Electric and Hybrid Vehicles: Technologies, Uses and Perspectives
Revenge of the Electric Car

The criteria used for defining motors cars have considerably evolved in the last decade. The trends have accelerated in the last five years, taking us further away from the times when car manufacturers based their development on the launch of energy-consuming SUVs and other over-powered four-door saloon cars.

We are now facing more frugal times.

Boosted by external factors such as constant petroleum shocks, measures for limiting CO₂ emissions and other pollutants, a planetary trend is now under way: the automotive industry on the whole has been focussing on the development of virtuous, fuel-saving solutions that emit low levels of polluting, silent gases while maintaining high levels of service and performance.

With no other choice than to radically evolve or risk encountering difficulties, some groups owe their survival solely to the massive intervention of public finances or takeovers by competitors. This is the case of GM, which has gone bankrupt, and Chrysler which has been sold to Fiat, as well as other European groups such as Volvo and Saab.

To face the serious problems involved in adapting their ranges, “top manufacturers” launched the urgent development of new motorisation systems for wider energy efficiency.

More or less reticent or enthusiastic, depending on the make, in less than five years, all car manufacturers have followed the path opened by Toyota, Honda, Tesla, Think and some other innovators, that of electric- and hybrid-powered cars.

Following the 2006 documentary entitled “Who killed the electric car”, which questioned what has led to the destruction of thousands of electric cars in the U.S., and more particularly the disappearance of the first electric car by General Motors, Director Chris Paine came back in the limelight with the launch of the documentary, “Revenge of the Electric Car”, a film based on the renewal of the electric car. For this, Chris Paine and his team conducted a survey with Nissan, General Motors and Tesla. This film revealed the strategic reversal of major car manufacturers with respect to electric power. It illustrates how a new generation of vehicles has entered the market in a few years’ time, vehicles in line with their era, with the greatest energy efficiency of all times.

We are truly entering a new age, one of mass production of electric and hybrid cars. It is now up to us to tailor our driving behaviour to these rather particular cars.

Philippe Brendel
President of the Corporate Vehicle Observatory
Chapter 1

Context, Energy, Savings, Environment
A rapidly-changing automotive market is now in progress. Ever-increasingly pressing economic and environmental constraints are inclining users to move towards less-polluting and energy-hungry vehicles at a lower operating cost.

This market upheaval is due to several factors:

• Firstly, the absolutely unavoidable increase in the price of fossil energies linked to their rarefaction. We have entered into a world where petrol is scarce and costly. While the sharp contraction of demand due to the world financial crisis has lowered prices over several months, the situation has since then been reversed. The rates of fossil energies have begun their inexorable ascent.

• Secondly, the degraded climate. The emission of polluting and greenhouse effect gases is modifying atmospheric protection conditions, thus seriously compromising the future of living organisms.

• Thirdly, the consequences of this same pollution on human health. Polluting particles emanating from the combustion of fossil products are harmful to mankind.

Constraints for Drivers

Now in a state of alert, at a crossroads of deep change, it is necessary to take more constraining, or even drastic measures following these observations.

Economic and political decision-makers are aware of the handicaps and nuisances caused by thermal vehicles. They have already begun to make decisions, limiting the emissions of pollutants (Law on air of 30 December 1996), with restrictions for traffic in cities, speed limits, urban tolls, and a bonus/malus insurance system.

Today, given the reality of techniques and the economy, in order to bring a sustainable response to environmental constraints, the most efficient vehicle for small journeys, urban and suburban traffic, is the electric vehicle.

Electric propulsion has made a grand entrance into the automotive industry. Following years of R&D, the automotive channel has included the advantages of electric propulsion. Energy efficiency, high level motor performance, reduced greenhouse emissions; reliability and silence are the advantages of this mode.

Energy Context

These past years, several alarming signals simultaneously turned on: sustained increase in oil price, gas and electricity, instability in major producing countries, Libya, Nigeria, Kazakhstan, crisis with Iran.

In 2011, the European Union oil bill amounted to 402 billion dollars, against 280 billion in 2010. This surge owes much to the weakening of the Euro against the dollar. It seems inevitable that the price of a litre of petrol reaches 2 euros in the near future.

The consequences of the Fukushima catastrophe on nuclear security, the scheduled shutdown of nuclear power plants, by higher cost of production, entail electricity costs increase.

In Europe, every source is increasing:

• Petrol: +22% since January 2010: drivers pay the highest price: in one year time fuels prices have soared (+22% for unleaded petrol, +8% for diesel), in the wake of crude prices on the world markets.

• Electricity: since 2010, the price of Kilowatt hours has increased by just over 6%. The trend will be upward sharply in the coming years. The grid is closed to breaking, nuclear is aging and huge infrastructure investments will have to be funded to connect the grid to the new wind and solar farms.

On the petrol front, the tendency will be upward. And the perspectives in future years appear to be quite dark, with many technical factors being added to the risks of political instability in oil-producing countries.

Rising petrol price: worrisome risk factors

The forecast for the year 2012 shows prices above 100 US dollars per barrel, with several factors combined that explain this new surge in crude oil prices.

Continued growth for demand

As for demand, its levels prior to the 2008 crisis have been reached, possibly exceeding them in 2012 (88.1 million barrels/day according to Wood Mackenzie Ltd.).
This demand is highly supported by that of emerging countries such as China and India.

**Discoveries down**

Discoveries have been receding considerably for several years now, and the situation has not reversed despite the gigantic technological means rolled out.

**Upturn in production costs**

The exploitation of resources is ever more costly, thus requiring tens of billions of dollars in investment per exploitation. Two examples of this are the deep offshore and new production units in Saudi Arabia.

**Deep offshore**

The consequences of the explosion of the Deepwater Horizon petrol platform in the Gulf of Mexico in April 2010 included the setting up of safety measures that affect the industry on the whole. The US Commission in charge of investigating the causes of the catastrophe recommended, on 11 January 2011, the creation of an independent agency in charge of the safety of offshore exploitation. The experts report did not mince its word: “The immediate causes of the explosion can be found in a series of identifiable mistakes on the part of BP, Halliburton and Transocean, which reveal such failures in risk management that there is good reason to doubt the safety culture of the whole industry”.

**New production units in Saudi Arabia**

In the past, when it was easy and abundant to produce petrol, derricks or pumps were needed. Now in Saudi Arabia, the leading world producer, with the most important reserves, new production units such as those situated in the Khurais oil field, must inject hundreds of thousands of cubic metres of water under pressure per day, this technique made absolutely necessary by the tank structure.

It is therefore a pipeline that brings seawater, from a distance of 160km into the desert to extract petroleum.

What an enormous project, covering square kilometres, the scale of which is comparable with the extraction site in bituminous sands of Alberta, Canada. For production purposes, this deposit must be kept constantly under pressure and generate high production costs, involving a sales price that is much higher than in the past.

**Ageing of installations and age pyramid of employees**

Another factor, which has been rarely explained, also affects the investments needed to continue to produce petroleum: the ageing of existing installations and the age pyramid of qualified staff currently active in the industry.

We owe this analysis to one of the most “listened to” experts in the field, Matthew R. Simmons, who died on 8 August 2010. He was the President and Executive Director of one of the largest petroleum investment banks, Simmons & Company International. At his last conferences, he raised a crucial point: The petroleum production and transport system is ill. It has been affected by the ageing of employees and by the deterioration of refining and transport installations due to rust.

If we take this information into account, all leading to the increase in the prices of the barrel of crude oil barrel, in a price forecast for the years to come, this will bring energy prices to peaks, thus justifying investments in less energy-consuming transport systems.
Chapter 2

A changing automotive industry
High performance to speed up change

In optimal conditions, engines offer maximum performance\(^1\) of about 35% for those running on petrol and about 40% for those running on diesel. Yet, as a general rule, automotive vehicles are used for small journeys in conurbations, quite far from the optimal conditions needed, which finally leads to degraded performance, the values reaching only 15% to 20%.

As a comparison, the performance of electric motors exceeds 80%, sometimes reaching up to 90%. The powerful electronics used also offer very high performance (close to 100%).

\(^1\) Motor performance is calculated as the percentage of energy supplied. In any motor, a more or less great share of energy is transformed into heat. Performance of 15 to 20% of energy received by the motor is lost and does not serve to help the vehicle to advance. Translated into fuel terms, this means that only 8 to 10 litres serve to move a vehicle with a tank of 50 litres. The rest is transformed into heat. Performance of 15 to 20% of energy supplied. In any motor, a more or less great share of energy is transformed into heat. Performance of 15 to 20% of energy received by the motor is lost and does not serve to help the vehicle to advance. Translated into fuel terms, this means that only 8 to 10 litres serve to move a vehicle with a tank of 50 litres. The rest is transformed into heat, which is wasted in the internal operation of the motor.

Ever-more-present electric motors

The tendency to electrify vehicles has speeded up since 2000 as a result of research into better engine performance in order to reduce greenhouse gas emissions, hence fuel consumption. For lower consumption, “assistance” for engines has appeared for electric motors, thus leading to the arrival of the first “hybrid” cars.

Toyota, with the Prius 1 (in 1997), then Honda with the Insight (in 1999), became pioneer manufacturers of this technology in the world market. These hybrids, such as the electric cars proposed by small manufacturers, benefit from one of the main advantages of electric motors, their high efficiency. This is because a modern electric motor is without contest more effective than an engine, whether for a car that runs on petrol, diesel or gas (such as LPG and VNG).

In addition, electric motors offer other benefits: they are reliable, cost-effective, require very little maintenance and are lightweight. They provide an enormous torque at start up, offer a very wide range of application when in gear, which in the majority of cases simplifies the transmission.

Hybrid and Electric Vehicle Categories

Micro-hybrid Cars

The Micro-hybrid (or Stop-Start) solution corresponds to the lowest level of hybridization. This concerns a reversible system that acts as a starter and alternator on a traditional car.

Micro-hybrid cars are traditional cars that are powered by an engine equipped with a Stop-Start function. The engine cuts off automatically when at a stop and is automatically triggered as soon as the driver starts up again. It helps save in fuel consumption for city driving (stopping at a red light, traffic jam, etc.) of about 10% for urban usage, 6% in a standardised mixed cycle, and up to 16% in heavy traffic.

Mild Hybrid Cars

This category, also known as semi-hybrid cars, appeared with the first models manufactured by Honda, which is the one to have promoted this technology. The hybridization level of mild hybrid cars is higher than that of micro-hybrid cars. The Stop-Start function is present, of course, while completed by a dual power system, thermal and electric, both engines working together to power the vehicle. The electric motor delivers its torque to help it at start up and when accelerating, the electricity being produced in an alternator mode is stored in specific batteries.

Mild hybrid cars are also able to recover energy when braking. The system operating in this case as a generator and develops resistance which is added to the motor brake.

Electrical energy, produced continuously or when decelerating, is stored in a battery pack of a capacity that exceeds that of simple batteries for starting up micro-hybrid cars.

A computer connected to a host of sensors manages in real time the power distribution of the two motors and the (couple)torque. When circulating in a city, the system operates like a Stop-Start system. The consumption saved, when compared to equivalent traditional models varies, of course, according to use, between 10 and 20% in the city.

Parallel Hybrid Cars

Parallel hybrid cars are the most widely known and widespread cars, mainly under the momentum of the world’s largest car manufacturer, Toyota.

As it is the case for the mild hybrid cars, an engine is coupled with an electric motor. The difference lies in the superior power of the electric motor which is of a size to power the vehicle alone, with the engine stopped, for short distances.

Parallel hybrid cars operate in an all-electric mode at start-up, at low speed, in traffic jams and when manoeuvring to park. This calls for a greater battery capacity than for the mild hybrid cars, as well as a rather particular transmission and high-performance management computer.

For the transmissions used on vehicles sold of the CVT (Continuous Variable Transmission) type, a device enables the motor to run in gear to deliver the ultimate performance.
The engineers who design hybrids of this type are seeking above all to increase the torque, which is synonymous with flexibility and acceleration, on a small motor with low emission. This is how the notion of a high-performance traction drive system came about, to replace the traditional engine/gearbox torque.

**Plug-in Hybrid Cars**

Plug-in hybrid cars have evolved from parallel hybrid cars, and are equipped with batteries of a greater capacity. We speak of plug-in hybrids when a hybrid vehicle can be charged on an electrical network, which enables the use of an electric car for daily journeys.

Three factors are propelling plug-in hybrid cars to the forefront:

- A substantial request on the part of users who are not satisfied with the performance of current hybrid cars.
- A reduction in the price of batteries, an increase in performance, a demonstration of their reliability.
- The arrival of major companies on the market, that of General Motors with the Volt, Toyota with the plug-in Prius, Ford, VW and others.

In Europe, EDF (The French Electricity Company) with Toyota, have been promoting the plug-in hybrid car. Tests have been conducted on some plug-in Prius cars in France as well as in the UK.

**Reduced consumption and polluting waste**

Reduced consumption is significant, of about 10 to 50% according to use, with urban driving offering the most spectacular gains.

The decrease in CO₂ emissions is in proportion to the reduction in consumption as a result of the high performance of parallel hybrid vehicles. A hybrid four-door saloon car of the M2 segment (VW Passat, Ford Mondeo, Citroën C5,…), such as the Prius, discharges as much CO₂ as any very small city car (Fiat 500, Peugeot 107, Toyota iQ,…), with better results than the cleanest of Clio’s.

When we compare the emissions of four-door saloon cars of the same category as the Prius, for 20,000km, it discharges one tonne less CO₂ into the atmosphere.

For other pollutants such as nitrogen oxide (NOx) and hydrocarbon (HC), emissions are lower than those of any petrol-powered car. The emissions of particles, which are a significant disadvantage for the diesel engines, are reduced to zero. Here, electric hybrid propulsion demonstrates its superiority.

“**All-electric**” Vehicles

The “all-electric” vehicle family encompasses many forms of chassis, from the super mini cars to delivery vehicles. Their source of energy is electricity and they run on rechargeable batteries, such as for PCs, hand-held electric tools, cordless tools...

- A reduction in the price of batteries, an increase in performance, a demonstration of their reliability.
- The arrival of major companies on the market, that of General Motors with the Volt, Toyota with the plug-in Prius, Ford, VW and others.

Their car manufacturers apply a traditional industrial rational: innovative products penetrate the market via the top-of-the-line, as there is no lack of innovation in electric sporty cars that are currently being sold: boosted aerodynamics, computer-driven energy management, motor wheels, etc.

Their production is hand-crafted, groomed, quasi “made-to-measure”, with significant delivery times and respectable rates. Yet, these cars are also symbolic in nature, as they are electric cars sold by small manufacturers, start-ups.

**Tesla Motors - California**

Nicholas Tesla was a Serbian engineer and inventor, specialised in the field of electricity, who emigrated to the United States.

Deceased in January 1943, he was considered to be one of the greatest scientists in the history of technology. He filed for over 900 patents (for the most part taken over by Thomas Edison) which dealt with new methods of “energy conversion”.

His theories on electrical energy led him to elaborate alternating current, of which he was one of the pioneers. The inventors of a high-performance electric car, whizzes in marketing and new technologies, chose the name of Tesla Motors to pay homage to the man considered as one of the founding fathers of electricity.

Tesla Motors saw the light of day in California, established by rich entrepreneurs of Silicon Valley. Elon and Kimbal Musk were the founders of Zip2 and Paypal, while their associate, Steve Westly, was one of the founders of eBay. They called on the British from Lotus Engineering for the design and production of a roadster with a modern sporty look, with electric propulsion.

The batteries designed by Tesla used the Lithium-ion technology of Panasonic, housed between the motor and the car interior, for 300km of autonomy. The Tesla is available in Europe. The cost amounts 84,000 Euros to become a proud owner of this vehicle, which propels its 1150kg in weight at 100km/hour in less than 5 seconds. It offers an autonomy of 250km and is on sale on order, as a priority in Tokyo, Los Angeles, Monte Carlo, Paris, London and Dubai at the price of 297,000 Euros, exclusive of tax.
phones, etc. Their evolution is closely linked to the progress made in the last ten years in terms of electrical energy storage.

Now truly sought by users who are concerned about reducing their dependency on CO₂ energy emission, they have now reached technological maturity, and enable wide-scale distribution. (See the principle of operation on page 42).

The city, the preferred location for electric cars

Beforehand limited to the centre of historic cities, traffic restrictions targeting large vehicles have become more and more frequent in European cities. The space available for circulating and parking being taken over by vehicles not tailored for cities, such as large 4-wheel drive saloon cars, has become saturated.

The municipalities have well understood this by applying voluntary policies to set up means for circulating in less energy-consuming and polluting ways.

Micro city cars are one of the responses to making traffic flow more freely in cities. The daily distances covered are low, approximately 20km per day, on average. These criteria fully meet the features of electric city cars, thus opening up a substantial market.

A new segment is also developing, which is intended for a host of new responsive and imaginative car manufacturers.

The Norwegians, pioneers of small urban electric cars

The climate in Scandinavia is rigorous, and the winters are long, with temperatures often below 0°C, making it not propitious to use car batteries. However, to meet the demand of the Scandinavian market, electric car manufacturers emerged in Norway. They now have several hundreds of cars in circulation in Northern Europe.

• The first one, Elbil Norge, has been manufacturing a three-seater since 1991. Five generations of the “Buddy” have been running since then, with over 1000 cars manufactured. Even so simple, almost rustic, this micro car of 2.44m is used frequently as a second car in Norway. It offers a maximum speed of 60km/hour and autonomy via lead-acid batteries of 60 to 80km.

A model propelled by Li-Ion batteries is also available, enabling 120 to 140km to be covered.

• The second Norwegian manufacturer, Think, is the most widely known, with communication extending outside its borders. Think is a company whose recent history has been quite hectic.

Established in 1990 under the name of Pivo, it was acquired by Ford in 1999. Ford’s ambition was for it to be its subsidiary specialised in electric cars. Pivo, was then renamed as Think. Car sales had been quite low for two years in California, after which Ford abruptly ended the project in 2003. A change in the laws in California overcame the will of the Detroit giant. The Think “City”, a car for which the production process is supervised by Porsche Consultation, is assembled by Valmet Automotive in Finland.

Unfortunately, even if sold since 2008 in Norway, and progressively introduced in other European countries such as Switzerland and France, the company’s rather chaotic path took an end in 2011. Its successor, the Russian billionaire Boris Zingarevich having announced plans to boost production in the country.

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European legislation authorises the circulation of two four-wheel vehicle categories whose characteristics have been tailored to electric motorisation. These are lightweight and heavyweight quadricycles:

• Lightweight quadricycles are vehicles for which the weight, empty, is limited to 350kg. They are fitted with a motor that develops a maximum of 4kW, for which the speed is lower than 45km per hour. They are assimilated with mopeds and can be driven with or without a driving licence according to the legislation in force in each European country.

• Heavyweight quadricycles are vehicles for which the weight, empty, is limited to 400kg for vehicles intended to carry persons, or 550kg for the transport of goods, for which the motor develops a maximum power of 15kW. They are comparable to tricycles and motorcycles. Their speed is limited to 80km/hour.

Designed for short distances, lightweight electric vehicles are either transformed thermal models or designed from the outset to hold an electric traction chain.

Heavyweight quadricycles, with or without a licence

“Roadster” Electric Vehicles

These cars rhyme with environmental-friendly behaviour, with style, for a true sense of tranquillity. These small cars are 100% electric,rather lightweight and fun, made for those seeking a simple, basic and playful means of locomotion, with zero pollution.

Their practical side is particularly attractive in leisure areas. These new vehicles are found ever more frequently by the sea, in natural areas, and are used for connecting travel to campsites, hotels and tourist accommodation.

The Simply City Sun model, designed by Eco&Mobilité in the Poitou-Charentes Region in France, is a four-seater convertible intended for all populations. On the market at a price of a 13,000 Euros, it offers autonomy of 50 to 100km, with a 9kW motor that propels up to 80km/hour. As implied by its name, this car is truly ideal for tourists.

The Volteis, the first electric 4-wheel drive, which may interest individuals and companies alike, has been designed for city use as well as for rides out in the country.
This off-road car is available in a lightweight or heavyweight quadricycle version of 70km at a price of ± 20,000 Euros.

Leaders of Fine Mobile GmbH, designers of the Twike and the concept car TW4XP, have validated the concept “hybrid human/electric” for 10 years in producing a similar vehicle, unique in its kind, the Twike with more than 900 vehicles into circulation.

Handmade and high quality product, the Twike was marketed mainly in Germany, Switzerland and Austria, Fine mobile ensuring developments, its production in small scales on demand, based on after sales service of a network of 20 Twike centres. The company has, over the years, earned a valuable return of experience in electric vehicles.

Targeted EVs on vertical applications

Engineering offices have been focusing on vehicles that offer particular services. Some examples of these niche cars are provided to us by two French players who are specialised in electric vehicle, Tazzari in Italy, Mia Electric and FAM in France.

Tazzari zero

The zero which dimension is slightly smaller than a Toyota IQ, but with a sportier appearance, is Italian through and through mirrors. Strict 2-seater, its autonomy is in the range of 140km with lithium-ion batteries for a top speed of 90km/h, with an electric motor of 15kWh. Weight distribution is neat (rear engine and batteries under the seats), as it was designed to be sporty. It comes in convertible and its registered quad doesn’t require a driving licence.

Mia Electric

The French car manufacturer, Heuliez, renamed Mia Electric, produces a small city car with 3 or 4 seats and a range of 100km and 110Km/hour (top speed). Heuliez was a forerunner of the electric car and assembled PSAs converted to this energy as early as in 1998.

Mia Electric is a compact city car of a completely new genre. Its originality lies in its being a three-seater. The driver is seated in the middle of the vehicle, with the passengers situated behind him, on either side.

The Mia style is quite unique: slightly resembling the miniature Combi-Volkswagen. With its small, round windows, it looks a bit like a full-scale toy. Barely 2.9m in length, it reigns as an urban queen, ready to grab the smallest parking spot.

This Mia exists in an “L” version, extended by 30cm, with four seats. This long version can also come in a commercial vehicle model with one seat, and a load capacity of 1,500 L. They are distributed in Germany and England.

FAM - F-City

The F-City model seems quite strange at first glance, with its highly compact chassis and visible tubes. F-City has been designed for modular use, and to meet all fleet requirements. Its lines are absolutely pure in order to resist small impacts and any other damage in a car-sharing system.

Inside, its minimalist interior with two seats, devoided of anything superfluous, is both resistant and functional despite its small size. The F-City also offers a generous boot of 410 litres.

The F-City has been targeting an exclusively urban use. In addition, there’s no need to expect any outstanding performance from this vehicle. The accelerations are flanged to ensure autonomy, its top speed culminating at 55 or 100km/hour, depending on the version; with or without a driving license.

A segment in itself, electric commercial vehicles

A range of electric commercial vehicles begins with vehicles without a licence, and covers all categories up to heavy vehicles of a commercial load of 7.5 tonnes.

Many chassis versions are available, from the cabin to the van, including microbuses, skips and other special fittings.

The technologies used are close to those of other EVs, while sized accordingly, with powerful battery backs, high-performance motors, electronically-powered regulation and charge.

Anything that can be carried in the city, with only a few exceptions, can be delivered electrically.

Some small vans enable the loading of pallets, and platform versions accept bulky loads. Minibuses also exist, and they can, on request, be equipped with devices for persons with limited mobility. They represent a vector of highly positive images and demonstrate the true involvement of institutions and companies in the implementation of a sustainable development strategy.
The Smith range is comprised of a commercial load Connect, the first EV sold by the American giant. Together with the Americans of Azure Dynamics, they over ten years, and proposes electric lorries able company has been working together with Ford for world leader in electric commercial vehicles. This car manufacturers, Smith Electric boasts the title of Founded in 1920, the most experienced of these British manufacturers electric propulsion and thus extend their range. The initial notion, that of “producing virtually indestruc-"Milk Float" manufacturers to specialise in electric propulsion and thus extend their range. Smith Electric Vehicles is one of these historic British manufacturers Founded in 1920, the most experienced of these car manufacturers, Smith Electric boasts the title of world leader in electric commercial vehicles. This company has been working together with Ford lor over ten years, and proposes electric lorries able to carry a commercial load of up to 12 tonnes. To-gether with the Americans of Azure Dynamics, they have provided Ford with traction chains for the Tran-sit Connect, the first EV sold by the American giant. The Smith range is comprised of a commercial load of 7.5 tonnes, which appeared in 2006, followed by a 3.5 tonne model launched in 2007, completed by a third model sold in 2008, a 2.3 tonne line. All the variants in terms of chassis are available.

Power Vehicles Innovation (PVI), designer of the Electric Renault Maxity.

Renault Trucks and PVI have jointly developed the electric Maxity, a zero emission utility dedicated to urban environment.

PVI, a French company with over 20 years’ expe-rience in the design and manufacture of electric powertrain, has implemented on the Maxity an asyn-chronous motor, a robotized gearbox with no clutch and battery-ion lithium of 42 kWh in the basic model.

Maxity electric is available in one product line, and offers and range of 100km, its maximum speed is 90km/h but the customer can chose to restrain it to 70km for urban uses.

PSA commercial vehicles propelled by Venturi

Venturi, Monegasque manufacturer of the Fetish sporty model, has broadened its range by bringing its expertise to commercial vehicles. To assemble its vehicles, it has invested in an assembly unit of 6,000 square metres with a staff of approximately 30 people.

It is one of the first sites to be specialised in the electric vehicle and one of the first car factories supplied with 100% renewable energies.

The assembly line of the Citroën Berlingo First and Peugeot Partner Origin “Powered by Venturi" works at a pace of 8 vehicles per day.

These vehicles, developed in partnership with PSA PEUGEOT CITROËN, are sold by Peugeot and Citroën in about ten countries in Europe.

500 Citroën Berlingo First and Peugeot Partner Origin “Powered by Venturi" cars have been, to date, produced by the Venturi assembly site. 250 of these Berlingo “Powered by Venturi” vehicles have been delivered to La Poste (the French Post-tal Service).

Equipped with Zebra batteries, the Citroën Berlingo First electric vehicle offers a range of 100km and runs at a maximum speed of 110km/h per hour.

Utilities by VW & Mercedes

VW unveiled its concept eT and an electric utility specifically designed to meet the requirements of postal workers. Developed in partnership with Deutsche Post and the University of Braunschweig, this electric van in its original style recalls the concept “Bulli” presented at the Geneva Motor Show in 2011.

VW has carried a study on the accessibility and offers 2 slide-doors and semi-automatic conduct.

Therefore, the eT offers a “follow-me” function which provides the ability to automatically track the driver when he has to walk up to several distribution points.

In turn, Mercedes experiences the release of the Vito electric, named the Vito e-Cell. After a 650,000km test in Germany in corporate fleets in the city of Berlin since January 2010 and Stuttgart since September 2011, 2,000 units of production are distributed in Europe. The Vito E-Cell are pro-duced on the Vitoria plant in Spain and offers a range of 80 to 130km depending on the journey and load, a maximum speed of 80km/h and a pay-load of 900kg.

City-centre Transport

The voluntary policy of a large number of cities to limit nuisances in historic city centres has brought about the circulation of lightweight vehicles dedica-ted to the transport of persons.

Used as shuttles or for regular transport lines, they have become increasingly successful.

From the tiny Porter made by Piaggio to the 47-seater PVI buses, the French leader in elec-tric heavy vehicles, not to mention the Microbus by Gruau, a complete range of electrical vehicles is available on the European market.

Car manufacturers committed to electric vehicles

The automotive landscape has changed, and is moving along this path at a rapid pace.

Marginal categories in the past years, such as hy-breid cars, have become a standard that cannot be ignored. Some of them, namely rechargeable hy-breid cars and “all-electric” city cars, are booming.

2011, a pivotal year in terms of change

We are currently witnessing the arrival of the first modern electric cars on the market, which have been mass produced; namely, the Nissan Leaf, Ford Focus, Transit Connect, Renault ZE, Opel Ampera (Chevrolet Volt in the US), the Ion and C-Zero of PSA, the Bluecar of Bollore, and the Tata Indica. Volume will initially represent a low percen-tage of the global automotive market, some tens or hundreds of thousands of cars per year for the most ambitious ones within the next three years.

Electric deliveries, English-style

The installation of new electric transport models is carried out in lines with an approach that has been well tested by our neighbours across the Channel. From the years 1950 to 1960, the streets in English towns were covered by typically British vehicles known as “Milk Floats”, vehicles that deliver milk or other fresh products.

Designed to be ultra-reliable and long lasting, dri-ving daily without noise or pollution, these vehicles are truly an institution that has placed electric com-mercial vehicles at the core of the daily lives of the British. Some of them, put in circulation over 30 years ago, are still in service, which expresses to what extent they play a part in the solid reputation of EVs in the UK.

The initial notion, that of “producing virtually indestruc-tible vehicles” has been followed up until today, thus enabling “Milk Float” manufacturers to specialise in electric propulsion and thus extend their range.
However, the impact of these vehicles on the market is significant indeed, as these cars will heavily speed up the research process for energy efficiency for all vehicle categories, thermal and hybrid.

Due to the still quite limited performance in terms of the range of the battery packs, the vehicles must become lighter, recover energy when braking, limit consumption of the peripherals that use energy, such as air conditioning.

The silent operation of electric motors requires reducing aerodynamic and pneumatic noise, for ever greater comfort.

This search for friction has enabled electrical consumption as well as fossil fuels to progress globally by several points.

This other more rational approach imposed by electric and hybrid cars is influencing the automotive industry on the whole.

An example of a development strategy under the impetus of the electrification of models has been provided to us by Toyota, who for its third-generation hybrid Prius, has focussed on optimising the aerodynamics, lightening the structure, with high-performance air conditioning and a sunroof to cool down the interior. In parallel, the Japanese Group has been progressively generalising the use of hybrid propulsion in its complete range: Auris, Camry and Lexus for the hybrids currently being sold, to which new models will soon be added.

**Dual and Complementary Change: Load Infrastructure and Use**

**Charging Points**

The public authorities have well understood the interest that lies in accompanying the development of electric and hybrid vehicles. In addition to the logical support brought to an industry that promises qualified jobs, in order to maintain the competitiveness of national companies, this also means reducing dependency on the fossil energies imported at a steadily-increasing rate. Electric city, whatever the technology needed to produce it; hydraulic, thermal, nuclear, solar or wind-powered, is a local energy.

The additional and complementary argument of a carbon footprint that is widely favourable for electric and hybrid motorisations with respect to engine vehicles has served to speed up awareness and decision-making. This is why in almost all countries: governments, companies and local communities alike have started up vast development programmes for a charging infrastructure, differing from petrol stations that provide liquid fuels.

Electricity is available everywhere or almost everywhere, including in the most remote locations. Charging points are easy and rather inexpensive to set up, whether at individuals’ homes, in companies, on public roads or in car parks.

**European incentives for electric and hybrids vehicles**

Here is a sampling of incentives that European governments offer to buyers of environmentally friendly vehicles:

**AUSTRALIA** In addition to tax breaks, owners of hybrid and other low-carbon vehicles benefit from a fuel consumption tax that pays bonuses to passenger cars with low carbon dioxide output. Alternative fuel vehicles, including hybrids, qualify for as much as $1,120 in annual bonuses.

**FRANCE** In a similar program, a maximum benefit paid for new e-car buyers is $7,000, while buyers of high-carbon-emissions vehicles can pay penalties of up to $3,650. France sees itself as a future leader in e-mobility and has begun construction of 400,000 charging points, expected to be in operation by 2015.

**GERMANY** Germany’s new post-Fukushima energy plan envisions great things for e-transport, a segment where this auto-producing nation has lagged. One proposal is for a $1.4 billion program of electromobility research and development; rebates are not in the mix. The current five-year grace period, during which private owners of E.V.’s are exempt from the annual motor vehicle tax, is being doubled to 10 years.

**BRITAIN** E.V. buyers can count on $3,200 to $8,000 in rebates until at least 2016. In London, electric-car drivers save the daily congestion charge (about $13) and enjoy limited free parking. Moreover, exemption from a vehicle excise duty (a car tax based on carbon emissions) could be worth up to an additional $1,500 a year.

**LUXEMBOURG** Buyers of electric or other low-carbon vehicles qualify for a rebate of up to $4,200. But there’s a catch: the buyer has to sign up to recharge with electricity from renewable energy sources.

**NORWAY** Norway, and in particular the city of Oslo, is the Shangri-La of electric transportation, though no monetary rebates are offered. The country provides other privileges, including the world’s largest E.V. parking lot as well as free charging. E.V. drivers on their way to work in the morning can use taxi and bus lanes, cruise through tolls without stopping and park free. Buyers are exempted from a wide range for taxes, fees, import duty and congestion charges.

**PORTUGAL** Portugal’s nationwide public network of 1,350 charging stations was visionary, enabling E.V. drivers to travel anywhere in the country. Buyers of electric vehicles and passenger cars with other exclusively renewable energy systems receive a premium of $7,000 and an additional $2,100 if they scrap their old car, as well as income tax relief of up to 30 percent, or $1,114.

**SPAIN** A federal fund covers up to 25 percent of an electric car’s retail price, the reduction depending on its efficiency, and regional authorities chip in as much as $8,400. The greatest aid is provided in Andalusia, where 70 percent of the vehicle’s cost could be covered.
New technologies and industrial investments

The rapid increase of new players on the market has been generating a growing demand for special components for electric traction chains.

For several years now, we have observed a considerable increase in R&D investments in this budding industrial sector. Such development efforts have been preceded by a pre-industrialisation phase since 2008, with mass production in the most advanced industrial units.

New components have been implemented: materials on a nanometric scale for battery electrodes, super-capacitors, electronics directly built into motors and composite materials to make vehicles lighter. Such innovations have reached the mark of mass production, which are now at the disposal of designers.

Essential component on the traction chain, batteries

Since the electric vehicles of 1990 to 2000, battery characteristics have progressed immensely. For the same weight and similar volume, the quantity of energy has been multiplied by 3 to 5. A direct consequence of this is that the range has gladly reached the mark of 150km on one charge for all-electric models, reaching 40 to 60km for rechargeable hybrid vehicles.

The life cycle, an essential feature, has also progressed considerably. Battery packs help make great mileage, about 200,000km before being replaced.

Several technologies are in competition to fit electric vehicles. These diverse offerings provide for a wide array of choices for designers. NiMH accumulators are currently the standard for hybrid cars, thus equipping several million units.

Lithium-based batteries are today first and foremost in the portable electronic market. They now equip most of the latest all-electric vehicles. Their prices, which are relatively high, are decreasing in proportion to the volumes produced by an increasing number of specialised factories in all continents.

Electronics giants such as LG, Panasonic, Toshiba, Nec and Samsung have directed their activity to the supply of batteries for vehicles. They have the know-how and substantial means needed at a time of intense competition, for leadership in a market with strong development potential.

Energy storage unit, two essential functions: tank and energy recuperator

The tank function is ensured by batteries coming from diverse technologies. The principle, ever so simple, has been the same for many years. Accumulator cells are connected and assembled together in a sealed container, the battery. To obtain the power needed, batteries are regrouped into one or more packs, and placed inside the vehicle.

The energy recuperation function is newer. This consists in storing the electricity produced by the motor in “generator” mode when slowing down. To be effective, it must use accumulators that accept high currents coming from the motor. Few battery technologies permit this. The most effective components for this are super-capacitors. Their charge and discharge time, lasting a few seconds, enables them to act as an energy buffer between the motor and the batteries.

They have entered into research laboratories to be produced in great volumes by firms such as Maxwell and Batscap, a subsidiary of the Bolloré Group.

Highly powerful, long-lasting batteries

To measure the progress made in the last years by batteries intended for electric vehicles, it is necessary to review some of the basic technical notions.

Power

The power of a battery is determined by the quantity of electrical energy it contains in a litre or in a kilogramme. Two units of measurement are used, the Watt hour per litre, i.e. Wh/L or the Watt hour per kilogramme, i.e. Wh/kg.

EV technicians also use another notion of power, the Watt per kilogramme, W/kg, which determines the maximum instantaneous power provided by a battery or a battery pack.

Life cycle

Another decisive criterion to compare battery performance is its life cycle. Indeed, battery performance becomes degraded in time, and some technologies offer a longer last than others. The criterion used is the number of charge and discharge cycles, in other words, the number of times we will need to “fill up” before having to replace the batteries.
The Industrial Stakes

Value Transfer

In petrol/diesel vehicles, a large share of the value is concentrated in the traction chain, the motor and its peripherals. Equipment manufacturers supply a wide majority of other parts, running gears, interior equipment, electronics; car manufacturers remain concentrated in the cell, design and, of course, motorisation.

The advent of electric and hybrid vehicles has created an upheaval in this process.

Battery packs charged to store energy, and no longer motors, are now at the core of the global value of vehicles.

This has led to the transfer of this value to specialised car equipment manufacturers, producers of new generation batteries.

New players in the world automotive landscape, battery producers

A new industrial sector is opening up before our very eyes, in real time. Giant production units have been coming out of the ground, to produce a sufficient quantity of battery packs, which are indispensable for the millions of electric and hybrid cars planned to be manufactured all over the world.

Huge amounts have been invested everywhere, in America, Europe and Asia. The stakes are enormous. It is a question of adapting lightweight technologies, initially planned for personal mobility markets (mobile phone, laptops, MP3 players, GPS, electrically-assisted bicycles, etc.) to the latest needs of the automotive sector.

The presence of general public electronics giants as well as suppliers of on-board energy solutions is not a surprise. They have the know-how that is needed. Innovation stems from, as it is the case for each technological change or breakthrough, a host of start-ups specialised in electrical energy storage.

The competition is tough between approximately 20 companies who have succeeded in mobilising the technical and human means needed for R&D, especially with regard to raising the capital needed for the launch of wide-scale production.

The technologies implemented are seeking to store as much energy as possible, for the least amount of weight and volume. In this aim, the efforts on the part of designers have been directed towards Li-Ion battery families.

Manufacturers have focused their mass production work on battery packs for which safe operation is guaranteed, for a long life cycle, all at a price that is acceptable for the market.

The most advanced ones are currently delivering batteries of a life cycle that reaches 3,000 cycles of charge and discharge, i.e. 300,000 km.

Battery pack production

From materials to cells

Lead-acid batteries

This old technology has been mastered perfectly in large-sized production units. Recent changes in the production process are now being used. These are sealed gelified electrolyte batteries and sealed absorbed electrolyte batteries in a glass microfiber separator (AGM technology).

Recently, front terminal batteries enabling optimised wiring have emerged of day. They have been completed by “pure lead” batteries with fine plates and batteries in spiralled plates with high-energy performance.

The automation of assembly lines, modern continuous production processes, grilles and plates and research on materials are all engines of progress for the lead-acid battery.

NiCd, NiMh and Lithium family storage batteries

Lithium battery production is very close to that used for NiCd and NiMh cell production. However, due to the high reactivity of the chemical compounds used in Lithium cells, special processes are needed. For example, we are going to explain, in detail, all the stages of Lithium cell production.

Coating of electrodes

The production of electrodes calls on technologies similar to those used in the semi-conductor, optical industry, fine layers.

At a microscopic level of the deposits made, to avoid any impurity, the machines operate in a controlled atmosphere close to a vacuum and produce rolls of components.

Anodes and cathodes, similar in shape, are produced in a rather equivalent manner on equipment that is either identical or very close in nature.
Electrode materials, mixed powders, are deposited on both sides of a metal film which serves as a current collector, which is then connected to the terminals. The thickness of the deposit is controlled continuously, then compressed and dried. We thus obtain rolls of electrode sheets in standard widths of 50cm up to one metre. These sheets are then cut in order to be assembled into cells.

This cutting stage is extremely precise so as to avoid any slight variation in size, which could cause a short-circuit following assembly.

Cell assembly

In the most high-performance factories, the assembly is carried out by robotised installations. However, some small producers, in countries in which the cost of labour is lower, continue to carry out assembly by hand.

The first stage of the assembly process consists in coupling the anode, the separator film and cathode. Then, according to the type of cell, whether prismatic or cylindrical, the assembly remains flexible, and is folded or rolled before being placed inside a resistant sheath. The electrodes are connected to external connectors, to which the electrolyte is added.

The cells obtained, whatever the technology used, deliver per unit voltages and powers that are too weak to supply motors. They are therefore logically going to be connected electrically and assembled mechanically into modules.

From cells to modules and packs

The first assembly level of cells is the production of separate modules, the latter being later incorporated into packs. There are two main constraints in this, the electrical connections and mechanical assembly.

Electrical connections must take the successive stages of modules into account at the time of charge and discharge. They enable, by adding specific electronic components, the measurement of the incoming and outgoing current for each cell, memorising them in order to then transmit them to a “central unit” that manages the batteries, currently known as BMS (Battery Management Systems). BMS is absolutely necessary in order to memorise the number of charge and discharge cycles involved, hence the ageing of modules, whatever the technology used. It also incorporates management functions of a current at the time of the charge and delivers the information needed to be displayed on the vehicle dashboard. Of course, protection against internal and external short-circuits is built into the modules.

The mechanical assembly of modules is fundamental for modules to be assembled in a rigid and sustainable fashion way, the mechanical parts having to resist the shocks and vibrations inherent in the circulation of vehicles. The aim of the housing is to protect the cells against humidity, dust and intrusions of any kind. Furthermore, they must be resistant in case of an accident, and also be easily interchangeable. The lowest possible weight and volume for the whole pack means choosing lightweight alloys, rigid plastics or composite materials for the containers. The latest constraints for manufacturers are the highly stringent production standards required of producers in order to minimise costs, automate assembly lines and ensure continuous Quality control for the whole production process.

Packs with on-board energy systems

We can see that the new generation batteries are not just simple batteries. They include all the functions needed for optimal operation, in complete safety.

Features such as a clear and efficient user interface, memorisation of all parameters of use have recently appeared. The wiring and electrical connectors have also changed substantially, thus offering added reliability, hence safe operation.

For this, they use the CANbus, a car communication standard between computerised components. This standard now applies also to battery packs. Producers such as the American company Valence Technology have been proposing packs equipped with a CANbus interface as well as a programming kit.

All these elements, cells, modules and related electronics/computerisation, packs cables, BSM, make up what we call an “on-board energy system”.

These systems require specific know-how prepared by companies specialised in this field; a host of innovative start-ups who offer more or less standardised solutions for vehicle manufacturers.

On the other hand, all the other components of electric vehicles have evolved considerably in the last five years. Motors optimised to consume as little as possible, driven by electronics, real time energy management computers, such components have become progressively standardised with regard to an exchange of information.
Recycling of batteries

The problems presented by used batteries are linked directly to the organisation and efficiency of recycling. Commodity prices and the rarity of raw materials also weigh heavily upon an absolute need for treating used batteries.

It is the car manufacturers or importers who bear the responsibility for informing users and providing a recycling service. They are assisted in this by channels that have been set up according to the technologies to be handled.

Companies specialised in the end-of-life-cycle collection and recycling exist for the following battery technologies: Lead, Ni-Cd, Ni-Mh, and Li-Ion. The collection of lead-acid batteries is carried out at the national level by recovery professionals, garages, waste recycling centres and car centres.

As for the other technologies, namely Ni-Cd, Ni-Mh, Li-Ion, specific channels have been set up to use the batteries from computers and other mobile phones. The substantial volumes distributed, thus to be recycled, have led to the creation of companies or specialised services.

The specialists in France are: SARPs Industries, subsidiary of the Veolia Group, SNAM, subsidiary of a German company, F.W. Hempel & Co.

A start-up from Grenoble in France, Recupyl, has developed and patented a lithium battery treatment process that is now in operation.

As for Umicore, it has decided to build an industrial-scale installation for the recycling of used rechargeable batteries in Hoboken, in Belgium. The new installation represents an investment of 25 million Euros, and will be endowed with an initial annual capacity of 7,000 tonnes. This is equivalent to about 150,000 EVs and hybrid batteries, or 250 million mobile phone batteries. Umicore is the largest precious metal recycling company in the world and one of the largest key materials producers for rechargeable batteries.

Raw Materials and Resources

The leaping growth of means of battery production implies a proportional increase in the volume of raw materials. The reserves of the latter, nickel, cobalt, lithium, zinc, among others, are found in large quantities on the surface of the earth. Their geographic distribution, quite different from that of fossil energies, such as petroleum or gas, generates a redistribution of economic maps. New States are, in fact, producers of strategic raw materials, to the benefit of their balance of trade.

Cobalt inventory is held by the Congo Republic, Australia and Cuba. The largest nickel mines are found in Australia, Cuba, France (in New Caledonia), Russia and South Africa. World zinc reserves are located in Australia, China, Peru, Kazakhstan, US, Mexico and Canada.

At the current consumption rate, reserves are ±43 years for nickel, ±95 years for cobalt, and about ±20 years for zinc.

Lithium in a sufficient quantity to supply battery production

Lithium is a special case. Traces of lithium can be found in oceans while they are not very profitable in terms of exploitation. Lithium is found in pegmatite deposits (magmatic rock), in some clay and in salt deserts in large quantities.

The largest salted deserts are situated in South America, in Argentina, Chile, Bolivia, as well as in China and in Tibet. One of these deposits, yet to be exploited, is in Bolivia. This concerns the “Salar de Uyuni”, the largest salt desert on the planet, which covers 10,582 square kilometres.

Japanese, Korean and French industrial groups have approached the Bolivian government to propose exploitation of this giant deposit. Known lithium resources, estimated by the USGS (U.S. Geological Survey) total about 4.1 million tonnes. Production in the year 2008 totalled 27,400 tonnes, which enables us to envisage the production of several tens of million battery packs intended for EVs without any major difficulty in terms of supply.

New lithium discoveries

The increasing demand for lithium for future EV batteries has created a boom worldwide for this ore. Several announcements have been made to confirm the fact that the lithium resources not yet exploited, or reserved, shall say, will be made available according to demand.

In October 2009, a Mexican company, Sutti Piero Mining Company, discovered in the centre of the country an enormous lithium and potassium deposit in the Zacatecas and San Luis Potosi regions. It may just be one of the largest in the world. Several companies from Japan, Sweden, Korea and Australia are ready to invest in this exploitation.

Another company, American this time, Western Lithium Corporation, has announced the future exploitation of a lithium deposit in the Nevada desert. It was discovered by chance by Chevron Resources in 1977, when mining for uranium. In 1991, given the reduced demand for lithium at that time, the Chevron Group sold its exploitation rights to Western Energy Development. The latter resumed research in 2005 and set up a subsidiary, Western Lithium Corporation, in charge of exploitation. The deposit is estimated at over 1 million tonnes of lithium carbonate.

A final example of lithium resources, not yet exploited up until now, is the increasing demand generated: the production in geothermal factories. A firm based in California, Simbol Mining Corp, established in 2007, operates patents from the U.S. Department of Energy (Lawrence Livermore National Laboratory), to extract geothermal sources from ores such as zinc, manganese, silver and lithium. It has become associated with geothermic-based electricity producers for the simultaneous production of energy and metal ores at a low cost. The construction of a pilot unit was launched in 2009.

We have observed, through these examples, that the “alarmist debate” covered widely by the media on the theme of “Will there be enough lithium for EVs?” does not need to be presented as dramatically as some pseudo-experts would like us to believe. Other raw materials such as gas or petroleum pose geostrategic and supply problems that are far more important, and infinitely more worrying, than lithium resources.

This must be kept in mind when making decisions with regard to electric vehicles.
Chapter 4

From plug to motor
The technical characteristics of electric vehicles are described in units of measurement that are specific to electrotechnical equipment. These units of measurement, differing from those used for engine vehicles, may not be easily understood. To decipher the technical data sheets and compare the different characteristics of EVs, some benchmarks are essential.

**Charging batteries and connection of the power plug**

EV batteries are rechargeable via domestic outlets in compliance with the European standards. They operate in France on 220 Volts (V) and deliver a maximum intensity of 16 or 32 Amperes (A). 16A plugs are the standard, 32A plugs are for large appliances such as ovens and electric burners. The maximum power\(^1\) delivered is expressed in Watts (W) or kilowatts (kW).

\(^1\) The calculation formal is: W = V x A

The length of use expressed in hours generates a consumption that is expressed in Watts per hour (WH) or in kilo Watts per hour (kWh). Batteries are charged for a period of time set with respect to their construction and technology. Lead-acid batteries require a slow charge, from 6 to 10 hours, while the latest technologies, such as NiCd and Li-ion, accept quicker charges, namely 4 to 8 hours.

The calculation of the electrical consumption is carried out from the characteristics of the vehicle’s charger. For example, a lightweight EV equipped with a 1,500 W charger will consume a full charge of 7 to 12kWh. This variation depends on the battery capacity.

**Battery capacity**

The battery capacity is expressed in ampere-hours (Ah). This is the quantity of electricity it supplies. According to its voltage, the stored energy is calculated using the equation: Ah x V = Wh (or kWh).

For example, a battery pack of 210 Ah for 48 Volts supplies 10kWh, while another pack for 72 Volts provides 15kWh. On the practical side, this on-board power will determine the vehicle’s autonomy according to the power of the motor, the total weight of the EV and the speed and profile of the journey involved.

**Motor power**

Motor power is expressed in kW. The figures indicated as a general rule express the nominal power, e.g., 4 kW for lightweight quadricycles and a range from 8 to 30 kW for lightweight vehicles. In certain cases, manufacturers also indicate the peak power of the motor. This concerns a maximum admissible value for a few seconds used when starting up or climbing a hill. In all cases, the motor power is regulated using an electronic speed drive, itself controlled by the accelerator pedal.

**Consumption per kilometre**

To compare the electrical consumption of EVs of the same category, the solution is to calculate the electrical consumption per kilometre covered. This is expressed in Wh per kilometre or in kWh per kilometre.

Consumption depends, of course, on the weight of the vehicle, its load, type of path covered and average speed. Consumption is thus expressed in terms of values within a range. These values are about 0.08 to 0.15kWh/km for vehicles of the quadricycle category and oscillate between 0.10 and 0.25kWh/km for miniature cars. A simple extrapolation for 100km enables the energy consumption item of electric vehicles with thermal vehicles.

Electric urban cars, from the smallest to the highest performance, consume 8 to 20kWh for 100km. This represents rates\(^2\), for “peak hours”, a budget of 1 to 2.55 EUR/100km. As for the prices for “off-peak hours”, used for night charges, consumption then varies from 0.7 to 1.72 EUR/100km.

**Filling up with energy**

Electricity is present everywhere, or just about everywhere. This illustrates a major advantage for the development of electric vehicles, especially since a simple plug of a current of 220 Volts of 16 amperes is enough. With an extension cord to hook up the vehicle to the network, the vehicle can be charged. The charge time varies according to the battery technology used. Lead-acid batteries require slow charges, from 6 to 8 hours, depending on the power, while most recent technologies enable a charge time of 5 to 6 hours.

A quick charge (1 to 2 hours), partial charges, additional charges are also made possible by some battery technologies, provided they are equipped with the suitable charges and outlets of an industrial type.

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\(^1\) Calculation based on: off-peak hours 0.0864 per kWh, inclusive of tax, peak hours 0.1275 per kWh, inclusive of tax.
Charging a vehicle in public places and at the workplace

Recharging stations have been designed to resist the constraints linked to an installation on public roads, outdoors. They are ever more present in car parks, with spaces reserved for electric vehicles.

In Europe: on the government’s initiative, a vast national recharging point development programme was launched. Car manufacturers, energy providers, local communities, building professionals and managers of public areas have rallied round this initiative. The aim is the creation of a recharging infrastructure (domestic, at the workplace, on public roads, at quick recharging stations) in order to supply several tens of thousands of vehicles at the dawn of 2012.

In France: The French government has set up a framework for the design and organisation regarding the development of such infrastructures. The rollout of recharging infrastructures will benefit, in their pilot phase, by the support of the “Investissement d’Avenir” Programme (Investments for the future) for the communities that have signed up within the scope of the “Cities of Tomorrow” campaign as well as for a State charter.

In Germany: 840 loading stations are operational in early 2012, 1,400 are under construction, a programme called “National Plattform Elektromobilität” was launched in May 2010.

In Switzerland: it’s 230 stations grouped under the banner of Park&Charge which are operational, while in Ireland BSE launched a project to equip 30 quick loading stations, 1,500 public stations and supports the installation of 1,500 domestic stations.

In the Netherlands: the 1,200 operational stations in 2012 will be complemented by an ambitious national programme to install over 10,000 loading stations, a project supported by the “formula e team”, a working group bringing together local governments, private companies and research institutes.

To complete this European tour on initiatives around loading infrastructure, we notice that after a pioneering initiative in London, where charging stations were installed in 2004, Britain continues to equip a large network, 1,500 terminals are being implemented to enrich the existing 600 units. Spain is currently implementing 200 units, Portugal putting in hand 1,300 units and at last but not least Italy with 500 units “under construction”.

Changes brought to charging systems

Along with recharging infrastructures, new technologies have been emerging, which are beginning to be used all over the world. Two parallel trends have arisen: reduced immobilisation time for vehicles needing to “fill up” with electric energy, and the production of renewable energy, locally.

Quick-charge

Several producers of storage batteries using technologies to reduce charging time such as LiFePo4, intend to sell packs for EVs that accept a charging time of about 5 to 10 minutes. This is the case for Toshiba, which offers its SCiB (Super Charge Ion Battery) technology, with records broken in this area.

The consequence of such high performance, the electric high throughput charging points, electric outlets accepting 40 Amperes of 230 Volts are needed. This power requires an industrial type electrical installation.

Some manufacturers are already on their mark, and have developed charging terminals that look like petrol station pumps, with one slight difference; in these stations, vehicles are supplied with energy via an electric current.

Wireless charge

Another technology demonstrating ultra-rapid progress is the wireless charger or induction charger.

All those who use an electric tooth brush, often without knowing it, resort to this technology, which consists in transferring electrical currents without a metal connector.

A charger without contact for EVs operates on the same principle, except for the fact that the quantity of energy carried is far greater.

The principle of physics used is the transfer of electricity via magnetic fields, called an induction charge. This way, it becomes possible to charge a vehicle, when stopped, without a wire and without a connector.

The vehicle must be equipped with a plate containing a coil, under its chassis, which needs only to be placed at a spot provided for this purpose, in a dedicated parking space, for example, with a coil of the same type, so that the charge process can be launched using a remote control. A magnetic field generated by the two coils carrying the current “in the air”.

Several companies already offer this induction charge system, which is expected to appear on the European market in 2012.

Stations supplied with renewable energies

The rationale of the designers of systems of this type is irrefutable. Car parks often offer huge outdoor surfaces, part of which remains to be used. They thus cover them with rows equipped with solar panels. There is a dual advantage in this: the parking spaces are now shaded, and this energy produced is used to recharge EVs while they are immobilised. When there is no longer any vehicle to be charged, the current is injected into the network, and sold.

Several companies have specialised in this specific area, and some have been offering individual charging stations since 2009, for individuals and small companies alike.
Performance, constraints and advantages of EVs
In electric vehicles, the parts that make up the traction chain are organised according to the same principle as for petrol/diesel vehicles. The energy stored on board is transformed by a motor and then sent to the wheels. The main difference lies in the simplicity of the electric traction chain with respect to its petrol/diesel equivalent.

- An energy tank made up of a battery assembly
- One or more electric motors
- An electronic/computer control unit and a charger
- Cables to hook up the entire system

The engine “peripherals” are thus disappearing: water pumps, oil pumps, injection pumps. No filter, exhaust or sparkplugs. What about the turbo compressor? There’s no longer any need for it. Transmission has been simplified, as there is no clutch or gear box.

The electric motors that equip modern vehicles derive from industrial motors. They are very easy to use, and offer unrivalled reliability. Designed to operate continuously for years without maintenance, they require only check-ups. To obtain the power needed, the batteries are regrouped into one or more packs and placed inside the vehicle.

At the dashboard, the energy consumption display can be seen. Coupled with a GPS, it can calculate the journeys and location of the nearest charging terminals.

**Constraints related to operation**

**Reduced autonomy**

The main constraint is very clearly the range of the “all-electric” vehicle. With progress made in the battery storage capacity, we are today or will be in the forthcoming months with a range from 100 to 200km, on average. Some exceptions, in the top-of-the-line range, offer up to 450km of autonomy, which minimises the use of EVs to what are known as “pendulum” type applications, point-to-point linkage, short-distance delivery, of about 10 to 150km per day.

**Limited speed**

This is a direct consequence of the choices made in terms of design. EVs are above all vehicles with great energy efficiency and low consumption. To reduce consumption, vehicles are therefore calculated to go as far as possible, not the most rapidly, with the battery charged. However, while limited to about 70 to 120km per hour, depending on the model, acceleration and speed can be provided in complete safety in vehicle fleets, including on major road networks.

**Still a limited number of charge points**

It is a fact; energy is everywhere, or almost everywhere. Of course, charging can be done (except for a quick charge) on a simple outlet of 220 Volts 16 Amperes, the European standard; there just needs to be one close to the parking location of the vehicle.

- If you are the owner of a single home (15.6 million in France) or a secondary residence (2 million), there’s no problem. There is a strong chance that you may have a garage with an outlet that meets the standards needed.
- If you live in a collective building, you will need to wait until charge points are installed in your car park or garage.
- If you work in a company or a community that has set up a support policy for the arrival of EVs, this will be easier for you, as the works needed to be performed to install charge points will be technically easy and not very costly.
- If you live in a “pendulum” city, such as Paris, where silent operation, limited speed, short distances and zero pollution are the key factors to success.

**Advantages related to operation**

**User comfort and flexible driving**

Very clearly, there is a difference between driving EVs or hybrids in electrical mode, and petrol/diesel-operated cars. The former imperatively rhyme with eco-driving, as the quantity of energy on board, in the “tank”, is limited. After several hours of training, drivers will take on the reflexes needed to drive in a more relaxed fashion, without any abrupt acceleration or braking, for a smooth, silent journey.

**Noise free**

Silence is complete when at a stop. Only a slight whistling sound from the motor transmission can be heard when starting up, and then only slightly at a stabilised speed. There is no noise when slowing down, only a very slight sound of the brake, even when the vehicle activates the electric motor brake to recover energy.

**Safety**

EVs are ever so tranquil when driving, and logically cause fewer accidents than engine-powered vehicles, which entitles them to special conditions on the part of insurance companies.

**Zero emissions**

EVs are without a doubt the ideal vehicles for environment-friendly areas, such as city centres, closed sites such as ports and airports, anywhere where silent operation, limited speed, short distances and zero pollution are the key factors to success.

The other characteristics inherent in EVs complete these advantages linked to usage.
Energy-saving

Energy consumption is highly reduced. When used during night-time charges, it is important to remember that, according to the vehicle’s power, the cost can vary from 0.8 to 2 Euros/100km at peak hours and 0.5 to 1.15 Euros/100km at “off-peak hours”. In comparison, a petrol/diesel vehicle consumes 7 litres/100km of fuel for the same distance of 100km, from 8 Euros (diesel at 1.15 Euros/litre) to 9.45 Euros (SP98 at 1.35 Euro/litre).

Ultra-low maintenance

Maintenance is down to a minimum, as regards the control of tyres, brake pads, windshield wipers; and the motors require no maintenance, as they have been designed for a lifetime cycle of several hundreds of thousands of kilometres. The life cycle of new-generation batteries, of the Nimh and Li-Ion type, reach or exceed 2,000 charge cycles. Assumed that the battery pack has been sized to travel hundreds of thousands of kilometres. The life cycle of batteries, of the Nimh and Li-Ion type, reach or exceed 2,000 charge cycles. Assuming that the battery pack has been sized to travel hundreds of thousands of kilometres.

What needs to be maintained?

The shock absorbers: Whatever the energy used to make the vehicle advance, there’s always a need for shock absorbers.

The brakes: They are solicited less often, as an EV recovers kinetic energy from the motor. Driving seems to be anticipated. We therefore brake much less often! (With about 50% less wear of the brake pads compared to a petrol/diesel model).

The transmission: It needs oil, even when there is no gear box (gear motor), with an oil change every 50 to 60,000km.

The tyres: Driving is smoother and more regular; they are less solicited, power consistent, which makes it difficult to wear the tires when accelerating, as there is no clutch (for about 50% less wear).

“All-electric” EVs are not all-purpose vehicles, but vehicles that are specialized for a specific usage. Their choice must necessarily be anticipated in this aspect, as there is a limited performance/features focus; while they are highly competitive in these areas.

Carbon footprint of electric and hybrid vehicles

Electric and hybrid vehicles discharge much less CO2 into the atmosphere, locally. This means zero pollution for the “all-electric” vehicles, with low emissions in each category for the hybrids.

These unrivalled advantages are completed by global footprints of CO2 discharge, “from well to wheel”, remaining favourable for electric and hybrid vehicles as compared to petrol/diesel vehicles.

The global “from well to wheel” analysis adds up the CO2 volumes emitted when producing energy, its transport (from well to tank), plus the CO2 emitted when using the vehicle (from tank to wheel). For electric vehicles, it is necessary to quantify the CO2 emissions at the time of electricity production. The latter vary according to the type of energy initially used.

Electrical production by renewable, hydraulic, wind-powered, biomass energies emit very little. What is produced by gas, fuel or coal thermal power stations emit substantial CO2 discharge. Electricity of nuclear origin is in an intermediary position, between renewable energies and fossil energies.

The global footprint will therefore logically vary according to the country and energy used to produce electricity.

France favours energies that emit only slightly; nuclear, plus renewable energies, with about 9.9% of fossil energies. With, on average, 75 grammes of CO2 per kWh, French electricity production is in the lead in Europe due to low CO2 emission.

A subject of debate

Recent history has demonstrated that the industrial stakes are high, the worst strategies being implemented such as the complete destruction of an EV fleet by GM and Toyota in the U.S. at the end of the 90s in order to limit the impact of their distribution, and thus put an end to any possible debate.

Today, while the initial situation has changed, major industrial companies such as the Renault/Nissan alliance, GM, VW, Ford, the Japanese, Chinese, Koreans have invested huge amounts in EVs. And, in addition, different lobbies in action in the transport sector have entered into a latent war, which has more or less been declared. Petroleum vs. Electricity, petrol/diesel motor producers opposed to battery producers, new mobility operations in direct opposition with competitors by producing their own clean vehicles, amongst manufacturers, the Japanese of Toyota and Honda having “locked” hybrid technologies; anything goes.

EVs are being accused of being too silent. Noise devices will have to be added, batteries could be explosive from some researchers, while they are based on the same technologies as PCs distributed in hundreds of millions units. It would never occur to anyone to forbid the use of the IPhone, Blackberry or other IPads in planes or in bedrooms. However, this is what is happening with those who accuse EVs of being dangerous in car parks or garages. Of course, there are technological risks, they are inherent in all modes of transport. However, they are very limited, the standards and how of manufacturers keeping them within acceptable limits for everyone.

From this angle, EVs are no more dangerous than traditional cars and lorries, for which their use is directly responsible for thousands of deaths on the road each year, without including their impact on health. So, the main risk linked to EVs is the societal upheaval that they provoke, and which accompany them.

Changing habits when it comes to mobility, learning how to consume the least amount of energy possible, to go from one point to another and back per day, being free to choose and use renewable electricity, wishing to travel in complete safety at a low speed, and above all, fundamentally, questioning the dogma of a dominant car.

These stakes, hidden behind kWh, km/h, 1,000 metres of stop&start, and autonomy are however very real, which explains why we are still going to hear about EVs and their plusses and minuses, which is part of any change process, before we are truly accustomed to them.
New Technologies to support Electric and Hybrid Vehicles
The advent of electric and hybrid vehicles coincides with the general use of ever more powerful on-board computer systems. It is therefore logical for their ranges to benefit from them, especially since their components can communicate by way of digital data networks.

Electricity enables a real-time control of all components. New generation motors are run by microprocessors, high-density energy batteries, smart chargers are coupled to an electronic/computerised control and management system; all of which is managed, administered by a controller, a central system aiming at the best possible output and for the greatest ease of use.

In all the vehicle categories, these controllers generate a host of data stored in their memory to be transmitted to an information system intended to assist the driver. These systems also benefit from current technological advance: a graphic user interface, touch-screen dashboard, communication interfaces with international standards, Bluetooth, USB, Wi-Fi, GSM, 3G. Electric and hybrid cars are therefore naturally communicating cars.

**Mobile communication, ideal addition to electrical mobility**

These past few years, multimedia communication technologies have invaded the automotive world. With the development of satellite navigation, increase in 3G Internet access, democratisation of GSM/GPRS, we can truly call them communicating vehicles. Applied to electric and hybrid cars, new practical functionalities have appeared such as charging point location, eco-driving to help reduce energy consumption, and the provision of traffic and weather conditions.

Whether for individuals or for corporate fleets, services help indicate precisely the location of the vehicle, trigger preventive alarms when the latter have encountered a technical problem or when they leave a predefined area. They help optimise an itinerary, a rotation, and the assignments of travelling staff.

To attract a wider number of users, geolocation products have been transformed over and over into true communication interfaces with vehicle drivers. It has become possible for the driver to see the number of kilometres covered, electric consumption, travel speed, and to transfer such data via a mobile phone or PDA to his personal computer in order to analyse them. This paves the way for self-training applications in eco-driving, which contributes to reducing CO₂ emissions.

Some car manufacturers have taken the use of information generated by vehicles even further by offering a virtual maintenance notebook, an emergency call number to a support centre and access to traffic information. Citroën, for example, sells “Wi-Fi On Board”, tools enabling all those on board to access their e-mails, instant messaging as well as practical guides.

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**Mobile applications tailored to vehicles**

Telecommunications operators and smart phone manufacturers have well understood the customer’s interest in communication services tailored for use in vehicles as well as on two-wheelers. Most phones now include a 3G connection and a GPS chip to transform the telephone into a miniature navigation system, especially when they are equipped with applications similar to that of personal computers.

Applications intended for electric vehicle users have seen the light of day. They provide the precise location of the vehicle with respect to a charging station network set up along public roads and in car parks that offer this service.

Car park managers have been preparing telephone payment applications, and electronic banking systems have been following this vast movement towards the installation of charging points. It will soon be possible to book a charging location and pay the amount in Euros that correspond to the electricity consumed, simply by sending an SMS.

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Chapter 7

The Media, Internet and EVs
When new technologies intended for the general public appear, they 
necessarily come along with vast, 
planet-wide communication cam-
paigns in order to convey the knowledge needed 
in order to perceive, understand and create an 
interest for future users.

A recent example of this is the introduction of elec-
tronic pads of the iPad type on the market, which 
was first announced by the media, with success varying 
in 2008. These new vehicle categories have natu-
relly appeared in the media, with success varying 
in years in advance.

The arrival of electric and hybrid vehicles on the 
market requires adapting to the paradigms linked 
to the automobile, therefore, several years before 
their arrival en masse on the market. All the players 
of the EV industrial channel had already begun to 
provide communication on these products.

In Spring 2012, at the very time these lines are 
being written, we are, according to the announce-
ments of major carmakers, still two to three years 
from a wide-scale rollout of “all-electric” vehicles in 
cities and on roads.

Hybrids having preceded them by a few years, 
Toyota reached the one-million mark for the Prius 
in 2008. These new vehicle categories have natu-
relly appeared in the media, with success varying 
according to the medium used.

Traditional Automotive Press

By reading automotive magazines attentively, it 
is shown that EVs are completely revolutionising 
the habits of editorialists, thus posing problems with 
regard to editorial strategy.

How is it possible to effectively and objectively pro-
mote such vehicles while they are completely tur-
ning around the entire sector? While nearly 100% 
of the turnover of the automotive channel is made 
with sales and after-sales service of vehicles with 
engines, and car manufacturers are building their 
image from top-of-the-range vehicle performance, 
what room has been left for what are known as 
alternative vehicles? We can already see that it is 
limited; in the majority of the most critical cases, 
the tone is often ironical and inappropriate.

Those who remember reading about the first tests 
of the Toyota Prius in 2001 and 2005 in the auto-
motive trade press will be able to confirm it: the 
hybrid is slow, ugly, expensive, and Japanese!

A few years later, the trend has still not turned 
around. If we are seeking complete information on 
EVs, it is necessary to turn to media other than the 
avtomotive press to become informed, objectively, 
and to be able to form an opinion.

Internet, a source of privileged 
information on EVs

The Internet boom came about almost simulta-
eously with the development of a new era for EVs. 
From 1998 (date announcing the creation of the first 
website dedicated to EVs) to 2011, at the outset 
concerning a network reserved for experts, it has 
become the main media on the planet. Internet is 
everywhere. It enables all user categories to be 
reached in real time and, above all, it requires a 
limited investment to become one’s own editor. 
Pioneers have well understood this, and gradually, 
as the years go by, new media have now become 
the main sources of information on an emerging 
industry. (See Appendix, page 78).

Many other useful Internet sites are available, the 
topic causing such effervescence that the number 
has increased significantly in the last three years.

For English-speakers, greencarcongress.com, 
edited by Mike Milliken, has been offering a month-
ly technological watch since 2004. It is a precious 
website that helps understand and analyse the 
industrial stakes involved.

autobloggreen.com, a website of the AOL Group, 
has been continuously supplied with information 
by a team of seven editors since 2006.

Content aggregators have appeared in French, 
which completes the range of dedicated 
websites, such as automobile-propre.com, techn-
ologicalvehicles.com, voituredirecte.net and 
voiture-electrique.durable.com.

In Germany, the magazine EMobile, published 
since 1987, remains one of the sources of informa-
tion dedicated to electric mobility while in Italy the 
dedicated website electricmotornews.com holds 
the upper hand.

To conclude this section, a website illustrating the 
“verticalisation” of information trend, made pos-
sible by the Internet, and the budding convergence 
between solar energy and EVs, is: solarcharged- 
driving.com.

EV Start-ups on the Internet

Some companies fundamentally stand out with 
respect to the more general strategy of large au-
tomotive groups. Their products are intended for 
niches, namely specific user categories. These 
new companies with brands that are known in their 
countries of origin, and for the most prestigious 
one, all over the globe, have started up their activi-
ity from scratch, or almost from scratch.

And, before attending all the international trade 
fairs, which are expensive indeed, they have given 
priority to setting up an Internet connection; firstly, 
to enhance the emerging image of both brands and 
products with investors by creating a large commu-
nity of fans and databases of potential customers 
at the lowest possible cost.

In less than five years, about 20 such companies 
have sprung up in the US, where the movement 
first took off, as well as in Europe and Asia.
American Pioneers

The initiators of this phenomenon were American entrepreneurs such as Zap World in 1999, Hybrid-Technologies in 2001 (which became Li-Ion Motors in 2010), followed by Tesla Motors in 2003 and Fisker Automotive in 2007, to cite a few.

Tesla has been from the outset using a powerful website to generate prospects and offer online vehicle reservations which, for vehicles of this category sold at over 80,000 Euros, truly a first. Tesla thus delivered, up until 2010, more than 1,000 roadsters, in North America and Europe, whereas Fisker proposed to configure its Karma, a rechargeable top-of-the-line hybrid vehicle.

Tesla’s success, the customer satisfaction level, the technology and corporate methods used have attracted the Toyota Group, which has invested 50 million dollars in the capital of the Californian start-up, taken in by the future potential of Tesla Model S, with production to begin in 2012. It is, of course, possible to reserve the Model S via the Internet. It will be available at the end of 2012 or in early 2013.

Positioned in a more popular segment, with a four-door saloon car, Coda Automotive, whose production to electrical power themselves rather than have to be subjected to the delays of major companies who are not very interested in low production volumes. This continues today, and given the difficulties of the traditional automotive sector, such companies are endowed with production units at a low cost.

The vehicles they produce will be on the market in the forthcoming month: Bolloré with the Bluecar, in Europe, and most probably in Canada, A123 Systems in the US with its Coda subsidiary, Enerdel in Europe and in the US via Think, of which the Group is shareholder.

In China, BYD, the second largest rechargeable battery producer, is getting ready to conquer markets in Europe, North America and Israel, with a range of several models, including an urban bus. BYD has a top-rate associate to assist it in its international development, Warren Buffet, a US multi-billionaire investor.

These companies rely on their development strategy by way of a communication policy of which Internet is the main vector.

Battery producers transformed into car manufacturers

Given the reticence of major automotive companies in the first years of the EV renewal, some battery producers, which hold key technology, battery packs, first improvised as electric car designers. After an initial period devoted to concept cars, true rolling laboratories, they invested in demonstration fleets in order to show the relevance of their first choices in the field.

Financially sound, with a production capacity, with, for example, Bolloré in France and the BYD Group in China, A123 System and Enerdel in the US, battery producers found it more rational to develop vehicles fully dedicated to electrical power themselves rather than have to be subjected to the delays of major companies who are not very interested in low production volumes. This continues today, and given the difficulties of the traditional automotive sector, such companies are endowed with production units at a low cost.

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Innovative SMEs in Europe

In Europe, those passionate about technology, small industrialists already convinced of the imminence of an upheaval in transport modes, have invested in innovative EVs.

Imperia Automobiles, an old Belgian brand, has been relaunched by Green Propulsion, a Belgian SME specialised in high-performance hybridisation. Endowed with a neo-retro line inspired by the history of the Imperia, the Power Hybrid is sold on reservation via the brand’s website.

In the UK, Gordon Murray, renowned for designing the Lotus for the F1 from 1987 to 1996, wished to launch the most efficient electric car in the world, the T.27. For this, the Gordon Murray Design engineering office has completely revised its production methods in order to reduce the costs of materials and assembly drastically. Their aim is to produce a four-door, three-seater saloon car with a price which does not exceed 16,000 Euros, while producing it in the UK in order to boost automotive activity in the country. To reach this objective, the T.27 relies on an exclusive production process, iStream®.

Another new UK car manufacturer, close to Aston Martin for its category, The Lightning Car Company, is offering an upscale GT, using a rather mysterious and luxurious website to contact possible buyers.

In Spain, more precisely in the Basque country, it’s a brand new concept that was initiated by a consortium of local companies, a folding car with limited floor space when parking. The idea was launched by the laboratory MIT-Media in Boston.
United States but was developed and produced by a group of 7 Basque companies under the name Hiriko. Once folded, this little 2-seater with a range of 120km is able to park in a space of 1.5m. Hiriko should be launched in 2013 and each member of the consortium will be in charge of a car module. Assembly sites will be located near the cities conquered by the project.

In France, innovation comes from Lumeneo with the Smera and Neoma. Both founders succeeded in mobilising investors for a four-wheel car that is compact, quite narrow in width that bends slightly while making turns. At the core of Smera, an electronic system takes charge of steering all the vehicle’s parameters from the signals provided by a built-in inertial station. According to the dynamic parameters of the car, the turning curve, driving mode and state of the road, it instantaneously decides on the optimal inclination needed. The Neoma is a four-seater, ultra-compact electric car. Its two built-in motors in front of the wheels and its battery placed under the seats enable it to come in a size of 2.5m x 1.60, an astonishing volume for an interior.

On another level, a company from the Ardèche Region in France, the Volteis, an electric 4-wheel drive is available for individuals and companies alike. It has been designed for urban as well as country use. This all-terrain car has a stainless steel chassis and aluminium body for the ultimate life cycle. It comes in a lightweight or heavyweight quadricycle version, with an autonomy of 70km, at a price of ±20,000 Euros.

In Italy and Switzerland, researchers and engineers focused on a key element in the electric vehicle, its weight. For the Blowcar, produced with the help of the Abruzzo region, the engineer Dario Di Camillo, former employee of the Group Fiat, announces a weight between 420 and 480kg. The Blowcar is a light quadricycle whose characteristics is to benefit from inflatable technology used in aviation and aerospace, to replace certain parts with inflatable materials of similar size and even appearance. This technology enables significant weight savings while maintaining a good level of security when needed.

To complete this review of the “young budding” EVs, it is important to go to Italy as well. The Tazzari Group, based in Imola, is one of the Goths of the automotive industry, and Italian leader in aluminium foundry. With a passion for cars and performance, managers Erik and Rafael Tazzari are endowed with substantial technical means, all that is needed to elaborate ultra-lightweight and resistant prototypes. This is how the Tazzari Zero was born.

Strictly a two-seater, its autonomy is about 140km, with Lithium-ion batteries, for a peak speed limited at 90km/hour, thanks to a 15kW electric motor. Weight distribution is quite meticulous (rear motor and batteries under the seats), as it has been designed above all for its sporty sensation.

With the same goal of having a better strength/weight reduction, the Swiss team of Catecar uses an aluminium chassis honeycombed shaped, an electric motor with a small battery (35kg) a range extender, in fact a small generator for hybrid consuming 1 litre per 100km, and a high performance solar roof.

The first Catecar model has to be produced in order to be sold, initially to airports in 2012 in order to save time and thoroughly test its technical skills.

The outside and inside cabin will be moulded in plant fibber, very light and resistant. Catecar, the “swiss green high tech urban vehicle” will be produced under the “swiss made” label. Ounce tested, Catecar may translate in more than 10 different interior. Sale to the public is scheduled for 2013.

Innovation also comes from the east E-avto, Russian joint venture formed by the Group Yarovit (and Onexim) will begin producing hybrid vehicles, named “E-mobiles” in Saint Petersburg in the second half of 2012. One plant can produce up to 10,000 vehicles a year. Developed at the initiative of Mikhail Prokhorov, general Manager of Onexim, three models of the hybrid are planned: a sedan, a cross-coupe and a van. These new vehicles are powered by petrol or electric motor coupled to gas.
Seeking new business models: Buy, Hire or Subscribe?

Chapter 8
For users, a stable economic model for EV remains relatively difficult to establish. We have similar models to those of petrol/diesel cars for traditional hybrids. However, the arrival of plug-in hybrids and “all-electric” vehicles on the market is taking us to unknown territory, meaning the actual life cycle of the battery pack in time.

Considerable progress has been made in less than ten years. At present, some technologies boast a rather high life cycle potential, as demonstrated in this graph showing a comparison in technologies.

Let’s take, for example, a battery pack for autonomy of 130km in one charge, like that of the Mitsubishi i-Miev. The batteries produced by Lithium Energy Japan offer a life cycle that exceeds 1,500 cycles according to the data provided by the manufacturer.

Therefore, the battery pack should theoretically enable 195,000km to be covered (130km x 1500), which is brought in to the number of kilometres covered annually. As per the annual mileage, the potential life cycle of the batteries will oscillate between 5 years (40,000km/year) and nearly 20 years (10,000km/year).

Here, we see that the key factors that determine the actual cost of use of new generation EVs are the actual life cycle of batteries and annual mileage. These factors determine the essential part of the resale value of a vehicle, its main component being the battery pack.

When Lithium Energy Japan or another manufacturer displays 1,500 cycles of charge/discharge, another indication must be provided. From 1,500 cycles, batteries fall below 80% of their capacity, which means that a far greater energy storage capacity remains in this pack: 80% of 16kWh, its nominal capacity, i.e. 12.8kWh. Before being recycled, it seems evident that a second life will await these storage units, for a second economic life.

These factors regarding the life cycle raise problems in elaborating realistically economic models. This is because before we take them into account, they will need to be validated, for which we will need to wait several years. The time it takes for tens of thousands of vehicles in circulation to age will, in fact, confirm or invalidate the initial assumptions.

In the meantime, financing modes depend highly on a safety margin, a “risk premium”, specifically for EVs, in such a way that all operators, manufacturers, distributors, short-term hire or long-term contract hire companies will be able to reduce it, once more experience has been gained and been made available.

The decrease in EV prices consecutive to a volume increase and competition between brands has begun. The current rates are quite high, as it is the case for each introduction phase of a new technology. While awaiting such volume increases, car manufacturers are offering several packages for additional acquisition:

- **Buy a vehicle and battery**, offered by small manufacturers, PSA with Ion and Citroën with C-Zero; a solution that gives responsibility to the driver as to the life cycle of the pack, inciting him to drive appropriately.
- **Hire a vehicle and battery**.
- **Buy a car and hire a battery**, offered by Renault for its Z.E. range.
- **Subscribe to a mobility service** with car-sharing.

In all cases, the main factor involved in decision-making is the TCO (Total Cost of Ownership) and the comparison to be made between an EV and a traditional vehicle.

Recent studies of the CVO show that the current TCO of electric commercial vehicles is close to that of petrol/diesel equivalent vehicles, in some specific cases such as for short-distance delivery fleets. Even if the purchase price is high, the intrinsic advantages of EVs, their low maintenance cost, life cycle and general law tax scheme are such that comparisons end up to their advantage. However, the TCO of individual electric vehicles is still far higher than that of their petrol/diesel equivalents, due above all to the confiscatory taxation scheme for this type of vehicle.

Renault’s price proposal, which consists in selling the car bare and hiring the battery separately at a reasonable price; thus by handling a large share of the excessive costs and risks, helps partly bypass these economic and fiscal pitfalls.
What is in store for the future?
Opportunities and trends

The massive arrival of car manufacturers in the electrical sector has been generating rapid growth of production means and volumes, a direct effect of progressively reducing costs. One of the critical points is the price of batteries, approximately 15,000 Euros for a 5-seater car of 1,300kg in 2010. Yet, these prices, given the competition, have begun to decrease, and this trend is still under way. The forecast for 2015 is about ± 6,000 Euros, and under 4,000 Euros in ten years for similar battery packs.

The evolution we have been witnessing resembles highly that of the micro-hybrid Stop & Start systems. Expensive in 2005, several hundreds of units have been sold, and many manufacturers adopted them in 2009, with sales reaching 900,000 units, and 10 million expected in 2015.

New players in the automotive landscape, mobile operators

Large groups have been investing in the distribution of EVs all over Europe. This is the case of Migros, in Switzerland, a leading distributor that has created m-way, a platform for electro mobility. In France, the MOBIVIA Group (Norauto, Midas, Carter Cash, Maxauto, Synchro Diffusion) has created O2 City, and offers firstly to a professional target (local communities, companies, etc.) the sale of a range of multi-brand electric vehicles, financing, maintenance and after-sales service as well as recharging solutions.

O2 City relies on 230 Norauto centres all over France.

The competition between major car manufacturers is now open

Never before in the history of the automobile have EVs and hybrids played such a role.

Each new international automotive trade fair shows the results of the major investments made by companies in ecological models. Full ranges of hybrid vehicles are now available and step by step all the major manufacturers are entering the market.

Japanese leaders, pioneers in the field are widening their range with 6 hybrid models, including 3 different versions of the Prius, Honda models, the Insight Hybrid, the CR-Z Hybrid, the hybrid version of the Jazz.

They were joined by German manufacturers: Mercedes/Smart, Volkswagen, Audi, BMW and Porsche which commercialise premium hybrids, just as in the US with GM (Opel Ampera) and Ford (Transit Connect).

The Group PSA, with the Citroen DS5 Hybrid 4, the 3008 Peugeot Hybrid 4 and 508 RXH developer of the Hybrid diesel while Renault gradually enriches its electric offer with the ZE offering 4 different models.

Demonstrating great dynamism in the industry, Nissan, with the leaf and Mitsubishi with the i-Miev complete the supply of all electric models in Europe.

Even the most reluctant to these technologies such as Fiat (500EV) or Seat are about to launch on the market electric and hybrid vehicles.

Thus, it is no less than one hundred hybrid and electric models available in 2012.

Convergence between solar energy and vehicles

What is in store for us in terms of energy?

Costly petroleum and nuclear electricity necessarily include an increased safety cost, which is therefore more expensive than today. We are practically certain that this will be the case, as reported in the latest news.

This quite simple observation has been made by many companies around the world who have been directing their activity to the supply of solar energy. Their current calculation is quite simple. Huge surface areas are used such as outdoor car parks, and the solar industry is able to provide hundreds of hectares of panels, thus reconciling them both.

Based on this, a new generation of products, solar car parks, is in the midst of being set up lastingly on the market, in line with the development of electric and rechargeable hybrid vehicles.

Solar car parks, a dual advantage

Their rapid development stems from the combined advantages they provide: protection, shade (for vehicles) and energy (for neighbouring buildings). Car park surfaces thus produce added value, electricity, which in addition is renewable, without CO2 emissions. Therefore, in some cases, for the hottest periods, the solar car park supplies electricity for office air conditioning systems. Other examples point to companies for which a high percentage of annual needs in electricity is produced directly by the sun.

Their operation is similar to that of residential solar installations. Panels are installed on shading roofs and connected to the electrical network via a converter. The costs are in proportion to the surfaces installed, about 2.7 to 3.4 Euros/Watt for medium-sized installations.

Some companies offer turnkey solutions, support infrastructures, panels, connections. The advantage of these installations lies in the optimisation of sunlight conditions, and consequently, system
productivity. Different designs can live side by side, from simple support masts connected to a network to the most complex architectures.

The pioneers of a new industrial channel

In less than five years, companies supplying a complete palette of services have appeared on the market, from site analysis to installation:

• Geotechnical, dimensioning studies.
• Technical and economical modelling, design and architectural integration.
• Administrative dossier, financing.
• Production, steering construction, installation.
• Inspections, controls, validation tests.
• Monitoring and maintenance.

In the US, the first arrivals were made by Envision Solar with a first installation of the US head office of Kyocera in June 2005. They have provided 25 “solar trees” of a power of 235 kW, sheltering 186 vehicles in the car park of this Japanese company, a producer, among other things, of polycrystalline photovoltaic cells and modules. Since then, Envision Solar has set up a host of ParkSolar™ facilities in California and Texas, for companies, campuses and restaurants.

The US has been not the only country in which solar parks have been set up, far from it. One of the most powerful stations of this type can be found in Italy, built by one of the leaders in the field, Solar, a German company. It is comprised of 24,700 modules divided into 4 zones, covering 13,000 square metres. The nominal power of 5.9 Megawatts is located in Piadena, in the Lombardy Region, along the latitude of Grenoble in France, which helps protect 6,000 cars from poor weather conditions.

In the US, the current record is held by SunWize Systems, with a car park of 4MW using 18,000 Samsung and Panasonic panels (Department of Veteran’s Affairs Medical Center, Phoenix, Arizona).

France is also on the same track, with a large photovoltaic solar station built into the roofs of a shopping centre car park, that of E.Leclerc situated in Saint Aunès (34), close to Montpellier. Centred round Sunvie, the project’s initiator, financers have opted for the Conergy modules, which produce ± 1.42 GWh per year. The 5,472 solar panels in 12 rows of wood shade structures of a length of 85 metres keep the cars cool (816 spaces) while producing electricity that is 100% clean, for annual savings of over 1,655 tonnes of CO₂.

Ever-greater installations

Throughout Europe roofs are covered with solar collectors. In Slovenia: the largest facility of this kind is located in Maribor, it will produce 1,200mWh in one year. In Belgium: an area close to eight football fields has been installed along the highway Antwerp-Amsterdam, this inaugurates a new generation of installation: solar tunnels, it is 50,000m² of rail tracks producing energy for traffic lights, lighting and electric trains.

This first European tunnel will soon be joined by one covering a historical monument in central London. The Victoria bridge, built in 1886, will be covered in 2012 of 650 m² of solar cells, creating the largest solar installation in London.

Solar car parks for electric vehicles

The number of solar car parks intended to charge batteries has been growing rapidly due to the arrival of electric vehicles on the market, mainly in the US, with the sale of the Volt and Leaf.

Working hours, the time when vehicles remain passively in car parks, are simply used to recharge them using “green” electricity. Many cities in the US, such as Los Angeles, have set the pace by affirming that electric vehicles and solar car parks are made for each other. They help speed up environmental quality improvement policies that are fully in line with their green initiatives.

Moving towards individual solar stations to charge vehicles

Several companies have directed their activity towards smaller solutions, turnkey system for communities and companies wishing to offer green electricity to electric vehicle users. Modules of 2 to 4 spaces, mixed terminals for cars and 2-wheelerers, wireless electronic money solutions as well as diverse offerings combined and sold by specialists of the sectors, companies with evocative names such as: Green Park Solution, Advansolar, SolarQuest.

Progressively meeting the rapidly growing demand, initiated by the national development plan of a recharging infrastructure for EVs, solar charge stations have been set up in the area. Companies, local public powers have been discovering them, with interest, and it is not to be excluded that in a short period of time, individuals will also be concerned, as the economic model of solar charge stations + electric vehicle becomes clearer.

Lightweight vehicles with low consumption

All those having to face the agony of riding a loaded bicycle uphill know it well; weight is truly an enemy. This is even truer for four-wheelerers, for which the majority of energy needed to move
them is required to propel the vehicle’s weight. Less weight calls for less energy, to such an extent that a 10% reduction in weight increases energy efficiency by 7%.

This constant has been forgotten, however, by a majority of manufacturers who offer vehicle ranges for which excess weight is quite clear. Yet, after a period of inflation in size and volume, hence weight, a movement has begun by many players in search of greater energy efficiency. The progress margin in this effort is quite significant, as shown by the prototypes made, with as their main objective, to reduce vehicle weight, hence consumption.

**Toyota 1/X Concept Car**

In February 2008, in Chicago, Toyota presented a concept car that offers low consumption, the 1/X. This four-door saloon car regroups several assets: a lightweight but safe construction, rechargeable hybrid technology and the flexibility of a “Flex-Fuel” vehicle, while offering the interior space of a Prius. Thanks to its weight, 420kg, in comparison with, for example, the Prius, which weighs 1,275kg, the designers of the Toyota 1/X are targeting consumption of 2.17 l/100km, less than half of the Prius one, or even less than that.

As a rechargeable hybrid car, it can run in the city in all-electrical modes, and for long journeys; the Toyota 1/X goes into the traditional hybrid mode, where it uses its battery and 500 cm³ motor installed at the back. The Toyota 1/X owes its “feather weight” to the use of a plastic body that has been reinforced with carbon fibre, thus offering a rigid safety cell able to absorb shocks in the event of a collision. Some of the solutions demonstrated in this rolling laboratory will be applied by Toyota to its future hybrids.

**The applied concepts of the Rocky Mountain Institute (RMI) IDEO of Bright Automotive.**

For about twenty years, experts of this “non-profit think-and-do-tank” have directed their research work towards greater energy efficiency, among others, in transport. The Rocky Mountain Institute (RMI) has been the main defender in putting low-consumption vehicles on the market in the US. The strategy recommended by the RMI has served as a basis for establishing new consumption standards, as announced in 2009 by the Obama administration, for 2016, aiming at an objective of 6.72 l/100km, on average. One of the RMI’s demonstrations consists in showing that lighter vehicles are as safe, or more, than those currently in circulation. Furthermore, they use less fuel.

By pushing their reasoning to the full, and facing the reticence of major companies, the heads of the RMI set up from scratch, in January 2008, a new car manufacturer, Bright Automotive, while relying on heavyweight partners. Associated with the fate of this start-up are the aluminium giant Alcoa, Google.org, Johnson Controls and the Turner Foundation. Bright Automotive is in the image of Tesla, one of the symbols of transformation of the American automotive industry, which are companies seen in the US as catalysts of a new economy, an economy based on reducing dependence on fossil energies.

The initial work of the RMI regarding lightweight vehicles has enabled Bright Automotive to develop, in two years, a lightweight commercial vehicle, a plug-in hybrid, to be sold in 2012: IDEA. Built from natural fibres and recycled materials, IDEA will be the lightest delivery, and greatest fuel-saving vehicle of its category.

The solution made was not the electrification of an existing model, but the design of a new structure to meet RMI’s specifications: excellent aerodynamics, low rolling resistance, lightness without loss of rigidity, or loss of safety, energy recovery on braking. These choices have been completed by adopting a light weight traction system, an ultra-lightweight small motor and a smaller battery pack, all offering IDEA unrivalled performance in its market segment, with 60km of autonomy and 6.5 l/100km consumption in hybrid mode.

To testify to the relevance of the solutions developed by Bright Automotive, the investment fund of GM, General Motors Ventures, has taken minority stakes in the company, this contribution enabling Bright to access GM motor technologies.

**VW – “1 liter car” & Formula XL1 Hybrid Concept**

The 1-litre car concept first appeared in 2002, led by the Chairman of the VW Group, Dr. Ferdinand Piech, at a private meeting for its shareholders. A highly aerodynamic vehicle, it reaches a drag coefficient of 0.159; decidedly more efficient than traditional cars (from 0.3 to 0.4 on average - 0.25 for the current Prius).
To make the vehicle lighter, VW did not cut any corners: unpainted carbon fibre body, aluminium wheels, carbon fibre brakes, titanium hubs, wear parts in alloys and ceramics, etc. The weight of the first version empty, powered by a one cylinder diesel engine, was 290kg, which helped it reach record consumption of 0.99 l/100km, about 650km with 6.5l of diesel in its tank. For safety purposes, VW is clear; it is similar to that of a Competition GT.

A second version of the “1 liter car”, named the L1, was presented at the EVs 21 in Monaco in 2005. It showed possible evolution towards a vehicle produced in a small series. With announced consumption of 1.38l/100km for a weight of 381kg, and a drag coefficient of 0.186, it also demonstrated the progress made in motorisation in three years’ time. VW adopted a hybrid powered vehicle for this second demonstrator, a bi-cylinder of 800cc TDI, assisted by an electric motor of 10.4 kW. The Group has illustrated its know-how in hybrid technology, up until then the hunting ground of the Japanese, and high performance of a diesel/electric drive.

The latest version, called XL1 Concept, was officially presented in Doha, Qatar, at the end of January 2011. VW engineers designed a car for two passengers sitting side by side, an advantage within the scope of possible small series production; especially since Volkswagen developed, for the occasion, a carbon fibre reinforced plastic manufacturing process (PRFC) that reduces production costs. The final aim appears to be the launch of a commercial version, VW having included components that are absolutely indispensable for safety, such as ABS and the ESP, the electronic stability program.

The characteristics of this Hybrid plug-in differ from those on previous versions: autonomy of 35km in all-electric mode, from 0 to 100km/h 11.9 seconds, the equivalent of 0.9 l/100km in electrical mode; once past the 35km of autonomy, the XL1 consumes 1.9l/100km (i.e. 51g/km of CO₂).

Its weight is 795kg: more than double that of the L1 version. This excess weight, 227kg for the motors, 153kg for the chassis, 80kg for equipment (bucket seats included), 105kg for the electrical system (with batteries), 230kg for the body, has been compensated for by the very high performance level of the two motors associated with an optimised consumption management.

Adopting energy recovery when braking has completed the technological devices of this prototype, for which VW says it is ready to produce in series, thus making it one of the most energy-saving cars for the time being.

Carbon fibre roller used to lighten and reinforce the body

**Edison 2 The Very Light Car**

This vehicle appeared in the US for a rather peculiar competition, the “Progressive Automotive X PRIZE”. As indicated by its name, this challenge is sponsored by “The Progressive Group of Insurance Companies”, the fourth largest insurance company in the US, with 14 billion US dollars in net revenue, and more than 24,000 employees. Through its X-Prize foundation, it finances innovation projects.

The winner in the main category, 4 wheels, 4 people, minimum autonomy of 321km, is a vehicle called VLC, “Very Light Car”. It has won a prize of 5 million dollars and now benefits from significant media coverage. Its designers are announcing a price of about 15,000 Euros, in compliance with the objectives of the competition. For 400km covered, in simulation, in the city, country, for long distance and speed, the VLC proved to be more economical in terms of fuel, with an average consumption of 2.2 l/100km. Powered by a 1-cylinder turbocharged combustion engine of 250cc, this astonishing and highly dynamic car (drag coefficient of 0.16), enables a maximum speed of 160km/h and autonomy of 100km.

The use of construction techniques taken from aviation, aluminium, carbon, an undeformable passenger compartment, enables Edison 2, its manufacturer, to reach a weight of 363kg, empty. At present, VLC developers are working on the 4th version of this high-performance vehicle, to make it compatible with serial production, and approval.
Appendices
Car manufacturers’ offerings, availability and prices

**Parallel and Mild hybrids**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Country</th>
<th>Availability</th>
<th>CO2 g/km</th>
<th>Price</th>
<th>No. seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>Prius 3</td>
<td>Jp</td>
<td>Available</td>
<td>104</td>
<td>26,220 to 33,080 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>Auris HSD</td>
<td>Jp</td>
<td>Available</td>
<td>89</td>
<td>23,300 to 27,300 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td>Lexus</td>
<td>RX 400h</td>
<td>Jp</td>
<td>Available</td>
<td>150</td>
<td>58,900 to 76,900 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>GS 450h</td>
<td>Jp</td>
<td>Available</td>
<td>186</td>
<td>58,500 to 71,300 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>CT200h</td>
<td>Jp</td>
<td>Available</td>
<td>89</td>
<td>± 30,000 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td>Honda</td>
<td>Insight</td>
<td>Jp</td>
<td>Available</td>
<td>101</td>
<td>19,990 to 21,190 Euros</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Civic</td>
<td>Jp</td>
<td>Available</td>
<td>109</td>
<td>25,350 to 29,050 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>CR-Z</td>
<td>Jp</td>
<td>Available</td>
<td>117</td>
<td>20,500 to 23,800 Euros</td>
<td>4</td>
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<tr>
<td></td>
<td>Jazz</td>
<td>Jp</td>
<td>Available</td>
<td>104</td>
<td>Unavailable</td>
<td>4/5</td>
</tr>
<tr>
<td>Mercedes</td>
<td>S400</td>
<td>Ger</td>
<td>Available</td>
<td>186</td>
<td>93,600 to 99,000 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td>BMW</td>
<td>ActiveHybrid X6</td>
<td>Ger</td>
<td>Available</td>
<td>231</td>
<td>from 113,600 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td></td>
<td>ActiveHybride 7</td>
<td>Ger</td>
<td>Available</td>
<td>219</td>
<td>from 126,900 Euros</td>
<td>4/5</td>
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<tr>
<td>Porsche</td>
<td>Cayenne S Hybrid</td>
<td>Ger</td>
<td>Available</td>
<td>163</td>
<td>from 80,000 Euros</td>
<td>4/5</td>
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<tr>
<td>VW</td>
<td>Touareg Hybrid</td>
<td>Ger</td>
<td>Available</td>
<td>193</td>
<td>from 84,500 Euros</td>
<td>4/5</td>
</tr>
<tr>
<td>Audi</td>
<td>Q5 Hybrid Quattro</td>
<td>Ger</td>
<td>Available</td>
<td>160</td>
<td>from 50,000 Euros</td>
<td>4/5</td>
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<tr>
<td>Peugeot</td>
<td>3008 HYbrid4</td>
<td>Fr</td>
<td>Available</td>
<td>99</td>
<td>31,000 to 35,000 Euros</td>
<td>4/5</td>
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<tr>
<td>Opel</td>
<td>Ampera</td>
<td>USA/Ger</td>
<td>Available</td>
<td>under 60</td>
<td>42,900 Euros</td>
<td>4/5</td>
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</tbody>
</table>

**100% electrics**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Country</th>
<th>Availability</th>
<th>CO2 g/km</th>
<th>Price</th>
<th>No. seats</th>
<th>Bonus</th>
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</thead>
<tbody>
<tr>
<td>Lumeneo</td>
<td>Smera</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>from 29,500 Euros</td>
<td>2</td>
<td>5,000</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>i-Miev</td>
<td>Jp</td>
<td>Available</td>
<td>0</td>
<td>33,000 to 35,000 Euros</td>
<td>4</td>
<td>5,000</td>
</tr>
<tr>
<td>Peugeot</td>
<td>Ion</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>499 Euros per month in Op. Leasing</td>
<td>4</td>
<td>5,000</td>
</tr>
<tr>
<td>Citroën</td>
<td>C-Zero</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>35,350 Euros</td>
<td>4</td>
<td>5,000</td>
</tr>
<tr>
<td>Mia Electric</td>
<td>Mia</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>19,900 Euros</td>
<td>3</td>
<td>3,980</td>
</tr>
<tr>
<td>FAM</td>
<td>F-City</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>from 20,000 Euros excl. of tax lead-acid batt. to 33,000 Euros excl. of tax Ni-Mh batt.</td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>Think</td>
<td>City</td>
<td>No</td>
<td>Available</td>
<td>0</td>
<td>± 28,000 Euros + batteries</td>
<td>3</td>
<td>5,000</td>
</tr>
<tr>
<td>Nissan</td>
<td>Leaf</td>
<td>Jp</td>
<td>Available</td>
<td>0</td>
<td>± 35,000 Euros</td>
<td>4/5</td>
<td>5,000</td>
</tr>
<tr>
<td>Bolloré</td>
<td>Bluecar</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>Announced 330 Euros per month</td>
<td>4</td>
<td>5,000</td>
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<tr>
<td>Tata</td>
<td>Indica Vista EV</td>
<td>India/No</td>
<td>Available</td>
<td>0</td>
<td>± 35,000 Euros</td>
<td>4</td>
<td>5,000</td>
</tr>
<tr>
<td>Smart</td>
<td>ForTwo ED</td>
<td>Ger</td>
<td>2012</td>
<td>0</td>
<td>Unavailable</td>
<td>2</td>
<td>5,000</td>
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<tr>
<td>Reva</td>
<td>NXR</td>
<td>India</td>
<td>2012</td>
<td>0</td>
<td>15,800 Euros</td>
<td>2</td>
<td>5,000</td>
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<tr>
<td>Renault</td>
<td>Kangoo Express ZE</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>20,000 Euros, exclusive of tax</td>
<td>4/5</td>
<td>5,000</td>
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<tr>
<td></td>
<td>Fluence ZE</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>26,300 Euros</td>
<td>4/5</td>
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<tr>
<td></td>
<td>Twizy</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>± from 8,500 Euros</td>
<td>2</td>
<td>5,000</td>
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<td></td>
<td>Zoe ZE</td>
<td>Fr</td>
<td>Available</td>
<td>0</td>
<td>15,700 Euros</td>
<td>4</td>
<td>5,000</td>
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</table>
### Batteries: Comparative Chart Power/Price

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Pb</th>
<th>NiMh</th>
<th>Zebra</th>
<th>LMP</th>
<th>Li-Ion</th>
<th>Li-Po</th>
<th>LiFePO4</th>
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<tbody>
<tr>
<td>No. of cycles</td>
<td>500</td>
<td>1,000</td>
<td>1,500</td>
<td>1,800</td>
<td>1,200</td>
<td>2,000</td>
<td>3,000</td>
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<tr>
<td>Power pack</td>
<td>16kWh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life cycle in kilometres</td>
<td></td>
<td>Base of 130km per charge</td>
<td>Pure electric</td>
<td>65,000</td>
<td>130,000</td>
<td>195,000</td>
<td>234,000</td>
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</table>

#### Hypothesis 1 - 2011

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<tr>
<th>Price per kWh in EUR, incl. of tax</th>
<th>300</th>
<th>1,100</th>
<th>1,250</th>
<th>1,300</th>
<th>800</th>
<th>900</th>
<th>1,300</th>
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<tbody>
<tr>
<td>Price per km in EUR</td>
<td>0.074</td>
<td>0.135</td>
<td>0.103</td>
<td>0.089</td>
<td>0.082</td>
<td>0.055</td>
<td>0.053</td>
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#### Hypothesis 2 - Projection end 2012

<table>
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<th>Price per kWh in EUR, incl. of tax</th>
<th>300</th>
<th>1,000</th>
<th>1,100</th>
<th>1,150</th>
<th>650</th>
<th>800</th>
<th>1,000</th>
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</thead>
<tbody>
<tr>
<td>Price per km in EUR</td>
<td>0.074</td>
<td>0.123</td>
<td>0.090</td>
<td>0.079</td>
<td>0.067</td>
<td>0.049</td>
<td>0.041</td>
</tr>
</tbody>
</table>

### Cetelem Observatory

The CETELEM vehicle observatory, conducted each year by the credit agency to analyse the market, released a survey on the opinion of Europeans on the electric vehicle.

This survey of around 6,000 interviewees was conducted in Germany, Belgium, Spain, France, Italy, Poland, The United-Kingdom, Russia and Turkey and results were published early 2012.

Marketing and economic analyses and forecasts were made in collaboration with the consultancy company BIPE (www.bipe.com) . The survey was conducted by TNS Sofres in September 2011.

When asked about what they most like about electric vehicles, 73% quote the absence of noise which is perceived as a major asset. Then, comes the budget: 64% of respondents believe that with electric vehicle it will be possible to make some savings in a short/mid term.

Furthermore, 84% of the European interviewees consider that electric vehicle is the best promising solution to protect environment.

Among the challenges, two main issues have been clearly identified: price and range. 49% do not consider making a financial effort to acquire an electric vehicle. Only 1/3 is willing to pay for that kind of vehicle up to 10% more than a petrol car. As for the renting of the battery, it remains unsuccessful: only 37% are considering this option.

The range of the batteries is another issue: 82% are driving less than 100km per day and yet, 55% are not willing to buy a vehicle with a range below 250km.

Interviewees wish furthermore a fast implementation of loading stations on public roads (90%) and consider, 71%, that public authorities are not helping and pushing forward enough this sector.

### Internet, privileged source of information for EVs

**observatoire-vehicule-entreprise.com** (French website)

The CVO, the editor of this publication, is also present on the Internet. Sustainable development and the environment, vehicle management, new technologies and road prevention are the themes covered by the CVO. The thought given by the CVO to such topics is constantly updated by the studies and feature articles presented in Corporate Vehicle Observatory publications or on its website.

**carfutur.com** (French website)

Car Futur is a professional blog devoted to corporate mobility. A laboratory of ideas, this community site brings together editors/experts from different horizons, under the umbrella of Philippe Brendel. The themes covered such as energy, mobility and tomorrow’s vehicles are seen from an angle related to behaviour and technology.
**evworld.com** (English website)
EV World is without a doubt the key website for the world of EVs. Created by Bill Moore in Nebraska. Relentlessly for 13 years now, every week, it delivers information enabling us to be kept in tune with the latest news, as seen by specialists.
Over 10,000 visitors per day access EV World, and when they subscribe to the website ($49 per year), they can access all the archives. Relying on a wide community of editors and links with thousands of websites, EV world truly sets the standard on the web.

**AutoblogGreen** (English website)
This blog provides each day a large flood of international information coming from worldwide. He is part of the AOL Autos galaxy and covers all the low emissions technologies as well as electrics and hybrids.
This information flow, generated by a team of professional journalists, is one of the richest web for anyone wishing to monitor trends.

**Greenmotorsblog.de** (German website)
A great magazine for german speakers, all categories of vehicles are covered, from hybrid and electric vehicles to electric fuel cells, all the different links gives the opportunity to discover the landscape of electric mobility in Germany.

**electricmotornews.com** (Italian website)
As suggested, this “L’informazione eco-compatibile” magazine is published in Italian. Pioneer of its kind in Italy, its creator, Marcelo Padin, has chosen the double support of internet and TV to broadcast information focused on the Italian Peninsula and with a European insight.

**CochesEco.com & QuéCocheEléctrico.com** (Spanish website)
Two blog dedicated to clean engine and electric vehicles.

**moteurnature.com** (French website)
Those of you who are part of the EV microcosm in France have certainly crossed paths with Laurent Masson, the founder of Moteur Nature. Since 2002, he has been covering all the news on EVs, hybrids as well as LPG/NGV-powered cars, combustible batteries, biofuels as well as petrol & diesel with low CO2 emission. The viewpoints expressed in Moteur Nature are independent, rather iconoclast, and often juicy.

**e-mobile.ch** (Swiss website)
Switzerland has been for several years now serving as a practical laboratory for efficient road vehicles on some parts of the territory, thus putting it several years ahead in time. In this field, it is of interest for French-speaking viewers. Many campaigns have been conducted by the e-mobile association in order to foster the sale of efficient road vehicles as well as fuels from renewable raw materials. Its “Swiss EV Centre” deals with all questions concerning electric and plug-in hybrid vehicles.

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