Electrification, the end of the ICE age

Electric vehicles are not new. Already by the end of the 19th century electric vehicles were built. In the beginning, electric motors seemed more promising than combustion engines. Only strong men were able to manually start the primitive 'Otto' combustion engines. The advantages of EVs were the excellent drive-ability and comfort of operation.

In 1914, the EV share in the Dutch car fleet was 2.4%, which is still higher than today. Most of them were 62 French-German Kriéger-Namag Taxis in Amsterdam and Haarlem. Already at his first job, Ferdinand Porsche designed the Lohner electric car. A four-wheel drive hybrid version used a petrol generator as a range extender. The last electric vehicle by Porsche was called the 'La Toujours Contente'.

This means 'always satisfied' in French.

What more did we need?

Little - until Cadillac introduced the first car with an electric self-starter in 1912.

Thanks to this electric motor, the internal combustion engine became the first choice for all. About hundred years later, we may now be, at the end of the ICE-age.

The end for the Internal Combustion Engine.

Rethinking the business as a system

The new game changer is de-carbonization by renewable electricity direct or indirect from the sun. Of course, the modern EV benefits from advanced electronics and battery technology. However, today, the EV has to compete in a huge and very mature market of combustion cars. Cars that are fabricated in efficient mass production with a perfect running supply chain. They are supported by a huge after sales network and established refueling infrastructure.

How can electric vehicles compete with that?

Let's start with the notion that good competitive EVs are not just electrified combustion vehicles. Designing and building optimized, reliable and profitable EVs needs a system approach. Especially, the new supply chain and the focus on mobility as a service are often underestimated. Moreover, rethinking of the business includes charging and a customer support data network. That's also why existing OEMs are struggling so hard to kick-start with electric vehicles. For them, it's a high risk disruptive technology, new business model and a waste of sunk capital.

EVs are not just electrified cars

Let's look at some general product design differences caused by the electric drive-train. As the energy density of batteries is 50 times lower than fuels, the vehicle will be much heavier. For cars, this is typically 300 to 500 kg more. For buses and trucks this increase in weight will be as much as several thousand kilograms. This leads to

a new design rule, which favors to the use of more advanced lightweight materials. Expensive composite or aluminum directly pay off by saving battery weight and battery cost. The allowed cost per kg weight saving is about 1€ for an ICE car, but up to 10€ for an EV.

- The packaging of EVs should respect the laws of gravity and driving stability.
- For stability, the heavy batteries should be places as low and distributed as possible.
- Battery packs can be integrated, to be part of a strong underbody floor structure.

On the other hand, compact size and low cost of electric motors, is beneficial for the packaging. The size and cost advantage opens the possibility to better distribute the power to all wheels. A nice example is the AUTOnomy “Skateboard”, which General Motors showed already in 2002.

E-vehicle packaging and styling

Electric motors are flexible and don’t need clutches and gears, a flywheel, starter nor dynamo. They are so compact and powerful that they can even be placed direct drive, inside the wheels. In-wheel motors are an ultimate solution to create the most efficient traction and more space. Buses and truck equipped with e-Traction® wheels leave more utility space inside the vehicle.

The platform design, with batteries in the middle floor, is now adopted in most modern E cars. Altogether, the EV packaging has extra space advantages like a 'frunk' (front trunk) and flat floor. The low point of gravity concept may also proof the be the best solution for trucks and busses. Styling is of all time importance; early electrified cars like the first Prius were born quite ugly. Maybe this was to limit the sales, but to quote the Fiat 500e: 'the worst form of pollution is ugliness'.

There is no substitute for Kilowatt-hours

Electric vehicles are not only very quick in acceleration but also fast in top speed. Air resistance is a quadratic function of speed, this is true for every vehicle. So, energy need normally increases consumption relatively strong at higher speed. However, this is not what we always experience driving combustion engine cars. This is because in low gear and idling for city traffic, combustion vehicles are very inefficient.

In contrast, electric motors show a very high and relatively constant efficiency at all speeds. At zero speed the energy consumption is near zero, at 60km/h it is about 5 Kw power for a car. However, at 120km/h, the electricity power need already has reached well above 20 Kw. To get a good high-speed range, excellent aerodynamics is very important for designing EVs.

We are used to fact that the speed of a vehicle equals the power of the combustion engine: "there is no substitute for cubic inches". In EVs the electric motor is often not the most limiting factor, but the capacity of the battery is. Hence, we can say: "There is no substitute for kilowatt-hours'.

Battery packs designed to last

The so-called C-rate, the battery power divided by the capacity, is an important design criterion. 60kW power drawn from, or charged in, a 30kWh capacity battery equals a C-rate of two. While the same 60kW delivered from a 90kWh battery only equals a C-rate of two-third.

A higher C-rate is more demanding for the battery and can lower the battery lifetime.

So, small batteries should deliver and be charged at proportionally less power than big ones. That’s why a Tesla S with 60kWh is slower than a 100kWh version, while having the same motor. Good thermal management of the battery can however reduce the difference in battery life. 10 years and 160 thousand km warranty is normal for modern electric cars.

However, practice shows that well-conditioned battery packs can even last longer.

The first series Tesla taxis at Schiphol airport, lost only 6% battery range after 300.000 km. And, the 2011 Chevy Volt shows no practical range loss after 400.000 miles!

Driving makes the difference

Battery electric vehicles of all sorts will show unprecedented driving characteristics.

But, batteries are heavy and expensive. This sometimes calls for a smart compromise. From a user perspective, the battery size can be based on the personal or typical driving needs. Driving cycles are important to choose EVs on practical range and avoid ‘batteries on wheels’. A high range is flexible but expensive, a limited range can be enough to commute and is cheaper.

Urban utility vehicles, like buses and trucks, can also be developed with dedicated charging. The newest electric city buses use on-route fast-charging, next to overnight depot charging. The big business advantage is that utility vehicles with smaller batteries can transport more. Although having smaller batteries, they still drive all day due to advanced fast charging strategies. To help energy management, trip monitoring is the most important control function for EVs.

EVs are computers on wheels

One could argue that EVs are basically computers on wheels in which all basic functions are electrified and digitized.

In modern EVs driving, charging, preheating and predicted range can be monitored remotely. It goes without saying that low energy heating should be a standard EV equipment. Because of the high efficiency of the electric motor there is little waste heat for interior heating. Individual heated seats, steering wheel and windshield

plus a heat-pump can offer this. Very pleasant is that a full electric powered heater is much faster than heating up an engine.

Electrification leads to dramatic reduction of moving parts and maintenance. The moving parts count for a combustion car is typically 2.000, for an EV it can be a few dozen. Apart from some auxiliaries there is no need for maintenance and service accessibility. Functional updates, predictive maintenance and crowd learning can be done from a distance with wireless connections. The electrification of vehicles makes them very suitable for automated driving and sharing.

- All basic functions are electric powered and in the well controllable electronic domain.
- User mistakes can be easily ruled out by a smart control system and IoT connectivity.
- And, last but not least, open source EV-technology will make sharing of innovation faster.

If the market demands, zero emission vehicles, the traditional OEM's, may change fast. However, the change will still make victims under 'laggers' and financial weak manufacturers.