



# To Euro 7 and beyond: Autocatalysts, EVs and refining

**EC-IPMI**

**November 2019**

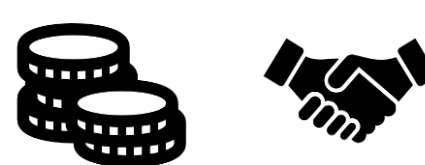
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## Mitsubishi: current market positioning

- 1) **Large liquidity provider** to the market, both physically and financially:
  - Largest Platinum and Palladium trader on the Tokyo Commodity Exchange (TOCOM)
  - In the top 3 on the New York Mercantile Exchange (NYMEX)
  - Substantial over-the-counter and spot business
  
- 2) **One of the largest/most active players in PGMs:**
  - Market share of 20-30% in PGM leasing globally
  - The largest lender to industrial customers
  - Strong links to the automotive sector in Japan, US and Europe (for forward purchasing, leasing, term contracts)
  
- 3) **Active in Market Development, e.g.:**
  - **Investment in future precious metals technologies** via AP Ventures, together with Anglo American and the Public Investment Corporation of South Africa. This fund has a particular focus on **hydrogen and fuel cells**



44 Ruthenium <b>Ru</b> 101.07 233.4	45 Rhodium <b>Rh</b> 102.906 1963	46 Palladium <b>Pd</b> 106.42 1555
76 Osmium <b>Os</b> 190.23 3033	77 Iridium <b>Ir</b> 192.22 2446	78 Platinum <b>Pt</b> 195.08 1769



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## To Euro 7 and beyond:

### Contents

**Euro 7:** What will the next stage of European emissions legislation mean for platinum group metals?

**CO<sub>2</sub> :** will a focus on CO<sub>2</sub> emissions reduction augur well for diesel demand? What about a move to more platinum-rich gasoline catalysts?

**Electrification:** To what degree will electrification impinge on palladium and rhodium demand?

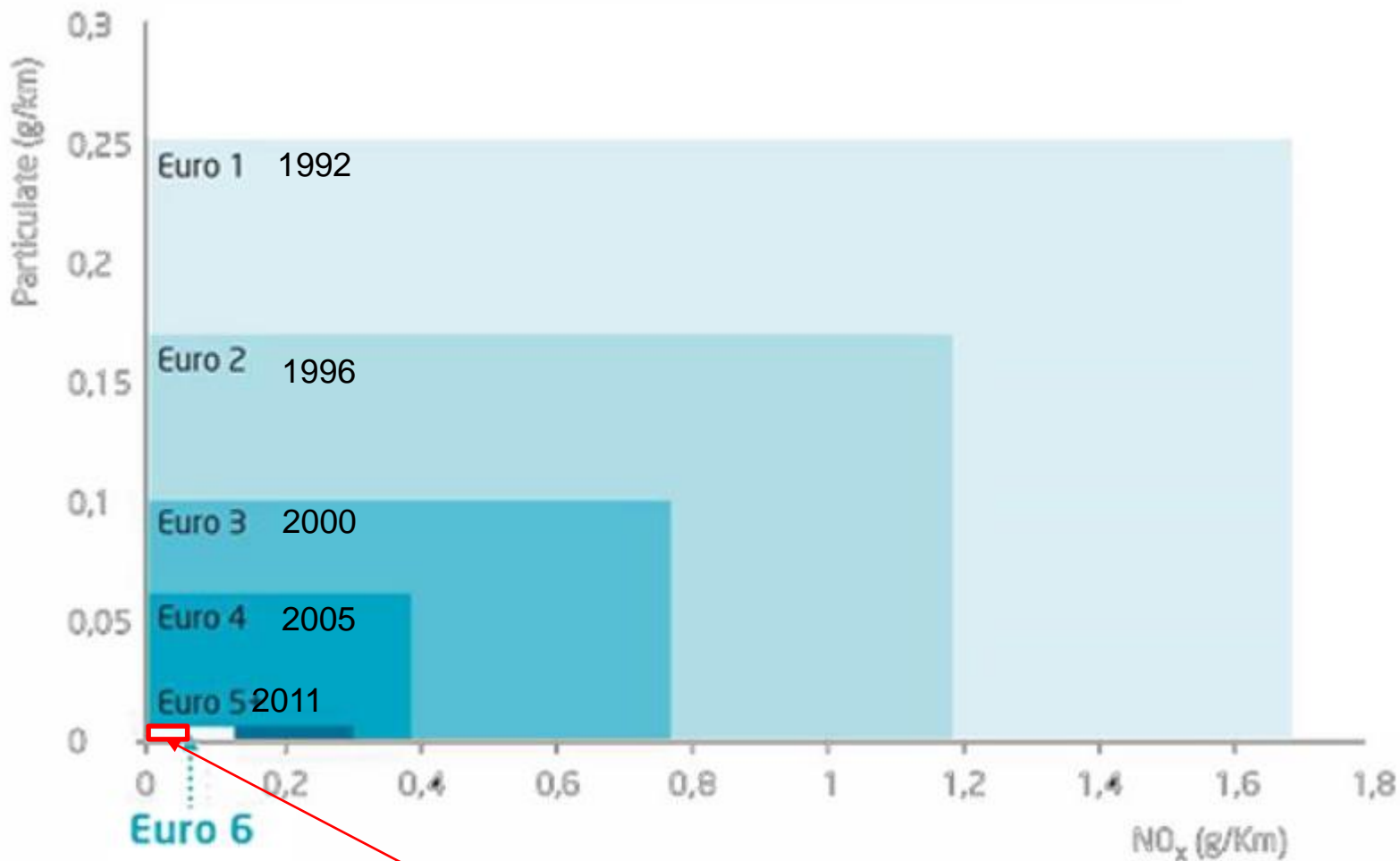
**China:** How will things play out in China, which follows similar standards to Europe at an ever faster rate?

**Refiners:** what will this all mean for refiners as emissions systems become ever more complex?



## Euro 7

2023-25 onwards?



2015

Euro 7: 2023-5 implementation?

## New test procedure

### **Worldwide Harmonised Light Vehicle Test Procedure from 2017/18**

All about testing under a wider range of driving conditions...





## Euro 7: diesels





### Focus on Real Driving Emissions (RDE) Conformity Factors

Legislation	Introduced	NOx limit	Conformity Factor	Effective NOx limit	PN limit	Conformity Factor	Effective PN limit
Euro 6-TEMP	2017/2019	80 mg/km	2.10	168 mg/km	$6 \times 10^{11}$	1.50	$9 \times 10^{11}$
Euro 6d	2020/2021	80 mg/km	1.43	114 mg/km	$6 \times 10^{11}$	1.50	$9 \times 10^{11}$
Euro 7	2023/2025	50-80 mg/km?	1.00?	50-80 mg/km?	??	1.00?	??

- Theoretical limits on Conformity Factors are governed by testing limitations in portable emissions measurement (PEM) equipment – it is assumed that these will improve over time, making the conformity factors **more stringent**
- From 2020 type approval of “**in-service**” conformity regulations designed to ensure that catalysts meet RDE standards not just when the vehicle is new but throughout the vehicle lifetime... again this argues in favour of more durable catalysts



## Diesels: increased complexity likely at Euro 7 Plus RDE gives a wider range of emissions scenarios

<i>Key driver</i>	<i>Detail</i>		<i>Result</i>	<i>Impact on PGM</i>
<b>Increasingly complex catalyst configurations</b>	Greater number of individual catalyst bricks e.g. SCRF, SCR	=	Higher loadings to generate the right mixture of gases to allow the catalysts to function under all conditions. More SCRs and filters	
<b>Focus on new regulated pollutants</b>	Tighter control e.g. of ammonia and N <sub>2</sub> O	=	Greater use of PGM ammonia slip catalysts	
<b>Conformity Factors</b>	Tighter NOx control in a wider range of scenarios	=	Greater use of ammonia based SCR	
<b>Electrically heated catalysts</b>	Light-off achieved quicker allowing catalyst to perform in wider range of scenarios	=	Less PGM may be used on heated catalysts however system as a whole may have more bricks	




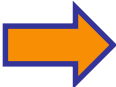

## Euro 7: gasoline

### Focus on Real Driving Emissions (RDE) Conformity Factors

Legislation	Introduced	NOx limit	Conformity Factor	Effective NOx limit	PN limit	Conformity Factor	Effective PN limit
Euro 6c	2017/2019	60 mg/km	2.1	126 mg/km	$6 \times 10^{11}$	1.50	$9 \times 10^{11}$
Euro 6d-TEMP/6d	2020/2021	60 mg/km	1.43	114 mg/km	$6 \times 10^{11}$	1.50	$9 \times 10^{11}$
Euro 7	2023/2025	50-60 mg/km?	1.00?	80 mg/km	??	1.00?	??

- **Particulate number limits** only apply to Gasoline Direct Injection (GDI) engines, so are a somewhat limited part of the overall gasoline market
- 2020 “in-service” **conformity** regulations also apply

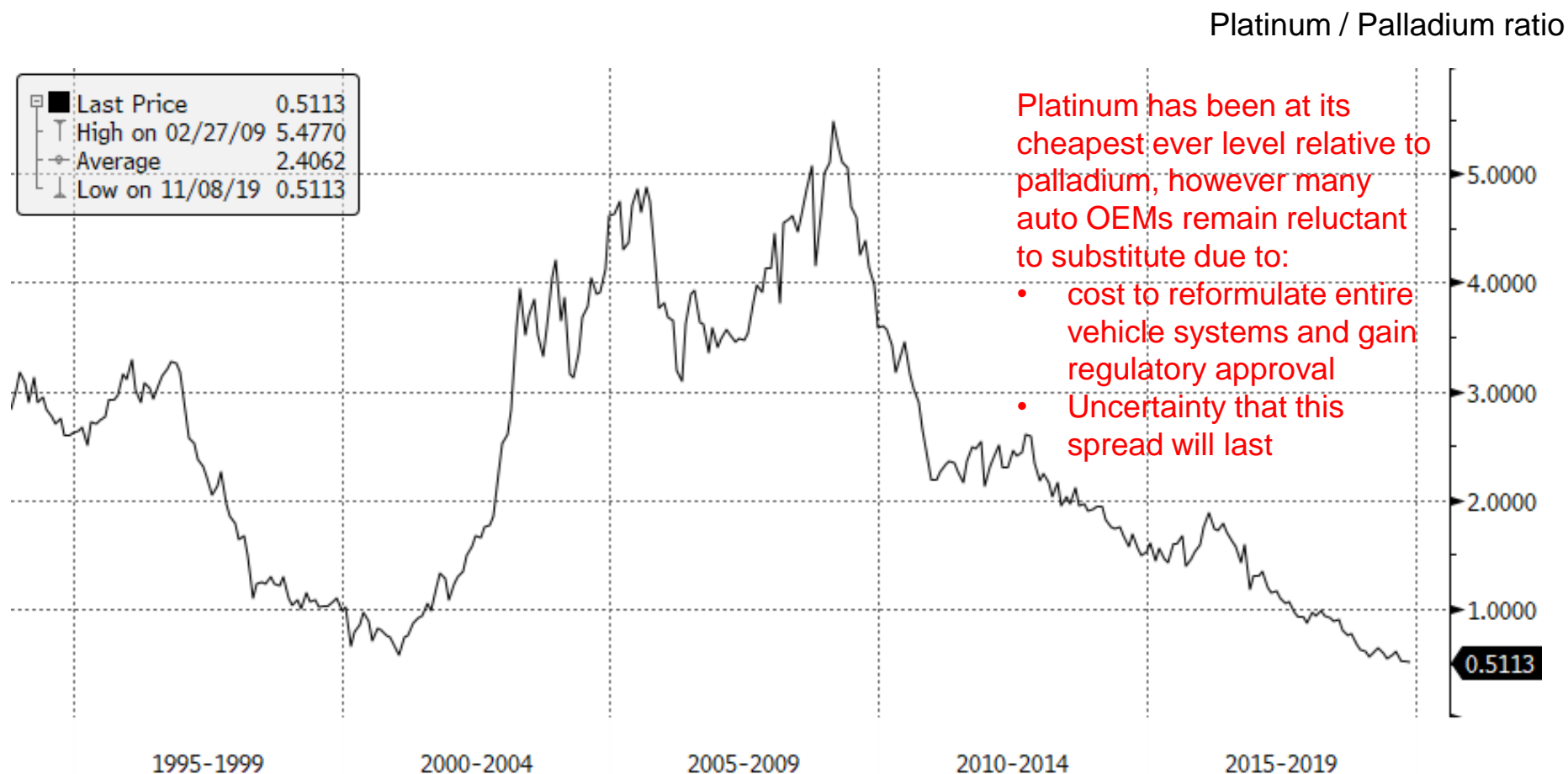
**Gasoline: increased complexity likely at Euro 7**  
**Plus RDE gives a wider range of emissions scenarios**

<i>Key driver</i>	<i>Detail</i>		<i>Result</i>	<i>Impact on PGM</i>
<b>Increasingly complex catalyst configurations</b>	Greater number of individual catalyst bricks	=	Higher loadings to generate the right mixture of gases to allow the catalysts to function under all conditions	
<b>Control of NOx and particulate matter in GDI engines</b>	Use of filters for particulate matter	=	Not all filters are coated	
<b>Electrically heated catalysts</b>	Light-off achieved quicker allowing catalyst to perform in wider range of scenarios	=	Less PGM may be used on heated catalysts however system as a whole may have more bricks	

Tighter control of NOx bodes well for **rhodium**, which is a superior reduction catalyst

## Substitution: more platinum in gasoline cars?

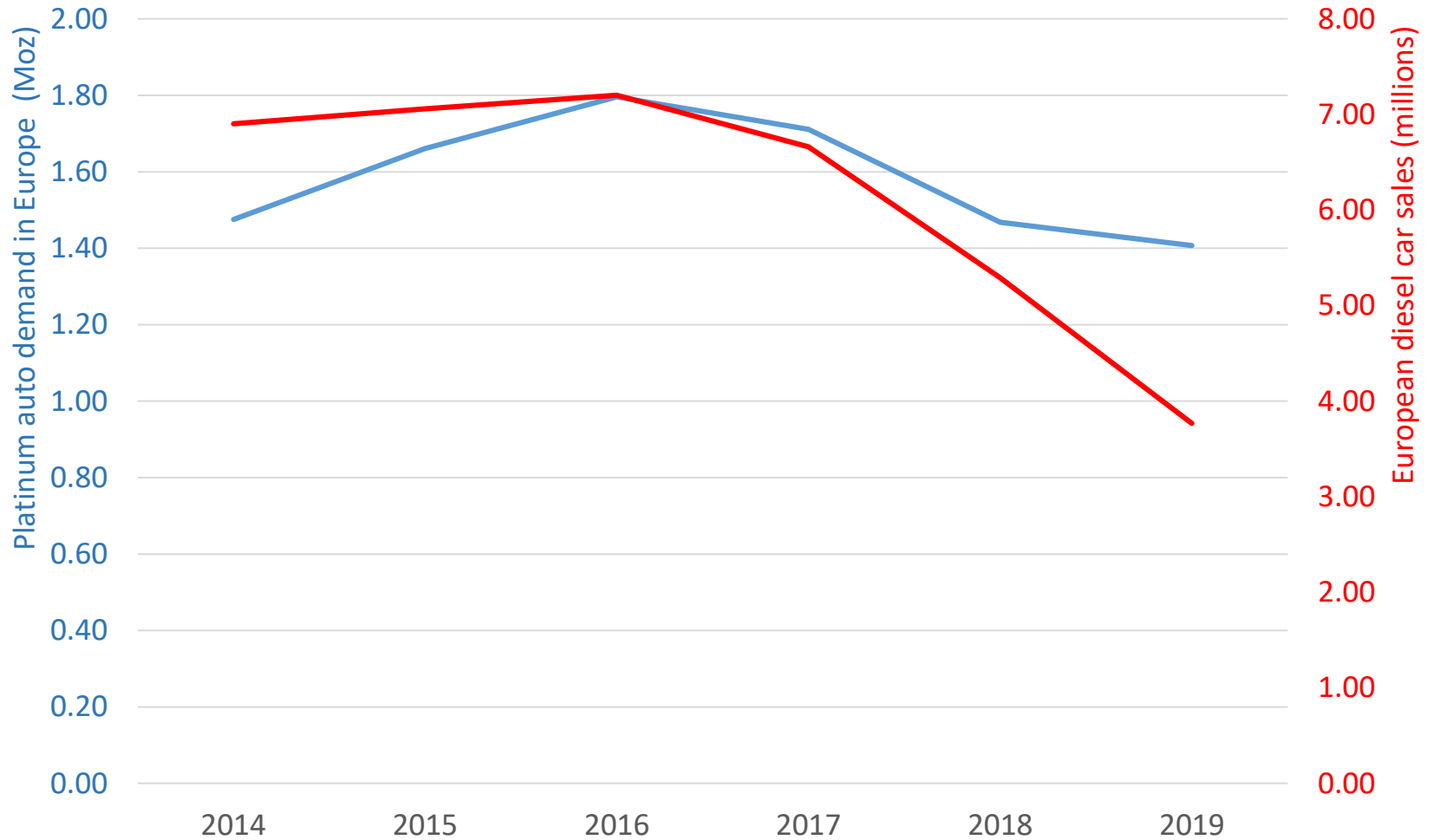
Extreme relative valuations but unlikely to stimulate short term substitution



Source: Mitsubishi from Bloomberg

Platinum is undervalued on a relative and absolute basis

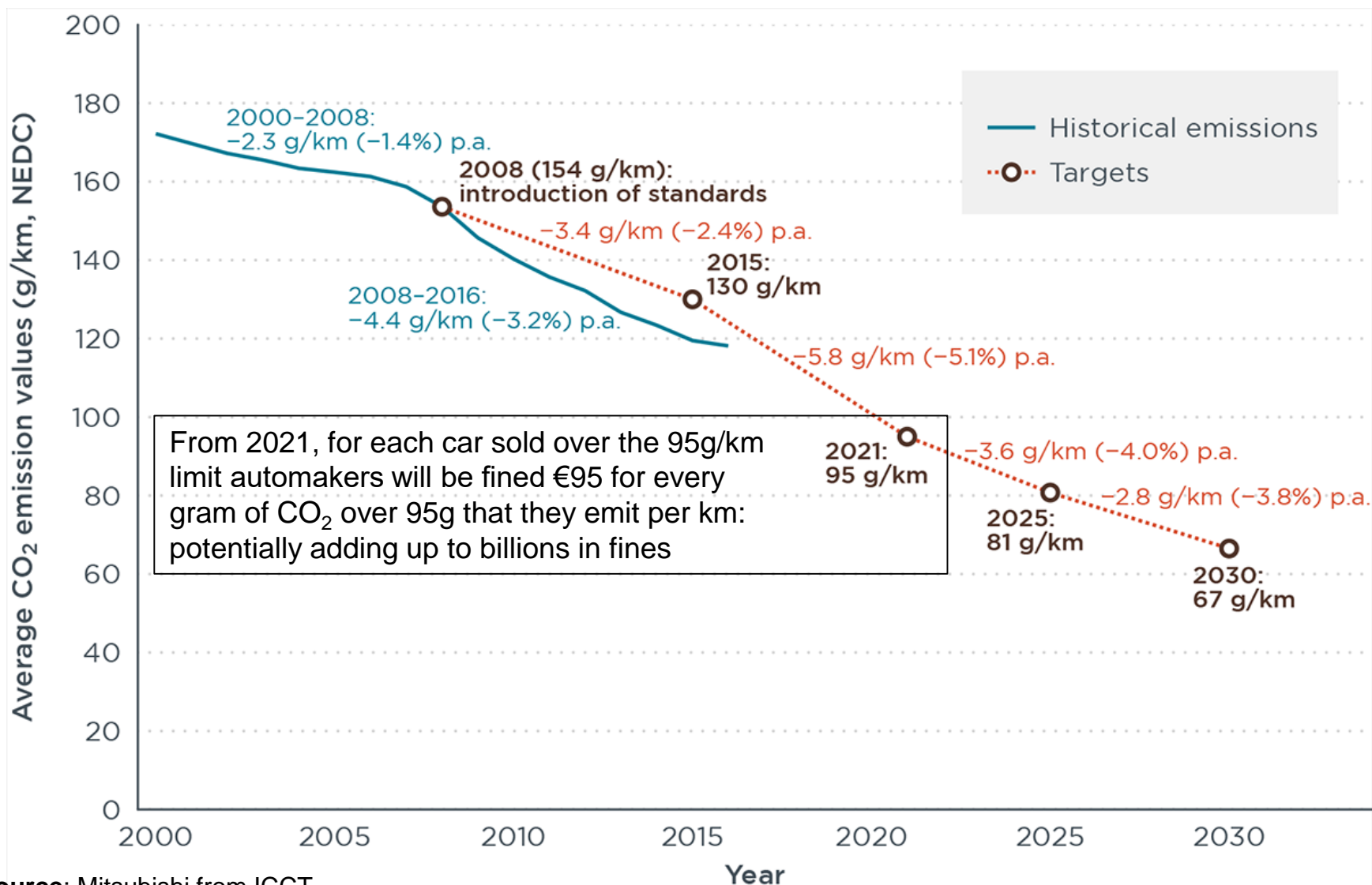
## Platinum and diesels



Average platinum use per vehicle has fallen despite implementation of Euro 6

## CO<sub>2</sub> targets

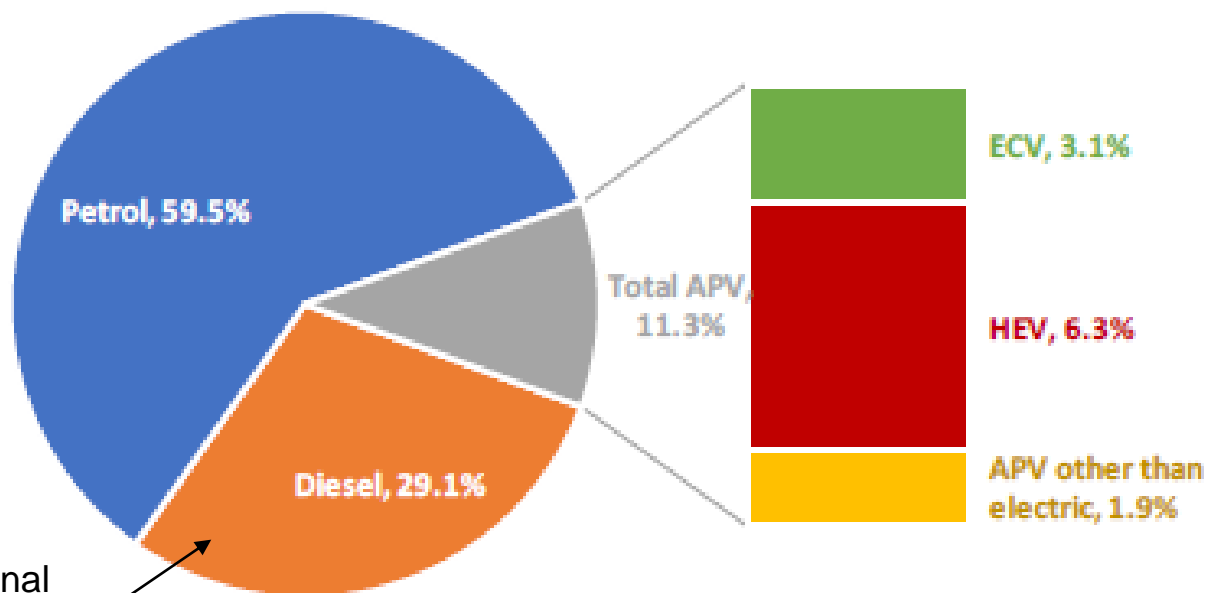
Independent to Euro 7, already set for 2025, 2030



## CO<sub>2</sub> targets

Diesels 20% more efficient than gasoline – CO<sub>2</sub> targets should drive uptake

Fuel types of new cars: petrol +6.1%, diesel -14.1%, electric +51.8% in third quarter of 2019



But some interesting regional differences, e.g. Germany diesel up 4.7% in the period

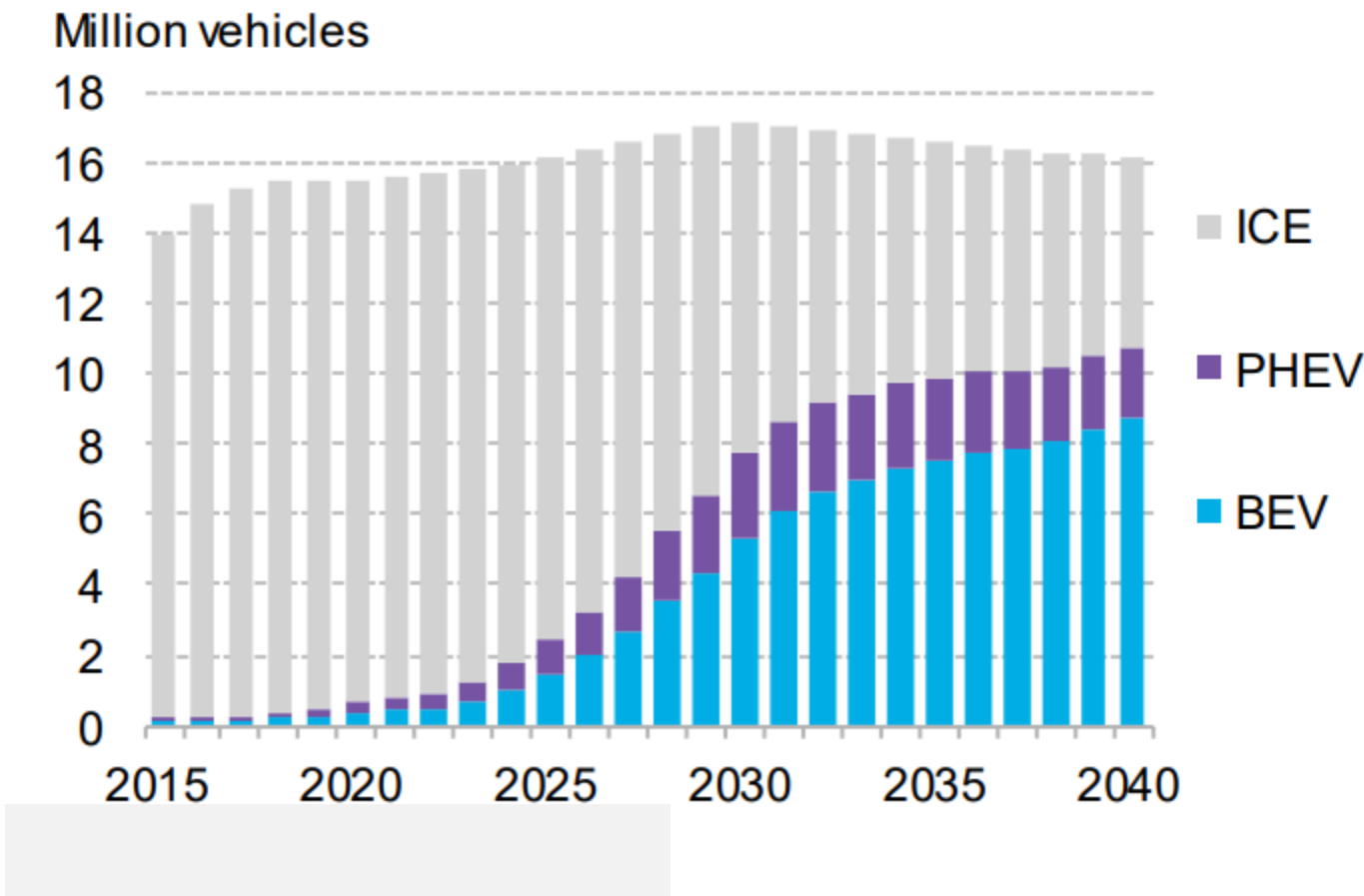
Source: Mitsubishi from ACEA

Rise in hybrids is generally positive for PGM loadings



Electrification: the saviour for CO<sub>2</sub> and other pollutant emissions?  
**Limited adoption in near term but some more bullish longer term**

**European passenger vehicle sales forecast**



Source: Mitsubishi from Bloomberg New Energy Finance

## Electrification: the saviour for CO<sub>2</sub> and other pollutant emissions?

**Hybrids** (mild, full and plug-in hybrids)

**BEVs** (pure battery electric vehicles)

**FCEVs** (fuel cell electric vehicles)

*PGM demand*



Higher loadings to deal with more frequent cold starts:

**JM:** 0-15% higher PGM  
**WPIC:** 25 koz for every 1% increase in 48v diesel mild hybrid market share



No engine = no catalyst (affects Pd more than Pt as gasoline vehicles take a bigger global market share)



Currently considerably higher loadings than ICE

Current loadings: 1-3 oz of Pt per vehicle  
 DoE target of <0.5 oz at volume

*European sales projections*

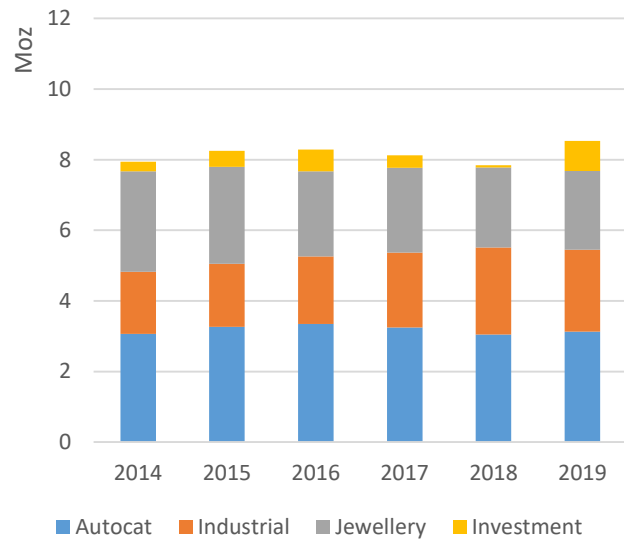
Sales of all hybrids to amount to ~**23%** of European market by 2025

Pure BEVs to amount to ~**14%** of the European market by 2025

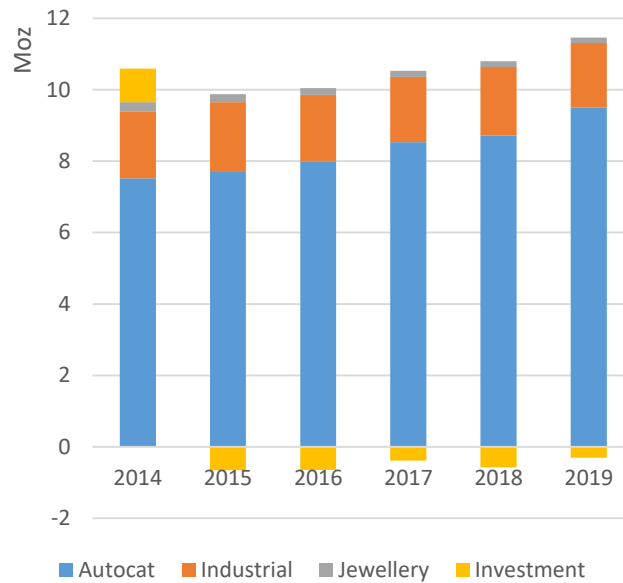
FCEVs to be **<1%** of global market by 2025

# Electrification: long term impact on PGMs

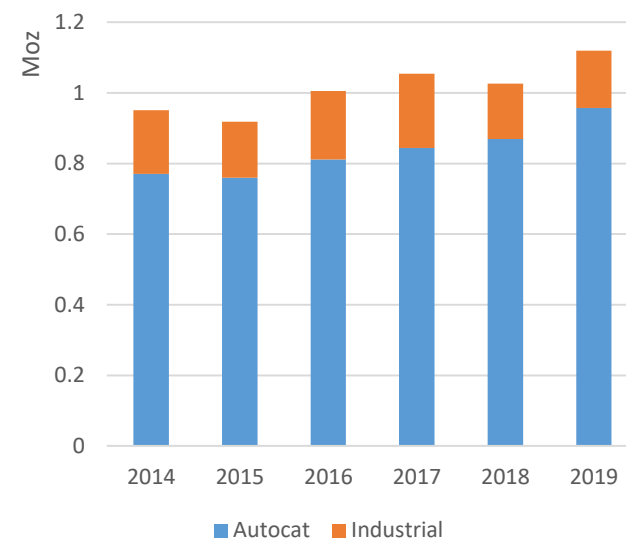
## Platinum



## Palladium



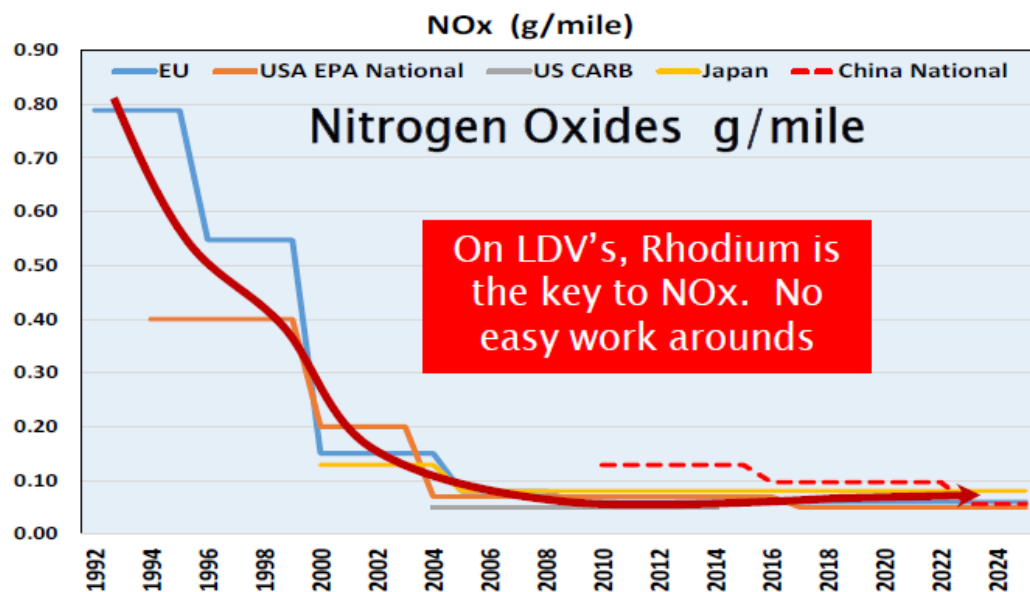
## Rhodium



Source: Mitsubishi from Johnson Matthey

# China

Following European regulations at an ever faster rate



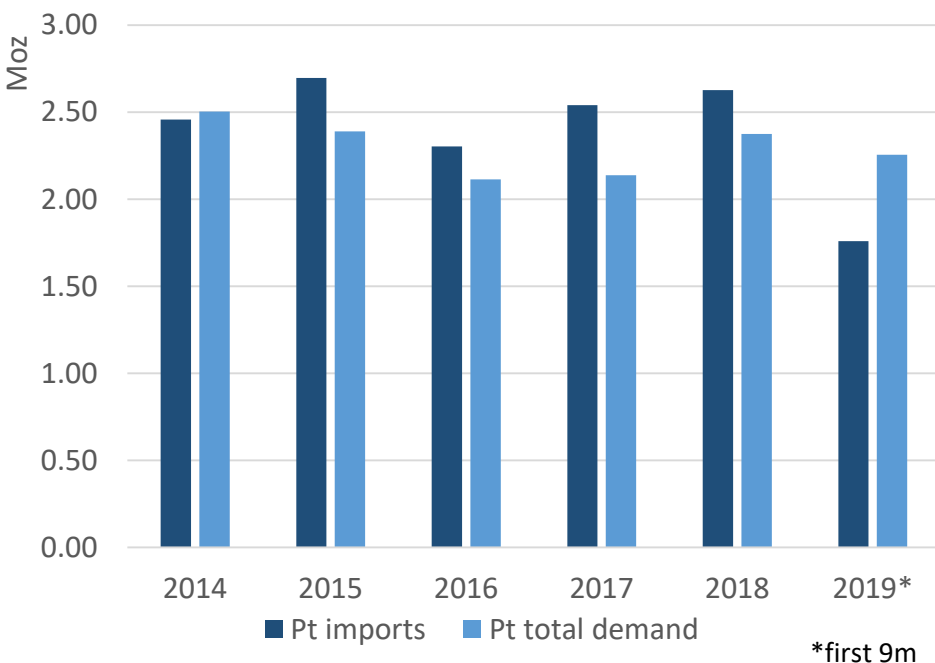
- **2019: China 6** standards start to be implemented, broadly following **Euro 6 but more stringent**
- **2020: WLTP and Nationwide** implementation of China 6
- **2023: RDE and Conformity Factors introduced** will be enforced for NOx and PN, starting at 2.1
- **Represents a large uptick in Pd and Rh demand**

Also India accelerating towards Bharat Stage VI (~Euro 6) nationwide in 2020

## Comparison of official imports and demand in China

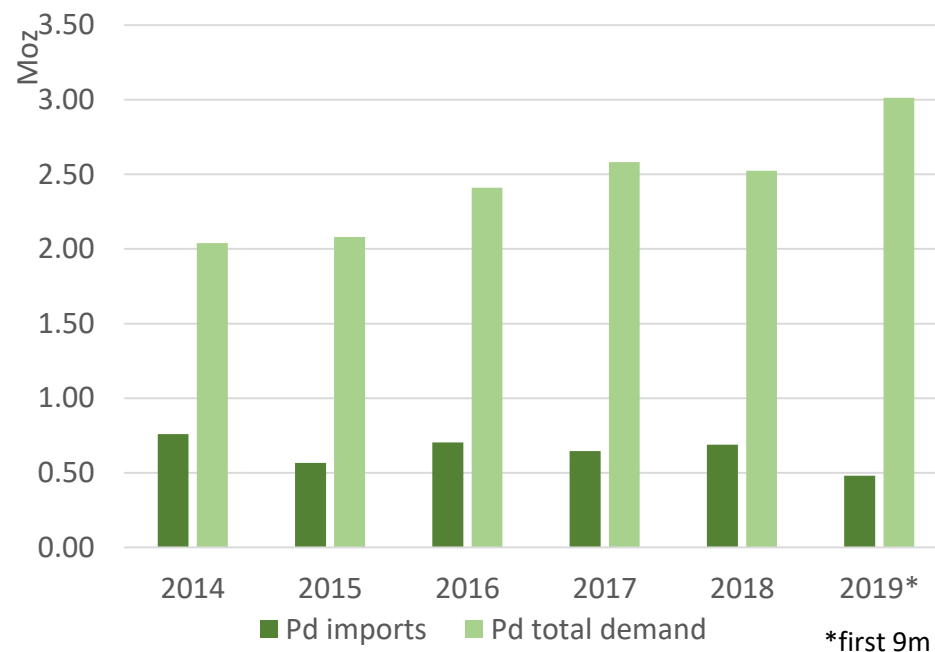
China has minimal domestic PGM production but recycling is growing

### Platinum imports and demand



Platinum demand and imports are roughly evenly balanced. The apparent mismatch in 2019 is due to demand projections for the full year and imports only for the first 9m

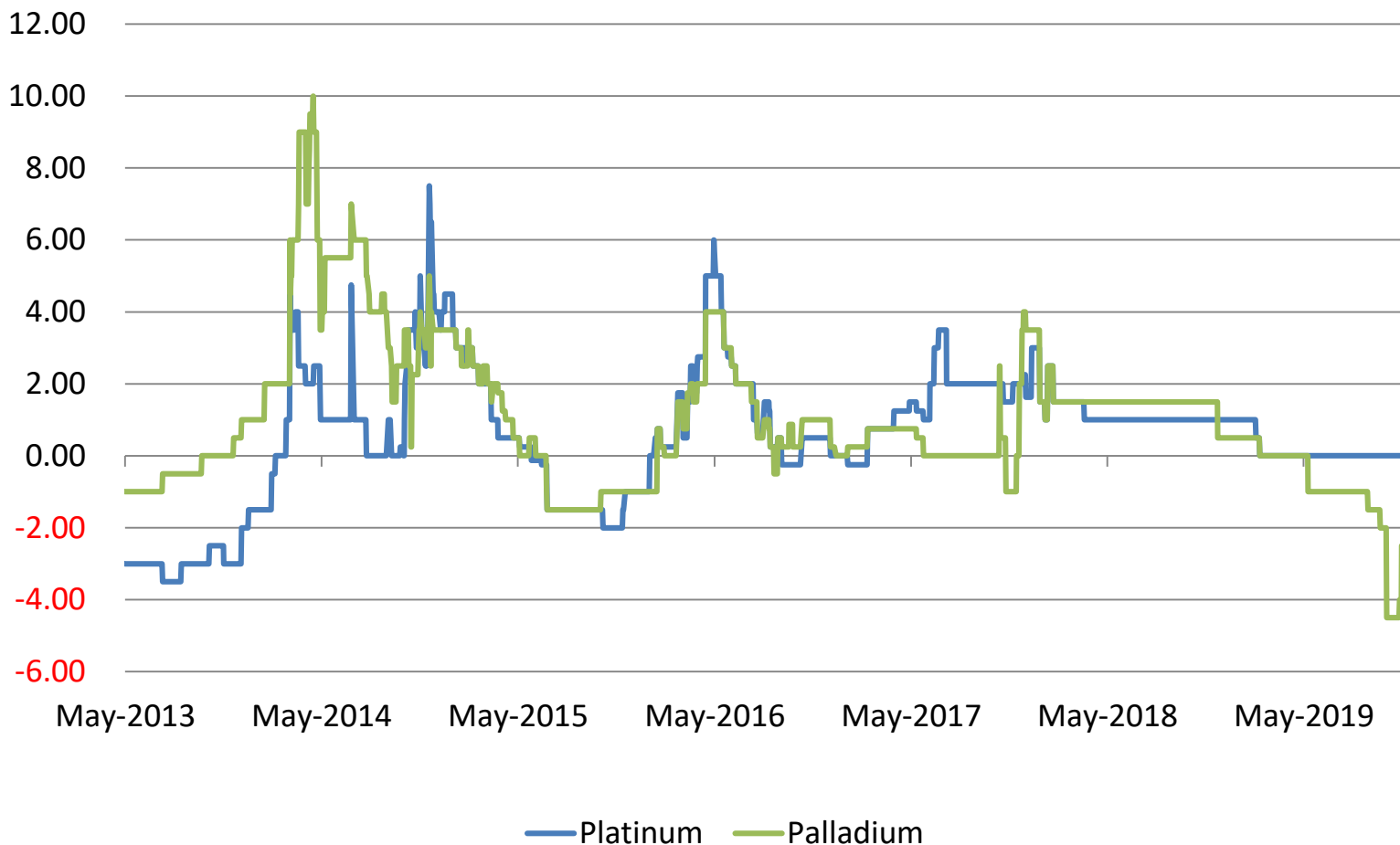
### Palladium imports and demand



Palladium demand has long been in excess of official imports. With recycling only around 30% of the market at best, this suggests the bulk of palladium comes from 'unofficial' imports

## Sponge discount reflects China trade

Sponge premium / discount relative to ingot (\$/oz)



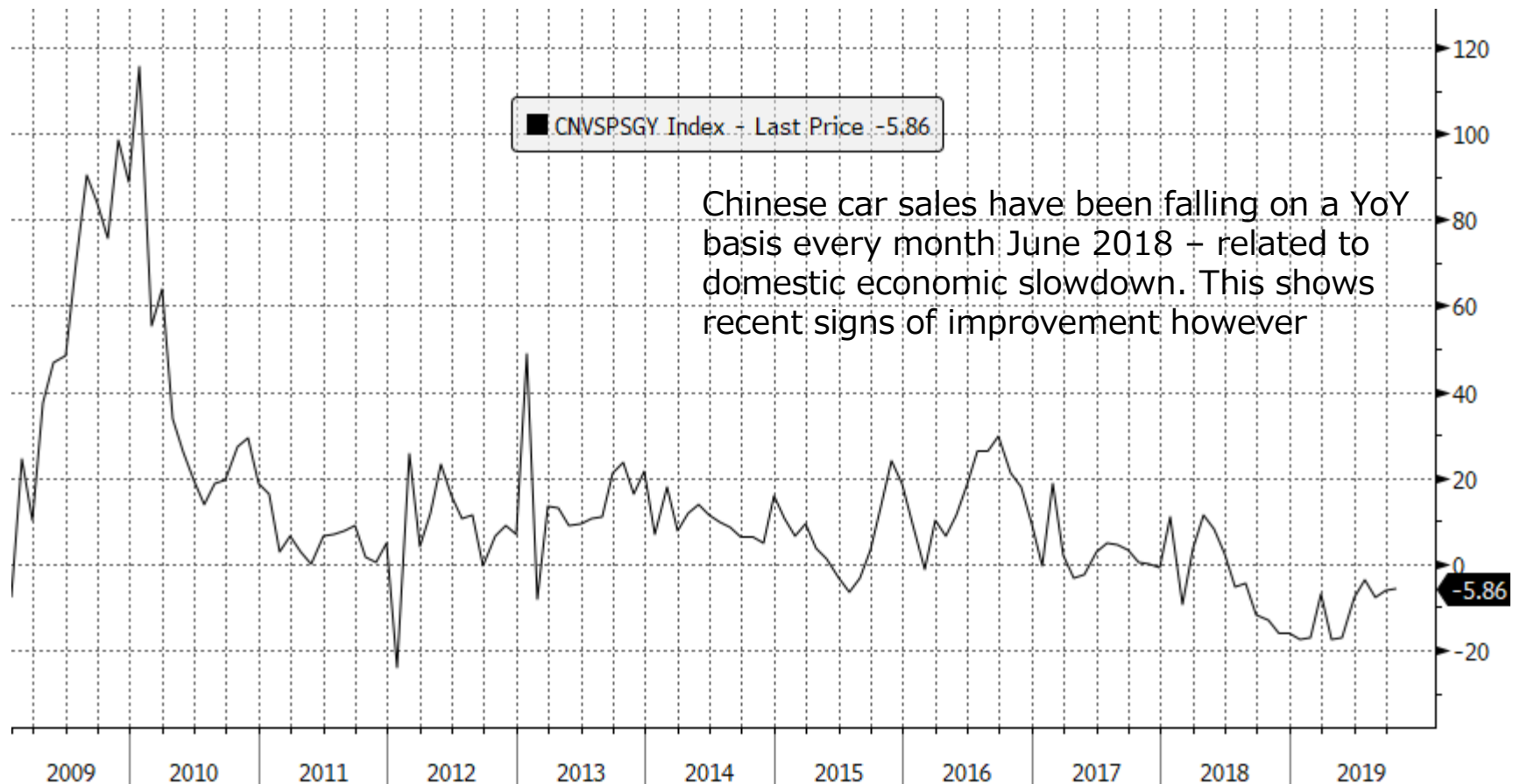


## Chinese car sales are slowing

Falling car sales offset by higher loadings from tighter emissions standards

YoY change in car sales in China (%)

Source: Mitsubishi from Bloomberg



Despite fall in car sales over the past year, vehicle catalyst loadings are increasing to meet China 6 emissions standards from next year

## Conclusions

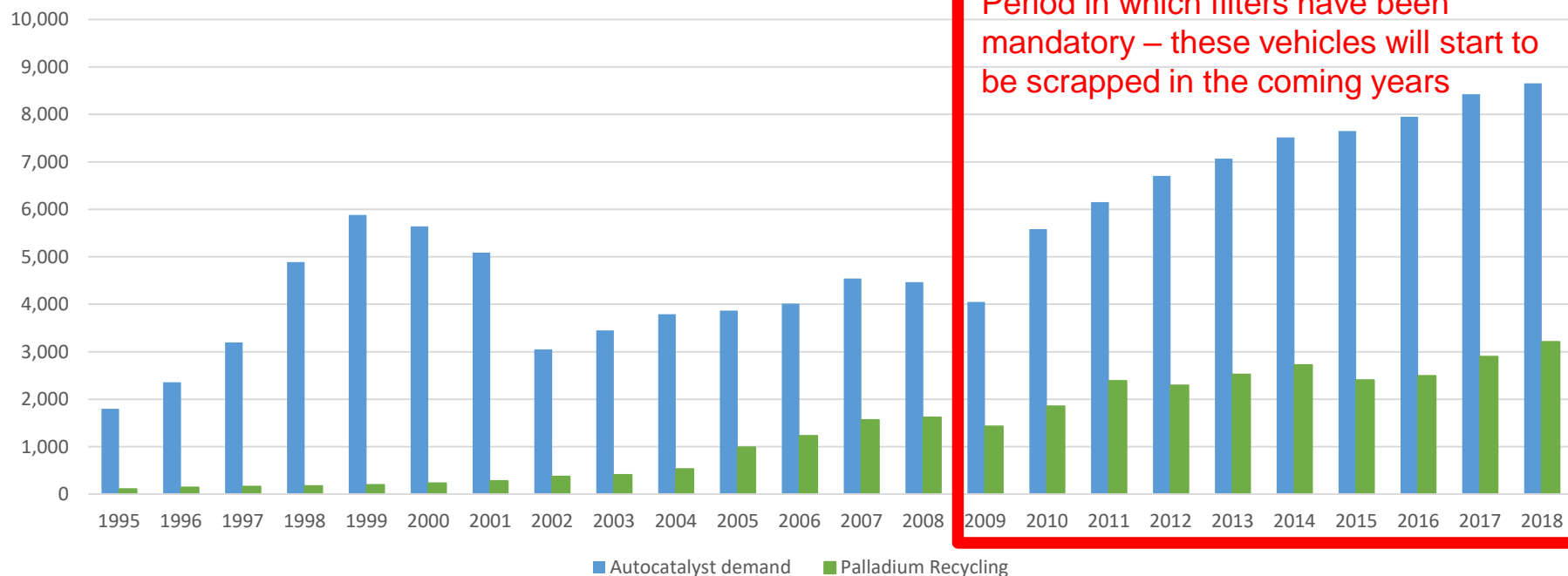
### Greater complexity, generally positive for PGMs

- Euro 7 is likely to focus on tighter **RDE NOx** control for **diesels** and **GDIs**
- This is likely to lead to more **complex catalysts** with higher **PGM loadings**
- Greater use of **SCR** and **filters**, plus SCRFs
- Little likelihood of major **substitution** of Pt for Pd, or any Rh substitution
- **Early implementation** of Euro 7 by some OEMs will bring forward PGM demand
- **CO<sub>2</sub>** targets are likely to favour **diesel**, therefore platinum demand
- Other parts of the world following more quickly, especially in RDE testing
- **Hybrids** are positive for PGM in medium term
- Pd and Rh most at risk from **electrification** in the longer term

## Secondary supply

Further growth in recycling in the near term likely

Palladium autocatalyst demand and total recycling (koz)



Volumes of recyclable material are rising at the same time as it becomes more difficult to process certain substrates, therefore increasing lead times

## What it means for refiners Bottlenecks in processing

“refinery capacity constraints could continue to dampen growth in secondaries in the short term. For platinum, capacity issues have been exacerbated by the fact that most refiners can handle only limited quantities of diesel particulate filter scrap, because of its silicon carbide content. Scrap with an elevated silicon carbide grade must usually be blended with other scrap materials to limit the carbon content of smelter feed.”

**JM Pgm Market Report, May 2019**

**Filters have been mandatory in Europe since 2009**



+

Refineries at full capacity

=



**Thank you!!**