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The Impact of Global Warming on the Automotive Industry

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Abstract. One of the main cause of global warming of environment are the emissions of automotives (methane, CO2, nitrous oxygen, etc.). Of the total global CO_2 emissions of the transportation sector contributes about 15%. In order to control the emissions of the automotive sector, all over the world, strict emissions targets were being set to reduce the Automobiles contribution of CO2. These leads to global maximum temperature increase to 2 degrees Celsius. In order to achieve these targets, the automotive industry will face a major change in its concepts. It will move from combustion to electrical engines. The technical realization of these engines will most likely be battery and fuel cell driven propulsion systems. In order to achieve that transition a major effort is required.

Key Words: CO -carbon monoxide, CO_2-Carbon Dioxide, NOx- Oxides of Nitrogen.

1. INTRODUCTION

Global warming causes increases the average temperature of earth's atmosphere. The main causes of global warming are industrial pollution and automotive. The major t contributor of rising temperatures is carbon dioxide CO_2,so it is need to reduce the percentage of carbon dioxide CO_2 production with 25%, agriculture, forestry and other land use with 24%, and industry with 21%. The transportation sector contributes with 15% to the total global CO_2 emissions. It comprises road, rail, air and marine transportation. It is important to understand that 95% of the world's transportation energy involves burning petroleum products. Here we are concentrating mainly on light passenger vehicles of the world.

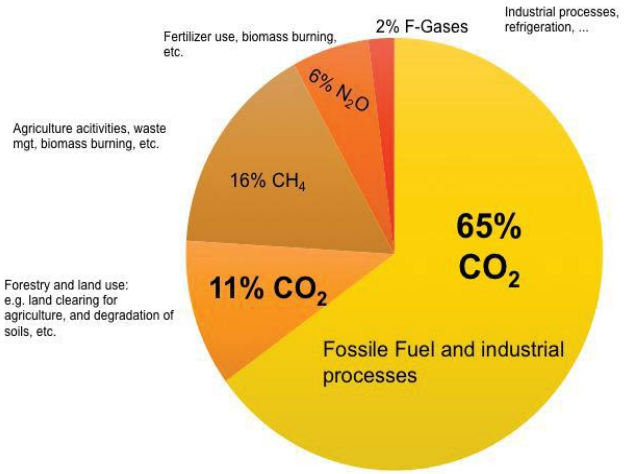

FIGURE 1: Man made gases contributing to global warming [1].

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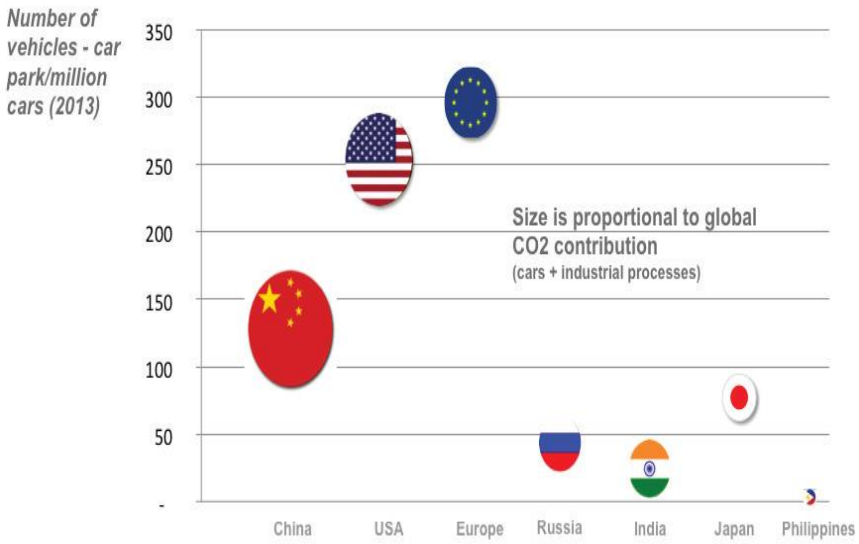

FIGURE 2: On transportation the „Big 6" make up ≈70% of all registered vehicles globally in calendar year 2013 (1.2 billion total) [2].

"Big 6" thereby stands for those countries / continents that make up the 6 most number of vehicles worldwide.

TARGET SETTING

In order to reduce the CO2 emissions governments around the world are setting ambitious targets for the emission of CO2 for road vehicles. Figure 3 shows the targets over time for passenger vehicles. Note that there are also targets for commercial vehicles, which we do not consider in this paper. They are facing similar time dependent reduction targets.

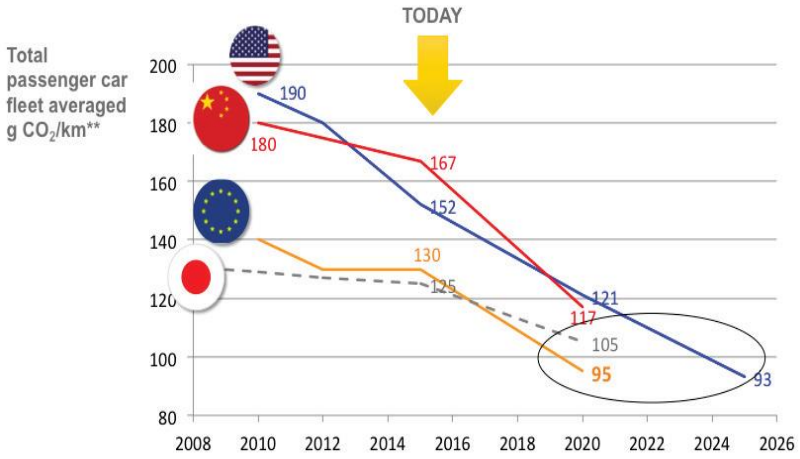

FIGURE 3: Total passenger car fleet averaged gram CO2/km (** normalized to NEDC = New European Drive Cycle)

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Important targets set for the automotive industry are an annual fleet average value of 95 grams CO2/km emission (e.g. Europe 95% of all registrations in 2020, 100% as of 2012) and possibly 10 grams CO2/km in 2050 (note that the latter is at the moment not finally decided but is still under discussion). The fleet average is calculated using the mass and sales volume of the automotive producer. Therefore the target value for each manufacturer varies from the 95gr target. Manufacturers with higher mass vehicles will have a slightly higher target, those with lighter vehicles a slightly lower target.

The development of European CO2 emissions is yearly being monitored and published by the European

Environment Agency (EEA) [3]. To enforce this the automotive OEM's (Original Equipment Manufacturer) in Europe will have to pay heavy emission premiums in case they miss their target. Those - call it "fines" for the moment – are calculated using a simple formula. Per fleet averaged missed gram of CO2, starting from the 4th gram of deviation the fine is 95€. (Note that below 4 gram CO2 deviation from the target the "fines" go down in steps). To give one example: If an automotive OEM misses the target by 4 grams and sells 1 million vehicles per year, the premium to pay is (4 - 3) x 1 mil x 95€ = almost 100 million € per year.

For illustration of the severity of the targets here are some numbers: A fleet average of 95 grams CO2/km corresponds to a fuel consumption of around 4l/100 km or 62 mpg (miles per US gallon). Daimler in Europe for instance, has still to reduce emissions by slightly more than 20 grams of CO2 versus 2015 status.

ELECTRIFICATION

Using regular combustion engines in vehicles and with today's sales mix of gasoline and diesel along with today's or near future technologies it will not be possible to meet these targets. In order to get the fleet average on CO2 emissions down the electrification of the drivetrain of future vehicles is a necessity. At the moment there are 4 different variants of powertrain electrification (Fig. 4): Hybrid electric vehicles (HEV), plug-in hybrids (PHEV) and range extender vehicles (EREV), battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV).

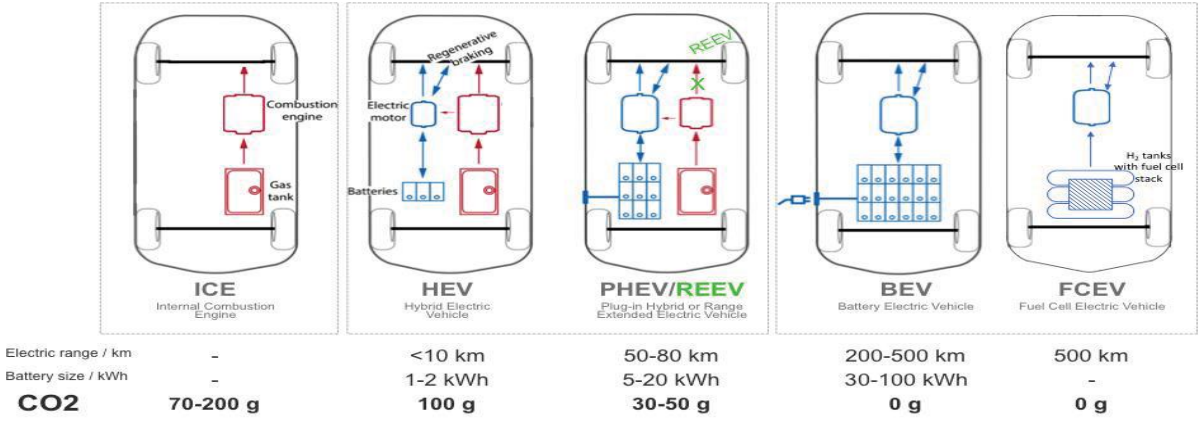

FIGURE 4: Different power train variants including average CO2 tailpipe emissions

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Due to the fact that electric vehicles have zero tailpipe emissions they are considered as the only solution and as a key enabler to reach the stringent CO2 targets in the countries mentioned above The governing question within the industry, however, is which of those four electric drive trains in Fig. 5 are the future power train as heavy investments and cost are required to develop vehicles with each and every possible propulsion variant.

THE YEAR 2050

McKinsey [3] projected (Fig. 5) – based upon a range of possible calendar year 2050 CO2 targets – which of the vehicle propulsion systems will become dominant. They investigated scenarios with 10 grams (0.4 l gasoline consumption per 100 km), 40 grams (1.6 l/100 km), or 95 grams (4 l/100 km) fleet averaged CO2 target for 2050 respectively. In all cases pure combustion engines (ICE) will vanish over time. On the other hand, pure electric drivetrains will only pertain if the target will be set at 10 gr CO2/km. In less stringent targets set combustion engines will be combined with batteries in the PHEV/EREV (called REEV [Range Extended Electric Vehicles] in McKinsey's paper) case.

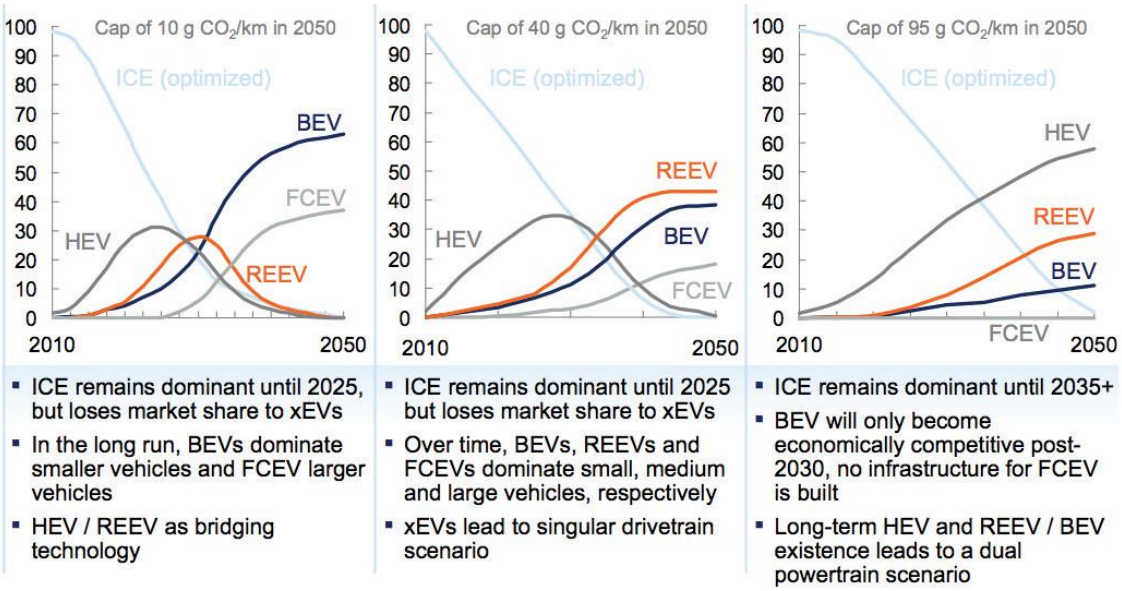

FIGURE 5: McKinsey's outlook of which powertrain in EV's will be the governing one depending on the CO2 fleet averaged target in 2050 [3] (*Reprinted with permission*).

ISSUES

In order to achieve a considerable penetration of electric vehicles there remain several major issues to be tackled and solved. Those are:

1 Range of electric vehicles (EV's) must grow into the order of today's combustion engines, i.e. up to 1,000 km of real range to deliver customer acceptable ranges.

2. Charging infrastructure ("gas stations for EV's") must grow into the same order of magnitude as today's fuel gas stations.

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3. Cost of the battery and fuel cell systems must come down drastically, so that the overall cost and therefore price to pay comes close to today's combustion engine vehicles.
4. Hydrogen needs to be produced using ecology friendly production techniques. Less CO2 and less energy consuming.

All of the above are currently being worked on in industry and research groups in order to cope with the challenge of the future.

OUTLOOK

Looking at the growth rate of electric vehicles in Fig. 6 (new registrations mean the cars that are newly registered in that year; the number of total vehicles is higher) in the last couple of years shows that, although their number is still small compared to combustion engines, it is steadily growing. In 2015 only 0.1% of all 1.2 billion vehicles globally are electrically propelled. Leading in number of electric vehicles are China and the US – the latter due to the ZEV (Zero Emission Vehicle legislation) and the former due to willingness of the Chinese government to clean China's large cities air pollution.

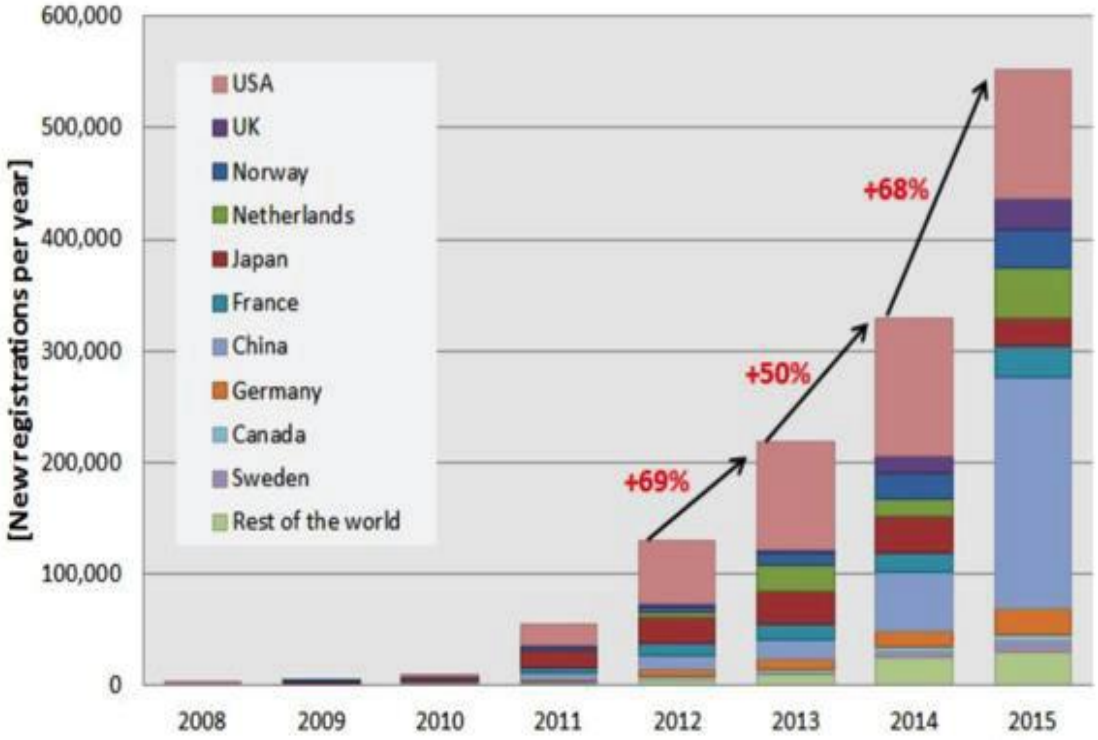

FIGURE 6: Global growth of electric vehicles (BEV, PHEV) over calendar years in new registrations over the last few years [5]
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SUMMARY

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One important enabler of keeping the global warming limited is – besides others – the need of reducing the CO2 emissions from vehicles. This can only happen via the transition from combustion to electric vehicles (EV's). Although EV's will become the primary propulsion system of the future due to the enforcement of stringent CO2 emissions regulations worldwide, combustion engines will very probably still be visible until the year 2050. Those, however, are expected to be only regionally relevant, e.g. in third world countries where the transition process to EV's will be slower than in those continents with tough CO2 targets on vehicles.

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