

The machine that changed the world

The historic book the '[Machine that Changed the World](#)' is about continuous improvement. It was the first publication about how lean production and Zero Defect in automotive works. Electric vehicles are by mechanical design less complex than combustion vehicles. So, the hardware has a good prospect to be Zero Defect and lean to produce. With EVs, many continuous improvements can be made by over-the-air updates of the software. But here also lays a big risk, bugs in the software can easily stay unnoticed during development.

GM [claims](#) that the Chevy Volt has more software lines than the Boeing Dreamliner airplane. This is the reason that the new [ISO 26262](#) design norm is obliged for software electronics. The norm safeguards the functional safety of the highly computerized electronic vehicles. Regulations, norms and open standards are needed the change the automotive world.

Zero emission mandates

Governments are pushing to move to a zero-emission transport system in the near future. They have to be in line with their goals for the Paris climate agreement. Governmental bodies therefore set mandates for emissions or number of clean vehicles. Good examples are the [European Commission Fuel](#) and [American EPA](#) fuel economy standard. The Californian air resource board adopted the first [zero-emission vehicle regulation](#) in 1990.

The most recent very successful one is the [New Energy Vehicle mandate](#) in China.



These mandates push automakers to continuously improve the efficiency of the vehicles as much as possible. If mandates become stricter, OEMs have to build zero-emission vehicles to comply the laws. Norway obliges the sale of zero emission vehicles only already in 2025, the Netherlands follows in 2030. Some cities will close the road for polluting cars, trucks and buses even before these dates.

Learning curve and cost reduction

Continuous improvement also occurs by higher production volumes with more automation. Improvement in batteries in the last years is primarily realized by better production tolerances. Better process control means less weak-points and potential hot-spot failures in the cells. One bad cell in the string reduces the performance and durability of the complete battery pack. A battery pack is as good as the 'weakest link in a chain'.

Cost reduction is a result of continuous improvement that comes with economies of scale. In this respect, the recent cost reduction in batteries is a good example. The traction battery production is at the point of overtaking the volume of cell phone batteries. As a consequence, prices drop 50% about every three years.

Also interesting is the recent [German study](#) about the cost price of a Tesla Model 3. Based on the bill of materials and parts teardown, the study found a significant cost reduction. At the calculated €17.000 cost prize, the Model 3 seems to be very compatible and profitable.



The Tesla Semi is already offered for lower cost per mile than diesels. Most Total Cost of Ownership calculations point in the same direction, at decent prices EVs are the winner. At mass production volumes, Just in Time delivery will be a significant cost reduction factor. Now battery production is still concentrated in Japan, Korea, China and North America. To shorten the transport distance and time to delivery, it will need to start in Europe too.

Global business outlook

Currently, the EV market and product development is more or less a battle of the continents. The USA has clearly the most innovative product leaders, but they are in California, not in the center of their automotive industry, in Michigan. China is the fastest growing player in the EV sector and may soon dominate the market as a cost leader. Europe can still be the premium quality leader, but then the industry has to wake up soon. The risk of coming late and losing and not-owning the production base, is there. The Chinese company Geely has become Daimler's biggest shareholder earlier this year (2018). There have been talks of battery production and motor delivery, but Daimler is unwilling so far. On top of that, the Tesla Model 3 is already the most sold premium middle-class sedan in the USA. Despite production problems, it finished ahead of the Mercedes C Class, Audi A4 and BMW 3.



Next eco-economy and employability

Ecology and new economy go hand in hand and most startups are focussed on sustainability. The expectation is that electro-mobility will provide profitability growth in the near future. We are still in the 'seeding' phase with a lot of investments, but soon the 'harvesting' follows. Most new business start as additional to the existing, however substitution will happen. For this moment in time, this has extra and high-quality employability as a result. The German auto-industry warns about a massive loss of jobs due to electrification. But German Prof. Dudenhöffer [warns](#) they risk to lose the whole future if they act too late.

Sustainable growth

It's a fact that EVs are the fastest growing market in near all automotive segments. Double-digit sales growth of vehicles and charging infrastructure per year are no exceptions. Regardless car, bus or truck, best-selling vehicles are more and more electric vehicles. Also, in electric car sharing we already see a sharp ramp up of new innovative companies. This growth is the result of private and government investments, subsidies or tax deductions. Countries like the Netherlands can still learn from Norway and California. A well-balanced policy, in which the polluter pays and stimuli for every citizen works best. In a transition, everyone has to benefit from e-mobility, otherwise social resistance builds-up.



Testing and homologation

To avoid failures, products need to be flawless in their design and quality. This is a renowned problem of the early EVs, they had designs which were not scrutinized. Most products were hardly tested and the production quality was not consistent enough. Technically unsafe and unreliable products are an unacceptable risk in traffic. Although we accept that car accidents happen, an accident with an EV is still front-page news. And, it may not only put the life of those involved at risk but is killing for the reputation of EVs as well.

Unreliability and unsafety immediately backfires on all EVs and for sure on trust in the brand. Likewise, for the charging infrastructure there are standards and, health and safety regulations. Open Charge Protocols are now adopted throughout Europe and guarantees interoperability. International roaming agreements and ad hoc payment is mandatory by the EU commission. [R100](#) & [R101](#) is about high voltage, [ISO 26262](#) about charging safety and [ISO 15118](#) about communication. In all European countries, local homologation also leads to European Type Approval.

