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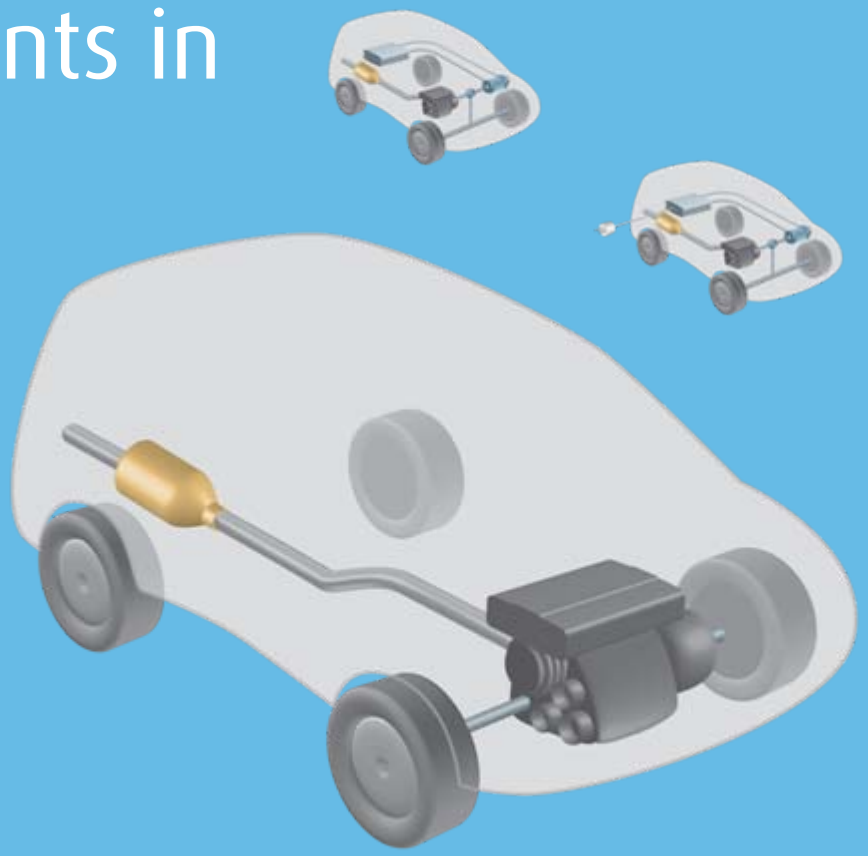
Key developments in Automotive Catalysts



Capital Markets Event
Seoul, 23 May 2012

What is an automotive catalyst?

Combustion engines produce toxic emissions due to incomplete combustion of fuel and the generation of by-products

Automotive catalysts are needed for reducing these toxic emissions

Legislation enforces this by setting emission limits for vehicles

Toxic pollutants

- Carbon Monoxide (CO)
- Hydrocarbons (HC, NMOG)
- Nitrogen Oxides (NO_x)
- Particulate Matter (PM)

Non-toxic by-products

- Carbon Dioxide (CO_2)
- Water (H_2O)
- Nitrogen gas (N_2)

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Umicore Automotive Catalysts business drivers

Growing global light duty vehicle production

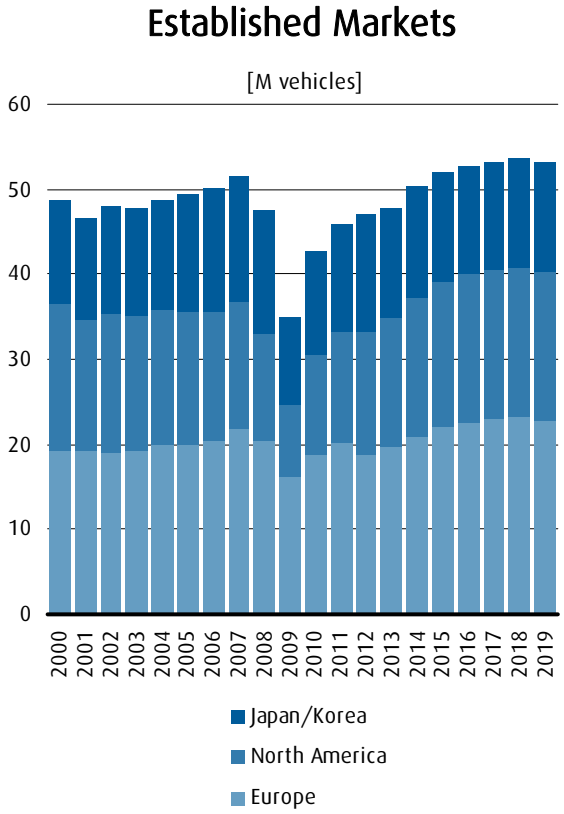
- Light duty vehicles (LDV): passenger cars, SUVs and light trucks
- Heavy duty diesel (HDD): trucks and buses
- Non-road applications

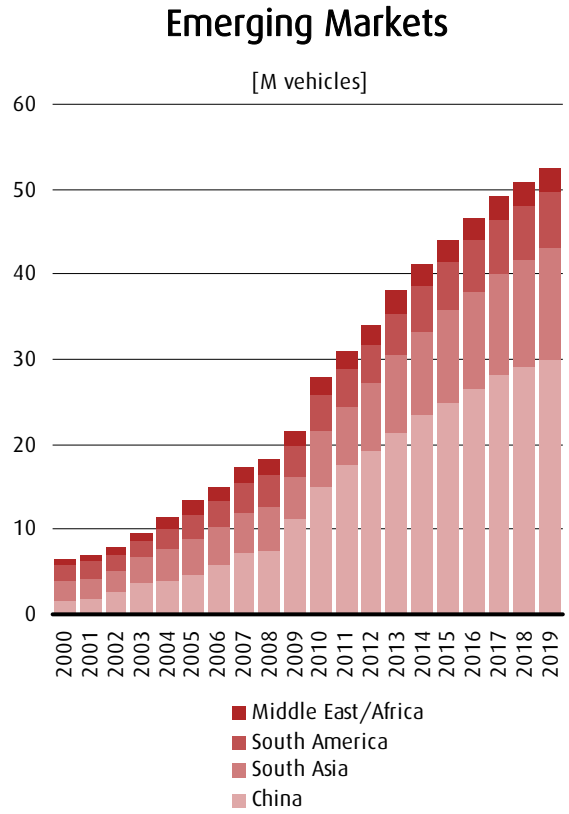
Emission legislation and air quality standards are becoming more stringent in developed and emerging markets

CO_2 emission reduction

- Impacts engine complexity and fuel types used in different regions
- Determines choice of powertrain

Global light duty vehicle production outlook





Source: Umicore estimates based on external databases

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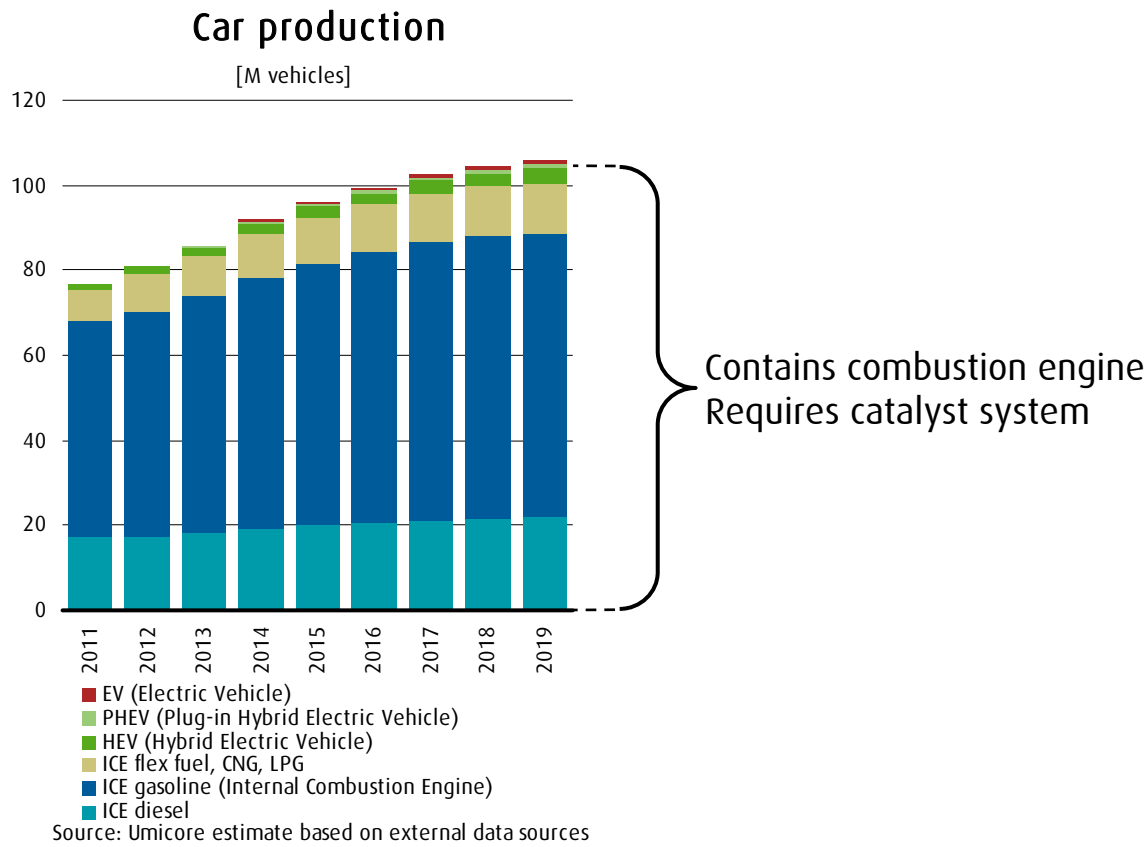
Global powertrain development
Internal Combustion Engine (ICE) remains dominant



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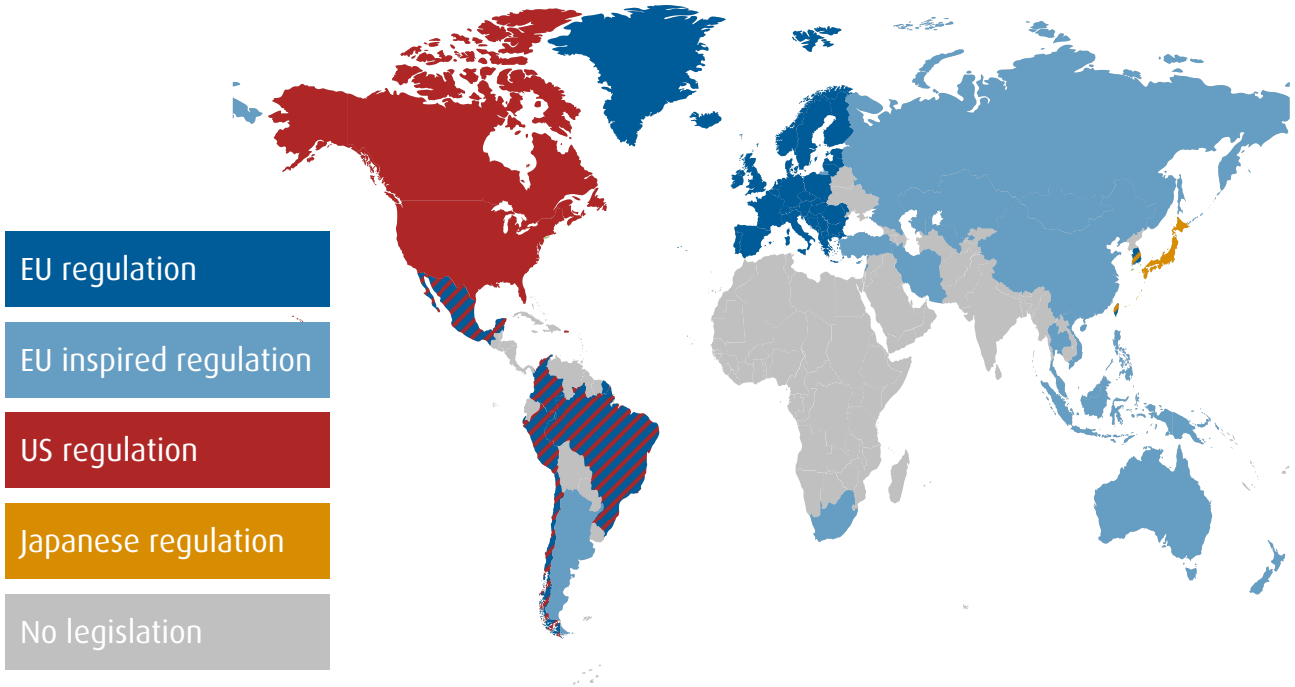
Global emission legislation present in most regions and becoming more stringent



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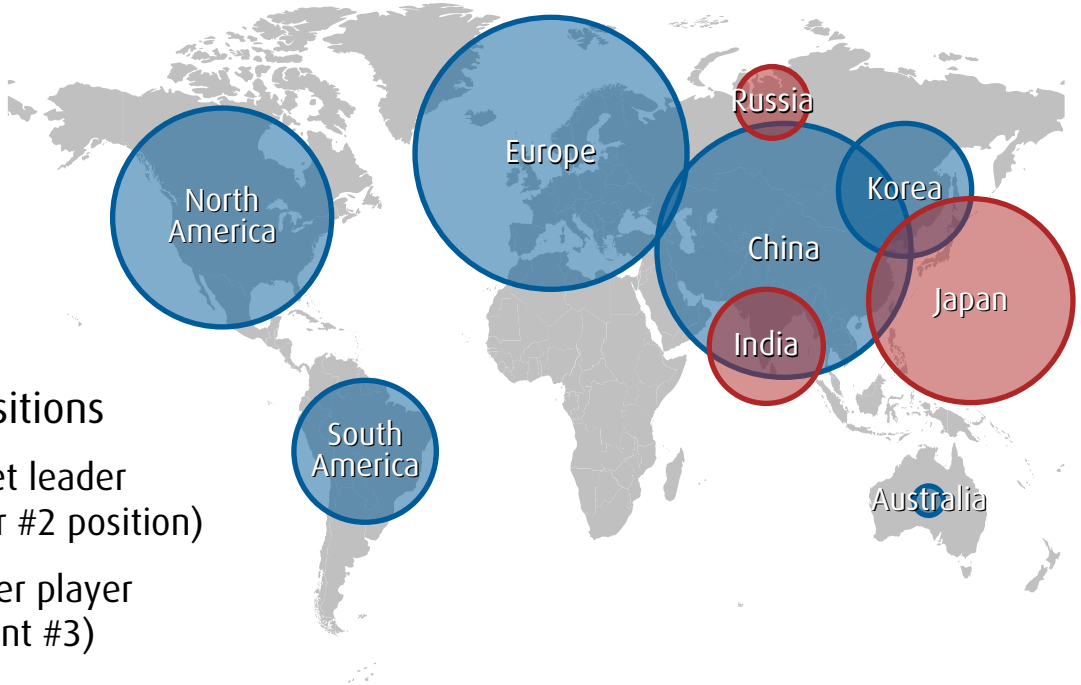
Umicore's global leadership position



Regional positions

- Market leader (#1 or #2 position)
- Smaller player (distant #3)

Circles indicative of 2011 light duty vehicle production volumes (≠ catalyst revenues)

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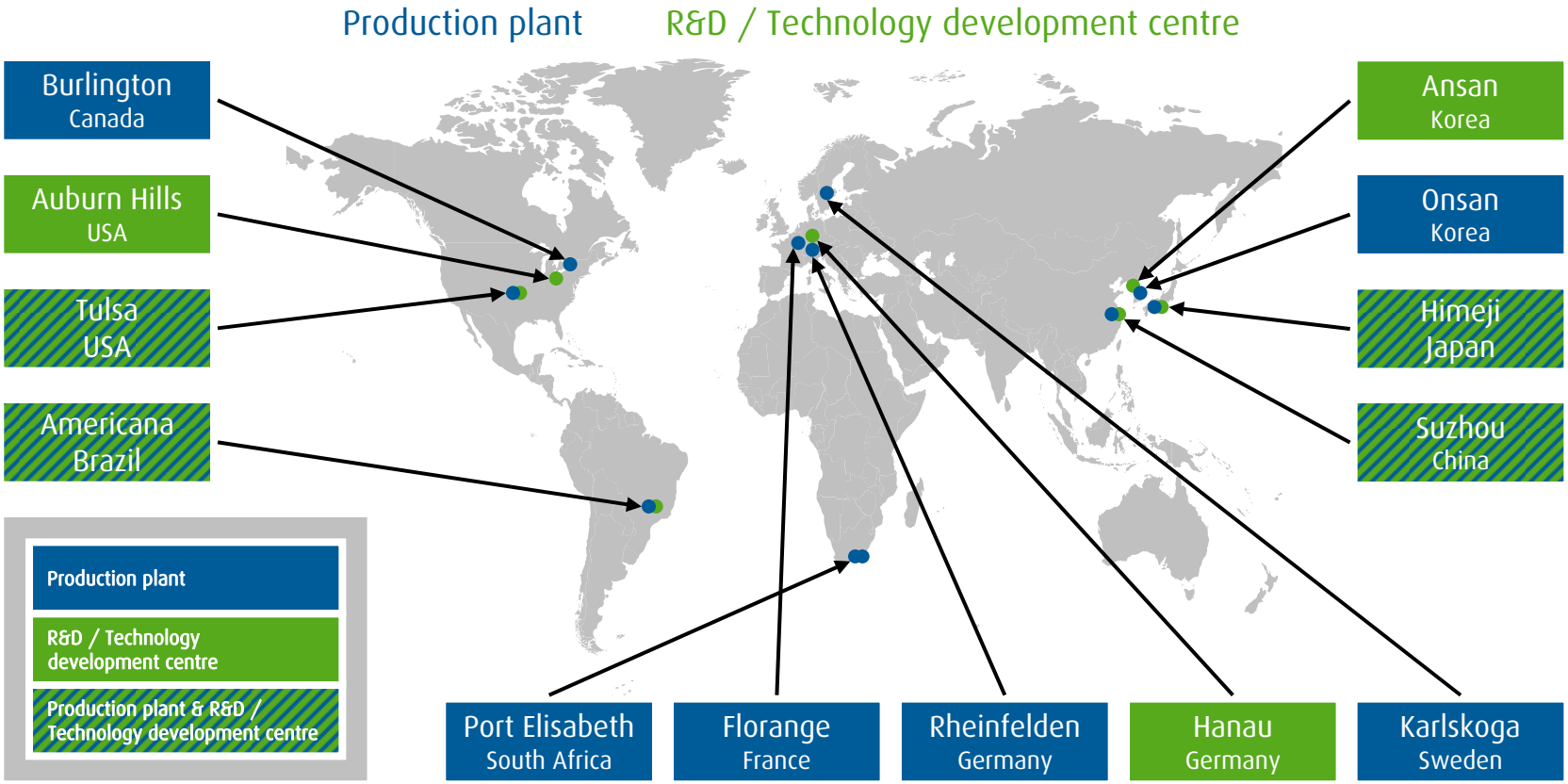
Umicore's global footprint in automotive catalysts



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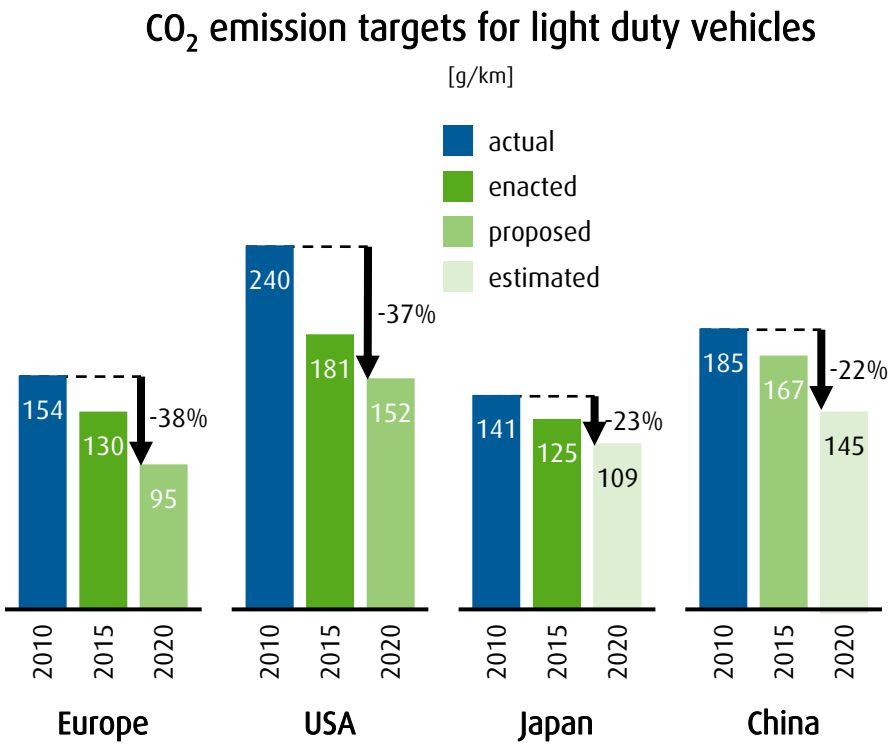
Impact of CO_2 regulation

Challenging CO_2 emission targets will push the use of advanced engine configurations



Source: Continental (2011)

Advanced engine configurations

- Down-sized turbo-charged gasoline engines
- Gasoline direct injection
- Lean burning gasoline engines
- Diesel
- Hybrid electric vehicles

All these configurations require complex catalyst solutions

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Downsized turbo-charged direct injection gasoline engines are being implemented more widely

Turbo-charged Direct Injection (DI) engines enable reduced fuel consumption

- By reduced engine displacement and decreased engine speed
- By flexible combustion process
- By significant torque increase, esp. at low rpm

Profile of exhaust gases is different

- Hydrocarbons (HC) emissions increase
- NO_x emissions decrease
- Exhaust gas temperature range increase due to heat sink - turbo charger effect

Catalyst requirements more complex

- Lower light-off temperature for the catalyst
- Catalyst bed temperatures above 1000°C require greater durability
- High dynamic lambda behaviour

Lean combustion provides the best fuel economy

Lean burning conditions offer better combustion properties

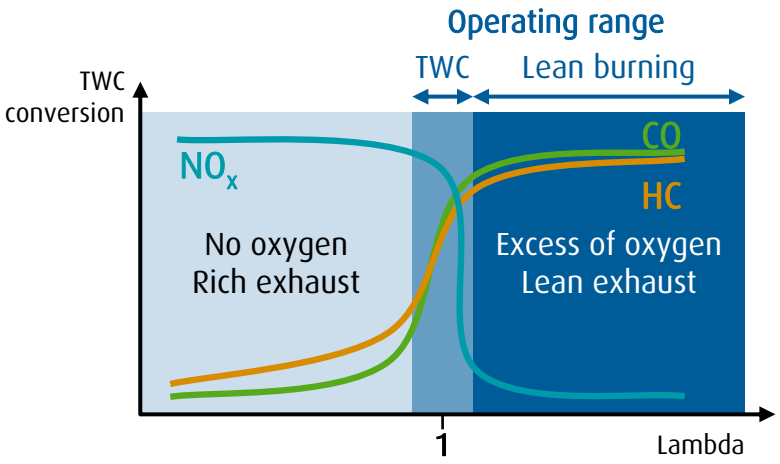
- Principle already used in diesel cars
- Introduced in lean burning gasoline engines
- Works in oxygen-rich environment

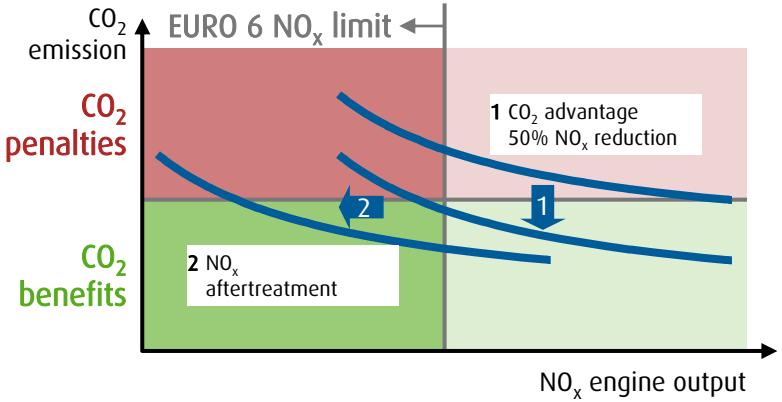
Direct NO_x reduction with excess oxygen is not possible

- Engine optimisation offers limited possibilities

NO_x aftertreatment solutions required in most cases

- Selective Catalytic Reduction (SCR)
- NO_x Storage Catalyst (NSC)





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Electrification of the powertrain impacts catalyst size and catalyst complexity

ELECTRIFICATION

ICE		HEV		PHEV		EV	
Normal	Start-stop	Mild	Full	Parallel system	Range extender	BEV	FCEV

	Normal	Start-stop	Mild	Full	Parallel system	Range extender	BEV	FCEV
Relative size	+++	+++	+++	++	++	+	No emission control catalyst	
Relative complexity	+	+	+	++	+++	+		

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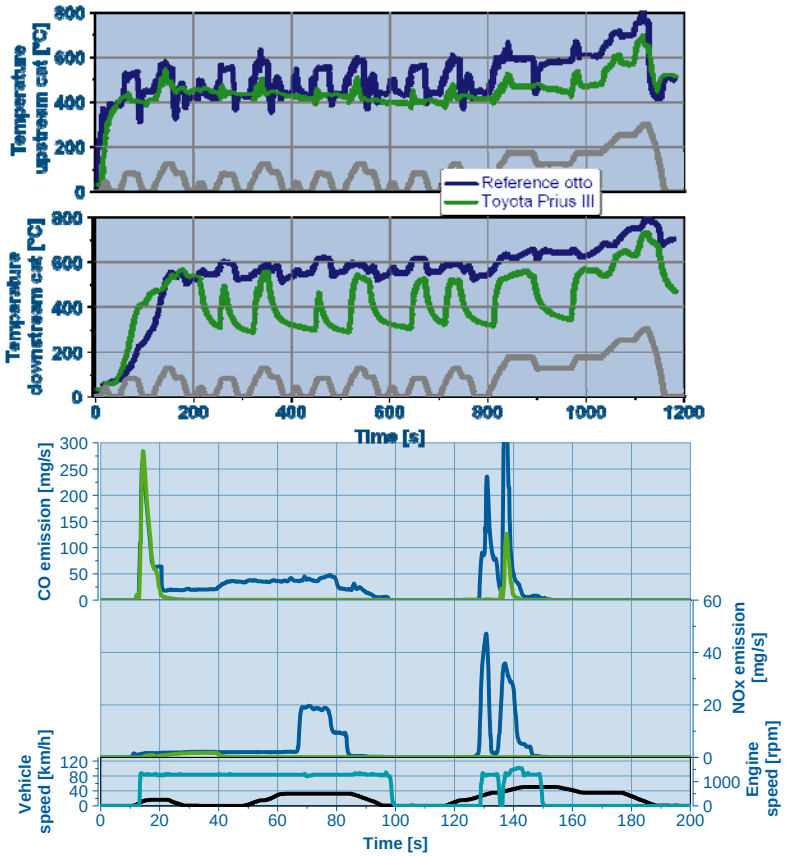
Hybrid powertrains require new operational conditions for the ICE and the catalyst

Engine-stop phases causes significant cooling of the emission control system

- Lower catalyst light-off temperature required
- High temperature stability especially required for gasoline applications

Engine restarts cause very high emissions peaks

Emission control for hybrid applications needs dedicated solutions



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Market status in Europe

Moderate growth of light duty vehicle production expected in Europe

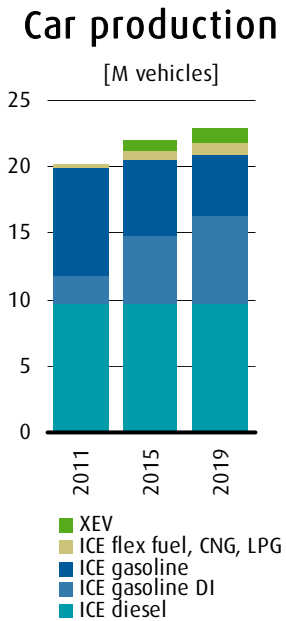
Production in 2014 expected to reach record 2008 level

CO_2 targets drive fuel efficiency

- 130g/km, phasing in in 2012, full compliance by 2015
- 95 g/km further reduction by 2020
- Engine configurations changing
  - Diesel should keep market share of ~50%
  - Gradual introduction of electrified vehicles
  - Downsized turbo-charged gasoline direction injection should grow fast

EURO 6 legislation comes into force in 2014

- Air quality requirements in cities drive NO_X aftertreatment introduction for diesel
- Particulate emissions regulation could drive Gasoline Particulate Filter (GPF) requirement



Source: Umicore estimate based on external data sources

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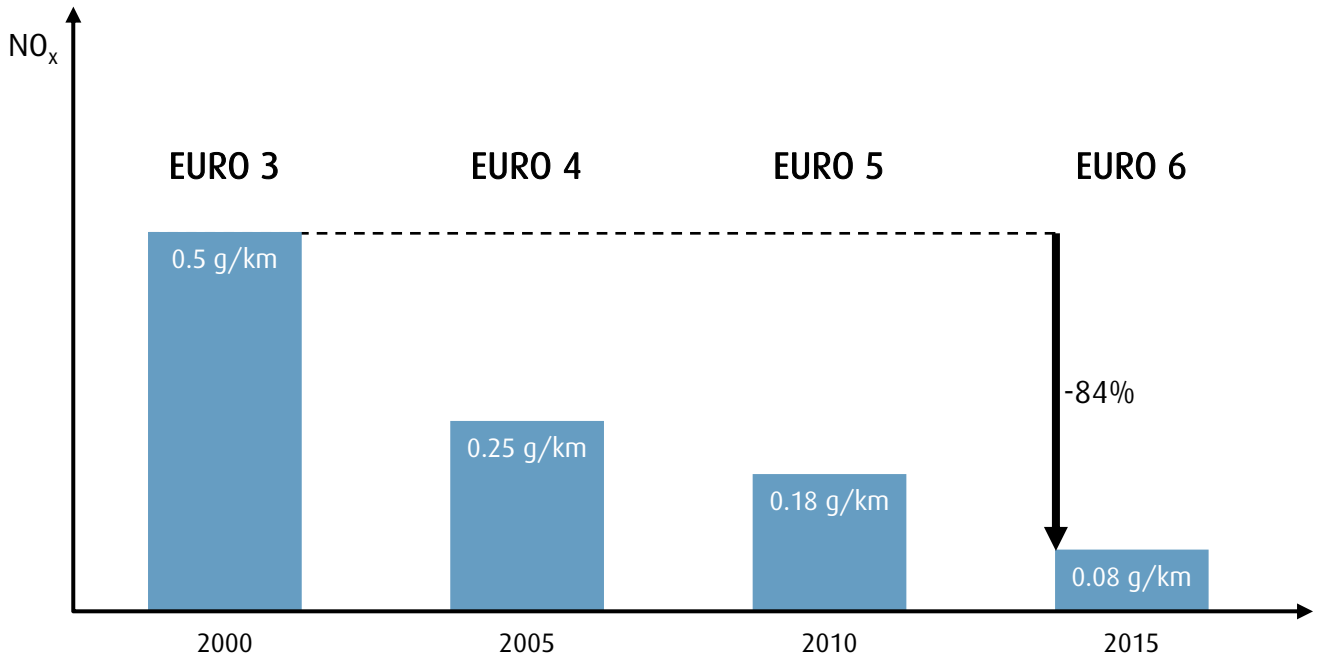
Strengthening EURO 6 NO_x limits for diesel cars require NO_x aftertreatment systems



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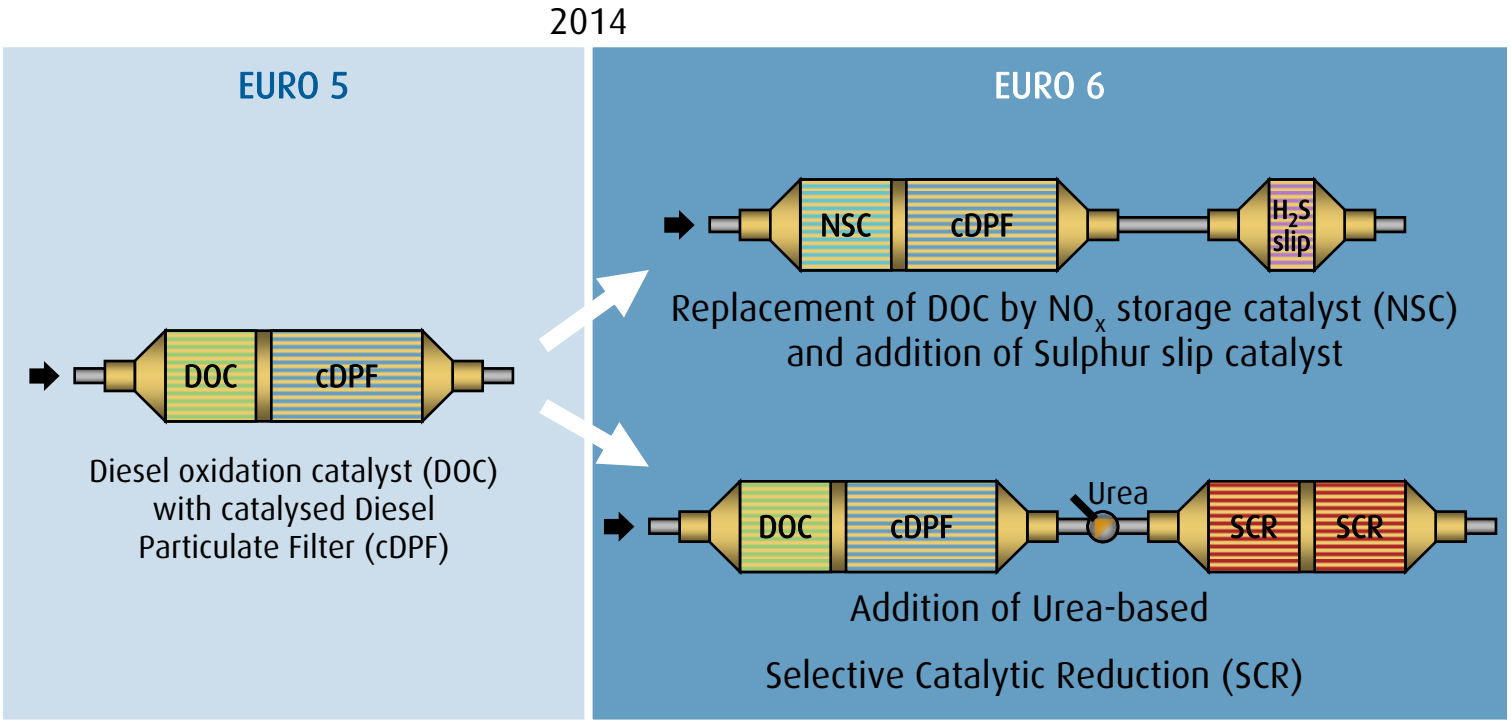
Diesel NO_x aftertreatment system concepts



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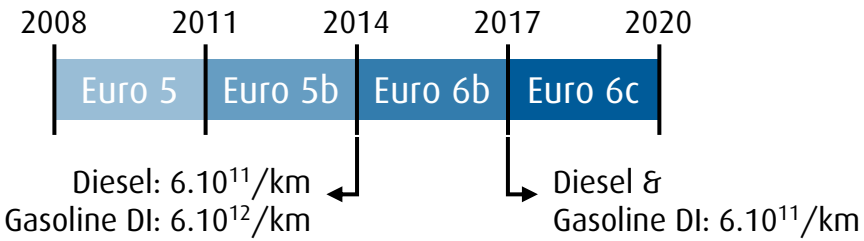
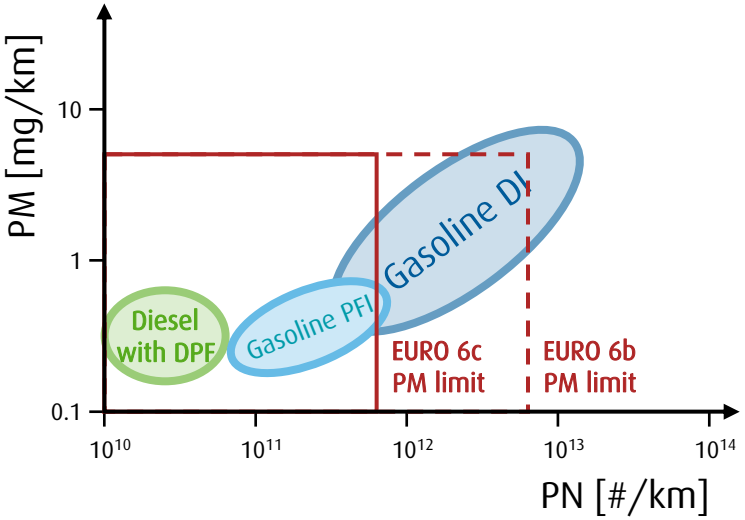
Strengthening EURO 6 PM limits may require gasoline particulate filters

EURO 6 legislations addresses the number of particulates, with a transition period of 3 years for gasoline engines



Gasoline Direct Injection (DI) engines have higher Particulate Matter (PM) emissions (in number of particles) compared to diesel engines with Diesel Particulate Filter



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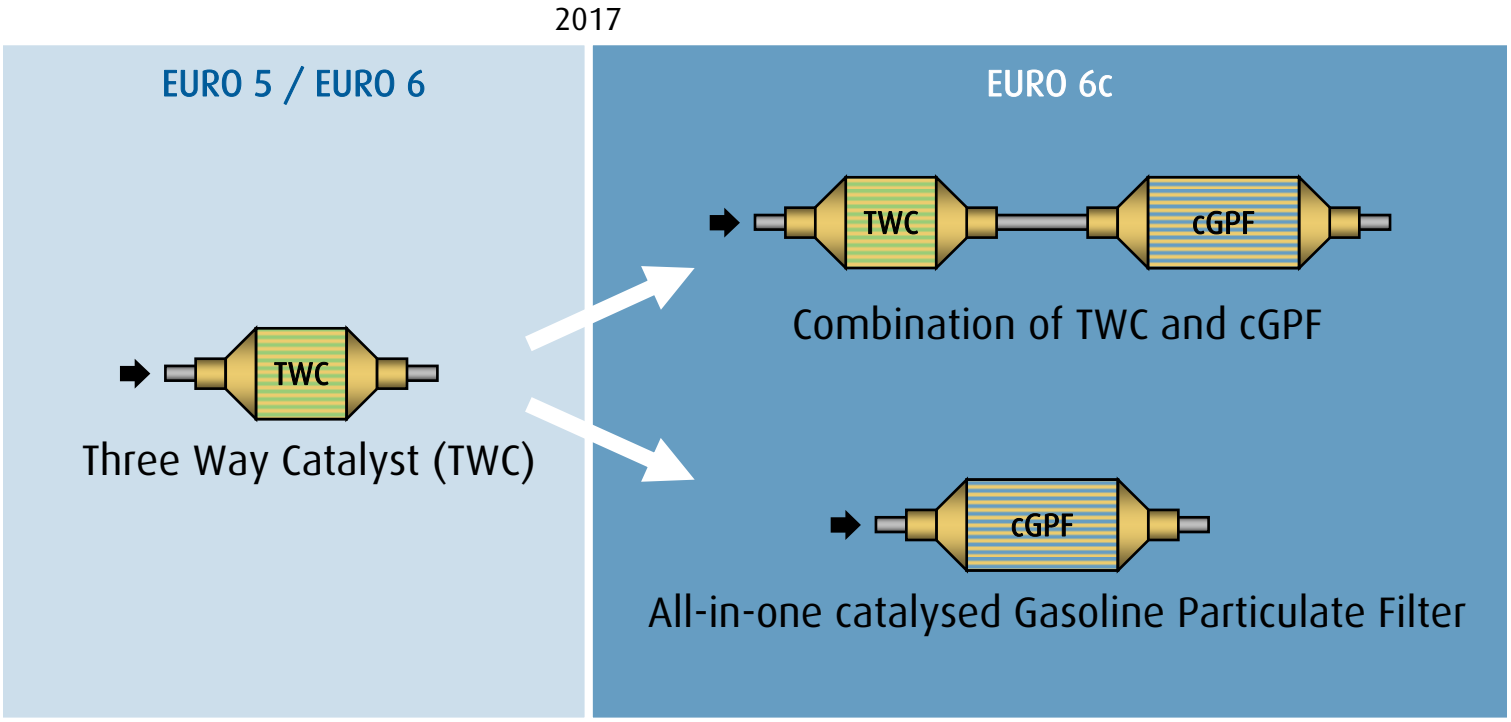
Potential Gasoline particulate reduction system concepts



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Umicore's market position in Europe

European catalyst market should continue to outpace vehicle production due to the introduction of new legislation

Umicore has a strong leadership position in the European market

- Catalyst production in Europe started in 1974

Umicore has strong technology portfolio and system knowledge available to support the market requirements

- First to market with NO_x storage catalysts and SCR systems
- Strong position in cGPFs established, critical IP generated and patents granted
- R&D centre supports development programmes with OEMs

New contract wins for EURO 6 diesel legislation (related to NO_x aftertreatment systems) should allow Umicore to further strengthen market position


Karlskoga plant, Sweden


Florange plant, France


Rheinfelden plant, Germany

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Market status in North America

Moderate growth of light duty vehicle production expected in North America

Production in 2016 expected to reach record 2000 level

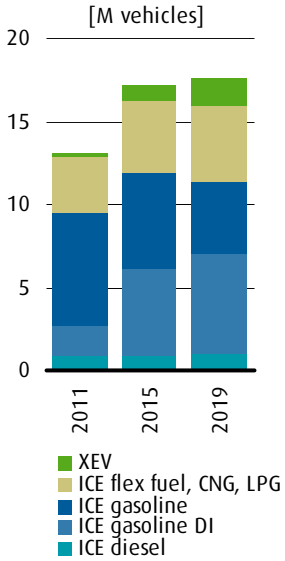
Corporate Average Fuel Economy (CAFE) regulation

- 35.5mpg (miles per gallon) to be reached by 2016 (now 23.1 – 27.5)
- From 2017 to 2025 fuel economy will increase to an average of 54.5mpg
- CAFE regulation pushes towards more efficient engine types
  - Focus on turbocharged gasoline direct injection
  - Diesel market acceptance is increasing gradually

New Emission legislation

- EPA Tier 3 is currently under discussion
- LEV (Low Emissions Vehicle) III cuts emissions by 50% of current most stringent SULEV legislation
- Green House Gas Standards (GHG) includes standards for secondary emissions (N_2O, methane and particulates)

Car production



Source: Umicore estimate based on external data sources

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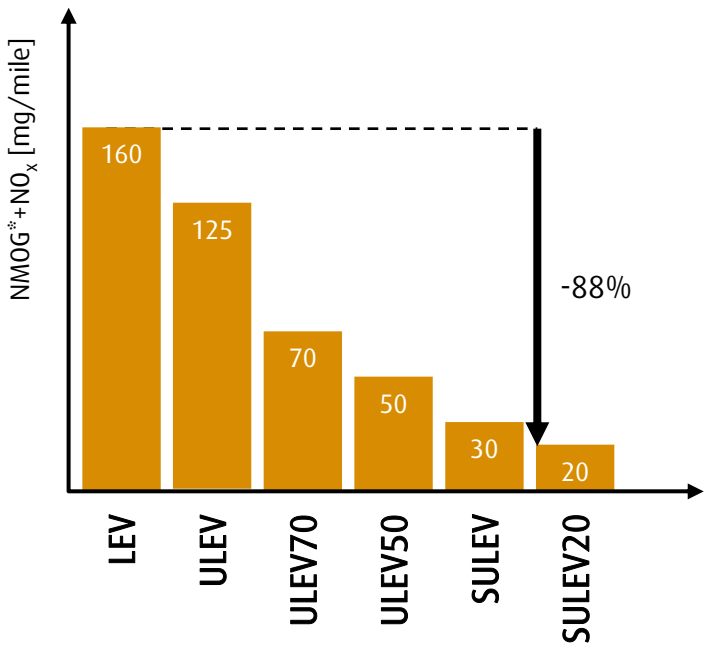
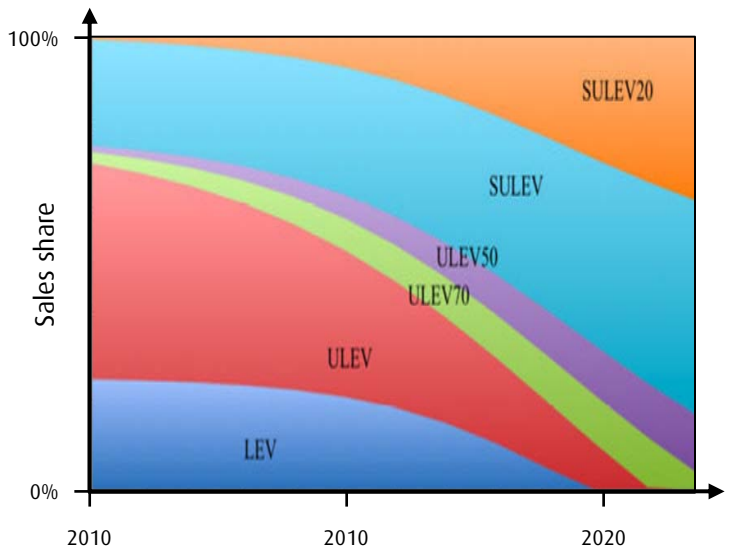
Gradual implementation of LEV III (SULEV20) emission standards to be reflected in vehicle fleet

Emission categories



* NMOG: Non-Methane Organic Gases

Sales share to be reached to meet emission norms



Source: CARB 2010

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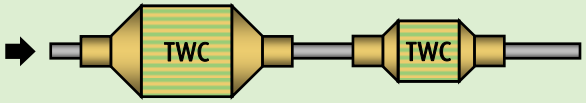
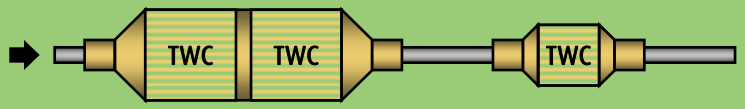
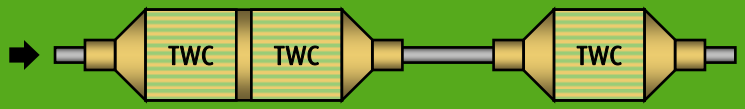
Various emission categories require more and more advanced catalyst technologies

	System requirements
ULEV 	• Low light-off • On-board diagnostics
SULEV 	• Increased Hydro Carbon (NMOG) performance • Robustness over lifetime
SULEV20 	• Combined NMOG/NO_x performance • Stricter particulate mass standards • Durability increased to 150,000 miles

Umicore's market position in North America

LEVIII and EPA Tier III pending legislation offers catalyst growth opportunities

Umicore has a leadership position in the North American market

- Catalyst production in North America started in 1983
- Acquisition of Delphi catalysts activities in 2007

Strong technology portfolio and system knowledge available to support the market requirements

- State of the art technology development centre in Auburn Hills to manage local development programs
- R&D centre in Tulsa to support local engine development


Burlington plant, Canada


Auburn Hills tech centre, USA


Tulsa plant, USA

Market status in Japan / Korea

Moderate growth of domestic light duty vehicle market expected in Japan and Korea

Korean and Japanese OEMs strongly positioned worldwide

- Japanese OEMs have strong growth path globally and especially South East Asia
- Strong position of Hyundai/Kia in Korea with global growth path

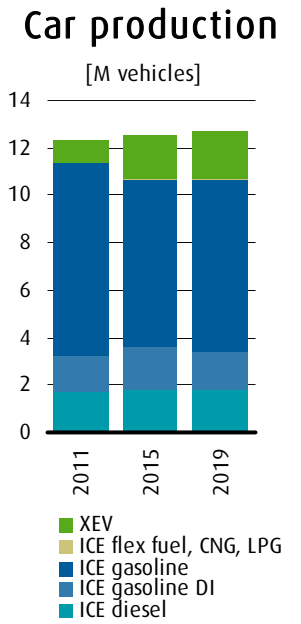
Decision making power remains strongly in the home country

- Strong local automotive catalyst presence is therefore essential

OEM's development focus for domestic and global markets

- Gasoline ICE mainly
- Strong focus on electrification

Emission legislation in Japan changing beyond 2015



Source: Umicore estimate based on external data sources

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Umicore's market position in Japan and Korea

Korean and Japanese OEMs driven by growing export markets


Onsan plant, Korea

Umicore has a leadership position in Korea

- Catalyst production started in 1987

Distant follower in Japan


Himeji plant, Japan

- Catalyst production started in 1993
- Core strategy to increase position with Japanese OEMs
- First successes gained, mainly related to diesel for export markets

Umicore is established in Japan and Korea through

- Local production facilities fully integrated into the global network
- Technology development centres in Korea and in Japan and R&D centre in Japan

Umicore supplies catalysts for various hybrid vehicles including PHEV

Market status in China

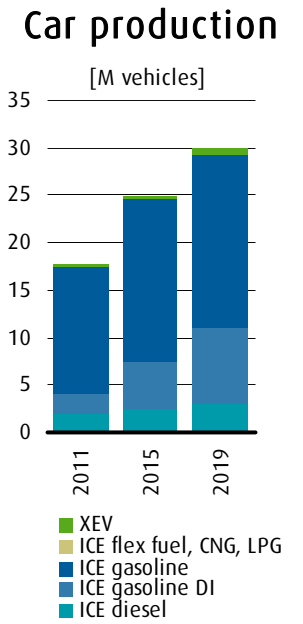
Continued strong growth of light duty vehicle production expected in China

Continued strong growth of vehicle production expected

Powertrain development mainly focused on conventional gasoline engines

Diesel gaining momentum

Legislation follows European norms with a 3 to 5 year lag



Source: Umicore estimate based on external data sources

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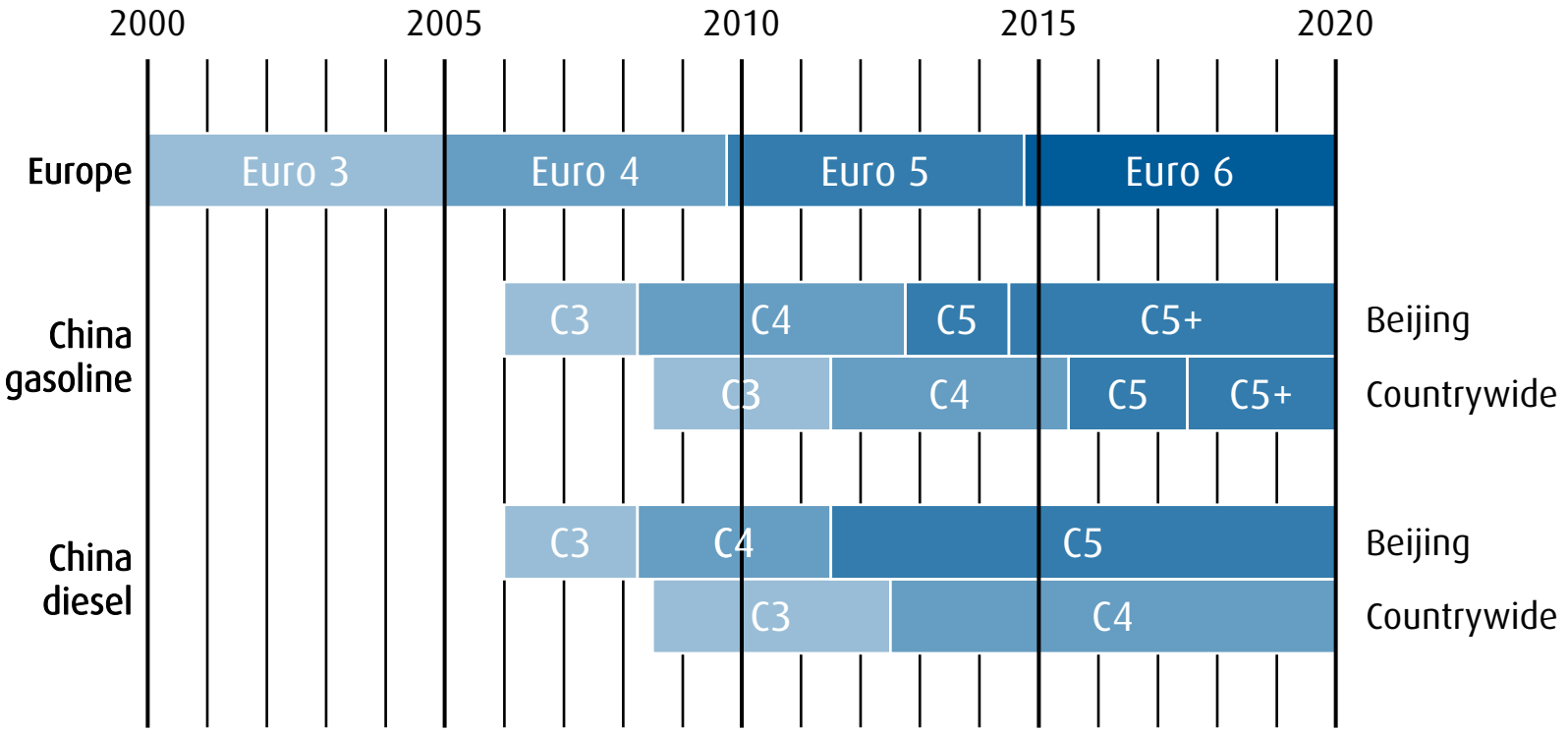
Chinese emission legislation closely following European standards



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Umicore's market position in China

Umicore has a leadership position in China

Local production capacity since 2005

Platform exposure with both global and domestic OEMs

New production line for LDV and HDD being built in Suzhou (commissioning in Q3 2012)

Technology development centre under construction in Suzhou (commissioning in Q3 2012)


Suzhou plant, China


Suzhou tech centre, China

Market status in South America

South American market drivers

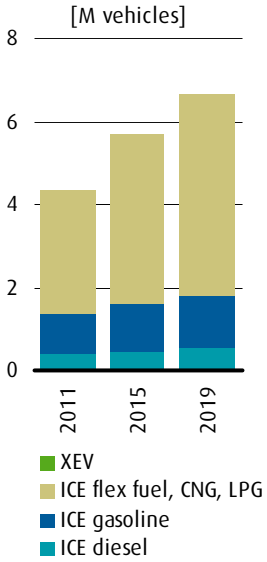
South American market for light-duty vehicles is growing

- Constant growth since early 2000
- Forecasts show local manufacturing of 6 million vehicles by 2017 (IHS)

Strongest market is Brazil

- Brazil emission legislation with upcoming PL6 regulations
- Flex Fuel systems are dominant for passenger vehicles and light duty power trains
- Driven by the Brazilian energy portfolio
- Specific flex fuel Technologies

Car production



Source: Umicore estimate based on external data sources

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Umicore's market position in South America

Umicore has a strong leadership position in the market

- Pioneer for Catalyst production in South America, started in 1991
- Launching of Vehicle Emission Tech Centre in 1992


Americana plant, China

Umicore has strong technology portfolio for bio-fuels and can provide system development capabilities locally

Investment in new vehicle test cell in Americana, Brazil was recently approved to help OEMs meet the upcoming PL6 and PL7 regulations

Market status in India, Russia and South-East Asia

Markets in Russia, India and South-East Asia

Car production growing with economic development of these countries

Legislation currently at low level

- Following European legislation with 5-7 year delay
- Very low durability requirements
- No in-use control

Umicore ready to invest when markets develop further

On- and non-road HDD market

Expansion of scope of emission norms

1985 2006 2011/2012 2016

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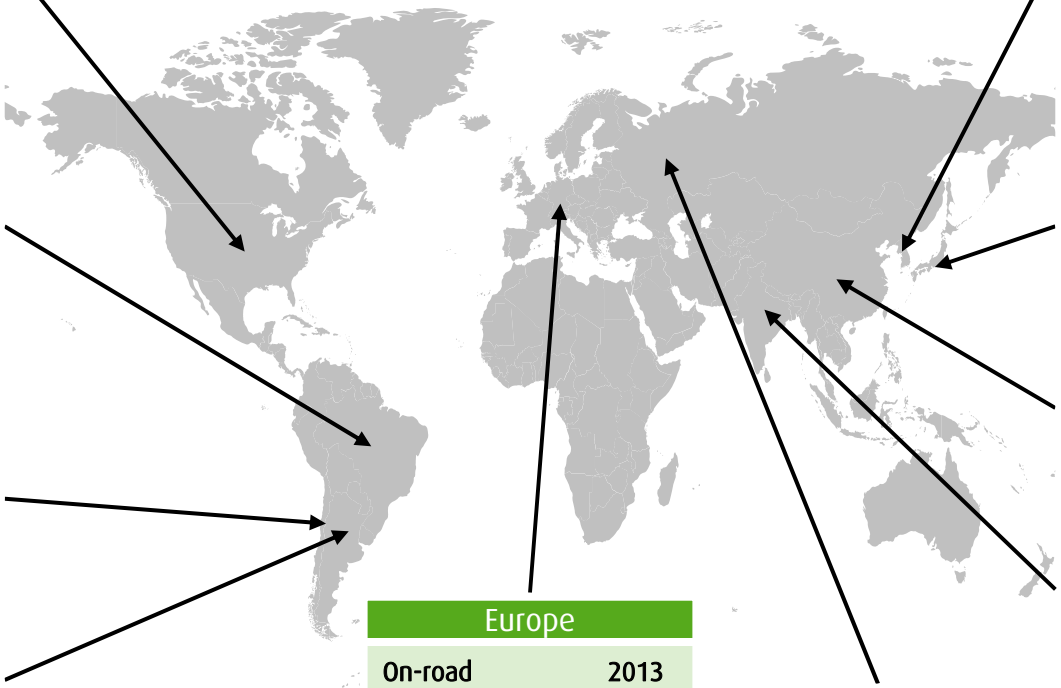
More stringent legislation enforces the use of emission control systems worldwide



USA/Canada

On-road	**2017**
US HDD fuel economy	
Non-road	**2014-2015**
Tier 4 final	

Brazil

On-road	**2012**
EURO V	
Non-road	**2015-2017**
Stage IIA	

Chile

On-road	**2012**
EURO IV + DPF / EPA 2007	

Argentina

On-road	**2014**
EURO V	

Europe

On-road	**2013**
EURO VI	
Non-road	**2014**
Stage IV & Tier 4 final	

Russia

On-road	**2015**
EURO V	

Korea

On-road	**2015**
EURO VI	
Non-road	**2013**
Tier 4	

Japan

On-road	**2014**
Post JP 2009	

China

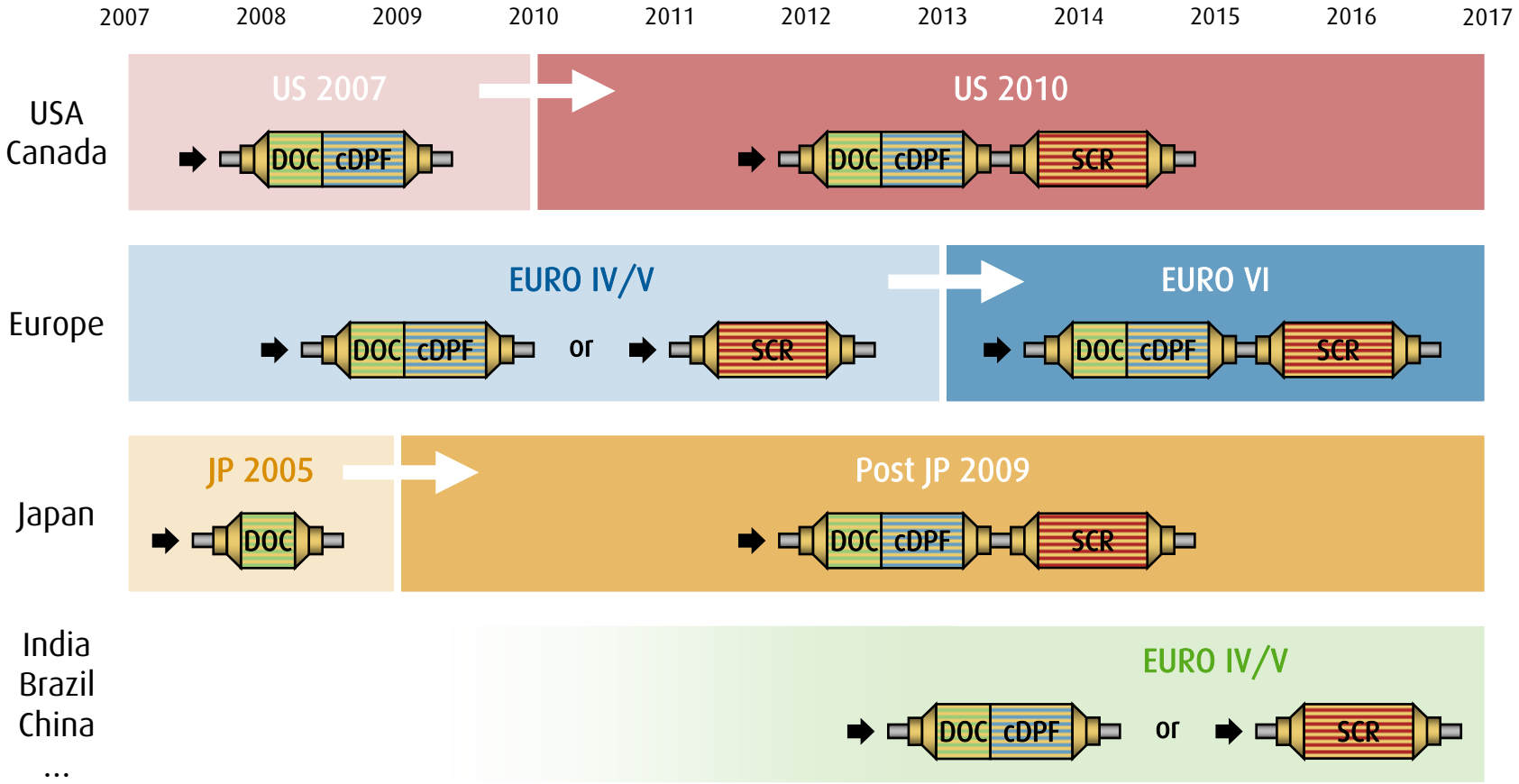
On-road	**2013**
EURO IV	

India

On-road	**2015**
BS IV	

HDD Global Technology Trends

Advanced legislation require PM and NO_x aftertreatment



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Umicore's market position in Heavy Duty Diesel

Umicore's position in on- and non-road HDD

- Decided in 2005 to step in HDD market and started R&D efforts
- Technology gap with competitors closed by 2008-2009 followed by market positioning
- Contract wins in all regions with relatively more success in Europe and emerging markets
- Umicore continues to position itself for additional HDD business to be awarded in the near future

Technology, system design and customer intimacy are key for success

- Existing HDD test capability in Korea, Japan, Brazil, Europe and North America
- New technology development centre in China to be commissioned in Q3 2012

HDD production capability being established in North America, Europe and China

- Dedicated HDD facility in Florange, France will be commissioned mid 2012
- Expansion of flexible capacity in Suzhou, China will be commissioned in Q3 2012

Conclusion

Umicore Automotive Catalysts

Automotive catalysts market set to grow faster than vehicle production due to more stringent emission legislation in all the major markets

Umicore is a global leader for light duty applications

- Well positioned in Europe, North America and Korea
- Strongly positioned in fast growing Chinese and Brazilian markets
- Aiming to increase position with Japanese OEMs
- Ready to seize opportunities in India

Umicore is gradually gaining ground in HDD, supported by customer awards

Umicore is continuing to invest in manufacturing and testing capabilities

Forward-looking statements

This presentation contains forward-looking information that involves risks and uncertainties, including statements about Umicore's plans, objectives, expectations and intentions.

Readers are cautioned that forward-looking statements include known and unknown risks and are subject to significant business, economic and competitive uncertainties and contingencies, many of which are beyond the control of Umicore.

Should one or more of these risks, uncertainties or contingencies materialize, or should any underlying assumptions prove incorrect, actual results could vary materially from those anticipated, expected, estimated or projected.

As a result, neither Umicore nor any other person assumes any responsibility for the accuracy of these forward-looking statements.

The presenter

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Global Technology Director, Research & Technology Umicore AG & Co. KG

Wilfried Müller started at the Applied Technology Group Automotive Catalysts of Degussa AG in 1990. He became the Head of the Global DaimlerChrysler Businessteam at Degussa/Umicore AG in 1996 and was appointed Director Research & Development NOx-Storage Catalysts Gasoline and Diesel at Umicore AG in 2003. Since 2006 he is the Director System Integration Automotive Catalysts, Light- and Heavy Duty Vehicles at Umicore AG. Wilfried holds a Mechanical Engineering diploma with the focus on internal combustion engines (University of Applied Sciences, Frankfurt).

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