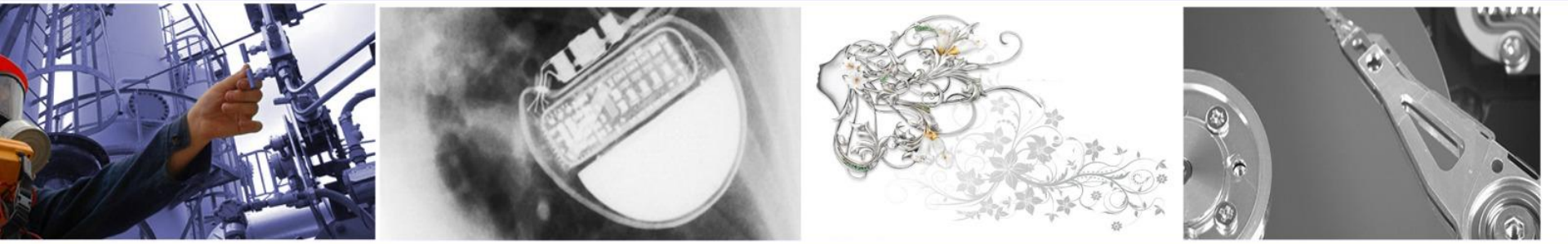
Lonmin Plc

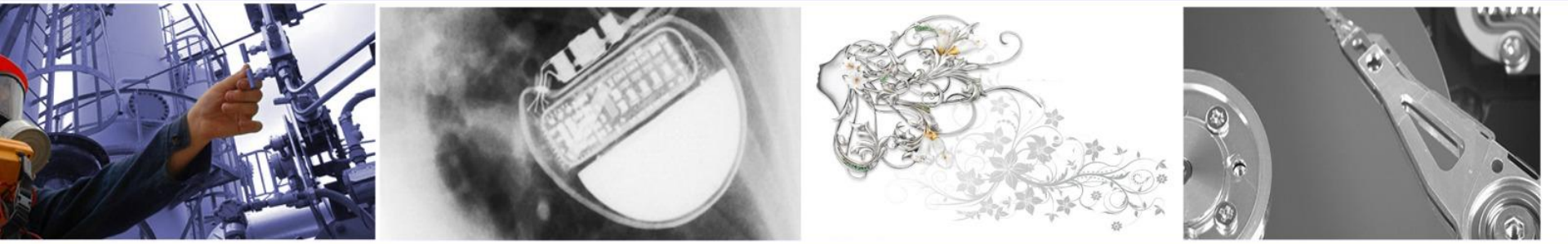


Markets Day – 7 October 2011

Powertrains and Power Struggles

Agenda

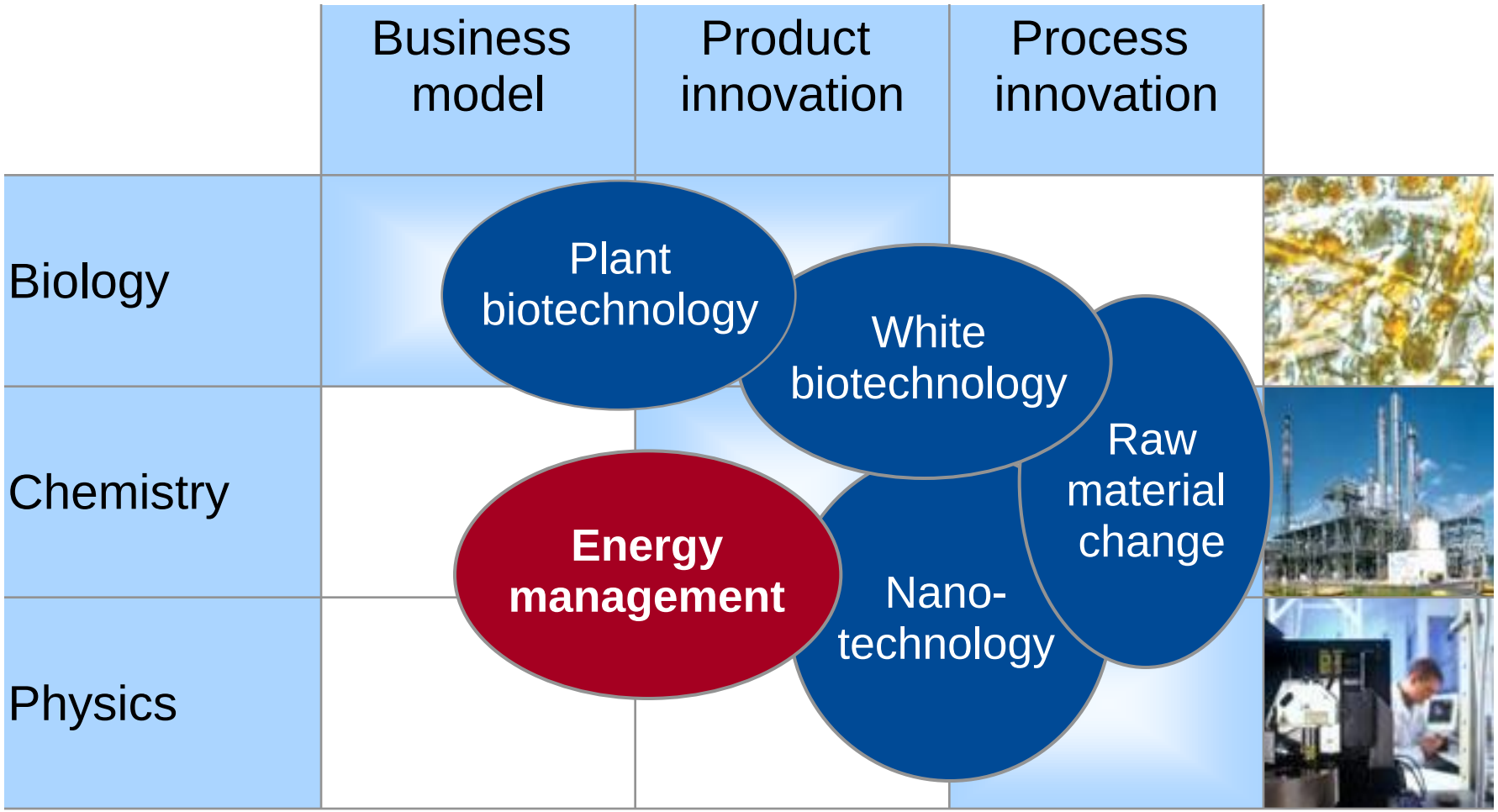
- 14h00 Introduction
- 14h05 Fuel Cells Update (Dr Emory De Castro)
- 14h45 Fuel Cells & Catalysis (Dr Bob Farrauto)
- 15h30 Tea/Coffee break
- 16h00 Lonmin View (Troye Brady & Wilma Swarts)
- 16h30 Q & A



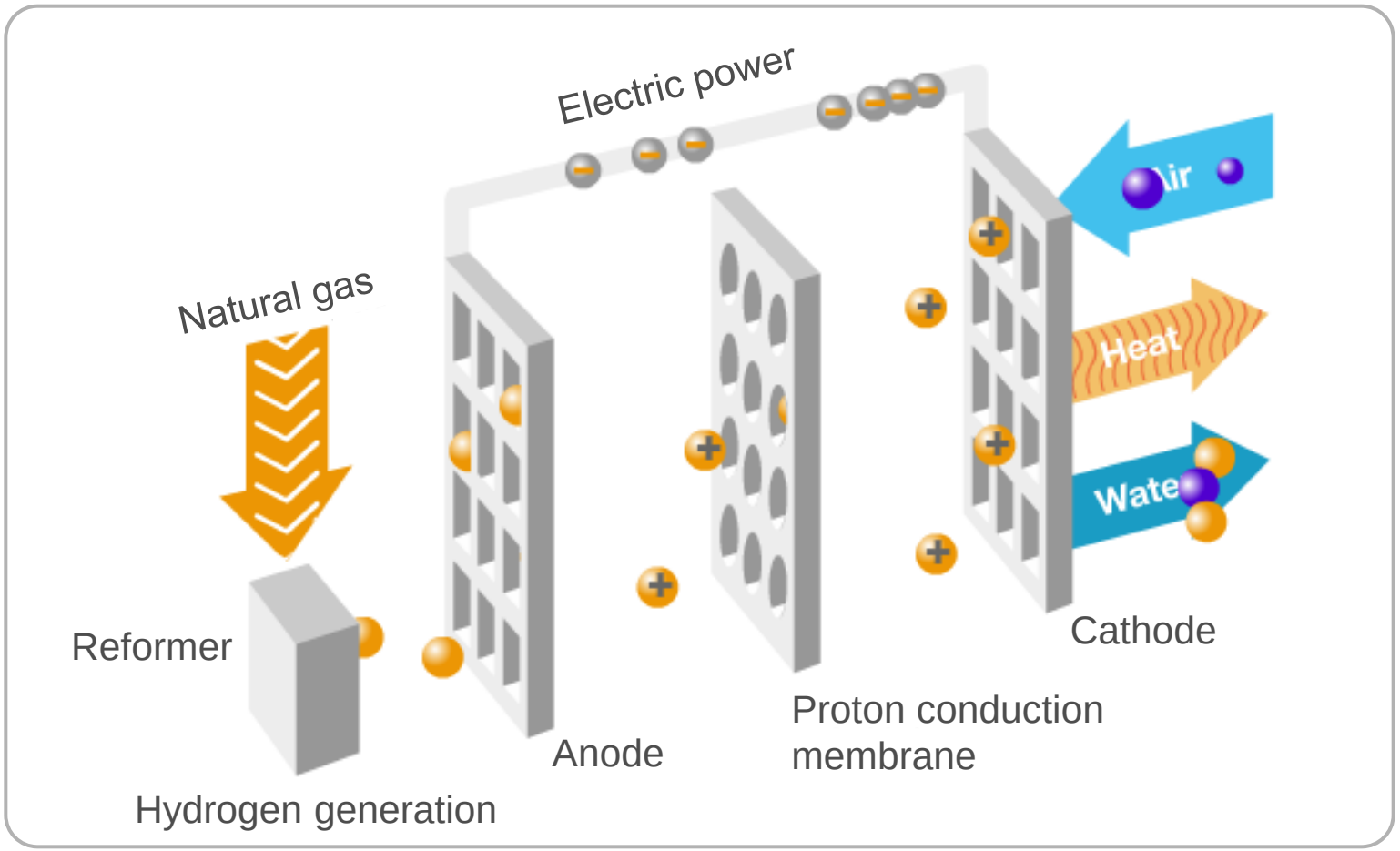
Fuel Cells Update – Dr Emory De Castro

Energy Management
BASF Growth Cluster Strategy

BASF
The Chemical Company



Concept of a Fuel Cell
Heat can be a Product



Fuel Cells offer an electric efficiency of 40-60%

Fuel Cell Energy Chain

Solar Energy
Wind Energy
Hydropower

Hydrocarbons
-Methanol
-Diesel
-Natural gas

Electrolysis

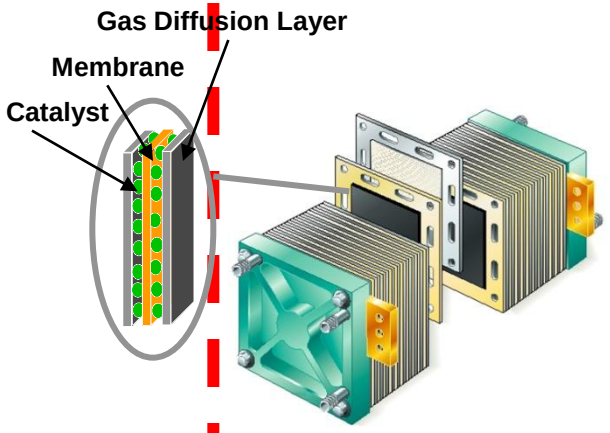
Gas Processor

Hydrogen

Fuel Cell System

Electrical Power

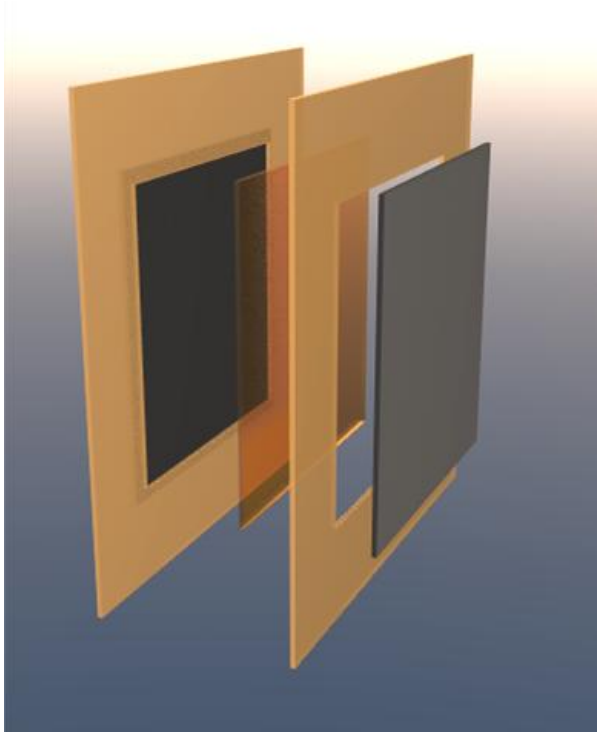
Heat Power

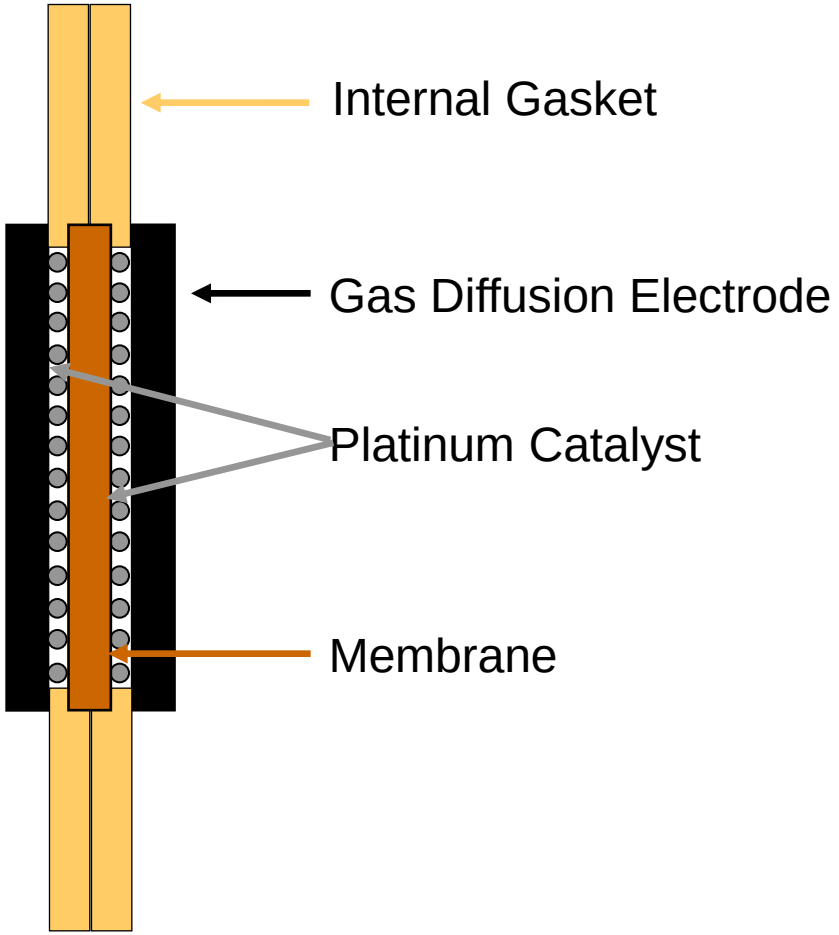


Celtec® MEA

Membrane Electrode Assembly (MEA)

5 Layer Assembly





Celtec® MEA for Power Generation

5 Layer Membrane Electrode Assembly

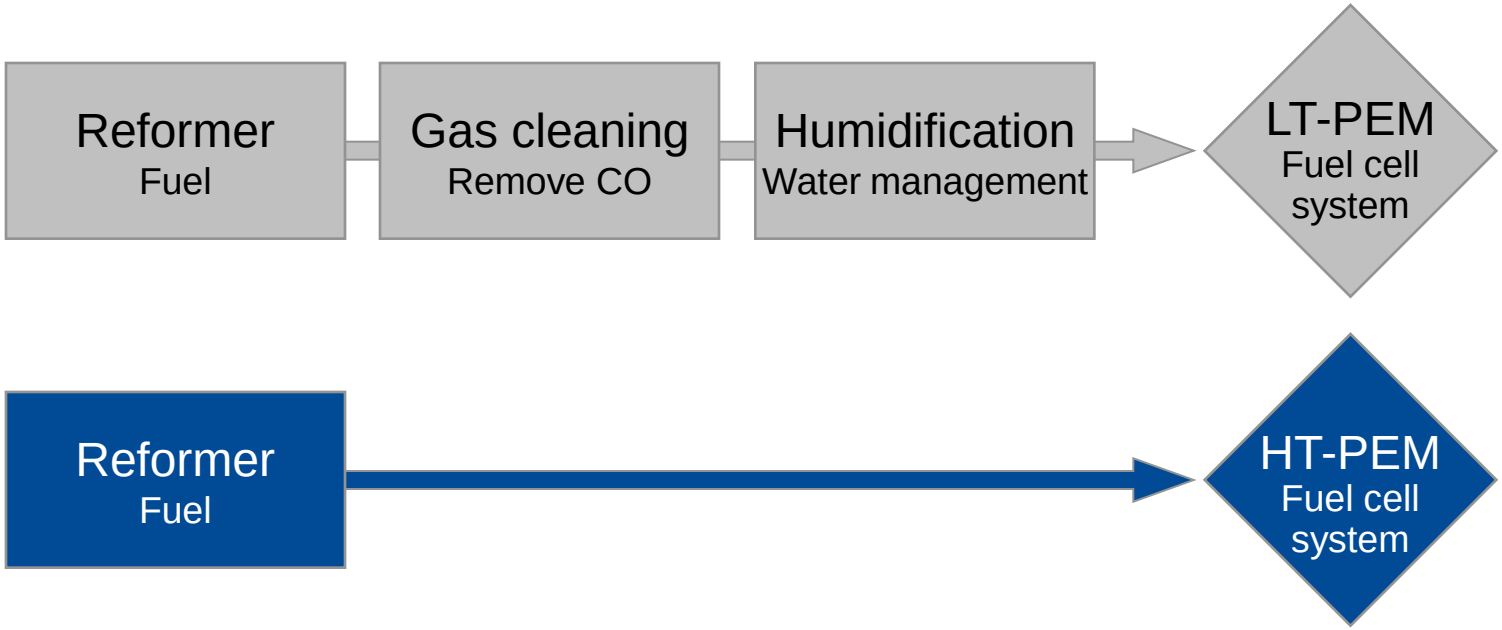
BASF
The Chemical Company

Unique characteristics:

- High operating temperature (120 to 180 °C)
- A hybrid of proven phosphoric acid technology with the simplicity of a polymer membrane electrode assembly
- No humidification necessary
- Tolerance to impurities in hydrogen gas

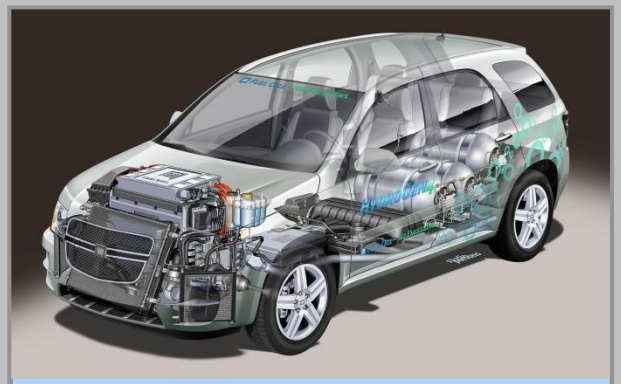
Benefits of HT PEM Technology

Reduction of System Complexity



HT-PEM technology enables simplified and cost-effective fuel cell systems

Potential Fuel Cell Markets
Overview



Automotive (GM HydroGen 4)

Auxiliary power units (APU)

Back up power, e.g. Telecom

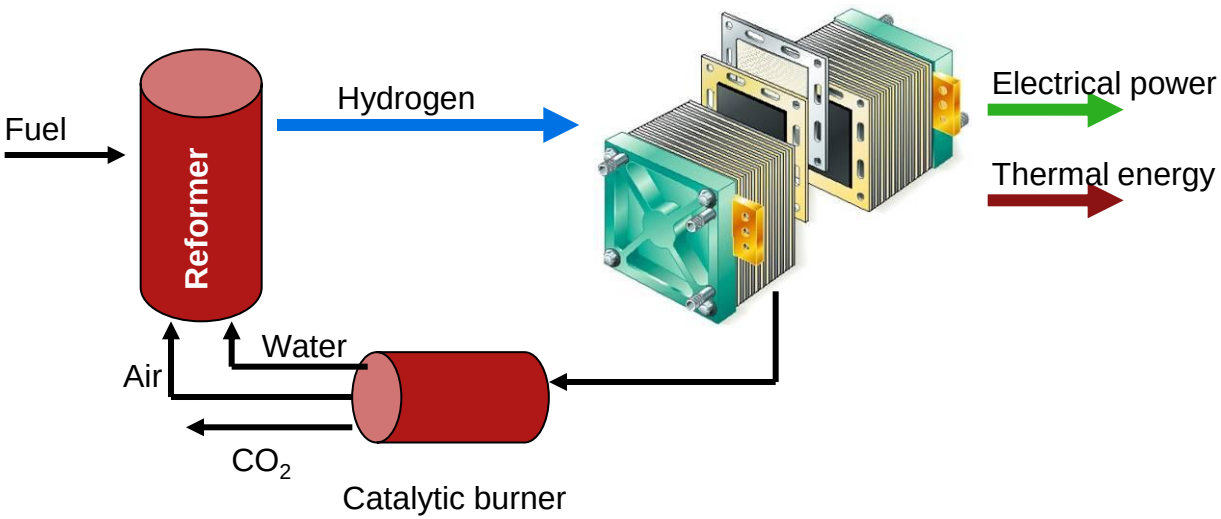
Combined heat and power (CHP)

Key Assumption

- Hydrogen Economy is a long term venture
- There is a drive to more efficient use of hydrocarbons
  - ➔ Distributed generation with natural gas, JP8 (military), diesel & propane

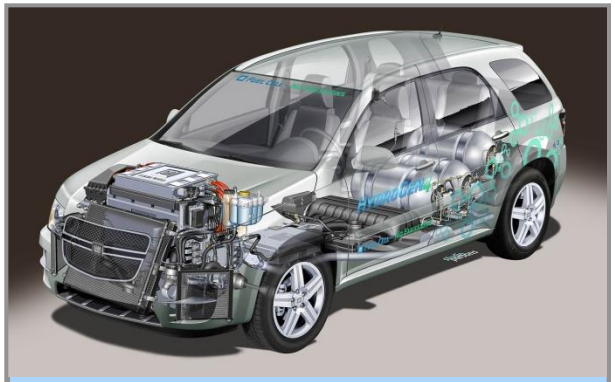
Electric Vehicle with FC Range Extender

- Recharge battery with liquid-fed fuel cell: use as heating element
- Reform MeOH, gasoline, diesel, or NG/propane



"For a $35k car, the Chevy Volt has meagre cabin heating when all-electric."

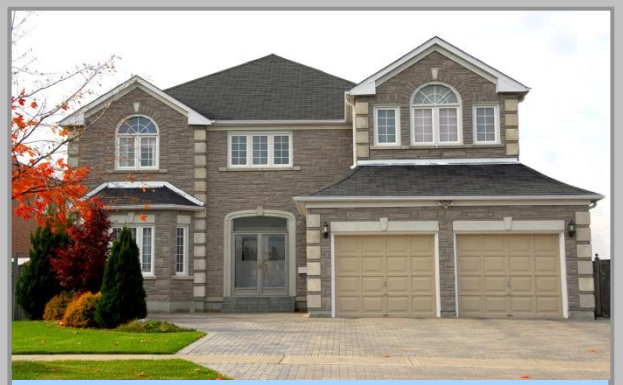
Potential Fuel Cell Markets



Automotive (GM HydroGen 4)

Auxiliary power units (APU)

Back up power, e.g. Telecom



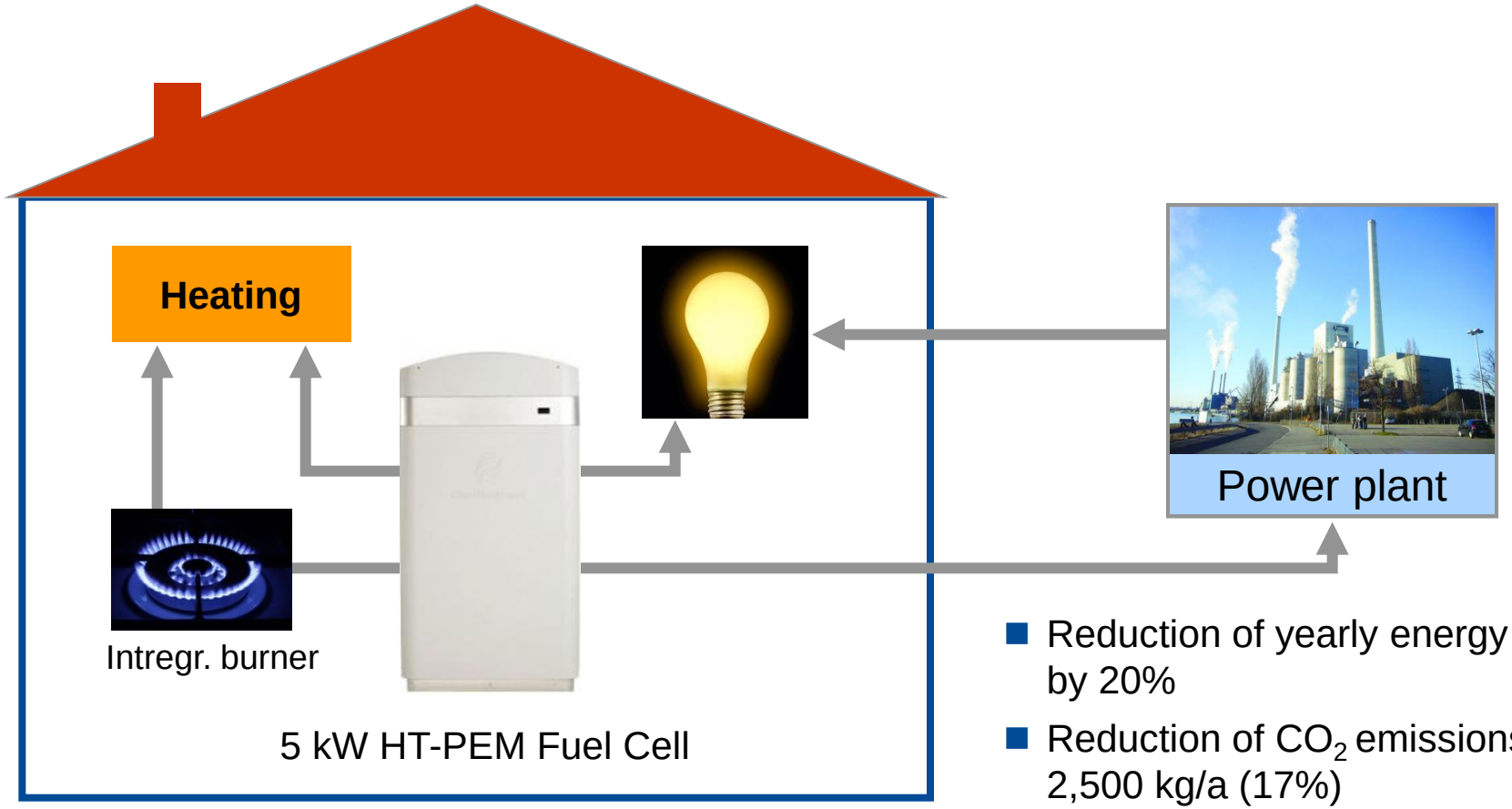
Combined heat and power (CHP)

Micro Combined Heat and Power (µ-CHP)
Driving Forces

- Smart Grid – distributed power
- Insufficient power grid capacity – free capacity of natural gas pipelines
  - ➔ Avoiding high investment in power grid infrastructure
- Opportunity for Natural Gas supplier
  - ➔ New market for gas supplier
- Increasing share of volatile renewable energy sources – virtual power plant
  - ➔ 100,000 µCHP with 1kW power supply ≡ 100MW coal based power plant
- The public tends to oppose the construction of new large-scale power plants
- Reduction of CO_2 emissions will become mandatory

Fuel Cells in the µCHP Market

Energy Cost and CO2-Calculation for Single Family House



- Reduction of yearly energy costs by 20%
- Reduction of CO_2 emissions by 2,500 kg/a (17%)

µCHP Market – Competitive Technologies

Overview

BASF
The Chemical Company

Electrochemical energy transformers (fuel cells):

HT-PEM

LT-PEM
(low temperature)

Solid oxide fuel cell
(SOFC)

Phosphoric acid
fuel cell (PAFC)

Molten carbonate
fuel cell (MCFC)

Mechanical-thermal energy transformers

Stirling

Combustion engine

Micro turbine

Power plant + heating

Fuel cells offer in general a high energy efficiency but suffer from undemonstrated long-term durability and higher cost per kW

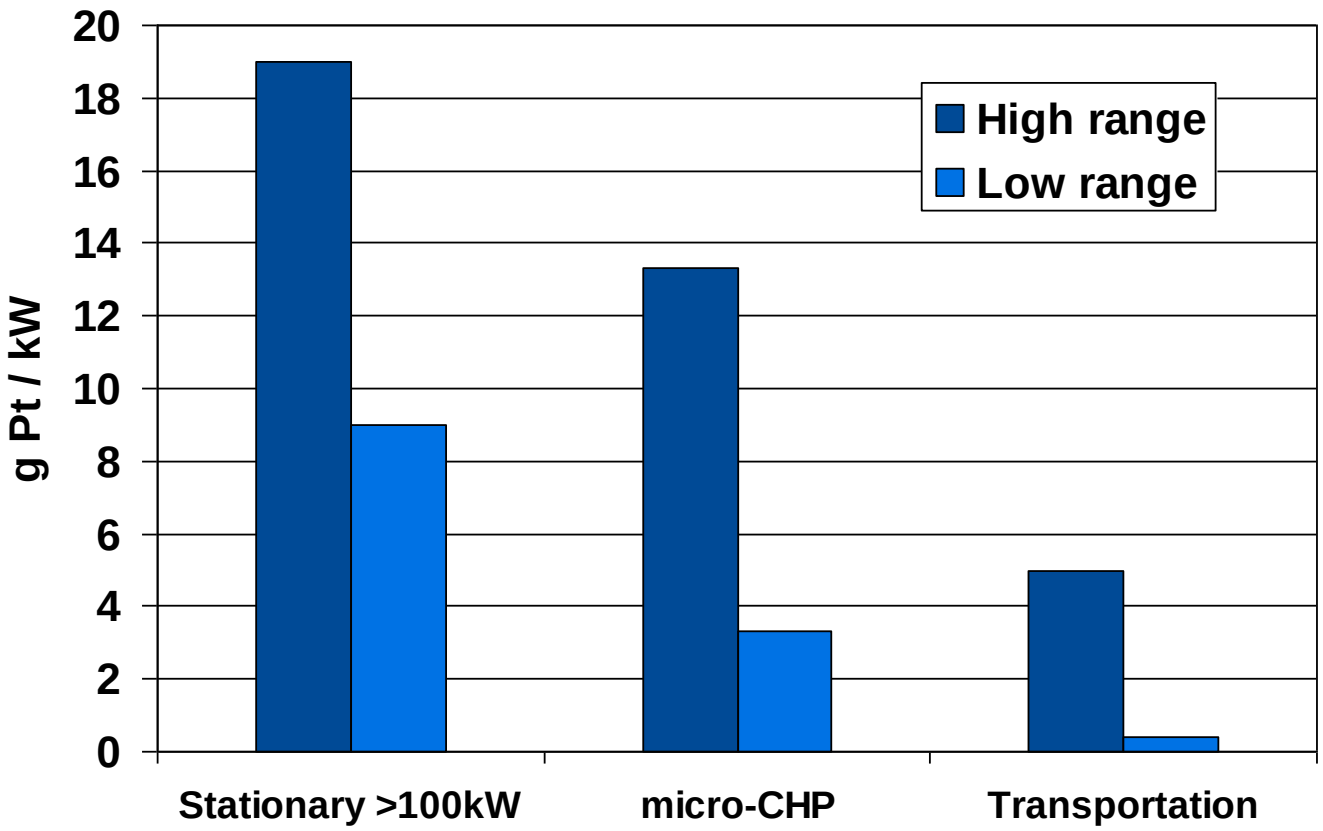
µCHP Market – Competitive Technologies

Comparison

BASF
The Chemical Company

	 HT-PEM	 Combustion engine	 Power plant + heating
Market players	ClearEdge Power	Honda, VW	Utility companies
Operation Temp.	170°C	< 1000°C	> 700°C
Power eff.	45%	22%	35-45%
Overall eff.	90%	85%	60-70%
Strength	efficiency	tech. maturity, durability	maturity, durability
Weakness	durability, cost	efficiency, vibration	efficiency, emission

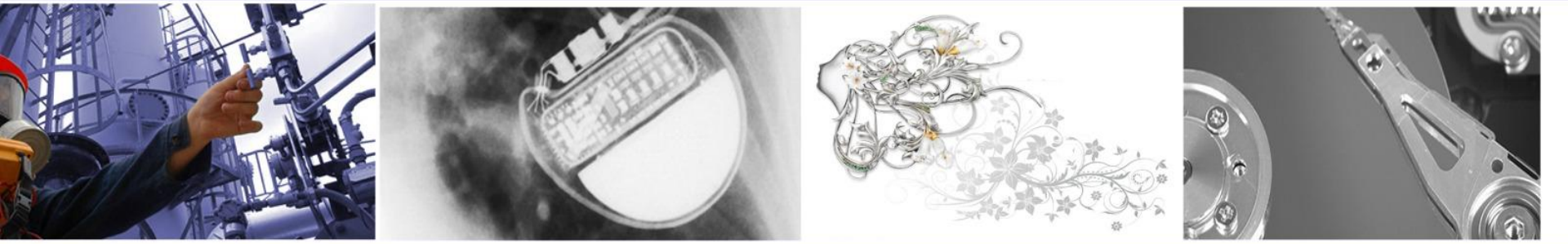
Typical Platinum Usage



Transportation life expectation 5,000 hrs, therefore lower Pt

Concluding Summary

- Fuel cell technology is used commercially today: >8,000 µ-combined heat and power systems in Japan alone
- Stationary power will be a near term opportunity
- BASF FC's main target market for high temperature membrane electrode assemblies is µ-CHP systems.

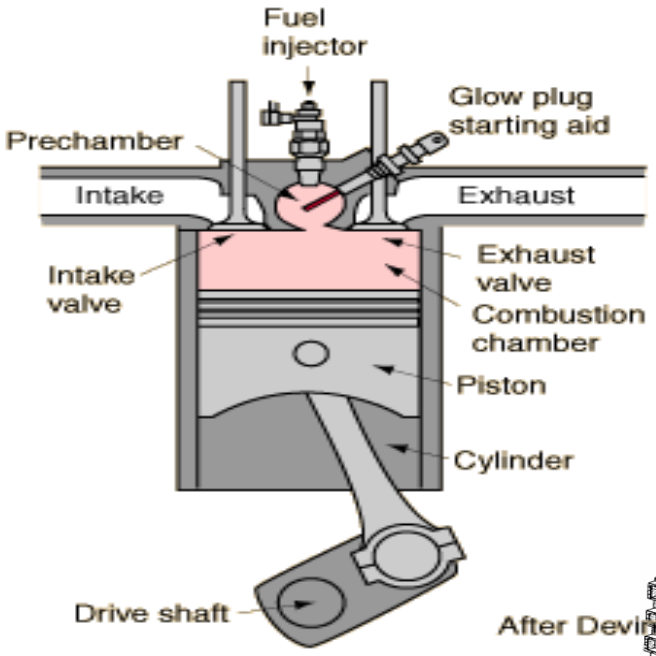


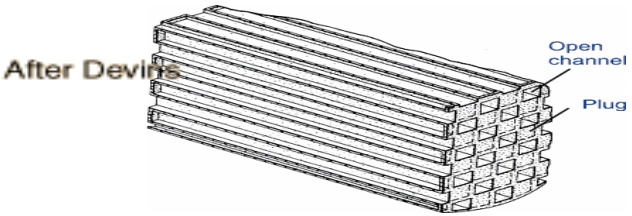
Fuel Cells & Autocats – Dr Bob Farrauto

Diesel Emission Control

BASF
The Chemical Company

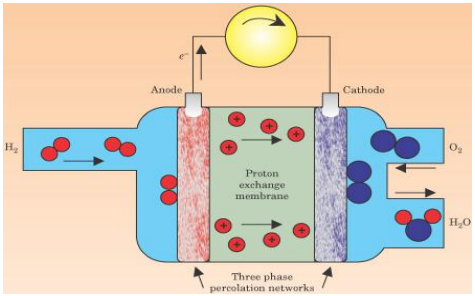
DIESEL EMISSION CONTROL



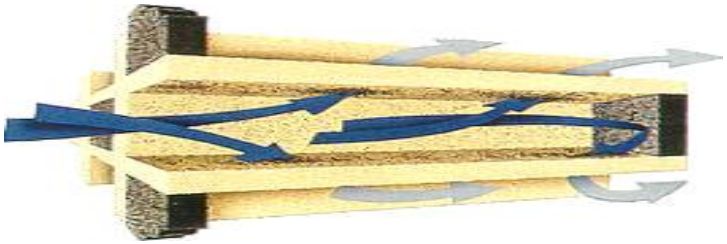


H_2 FOR FUEL CELLS

H_2



O_2



Fuel Cell Advantage

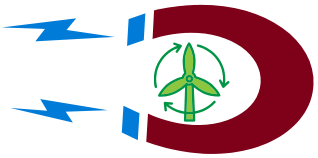
- No combustion, no pollutants, product is H_2O
- No mechanical heat cycle limitation → greater efficiency
- Potential for natural sources or renewable fuels: no fossil fuel

Power plant

heat
CO
HC
NO_x

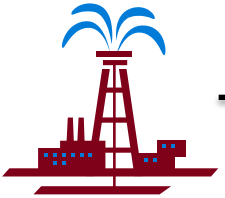
steam

Electromagnetic induction

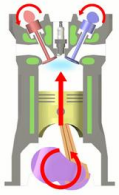


40-55% AC Electrical Efficiency

Vehicle



heat
CO
HC
NO_x



20-25% efficiency

Natural gas or E85

Catalytic reforming to H_2

$H_2 + 1/2O_2$

$H_2O + e^- +$ heat

membrane

e^-

air

50-60%

40-80% efficiency

Combined Heat and Power Fuel Cell System

BASF
The Chemical Company

New model

Left: Hot water unit Right: Fuel cell unit

Conventional model

Left: Fuel cell unit Right: Hot water unit

Panasonic/Tokyo Gas Natural Gas - 1 Kw_e ~ $17,000

Fuel Reforming Catalysts for Low Temperature Fuel Cells

BASF
The Chemical Company

MAJOR CHANGE IN HYDROGEN GENERATION TECHNOLOGY

Rh-containing catalysts will replace Ru and Ni for reforming to eliminate NH3 formation (from N2 in natural gas) for low temperature fuel cells

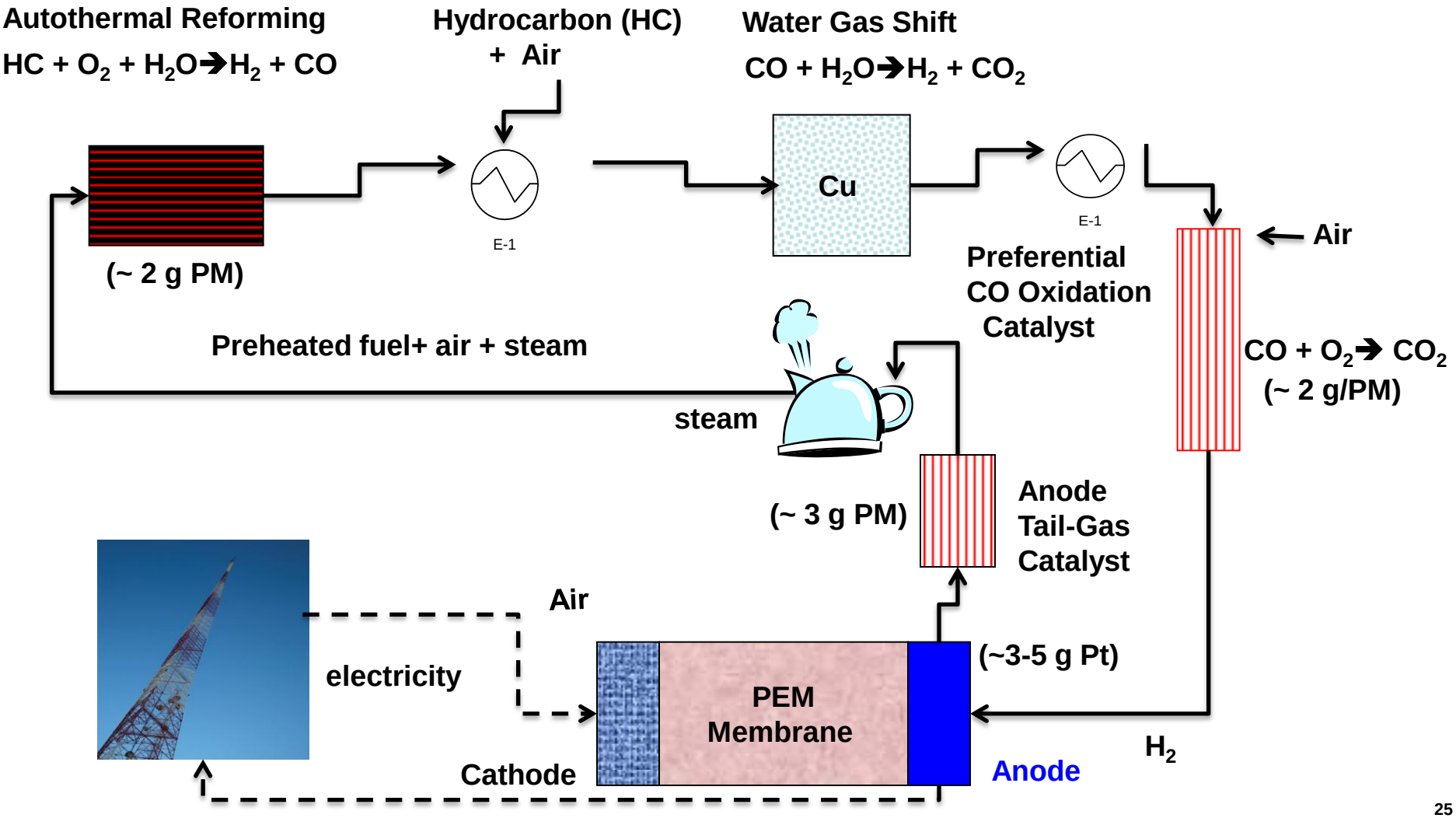
$$CH_4 + H_2O \xrightarrow{650\text{-}750^oC} 3H_2 + CO$$

$$N_2 + 3H_2 \xrightarrow{650\text{-}750^oC} 2NH_3$$

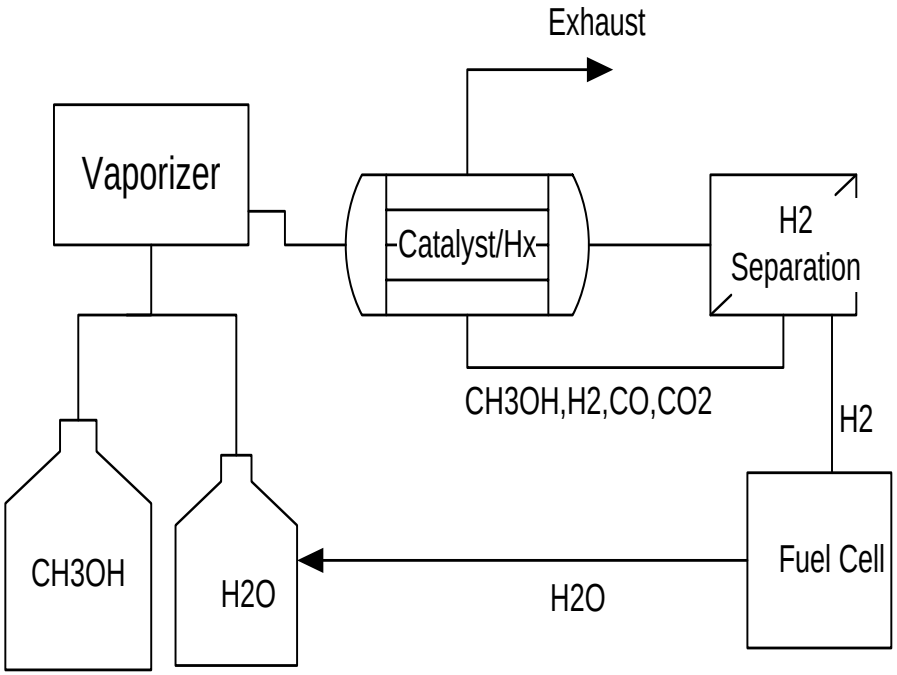
- BASF RM-75 (1Pt:3Rh, 4.2 g/liter) on Stabilized Al_2O_3 for natural gas. No ammonia production (~ 0.5-1 g PM)

- Existing Ru and Ni catalysts for fuel processing make unacceptable ammonia for low temperature fuel cells

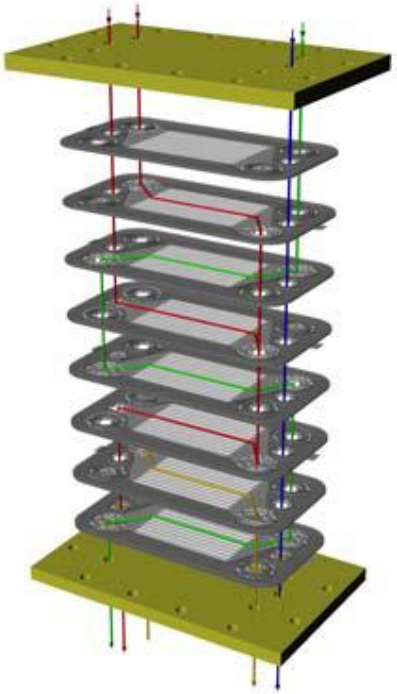
Stationary Power Generation for Cell Phone Towers (6 kw_e)



Steam Reforming for Portable Power Applications



Canister of methanol and water



Integrated Plate Reformer

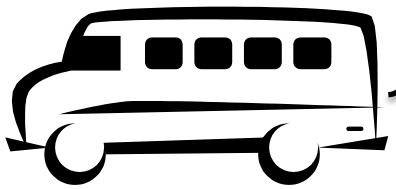
Pd// metallic foam

$CH_3OH + H_2O \rightarrow H_2 + CO\ (CO_2)$

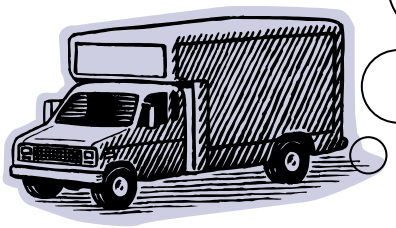
(1-2 g Pd)

250 watts: Emergency Power

Composition of Diesel Emissions

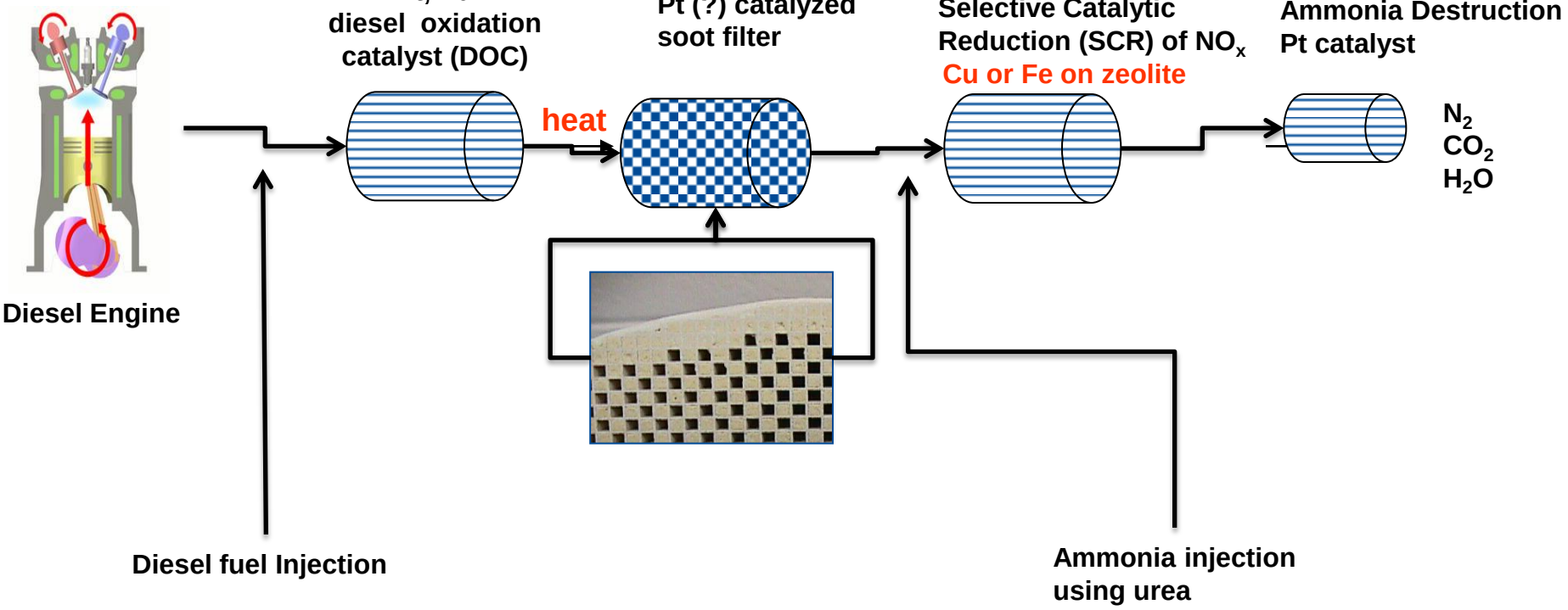


-PM (Particulate Matter)
- dry soot
- liquid particulates
- sulfates
- Carbon monoxide
- Gaseous hydrocarbons
- Nitrogen oxides

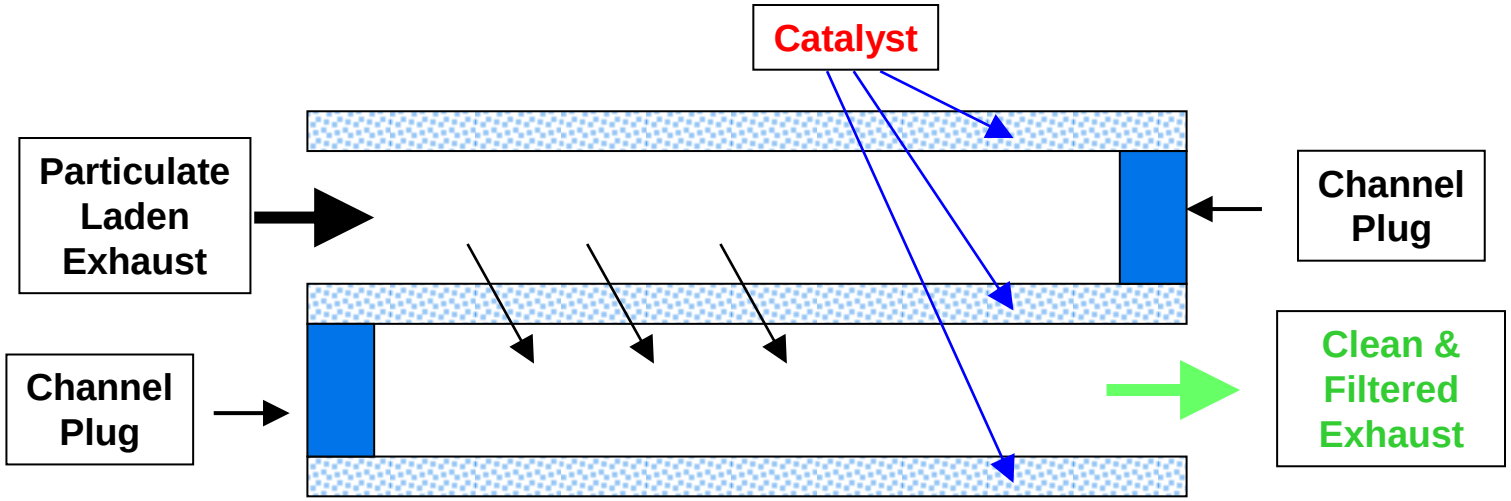


- Diesels operate with a large excess of air making them more fuel efficient with longer life than gasoline engines.

Simplified Diesel Truck and Off-Road Exhaust Strategy with Cat After-treatment

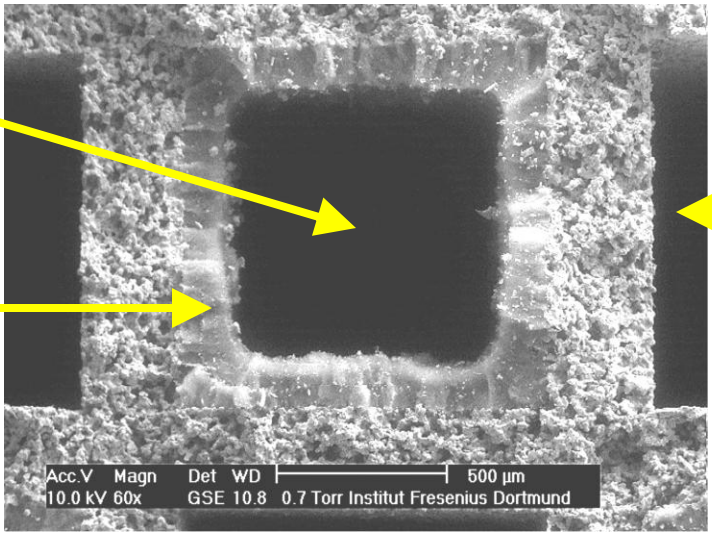


Wall-flow Filter



Material:

SiC
Cordierite
AT
others



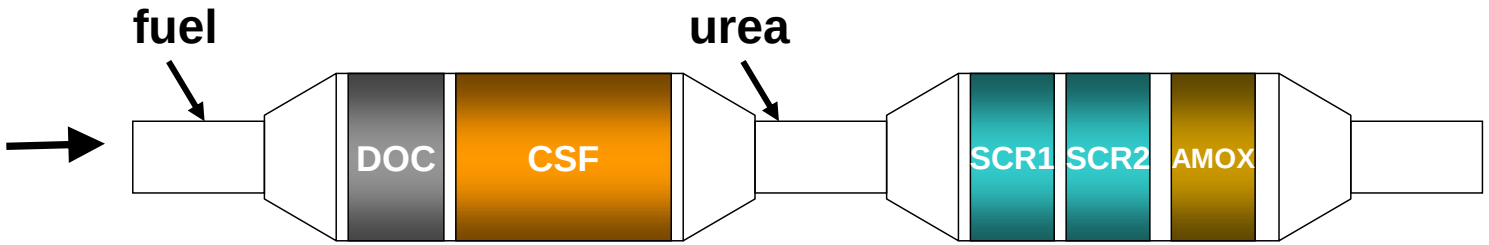
Design:

200-300 cpsi
12-18 mil
wall thickness

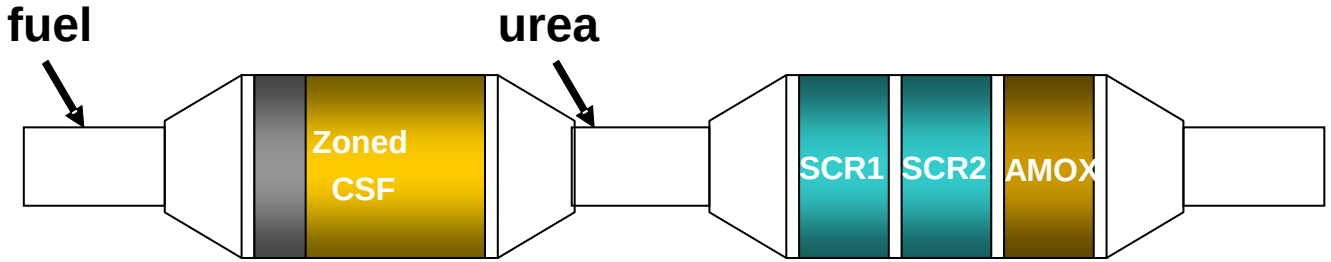
Heavy Duty Diesel System Design
Options to Meet US 2010 HDD Regulations

BASF
The Chemical Company

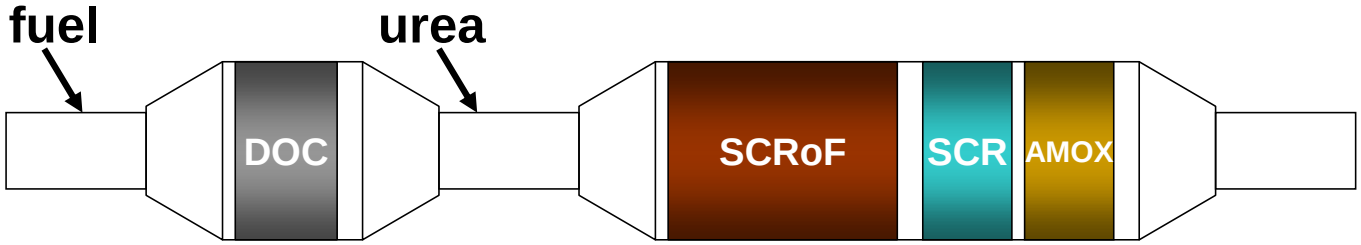
(option #1)



(option #2)



(option #3)

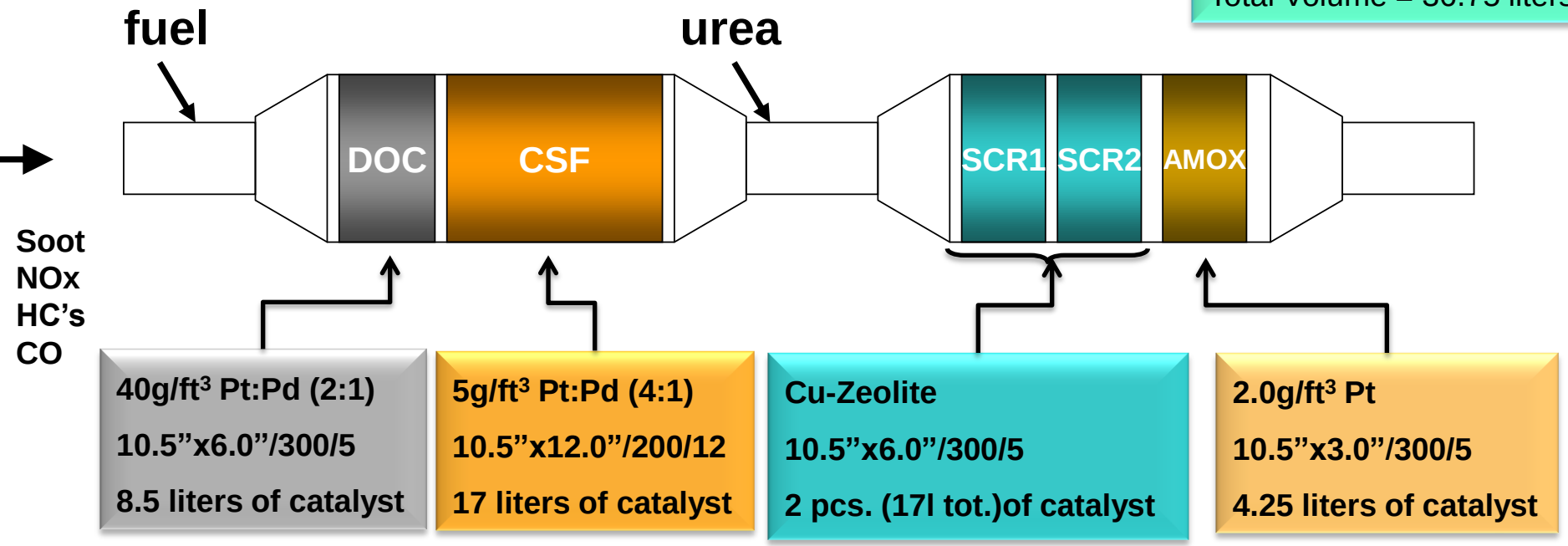


Heavy Duty Diesel (8 liter Engine) Typical 2010 After-treatment System has Multiple Catalyst Components & Functions

BASF
The Chemical Company

(option #1)

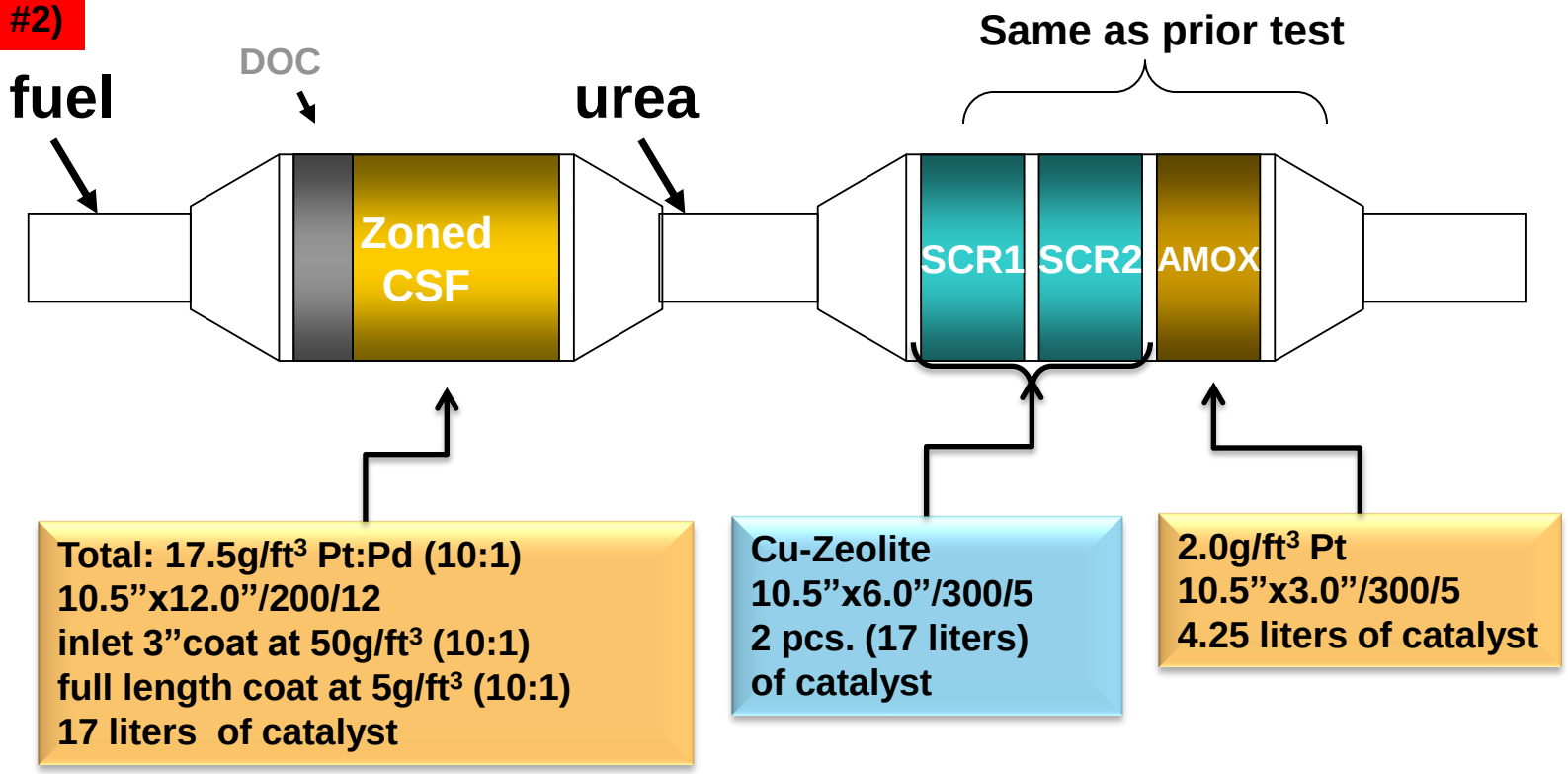
Total Volume = 36.75 liters



Components aged on engine under active regeneration conditions 50hrs/650°C at CSF-in

Alternate System – Adding DOC to CFS Inlet Zone Coat Reduces System Size 18%

(option #2)



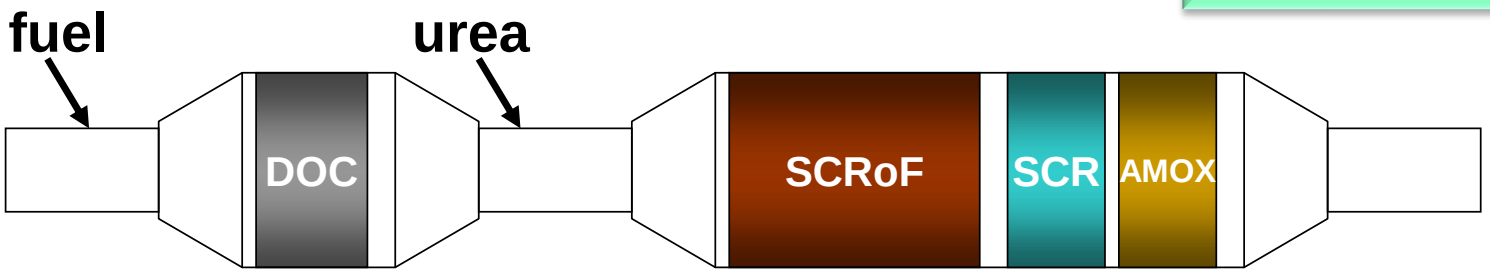
System aged under continuous active regeneration conditions (50hrs/650°C at DOC-out) prior to transient emissions testing.

Alternate System adds SCR Function onto Soot Filter which Reduces System Size 18% if Additional SCR is Needed

BASF The Chemical Company

(option #3)

Total System Volume = 38.25 liters



40g/ft^3 Pt:Pd (2:1)	Cu-zeolite SCR on filter	Cu-Zeolite	2g/ft^3 Pt
10.5”x6.0”/300/5	10.5”x12.0”/300/12	10.5”x6.0”/300/5	10.5”x3.0”/300/5
8.5 liters of catalyst	17 liters of catalyst	8.5 liters of catalyst	4.25 l of catalyst

System aged under continuous active regeneration conditions (50hrs/650^{o}C at DOC-out) prior to transient emissions testing.

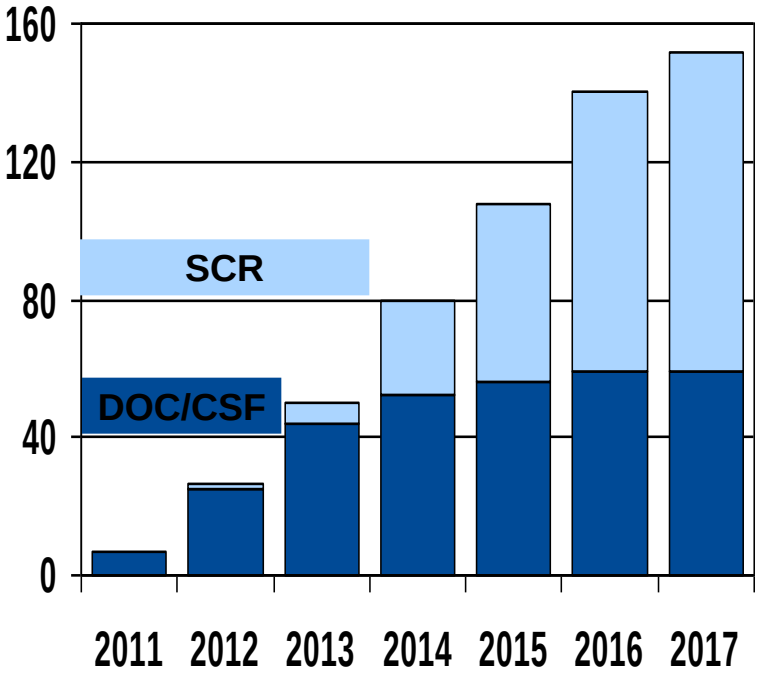
Off-Road Applications

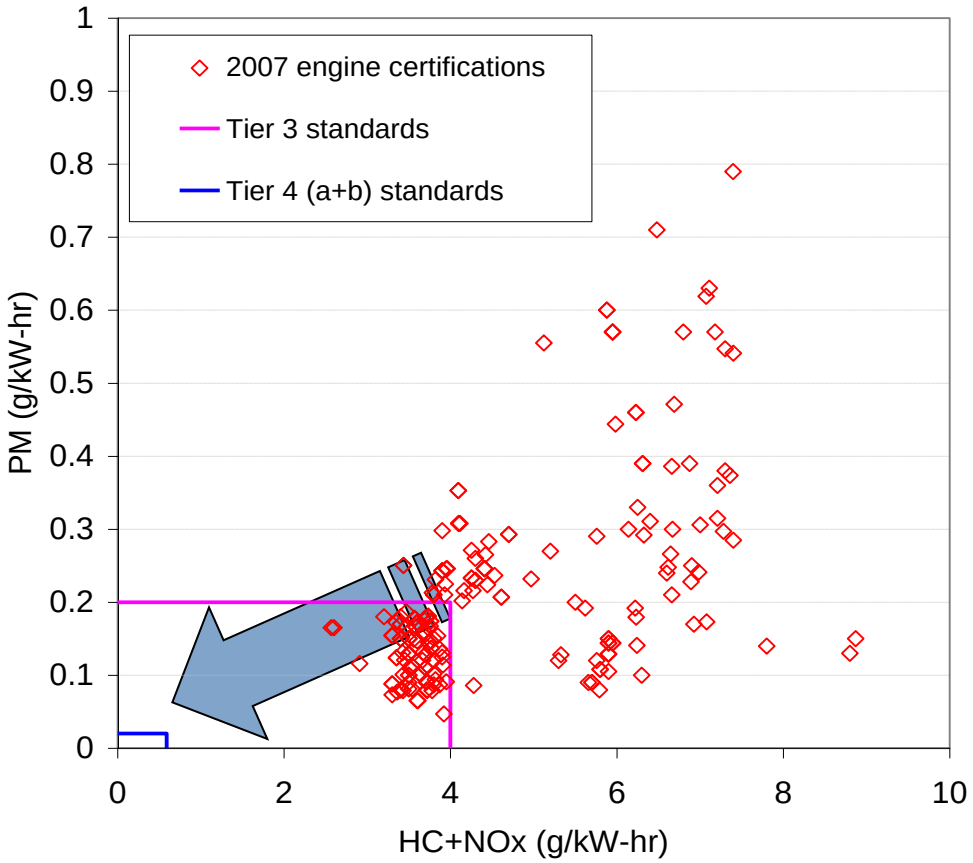
BASF
The Chemical Company

Global Market & Technical Challenges for Off-Road Equipment

BASF
The Chemical Company

Catalyst market (ex Substrate; ex PM; Mio. €)

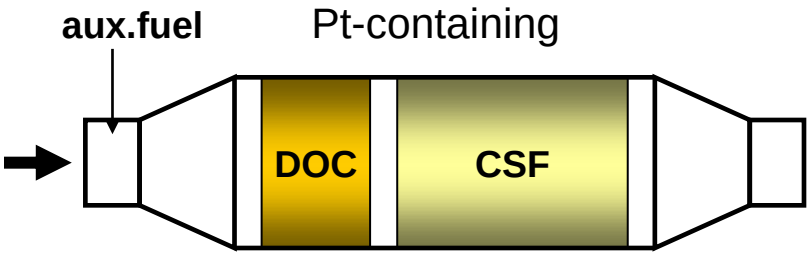




- Tier 4(a+b) regulations cannot be met with engine controls alone
- European Stage III & IV roughly equivalent to US Tier 3 & 4 (a+b)

Catalytic Strategies for Off-Road Equipment

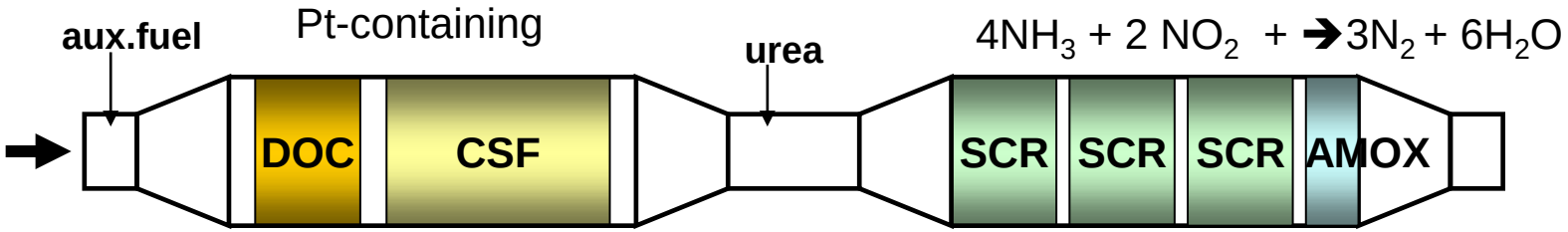
Tier 4 a



DOC = Diesel Oxidation Catalyst
CST = Catalyzed Soot Filter

Tier 4 b

SCR
Cu or Fe on zeolite



$4NH_3 + 2\,NO_2 + \rightarrow 3N_2 + 6H_2O$

Pt
AMOX: $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

Develop off-road systems based on on-road system components. All monoliths

Alternate Vehicle Powertrains Options

- **ICE/Battery Hybrid**
  - Combines a gasoline with a Li ion battery for enhanced fuel economy
  - Battery powers the vehicle in start/stop modes (urban driving) while the ICE operates at higher (steady state) speeds
  - Consumes fossil fuel and requires larger amounts of precious metals in the
  - TWC catalytic convert than 100% ICE
  - Diesel-hybrid not commercially available

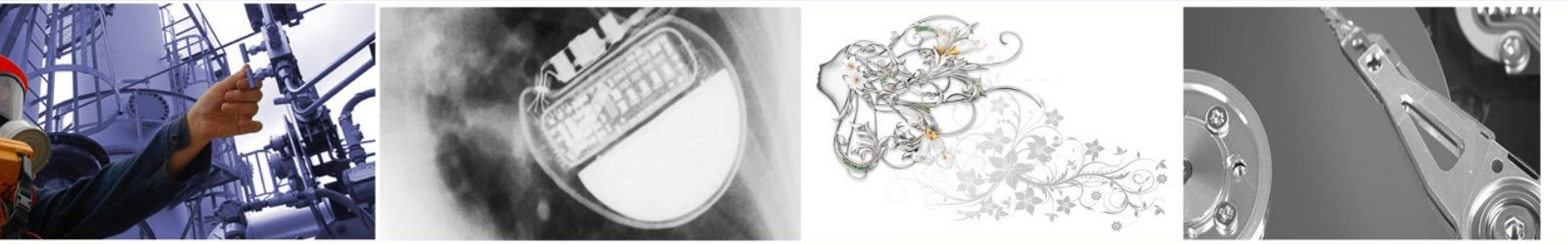
- **Gasoline regenerator/battery**
  - On–board generator re-charges battery (Chevy Volt)
  - Uses fossil fuel. Requires a catalytic converter

- **Battery only:**
  - No fossil fuel on-board but CO_2 emissions at central power station
  - No suitable recharging infrastructure available
  - Long recharging times
  - Range bound (30-80 miles)
  - No catalytic converter necessary

- **Fuel Cell only**
  - Hydrogen stored on-board powers the vehicle with water as the only product
  - Range 200-300 miles with current storage capacity
  - Efficiency is 50-60%. CO_2 generation for H_2 is 40-50% lower than ICE
  - Hydrogen produced from reforming natural gas (for which infrastructure exists)
  - Hydrogen generation will likely use precious metals
  - Need to equip service stations with reformers
  - Fuel cell contains Pt (30 g in 2005)

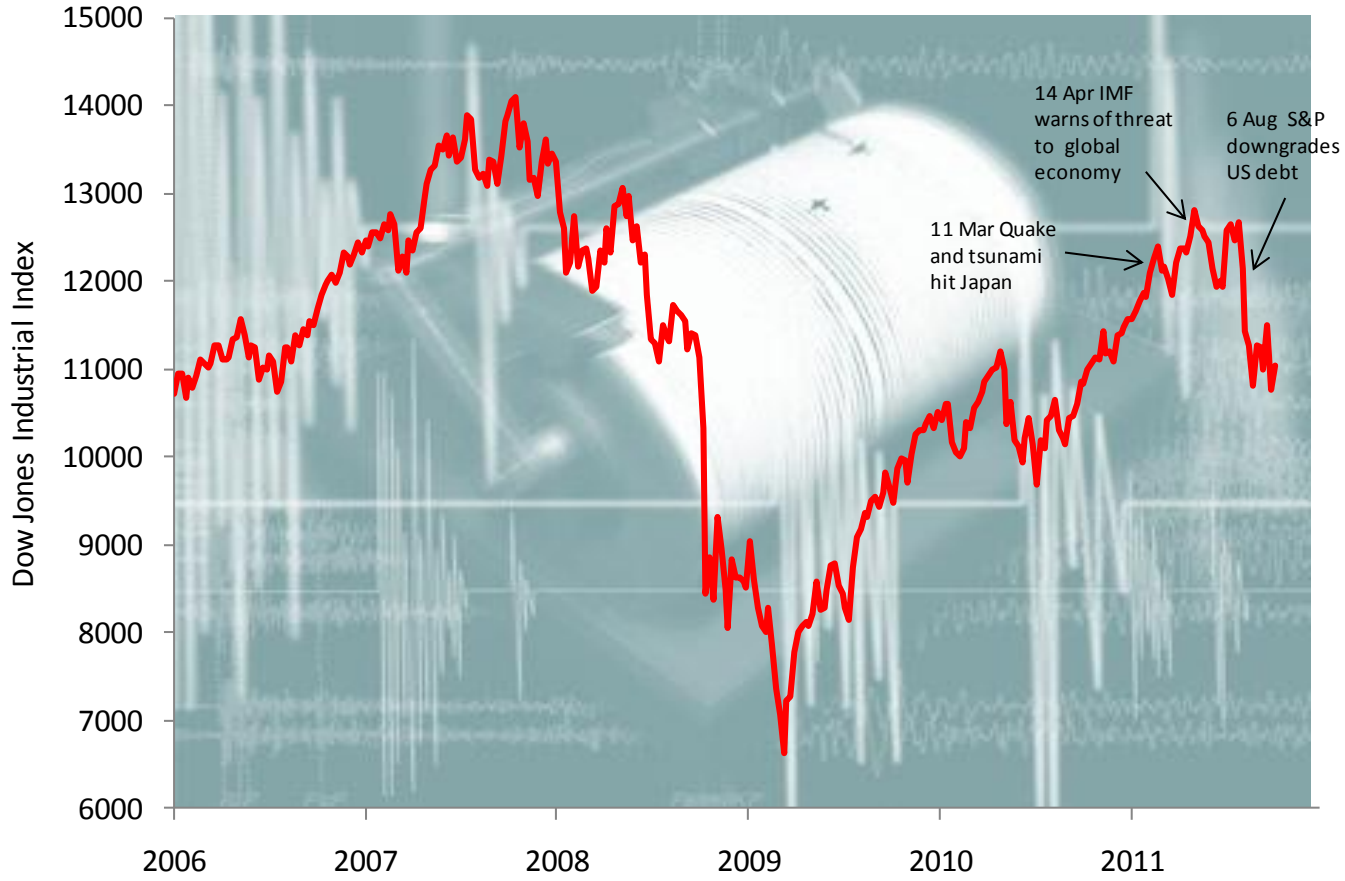
Conclusions

- Expanded use of fuel cells for residential combined heat and power, portable and distributed power is now occurring
- The generation of hydrogen from infrastructure fuels such as natural gas and LPG will require some use of precious metals (likely Rh) to avoid ammonia formation present in natural gas
- Diesel engine exhausts will require precious metals for the diesel oxidation, ammonia destruction catalysts and the soot filter
- Technology for off-road pollution abatement will be derived from diesel truck
- Gasoline vehicles will continue to use three way catalysts in which Pd has been substituted for Pt. The modern TWC is Pd rich with small amounts of Rh
- The NO_x trap will still use Pt and Rh for small diesel passenger cars



Lonmin View

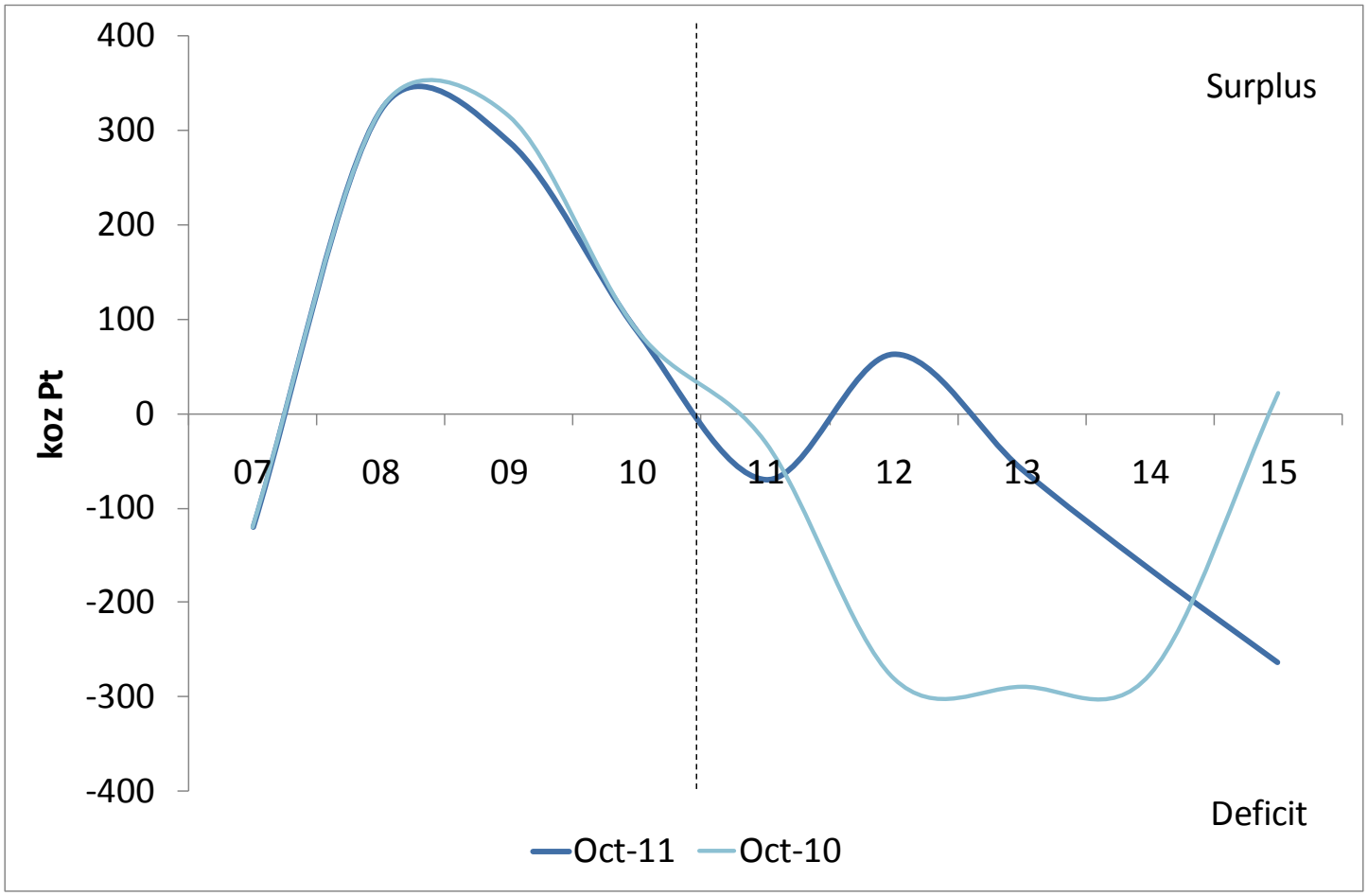
Seismic Shifts



Source: Lonmin

Japan's coastline shifts, EU & US debt moves up, ratings fall

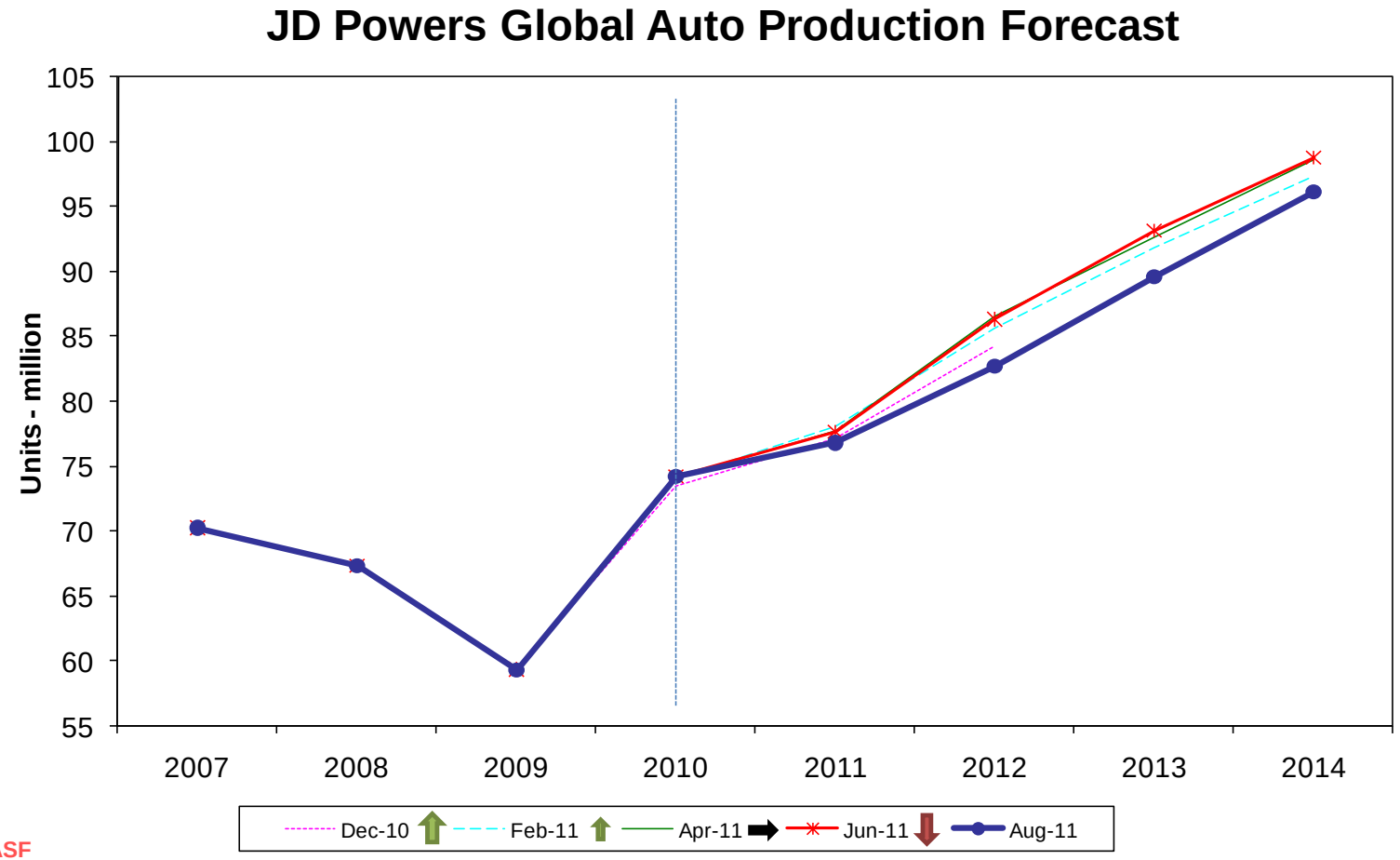
Supply/Demand Balance



Source: Lonmin

Demand recovery – postponed, definitely not cancelled

Automotive Demand

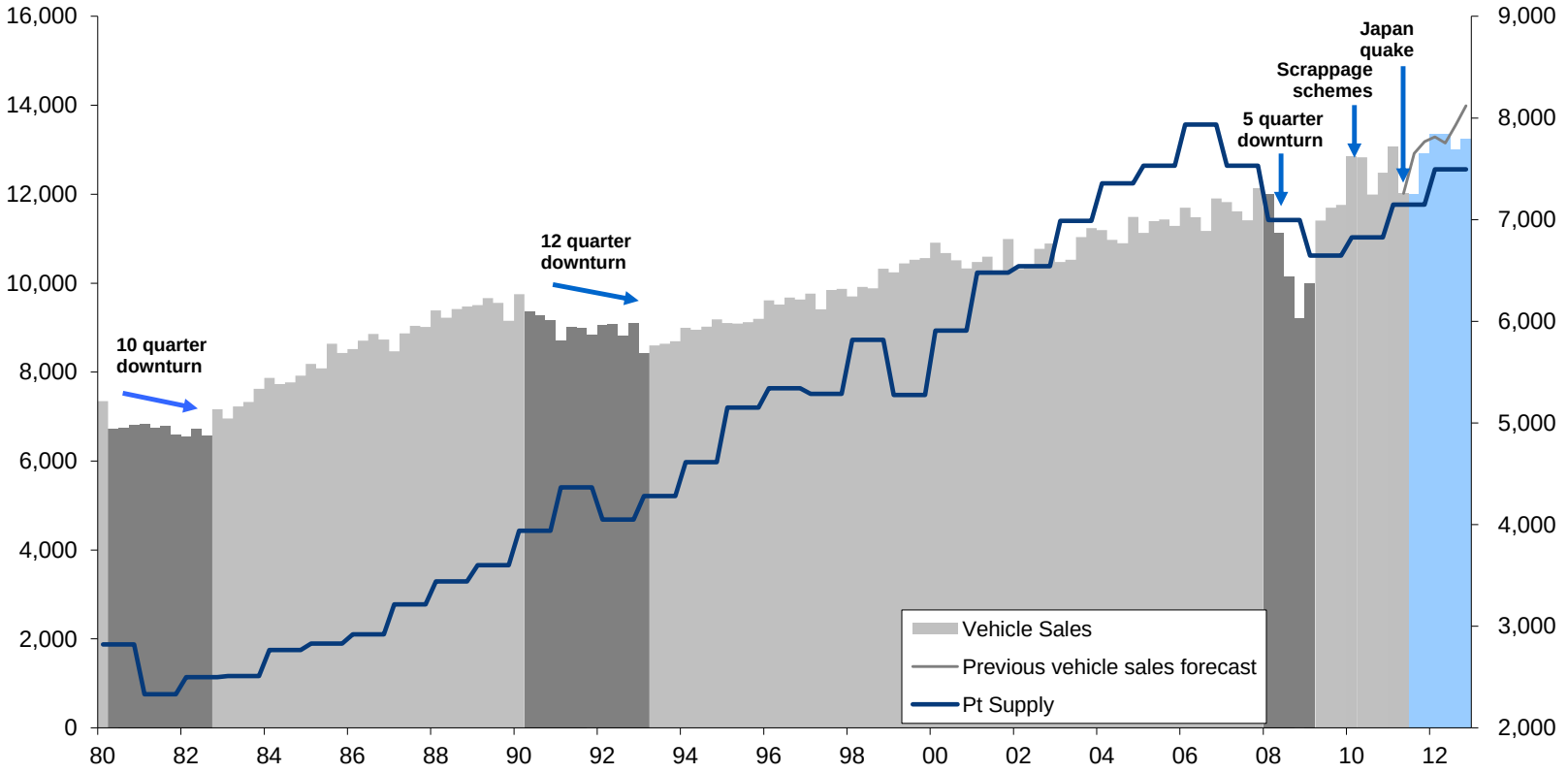


Source: BASF

Revisions still reflect year on year growth

Automotive Demand

Quarterly vehicle sales* and platinum supply
(rhs '000 oz; lhs '000 units)

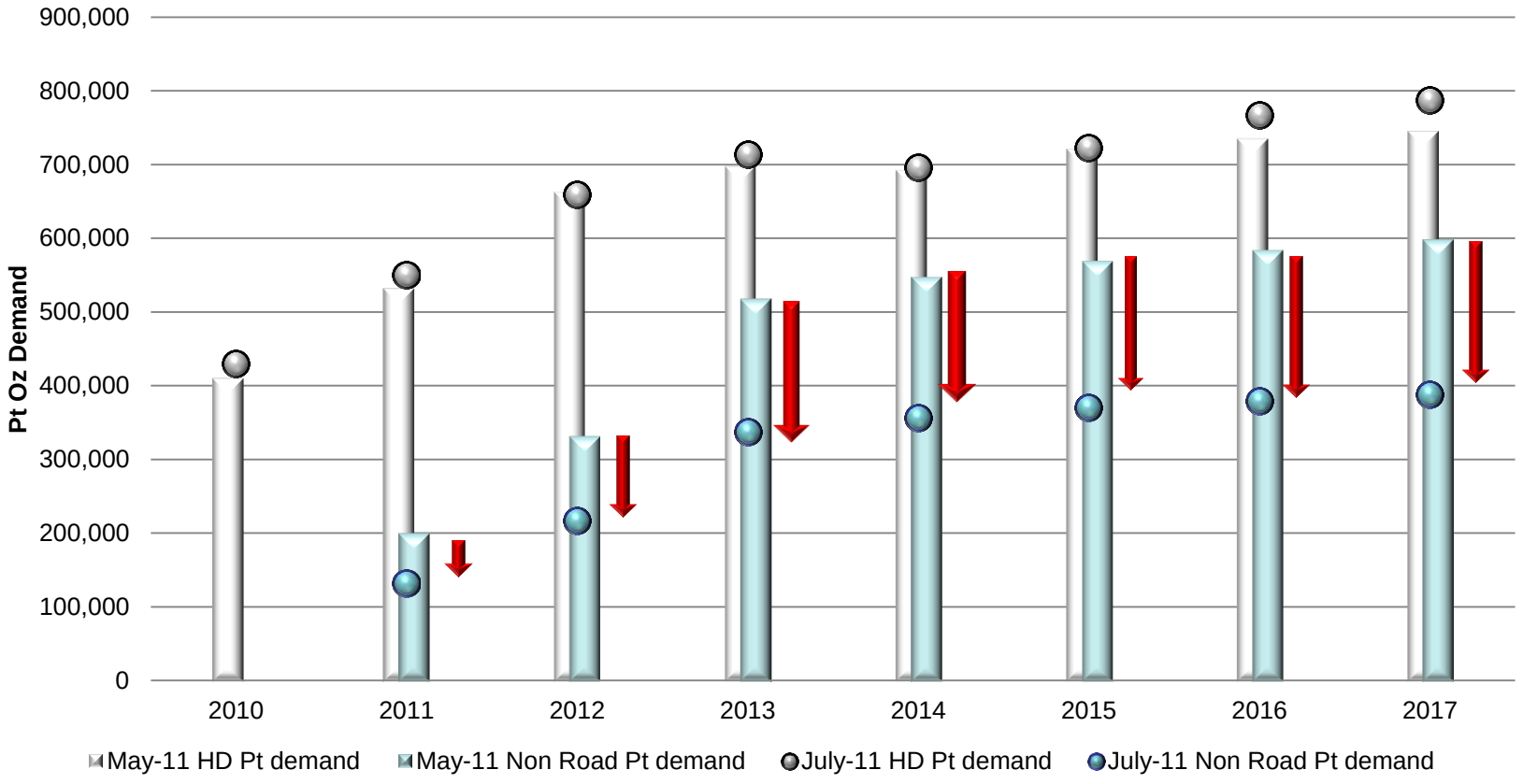


Source: SFA (Oxford) from Oxford Economics, ACEA, JAMA, Ward's Auto, CAAM, Bloomberg
* Include all vehicle sales in W.Europe, Japan, China and light vehicle sales in the United States

Source: SFA (Oxford)

Release of pent up demand

Off-Road and Heavy Duty



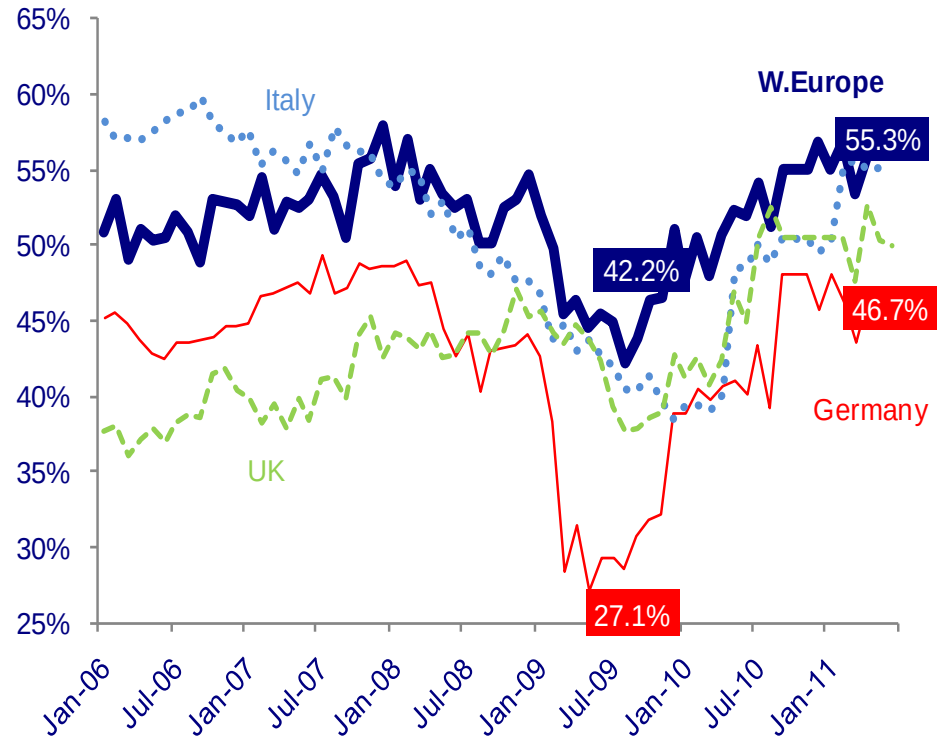
Source: SFA (Oxford), Power Systems Research

Remains a significant new demand element

Diesel Market Share

DIESEL CAR SALE TRENDS - EUROPE

Passenger car diesel share in W.Europe, %



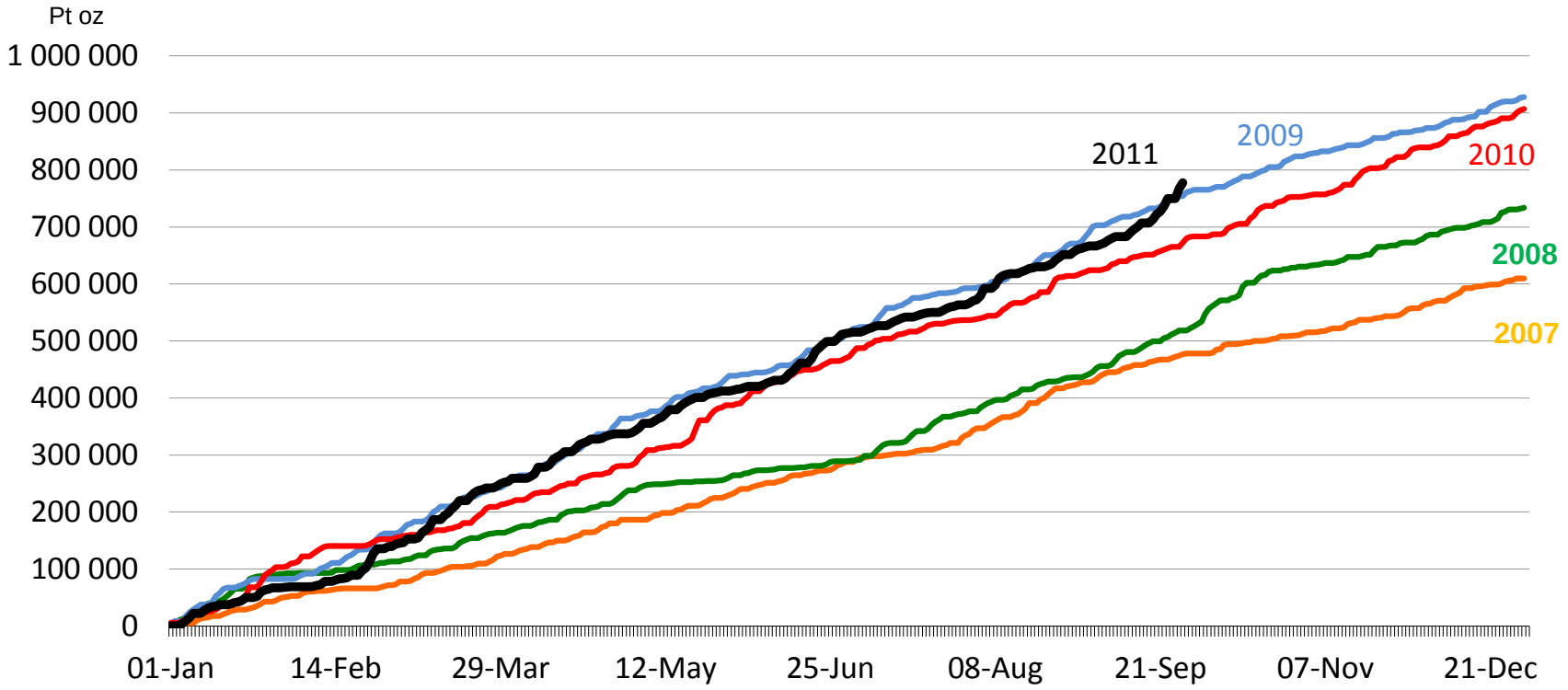
Source: SFA (Oxford), Various

DIESEL CAR SALES TRENDS - US

- Jan-Aug 2011 growth of 37% y-o-y vs 10.4% overall US car sales
- Growth rate outstripped hybrids since April this year
- German auto company US diesel car sales:
  - 45% of Audi Q7
  - 69% of Audi A3 hatchback
  - 24% of VW overall
- JD Power forecast:
  - from 3% share currently
  - to 7.4% by 2017

Diesel reclaims Europe and advances faster into US

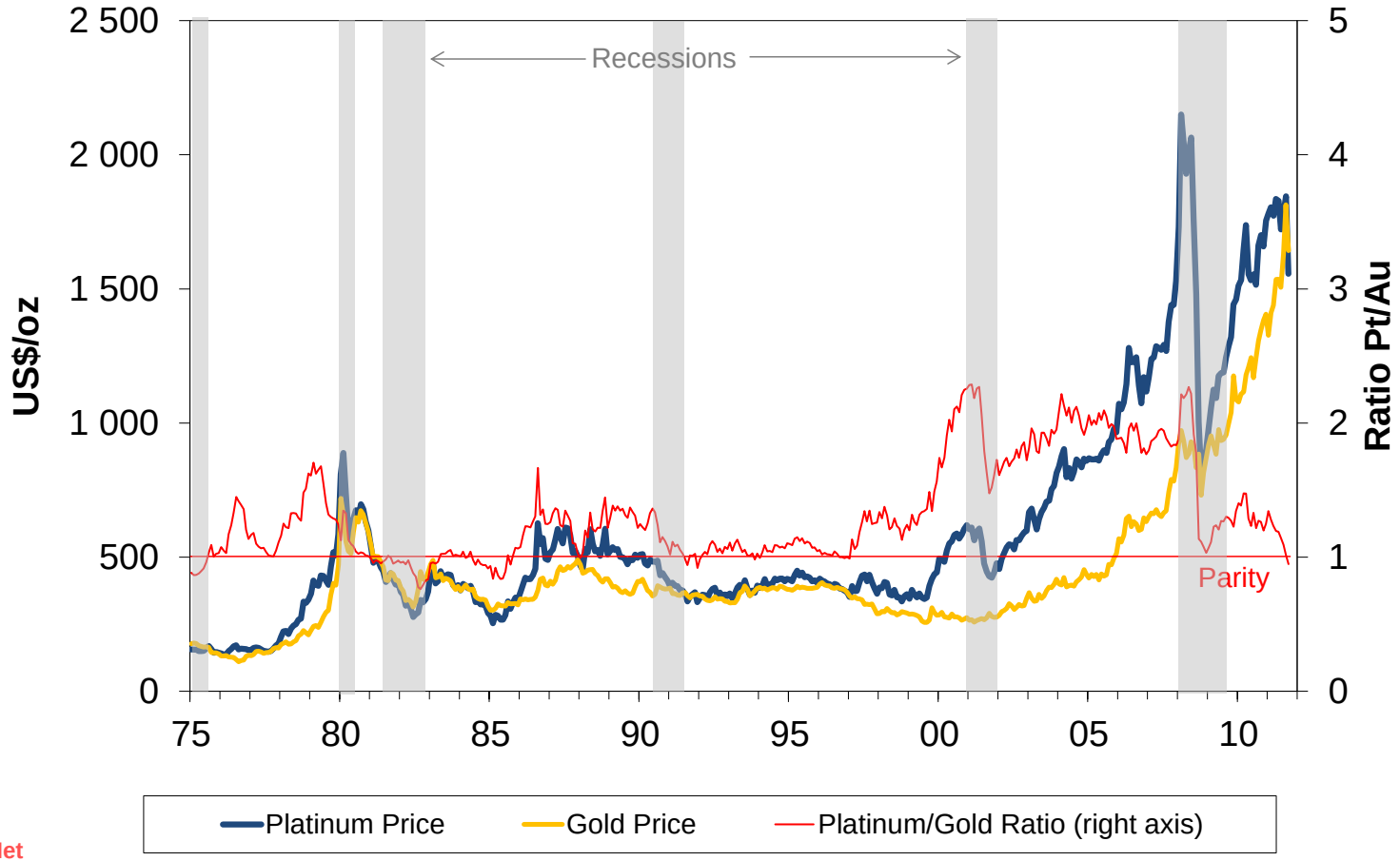
Jewellery Demand Proxy - SGE



Source: SGE

Pt jewellery demand - set for new record highs

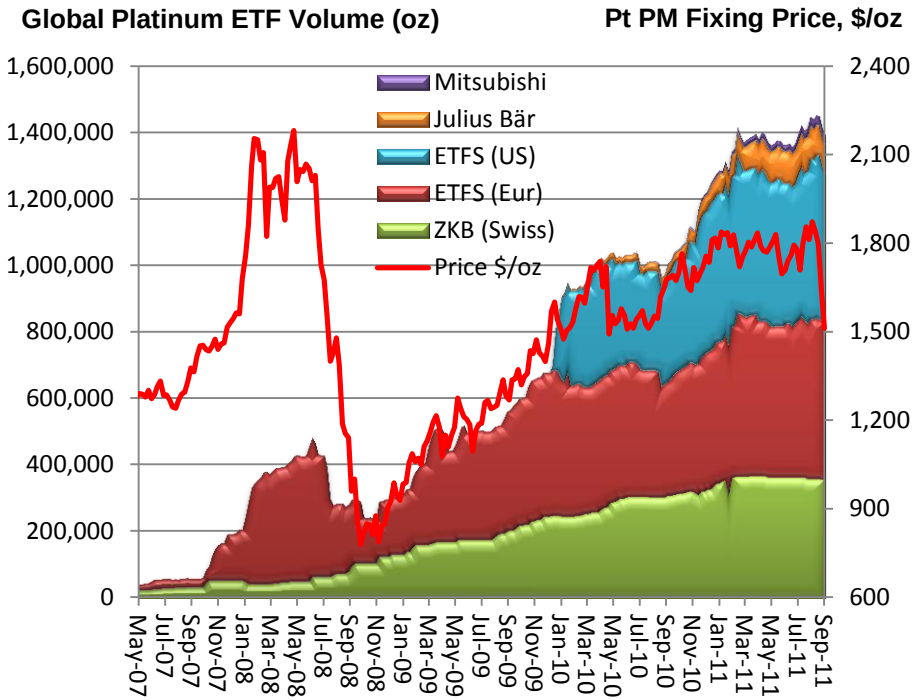
Platinum/Gold Price Ratio

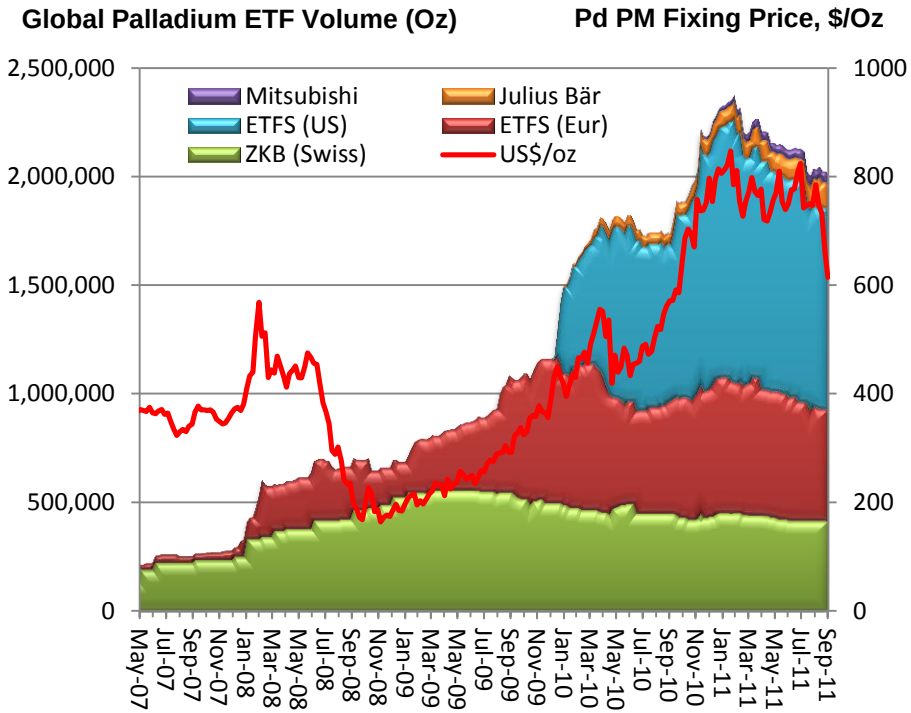


Source: I-Net

Pt price – yellow brick floor?

Investment Demand

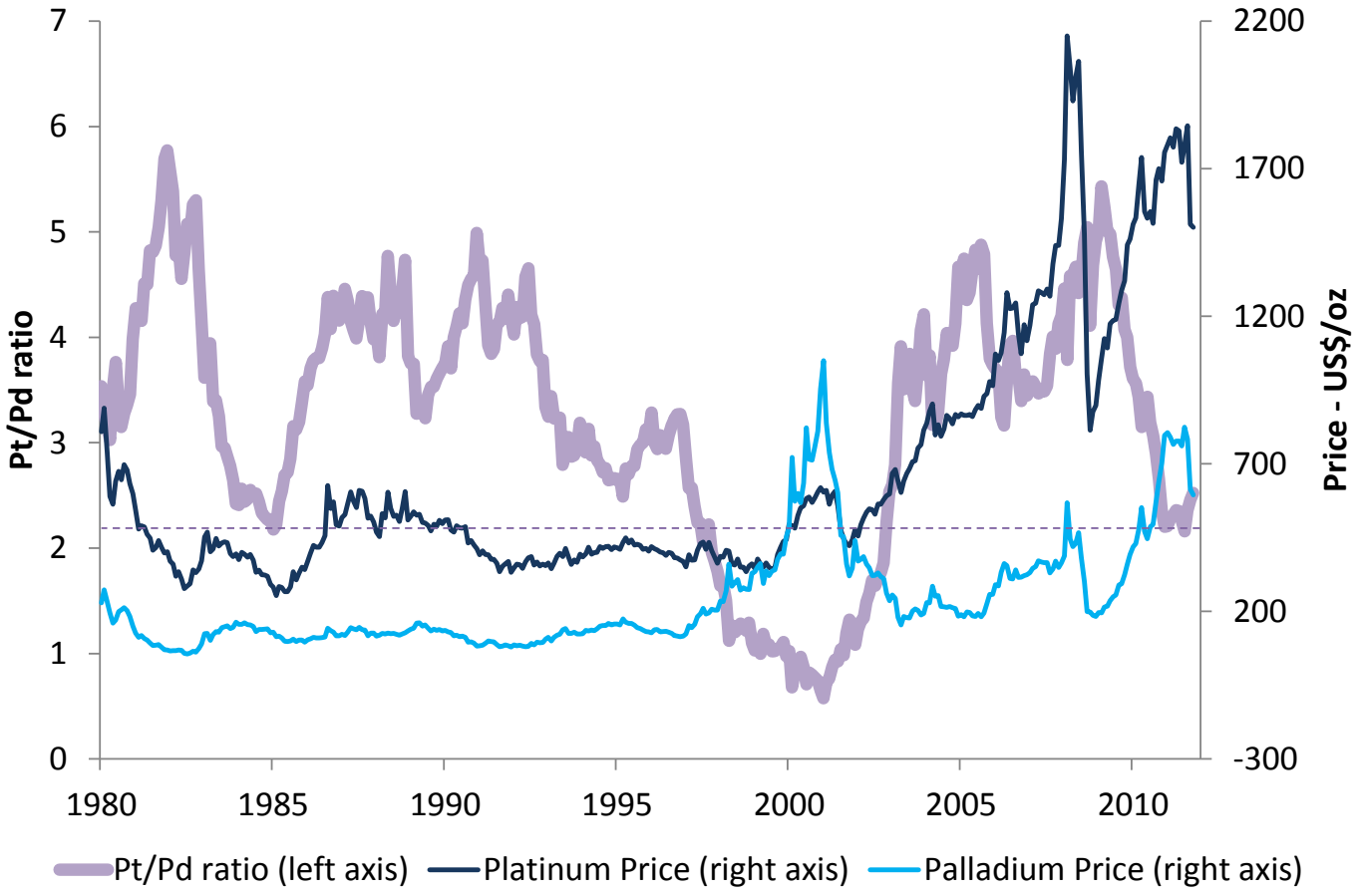




Source: Lonmin

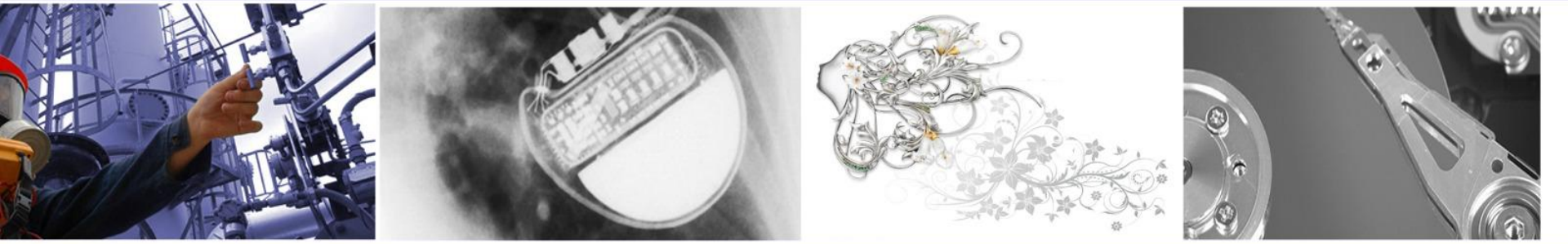
Early signs of normal investment asset behaviour

Substitution Price Driver



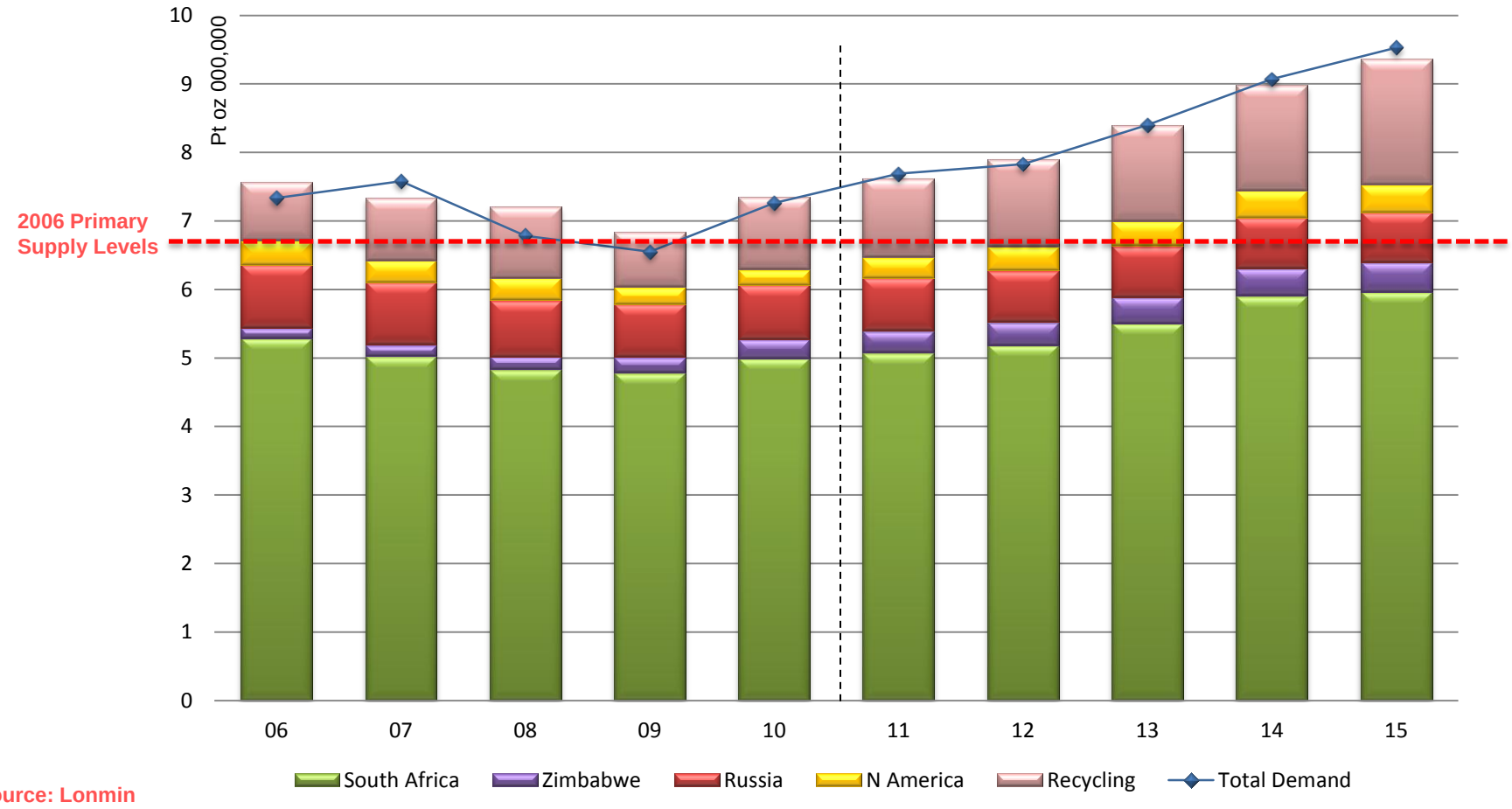
Source: I-Net

2:1 Ratio - equilibrium point?



Supply

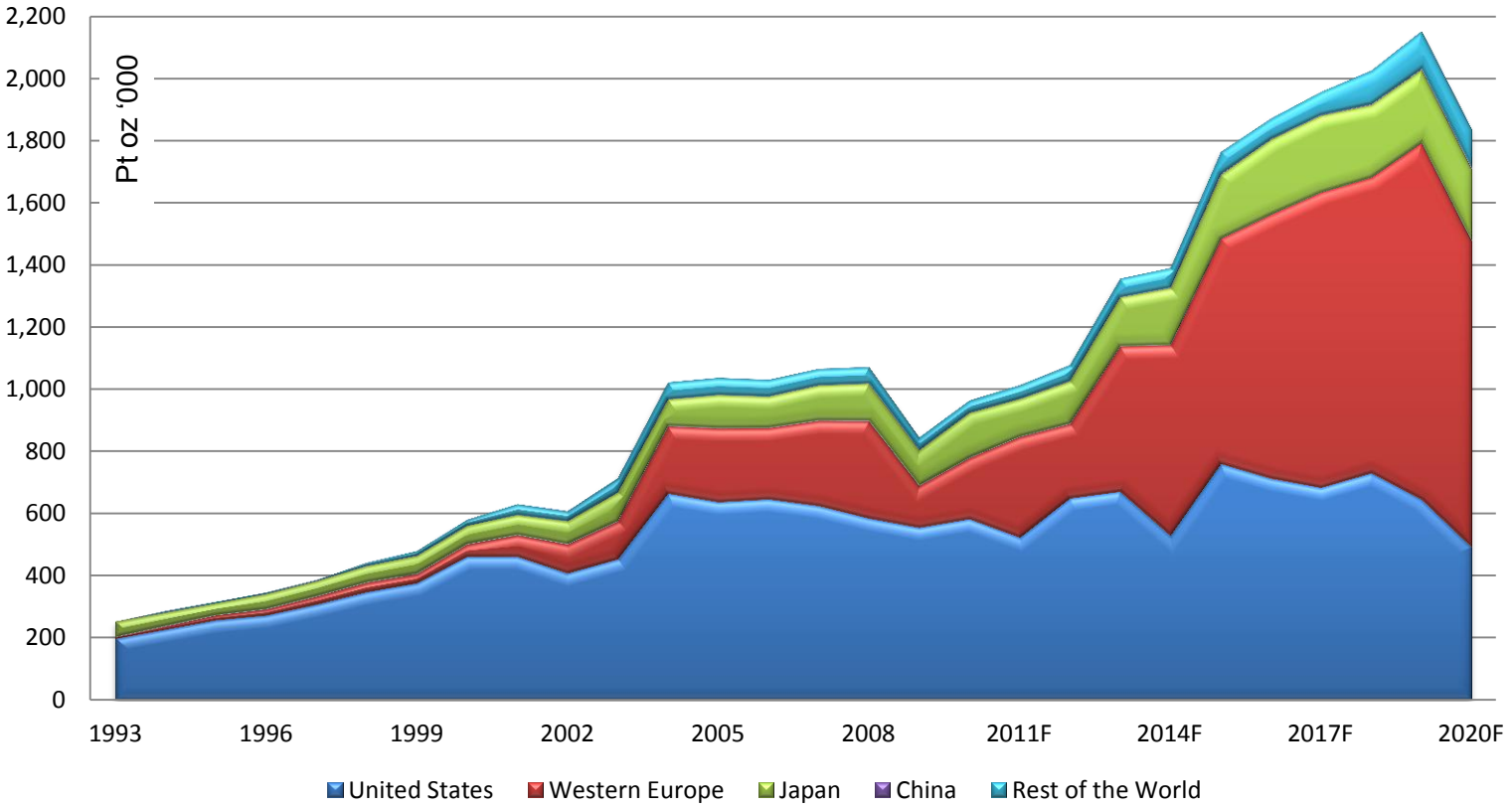
Platinum Supply Outlook



Source: Lonmin

SA supply - 3 steps back 2 steps forward

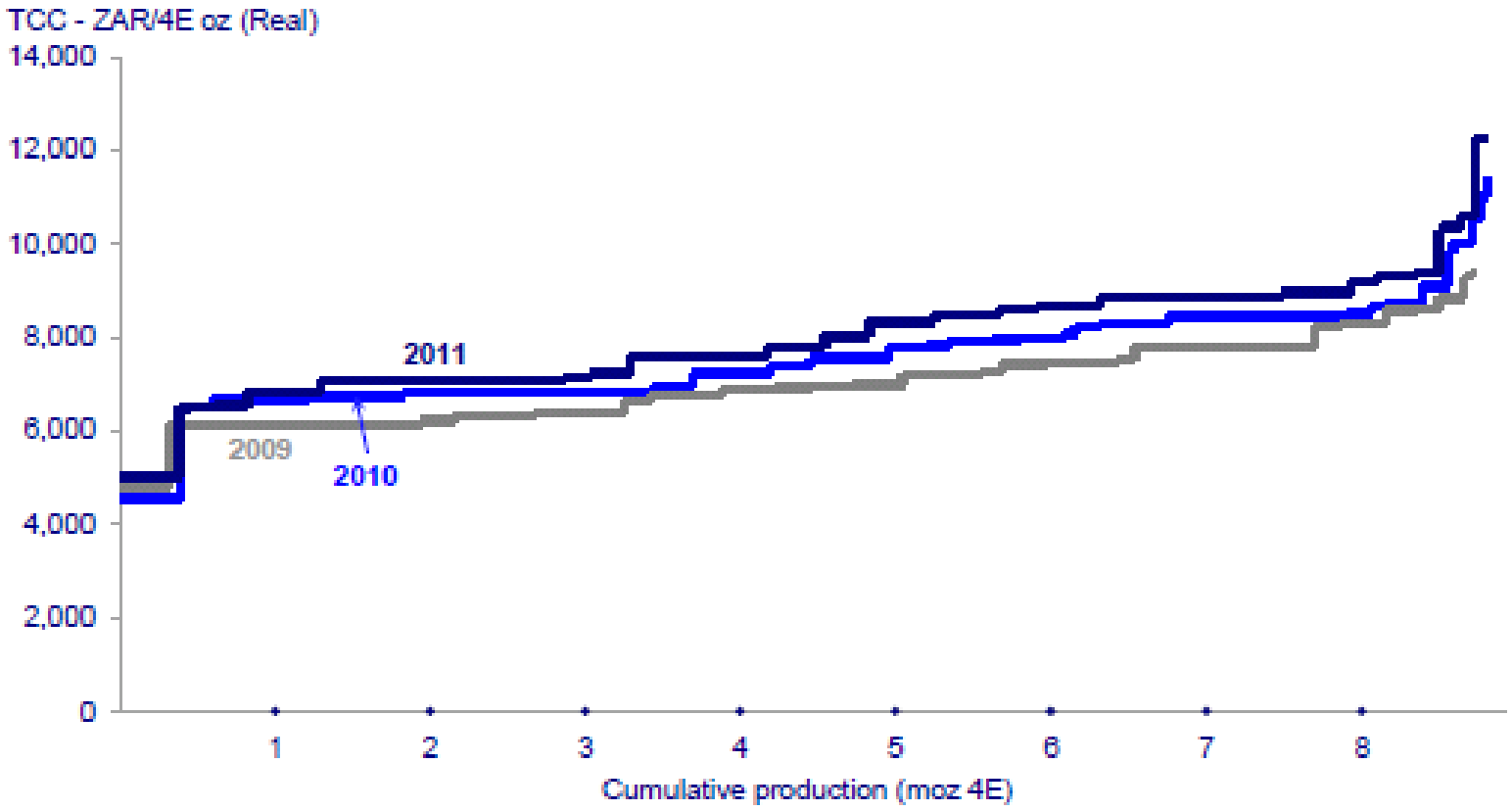
Growth in Secondary Supply



Source: SFA (Oxford)

Filling the primary supply gap

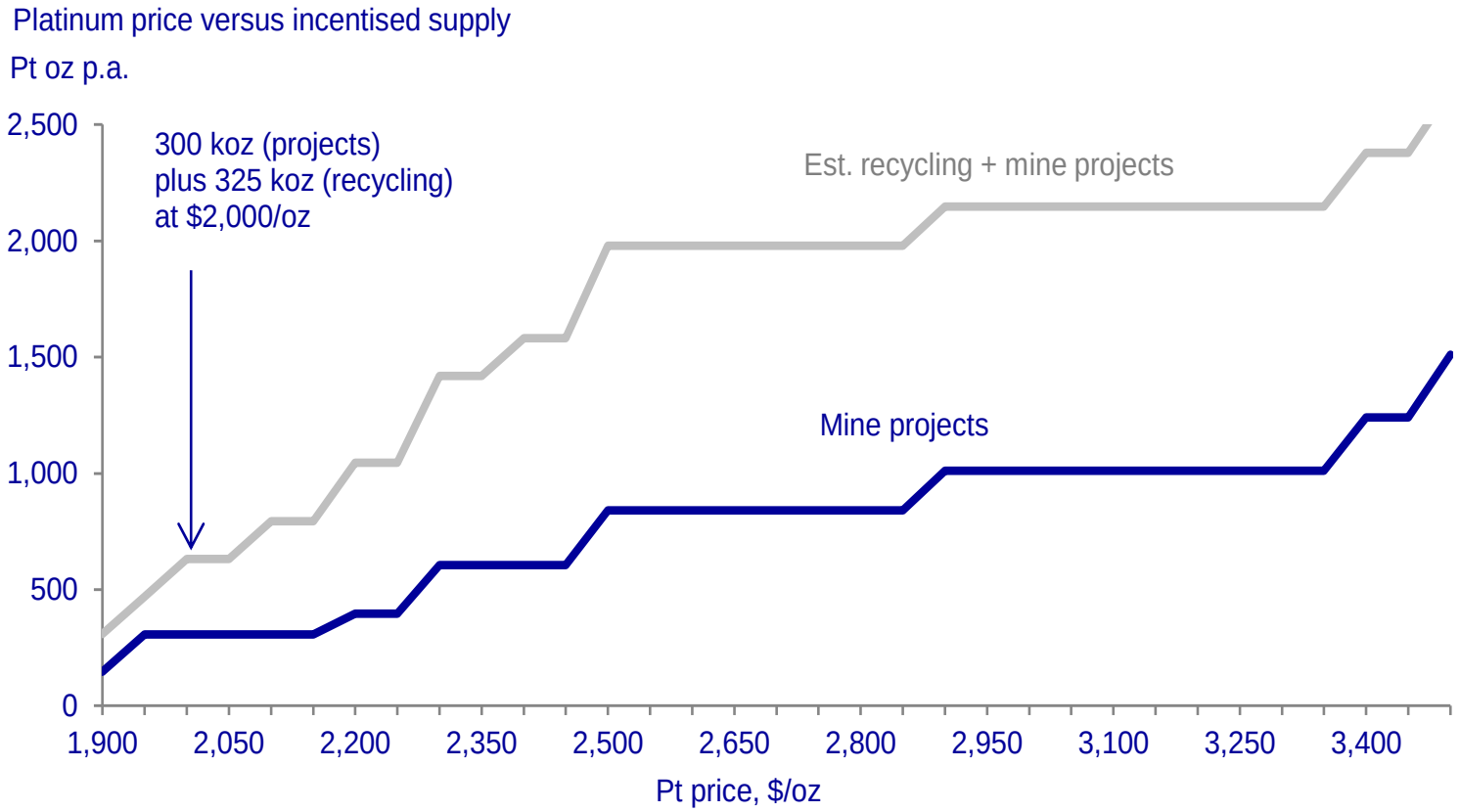
Rising Industry Cost Curve



Source: SFA (Oxford), Company Reports

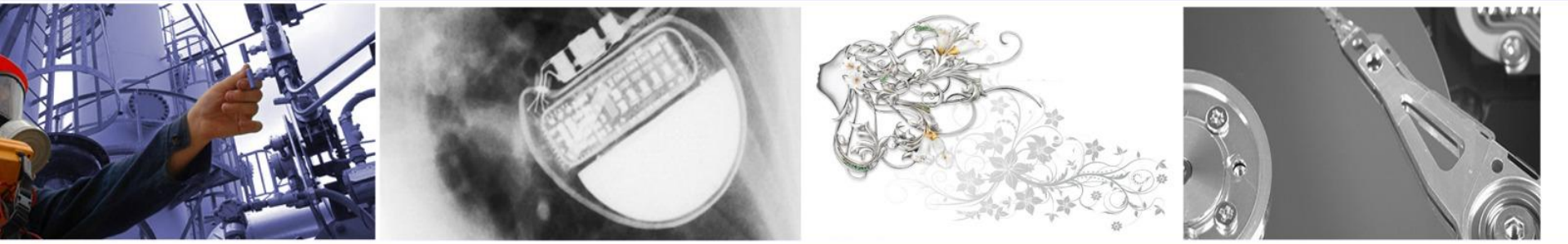
Cost pressures keep supply constrained

Incentive Pricing



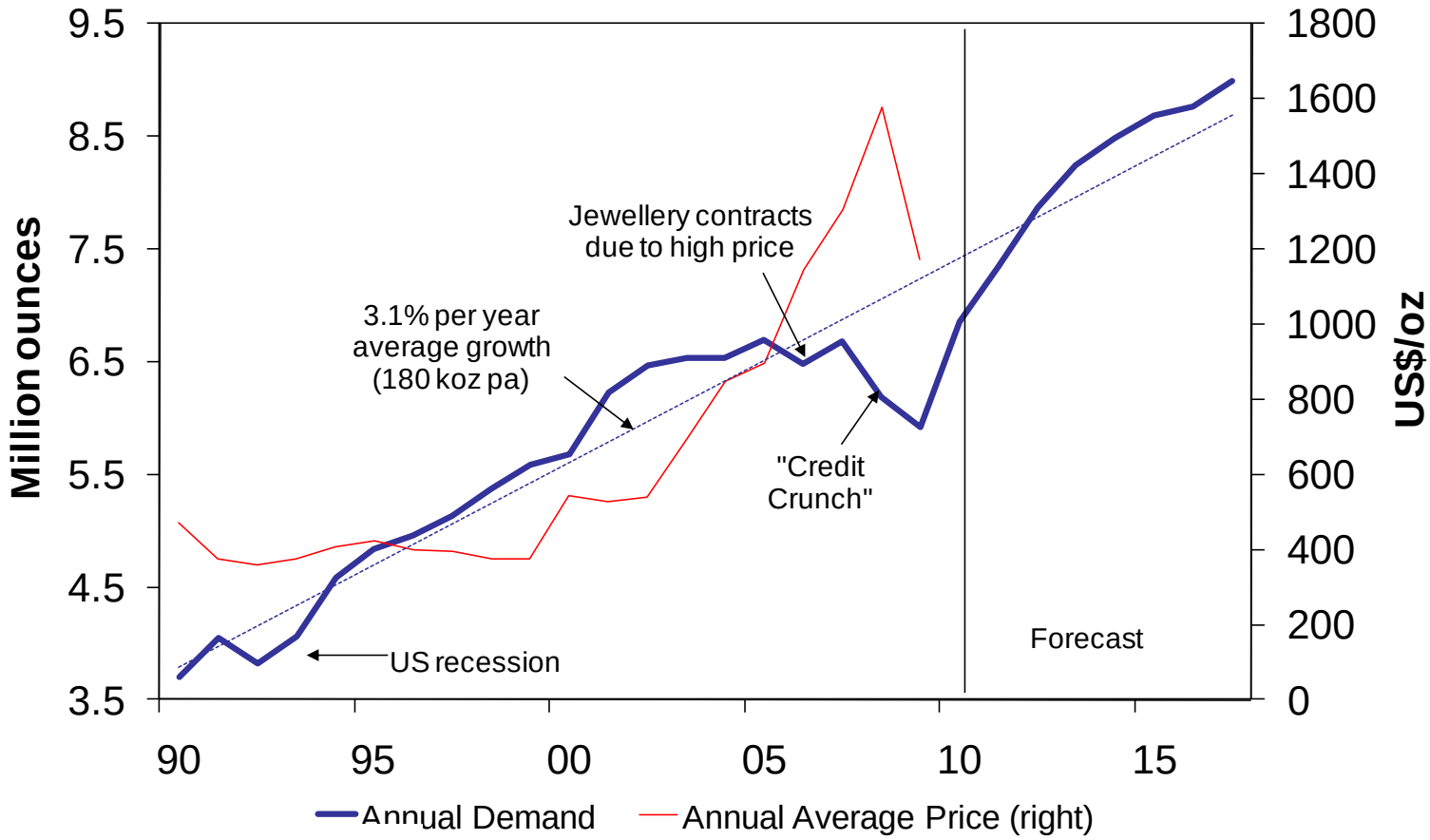
Source: SFA (Oxford) Other variables: Palladium $789/oz, Rhodium $1984/oz, Ruthenium $180/oz, Iridium $1050/oz, Gold $1573, Rand R7.32/$

Prices need to be upwards of US$ 2000 to entice new project supply



Long term

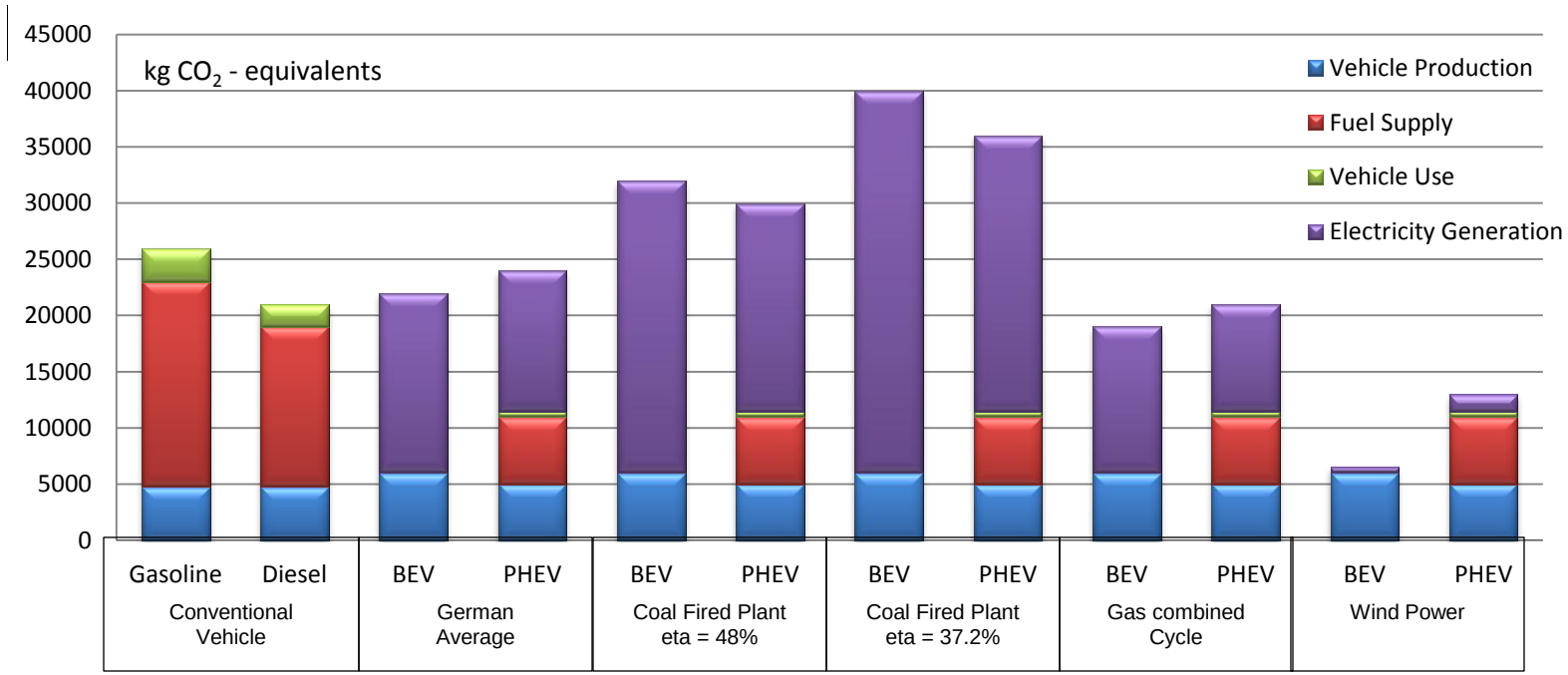
Long Term Platinum Demand



Source: Historical JM, Forecast - Lonmin

A Lonmin size operation required every 3 years

Life Cycle Greenhouse Gas Emissions



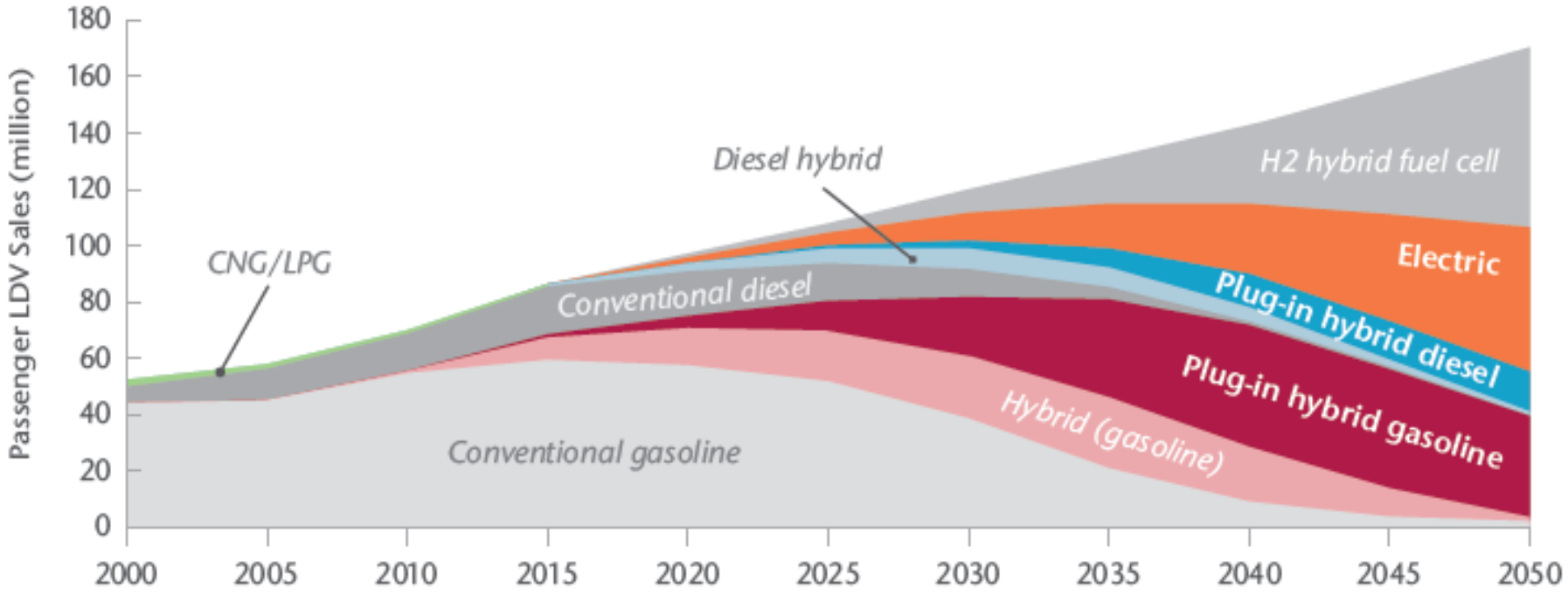
Source: Ifeu – Institut fur Energie- und Umweltforschung

BEV - Battery Electric Vehicle

PHEV - Plug-in Hybrid Electric Vehicle

Cradle to grave assessment – key to sustainable powertrain investment

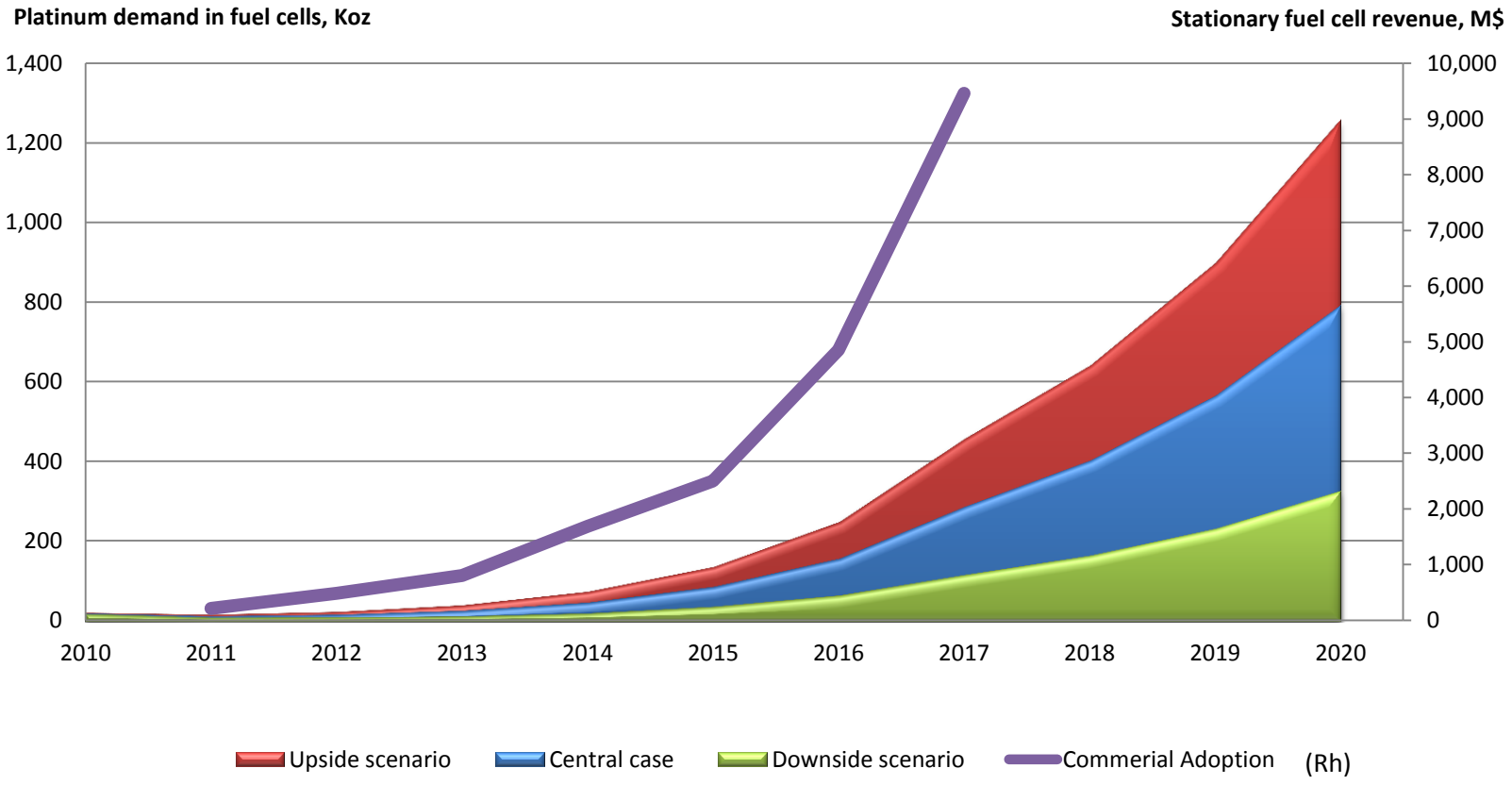
Evolution of Powertrains



Source: International Energy Agency

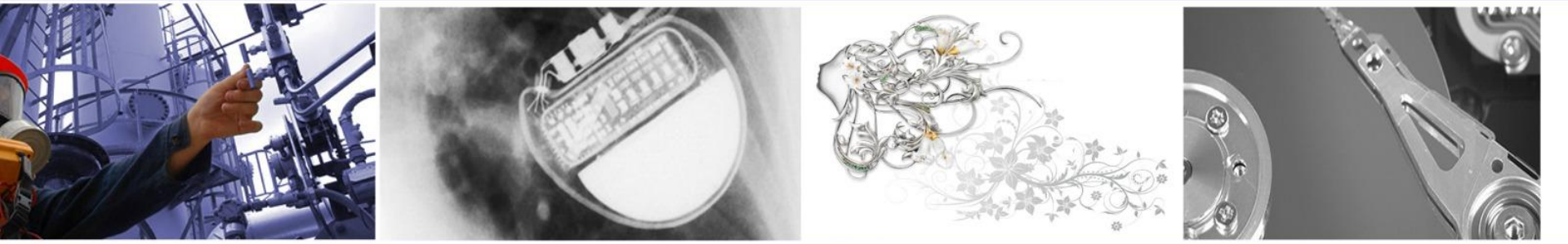
ICE will retain dominance through advancement in hybrid solutions

Stationary Fuel Cell Demand



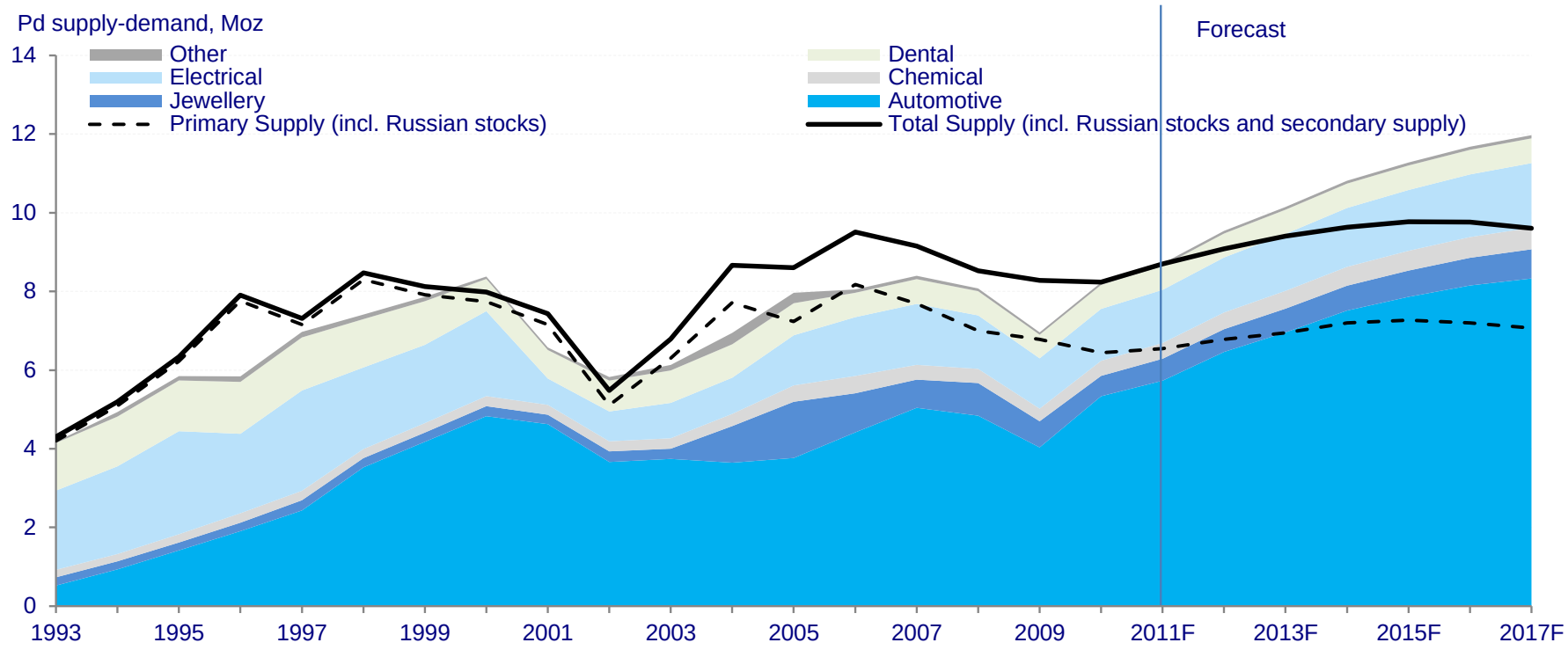
Source: SFA (Oxford) scenarios using BASF loadings, Pike Research

Sizeable commercial adoption promising for Pt demand



OPMs

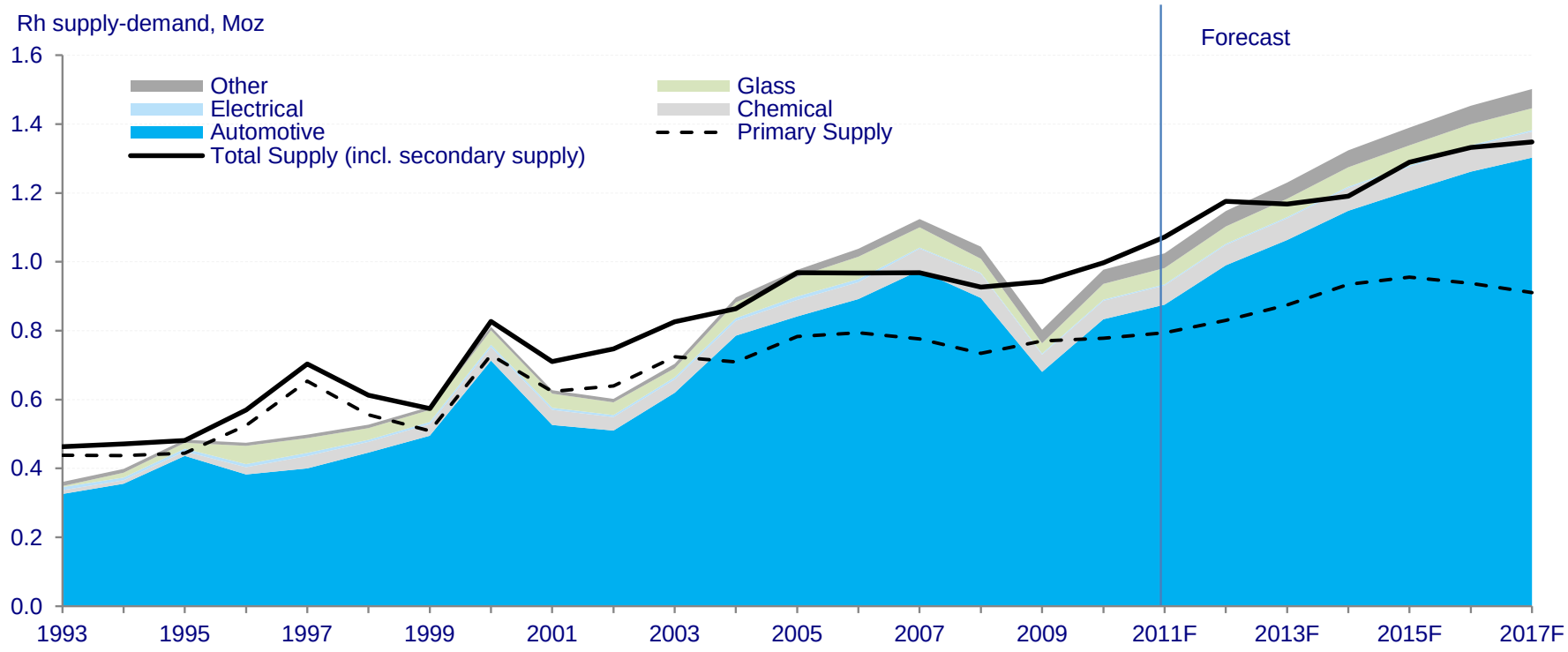
Palladium Supply/Demand



Source: SFA (Oxford),

Growing automotive demand keeps metal in structural deficit

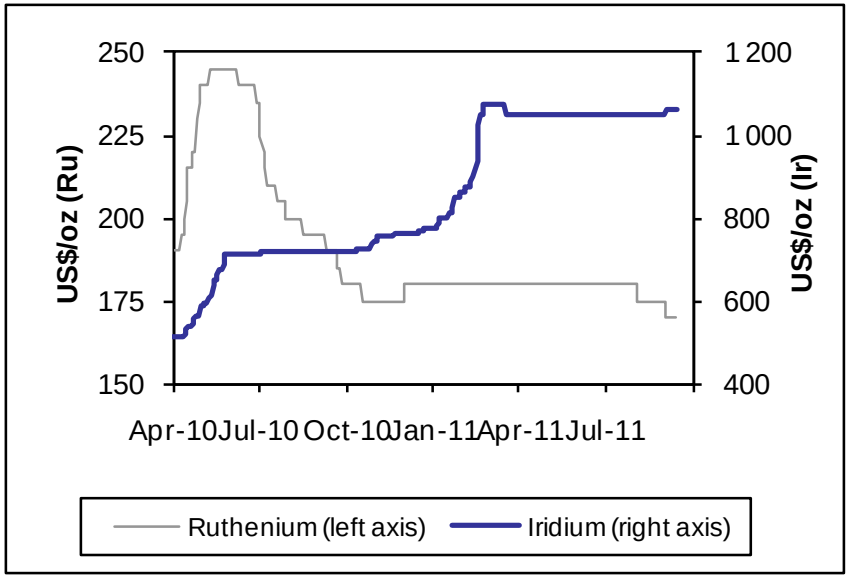
Rhodium Supply/Demand

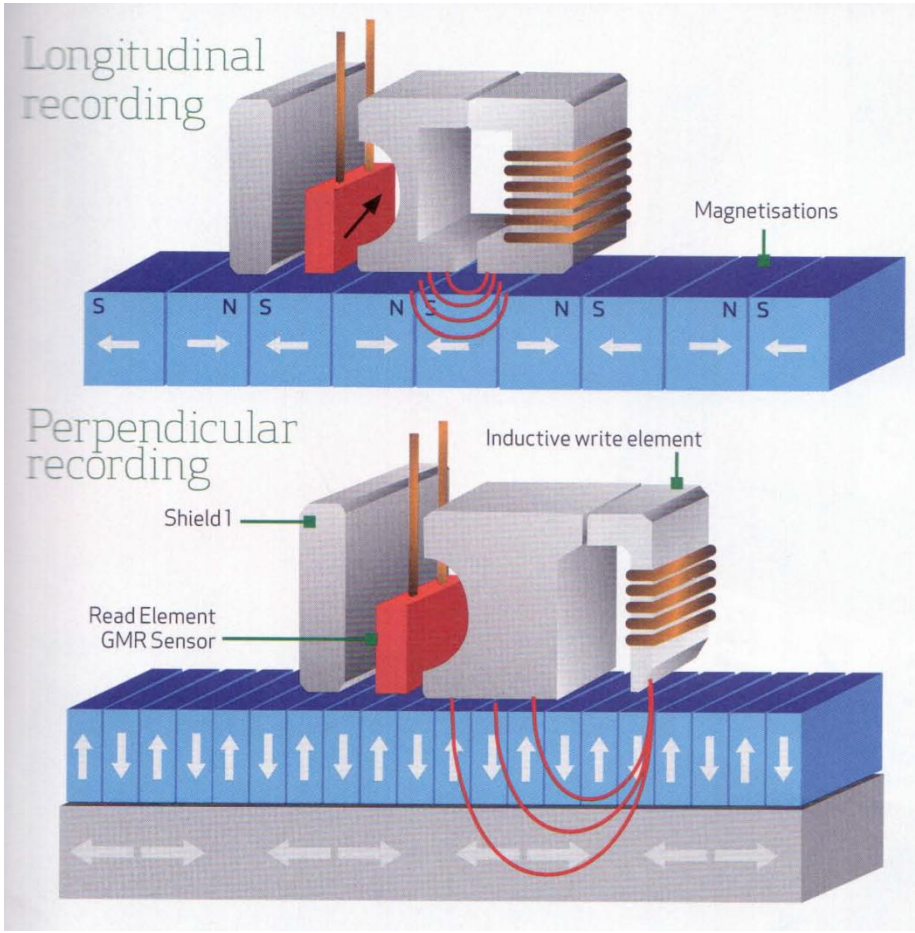


Source: SFA (Oxford)

Range bound, due to significant thrifting

Ruthenium and Iridium





Source: I-Net

Ruthenium past, Iridium future?

Conclusion

- **Short term (2012)**
  - Challenging, but underpinned by gold, jewellery and cost structure
  - Market share gains by light duty diesel
- **Medium Term (2013 - 2015)**
  - Supply constraints, some relief by recycling
  - ICE remains dominant, strong non-road diesel growth
- **Long term (beyond 2020)**
  - Stationary fuel cell becomes sizeable market
  - Hybrid and electric are bridge technologies and fade away

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