have been extracted from the same ICE vehicle, a Volkswagen Golf A4, so the glider is a common part for both of them. However, all the sub-components constituting the ICE drivetrain were subtracted from the dataset, and substituted for a set of components that would compose a 55 kW drivetrain plus the batteries.The main differences between them appear in:

- Acceleration
  - BEV: 85 Nm nominal torque, maximum 223 Nm.
  - ICEV: 128 Nm maximum torque.
- Driving autonomy
  - ICEV approximately 940 km with 50 litre-tank and 5.2 litre /100 km (fuel energy approx 47 kWh/100km).
  - BEV approximately 200 km with 34 kWh battery and 17 kWh/100 km).

3.1.3- RESULTS AND CONCLUSIONS

The following figure shows the environmental burdens, assessed by four different methods:



Environmental impact of BEVs and ICEVs, divided in shares.

- GWP (global warming potential): It measures how much heat a GHG (greenhouse gas) traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount heat trapped by a similar mass of carbon dioxide. In this case, the GWP has been calculated over 100 years.

- CED (cumulative energy demand): This approach addresses the entire product lifecycle, from materials and production to operation and recycling, in terms of energy consumption. In this study only the fossil fuel and nuclear energy are considered.

- EI 99 H/A (Ecoindicator 99): It measures the environmental impact from various points of views. This one uses the hierarchic perspective, which includes the effects on human health, the quality of an ecosystem, and the fossil and mineral resources.

- ADP (abiotic depletion potential): This scale refers to the resource depletion and it focuses on the use of resources, especially metals.

After explaining the four methods used to compare both cars in an environmental point of view, some results and conclusions come up.

	EI 99 H/A points		CED 10^3 MJ eq.		GWP 10^3 kg CO_2 eq.		ADP kg Sb eq.	
	BEV	**ICEV**	**BEV**	**ICEV**	**BEV**	**ICEV**	**BEV**	**ICEV**
Total	1570	2530	480	593	24.3	37.7	190	261
Road	134	134	31.7	31.7	1.08	1.08	13.7	13.7
Glider	270	270	66.5	66.5	3.74	3.74	30.4	30.4
Drive-train	120	127	21.9	27.8	1.35	1.46	9.68	12.2
Maintenance, disposal car	81.5	84.4	23.7	24.0	1.14	1.17	9.80	10.1
Li-ion battery	240	0	31.2	0	1.80	0	14.6	0
Operation	720	1920	305	443	15.2	30.2	112	194

Environmental burden assessed with EI 99 H/A (unit: points), non renewable CED (unit: MJ equivalents), GWP (unit: kg carbon dioxide equivalents) and ADP (unit: kg antimony equivalents).

From the figure and the table above we can state that there are no differences in road use and glider. But this is just a logical consequence of the similarities between the modelling of the cars. Furthermore, the differences related to the maintenance, disposal and the drivetrain are nearly negligible (they are slightly favourable to the BEVs, but they do not make a big difference).

So the main difference between both types of cars is shown in the operation phase and the batteries. This can be seen not only in the reference study (Ref 5), but also in other studies which conclude the same (Refs 2, 3 and 4). So the operation phase is the dominating part in the LCA.

Anyhow, an analysis of the whole vehicle life (i.e. 240.000 km) shows a small decrease of the total environmental burden per vehicle-kilometre. That reduction would be of about 7-8% in both cases, being slightly superior for the BEV, and would also imply a change of battery set.

Besides, a variation of a ±20% in the electricity consumption (i.e. 0,14-0,20kWh per km) would lead to a variation of the environmental burden of approximately 8%.

Another important point in these considerations about the impact of transportation would be about the generation of electricity.

The generation of electricity was considered to be as it is in the European electricity mix. In case all electricity was generated by hard coal, the environmental impact would increase approximately a 13%, and if it was generated by hydropower plants, the reduction would be of around a 40% approximately, which would represent less than a 10% share in the operation phase (All the assumptions have been done using the method EI99 H/A).

Now going to the batteries, it has to be remarked that lithium-ion batteries do not play main role in the environmental burdens – 7 to 15% depending on the method used – due to the fact that lithium represents a small part of the battery (0,007 kg Lithium per kg of battery).

That is why its scarcity in the Earth’s crust is not a big problem (it represents the 0,001% of the whole).

It is assumed that all these conclusions are made under the premise that all the lithium is extracted from brines so that no additional energy is required (it only uses the fuel to be pumped to the surface). However, as any mining process, it keeps on being environmentally aggressive (see appendix 2).

From the points mentioned above certain advantages of the BEV over the ICEV are foreseen. However, some solutions can be proposed in order to make these advantages even more attractive from an efficiency point of view.

As it was mentioned before, a change in generation would lead to a huge reduction of the environmental burdens. The study has been made without considering a possible generation of electricity from renewable energy sources – otherwise the cars would not be in the same conditions to be compared – so this point has also to be taken into account.

The study has been made in a worst-case scenario so no advantages have been taken from a possible recycling of the parts of the cars.

According to Ref 1, the recycling of the battery materials would imply about a 51% saving in natural resources for the battery components.

So it is clear that the environmental burden of lithium batteries do not overcompensate the benefits of electrical mobility, and considering the whole lifetime of the vehicle (manufacturing, use, disposal and recycling), BEVs are environmentally more beneficial than ICEVs.

3.2- ENERGETIC EFFICIENCY

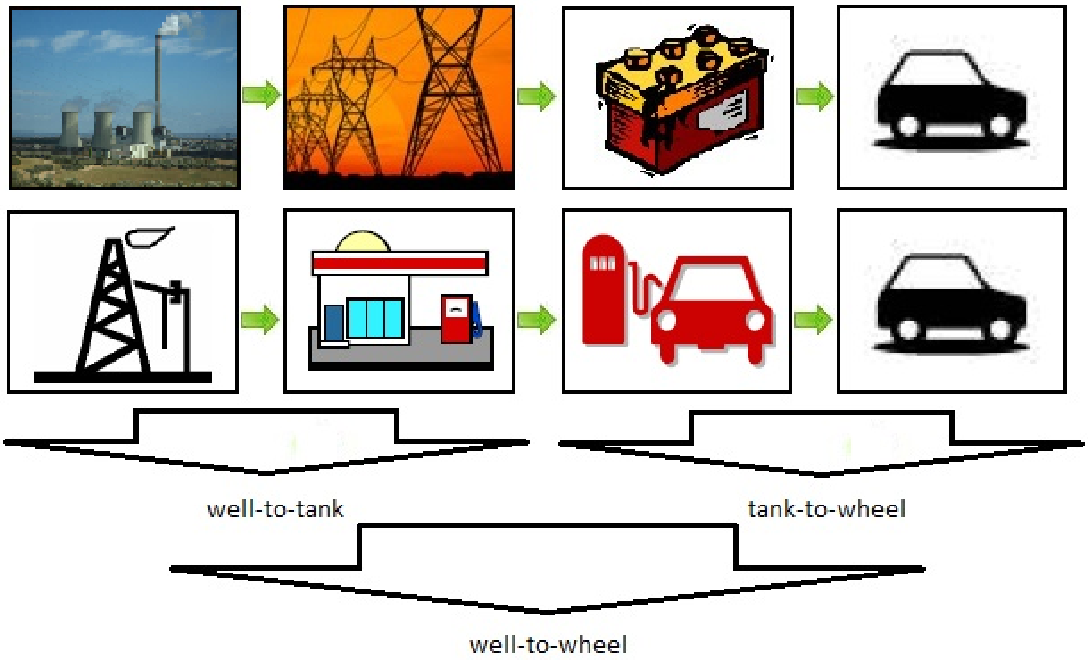
3.2.1- INTRODUCTION

It is logical to think that the energetic efficiency of a vehicle is a very variable parameter. It varies depending on the way of driving and external conditions (weather, road conditions, etc), but also in the case of BEVs, the energy source used for generating the electricity changes the average efficiency of the whole vehicle enormously. That is why while talking about energetic efficiency, it is mandatory to difference some types of efficiency:

- Well-to-tank efficiency: This concept would be referred to the efficiency of filling up the deposit with fuel or the batteries with electricity. In this case it will consider non-renewable sources (i.e. coal, petrol and gas. No nuclear plants are considered)

- Tank-to-wheel efficiency: This concept is referred to the efficiency of the car itself, that is, from the chemical energy inside the batteries/fuel tank to the amount of kilometres that can be driven.

- Well-to-wheel efficiency: This efficiency would join the two previous concepts so both types of vehicles can be compared under the same conditions. It would take into account the whole efficiency from the primary energy source to the movement of the vehicle.



Scheme of the different efficiencies considered in a vehicle use.

3.2.2- EFFICIENCY IN ICEVS

While referring to the efficiency in this kind of vehicles, it is a very interesting to make a difference between diesel and petrol, due to the fact that the average well-to-wheel efficiency is different from one type of ICEV to the other.

- According to different organisations, such as Going-Electric and the U.S. Department of Energy (Refs 6, 7), the well-to-tank efficiency for an ICEV is around 83%. This includes the energy used in the production, refining and transportation of the fuel.

- While looking at the tank-to-wheel efficiency, the percentages vary slightly, as long as this parameter is really dependent on traffic conditions and the way of driving. Nevertheless, the efficiency varies between 16-18% for petrol vehicles, and for diesel vehicles, those percentages increase up to 18-22% for diesel vehicles (Refs 6, 7).

- According to the previous references and using the results previously obtained, the well-to-wheel efficiency for an ICEV is:
  - For petrol cars:

($\eta_{total} = \eta_1 \cdot \eta_n .. \eta_n$) 16%*83%=13%

18%*83%=15%

Obtaining an average value of 14%.

  - For diesel cars:

18%*83%=15%

22%*83%=18%

Obtaining an average value of 17%.

These calculations were made in ideal conditions, so in real conditions the percentages would be lower, but the results give a useful approach that make the comparison possible.

3.2.3- EFFICIENCY IN BEVS

Well-to-tank efficiency is highly variable depending on the way the electricity is generated (data in generation from ref 7).

- Conventional coal power plants have an efficiency range of 30-40%.
- Combined cycle power plants with integrated gasification have a higher efficiency, 50-55%.

- Combined cycle gas power plants are 50-60% efficient.
- Combined systems where all the heat is re-utilised can reach efficiency values up to 90%.

Although the efficiency range is very wide, it is commonly considered a 40% as an average value of generation efficiency.

Apart from generation, the efficiency on electricity transportation has to be taken into account. Different sources differ a bit in the range of the value, but an average 92,5% can be used for the calculations (as it is a valid percentage according to refs 7 and 8).

Then, according to the previous data, well-to-tank efficiency for a BEV is:

92,5%*40%=37%

As well as ICEVs were separated in petrol and diesel, electric vehicles are going to be separated by the most common types of battery, that is lead-acid and lithium batteries. That would make possible to calculate the tank-to-wheel efficiency:

- In the case of lead-acid battery cars, the average tank-to-wheel efficiency is 62% (55-65%, ref 7).
    - The charger is around 86% efficient.
    - The charging cycle has an efficiency of 80%.
    - The electronic motor management has an efficiency of 97% (ref 7).
    - The electric motor is 92,5% efficient (ref 7).

So the average tank-to-wheel efficiency would be:
86%*80%*97%*92,5=62%

- For lithium battery cars, the tank-to-wheel efficiency is around 72% (65-80%, refs. 7, 9).
  - The charger is around 89% efficient.
  - The charging cycle has an efficiency of 90%.
  - The electronic motor management has an efficiency of 97% (ref 7).
  - The electric motor is 92,5% efficient (ref 7).

So the average tank-to-wheel efficiency would be:
89%*90%*97%*92,5=72%

Therefore, the average well-to-wheel efficiency for BEVs is:

- 37%*62%=23% for lead-acid battery cars.
- 37%*72%=27% for lithium battery cars.

	BEV		ICEV	
	Lead-acid	Lithium	Petrol	Diesel
Well-to-tank	37%	37%	83%	83%
Tank-to-wheel	62%	72%	18%	22%
Well-to-wheel	23%	27%	14%	17%

Efficiencies in the BEVs and ICEVs

3.2.4- CONCLUSIONS

From the results previously calculated we can see some clear conclusions.

Even in non-optimal conditions, the BEV has a higher efficiency (At least 6% higher). This difference in the percentages would be much bigger if renewable and nuclear energy sources were considered (Assuming a well-to-tank efficiency of 100% when using a renewable energy source, the difference would be of a 58%, since the well-to-wheel efficiency would be in that case a 72% for lithium BEVs).

According to Going-Electric, electrical infrastructure will not require a major change until the amount of electric cars reaches 20-25% of the whole vehicle fleet.

Furthermore, if electric vehicles were systematically used for city driving, the results worldwide would be very noticeable. Around 20% of oil production would be saved. Furthermore, urban pollution and traffic noise would be enormously reduced.

Energy source	Non renewable		Renewable	
Type of vehicle	Petrol ICEV	Lithium BEV	Petrol ICEV	Lithium BEV
Well-to-tank	83%	37%	83%	100%
Tank-to-wheel	18%	72%	18%	72%
Well-to-wheel	14%	27%	14%	72%

Major differences in efficiencies depending on the sources of energy

3.3- ECONOMIC COMPARISON

3.3.1- INTRODUCTION

This part of the study will give a clear answer to the question whether electric cars are economically profitable or not. The economic comparison between BEVs and ICEVs is going to be conducted in three different stages.

In all those stages, four cars are going to be presented. Two of them are representatives of the so called city cars. One of them is an electric model, and the other one is a fuel efficient diesel car. The other two cars are representative models of the family cars sector. As in the previous case, one is going to be diesel and the other one electric.

3.3.2- PRESENTATION OF THE VEHICLES

The main specifications of the vehicles are shown in the following lines:

- Mitsubishi I-Miev (electric car, 2011, See Appendix 4)
    - Power 48 hp/ 35 kW.
    - Dimensions: 3,475/ 1,475/ 1,610 m (L/ W/ H).
    - Range 150 km.
    - Consumption 0,135 kWh/km
    - Battery capacity 16 kWh.
    - Local emissions 0 g CO_2/km.
    - Price (ex VAT) 26.592 €

- SEAT Ibiza (1.2 TDI Reference E-ecomotive, 2011, See Appendix 5)
    - Power 75 hp/ 55 kW.
    - Dimensions: 4,052/ 1,693/ 1,439m (L/ W/ H).
    - Fuel consumption (mix) 3,4 l/ 100 km.
    - Tank capacity 45 l.
    - Local emissions 89 g CO_2/km.
    - Price (ex VAT) 12.695 €

- Nissan Leaf (electric car, 2011, Appendix 6, ref 12)
    - Power 109 hp/ 80 kW.
    - Dimensions: 4,445/ 1,770/ 1,545 m (L/ W/ H).
    - Range 175 km.
    - Consumption 0,137 kWh/km
    - Battery capacity 24 kWh.
    - Local emissions 0 g CO_2/km.
    - Price (ex. VAT) 29.403 €

- Opel Zafira(1.7 CDTI ecoFLEX, Appendix 3)
    - Power 110 hp/ 81 kW.
    - Dimensions: 4,467/ 1,801/ 1,635 m (L/ W/ H).
    - Fuel consumption (mix) 5,1l/ 100 km.
    - Tank capacity 58 l.
    - Local emissions 134 g CO_2/km
    - Price (ex VAT) 17.137 €

3.3.3- ASSUMPTIONS FACING THE CALCULATIONS

The calculations for the study were made under the following assumptions:

- The price of electricity in the Netherlands is 0,19 €/kWh, and the price of diesel is 1,36 €/l (Ref 11).

- Both prices are supposed to remain as a constant parameter (i.e. neither the price of electricity nor the price of diesel is supposed to rise).

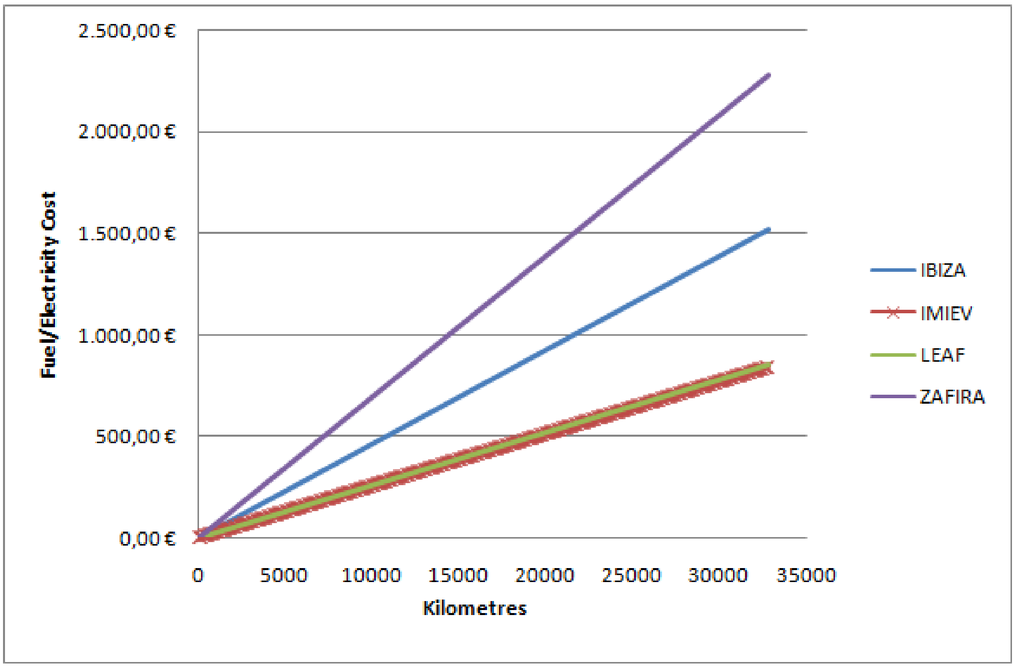
- The different calculations will be done under two different hypotheses:
  - The average daily distance for a dutch driver accounts for 18 km. That would mean 6.750km per year. The first hypothesis will be based on the equivalent distance of 5 years (i.e. 32.850km). The distances have been chosen according to the CBS (Centraal Bureau voor de Statistiek).
  - The estimated lifetime for an average vehicle is 300.000 km, so that will be the amount of kilometres used for the calculations. This distance is the estimated by different german car manufacturers (e.g. Volkswagen, Daimler, etc.).

- Maintenance, insurance, and the different grants and taxes are not going to be considered for the calculations, due to the fact that they are very variable parameters that depends on the type of buyer, the government and the region.

3.3.4- MODEL I-FUEL/ELECTRICITY CONSUMPTION

This model will consider only the fuel consumption under two hypotheses:

HYPOTHESIS 1- USAGE OF THE VEHICLES FOR A FIVE-YEAR PERIOD.



Expenditure in fuel/electricity during five years

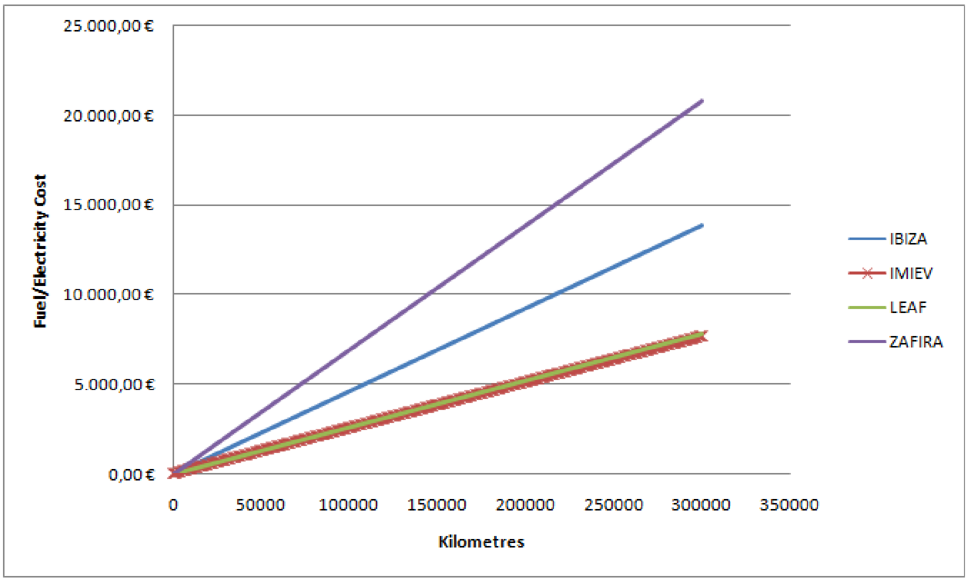
As it is shown in the graph, the expenditure related to fuel consumption at the end of those five years between the cars considered is:

Formula used for this model:
total_cost=purchasing_price+ consumption*fuel_ptrice*nº_kilometres
total cost=purchasing_price+consumption*electricity_price*nº_kilometres

Cost of the fuel/electricity after 5 years(Netherlands)				
kilometres	IBIZA	IMIEV	LEAF	ZAFIRA
32850	1.518,98 €	842,60 €	855,09 €	2.278,48 €

Total cost of electricity after five years

HYPOTHESIS 2- USAGE OF THE VEHICLES DURING THEIR ESTIMATED LIFETIME.



Expenditure in fuel/electricity during 300.000 Km.

As it is shown in the graph, the expenditure related to fuel consumption at the end of the lifetime of the vehicles is the following one:

Cost of the fuel/electricity after the vehicle lifetime				
kilometres	IBIZA	IMIEV	LEAF	ZAFIRA
300.000	13.872,00 €	7.695,00 €	7.809,00 €	20.808,00 €

Total cost of electricity after five years

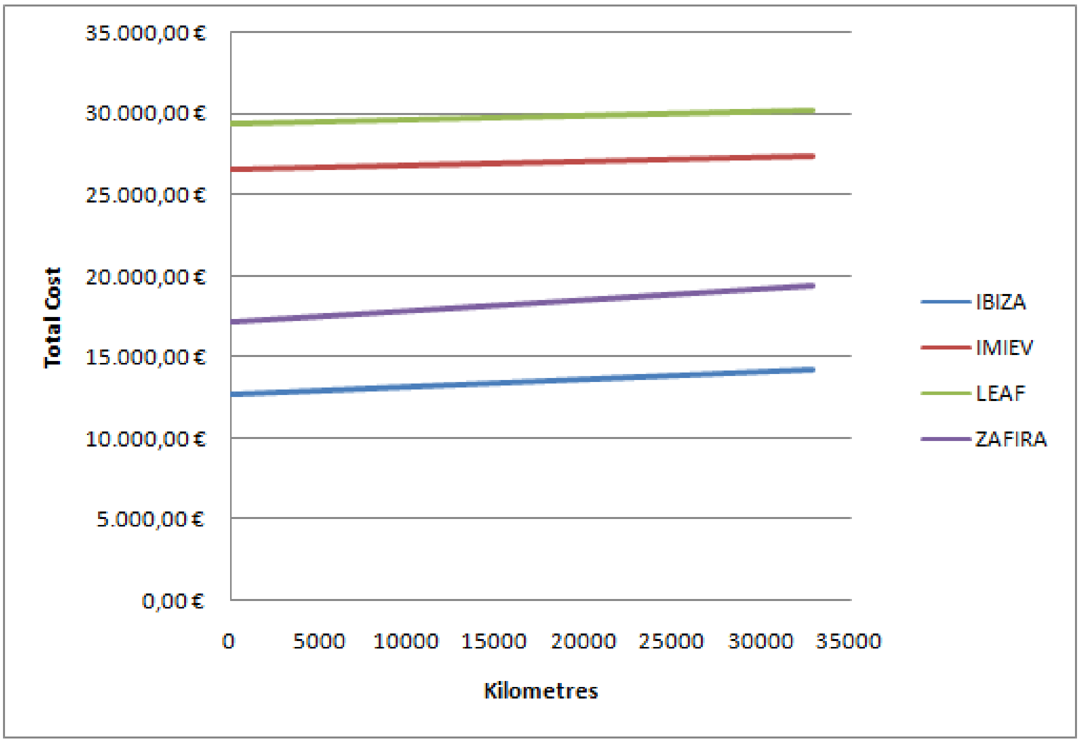
As it can be seen from the results, both figures start without any initial cost, so that the differences between both types of vehicles get higher the more kilometres the vehicles cover.

Basing the conclusions on the distances calculated for the Netherlands and assuming a five-year use of the vehicle, the biggest difference occurs within the pair of family vehicles. This difference reaches 1423 €, that is 284 € per year.

Looking at the hypothesis that considers the whole lifetime of the vehicles and due to the fact that many more kilometres are covered, a much bigger saving can be observed. The difference results in a total difference of around 13000 € (the comparison is between the family cars because the difference is bigger in that case).

3.3.5- MODEL II- INITIAL PRICE + FUEL/ ELECTRICITY CONSUMPTION

The results obtained under the five-year-hypothesis are the following ones:



Expenditure during five years considering the purchasing price of the car.

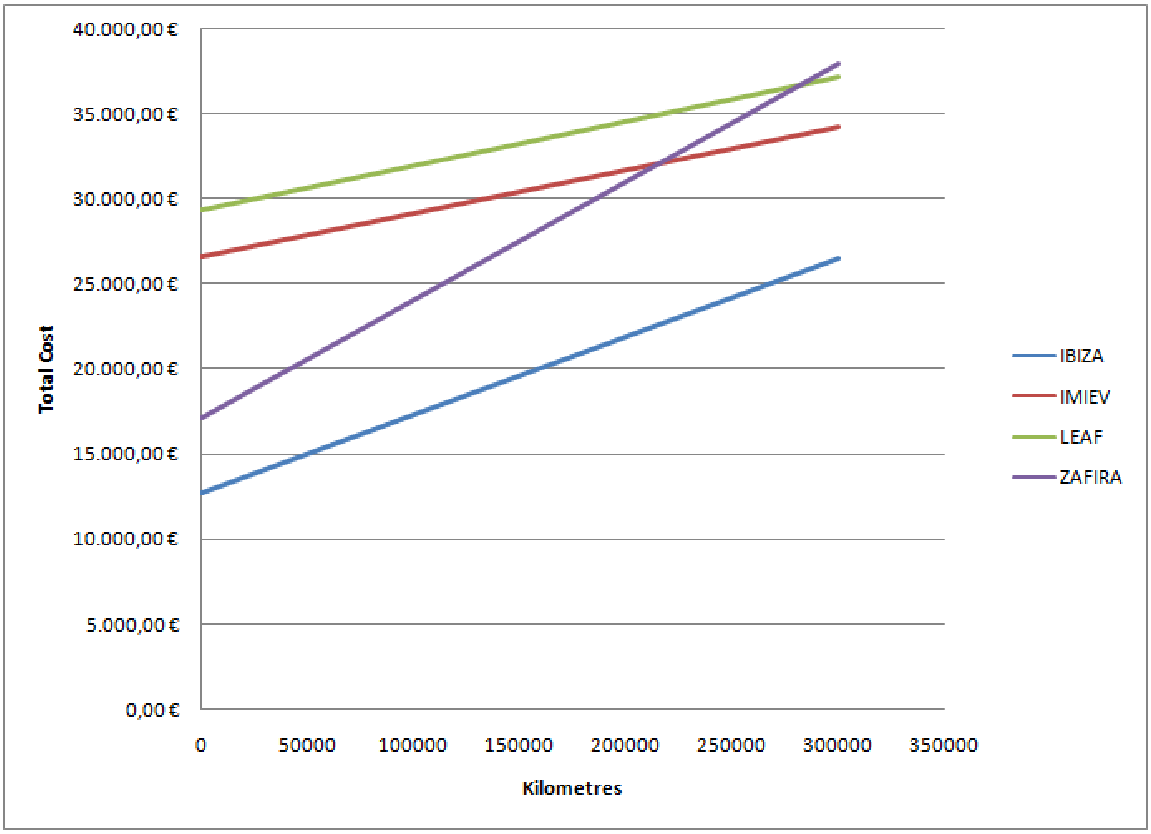
It is convenient to repeat that the assumptions for this model have been made excluding all the different taxes involved in the vehicle purchase and taking into account only the initial payment for the vehicle and the fuel/ electricity costs.

Due to the fact that the price of the electric vehicles is much higher, it is not strange that after those five years, the total cost of the electric vehicle keeps on being higher in spite of what could be thought from the model without initial cost.

Anyhow, while looking at the last graph from this model (five-year time and adding initial price), there are two different tendencies clearly recognizable.

The plots representing the electric cars increase slower than the plots representing the ICE cars. That is why both plots are going to cross at some point.

This idea is much clearer in the picture that represents the model II under the hypothesis II (i.e. the whole lifetime of the car including the purchasing price).



Cost of the purchase and the fuel/ electricity during the vehicles lifetime

From that point on, the electric vehicle will be economically more profitable than the ICE vehicle.

In the previous figure, the intersection points show where the Zafira starts being more expensive than the I-Miev (first intersection) and the Leaf (second intersection).

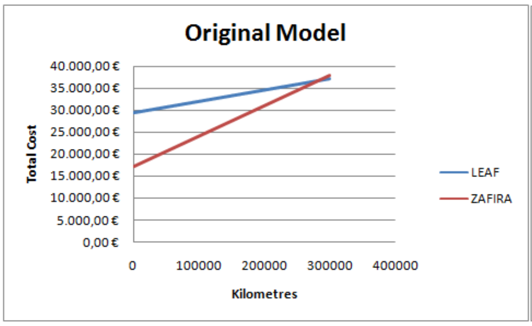
The Ibiza does not get crossed with any other plot inside the picture because of the low price and fuel consumption it has. However, it will intersect with the other plots for a very high number of kilometres.

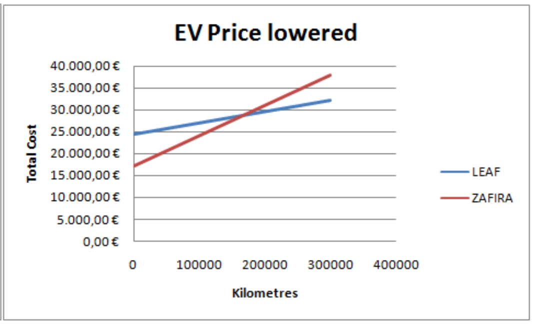
3.3.6- CONCLUSIONS AND DISCUSSION

Reasoning in terms of money, with the current prices and without taking into account taxes or subsidies, the electric car does not seem economically profitable.

However, there are strategies that change that first approach. The possible ways to make the electric vehicles profitable is by moving the intersection point mentioned before to the beginning of the picture. That goal can only be achieved by:

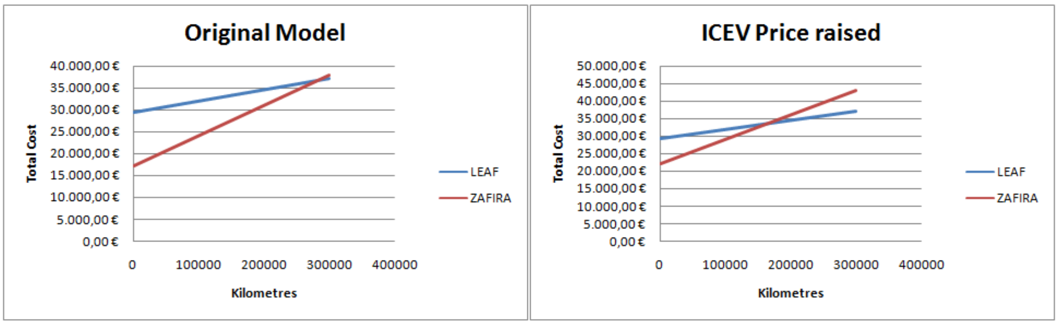
- Lowering the plot of the EV (i.e. decreasing the initial price)





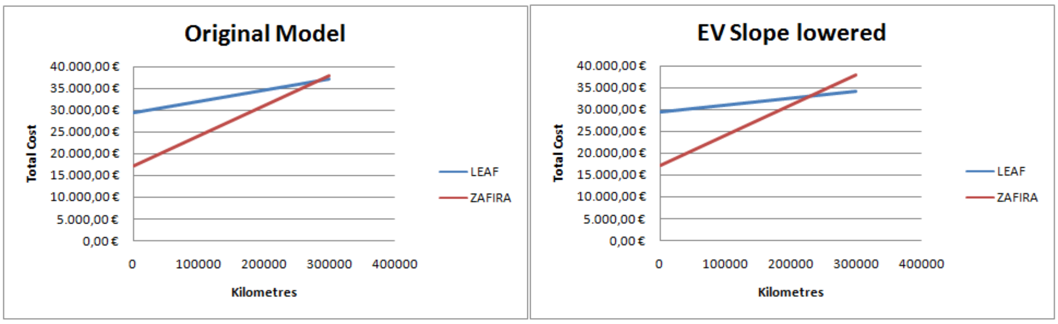
The price of the EV has been lowered 5.000 €

- Moving up the plot of the ICEV (i.e. increasing the price of the ICEV)



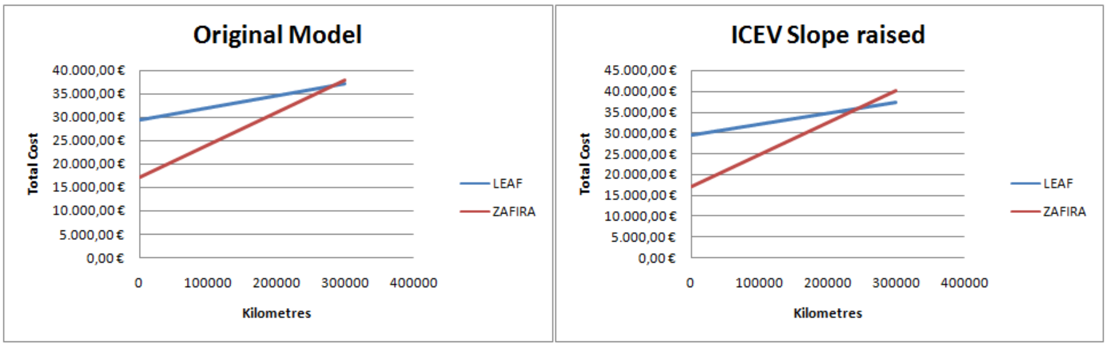
The price of the ICEV has been raised 5.000 €

- Changing the slope of the EV (i.e. making it less pronounced). That would mean making them more efficient so they would consume less electricity, or making the electricity cheaper.



The price of the electricity and the consumption has been changed to 0,13 €/kWh and 12 kw/100km.

- Changing the slope of the ICEV. It makes no sense making ICEVs more fuel consuming, so the only option possible is increasing the price of the fuel.



The price of the diesel has been changed to 1,5 E/l.

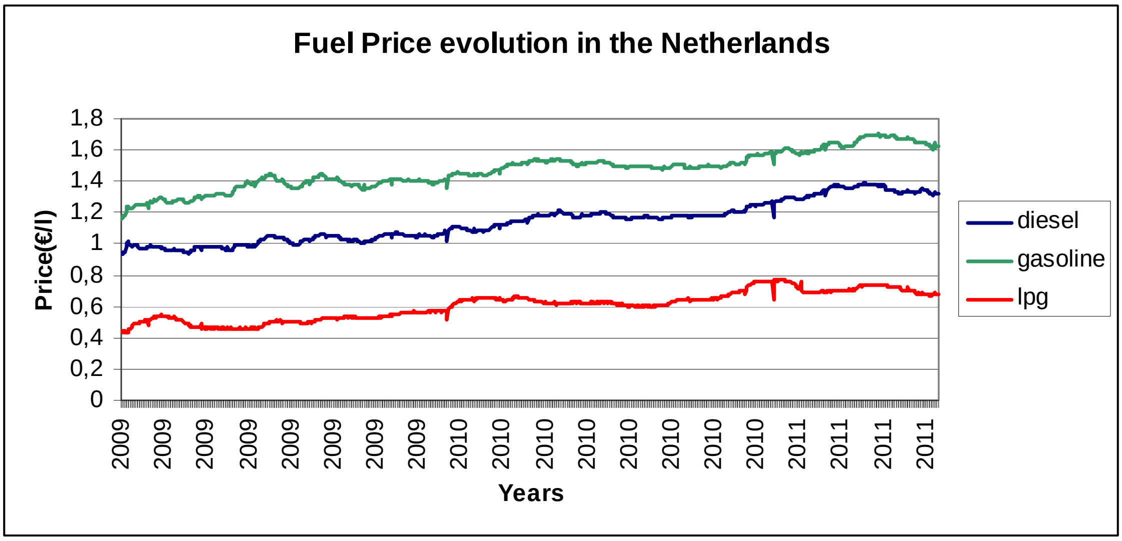
Some of these solutions have already been taken into account. The Netherlands is a clear example of this:

- The lowering of the price of the EV is accomplished by grants given by the government or tax deductions.
    - Some cities in the Netherlands are actively encouraging the purchase of electric cars by individuals and businesses by subsidies. In Amsterdam the subsidy is worth 5000 € (Ref 15) and in Leeuwarden it is 2500 € (Ref 14). Furthermore, it is likely for the Dutch government to move this kind of incentives to a higher level by adding more cities apart from Amsterdam and Leeuwarden in a near future.

- Furthermore, and for the particular case of the enterprises, there is the possibility to deduct an additional 36% of the taxes and to accelerate the depreciation of the car (about a 75% of the cost) via the MIA and the VAMIL. Both of them are also applicable to the investments in fully automatic charging stations and battery exchange stations (Ref 13).

- The increase of the price of the ICEV is done by taxing them at a very high rate (e.g. road tax, BPM, etc.).

- The price of fuel is constantly rising, and that will be the tendency due to the fact that it is a limited resource.

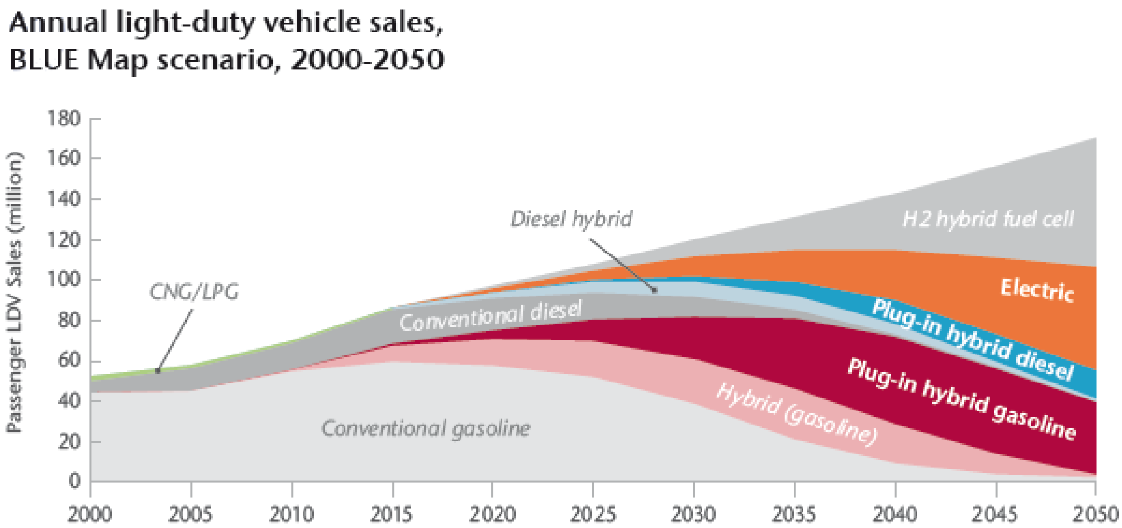


Fuel price evolution in the Netherlands (2009-2011). Source CBS.

Making the vehicles more fuel efficient is a constant goal not only for the electric vehicles car manufacturers but also for the ICEV manufacturers. The tendency of all the different firms is to obtain real consumption rates of 3- 4 l/ 100 km. In a near future this goal is going to be obtained by developing very efficient fuel cars and hybrids.

That is why the electric vehicles are going to be a good choice in a future only if the purchasing prices are competitive or the users are given facilities. Of course they will be an option just for a certain kind of users.

Furthermore, the perspectives for vehicles in a near future join different types of vehicles (i.e. diesel, gasoline, full electric, hybrids, fuel cell, etc), so the future is not only full electric.



Future perspectives for light-duty vehicles (source: International Energy Agency)

4- CONCLUSION

As a final conclusion about the electrical mobility the following ideas must be outlined:

Focusing only in environmental terms, the manufacture of a fuel powered vehicle and an electric one does not present big differences.

The big differences come up in the operation phase and in the batteries. However, the batteries represent a maximum of a 15% of the whole environmental impact of the vehicle.

Electric cars are environmentally advantageous in that aspect, and this feature is even more noticeable if the energy used to power them is obtained from renewable energy sources.

Furthermore, electric vehicles are a 6 to 58% more efficient than the ones powered by fuel.

In terms of economy, they can get to be very competitive in price since they save the user a lot of money per kilometre but first, they have to get a market share, so that the prices can get lower.

Currently the purchasing price is too high but, on the other hand, some governments like the dutch promote the buying of the vehicles offering facilities and economic subsidies. The future perspectives are promising.

Anyhow the future vehicle market is shared among the different technologies and types of vehicles, which would be adapted to what the users need.

To sum up, the electric vehicles are sustainable and even recommendable facing a near future.

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Ref 3

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Life Cycle Assessment of Automobile/Fuel Options

Ref 4

Samaras, C.; Meisterling, K. Life Cycle Assessment of Greenhouse
Gas Emissions from Plug-In Hybrid Vehicles: Implications for Policy.

Ref 5

Dominic A. Notter et ál. Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles

Ref 6

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Ref 7

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Ref 8

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Ref 9

IEA
http://www.iea.org/

Ref 10

Kokam Co., Li-Ion Cell specifications link:
http://www.superlatticeinc.com/downloads/SLPB100216216H.pdf

Ref 11

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Ref 12

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Ref 13

http://www.agentschapnl.nl/programmas-regelingen/mia-milieu-investeringsaftrek-en-vamil-willekeurige-afschrijving-milieu-invest

Ref 14

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Ref 15

http://www.trouw.nl/tr/nl/4332/Groen/article/detail/2437154/2011/05/25/Amsterdam-schoner-kan-ook-goedkoper.dhtml

Ref 16

Van Vliet et ál.

Energy use, cost and CO2 emissions of electric cars

Ref 17

Van Vliet et ál.

Techno-economic comparison of series hybrid, plug-in hybrid, fuel cell and regular cars

6- APPENDICES

APPENDIX 1- NEDC

http://www.dieselnet.com/standards/cycles/ece_eudc.html

The NEDC Emission test cycle is a main step to homologate light duty vehicle in Europe. It joins two different tests in it, the ECE and the EUDC. The NEDC is performed on a chassis dynamometer.

The entire cycle includes four ECE segments, Figure 1, repeated without interruption, followed by one EUDC segment, Figure 2. Before the test, the vehicle is allowed to soak for at least 6 hours at a test temperature of 20-30°C. It is then started and allowed to idle for 40s. Effective year 2000, that idling period has been eliminated, i.e., engine starts at 0s and the emission sampling begins at the same time. This modified cold-start procedure is also referred to as the *New European Driving Cycle* or NEDC.

Emissions are sampled during the cycle according the the "Constant Volume Sampling" technique, analyzed, and expressed in g/km for each of the pollutants.

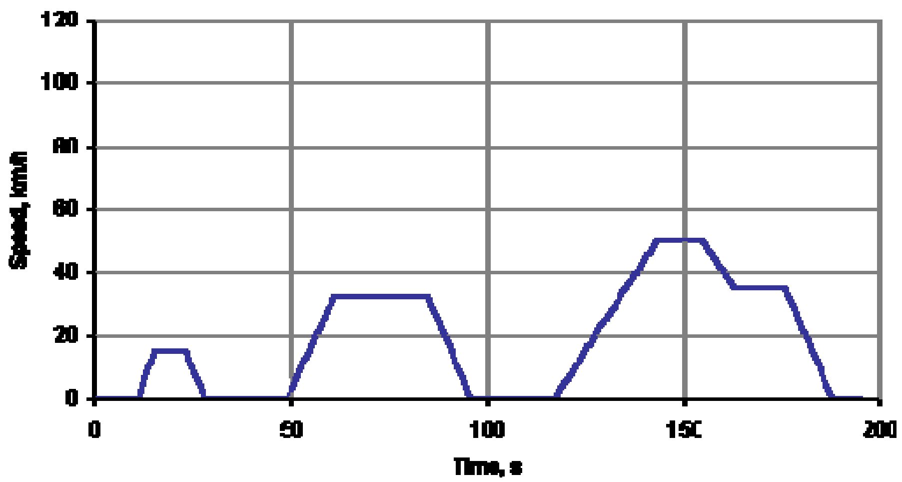


***Figure 1**. ECE 15 Cycle*

The ECE cycle is an urban driving cycle, also known as UDC. It was devised to represent city driving conditions, e.g. in Paris or Rome. It is characterized by low vehicle speed, low engine load, and low exhaust gas temperature.

The above urban driving cycle represents Type I test, as defined by the original ECE 15 emissions procedure. Type II test is a warmed-up idle tailpipe CO test conducted immediately after the fourth cycle of the Type I test. Type III test is a two-mode (idle and 50 km/h) chassis dynamometer procedure for crankcase emission determination.

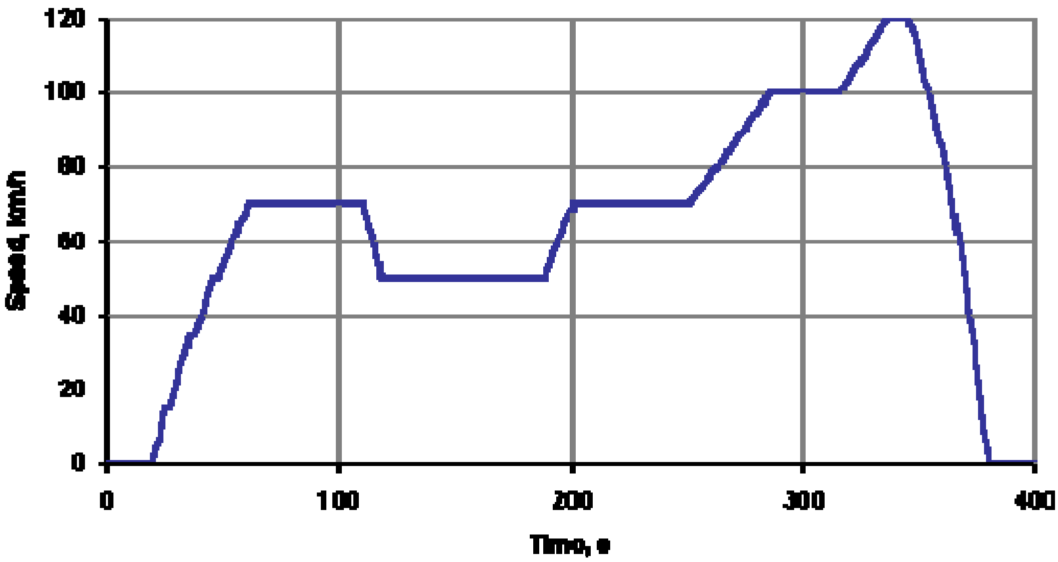


Figure 2. *EUDC Cycle.*

The EUDC (Extra Urban Driving Cycle) segment has been added after the fourth ECE cycle to account for more aggressive, high speed driving modes. The maximum speed of the EUDC cycle is 120 km/h. An alternative EUDC cycle for low-powered vehicles has been also defined with a maximum speed limited to 90 km/h (Figure 3).

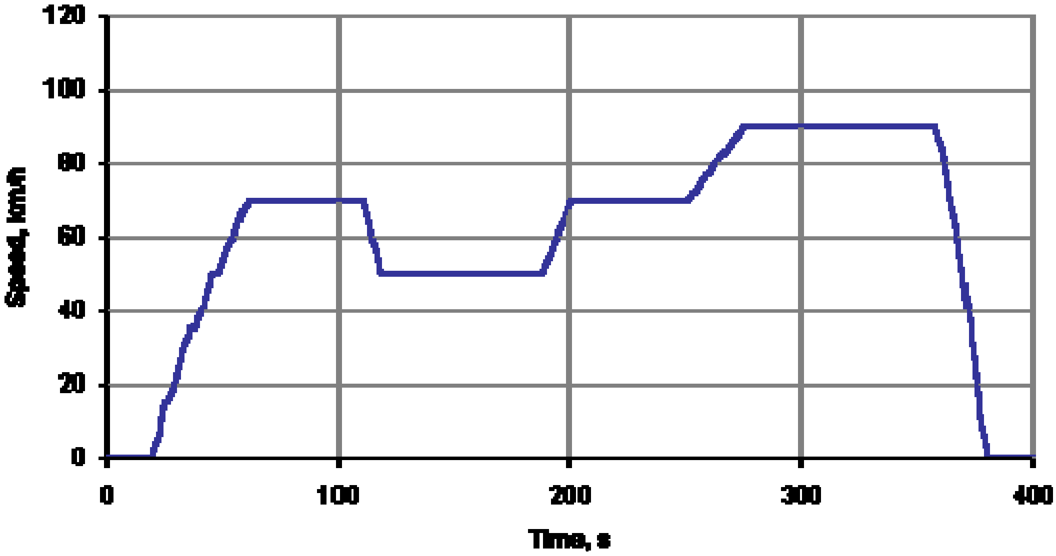


Figure 3. *EUDC Cycle for Low Power Vehicles.*

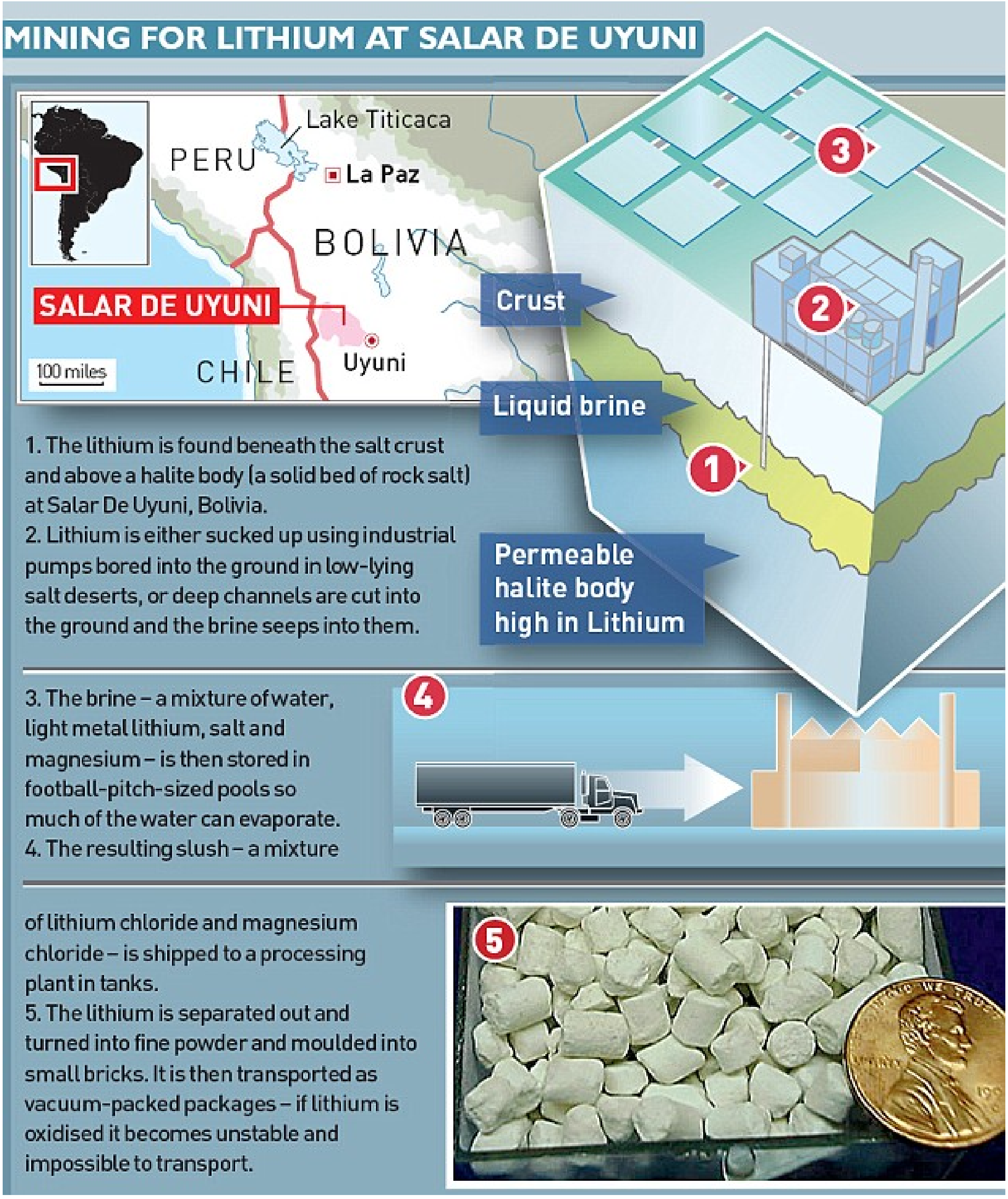
The following table includes a summary of the parameters for both the ECE and EUDC cycles.

Characteristics	Unit	ECE 15	EUDC
Distance	km	4×1.013=4.052	6.955
Duration	s	4×195=780	400
Average Speed	km/h	18.7 (with idling)	62.6
Maximum Speed	km/h	50	120

APPENDIX 2- MINING/ PRIMARY EXTRACTION OF LITHIUM

MINING

http://www.dailymail.co.uk/home/moslive/article-1166387/In-search-Lithium-The-battle-3rd-element.html



EXTRACTION OF LITHIUM

http://www.tutorvista.com/content/chemistry/chemistry-iii/s-block-elements/lithium-and-sodium.php

- Ores of Lithium
    - Lepidolite or lithia mica $(Li,Na,K)_2Al_2(SiO_3)_3(F,OH)_2$
    - Petalite $LiAl(Si_2O_5)_4$
    - Spodumene $LiAl(SiO_3)_2$
    - Triphylite $(LiNa)_3PO_4(Fe,Mn)_3(PO_4)_2$
    - Amblygonite $Li(AlF)PO_4$
- Considerations about the extraction of lithium: The alkali metals are very reactive and strong reducing agents. Usual methods of extraction cannot be employed due to the following difficulties:
    - Lithium cannot be isolated by reduction of their oxides or other compounds, as they are very strong reducing agents.
    - This metal cannot be extracted from its ore by the electrolysis of their aqueous solutions, as the formed metal will immediately react with water giving the hydroxide instead.
    - Because this metal reacts with water violently, it cannot be prepared from the aqueous solution of its salt by the metal displacement method.

Therefore, this metal is generally isolated by the electrolysis of its fused metal halide.

The extraction of lithium from its minerals involves the following two steps:

- Conversion of lithium into lithium chloride: The minerals are first of all converted into lithium chloride by any one of the following methods:
  - **Acid treatment method:** The mineral is finely powdered and boiled with sulphuric acid. The insoluble silica (SiO_2) thus formed is removed by filtration. The solution is treated with the requisite amount of sodium carbonate to precipitate iron and aluminium. Then, excess of sodium carbonate is added to the filtrate to precipitate lithium as lithium carbonate. It is filtered and dissolved in hydrochloric acid to obtain lithium chloride, which is purified by extraction with alcohol.
  - **Fusion method:** The finely powdered ore is fused with a mixture of barium carbonate, barium sulphate and potassium sulphate. The fused mass is separated into two layers, the upper layer consists of lithium, sodium and potassium sulphates and the lower layer consists of barium sulphate, alumina and silica. The upper layer is separated, dissolved in water and the solution treated with barium chloride solution. Barium sulphate gets precipitated while the chlorides of lithium, sodium and potassium remain in solution. The precipitate of barium sulphate is filtered off and the filtrate is evaporated to dryness. The residue thus formed consists of the mixture of alkali metal chlorides from which lithium chloride is dissolved out in pyridine (other alkali metal chlorides are insoluble). From this solution pyridine is distilled off while lithium chloride is left behind.

- Electrolysis of lithium chloride: Dry lithium chloride is fused with potassium chloride and electrolysed in an electrolytic cell. Potassium chloride is added to lower the temperature and increase the conductivity of lithium chloride. The cell is operated at a temperature of about 720 K and a voltage of 8 to 9 volts is applied. The following reaction takes place

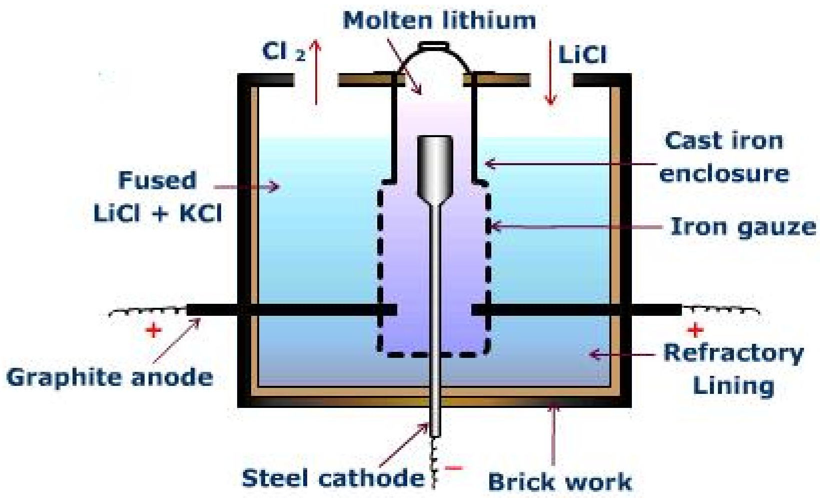


Fig:12.1 - Electrolytic preparation of lithium

$$LiCl \rightleftharpoons Li^{+} + Cl^{-}$$

$$Li^{+} + e^{-} \longrightarrow Li$$
At cathode

$$2Cl^{-} - 2e^{-} \longrightarrow Cl_2$$
At anode

Chlorine gas liberated at the anode leaves the cell through an exit and the molten lithium metal rises to the surface of the fused electrolyte and collects in the cast iron enclosure surrounding the cathode.

APPENDIX 3- OPEL ZAFIRA SPECIFICATIONS

http://www.opel.nl/Showroom/Zafira/Default.aspx

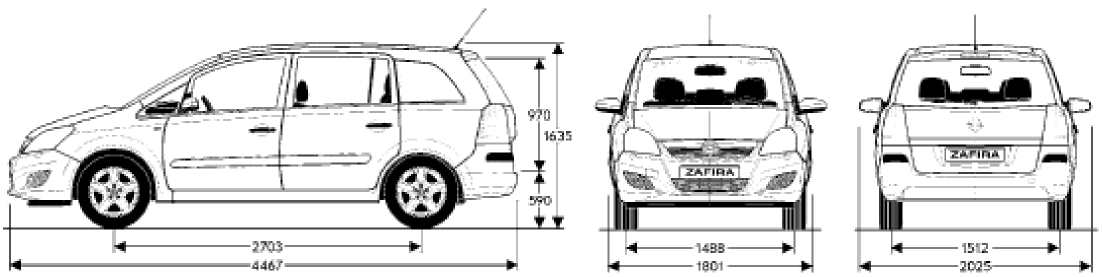
Opel Zafira		Vermogen (kW/pk)	CO_2 uitstoot (gr/km)	Bijtelling-categorie	Energie-label	Prijs excl. BTW/BPM	BPM	Consumentenprijs incl. BTW/BPM
BENZINE								
1.6 ecoFLEX® 5 versnellingen Selection	0QL75I9G1	85 / 115	157	25%	B	€ 15.298	€ 4.940	€ 23.145
1.6 ecoFLEX® 5 versnellingen Edition	0QW75I9G1	85 / 115	157	25%	B	€ 17.110	€ 5.284	€ 25.645
1.6 ecoFLEX® 5 versnellingen '111' Edition'	0QQ75I9G1	85 / 115	157	25%	B	€ 17.110	€ 5.284	€ 25.645
1.6 ecoFLEX® 5 versnellingen Cosmo	0QP75I9G1	85 / 115	157	25%	B	€ 18.559	€ 5.560	€ 27.645
1.8 Ecotec® 5 versnellingen Selection	0QL75K251	103 / 140	168	25%	C	€ 15.537	€ 5.657	€ 24.145
1.8 Ecotec® 5 versnellingen Edition	0QW75K251	103 / 140	168	25%	C	€ 17.348	€ 6.001	€ 26.645
1.8 Ecotec® 5 versnellingen '111' Edition'	0QQ75K251	103 / 140	168	25%	C	€ 17.348	€ 6.001	€ 26.645
1.8 Ecotec® 5 versnellingen Cosmo	0QP75K251	103 / 140	168	25%	C	€ 18.797	€ 6.276	€ 28.645
1.8 Ecotec® Easytronic® Selection	0QL75KBB1	103 / 140	164	25%	C	€ 16.362	€ 5.569	€ 25.040
1.8 Ecotec® Easytronic® Edition	0QW75KBB1	103 / 140	164	25%	C	€ 18.174	€ 5.914	€ 27.540
1.8 Ecotec® Easytronic® '111' Edition'	0QQ75KBB1	103 / 140	164	25%	C	€ 18.174	€ 5.914	€ 27.540
1.8 Ecotec® Easytronic® Cosmo	0QP75KBB1	103 / 140	164	25%	C	€ 19.623	€ 6.189	€ 29.540
DIESEL								
1.7 CDTI ecoFLEX® 6 versnellingen Selection	0QL75JH61	81 / 110	134	25%	C	€ 17.137	€ 7.152	€ 27.545
1.7 CDTI ecoFLEX® 6 versnellingen Edition	0QW75JH61	81 / 110	134	25%	C	€ 18.587	€ 7.427	€ 29.545
1.7 CDTI ecoFLEX® 6 versnellingen '111' Edition'	0QQ75JH61	81 / 110	134	25%	C	€ 18.587	€ 7.427	€ 29.545
1.7 CDTI ecoFLEX® 6 versnellingen Cosmo	0QP75JH61	81 / 110	134	25%	C	€ 20.036	€ 7.702	€ 31.545
1.7 CDTI ecoFLEX® 6 versnellingen Selection	0QL75JQ61	92 / 125	134	25%	C	€ 17.789	€ 7.275	€ 28.445
1.7 CDTI ecoFLEX® 6 versnellingen Edition	0QW75JQ61	92 / 125	134	25%	C	€ 19.239	€ 7.551	€ 30.445
1.7 CDTI ecoFLEX® 6 versnellingen '111' Edition'	0QQ75JQ61	92 / 125	134	25%	C	€ 19.239	€ 7.551	€ 30.445
1.7 CDTI ecoFLEX® 6 versnellingen Cosmo	0QP75JQ61	92 / 125	134	25%	C	€ 20.688	€ 7.826	€ 32.445
CNG								
1.6 CNG Turbo ecoFLEX 6 versnellingen Edition	0QW75II61	110 / 150	139	20%	A	€ 20.938	€ 5.329	€ 30.245
1.6 CNG Turbo ecoFLEX 6 versnellingen '111' Edition'	0QQ75II61	110 / 150	139	20%	A	€ 20.938	€ 5.329	€ 30.245
1.6 CNG Turbo ecoFLEX 6 versnellingen Cosmo	0QP75II61	110 / 150	139	20%	A	€ 22.387	€ 5.604	€ 32.245

Technische specificaties Opel Zafira

			Brandstofverbruik in liters volgens 2004/3/EU			
	Topsnelheid in km/u	Acceleratie 0-100 km/u in seconden	Binnen de stad	Buiten de stad	Gemiddeld	CO_2 emissie in gr/km
HANDGESCHAKELD						
1.6 ecoFLEX® 5 versnellingen (85 kW)	185	13,4	8,7	5,5	6,7	157
1.8 ECOTEC® 5 versnellingen (103 kW)	197	11,5	9,6	5,7	7,2	168
1.6 CNG Turbo ecoFLEX (110 kW) (kg H-Gas)	200	11,4	10,8 m^3	6 m^3	7,7 m^3	139
1.7 CDTI ecoFLEX® 6 versnellingen (81 kW)	179	13,5	6,1	4,5	5,1	134
1.7 CDTI ecoFLEX® 6 versnellingen (92 kW)	189	12,3	6,1	4,5	5,1	134

Technische specificaties Opel Zafira

BUITENAFMETINGEN IN MM	
Lengte	4.467
Breedte met uitgeklapte / ingeklapte buitenspiegels	2.025 / 1.801
Hoogte (leeggewicht)	1.635 / 1.645
Hoogte (leeggewicht, versies met panoramadak)	1.670
Wielbasis	2.703
Spoorbreedte, vooraan	1.488
Spoorbreedte, achteraan	1.512
DRAAICIRKEL IN M	
Muur tot muur	11,50
Stoeprand tot stoeprand	11,10
AFMETING BAGAGERUIMTE IN MM (VOLGENS ECIE-METHODE)	
Lengte van de laadvloer tot de derde/tweede zitrij	455 / 1.088
Lengte van de laadvloer tot de voorste zitrij	1.809
Breedte tussen de wielkasten	1.071
Maximale breedte	1.114
Hoogte opening	893
INHOUD BAGAGERUIMTE IN LITERS (VOLGENS ECIE-METHODE)	
Tot de achterbank derde zitrij	140
Derde zitrij neergeklapt	645
Derde en tweede zitrij neergeklapt	1.820
GEWICHTEN & ASBELASTING IN KG (VOLGENS 70/156/EEC)	
Leeggewicht, incl. bestuurder*	1.505
Toegelaten totaalgewicht	2.075
Laadvermogen	570
Toegelaten asbelasting, vooraan	975
Toegelaten asbelasting, achteraan	1.115
Toegelaten daklast** met/zonder dakrails	75 / 100
OVERIGE MATEN	
Inhoud brandstoftank in liters	58 (CNG 14 liter / 21kg)



*Vanaf kentekengewicht, raadpleeg uw dealer voor het kentekengewicht per motorisatie
**Rekening houdend met het bruto toegestane totaalgewicht. Om veiligheidsredenen wordt een maximale snelheid van 120 km/u aanbevolen met dakbelasting.

APPENDIX 4- MITSUBISHI I-MIEV SPECIFICATIONS

http://www.mitsubishi-cars.co.uk/imiev/brochure.aspx

Technical Specifications

Model		I-MIEV
Motor		
Type		AC, permanent magnet synchronous
Rated output*1	kW (bhp)	35 (47)
Maximum output*2	kW (bhp)/rpm	49 (66)/2500-8000
Maximum torque	Nm (lb.ft)/rpm	180 (133)/0-2000
Charging voltage		200-240V
Traction Battery		
Type		Lithium-ion
Total voltage		330V
Total energy		16kWh
Charging time		
Domestic supply*3	Full charge	Approx. 7 hours (at 220-240V, 13A)
Rapid charger*4	80% charge	Approx. 30 minutes (at 3-phase 200V-50kW)
Performance		
Electric energy consumption (NEDC)*5	Wh/km	135
Maximum range (NEDC)*5	miles (km)	93 (150)
Maximum speed	mph (km/h)	81 (130)
Acceleration 0-62 mph	secs	15.9
Suspension/Steering		
Suspension	Front axle	Front MacPherson strut and coil spring with stabiliser bar
	Rear axle	Rear 3-link De Dion
Steering		Rack and pinion, electrically assisted
Minimum turning circle	m (ft)	9.0 (29.5)
Brakes		Anti-lock Braking System with Electronic Brakeforce Distribution (ABS +EBD) and Brake Assist
	Front	257mm (10.1") ventilated disc brakes
	Rear	203mm (8") drum brakes
Tyres/wheels	Front	145/65R15 72S tyres/15" x 4.0J alloy wheels
	Rear	175/55R15 77V tyres/15" x 5.0J alloy wheels
Driveline/Transmission		
Type		Rear-mounted motor/rear wheel drive
		Mitsubishi Active Stability and Traction Control (M-ASTC)
Transmission		1 speed fixed gear
	Final gear ratio	6.066
Dimensions		
Exterior l x w x h	mm	3475 x 1475 x 1610
Interior l x w x h	mm	1790 x 1270 x 1250
Wheelbase	mm	2550
Track Front	mm	1310
Rear	mm	1270
Ground clearance	mm	150
Weights/Volumes		
Gross vehicle weight	kg (lbs)	1450 (3197)
Kerb weight	kg (lbs)	1110 (2447)
Seating capacity	persons	4
Servicing/Insurance/Warranty		
Service intervals		Every 12,500 miles or 12 months, whichever occurs first
Insurance group (50 Group rating)		29
Warranty		3 years unlimited mileage vehicle warranty. Electric vehicle components up to 5 years warranty (first 36 months unlimited mileage, thereafter 24 months or 62,500 miles from date of registration, whichever occurs first). 8 year anti-corrosion perforation warranty. 3 year pan-European roadside, home and accident assistance

*1 Corresponds to "Maximum 30 minute power", certified in accordance with ECE R85
*2 Corresponds to "Maximum net power", certified in accordance with ECE R85
*3 Full charge from low energy warning indicator flashing. Low temperatures in winter may prolong charging time.
*4 Approximately 80% of full charge from low energy warning indicator flashing. Low temperatures in winter may prolong charging time.
*5 NEDC stands for New European Driving Cycle. The values of electric energy consumption and electric range are based on ECE R101. These values vary depending on driving style, road and traffic conditions, ambient temperature, use of air conditioning, etc.

Standard Equipment

EV function
- Charging cable, normal charge
- Drive mode 'D' – normal driving
- Drive mode 'C' – reduces regenerative braking while cruising
- Drive mode 'B' – increases regenerative braking during downhill driving
- High voltage cut-off system

Security and Safety Features

Security
- Central door locking with keyless entry
- Motor immobiliser and alarm

Safety
- ABS with EBD and Brake Assist
- Airbags SRS – dual front, front side and front/rear curtain
- Airbag SRS, front passenger's deactivation switch
- Child-protection rear door locks
- ISO-FIX child seat anchor x 2
- Mitsubishi Active Stability and Traction Control (M-ASTC)
- Seatbelts, 3-point ELR x 4 with force limiters and pretensioners, front
- Tyre inflation kit

Exterior Features

Styling
- Alloy wheels, 3-spoke, 15"
- Door mirrors and handles, colour-keyed
- Metallic/pearlescent paint finish (OPT)
- Privacy glass, rear door windows and tailgate window
- Roof spoiler with high-mount stop lamp

Functional
- Automatic lights on/off
- Door mirrors, electric/heated/folding
- Front and rear fog lamps
- Halogen headlamps, projector type with levelling device
- LED rear lamps, with clear type lens
- Rear window demister with auto-off function
- Windshield wiper, single arm, variable intermittent with washers
- Wiper & washer, rear, intermittent

Interior Features

Audio
- Aerial, front roof mounted
- CD/tuner with 4 speakers
- Kenwood satellite navigation system with Bluetooth hands-free 'phone kit, iPod connection and rear view camera (OPT)

Styling
- Interior trim, black with silver accents
- Seat trim, fabric, black
- Steering wheel and gearshift knob, leather-wrapped

Convenience
- Air conditioning, manual type with deodorant filter
- Assist grips x 4
- Driver's footrest
- Front interior & map lamp with dimmer function
- Front seat backrest pockets
- Glove box with card holder
- Instrument panel secret box (Upper of glove box)
- Sunvisors, dual front with lidded vanity mirrors and ticket holders

Functional
- Electric windows, front/rear with driver's window one-touch down
- Instrument panel: 12V accessory socket, digital speedometer, EV system warning/range remaining/energy usage indicators, energy level gauge, instrument panel light dimmer

Seats
- Driver's seat heater
- Driver's seat height adjuster
- Front seat sliding and reclining adjusters
- Headrests, height-adjustable x 4
- 50:50 split-folding backrests

APPENDIX 5– SEAT IBIZA SPECIFICATIONS

Prices and specifications Seat Ibiza from the catalogue for the Netherlands

http://www.seat.nl/ibiza.aspx

TECHNISCHE GEGEVENS

MOTOR	1.2 75pk Ibiza 3-deurs SC	1.2 75pk Ibiza 5-deurs	1.2 75pk Ibiza ST
Motortype	3 cilinders in lijn	3 cilinders in lijn	3 cilinders in lijn
Cilinderinhoud (cc)	1199	1199	1199
Boring x slag (mm)	79,5 x 80,9	79,5 x 80,9	79,5 x 80,9
Compressieverhouding	16,5	16,5	16,5
Max. vermogen (kW/pk/tpm)	55/75/4000	55/75/4000	55/75/4000
Max. koppel (Nm/tpm)	180/1500 - 3450	180/1500 - 3450	180/1500 - 3450
Emissienorm	EURO 5	EURO 5	EURO 5
Mengselvorming	Directe inspuiting met commonrailtechniek	Directe inspuiting met commonrailtechniek	Directe inspuiting met commonrailtechniek
Transmissie	5-versnellingsbak met Start/Stop systeem	5-versnellingsbak met Start/Stop systeem	5-versnellingsbak met Start/Stop systeem
Uitlaatgasreiniging	Oxydatiekatalysator met dieselroetfilter	Oxydatiekatalysator met dieselroetfilter	Oxydatiekatalysator met dieselroetfilter
PRESTATIES			
Topsnelheid (km/h)	173	173	173
0-100 km/h (sec.)	13,9	13,9	14,6
BRANDSTOFVERBRUIK (L/100 km, 99/100 EG-norm)[1]			
Buitenweg	3,0	3,0	3,0
Stad	4,1	4,1	4,1
Combinatierit	3,4	3,4	3,4
Brandstof	Diesel	Diesel	Diesel
Service-interval indicatie	ja	ja	ja
GEWICHTEN (kg)			
Gewicht op kenteken	1050	1050	1105
Max. toelaatbaar gewicht	1601	1601	1645
Max. aanhangergewicht geremd	1000	1000	1000
Max. aanhangergewicht ongeremd	570	570	600
REMMEN			
Remmen voor	Geventileerde schijven	Geventileerde schijven	Geventileerde schijven
Remmen achter	Trommels	Trommels	Trommels
VELGEN- EN BANDENMATEN			
Reference, Copa, Style	6J x 15", 185/60 R 15	6J x 15", 185/60 R 15	6J x15", 185/60 R 15

[1] De verbruiksmetingen volgens de norm 99/100/EG gaan uit van het leeg gewicht van de auto. Meeruitvoeringen kunnen deze waarde verhogen, en kunnen het verbruik dus enigszins doen toenemen. Afhankelijk van rijstijl, weg- en verkeersomstandigheden en de conditie van de auto kunnen daarnaast in de praktijk verbruikswaarden voorkomen die afwijken van het in deze test gemeten gemiddelde.

PRIJZEN

ALLE PRIJZEN IN €			Netto catalogusprijs excl. BTW	Consumentenprijs incl. BTW	CO_2 emissie (g/km)	Energielabel	Fiscale Bijtelling
Ibiza 3-deurs SC							
1.2 TDI Reference E-Ecomotive	55kW/75pk	6J123V/11/REF	12.349,00	**14.695,00**	89	A	14%
1.2 TDI COPA E-Ecomotive	55kW/75pk	6J123V/11/CPE	13.021,00	**15.495,00**	89	A	14%
1.2 TDI Style E-Ecomotive	55kW/75pk	6J133V/11/STY	13.693,00	**16.295,00**	89	A	14%
Ibiza 5-deurs							
1.2 TDI Reference E-Ecomotive	55kW/75pk	6J523V/11/REF	12.685,00	**15.095,00**	89	A	14%
1.2 TDI COPA E-Ecomotive	55kW/75pk	6J523V/11/CPE	13.357,00	**15.895,00**	89	A	14%
1.2 TDI Style E-Ecomotive	55kW/75pk	6J533V/11/STY	14.029,00	**16.695,00**	89	A	14%
Ibiza ST							
1.2 TDI Reference E-Ecomotive	55kW/75pk	6J823V/11/REF	13.525,00	**16.095,00**	89	A	14%
1.2 TDI COPA E-Ecomotive	55kW/75pk	6J823V/11/CPE	14.198,00	**16.895,00**	89	A	14%
1.2 TDI Style E-Ecomotive	55kW/75pk	6J833V/11/STY	14.870,00	**17.695,00**	89	A	14%

Prijsafstand van Ibiza 3-deurs SC naar Ibiza 5-deurs: €400,00
Prijsafstand van Ibiza 5-deurs naar Ibiza S: € 1.000,00

De Ibiza 1.2 TDI Ecomotive heeft een CO_2-emissie van 89 gram waardoor deze is vrijgesteld van BPM. Zie toelichting BPM en bijtelling op pagina 8.

TOELICHTING BPM

BPM-DIFFERENTIATIES

Voor het bepalen van het BPM-bedrag gelden de volgende differentiaties:

- Een BPM-percentage voor benzine- en diesel auto's
- Een BPM-correctie voor benzine- en diesel auto's
- Een BPM-opslag voor auto's met een CO_2-uitstoot boven een grenswaarde volgens een malustabel
- Een BPM-bonus voor auto's net boven de BPM vrijstelling grens
- De eventuele prijsconsequenties zijn in deze prijslijst reeds verrekend

Tabel tarieven BPM 2011	
Basispercentage BPM	19%
Benzine korting	– 824,00
Diesel toeslag	1.526,00

Benzine	
Vrijstelling bij CO_2 ≤ 110 g/km	
Bonus bij CO_2 111 t/m 120 g/km	– 500,00
CO_2-grens eerste schijf	110 g/km
CO_2-grens tweede schijf	180 g/km
CO_2-grens derde schijf	270 g/km

Diesel	
Vrijstelling bij CO_2 ≤ 95 g/km	
Bonus bij CO_2 96 t/m 120 g/km	– 500,00
CO_2-grens eerste schijf	95 g/km
CO_2-grens tweede schijf	155 g/km
CO_2-grens derde schijf	232 g/km
Tarief eerste schijf per g/km	61,00
Tarief tweede schijf per g/km	202,00
Tarief derde schijf per g/km	471,00

Fiscale bijtelling
Op basis van de CO_2-uitstoot valt elke SEAT in een bijtellingscategorie voor privé-gebruik van een auto van de zaak.

Categorie	Benzine	Diesel
14%	≤ 110 g/km	≤ 95 g/km
20%	≤ 140 g/km	≤ 116 g/km
25%	› 140 g/km	› 116 g/km

APPENDIX 6- NISSAN LEAF SPECIFICATIONS

http://www.nissan.nl/etc/medialib/nissaneu/_NL_nl/_Brochures/_Electric_Vehicles/103856.Par.60680.File.pdf

NISSAN PRIJSLIJST MAART 2011

Nissan LEAF 

	Energie Label	Consumenten adviesprijs incl. BPM/BTW*	Consumenten adviesprijs excl. BTW/incl. BPM	BPM bedrag	Netto catalogus adviesprijs excl. BPM/BTW
Nissan LEAF	A	34.890,00	29.403,36	0,00	29.403,36

OPTIES

	Consumenten adviesprijs incl. BPM/BTW*	Consumenten adviesprijs excl. BTW/incl. BPM	BPM bedrag	Netto catalogus adviesprijs excl. BPM/BTW
Meerprijs metallic	600,00	504,20	0,00	504,20
Zonnepaneel op dakspoiler	300,00	252,10	0,00	252,10

	Totaal (incl. BTW)*	Legeskosten deel 1	Kosten rijklaar maken incl. BTW	Kosten rijklaar maken excl. BTW
Kosten rijklaar maken**	670	38	532	447,06

* Prijzen excl. verwijderingsbijdrage/kosten rijklaar maken. Alle prijzen zijn in euro's.
** De kosten rijklaar maken omvatten: Transportkosten, kentekenplaten, Nissan Schade Hulpset (met o.a. wegwerpfototoestel en light stick), Life hammer, nulbeurt, poetsen en legeskosten kenteken deel 1. (€ 38,00 BTW-vrij)

De kosten voor de tenaamstelling van het kenteken deel II op het postkantoor bedragen € 9,25 (BTW-vrij)

DISCLAIMER

DE BPM
Per 1 januari 1993 is de wet op de belasting personen wagens en motorrijwielen "1992" (BPM) ingevoerd.

BPM TARIEF PERSONENAUTO'S
De BPM wordt berekend over de netto catalogus prijs.
De BPM voor 2011 bedraagt:
Met ingang van 2010 bestaat de BPM uit twee hoofdcomponenten: De grondslag als percentage van de netto catalogusprijs, en een gedeelte dat wordt gebaseerd op grond van absolute CO_2 uitstoot.
De grondslag voor 2011 bedraagt 19,0% van de netto catalogusprijs minus € 824 voor de benzinemodellen, en 19,0% van de netto catalogusprijs plus € 1,526 voor de dieselmodellen.
De CO_2 uitstoot wordt per gram belast door middel van "schijven"; het tarief per schijf varieert van € 61 per g/km in de eerste tot € 471 g/km in de derde schijf.
Indien van toepassing is de korting voor zuinige voertuigen en de korting voor een roetfilter verwerkt in de BPM berekening.
Met ingang van 1-1-2010 worden de relatieve energielabels A t/m G niet langer verwerkt in de BPM berekening.
De BPM wordt op hele Euro's (naar beneden) afgerond op het kenteken afgedrukt, maar is voor de volledigheid onafgerond op deze prijslijst weergegeven.
Elektrische voertuigen zijn in 2011 ontheven van BPM.

BPM APART VERMELDEN OP DE FACTUUR
Op alle verkoopfacturen voor personenauto's en motorrijwielen moet altijd het BPM-bedrag worden vermeld. Dit geldt zowel voor de verkoop aan ondernemers en particulieren. Omdat het oorspronkelijke BPM-bedrag bij latere verkoop van belang is, is het raadzaam de factuur te bewaren.

DE BTW
De BPM maakt geen deel uit van de heffingsgrondslag van de BTW.

VERWIJDERINGSBIJDRAGE: VOOR ALLE MODELLEN
€ 45,00 INCL. BTW.
Sinds 1 januari 2007 is de verwijderingsbijdrage een vrijwillige bijdrage van de importeurs aangesloten bij de RAI Vereniging per op naam gesteld voertuig.
Auto Recycling Nederland (ARN) coördineert de autoverwerking namens de importeurs en is een initiatief van de autobranche (RAI Vereniging, BOVAG, FOCWA en STIBA). De doelstelling van ARN is niet langer alleen op demontage gericht maar ook op verwerking voor hergebruik, waarbij Post shredder scheiding wordt ingezet om hogere resultaten van hergebruik te bereiken. Op initiatief van de RAI Vereniging wordt een verwijderingsbijdrage per op naam gesteld voertuig in rekening gebracht om het project te financieren en zo in belangrijke mate aan het succes van een schoner milieu bij te dragen.

BEHEERSBIJDRAGE LITHIUM-ION BATTERIJENPAKKET
€ 180,00 INCL. BTW.
Het beheersbijdrage zal ingaan op 1 januari 2011 en geldt voor Lithium Ion accu's voor elektrische voertuigen die gedurende 2011 op de markt worden gebracht. Bij de vaststelling van de Beheerbijdrage heeft ARN rekening gehouden met de veiligheidsaspecten die aan de orde zijn bij het veilig inzamelen, opslaan en verwerken van hoogvoltage Lithium Ion accu's. Over de mogelijkheden van producthergebruik (zogenaamde 'second life' toepassingen) en materiaalrecycling is op dit moment nog weinig bekend. ARN neemt daarom in 2011 samen met een aantal kenniscentra deel aan een omvangrijk onderzoek dat de mogelijkheden en onmogelijkheden op het gebied van verwerking en hergebruik in kaart moet brengen. De resultaten van dit onderzoek zullen meegenomen worden bij de bepaling van de Beheerbijdragen voor 2012.