Alternative Powertrain and Challenges for Next Decade

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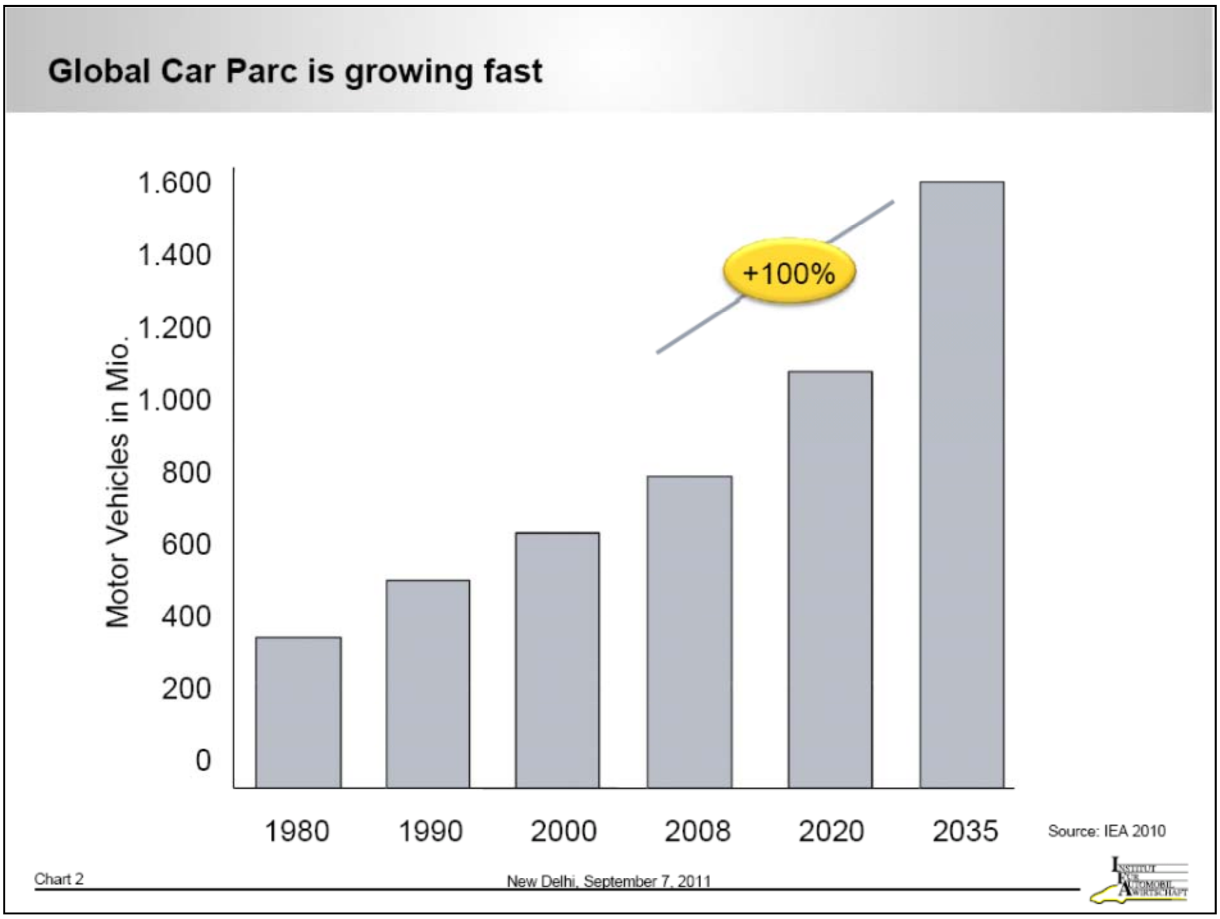
Dear Mr. President,

Ladies and Gentlemen,

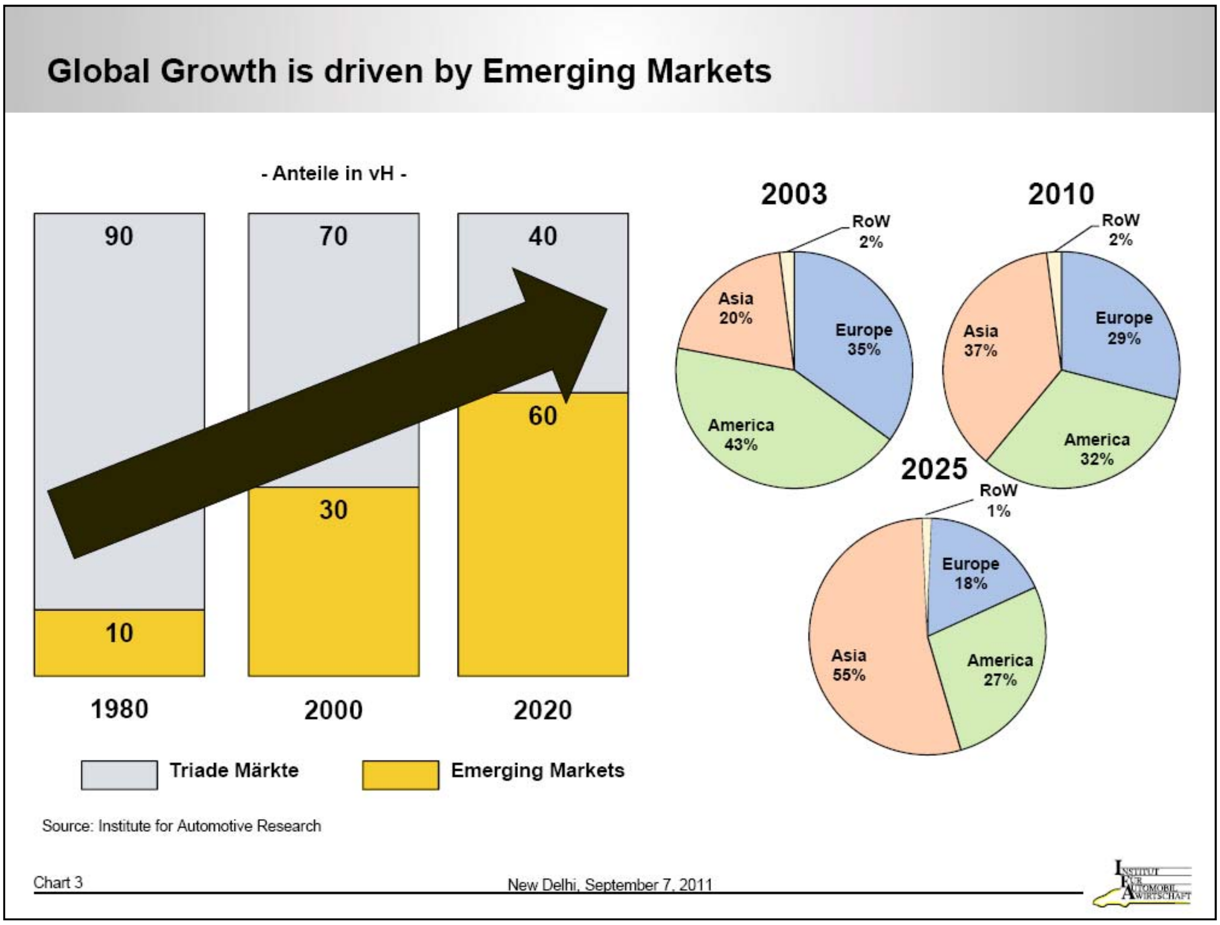
The global automotive market shows a tremendous growth in the last decade only shortly interrupted by the financial crisis in 2008 and 2009. We expect that car ownership will increase further over the next years.

According to a forecast of the International Energy Agency (IEA) the global motor vehicle parc will grow from round about 800 mio. motor vehicles in 2010 to more than 1.5 billion cars and trucks in 2035.



This increase is mainly driven by the motorization process in many emerging markets like China, Brazil, Russia and - last not least – India. We expect that the India market will reach a volume of more than 5 mio. cars a year up to the midth of this century.

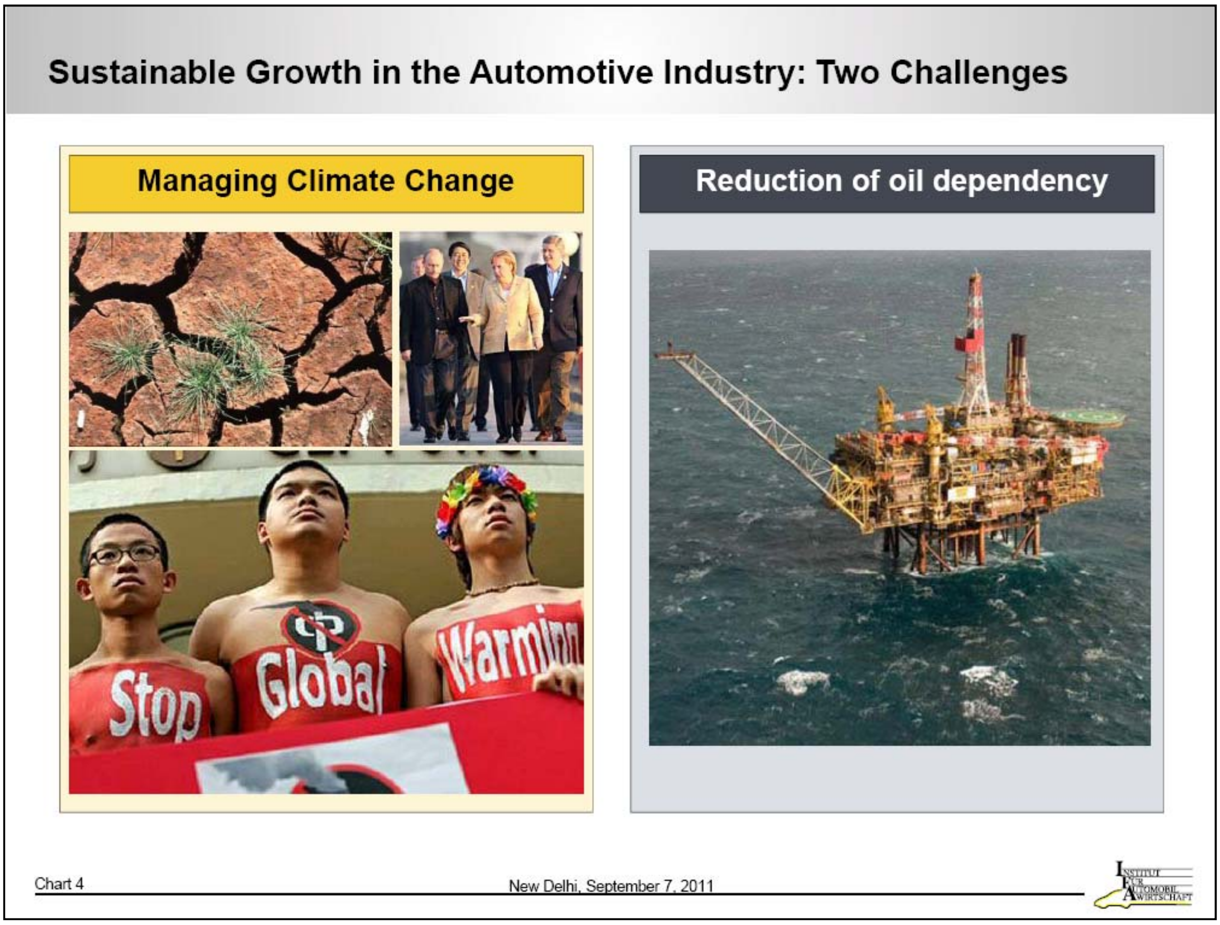
Asia will drive the demand for new cars and light vehicles to new hights in future. Up to 2025 global sales of cars will reach 107 mio. units a year and Asias share at global car sales will increase from 37 per cent in 2010 up to 55 per cent and outstrip Europe and America as the worlds biggest sales region.



As a consequence of the growing car parc on a global scale and the shift of sales to the emerging markets energy demand will also increase dramatically by 2 to 3 per cent a year within the next decades.

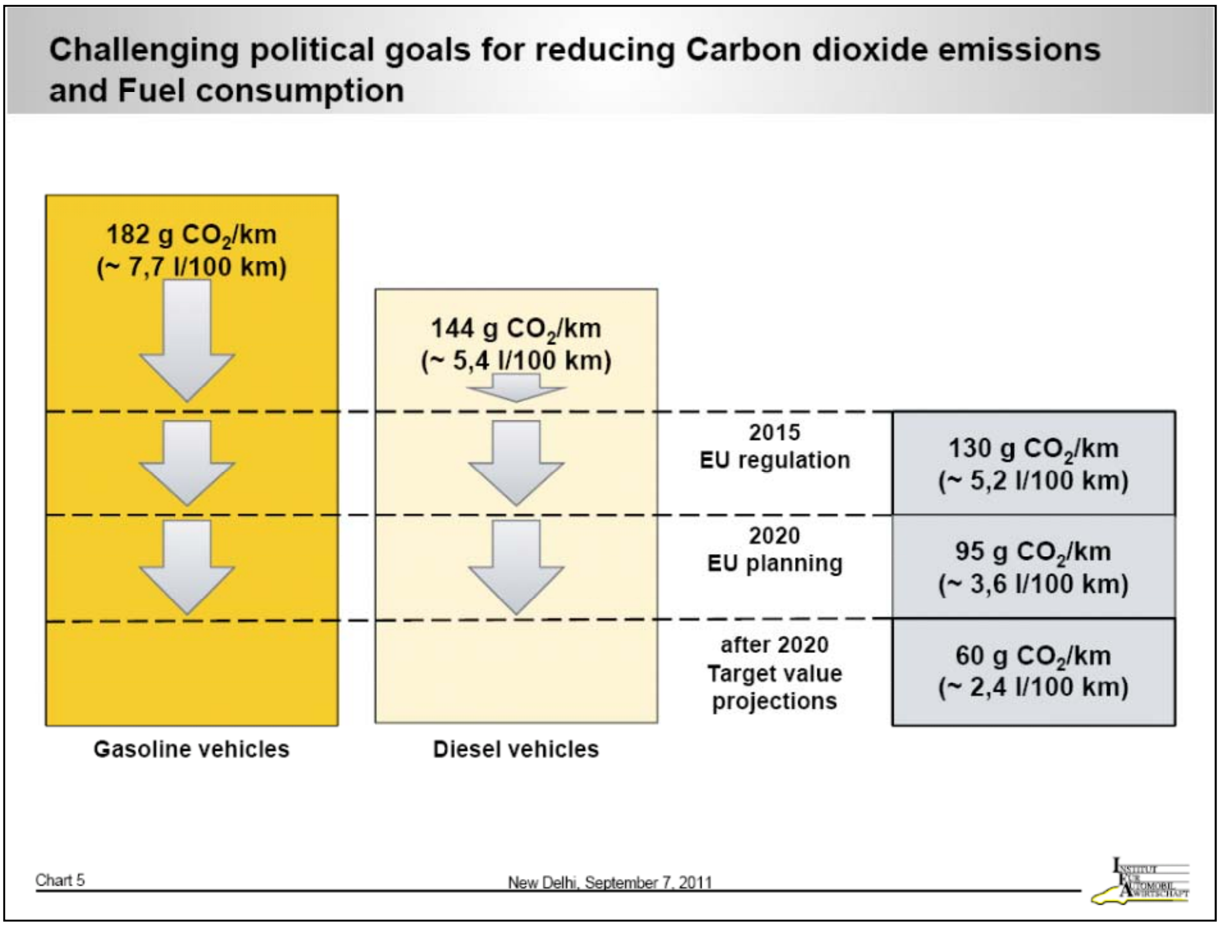
The concerns about the supply of petroleum are matched by the growing awareness of carbon dioxide emissions and their effect on global climate change. To ensure that the increase of global temperature will not exceed 2 degrees Celsius, fuel consumption must be reduced significantly.

Therefore the automotive industry is faced with two main challenges: the reduction of oil dependency and the lowering of carbon dioxide emission. Because the emission of carbon dioxide emission is closely linked to fuel consumption both challenges require common strategies.



Based on the political goal of limiting global warming up to 2 degree Celsius we see more and more regulations on the emission of carbon dioxide and fuel consumption around the world.

The European Union for example is limiting carbon dioxide emission on a fleet sales basis to 130 g CO2/km up to 2015 and a further reduction to 95 gCO2/km up to 2020 is under discussion. This equals a fuel consumption of 3.6 litres gasoline and diesel per 100 km. In the long-term the industry has to expect carbon dioxide emission lower than 60 g CO2/km.

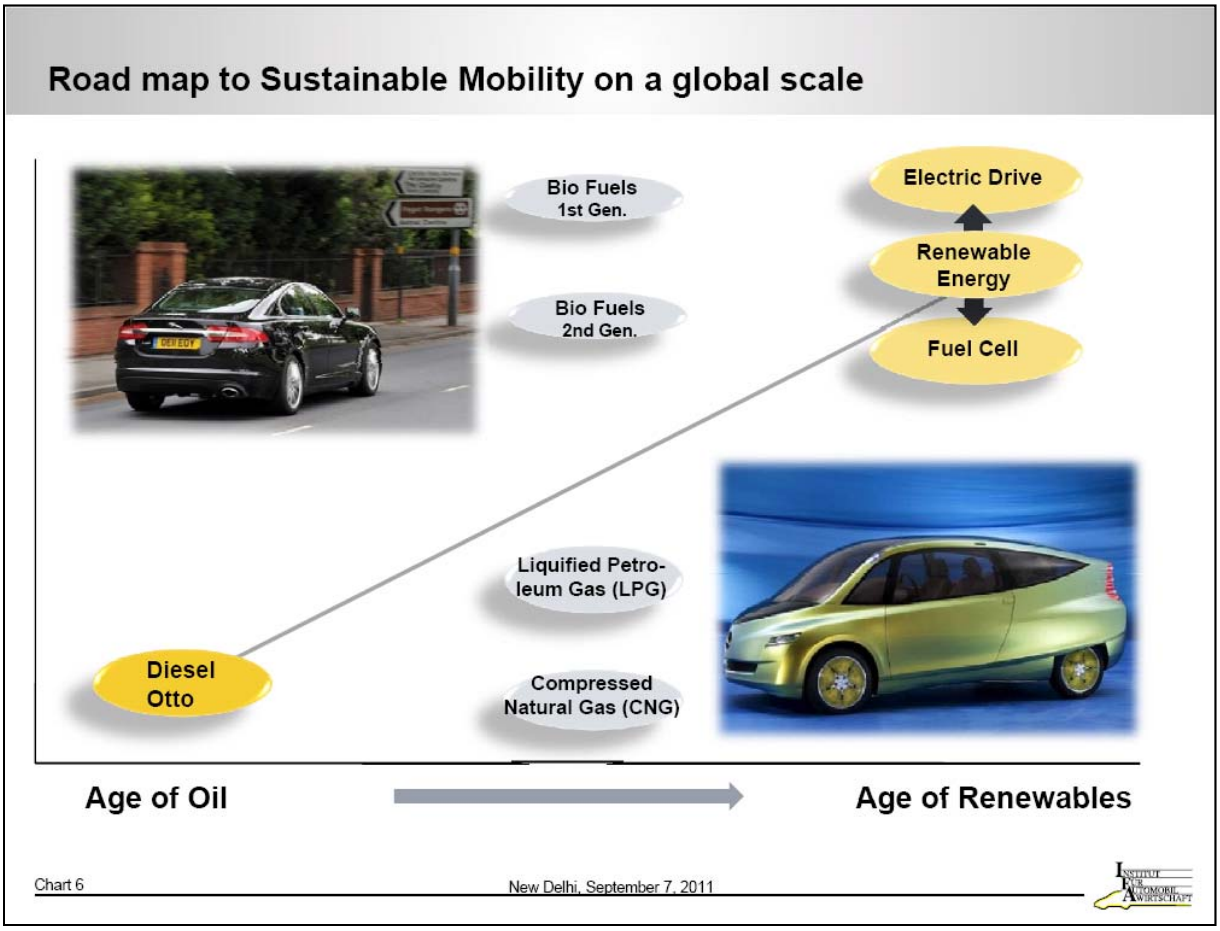


It is quite clear that there is no simple answer to these challenges. To reduce carbon dioxide emissions, fuel consumption and the dependency on oil a multiple technology strategy is required comprising the optimization of Internal Combustion Engines (ICE), the accelerated use of alternative fuels and the electrification of the powertrain.

A combination of this elements is not only necessary for cost and environmental reasons, it is also necessary because we have different political strategies and different customer preferences for the different types of propulsion systems in the world.

Diesel engines for example have a high market share in Europe, but they have only a low acceptance in North America and Japan, where gasoline engines and hybrids have a high market penetration. On the other side has Brazil an extremely high share of biofuels and in other regions natural gas is relatively popular.

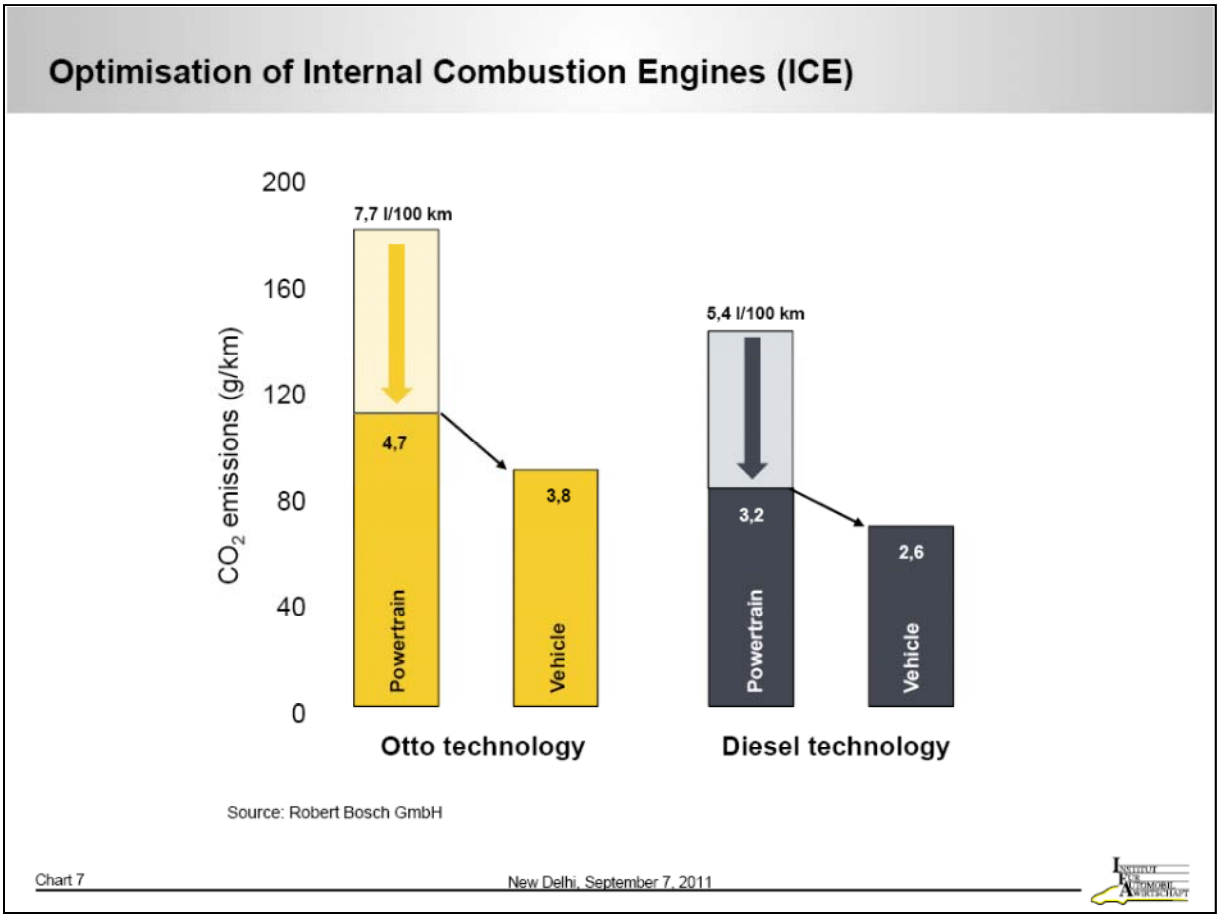
Therefore a mix of technologies is required to match the different requirements in the markets.



Up to now ICE's are dominating the automotive market. More than 95 per cent of powertrain systems are based on ICE technology. There are good reasons for this, because gasoline and diesel have a very energy density and therefore they are ideal for the use in automobiles. They combine a low weigth and volume with a relatively big range of more than 500 up to 1.000 kilometres.

In the last years is has been made strong progress as far as fuel efficiency and the reduction of emissions is concerned. But there is still a huge potential for further reduction. As far as gasoline engines are concerned fuel consumption can be reduced from todays 7,7 litre/100 km (this is the European average) to 4,7 litres, mainly by direct injection systems, variable-valve actuation, downsizing and hybrids. A further potential is given by optimizing the vehicle by using lighter materials like aluminium and carbon.

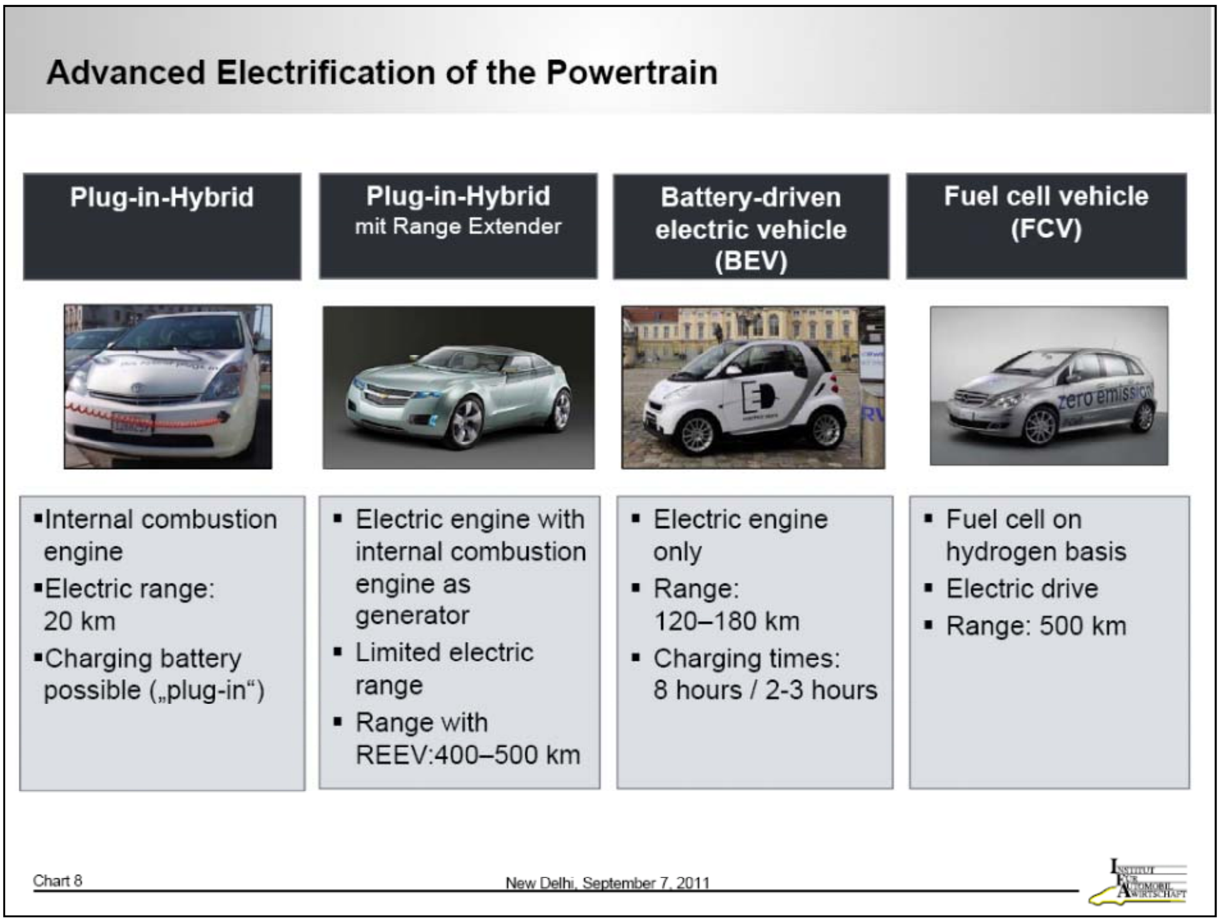
Even diesel engines which have today a relative lower consumption with 5,4 litres/100 km have an additional reduction potential to 3,2 litres/100 km by turbocharging, high peak pressures and hybrid solutions. Similar to vehicles with gasoline engine an additional potential lies in the optimization of the total vehicle. It is a realistic vision that consumption of diesel can be reduced to 2,6 litres per 100 km.



The optimization of the ICE powertrain can make a significant contribution to reduce carbon dioxide emission. But on the other side we also have to reduce oil dependency by achieving a better energy diversity.

To make achievements in this direction the electrification of the powertrain is necessary. There are four technological concepts for an advanced electrification:

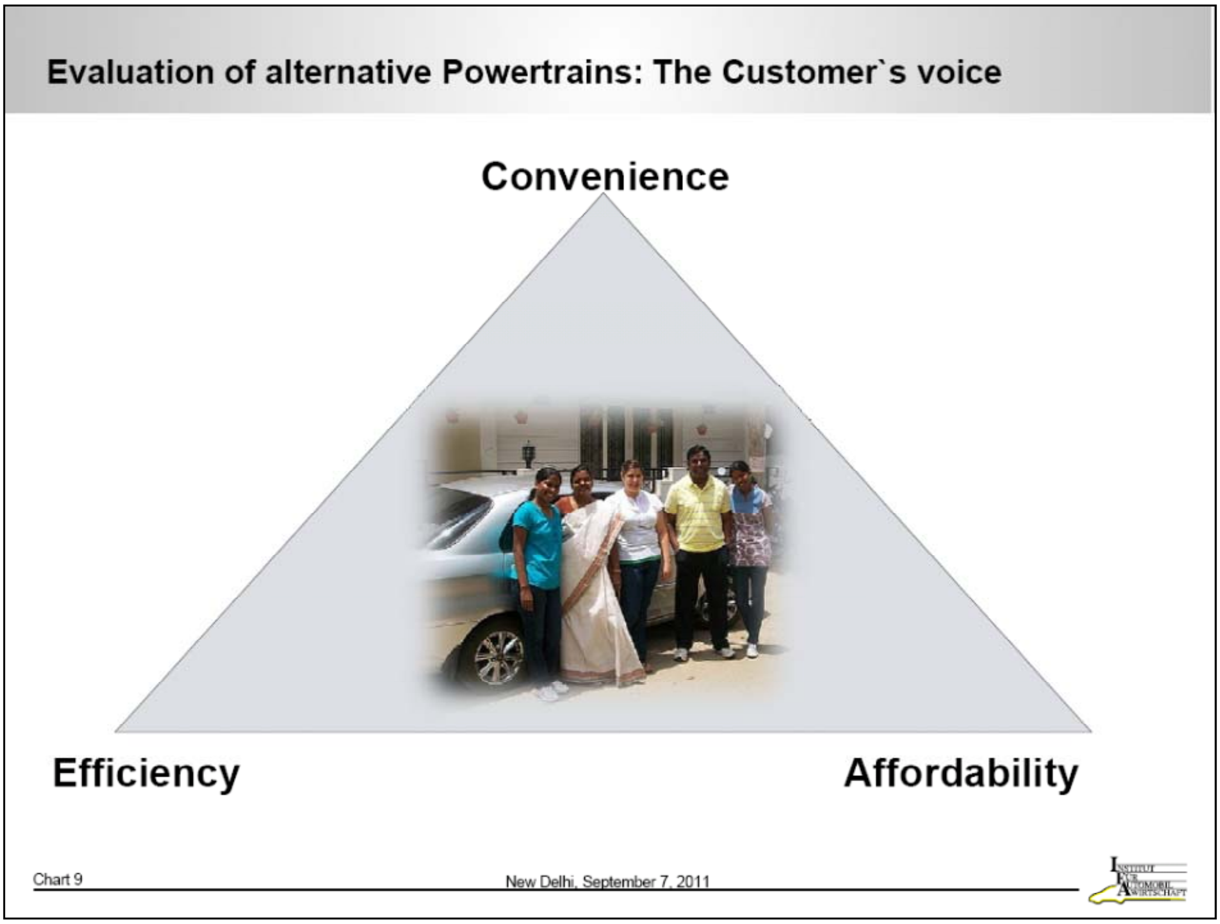
- Plug-in-Hybrids
- Plug-in-Hybrids with a Range Extender
- Battery driven electric vehicles and
- Fuel cell vehicles.



We can evaluate these technologies under different aspects, like there technological potential, how sustainable these technologies are or how fast they can be realized. A lot of research about the diffusion of new technologies has shown that at the end of the day only the voice of the customer counts. He decides which technology will be successful and which powertrain system gets a high or only low share in the market.

From consumer research we also know that three main criterias have to be fulfilled that customers accept a new technology. These criterias are:

- Convenience
- Efficiency and
- Affordability.



Applying these criterias to the different technological concepts of electrification we get the following result:

- As far as convenience is concerned Plug-in-Hybrids are as good as vehicles with ICE. BEV suffer from a limited range which could cause range anxiety by the customers. Also the long charging times are uncomfortable in comparison with an ICE vehicle. A barrier for the fast diffusion of FCV is the lack of a hydrogen infrastructure and the problem with storaging hydrogen onboard.
- As far as efficiency is concerned BEV and FCV have no local emission. There well-to-wheel efficiency depends on how the energy is generated. Because of the bigger range of electric drive plug-in-Hybrids have lower carbon dioxin emission and if the daily driving range is not longer than 60 to 80 kilometres local zero emission is possible.
- As far as the affordability is concerned, Plug-in-hybrids have comparable costs on a TCO basis as ICE’s. Plug-in- Hybrids with range extender are more expensive because of the more complex technology and the battery with a higher capacity than in a simple plug-in hybrid. BEV and FCV are the most expensive technologies at the moment.

Strength & weaknesses of electrified Powertrains

	Convenience	Efficiency	Affordability*)
Plug in Hybrid (PHEV)	like ICE	<80g/km	Comparable to Full Hybrid
Plug in Hybrid with RE (PHEV-REEV)	like ICE	<50g/km, zero emission possible	>20-30 per cent
Battery Electric (BEV)	Limited range; long charging times	Local zero emission	>50+ per cent
Fuel Cell (FCV)	like ICE, but lack of infrastructure	Local zero emission	>50+ per cent

*) on TCO basis

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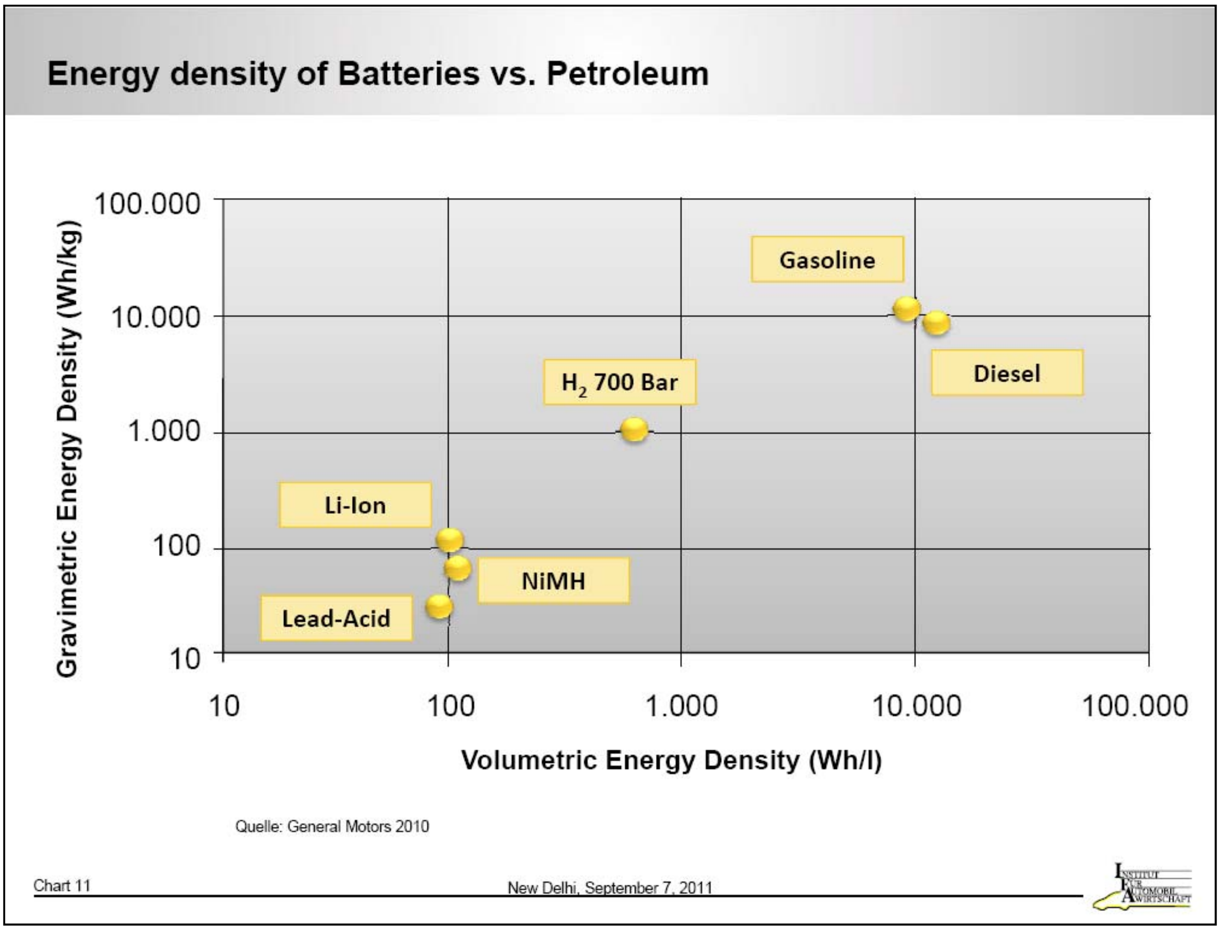
To summarize this we see that BEV have two major problems from a customer point of view:

- the low range and
- the high costs.

This chart shows the energy density of batteries vs. petroleum. As you can see the energy density of gasoline and diesel is about one hundred times higher than that of battery storing electricity.



As far as the costs of a BEV are concerned we have made a calculation for the Total Cost of Ownership of a BEV compared with a model with ICE. The calculation is based on German datas as far as prices, taxes and so on are concerned.

As you can see the Citroen C-Zero, which is a BEV has a round about three times higher list price than a comparable Citroen C1 with an ICE. On the other side the fuel price for the BEV is significantly lower than for the ICE. Nevertheless on a three user cycle the TCO's of the BEV are more than two times higher than that of the ICE.

Cost comparison: BEV vs. ICE

TCO-Comparison monthly costs				
	Citroën C-Zero		Citroën C1	
List price	29.550 €		8.672 €	
Fuel price	0,21 € / kWh		1,22 € / l	
3 years / 10.000 km p.a.				
Residual Value	40%	%	37	%
Depreciation	581	€	176	€
Insurance	97	€	97	€
Taxes	-	€	1	€
Fuel Cost	22	€	46	€
Cost per km	**0,86**	**€**	**0,41**	**€**

Source: EurotaxSchwacke 2011

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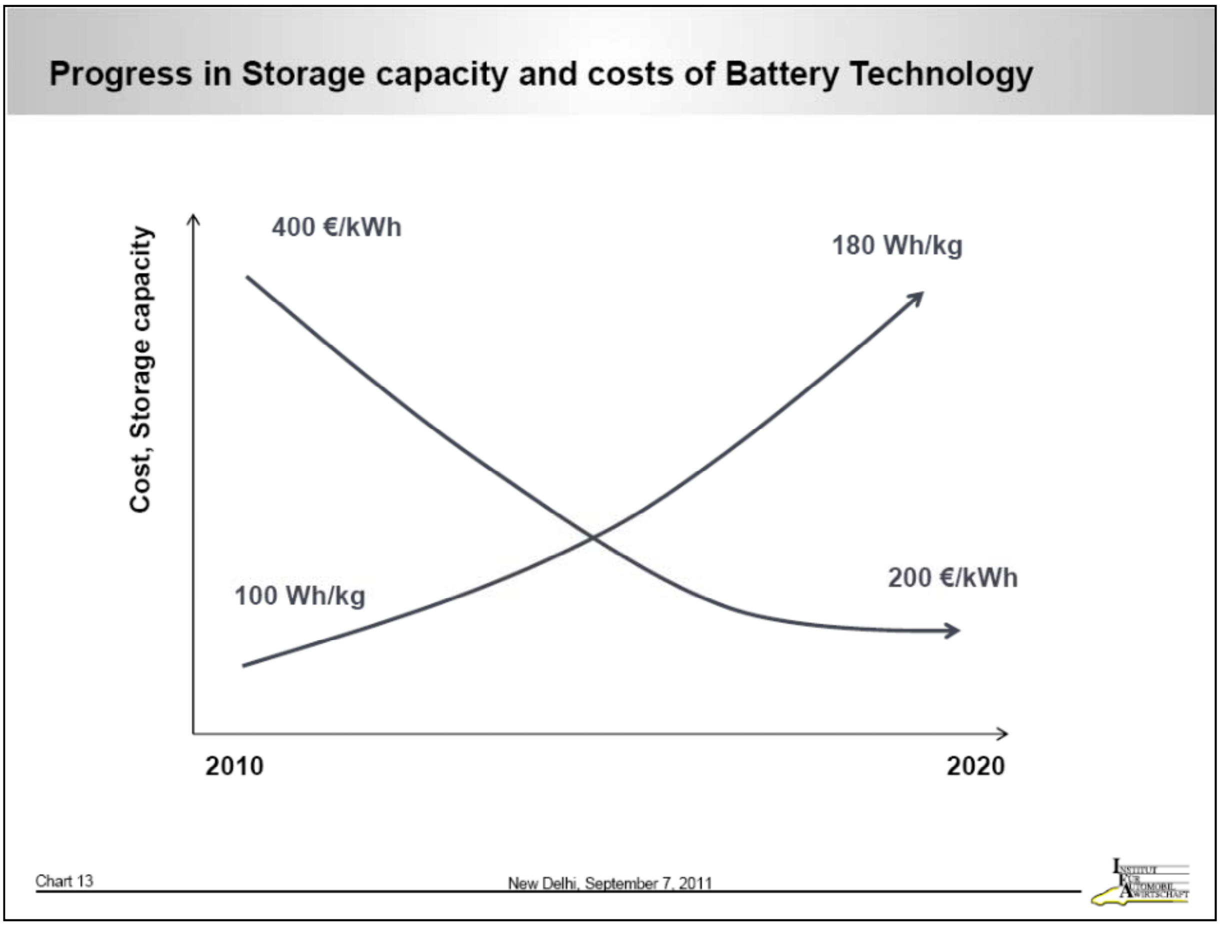
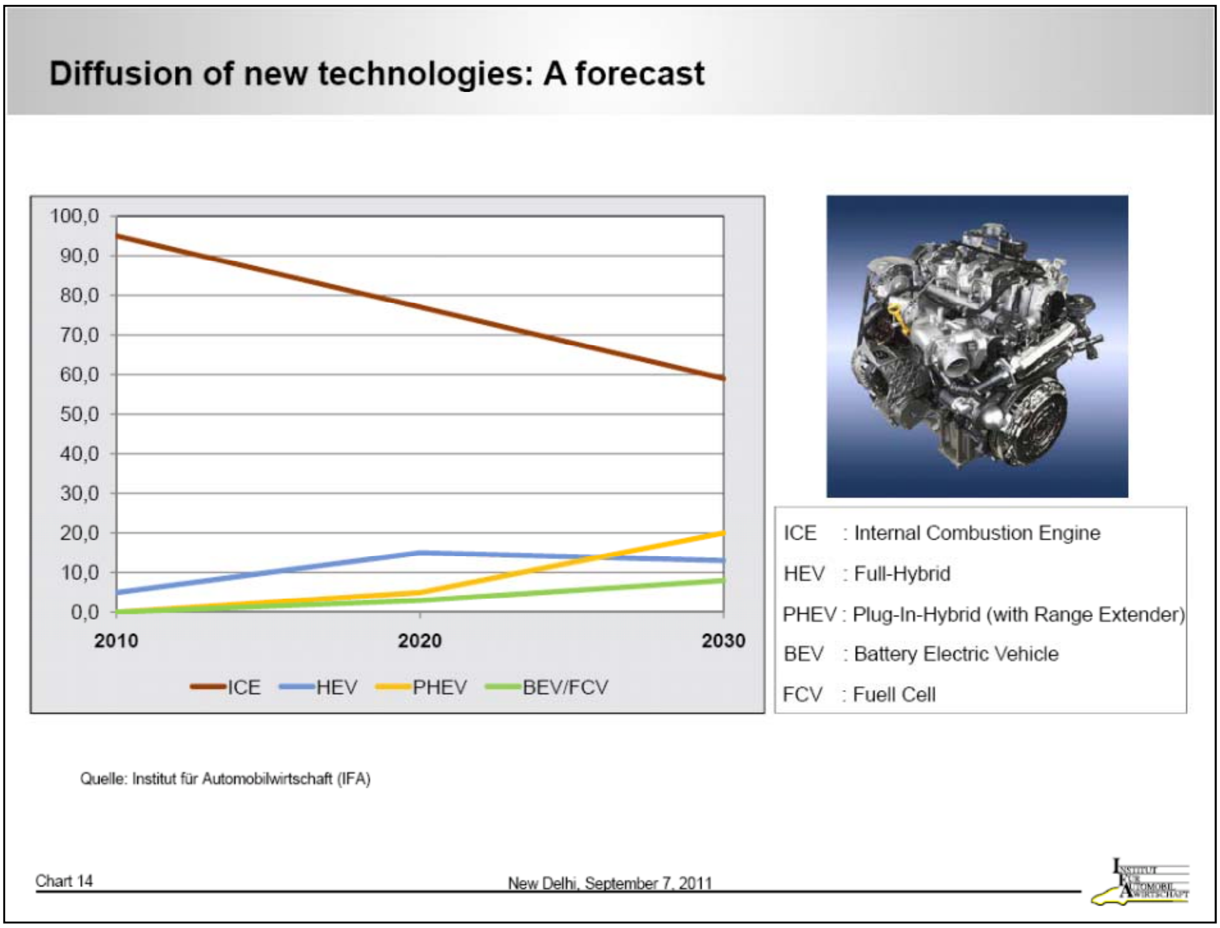
Based on actual situation BEV are not very attractive for private customers. But we don't have to underestimate the progress that will be made as far as the storage capacity and the costs of the battery technology are concerned. As we know from the batteries in consumer electronics, a rapid decrease has occurred in the last 10 to 15 years. At the same time the durability has been increased very well.

We expect that the storage capacity for batteries will increase up to 2020 from 100 Wh/kg today to 180 Wh/kg. In the same time period the costs for battery technology will decrease from 400 to 200 Euro/kwh. This will make BEV more competitive with ICE vehicles than today.



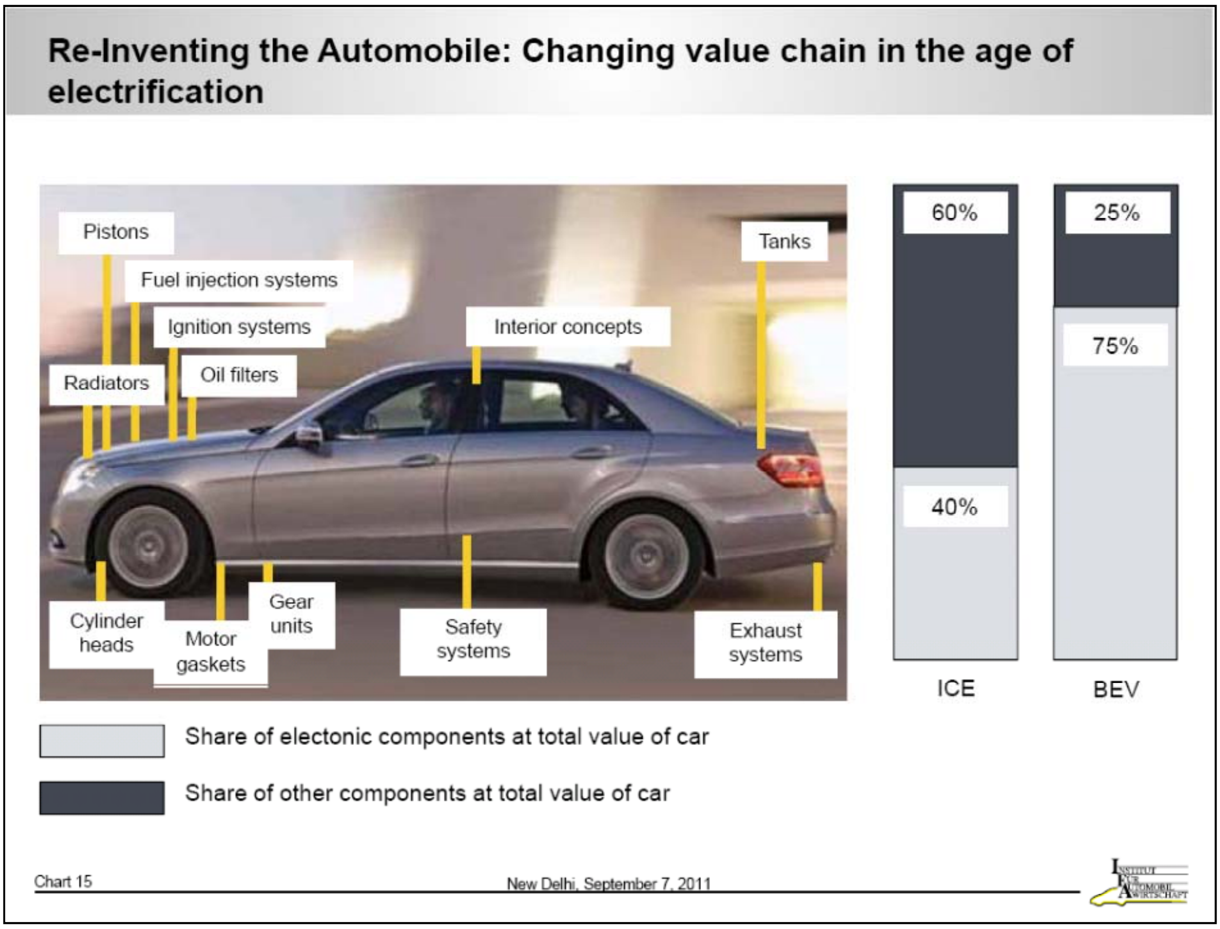
Based on these and other assumptions we have made a forecast for the diffusion of new powertrain technologies and the future of the ICE. In our forecast BEV (and FCV) will have a market share of nearly 10 per cent in 2030 on a global basis. We expect that the market penetration will be higher in urban than rural areas and it will be higher in North America and Asia than in Europe and Latin America.

We are very optimistic for Plug-in-Hybrids with Range Extender because these technology combines the advantages of an electric drive with the range of the ICE. According to our forecast Plug-in with Range Extender can achieve a market share of 20 per cent in 2030.

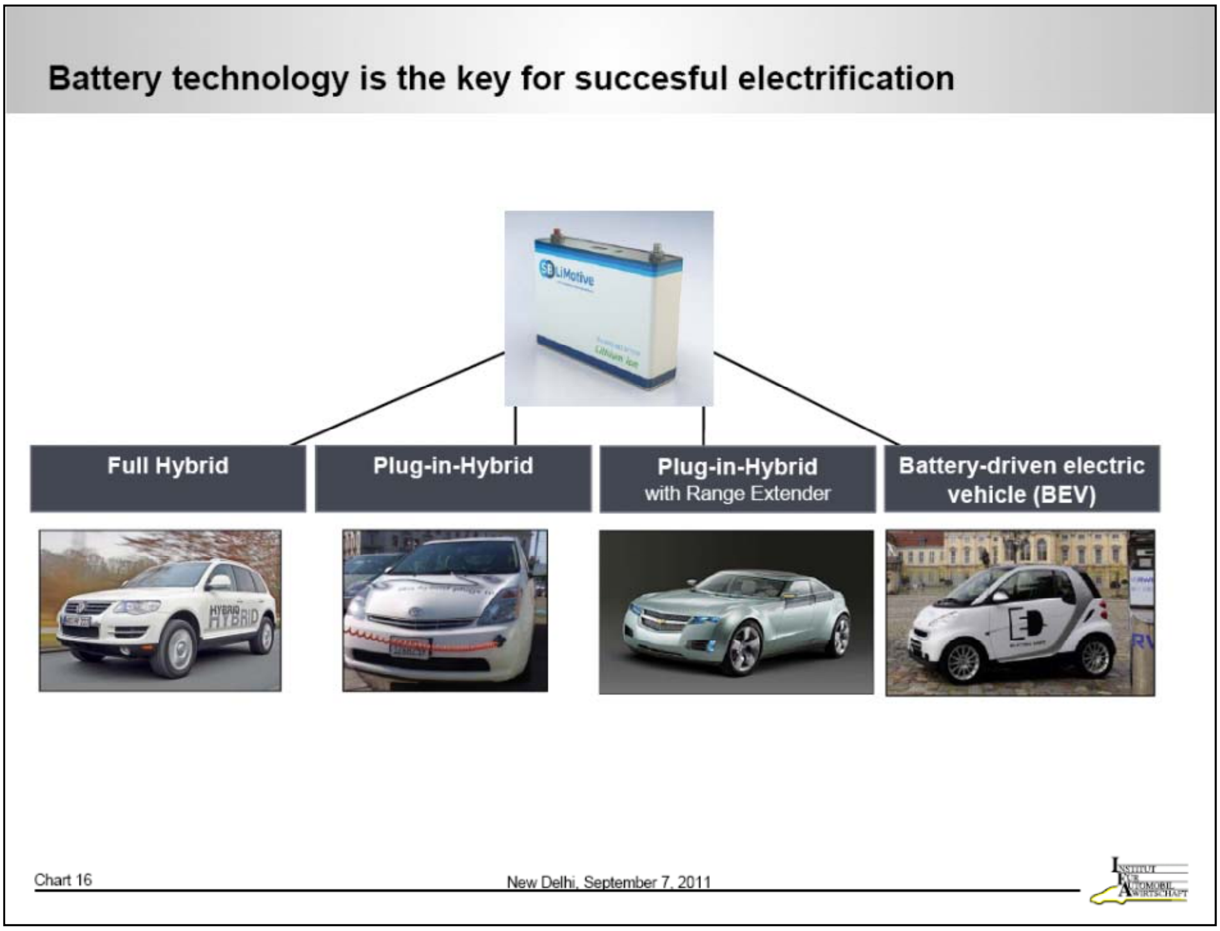


Finally I would like to mention that the electrification of the powertrain will have tremendous effects on many aggregates and components of cars and light vehicles. Not only the engine and transmission system is affected. Even the cooling and safety system must be changed. There also a lot of components which will not be needed in a pure BEV like oil filters or an exhaust system.

As a consequence of that the share of electronic components at the total value of the car will increase from 40 per cent in an vehicle with ICE to 75 per cent in an BEV. Car electronics is getting more and more important and a field of substantial growth in the next decade.



Even the core competences of car manufacturers will change. In the past the engine and the powertrain are the most important technical systems to different models from each other and to gain a unique selling proposition. In the age of electrification battery technology will key for success in the market. This gives manufacturers of batteries a dominant role in automotive business in future.



The automotive industry is in transition. It faces two main challenges to ensure sustainable growth in the future: The technological change we will see in the next decade of the automobile is a chance for the developing industries like the automotive industry in India. I am quite sure that India can play an important role in managing the challenges the automotive industry is facing on a global scale.

Summary: Automotive industry in transition

- **Automotive industry faces two main challenges to ensure sustainable growth in the Future:**
  - ➡ Reduction of carbon dioxide emissions and
  - ➡ Reduction of oil dependency
- **To match this challenges the industry must follow multiple technology pathways**
  - ➡ Optimisation of ICE plus electrification of powertrain (plus alternative fuels)
- **Transition to a elecetrified powertrains will completely change the value chain in the automotive industry**
- **New players have a huge chance to enter global automotive markets**

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Anhang

Bild 1 zeigt Professor Diez mit Rinki Verma, die den Kongress mit organisiert hat.

Bild 2 zeigt Professor Diez bei seinem Vortrag.