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Between desire and

All the euphoria about the demise of diesel and the rise of the e-car deserves a closer look, says **Reinhold M. Karner.**

Diesel is dead – long live the e-car. But is it?

Unfortunately, the debate over engine types, triggered by the fraudulent diesel scandal of certain manufacturers, is lacking in evidence-based arguments. The debate is more emotional and interest controlled. Furthermore, because of the problem of air quality in many cities, there is an increase in pressure for something to happen quickly.

The latest decision by the German Federal Administrative Court, which says diesel cars may be banned in cities, makes the argument even more complex. Moreover, the effect of this decision is hardly isolated to Germany but will be felt across several other EU Member States.

One might immediately jump to the conclusion that we must solely drive e-cars in the future. However to consider the electric car solution as the ultimate sustainable route is wrong and short-sighted. In truth, sustainable automobility faces other challenges that are scarcely being talked about.

The first electrically powered car was ready for serial production in 1902. The Lohner-Porsche Semper Vivus was the first hybrid in the world with 2.7hp and a 35km/h speed limit. Electric cars existed even earlier, due to the cranking required to start an internal combustion engine by hand. But then in 1911, the first ICE Cadillac with an electric self-starter was available on the market. This was the dawn of the triumphant internal combustion engine.

So electromobility was not approached for the first time by Tesla's founder Elon Musk. And as cool as Tesla's cars may be, the company generates horrendous losses, quarter after quarter. Investments will hardly hide the fact that the e-car hype is currently leading to a dead end, despite good intentions.

The global trend-setting European car industry would have had plenty of time to develop ecological and sustainable technologies in full throttle. For some reason it did not and instead focused on the interests of its shareholders, often being oil producers, maximising shareholder value. This has done them, us and the climate a disservice. The solutions we need so desperately are missing and they could have possibly existed already and in use today.

But let's consider objectively speaking about the situation with the development of the propulsion technologies in the near future.

First, nitrogen oxides and fine dust. The emissions problem continues to be brought up time and again: carbon dioxide, nitrogen oxides and fine dust are the key culprits here. Of course, such emissions do not just stem from the internal combustion engines that our cars emit but also from domestic coal and fuel, manufacturing, aviation and shipping industries which all contribute massively to this pollution.

Moreover, perpetrators of the emissions in road transport also stem from the abrasion coming from tires and brakes – particularly in cities. This particulate matter also exists with e-cars.

If you put an old Mini Cooper, first built in 1959, and the current Mini next to each other, you have the obvious evidence of the next polluter: our demand for larger, heavier cars, which is becoming more obstructive in cities and parking, resulting in traffic and a general waste of space, known as space pollution.

Of course, engines need power – the more fuel an engine consumes, the higher the resulting emissions. Us consumers are increasingly demanding more powerful engines, yet have little regard for how engine displacement and power affect emissions. This despite the complete contradiction that the engine power gets ever larger and the achievable speeds in the day-to-day use are decreasing due to the increasing traffic density and speed limits. In fact, we actually need less power.

How is diesel rated nowadays? First off, in general, the diesel engine will be retained. This is because of the high level of diesel efficiency in trucks and excavators. Even modern diesel technologies, which meet the latest Euro-6-d-TEMP standard specifications, will probably continue to exist. All the more thanks to the future developments and improved emission control systems. Therefore, diesel has a high probability to remain in service, especially in larger or heavy passenger cars. Also, a diesel engine consumes 15 per cent less than petrol, which in turn benefits the global climate.

There's another point: diesel engines now meet the nitrogen oxide limits of petrol engines, albeit costing more. Also, the highly equipped direct-injection petrol engines produce more ultrafine dust than its diesel counterpart. After all, more petrol engines on the road inevitably means higher carbon monoxide emissions versus the diesel engine counterpart.

Of course, we need alternatives, not just for the sake of the environment, but also for energy diversity for the transport industry and its need to move away from oil-dependency. Diesel itself, at least the most modern versions, should not be demonised. Having said that, it also should not be a credo for diesel, as petrol in general is still better off with regards to emissions. True that there is a serious problem with older diesel engines. And retrofits, even for Euro 5 with existing particulate filters, are considered sceptical for several reasons. However, carmakers like Fiat and Toyota have already announced their departure away from diesel production and sales in the near future. Volvo will undergo a full conversion to electric from 2019. The entire industry is now focusing on the electric car.

However it is important to understand the differences. Which e-car are we talking about? A purely accumulator-based one and therefore only rechargeable at the recharging unit, a battery only electric vehicle, a plug-in hybrid car which operates in addition to an internal combustion engine also with a rechargeable battery-based electric drive that is rechargeable at the charging station via power supply, a hybrid vehicle that charges their battery partly or totally via the combustion engine, or cars which partially recycle and recharge energy via brake energy?

The electric powertrain itself is not the problem. The big question is, where does the current electric energy come from? Because even the still very expensive hydrogen fuel cell ultimately generates electrical energy. At first, it sounds quite tempting to believe that there is currently no more efficient propulsion technology than electric. Let's look at the numbers. To get a mechanical kilowatt-hour into a vehicle, just 1.4 kilowatt-hours are needed from for example a photovoltaic power station. A loss of only 30 per cent of energy to the wheel is considered to be extremely low.

The problems lies elsewhere. Generally speaking, an electric car boom would make electricity more expensive. To generate nationwide electricity we will need primarily non-renewable energies. Therefore, for battery-based e-cars we are just shifting the exhaust gas pollution from the car exhaust to the fossil power plants chimney. To be fair, there is some upside as the emissions at knee level (exhauster) particularly that occurs in cities is reduced, and the chimneys in the power plants have better filters than a car.

Batteries, or rather its so-called battery-cells, for e-cars are almost identical to the commercially available ones we use at home but are rechargeable and bundled en masse. This quickly adds up to a weight of up to 750kg. And as we all know, batteries consist of an extremely questionable interior. In the steel casing there is a mix of resources that often need to be mined all over the world through inhumane working conditions and collected under enormous logistical efforts, like lithium from Chilean salt lakes, graphite which is often cleaned under pollutive circumstances, and cobalt mining which is often driven by child-labour. And this does not stop here, as the electronics and capacitors also require coltan and tantalum, and copper is needed for the cable. Unfortunately, most of them are anything but sustainable or fairly-produced.

To produce battery cells, an immense amount of energy is needed. If this energy doesn't come from ecologically renewable sources then the process to get just one battery-set for an e-car causes as much carbon dioxide as driving seven to eight years with a combustion engine.

The use of such sacrilegiously manufactured batteries is disproportionate since the batteries only last for about four years – and over the course of the battery's lifetime, rapidly becoming weaker. Just recall the outcry of Apple's iPhone customers as it became clear that the performance of the iPhone predecessor models were deliberately throttled to compensate for the battery degradation. This energy footprint is already much worse than the one of an ICE.

And this calculation does not even incorporate the pollutants emitted from the generated electricity that is needed for the ongoing charging of the batteries, so that's not a single mile

reality

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drive. In short: the energy footprint of the electric car is currently a disaster. But hardly any politician either knows or wants to accept it.

Strategically, the European car industry needs at least 10 manufacturing plants to produce battery cells, and each one requires around €3 billion of investment. Otherwise, our EU car-industry will depend, as per today, on Asian battery producers as it had been dependent on the oil-exporting countries in the past. It would be a disastrous move to leave the technology know-how and competitiveness to other continents.

Once the batteries are at the end of their life cycle, what fate do they face? Likely a complex recycling process or a pollutive disposal follows. At best, there could be an intermediate stage, causing a second life as storage batteries with less power such as for photovoltaic systems. A more circular approach is still needed where the precious resources found in these batteries can continuously be cycled.

Another challenge for the e-car lies in waiting: the average lifespan of a car with a combustion engine is around 17 years, whereas that of an electric car is probably half that. This is due to more electronics and the need for faster technology updates. As a result, significantly more new electric vehicles must be produced to sustain the demand.

That may make the car industry happy, but is hardly sustainable. According to BP Energy Outlook 2018, the number of cars will double by 2040 to around two billion, particularly due to the rising prosperity in developing economies; the current number of 84 million new vehicles produced per year will increase to an estimated 100 million by the year 2030.

Finally, imagine that almost every used e-car has to park several hours at a charging station on a daily basis. Here the question arises of whether our power grids and plants have the capacity to withstand this gigantic increase in energy demand. In Norway, the country with the largest electric cars market share worldwide thanks to government funding, the electricity motorists lobby advised the general public not to purchase e-cars since September 2017, unless one would have a charging station at home. This caused an energy capacity problem.

Increasing the energy capacity evolves at a snail's pace. One can only look at the many challenges of high-voltage transmission lines in the financially strong country of Germany.

The Norwegian example shows the electric car hype is not a thoroughly thought through revolution. In that sense, in the long term, only a technology with hydrogen will really solve our problems around clean energy and energy storage sustainably. In light of this, it is understandable why Toyota and Hyundai has offered for quite some time hydrogen vehicles and remain undeterred in their strategy to continue to invest heavily in this technology.

The problem with hydrogen is that an electric vehicle with a fuel cell for hydrogen consumes about twice as much output power as a battery-based electric car. Fuel cells are different from batteries in requiring a continuous source of fuel and oxygen (usually from the ambient air) to sustain the chemical reaction for producing electricity.

As long as the energy for liquid or gaseous hydrogen fuel production is not predominantly or only generated from renewable sources, the life cycle assessment for this technology is not consistent. Such renewable energy sources would be almost inexhaustible. The range of hydrogen fuel cell cars is indeed similar to the ranges of petrol and diesel, and refuelling is also fast; but because hydrogen fuel is still mostly produced by steam reforming of natural gas, causing a loss of approximately 70 per cent of energy to the wheel this is still not attractive. But in the overall view of today's lifespan of a car of 15-17 years, this is better than an e-car. If the renewable sources of energy were unlimited in themselves and can be continuously used, with energy still available at night and when there is no wind since stored as hydrogen, then this certainly would be the breakthrough

By the way, the spectre of horrendous costs for the establishment of an infrastructure for a hydrogen filling station network is completely negligible given the huge irretrievable costs of burned fossil fuels. Also, hydrogen tanks are not a problem – the pressure tanks are now denser than those of petrol cars. In the bad case, the tank does not explode, but it is followed by a rapid burn.

Batteries are not without danger. Think of media reports on exploded cell phone batteries followed by a ban of certain smartphone models on flights. Also, consider the radiation effects of sitting in an e-car.

An interesting interim solution could be what Ulrich Bez demonstrated at Nurburgring. Dr Bez was from 2000 to 2014 CEO and chairman of Aston Martin, prior to that a C-level top-manager at Porsche, BMW and Daewoo. In 2013, he drove an almost standard Aston Martin Rapide successfully to second in class as a world's-first hydrogen-powered racing car for the Nurburgring 24h race. This hydrogen internal combustion engine is a transition technology allowing zero emissions capability with existing technology and helping to drive the development of a hydrogen distribution network. He could always switch to petrol and even petrol and hydrogen working in tandem.

With this technology solution one could for example predominantly drive in cities – where such a hydrogen gas service station network is faster, easier and cheaper to set up – and hereby largely reduce emissions and still use petrol for a long range trips.

As a welcomed side-effect, the automotive supply industry would not be in such dire straits, particularly because a car with an internal combustion engine consists of around 2,500 parts, but an e-car is well below 1,000 parts. Such a model would soon give us more experience when it comes to hydrogen use and the associated infrastructure.

In the near future and for a long time we will see a mix of different drive technologies on our roads. The BP Energy Outlook 2018 predicts more than 300 million electric cars in 2040, around 15 per cent across the globe. Which of propulsion technology ultimately prevails is still written in the stars.

I owe it to my esteemed friend Dr Bez that I have learned so much about this topic. My thanks extend to Prof. Dr.-Ing. Manfred Weissenbacher, for his support regarding the fact checking of this article as he is an expert in the field of energy, particularly batteries from the Institute for Sustainable Energy at the University of Malta.

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