

All-Electric Vehicle

The long-term solution to sustainable transportation (?)



Agenda

Drivers

Technology

Overcoming barriers to commercialization

Introduction

Pure electric vehicles (PEV): Marketing or technological break-through?

PEV & PHEV model launches, 2008-12





Seg	OEM	<u>Model SOP in...</u>					<u>Through</u>
		2008	2009	2010	2011	2012	2012
A / B	Qingyuan	Happy Messen.					335k
	Renault*					City EV	140k*
	REVA	G-Wiz					126k
	Th!nk	City					53k
	Mitsubishi		iMiEV				30k
	Subaru		R1e				12k
	Daimler			Smart EV			30k
	Other		Nice Cars Zero Tata Indica	Tata Nano Nissan Cube	Mercedes A-/B- class EV	Toyota iQ EV VW Up EV BMW Project i	40k
C / D	Wanxiang		WXEV7050				130k
	Renault*				Megane EV		140k
	Tesla					Whitestar	10k
	Miles		XS 500				8k
	Toyota			Prius Plug-in			10k
	Other			BYD F6DM BYD F3e, F3DM GM Volt / Ampera	Renault Kangoo EV Ford Connect EV	Ford Mondeo PHEV	60k
G / SUV	Wanxiang		ZN5490EV				50k
	Fisker			Karma			30k
	Tesla	Roadster					42k
							Σ 1.1 mn

*In total across all segments.

Drivers

Favourable Development

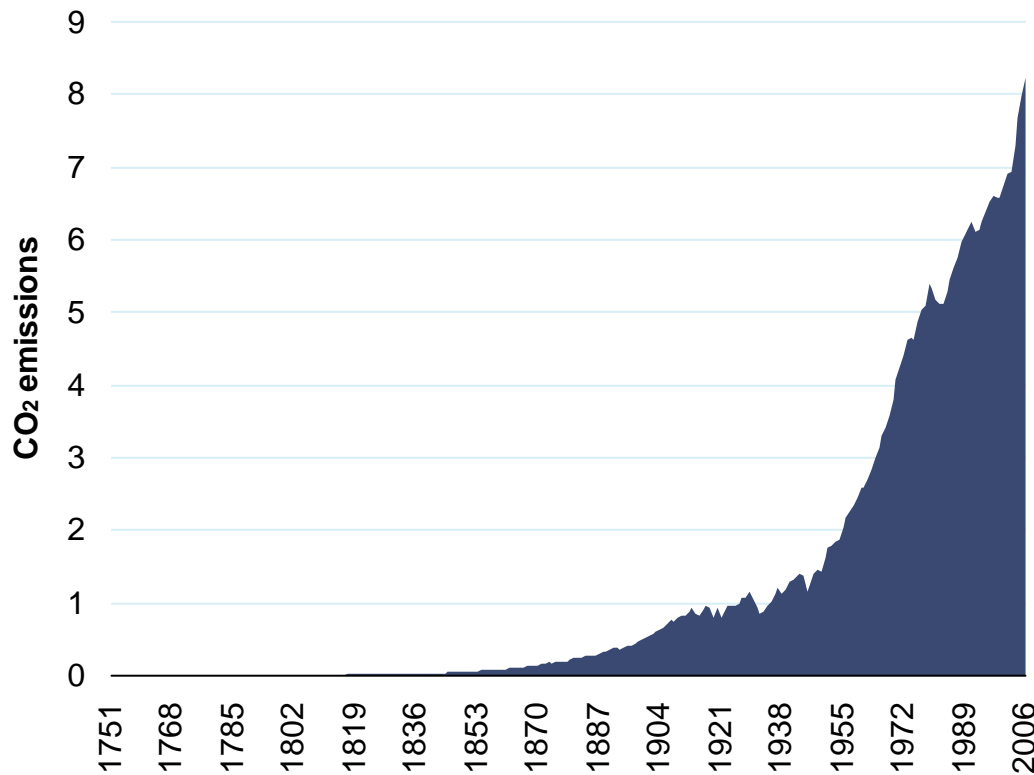
Driving the world towards electric vehicles

Driver	Development	Long term impact
Environment	<ul style="list-style-type: none">• Reducing anthropogenic CO₂ emissions a major challenge• Resource constraints making alternative fuel and powertrain concepts necessary	
Policies	<ul style="list-style-type: none">• National targets for PEV parcs• Governments subsidizing and incentivizing PEVs• Regulations on (CO₂) emission standards	
Consumer	<ul style="list-style-type: none">• Consumers are getting more sensible for environmentally friendly labels• Reduction in total cost of ownership for PEVs expected	
Urbanization	<ul style="list-style-type: none">• EV suits short distance commuter runs in urban areas• People's average driving distance less than 50km• 60% of world population in cities by 2030 (70% by 2050)	

CO₂ Emission Development

Finally, global warming is largely considered a real threat to mankind

CO₂ emission history, 1751-2006
in bn metric tons



Climate change

- One of the main contributors to global warming is CO₂
- Reducing CO₂ is finally considered to be essential for future climate stability
- Resource depletion is an additional cause making alternatives to crude oil and internal combustion engines necessary

Policy

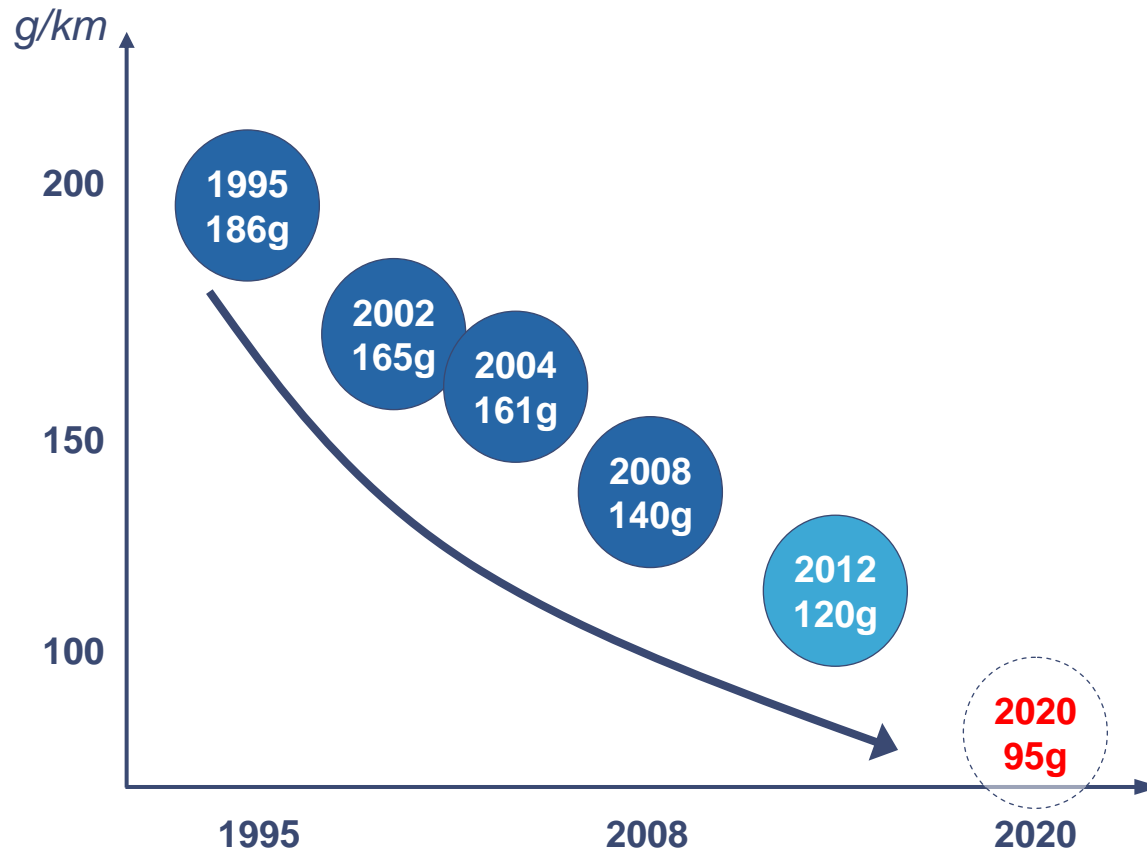
Subsidies of various countries

Country	Policies
Germany	<ul style="list-style-type: none">• 1 mn / 5 mn units of EVs targeted until 2020/2030• € 500 mn for development in e-mobility ('Konjunkturpaket II')• Carbon dioxide based tax regime
USA	<ul style="list-style-type: none">• \$ 1.5 bn for high-efficiency battery and components R&D• \$ 500 mn support for PHEV engine producers• \$ 400 mn to develop infrastructure and offer professional training
Japan	<ul style="list-style-type: none">• \$ 200 mn for developing better traction batteries• Discounted parking and highway/toll fees
China	<ul style="list-style-type: none">• \$1.46 bn program to innovate automotive industry• Plan to create production capacity for 500,000 EVs by 2011• 60,000 EVs target in Wuhan pilot project by 2013

Policy (2)

CO₂ regulations are challenging

CO₂ emission targets, 1995-2020
EU-27



Various national regulations

- More regulations towards higher fuel efficiency and stricter emission standards
- EU-27 with direct CO₂ mandate
- USA, Japan, and China w/ mileage thresholds

Technology

Assessing Electric Propulsion System

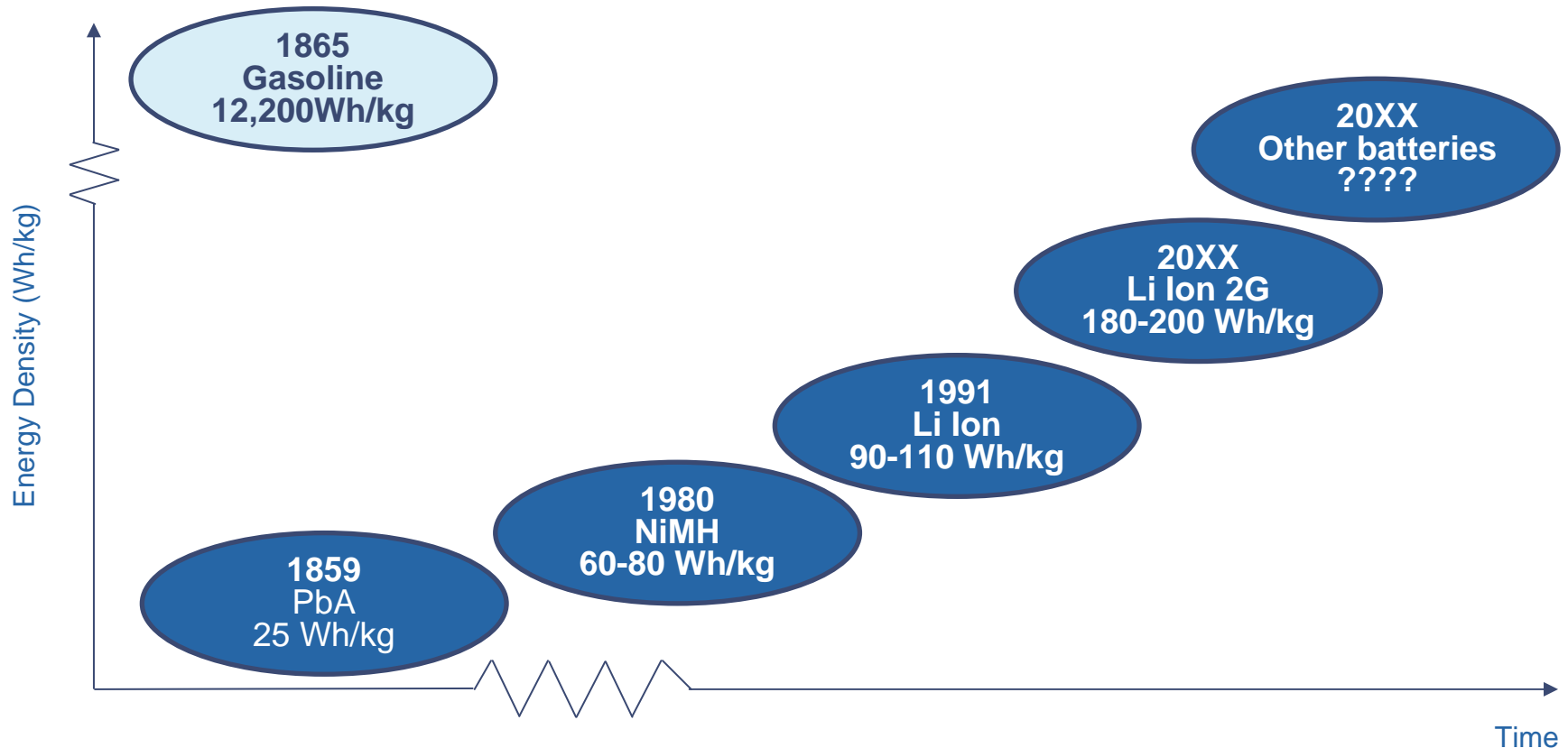
Bird's eye perspective for evaluating alternative technologies

	Indicators		Impact on
A Battery performance	Energy density	→	Energy storage (runtime)
	Power density	→	Power delivery on demand (power bursts)
B Vehicle performance	Battery weight / size	→	„Fuel“ consumption, design, driving characteristics
	Battery capacity	→	All-electric driving range
C Environmental performance	Energy efficiency	→	Potential to reduce fossil fuel consumption
	Lifecycle CO ₂ -emissions	→	Overall greenhouse gas mitigation

Battery Technology



Laboratory progress is leading the way

Battery Development Timeline
Indicative



Technology - Battery Systems vs. Fuel Cells (1)

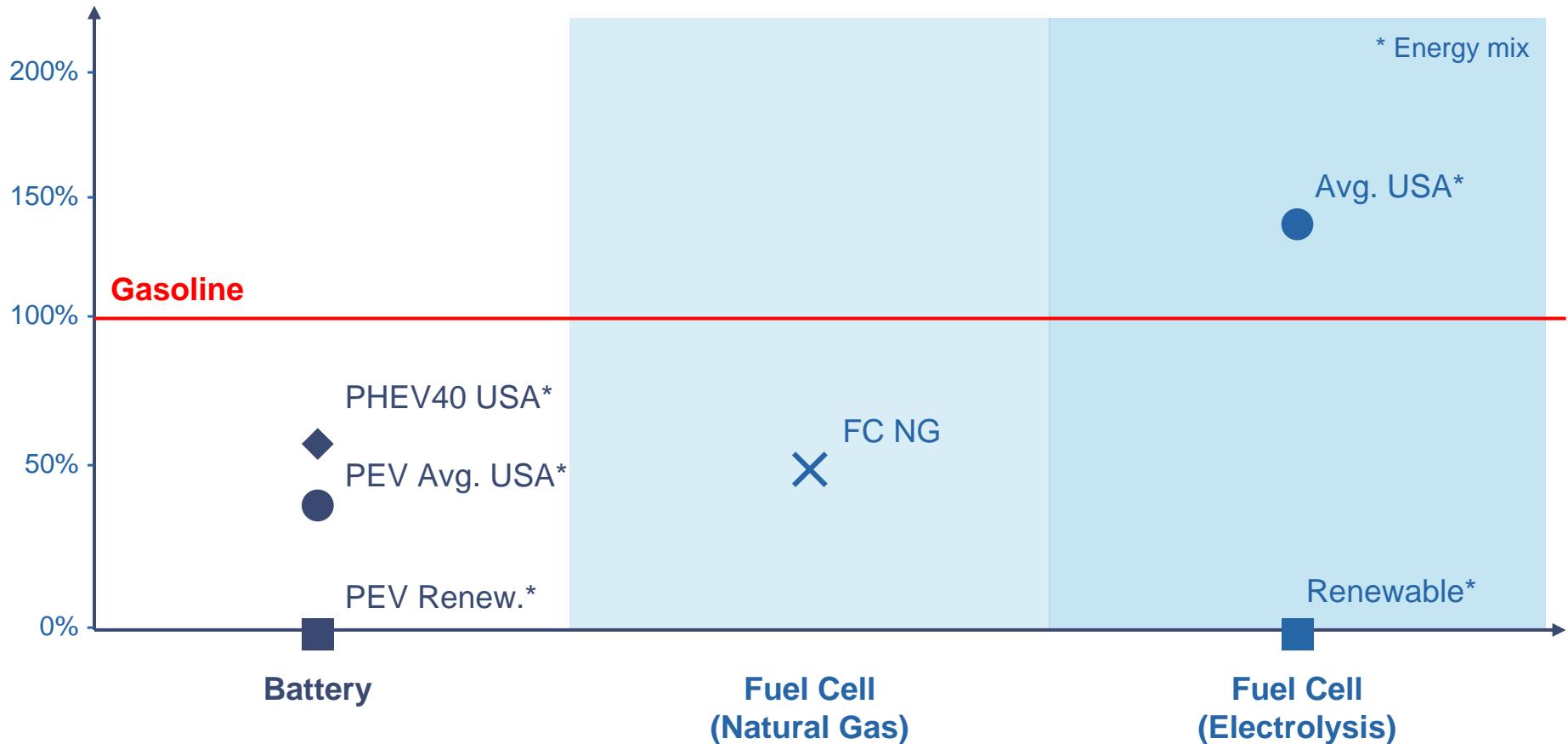
Are Fuel Cells really in the lead?

	Battery 	Fuel Cell 
Energy density [Wh/kg]	Today (NiMH): 60 2020 (Li-Ion): 180	Today (70 MPa vessel): 1.600
Capacity [kWh] (300 kg storage)	Today (NiMH): 18 2020 (Li-Ion): 54	Today (70 MPa vessel): 480
Range [km] (100% tank-to-wheel efficiency)	Today: 90 2020: 270	Today: 2400

Technology - Battery Systems vs. Fuel Cells (2)

Performance indicators can be misleading

Well-to-Wheel CO₂-emissions
(ICE as reference)

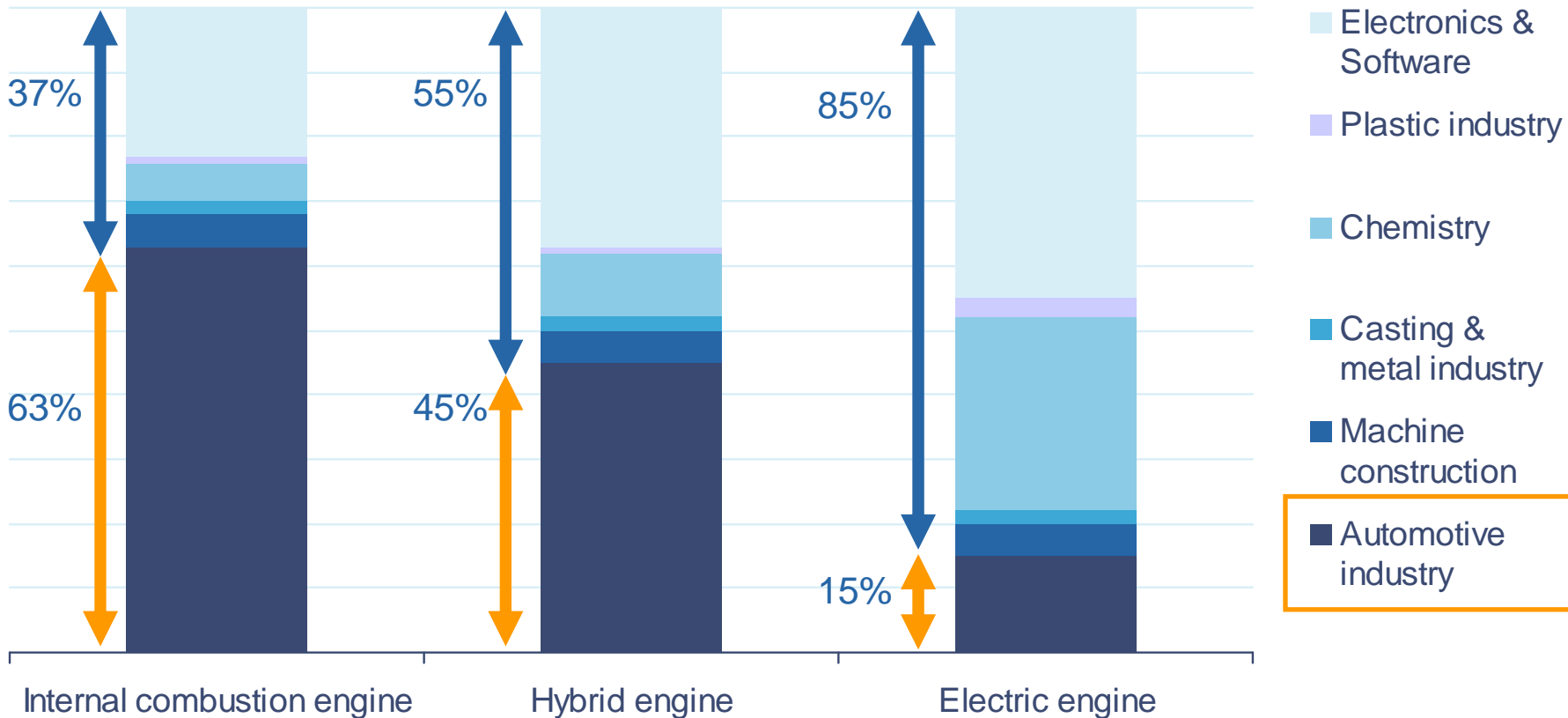


Overcoming barriers to commercialization

Shifting Industry Pattern

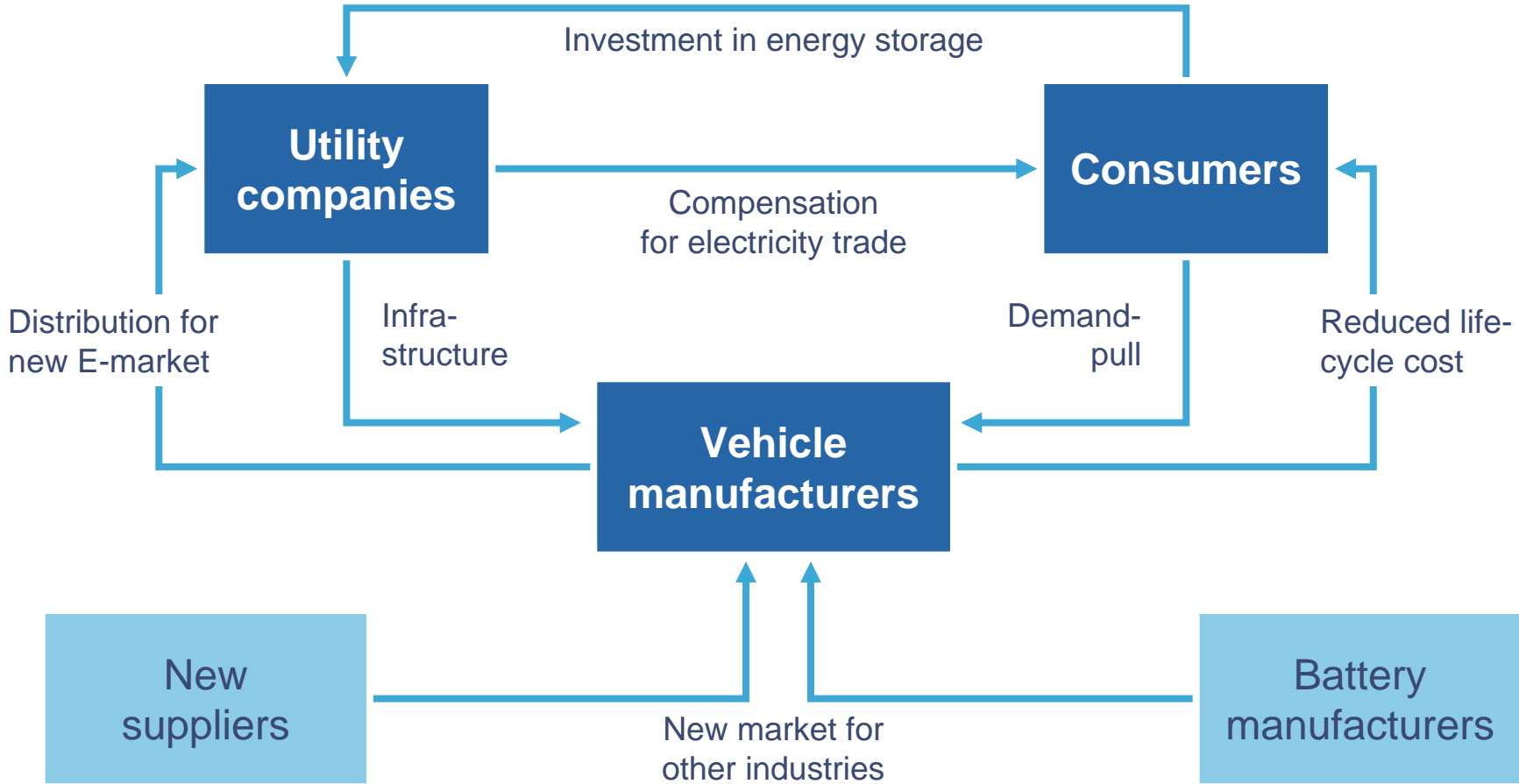
What can OEMs contribute to PEV's drivetrain?

Know-how and production share by engine type in %



New Stakeholders

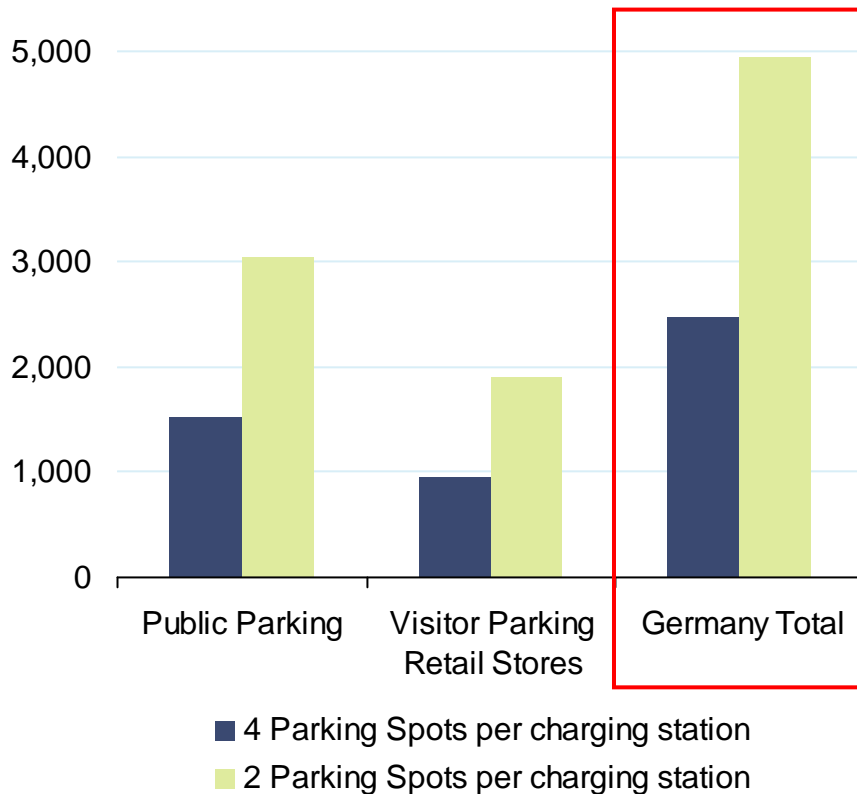
The traditional structure has to change and new players will emerge



Infrastructure Related Costs

New investments into a whole new charging infrastructure

Cost of establishing charging stations
in million €



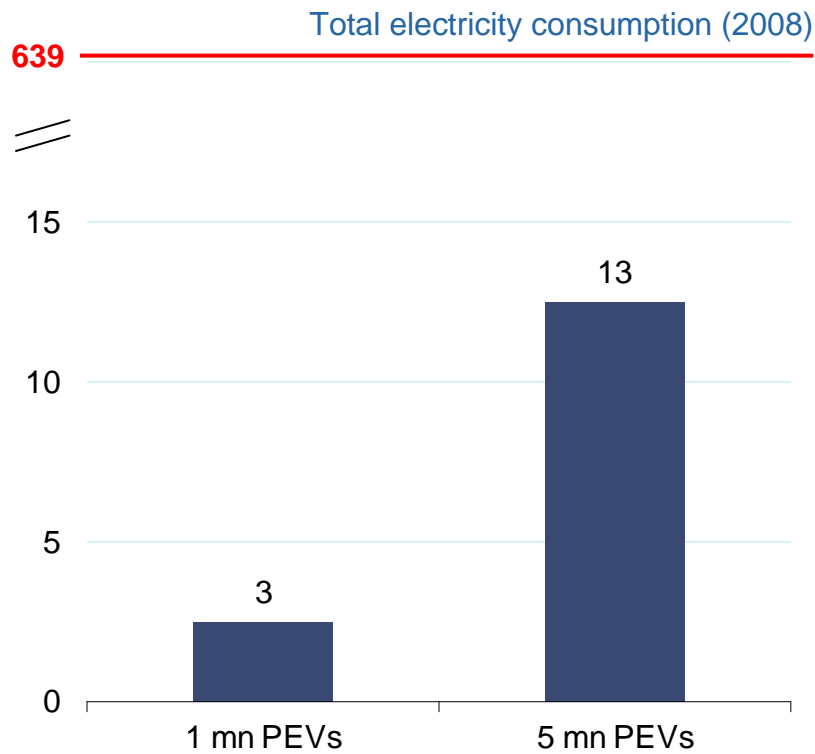
Assumptions

- Every single parking spot has charging access (homes not included)
- 3.04 mn public parking spots (13.6 cars per parking spot)
- 1.91 Mio. retail parking spots (55,000 retail stores)
- € 2,000 per charging station

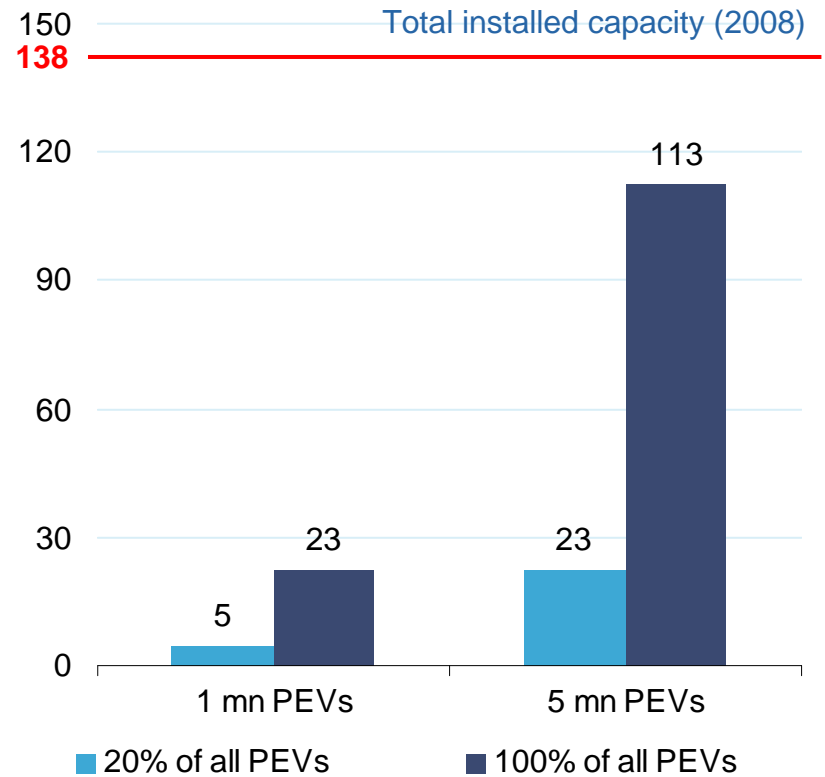
Infrastructure Related Costs (2)

Additional power plants needed in Germany?

Electricity consumption
in TWh



Electricity load
in GW



Current Vehicle Prices

Small cars, high prices - current prices are not competitive

Nameplate	Battery Specification	Range	Price*
Commuter Cars Tango	Lead-acid (Li-Ion optional)	100 km	79,000 €
Tesla Roadster	Several laptop Li-Ion batteries	390 km	72,000 €
AC Propulsion eBox	Re-engineering (Li-Ion)	225 km	53,500 €
Th!nk City	Zebra or Li-Ion	180 km	24,500 €
Micro-Vett Ydea	Pb-Gel or Zebra (Na-NiCl)	160 km	21,800 €
Elbil Norge Buddy	Lead-acid (Li-Ion optional)	100 km	16,000 €
Reva (G-Wiz)	8 lead-acid batteries	129 km	9,000 €
Zenn	Lead-acid	60 km	8,800 €

*USD Exchange rate (2008)

Approaches To Feasible PEVs

Splitting costs for PEVs is key to the eventual success

Cost sharing	<ul style="list-style-type: none">• New business models needed• ‘Better Place’ teams up with OEMs and utilities to provide charging infrastructure and batteries• Daimler Car2Go-concept
Incentives	<ul style="list-style-type: none">• Great Britain: Up to £ 5.000 allowance per electric vehicle• USA: Up to \$ 7.500 tax credit for Plug-in vehicles• Japan: 90% tax reduction for car and purchase taxes for EV• China: Up to \$ 8.000 per car incentive for taxi fleets
Technological breakthrough	<ul style="list-style-type: none">• Lithium-based batteries are expected to fuel first available fleets• Next generation: ultra-capacitors, nano-materials?• Economies of scale in manufacturing

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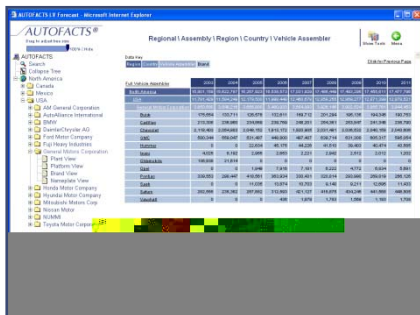
Capabilities Summary: 2009 Q2

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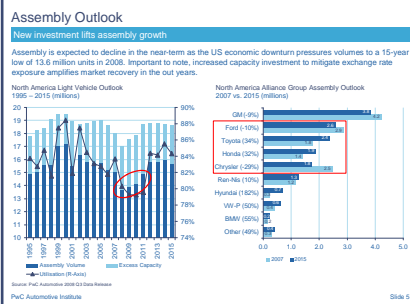


Analyst Briefings

Issues-Based POV Analysis
Regional Market Analysis
Strategic OEM Profiles

Providing a differentiated point of view on the key market issues facing companies operating in the global automotive sector:

- Deep Regional Insights
- Global OEM Analysis
- Power train Technology Trends

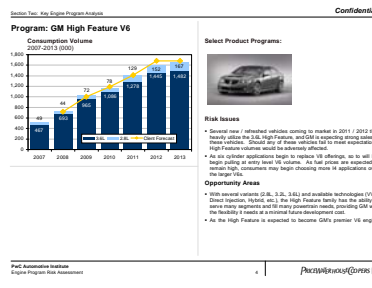


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- M&A Valuation Support
- Portfolio Risk Assessment
- Commercial Due Diligence



Analyst Notes

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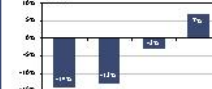
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PwCAutomotiveInstitute

North America:
A Tough Time for Tough Trucks

With the introduction of the all-new 2009 Dodge Ram and Ford F-150 at the North American International Auto Show, leading pickup offerings are now ready to compete in a market cornered by long-led economy-to-mid-range and consumer demand expansion.

North America Light Vehicle Assembly Growth by Segment in 2008 Year-over Growth



With new models like the 2009 Ford F-150 and Dodge Ram, increased price sensitivity in the segment may curb transaction price and profitability growth, limiting the full impact of technical products.

As the housing market downturn extends into 2009, problems facing the full-size pickup segment are expected to intensify. Recreational buyers are being priced out of the segment as full prices remain elevated, and a sluggish residential construction outlook exposes additional weaknesses.

A material improvement in US economic growth is not expected until the third quarter of 2009. As near-term outlook in various markets continues to worsen, liquidity inequality and credit markets is, consumer spending on expensive and highly differentiated purchases like new vehicles will remain depressed.

A difficult operating environment complicates pricing as automakers attempt to roll down existing inventories ahead of new vehicle launches. The liberal use of incentives in 2008, lower factory production demand, has resulted in demand

*connectedthinking

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