Global E-Mobility Outlook

IHK München
2018 FEB 19

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Global Head of e-Mobility, TÜV SÜD AG
Since 150 years TÜV SÜD stays true to its founding principles of protecting people, environment and property against the adverse effects of technology.
1.3 Billion vehicles are on the road globally

89 Million will be produced in 2016

this leads to additional

100 Million vehicles every 3 years
What if the whole world has the same motorization rate as Europe?

And what if the whole world had the same motorization rate as North America?

Data source: International Organization of Motor Vehicle Manufacturers
Historical CO₂ concentration

CO₂ concentration in the last 400,000 years

Critical CO₂ concentration 400 to 450 ppm

Year
What if the entire world population emitted the same amount of CO₂ as an average European citizen?

And what if the entire world population emitted the same amount of CO₂ as a North American?

Data source: International Energy Agency
CO₂ emissions per Capita [t / capita]

North America: 15.9
EU-28: 8.7
Middle East: 7.7
China: 6.7
Korea: 11.3
Japan: 9.4
Central & South America: 2.4
Africa: 0.9
India: 1.6
Rest of Asia: 1.6

Data source: International Energy Agency
Global CO₂ emissions – cumulated 1850-2013

Emissions of USA & EU account for 55 % of overall CO₂ pollution

Share of states of historic CO₂ emissions

<table>
<thead>
<tr>
<th>Country</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>29%</td>
</tr>
<tr>
<td>EU</td>
<td>26%</td>
</tr>
<tr>
<td>Rest of world</td>
<td>20%</td>
</tr>
<tr>
<td>China</td>
<td>10%</td>
</tr>
<tr>
<td>Russia</td>
<td>8%</td>
</tr>
<tr>
<td>Canada</td>
<td>4%</td>
</tr>
<tr>
<td>Other countries</td>
<td>2%</td>
</tr>
</tbody>
</table>
World Population Growth – 10 Billion by 2050

Even more relevant: The affluent population will triple or even quadruple by 2050 compared to today's levels!
25 tons of organic substances (mostly algae)

1.250 x

for 50 liters of gasoline
Nations Unies
Conférence sur les Changements Climatiques 2015
COP21/CMP11
Paris, France
< 1.7°C  UN agreed on stabilization of temperature rise

that means stabilization of CO₂-concentration

< 450 ppm

anually we add another 2.5 ppm to 400 ppm existing concentration

that leaves us another 20 years to get to 0 ppm increase!
But what does this really mean?

Real Estate

Transport

Power Supply

Industry

0 \( \text{CO}_2 \)

0 \( \text{CO}_2 \)

0 \( \text{CO}_2 \)

-90% \( \text{CO}_2 \)

by 2050 (industrialized countries!)
Real Estate: Plus Energy House (TU Vienna)
Global Investments into electricity production capacities

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Investments 2015 (in billion US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>148</td>
</tr>
<tr>
<td>Wind</td>
<td>107</td>
</tr>
<tr>
<td>Hydro</td>
<td>98</td>
</tr>
<tr>
<td>Gas</td>
<td>31</td>
</tr>
<tr>
<td>Coal</td>
<td>78</td>
</tr>
<tr>
<td>Nuclear</td>
<td>21</td>
</tr>
</tbody>
</table>

The pie chart shows the distribution of investments in different energy sources for 2015.
What options do we have for „zero emission“ transport?
Global EV and PHEV market by 2017

- Cumulative numbers for BEV and PHEV: Sales volume increased in 2016 to more than 765k units/a!
- More than 890k units have been sold in China alone!
- Thus market growth will increase significantly and PHEV are not even really present yet!

In fall 2016 total number of EV on the road exceeded 2 Million vehicles!
Total vehicles on the planet: 1300 Million!

Source: ZSW (2009-2014,), TÜV SÜD 2017
What motivates Governments to push for NEV?

- Climate change, local pollution / air quality in cities
- Local pollution / air quality in cities
- **Global technology domination in electric vehicles (NEV)**
- (In) dependence on oil) imports, India spends 80 Billion US$ on oil imports - own production is in decline – demand is still growing!
- Industries: New radical players, keep global market share! Survive!
Markets: China outperforms all

- Sales are up to >40-55k units per month
- Except of Tesla no Western/ European / Japanese brand plays a role in the top 20 e-vehicle charts (Tesla 17th)
- China is using e-Mobility as one key element of their growth stimulus package in the next 5 years
- There is a clearly visible industrial strategy behind the e-vehicle sales stimulation measures!

Source: Timer Auto, Monthly Market Performance of Domestic New Energy Vehicles

All foreign OEMs must act, not to lose market share in China, the trend is clear!
Why is the current German „Diesel“ strategy might be dangerous?

- **Even if German OEMs succeed to keep Diesel cars in the German market!**
  - Rest of Europe/RoW will ban Diesel cars, municipalities will ban Diesel cars in cities!
  - BMW achieves 38% of its revenue in China, profit is close to 50% from China!
  - VW Group achieves 50% of its total rev. in China! Profit share is close to 60%!

My prediction: China will ban all combustion engines in big cities starting from 2025! (Beijing, Shanghai, Guangzhou, Shenzhen, others will follow)

China is already dominating the global market for electric buses! More than 100k electric buses are on the road in China! Sales in Europe increase! (Paris, London, Amsterdam…) 3000 Fuel Cell buses planned for 2018, 10,000 for 2019!
Dynamic encounters:

German postal service became a vehicle manufacturer!
Problem: Old power outlet sockets and not appropriate wall cabling
Furthermore holistic thinking is necessary – e-Mobility is a “system”!
Typical e-Mobility is a system – safety needs to have a system approach too!
Home Charging – everything set?

Example: Town house style, 28 Units, 32 underground parking lots, 15 overground parking lots, built 2016
Mittelspannung
Highway fast charging
## Fast charging at highways

- World largest fast charging site (Norway, 20 x 120 kW (2.2 MW total))
- Holzkirchen near Munich

### Peak demand resting area „Holzkirchen“

(16 refueling points, 6 Minutes processing time, 10h peak demand, 14 hours 50% of peak demand)

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total refuellings peak-day</td>
<td>3264</td>
<td>Highway resting areas in Germany:</td>
<td>380</td>
</tr>
<tr>
<td>Charging power</td>
<td>150 kW</td>
<td>Requires roughly 38k chargers with 5.7 GW power</td>
<td></td>
</tr>
<tr>
<td>Charging time</td>
<td>30 Min.</td>
<td>(calculations by Blandow, TÜV SÜD)</td>
<td></td>
</tr>
<tr>
<td>⇒ No charging points:</td>
<td>96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>⇒ Peak power demand</td>
<td>14,4 MW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Safety relevant battery trends 2017+

- No „relevant“ technology change in the next 3-5 years
- Batteries are getting bigger (300-500 km range, 40-90 kWh)
- Batteries need to have fast charging (and HPC150/350) capabilities
  - Reduced resistance of anode and cathode (e.g. Ni doting, nano coat)
- Higher capacity (bigger!) batteries require higher densed packaging
Beyond product safety…

- Product Safety
- Rescue work
- Recycling / Decommissioning
Global TÜV SUD Battery Testing Network

Toronto, Canada
Auburn Hills, USA *)
Complete service portfolio for cell, module and system testing

Garching, Germany *)
Complete service portfolio for cell, module and system testing

Shenzhen, China
Performance, environmental and abuse testing on cell and module level – system level in 2015

Singapore *)
Performance and environmental testing on cell, module and system level

Suwon, Korea
Performance testing on cell, module and system level, Abuse test on cell level

Utsunomiya, Japan
Environmental and abuse test on cell, module and pack level

*) ISO/IEC 17025 accredited test lab or accreditation in 2015, Issuance of CB certificate / report possible
TÜV SÜD Battery Lab Germany: EV scale battery safety testing up to 800 kg
Full vehicle immersion and propagation test (thermal runaway) by TÜV SÜD!
300 HP, V6 Diesel engine

380 HP electric Motors 2x

E-Motor: Maintenance free, oil free, no moving parts, minimum 10 Years, 95% efficiency!

Source: E-Force One AG
TÜV SÜD Group
One-stop testing, inspection, certification and training.

For a Safer and Greener Future.

Vielen Dank!
Backup

Choose certainty.
Add value.
Martkets: The “Premium” challenge, Tesla put it upside down!

US premium segment vehicle sales

- All established OEMs lost ground in 2016 in the premium segment, except of Tesla Model S, BMW 7-series and Jaguar XJ
- Tesla Model S outperformed all premium vehicles
- California (with 40 Mio people) traditionally was the most important premium market for Japanese and German OEM (for Germany now China)!
- In 2016 the new Model X rivaled the successful SUV segment additionally
- Thus: Audi Q7, Porsche Cayenne, VW Touareg, BMW X5/X6, Lexus LS
- In 2018 Tesla will rival even the compact class with it’s Model 3!

**US premium segment vehicle sales**

<table>
<thead>
<tr>
<th>Model</th>
<th>2016 sales</th>
<th>2015 sales</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audi A7</td>
<td>6558</td>
<td>7721</td>
<td>-15.06%</td>
</tr>
<tr>
<td>Audi A8</td>
<td>4149</td>
<td>4990</td>
<td>-16.85%</td>
</tr>
<tr>
<td>BMW 6-series</td>
<td>3947</td>
<td>8146</td>
<td>-51.55%</td>
</tr>
<tr>
<td>BMW 7-series</td>
<td>12918</td>
<td>9292</td>
<td>39.02%</td>
</tr>
<tr>
<td>Jaguar XJ</td>
<td>3834</td>
<td>3611</td>
<td>6.18%</td>
</tr>
<tr>
<td>Lexus LS</td>
<td>5514</td>
<td>7165</td>
<td>-23.04%</td>
</tr>
<tr>
<td>Mercedes Benz CLS-Class</td>
<td>4156</td>
<td>6152</td>
<td>-32.44%</td>
</tr>
<tr>
<td>Mercedes Benz S-Class</td>
<td>18803</td>
<td>21934</td>
<td>-14.27%</td>
</tr>
<tr>
<td>Porsche Panamera</td>
<td>3140</td>
<td>4985</td>
<td>-37.01%</td>
</tr>
<tr>
<td><strong>Tesla Model S</strong></td>
<td>29421</td>
<td>25202</td>
<td>16.74%</td>
</tr>
<tr>
<td><strong>Tesla Model X</strong></td>
<td>18223</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>110663</td>
<td>99198</td>
<td>11.56%</td>
</tr>
</tbody>
</table>
Markets: Tesla’s impact is not only in the US, Europe is challenging for “classic” players as well!

Official statistics hide away Tesla from premium statistics (not classified as premium car!)

Tesla Model S outperformed all premium vehicles except of the all new Mercedes S-Class and BMW 7-series, but Model S is almost at similar sales levels!

In the German premium market Tesla was not (yet) successful, while in others it gathered up to 60% of the premium market! (Norway, Denmark, The Netherlands, Switzerland, even Austria!)

Model X and Model 3 are also about to start in Europe, Model X availability will be limited in 2016, Tesla focus is China and USA..