Johnson Matthey

Presentation to
Analysts & Investors

Johnson Matthey Technology Centre
Sonning Common
26th January 2005

Johnson Matthey

Neil Carson

Chief Executive

JM Executive Board

Neil Carson	-	Chief Executive
John Sheldrick	-	Group Finance Director
David Morgan	-	Executive Director, Corporate Development, Central Research and Colours & Coatings
Dr Pelham Hawker	-	Executive Director, PCT
Larry Pentz	-	Executive Director, ECT

Other Senior Management

Dr Jack Frost	-	Director, Fuel Cells
Dr Barry Murrer	-	Director, JMTC
Dr David Prest	-	Director, HDD
Ian Godwin	-	Investor Relations

Programme

10.00	Welcome and trading update (Neil Carson)
10.15	ECT and Light Duty Diesel (Larry Pentz)
10.30	Heavy Duty Diesel (David Prest)
11.00	Coffee Break
11.15	Fuel Cells Update (Jack Frost)
11.45	The Hydrogen Market (Pelham Hawker)
12.00	Hydrogen Storage (Barry Murrer)
12.30	Site tour
13.30	Buffet Lunch
14.15	Visit Wrap Up Q&A
14.30	Depart for station

Current Trading

- Trading in line with expectations
- Catalysts division continuing to benefit from growth in diesel in Europe
- Demand in China down in Q4 2004. Rest of Asia ahead
- Good trading conditions for pgms
- Pharmaceutical Materials slightly down
- Average US dollar rate worse than first half
- Confident of growth in full year earnings (before exceptional items and goodwill amortisation)

Johnson Matthey

Johnson Matthey Catalysts

Larry Pentz, Executive Director

Environmental Catalysts and Technologies

Environmental Catalysts and Technologies

Environmental Catalysts and Technologies

- Continued growth in Autocatalysts
  - Tightening of legislation
  - High technology catalysts. PGM thrifting
  - Asia

- Growth in light duty diesel
  - Increasing share of light vehicle market
  - Particulate control

- New heavy duty diesel market
  - On road
  - Off road

Light Duty Diesel

Continued Market Growth

- Europe
  - 48% share of passenger car sales in 2004 and rising
  - Diesel growing in all car segments with fastest growth in lower medium and small car segments
- Asia
  - Japanese and Koreans now diesel producers
  - Korea set to lift regulatory barrier to diesel car sales
  - Already Asian market for diesel (1 tonne trucks)
- US
  - Potential via light truck sector and imports
  - CAFE requirements

Light Duty Diesel

Emissions Control to Move from Catalysts to Filter Solutions

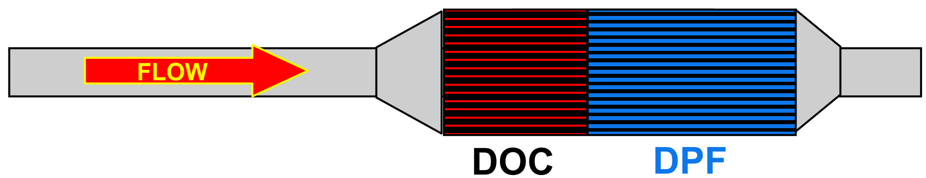
- Demand Side Drivers
  - Health concerns over diesel particulate matter (PM) now a major focus for air quality management
  - Availability of competitive diesels with particulate filters
  - Proactive response from European Governments (Germany, France, etc)
  - Legislation expected to force filter use (Euro 5, 2010)

- Supply Side Considerations
  - Technology is challenging and not yet matured
  - Vehicle uptake still limited by filter availability
  - For catalyst suppliers = major value-add opportunity requiring investment

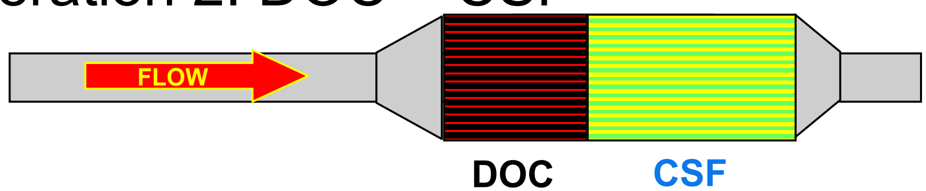
Light Duty Diesel

Evolution of Technology

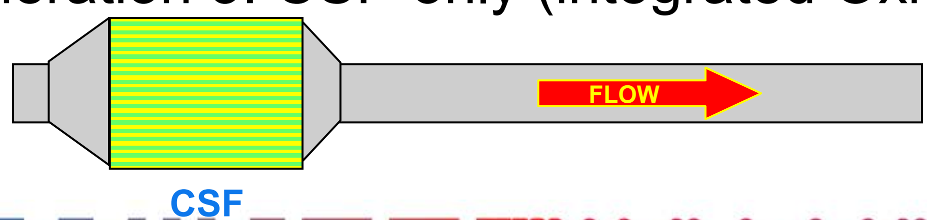
- Pre-Filter: DOC only
- Generation 1: Fuel Additive Type



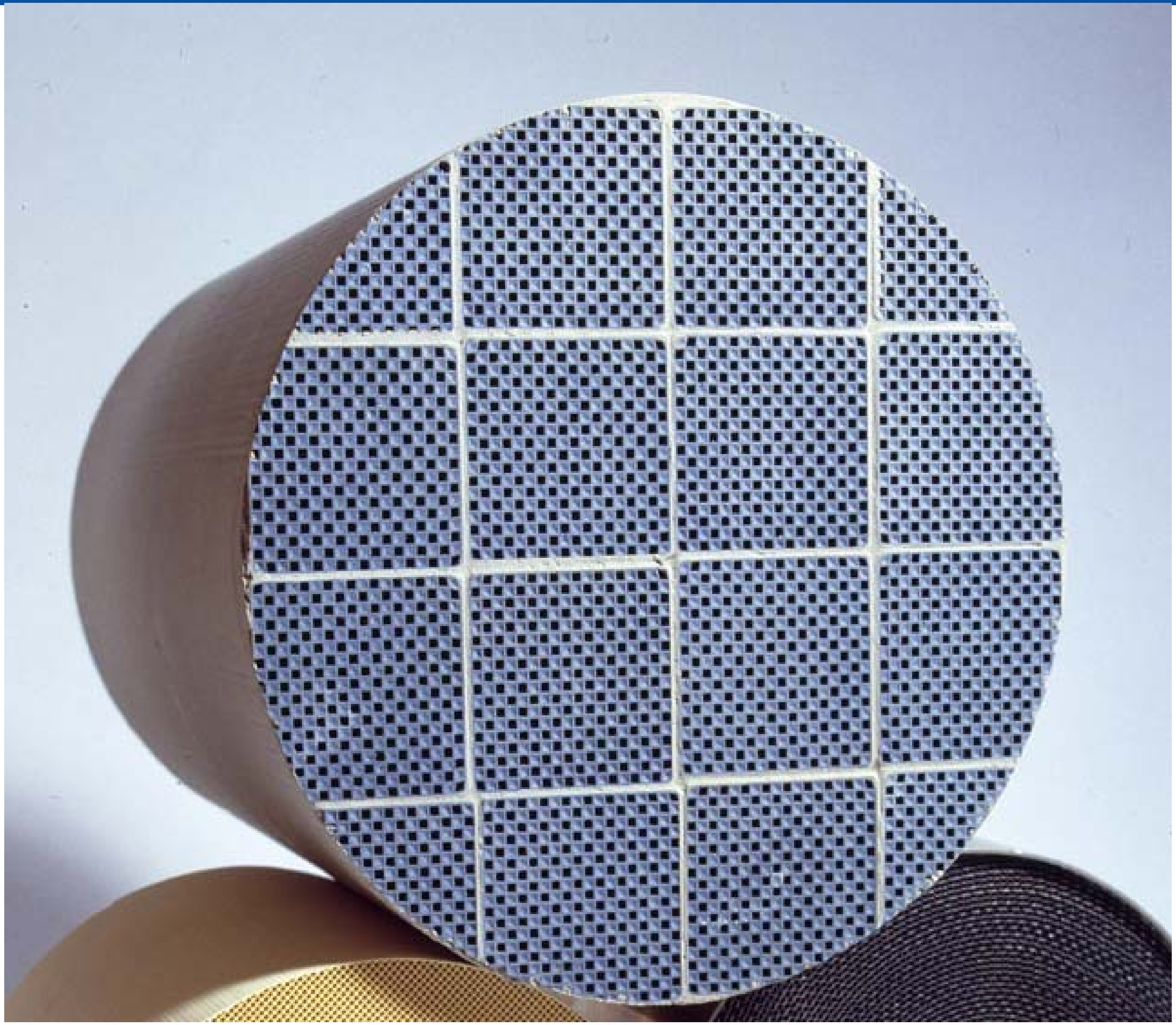
- Generation 2: DOC + CSF



- Generation 3: CSF-only (integrated Oxidation Catalyst)



Light Duty Diesel
Catalysed Soot Filter



Heavy Duty Diesel

January 2005

Johnson Matthey Catalysts

Dr David Prest

Director, HDD

HDD Market Sectors and Legislation

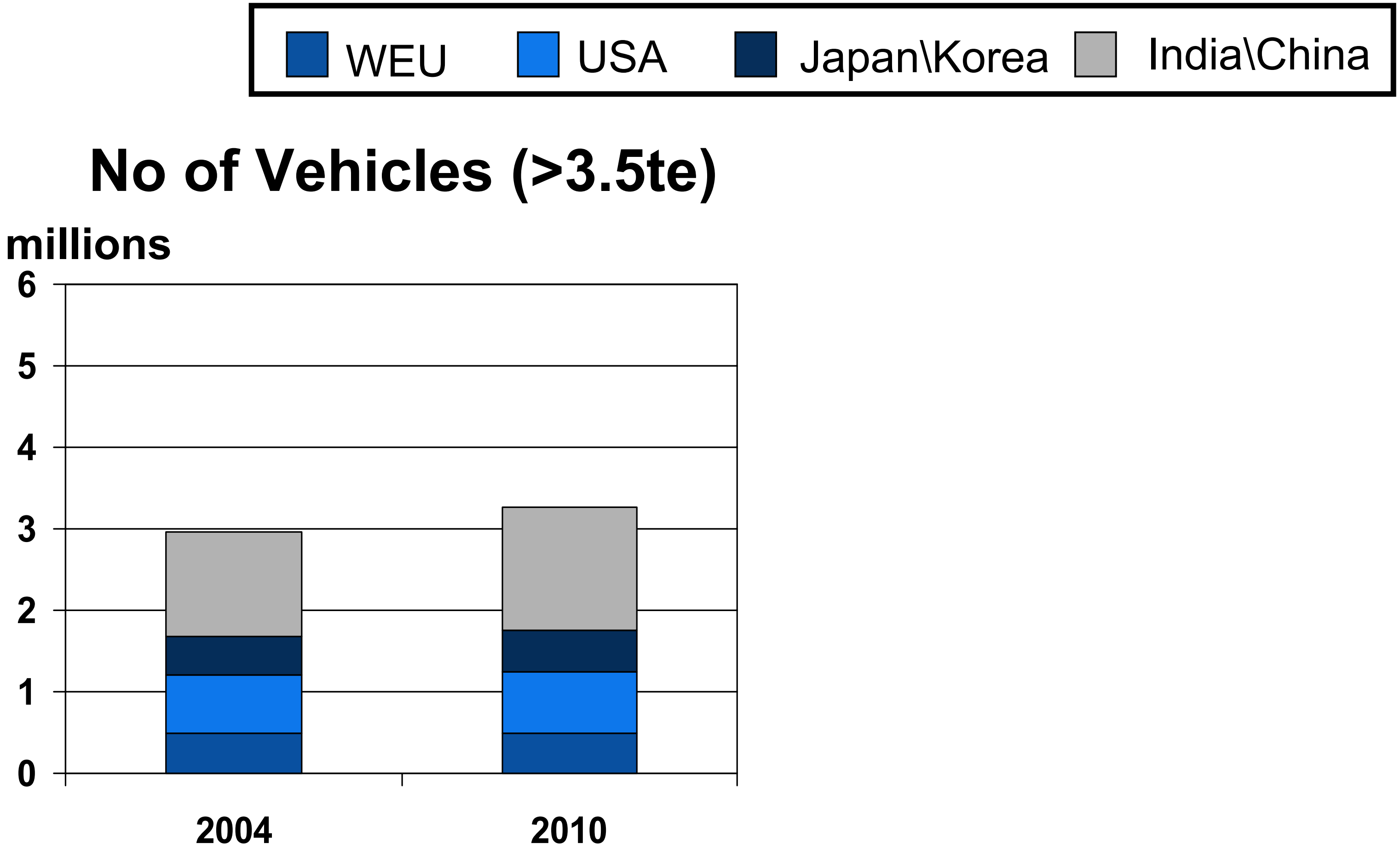
HDD
Two market segments in each region

HDD: Generally vehicles > 3.5te gvw, cylinder displacement >1 litre

- OE
  - Regulatory compliance
  - Technical approval by OE
  - Includes option-fit
  - Supply chain via system integrators / canners

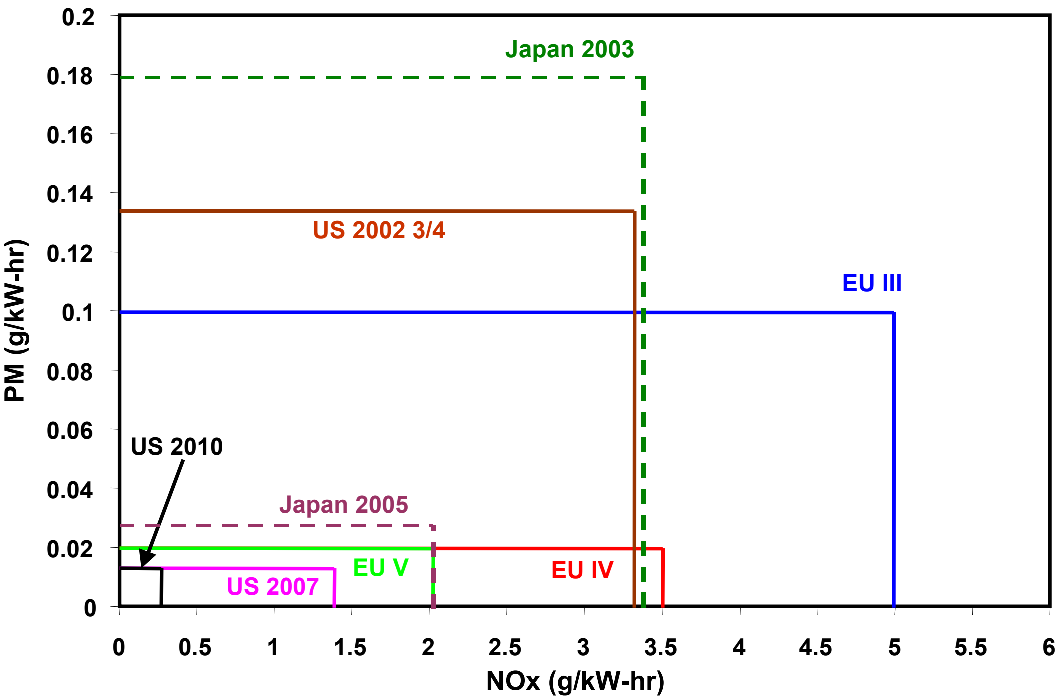
- Retrofit
  - Local legislation
  - Approval by verifications
  - Incentives & restrictions for users
  - Supply chain via agents or direct

HDD
OE Market



Source Global Insight & Johnson Matthey

HDD
On-road regulation development



	New Models	All Models
Europe		
Euro IV	Oct-05	Oct-06
Euro V	Oct-08	Oct-09
United States		
US2007	Jan-07	Jan-07
US2010	Jan-10	Jan-10
Japan		
New Short Term		
2.5-12t	Oct-03	Oct-03
12t +	Oct-04	Oct-04
New Long Term		
2.5t+	Oct-05	Oct-05
China		
Euro III - selected cities	2008?	
India		
Euro III - selected cities	Apr-05	
Euro III - nationwide	2010?	

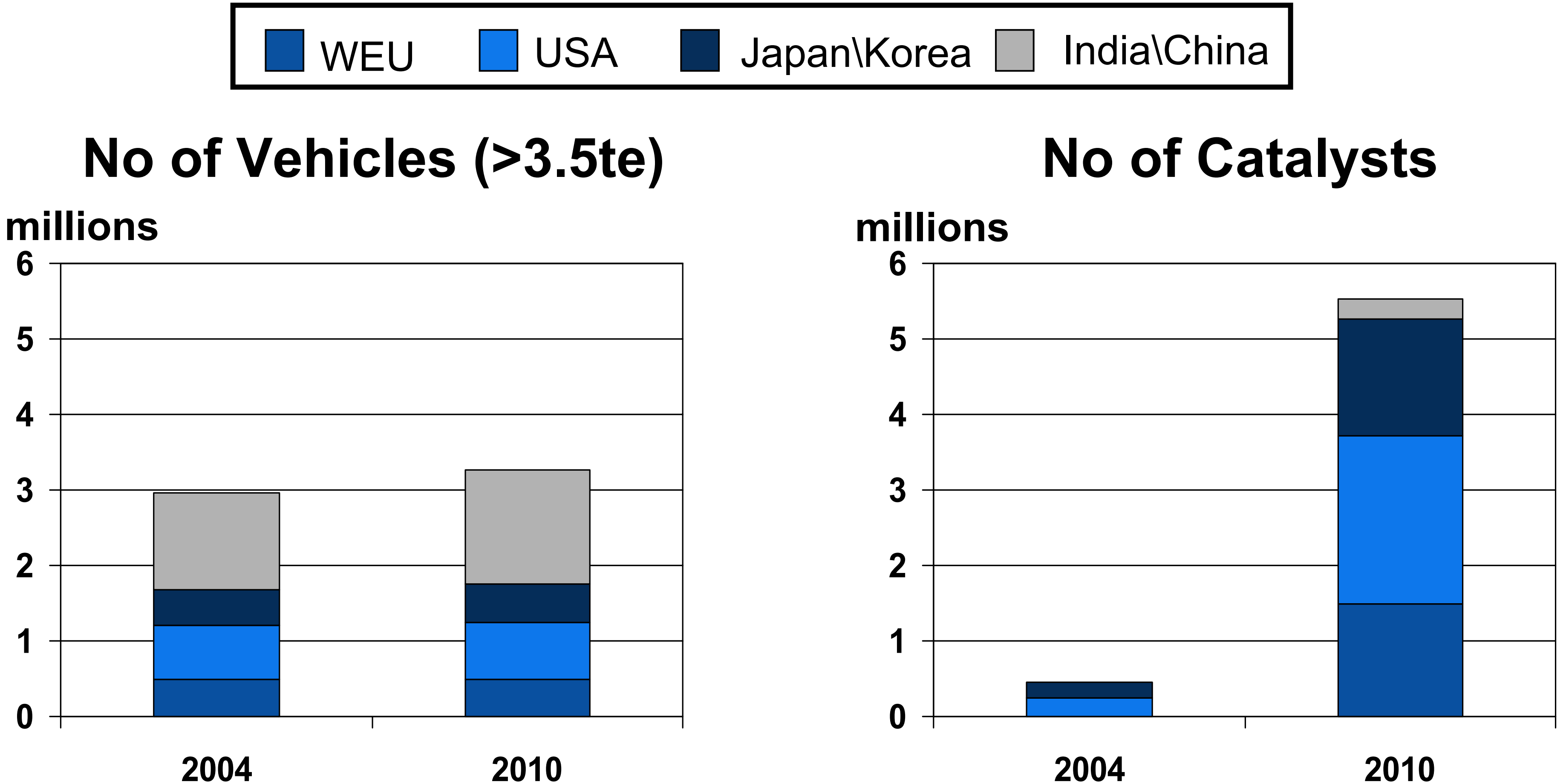
HDD
World Diesel Fuel Standards

Sulphur Content in PPM

Country	Year															
		95	96	97	98	99	2000	01	02	03	04	05	06	07	08	09	10
European Union							350					50				10	
USA	500													15			
Australia	500												50				
China	2000 (Ave 800)											350 for Beijing					
Hong Kong - China							50						10				
India (11 Major Cities)							500					350					50
India	2500											500					
Japan	2000			500							50				10		
Korea	2000								130			50	30				

- Over 1000 ppm
- < 500 ppm
- 50 ppm
- Less than 30 ppm

HDD
OE Market



Source Global Insight & Johnson Matthey

HDD Technologies

HDD
Johnson Matthey's Technology Toolbox

	CO	HC	PM	NOx
DOC – Diesel Oxidation Catalyst	X	X	x	
CRT® – Continuously Regenerating Trap (DOC+ filter)	X	X	X	
CCRT® – Coated CRT (DOC+coated filter)	X	X	X	
SCR – Selective Catalytic Reduction				X
EGR – Exhaust Gas Recirculation				X
SCRT® (SCR+CRT)	X	X	X	X
EGRT® (EGR+CRT)	X	X	X	X
NAC – NOx Adsorber Catalyst	X	X		X

Red = JM patents

HDD

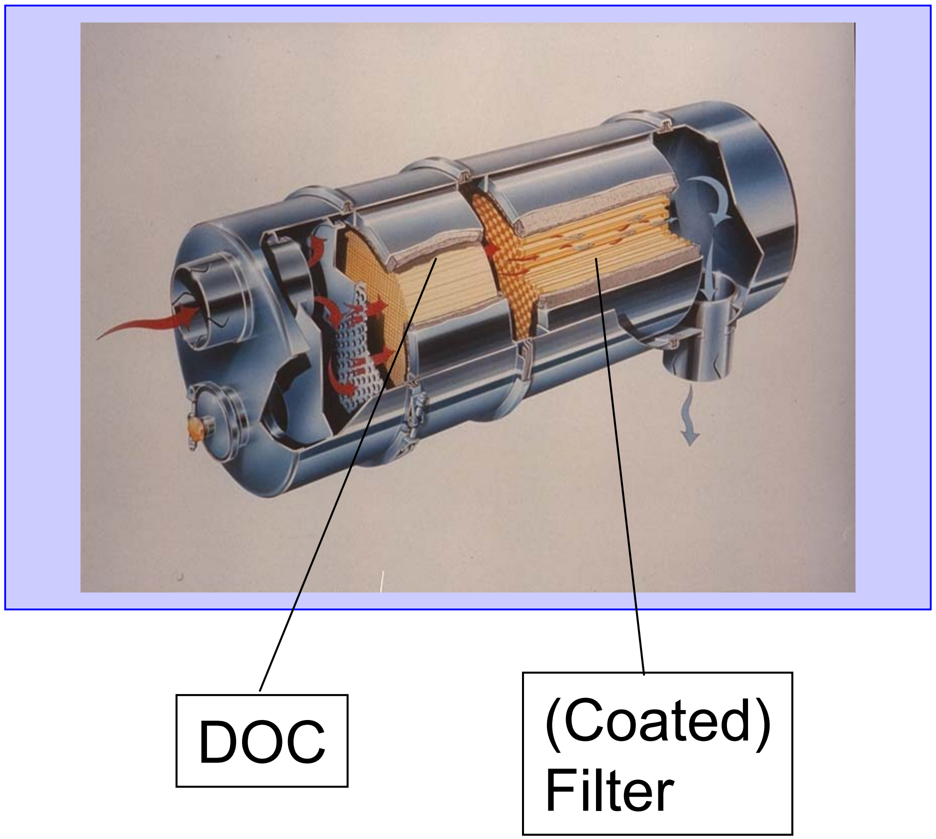
OE Prime Path Options

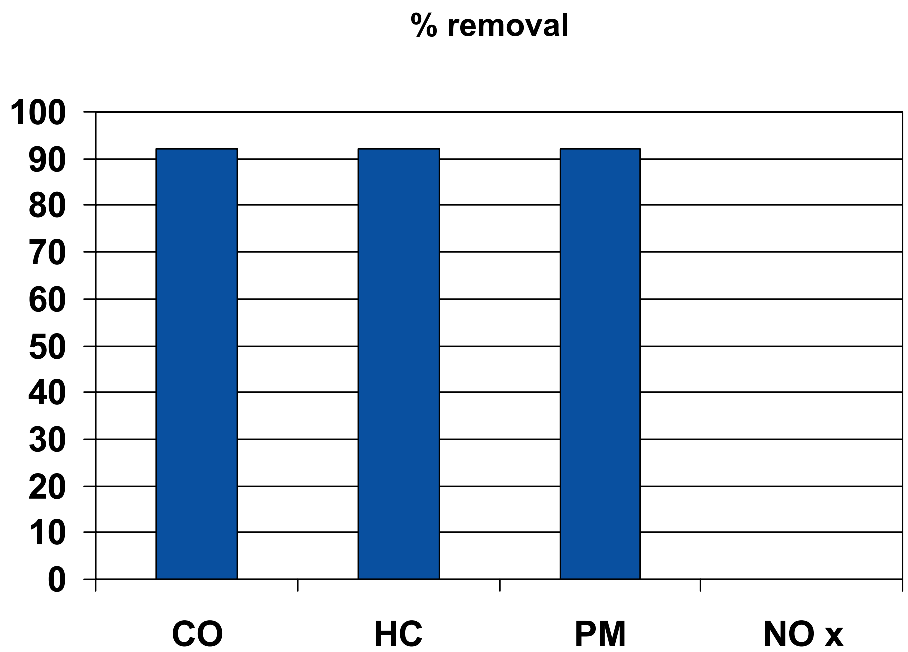
HDD (on road)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Europe		SCR EGR + DPF EGR + DOC			SCR EGR + DPF EGR + DOC				SCR + DPF					
USA	EGR			EGR + DPF			NAC + DPF SCR + DPF							
Japan		EGR		EGR +DPF SCR			SCR + DPF NAC + DPF							

Non Road Mobile Machinery	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
USA and Europe				DOC + DPF / CSF			SCR + DPF / NAC + DPF			

Note: "DPF" covers DOC + DPF (CRT®), DOC + CSF (CCRT®) and CSF - only

CRT® / CCRT®


DOC
(Coated)
Filter


% removal
100
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70
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30
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10
0
CO
HC
PM
NO x

CRT® / CCRT®

Mumbai

Seoul

Seattle

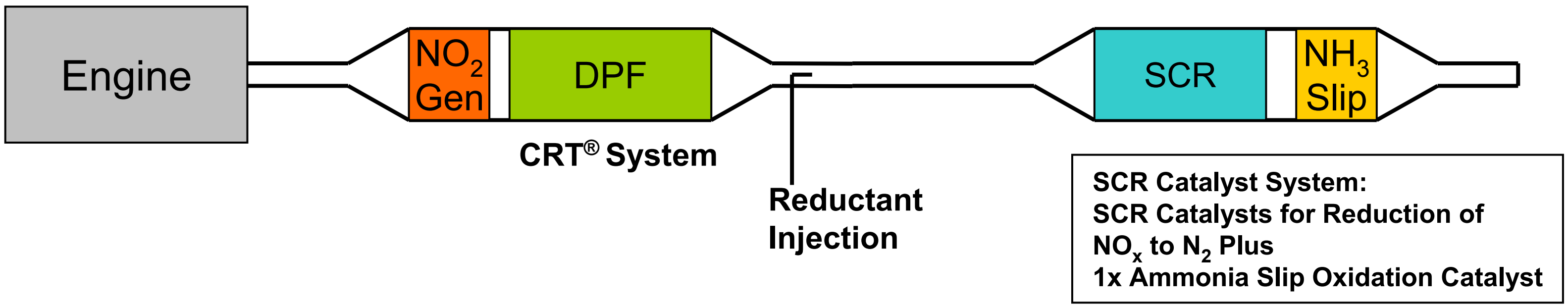
US Delivery truck

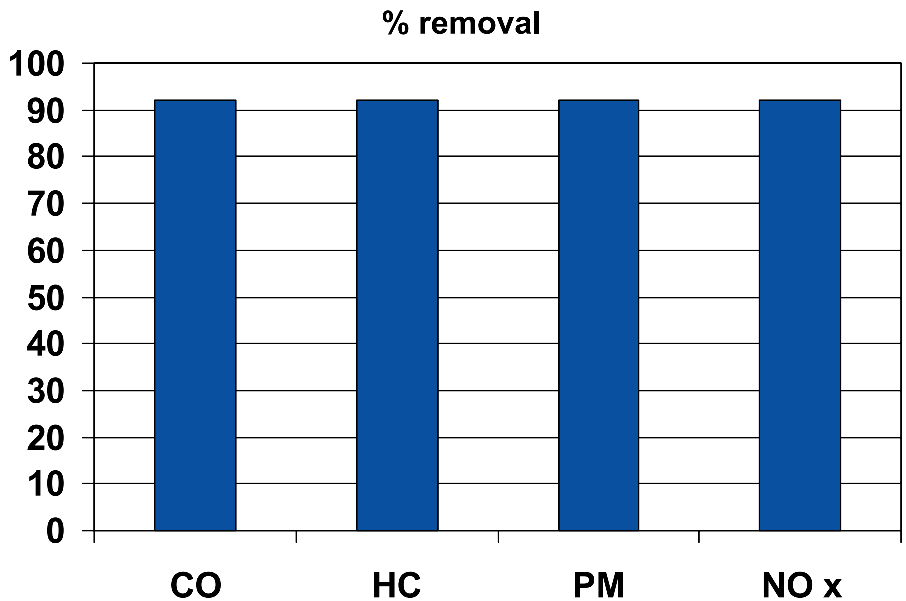
Switzerland
Off Road

US Utilities

SCRT®

SCRT®


Engine
NO2 Gen
DPF
CRT® System
Reductant Injection
SCR
NH3 Slip
SCR Catalyst System:
SCR Catalysts for Reduction of NOx to N2 Plus
1x Ammonia Slip Oxidation Catalyst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CO
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PM
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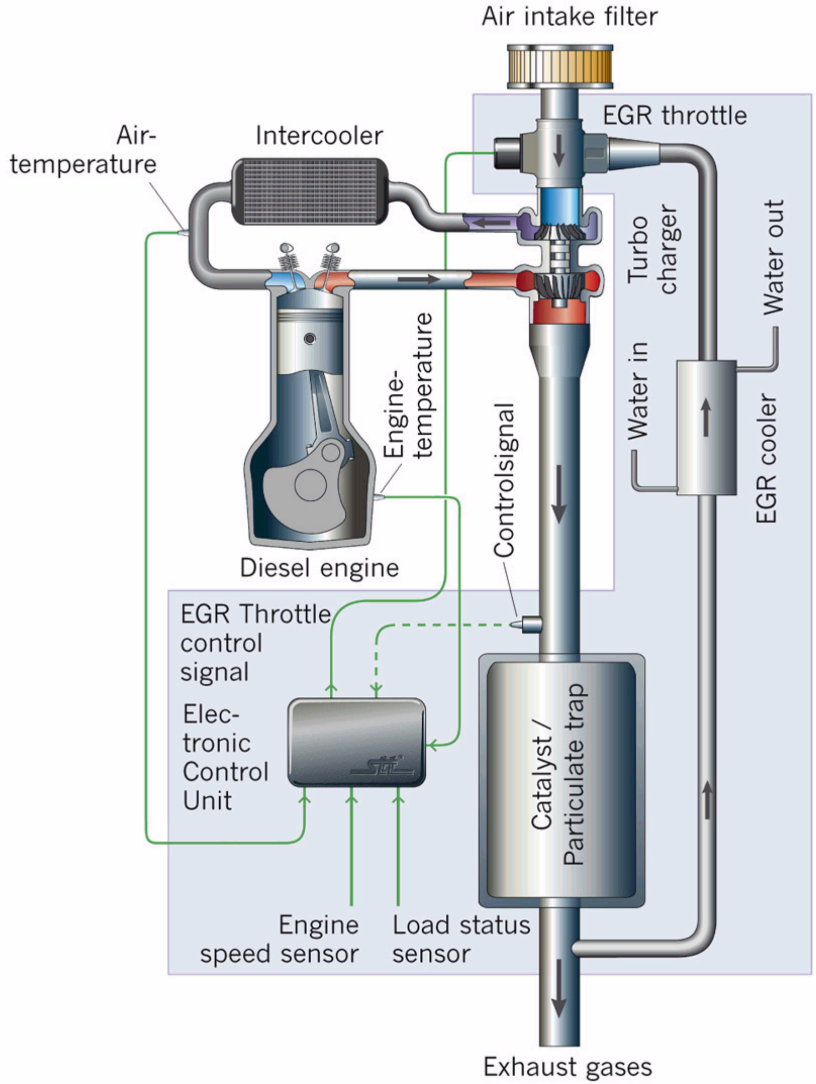
SCRT®

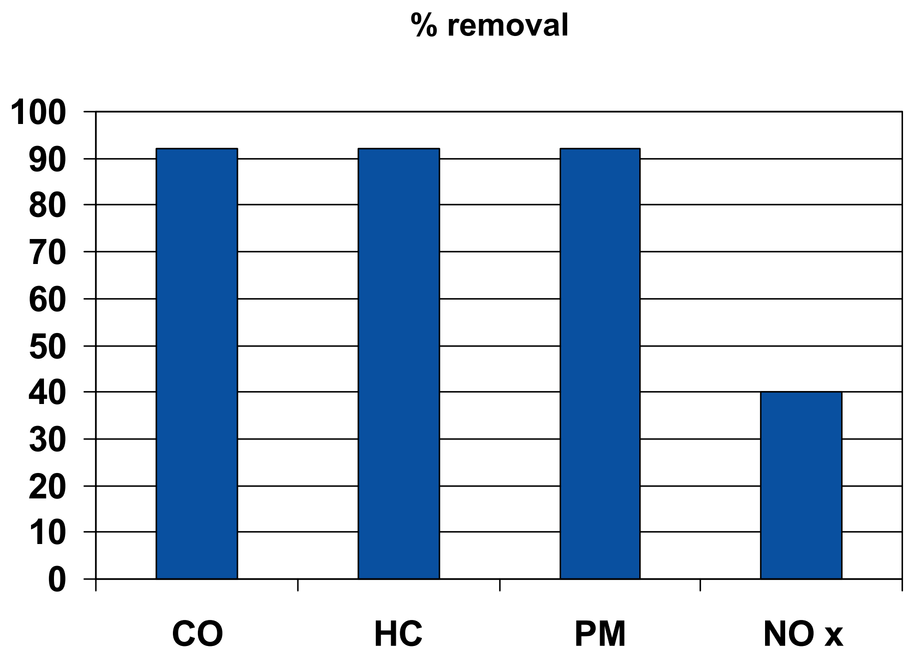
London

Paris

California

EGRT®


Air intake filter
EGR throttle
Air-
temperature
Intercooler
Turbo
charger
Water out
Water in
EGR cooler
Engine-
temperature
Controlsignal
Diesel engine
EGR Throttle
control
signal
Elec-
tronic
Control
Unit
Catalyst /
Particulate trap
Engine
speed sensor
Load status
sensor
Exhaust gases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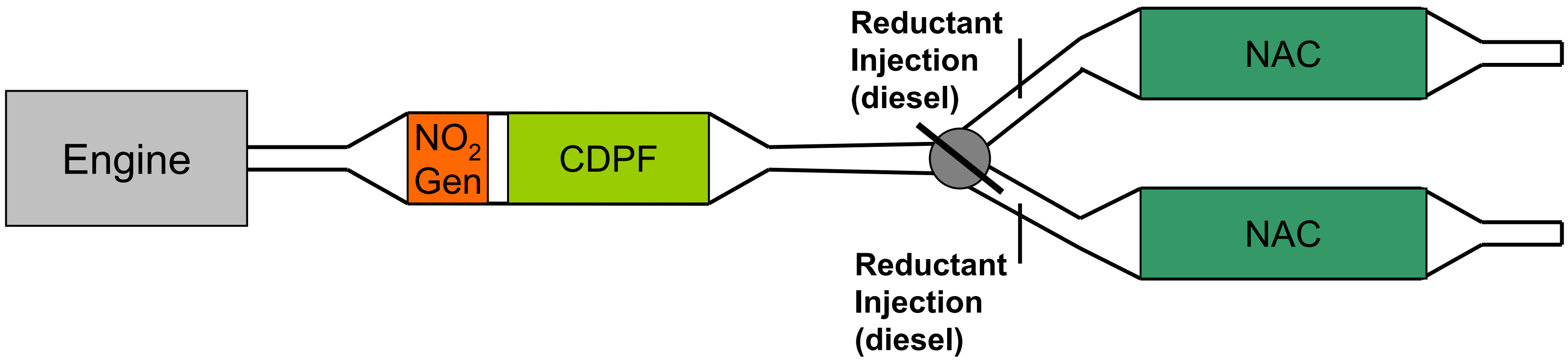
EGRT®

California

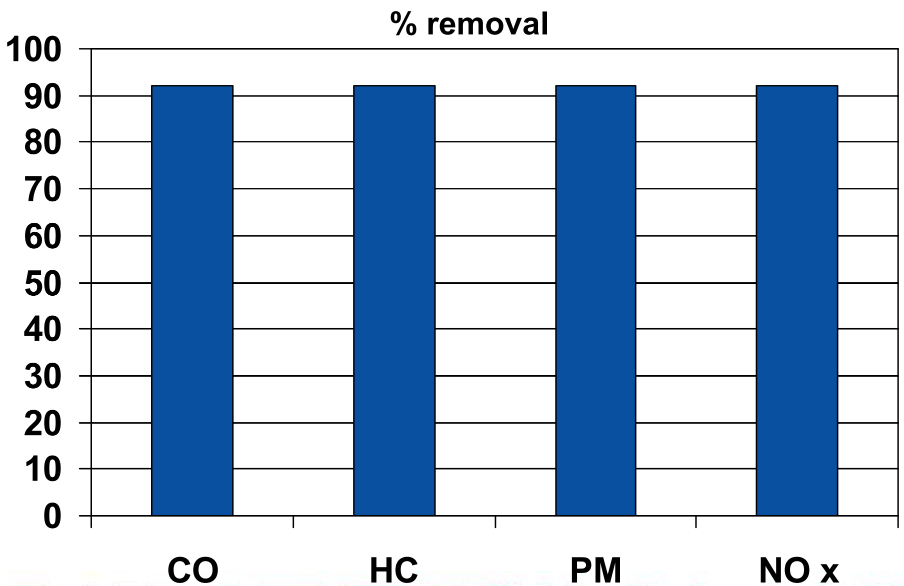
California

EGRT®

NAC + CCRT®



Engine
NO2 Gen
CDPF
Reductant Injection (diesel)
NAC
NAC
Reductant Injection (diesel)



% removal
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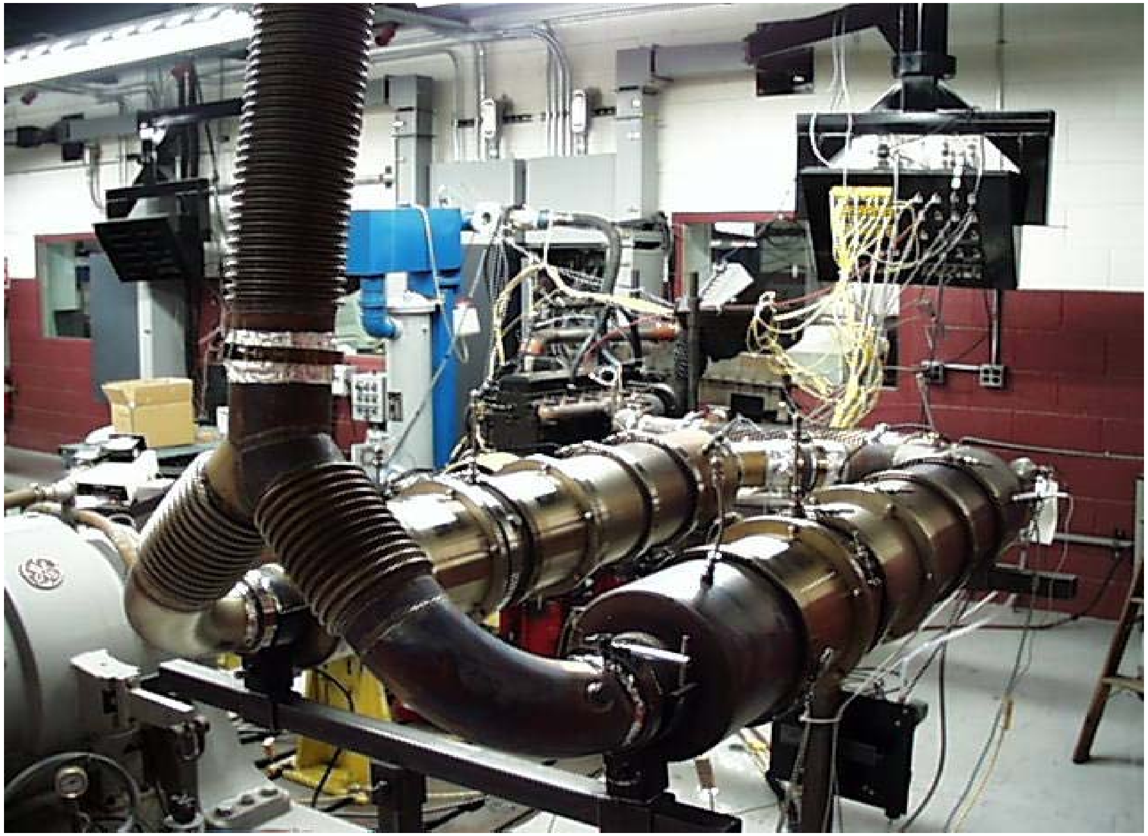
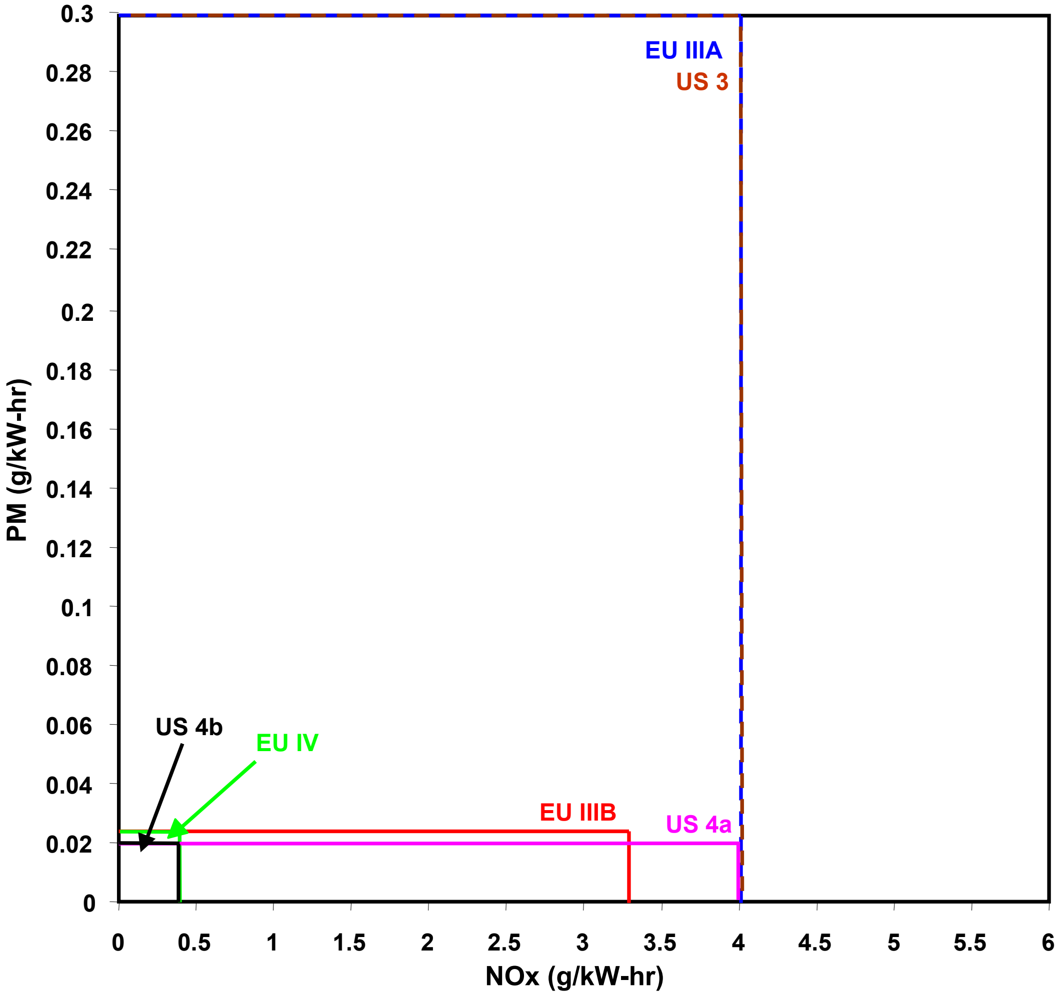
NAC
Johnson Matthey Development Facility



Beyond 2010
The Off Road or Non Road Sector

- Generally covers engines used in mobile sources such as:
  - Construction machines
  - Materials handling equipment
  - Mining and quarrying
  - Agricultural and forestry equipment
  - Airport ground equipment
  - Locomotives and trains
  - Inland boats
- Similar number of engines used in off road as in buses & trucks
- Legislation requiring emissions after treatment is in place in EU and US and will take effect from 2011
- Similar technology requirements

HDD
Non Road Regulation Development



Regulation is by engine power. The chart and table show information for 100kW engines, eg construction. Limits for larger engines are tighter and implemented sooner; those for smaller engines less stringent and later.

Europe	New Models	All Models
Stage IIIB	Jan 2011	Jan 2012
Stage IV	Oct 2013	Oct 2014
United States		
Tier 4a	Jan 2011	Jan 2012
Tier 4b	Jan 2014	Dec 2014

Heavy Duty Diesel
Summary

- OE sales start in Europe and Japan mid 2005, followed by US 2007
- Retrofit sales continue throughout the period
- By end of calendar 2008, HDD market sales $600m excluding precious metals
- By end of calendar 2006, market sales should be around $200m
- Off road OE regulations begin 2011
- JM has a full range of technologies for emission control
- JM has extensive retrofit experience and OE relationships
- JM will be market leader

Johnson Matthey Fuel Cells

the power within

Update on Market Developments And Swindon Facility

Dr Jack Frost

Director, Fuel Cells

Key recent developments in the market

- Substantial interest in hydrogen drives fuel cell automotive programs
- Hybrid vehicle success show the way for fuel cell vehicles
- Experience in real applications provides guidance on improvements in fuel cell systems and MEA materials
  - Durability issues delay the anticipated early market for stationary applications
  - Automotive plans on track but all car companies emphasise need for further advances before key commercialisation decisions.
- Considerable interest in smaller early markets eg DMFC and battery replacement

Hydrogen

- **Hydrogen addresses many of society's needs**
  - **reduce oil and gas imports – energy security**
  - **reduce CO_2 emissions - global warming**
  - **improve local air pollution – quality of life**
  - **prepare for (ultimately) limited fossil fuel resources**
- **Hydrogen fuel benefits the car companies**
  - **Much smaller environmental signature for the car**
  - **More competition in fuel supply**

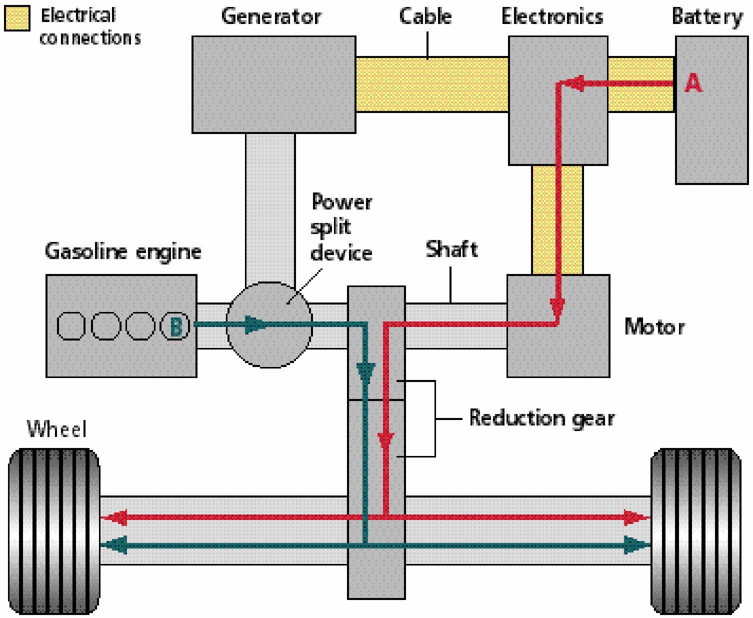
Hydrogen and Fuel Cell Vehicles

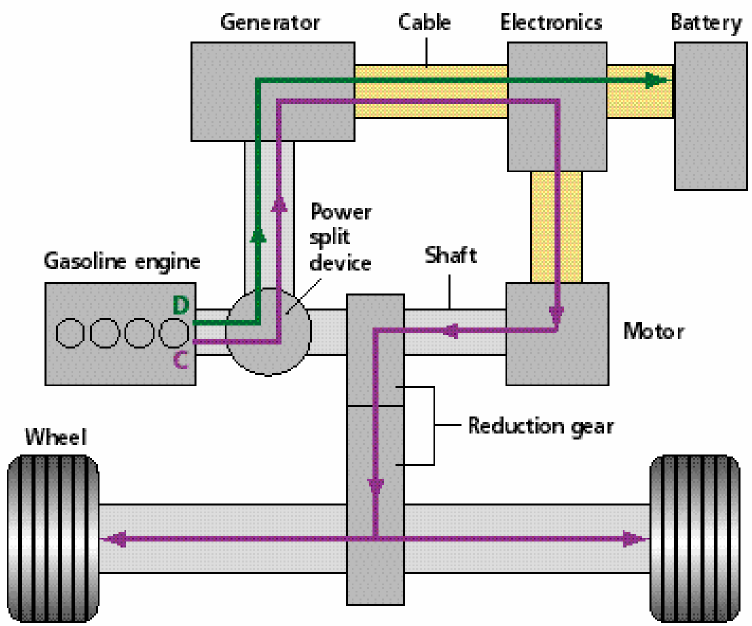
- If hydrogen is the preferred fuel – fuel cells are the preferred power source
- For the fuel cell car this raises 3 questions
  - Source and efficiency of (renewable) hydrogen production
  - Hydrogen storage
  - Hydrogen supply infrastructure
- Car companies emphasise the hydrogen “problem” but believe the Fuel Cell car is the way forward.

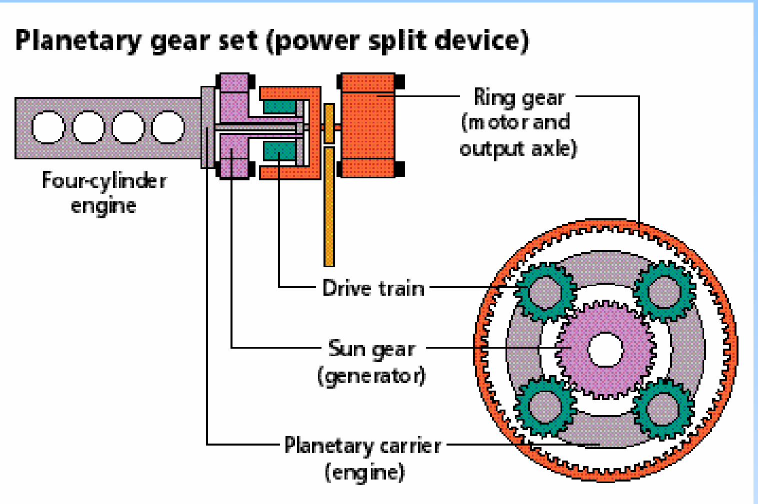
Hybrid vehicles

- Hybrids are the route to fuel cell vehicles
  – Electric vehicle components, supply, cost and reliability
  – Customer and society acceptance
  – leading to competition by the OEM's
  – Complex configuration and expensive batteries make fuel cell substitution attractive

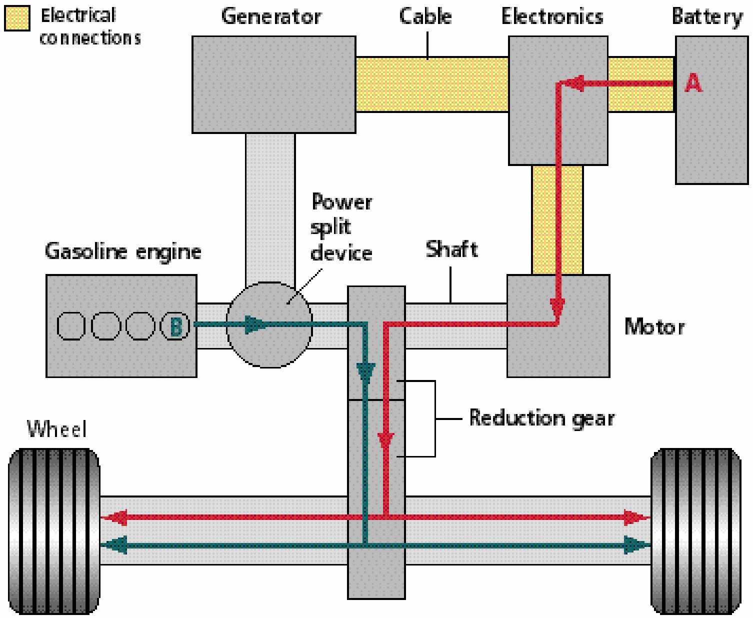
- Hybrid introduction experience curve provides a model for fuel cell introduction

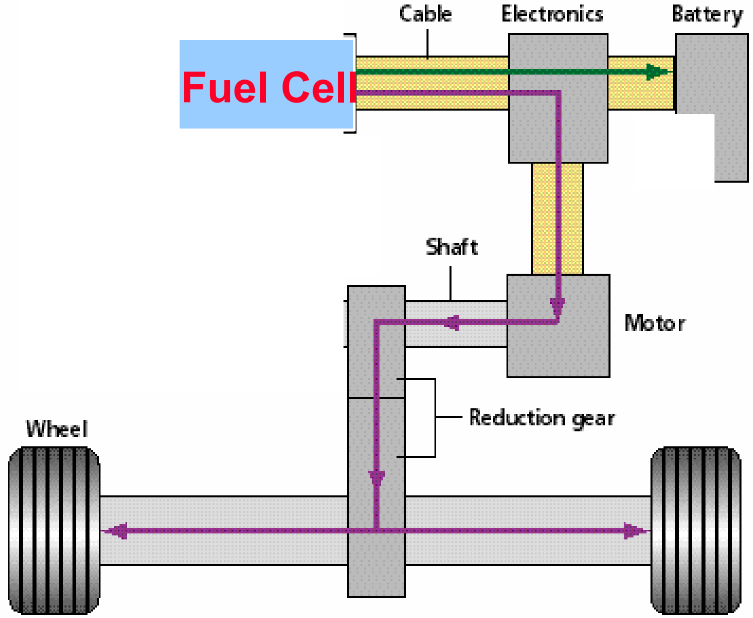






Source: Toyota Motor Company

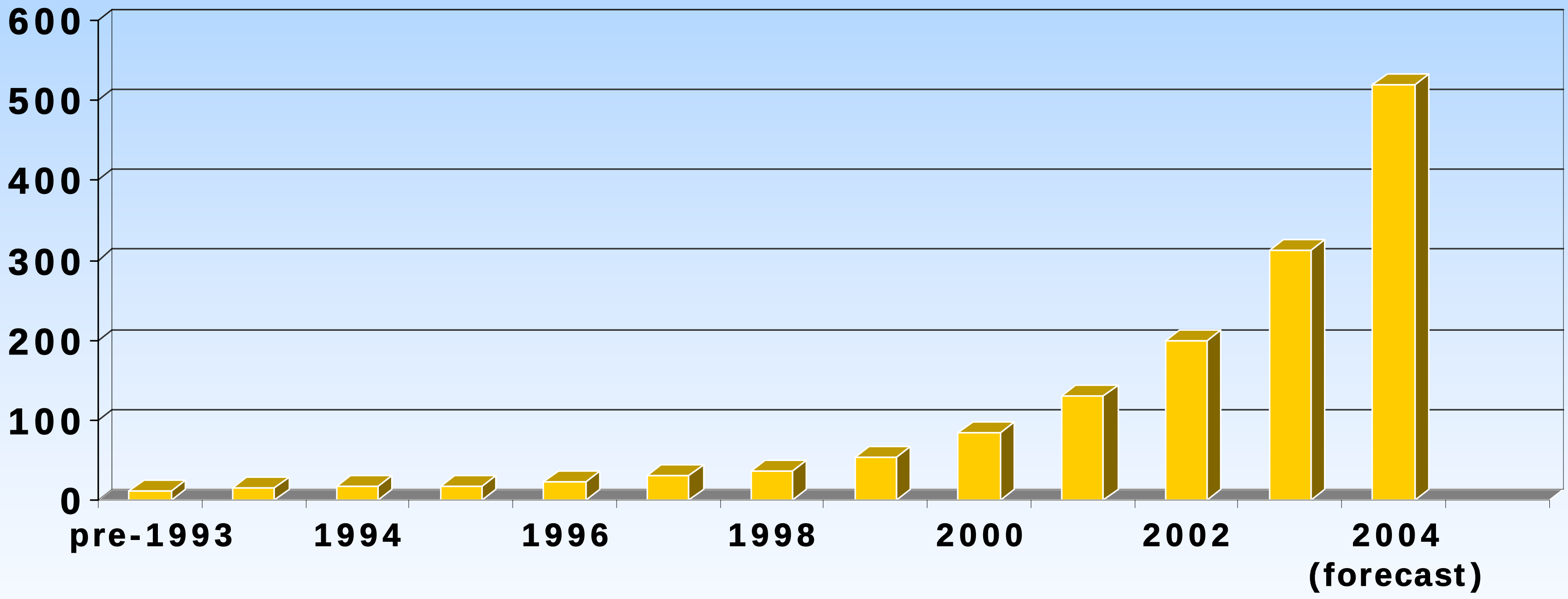




Some routes to Fuel Cell Vehicles

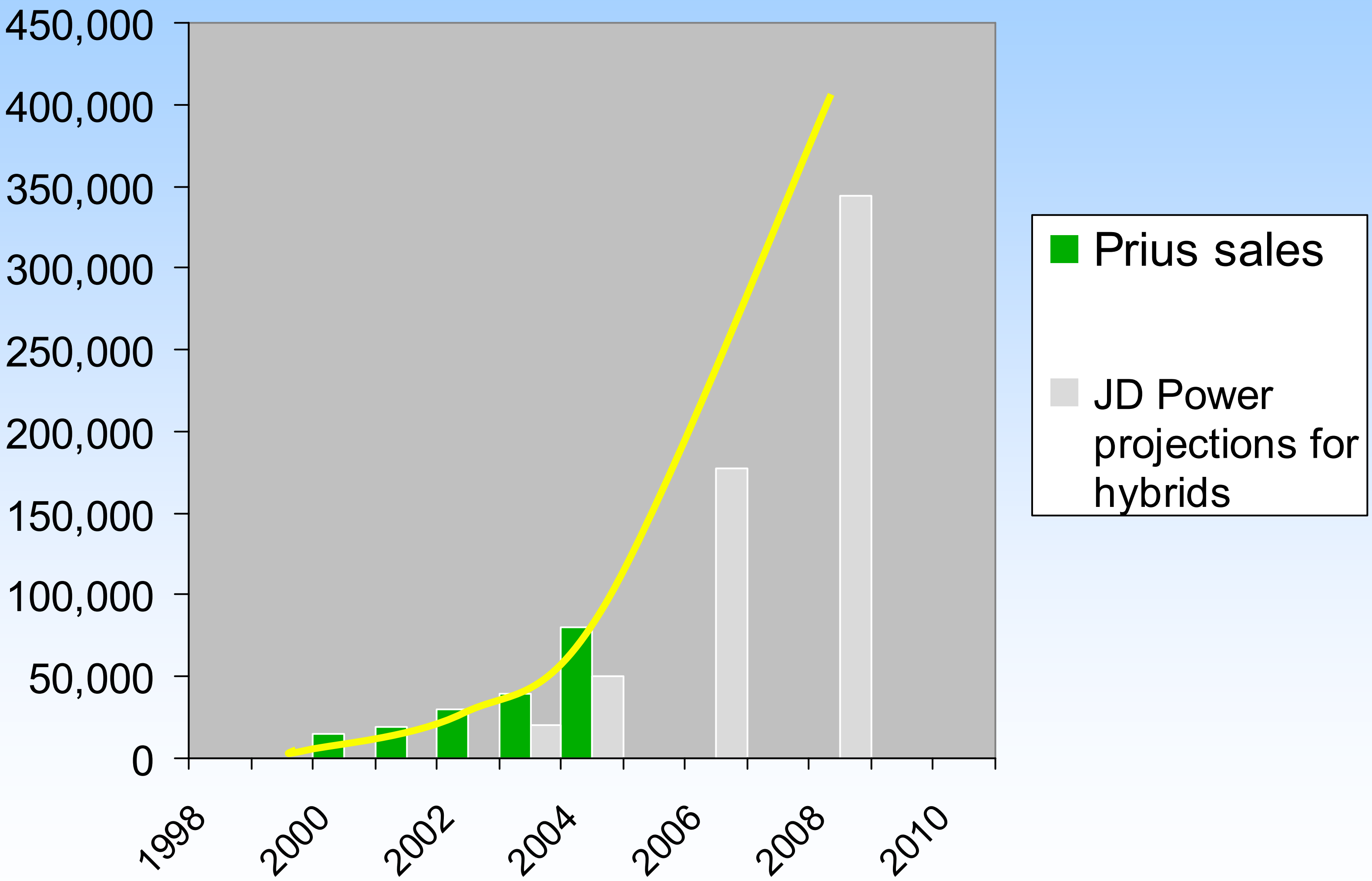
1. 100% fuel cell car
2. Auxiliary power fuel cell
3. Fuel Cell Hybrid cars

Numbers of fuel cell cars to date

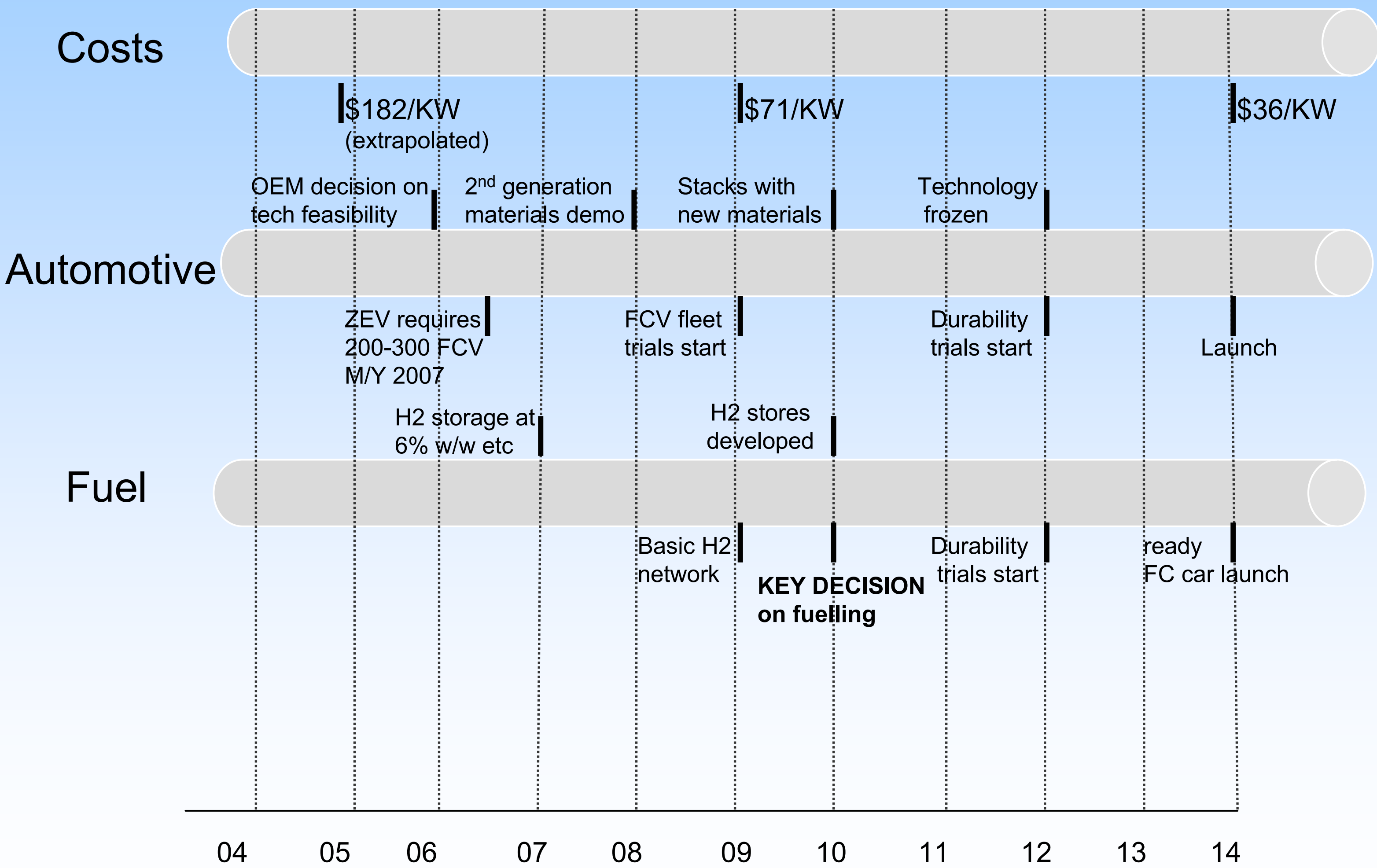


Source: General Motors

Hybrid car annual production



Automotive fuel cells time line



Conclusions

- Market development in stationary is slower than hoped
- Early market smaller and more fragmented
- Automotive programs on schedule
- Strong drivers underpin the market

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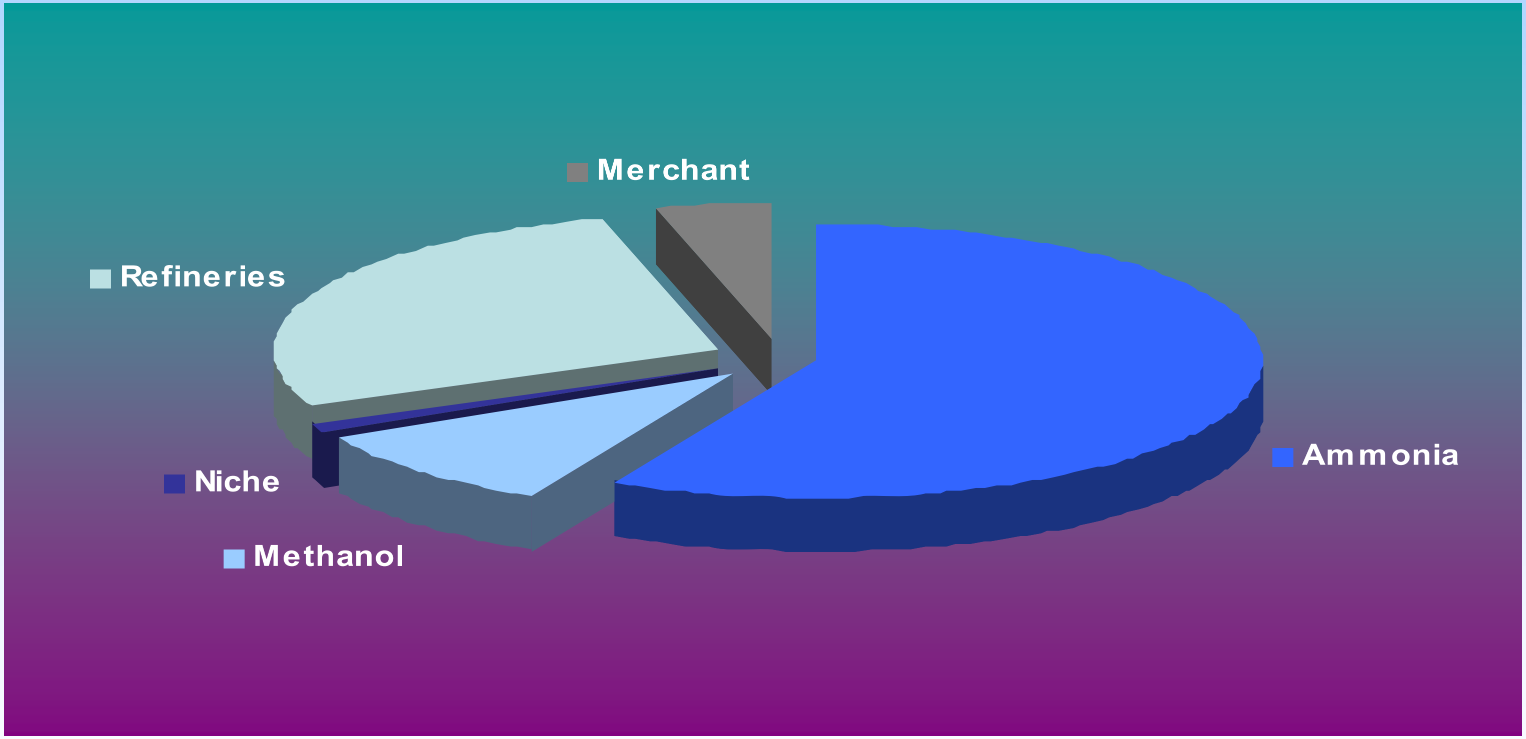
Catalysts

The Hydrogen Market

Dr Pelham Hawker

Executive Director, PCT

Global Hydrogen Consumption



Source: SRI International – August 2004. World consumption of intentionally produced or merchant hydrogen

Global Hydrogen Consumption

Ammonia

- Fertiliser
- Explosives

Methanol

- Acetic Acid
- MTBE
- Formaldehyde

Refining

- Purify Oil
- Upgrade Oil

Niche & future

- Edible Oils & Fats
- Electronics
- Gas To Liquids
- Coal To Liquids
- Fuel Cells

- Population
- Mining

- Construction
- Fuel
- Regulation (US)

- Clean Fuels
- Tighter Engine Specs
- Heavier Crude Oil

- Clean Feedstock
- Political Uncertainty
- Global Warming

JM Participation in Hydrogen Production

Ammonia

- 369 plants
- £125m pa catalyst market
- JM Global #2

Methanol

- 89 plants
- £30m pa catalyst market
- JM Global #1

Refining

- 670 plants
- £80m pa catalyst market
- JM Global #2

Niche & future

- Enormous potential from Gas To Liquids

JM

Global Hydrogen Production Today

Steam Reforming (90% of intentionally produced hydrogen)

- Primary method of manufacturing hydrogen
- Natural gas or naphtha is feedstock

Partial Oxidation

- Non Catalytic process reacting hydrocarbons at high temperatures & pressures to make Syngas

Bi-Product Generation

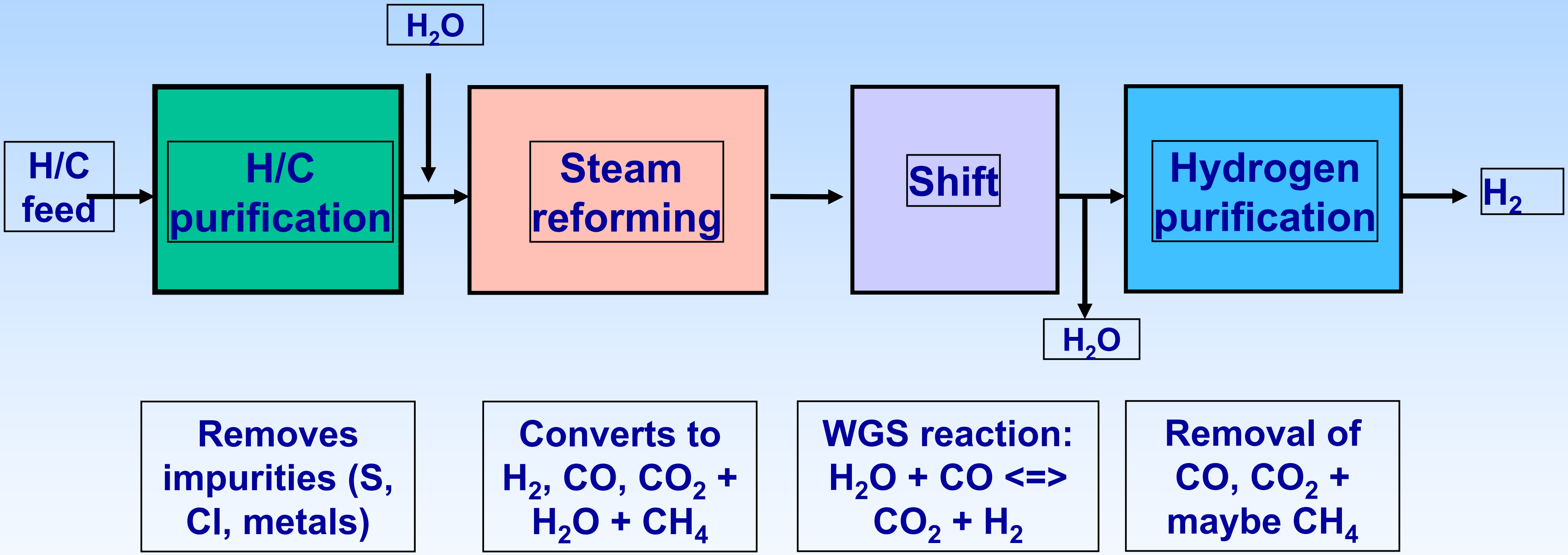
- Catalytic Reforming – usually directly consumed
- Requires sulphur and chloride purification and PGM recycle

Electrolysis

- Very small and high electricity requirement
- Primary use to produce high purity hydrogen

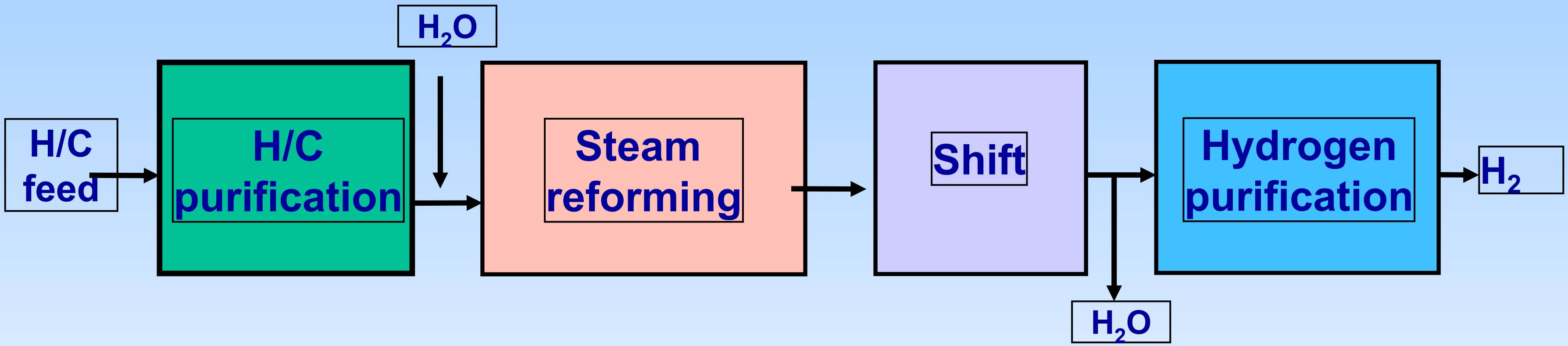
Steam Reforming H_2 plant

- Simplified process step and reaction



Steam Reforming H_2 plant

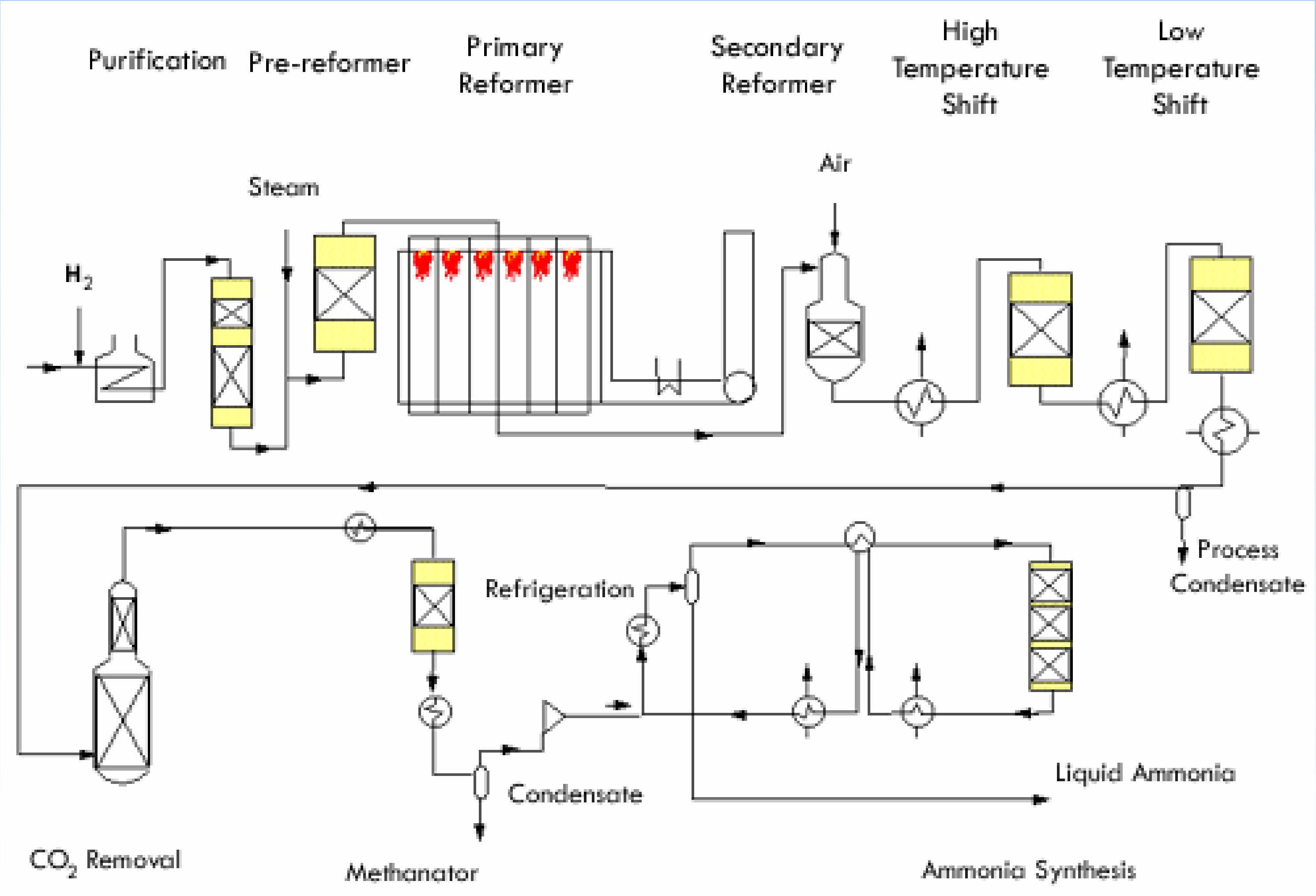
- Typical Catalyst Type and Volumes



HDS 15 m^3 Zinc Oxide 20 m^3	Pre reformer 10 m^3 Primary reformer 45 m^3	HTS 40 m^3	100 mmscfd Hydrogen plant
HDS 15 m^3 Zinc Oxide 30 m^3	Primary reformer 45 m^3 Secondary reformer 35 m^3	LTS 90 m^3 HTS 60 m^3	2000 tpd Ammonia plant (Plus 90 m^3 Amm. synthesis)
HDS 20 m^3 Zinc Oxide 70 m^3	Pre reformer 20 m^3 Primary reformer 150 m^3		5000 tpd Methanol plant (Plus 150 m^3 Meth. synthesis)

JM

Ammonia Plant Flowsheet



Catalyst Improvements

- Generic:
  - Increase selectivity, activity, stability
- Purification (PURASPEC™):
  - Trend to tighter impurity levels (ppb)
  - Improve poison pick up per unit volume
- Steam reforming:
  - Improvements in heat and mass transfer
  - Increase throughput of process
  - Increase ability to handle process upsets
  - Increase activity for operating cost and capital cost saving
- High Temperature Shift:
  - Increase stability to survive boiler leaks
  - Increased activity to generate more hydrogen
- Low Temperature Shift:
  - Increased selectivity to reduce methanol bi-product
- Methanol Synthesis:
  - Increased activity to produce more methanol

Latest Syngas Research Rig

JM

Gas Heated Reformer

- Capital savings:
  - 5-10% capital advantage ($1bpd in GTL)
- Efficiency savings:
  - 7.5% feedstock efficiency ($0.3 bpd in GTL)
- Reduction in CO_2 emissions:
  - 25% reduction in typical GTL plant
  - Significant emission credits in some locations
- Technology status:
  - Proven mechanically (15 year references)
  - More aggressive process conditions in GTL requires improved metallurgy (MDU)

JM GHR at Coogee, Australia

Material Demonstration Unit

JM

one

SYNERGY

JM

Johnson Matthey

Catalysts

Davy Process Technology

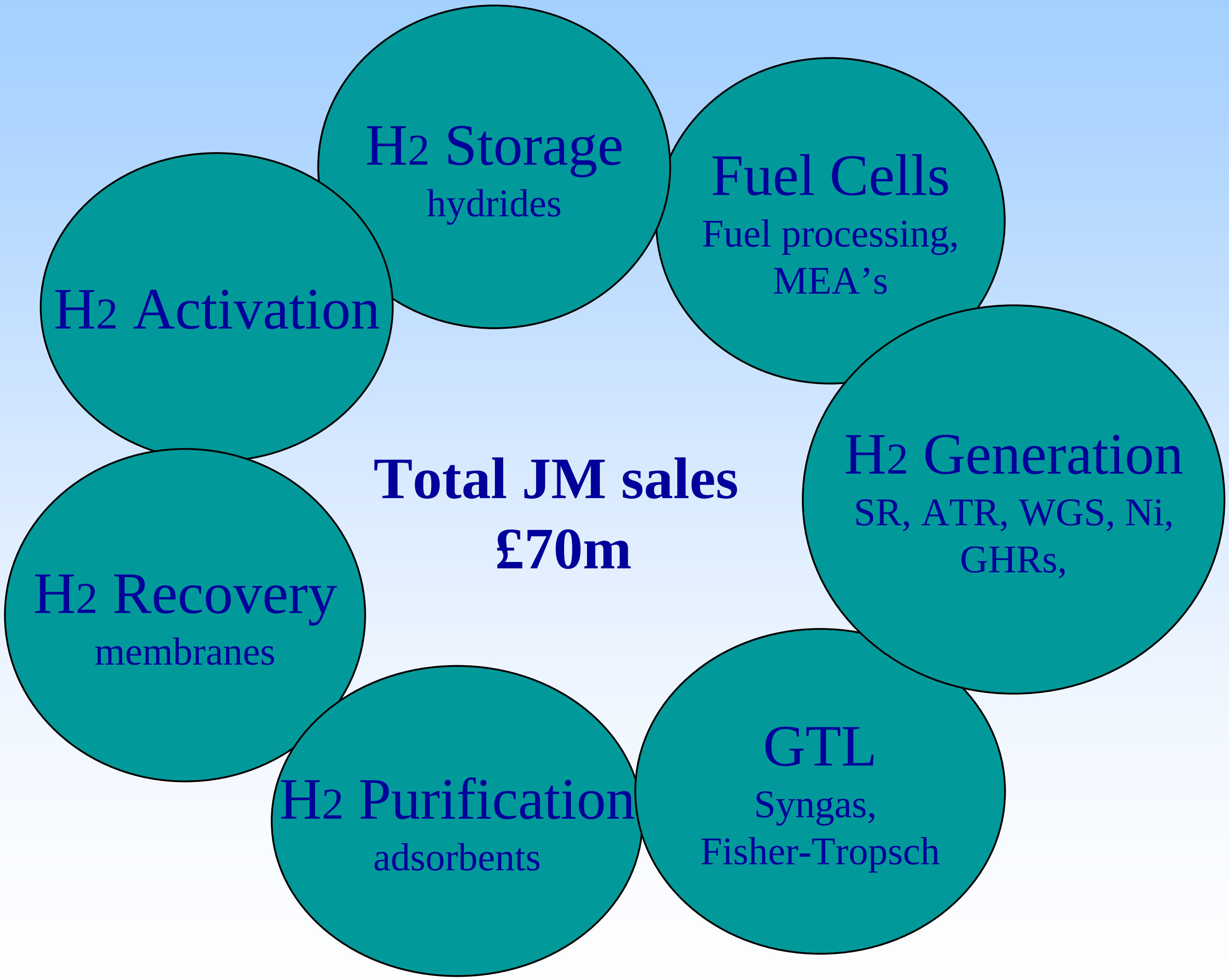
AKER KVÆRNER™

- World-class **technology**
- High performance **catalysts**
- Conceptual **design** and **licensing**
- Basic and detailed **engineering**
- **Procurement** and **construction**
- **Commissioning** and **start-up**
- Ongoing **operational support**

Strengths that are unique and complementary

- Know-how in purification, steam and compact reforming, methanol technology and catalysis
- Proven technology including that used for the largest plant currently under construction - 5400 tpd
- Extensive design & construction experience
- Off-shore oil and gas expertise

JM Hydrogen capabilities



Johnson Matthey
Catalysts

Johnson Matthey
Catalysts

Dr Barry Murrer

Director, JMTC

The problem

- For 500km range a fuel cell powered car needs to store 6kg of hydrogen on board (cf ~35 kg gasoline for ICE powered vehicle)
- 6kg hydrogen is equivalent to 81,000 litres of hydrogen gas at atmospheric pressure –6 times the volume of this room

Hydrogen storage –a technology barrier?

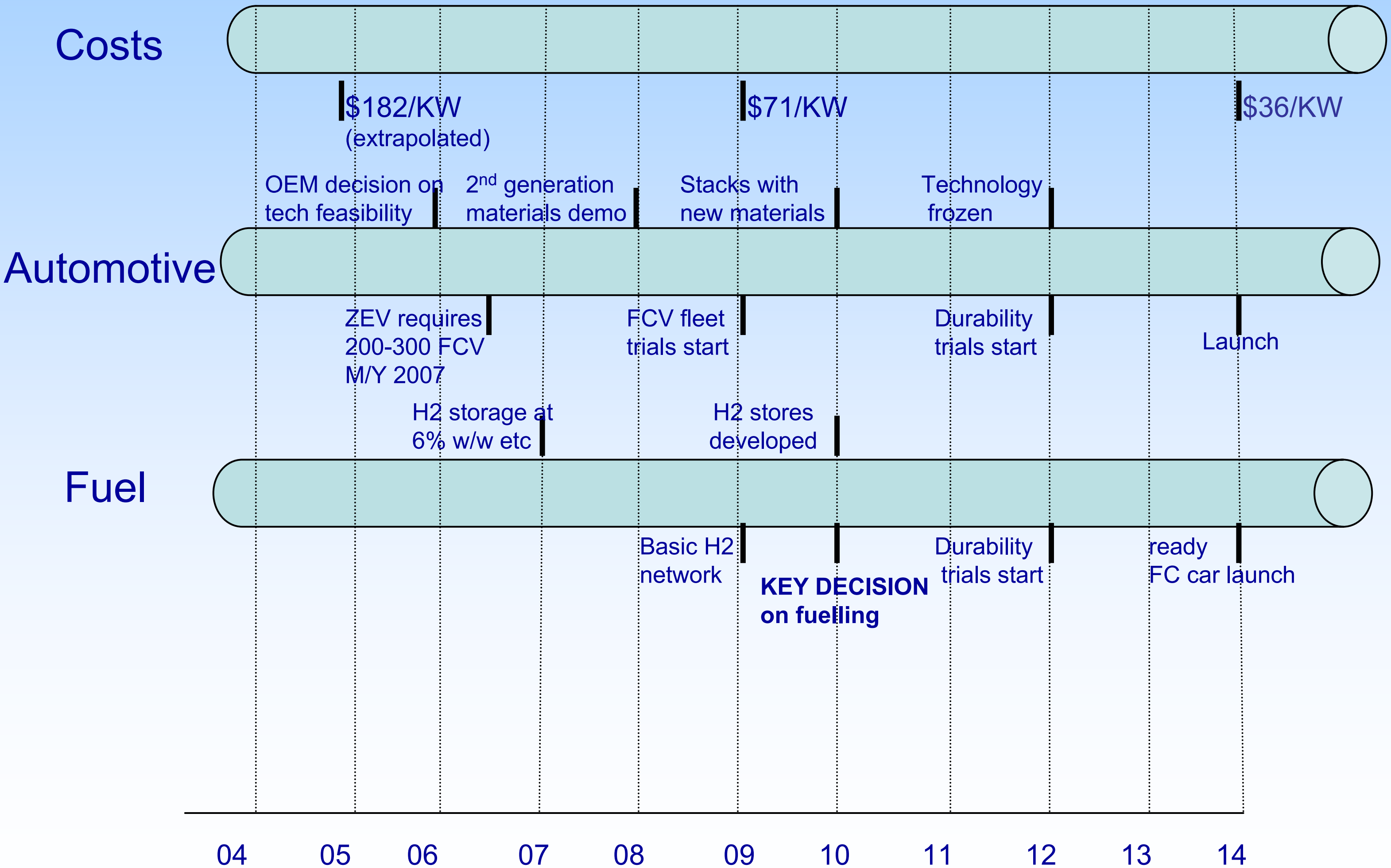
- UK DTI acknowledges that '..hydrogen storage is the fundamental technical barrier to the more widespread use of hydrogen' www.dti.gov.uk/renewables/publications/pdfs/technologies/tech11.pdf
- US DoE '..hydrogen storage is a key enabling technology. None of the current technologies satisfy all the H storage attributes sought by manufacturers and end users...' http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/national_h2_roadmap.pdf

What do we need? US hydrogen storage roadmap

store parameter	units	2005	2010	2015
Specific energy	kgH_2/100kg system	4.5	6	9
Energy density	gH_2/l system	36	45	81
Storage system cost	\$/kgH_2 capacity	200	133	67
Refuelling rate	kgH_2/min	0.5	1.5	2
Loss of H_2	(g/h)/kg stored	1	0.1	0.05
Cycle life	Cycles(1.4 to full)	500	1000	1500

Source: US Department of Energy

Automotive fuel cells time line



What have we got?
Options for on-board storage

Compressed hydrogen

Liquid hydrogen

Solid state hydrogen store

Compressed hydrogen

- Hydrogen in steel or composite cylinders
- High pressure
- Heavy and bulky
- Good for buses, demonstration cars


Fuel Cell Bus
Oxford Circus
25
CITARO
fuel cell powered
no emissions
hydrogen
fuel
FUEL CELL

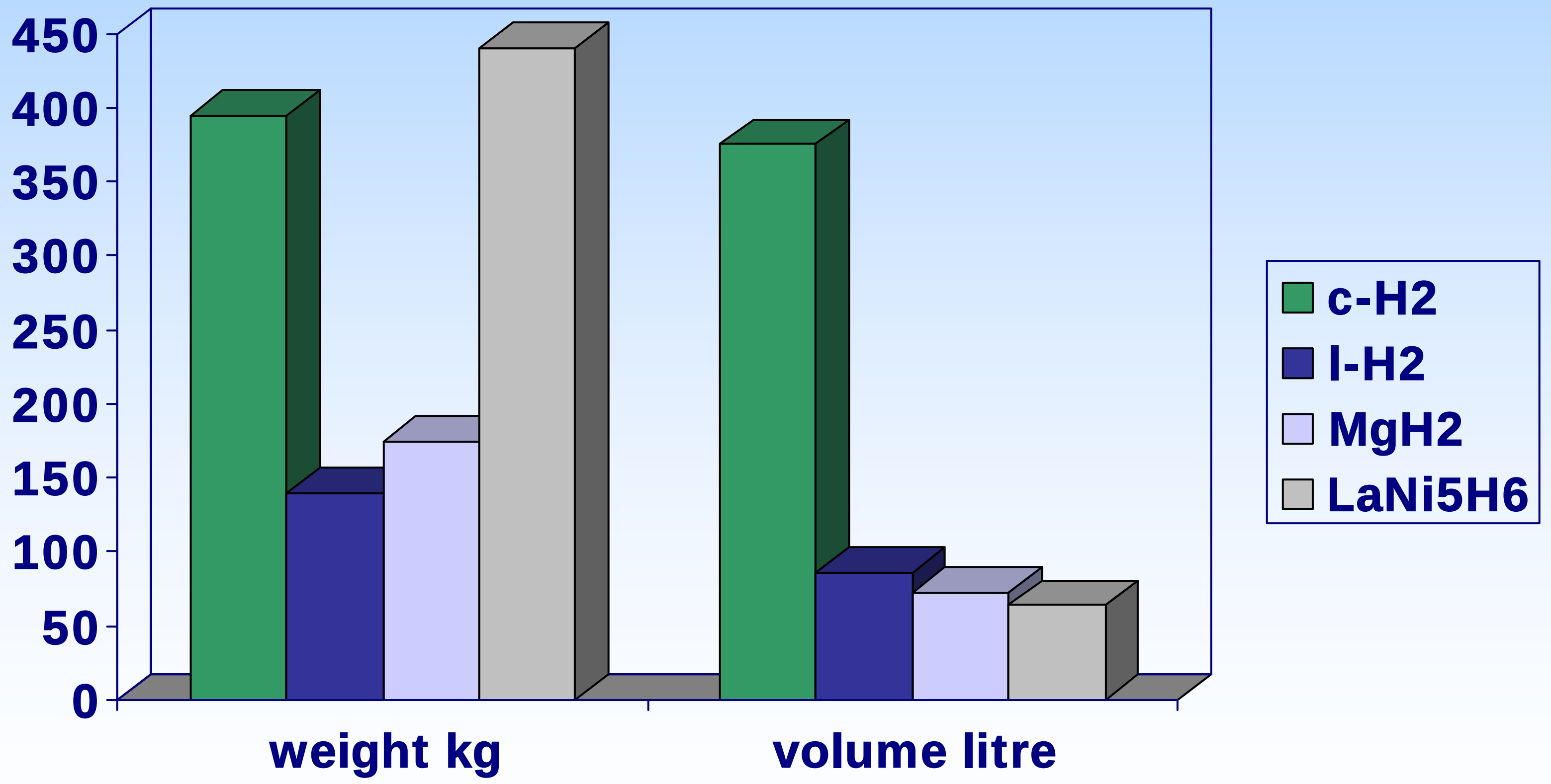
Liquid hydrogen

- Cryogenic storage at – 253 deg C
- 30% of the energy in hydrogen is needed to cool it to this temperature
- Constant 1-3% boil off rate
- Being evaluated in some demonstrators, but unlikely to be viable

Solid state hydrogen stores

- Hydrogen stored in a metal alloy with chemical bonds to metal atoms
- Can be reversible
- Can store more hydrogen than the same volume of liquid hydrogen
- Can operate close to atmospheric pressure
- Can operate from –20 to + 300 deg C depending on metal alloy
- But... no current alloy meets all criteria for commercial use

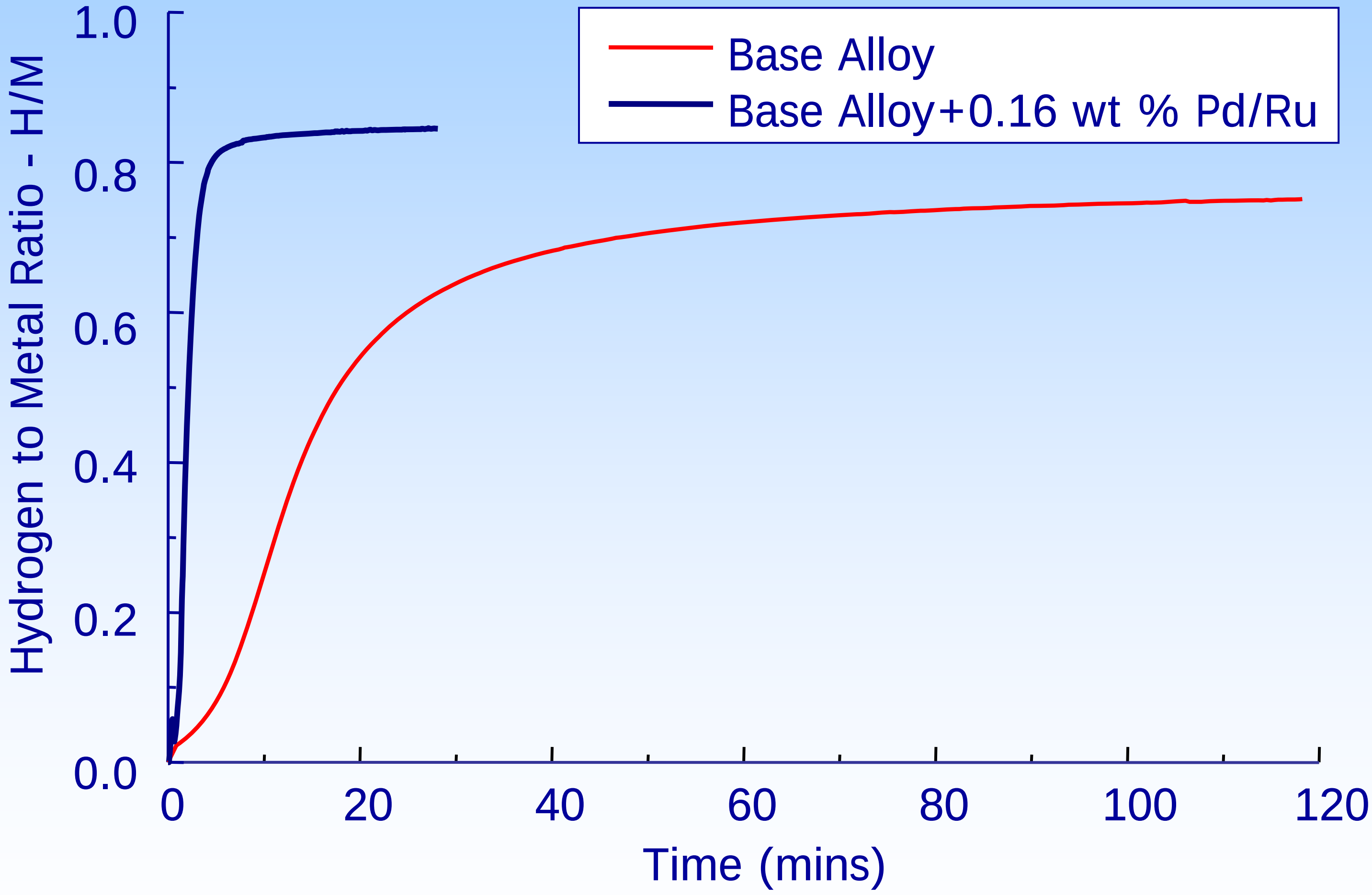
Storage options compared: 6 kg H_2, system weight and volume



Known reversible solid state hydrogen stores

- AB_5 eg $LaNi_5H_6$ room temperature but only 1.36 wt% hydrogen
- AB eg $FeTiH_2$ 1.87 wt% hydrogen
- MgH_2 7.6 wt % hydrogen, but only works at 300 deg C –needs to absorb/desorb hydrogen faster at lower temperature to be useful
- No known, reversible , safe hydrogen stores with higher capacity

The effect of Pd activation on $LaNi_5$



Latest estimate of JM position on roadmap

store parameter	units	2005	2010	2015
Specific energy	kgH_2/kg system%	4.5 √	6	9
Energy density	gH_2/l system	36 √	45	81
Storage system cost	$/$kgH_2$ capacity	200 √	133	67
Refuelling rate	kgH_2/min	0.5 √	1.5 √	2
Loss of H_2	(g/h)/kg stored	1 √	0.1 √	0.05 √
Cycle life	Cycles(1/4 to full)	500 √	1000	1500

UK hydrogen energy strategic framework- December 2004

www.dti.gov.uk/energy/sepn/hydrogen.shtml

Johnson Matthey
Catalysts

Glossary of Terms

Product Technologies	
CRT®	Continuously regenerating trap
CCRT®	Coated continuously regenerating trap
CSF	Catalysed soot filter
DOC	Diesel oxidation catalyst
DPF	Diesel particulate filter
EGR	Exhaust gas recirculation
EGRT®	EGR + CRT®
NAC	NOx Adsorber catalyst
SCR	Selective catalytic reduction
SCRT®	Selective catalytic reduction + CRT®
Emissions	
CO	Carbon monoxide
HC	Hydrocarbons
NOx	Nitrogen oxides
PM	Particulate matter
General	
HDD	Heavy duty diesel
OE	Original equipment
Fuel Cells	
DMFC	Direct methanol fuel cell
ICE	Internal Combustion engine
LCA	Life cycle analysis
MEA	Membrane electrode assembly
PEM	Proton exchange membrane