Light Duty Gasoline Systems TWC+GPF development for BS VII

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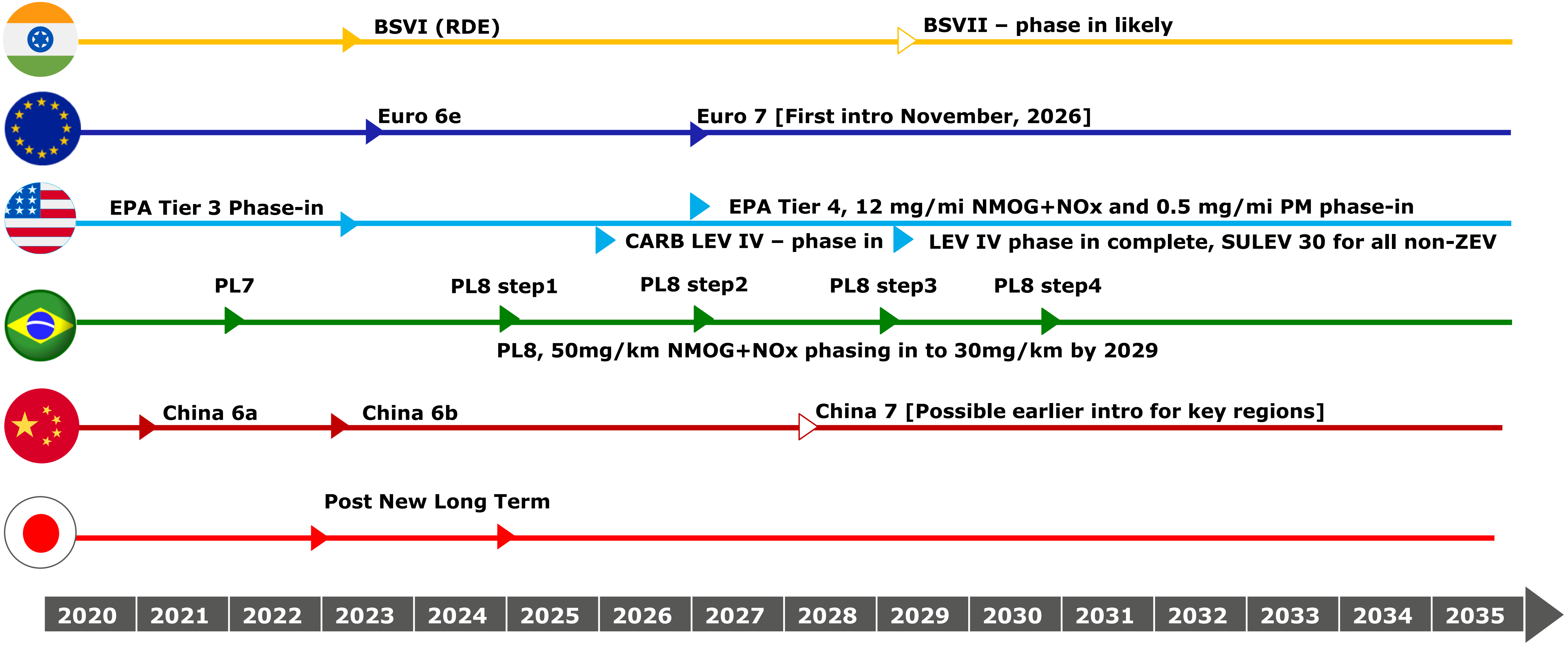
Outline

01 Light Duty Gasoline Roadmap for key regions

Criteria emissions (NOx, PN etc.)



European Emission Legislation

General legislation timeline

Eu6e - set to run until 11/26 and onwards - general emission requirement remains the same

Most tailpipe emission based features stay the same

Works alongside Eu FIT for 55 package CO_2 ambitions

Eu6e

60mg/km NOx
PN_{23} 6 x 10^{11} #/km
No Sec Emissions
Eu6 RDE dynamics
Eu6 boundaries
CFs 1.1 NOx, 1.34 PN
Trip distance > 16km
160k km

Eu7 11/26

60mg/km NOx
PN_{10} 6 x 10^{11} #/km
Eu6e RDE dynamics
Eu6e boundaries
CFs 1.1 NOx, 1.34 PN
Trip distance > 16km
160k km + x1.2 at 200k km

Timeline

The data included herein were collected in a Johnson Matthey laboratory which has not been certified by the relevant authorities/agencies to perform emissions testing. These are indicative data and do not represent a guarantee that the tested catalyst or emissions system will pass the relevant emissions legislation.

Top level overview about route to EU7

Formation of Legislation and impact on OEMs / Development

- Initial CLOVE A/B proposals were **very severe** – even the **introduction dates**
  Met with lots of opposition from OEMs – and support from other stakeholders
  Pushed technology to limit – and products like **EHC / ASC** were developed
  For some applications would **some limitations in engine operation**

- Iterations of legislation from EU Commission, Parliament, Council **reduced in severity**

- In April 24 EU Council set EU7 at **almost the same as today (EU6e)** with some minor changes.
  Some other features for **tyres / brakes / OBM** which are separate from tailpipe emissions
  Aftertreament system remain **broadly the same as from E6e**
  Focus is on using minimum PGM using best technology

European Parliament / Council Eu7 (24.4.24)

Gasoline ATS designs reflecting change from Eu6e to Eu7 latest proposal

	Date	NOx km	Trip #/km	PN mg/km	2^{nd} Em -	CF -	FUL '000km	Dyn -	Towing -	Temp °C	Alt m
Eu6e to Eu7 severity	From 11/26	=	=	↑	x	=	↑	=	x	=	=

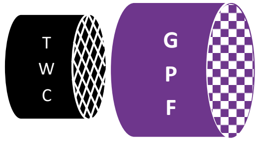
System

1st Eu7

GPF : Coated / uncoated + EFC / membrane

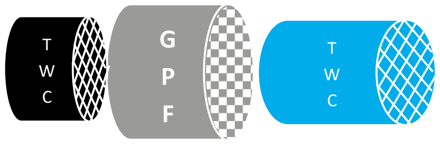
Euro 6e (today)

Act.Eu7



coated

or



uncoated

System Requirements

CANCELLED

- Very low emission level
- Any driving
- Higher TWC volumes

- **Emission levels equivalent to 6e**
- **Requirements broadly follow on**

Technology impact

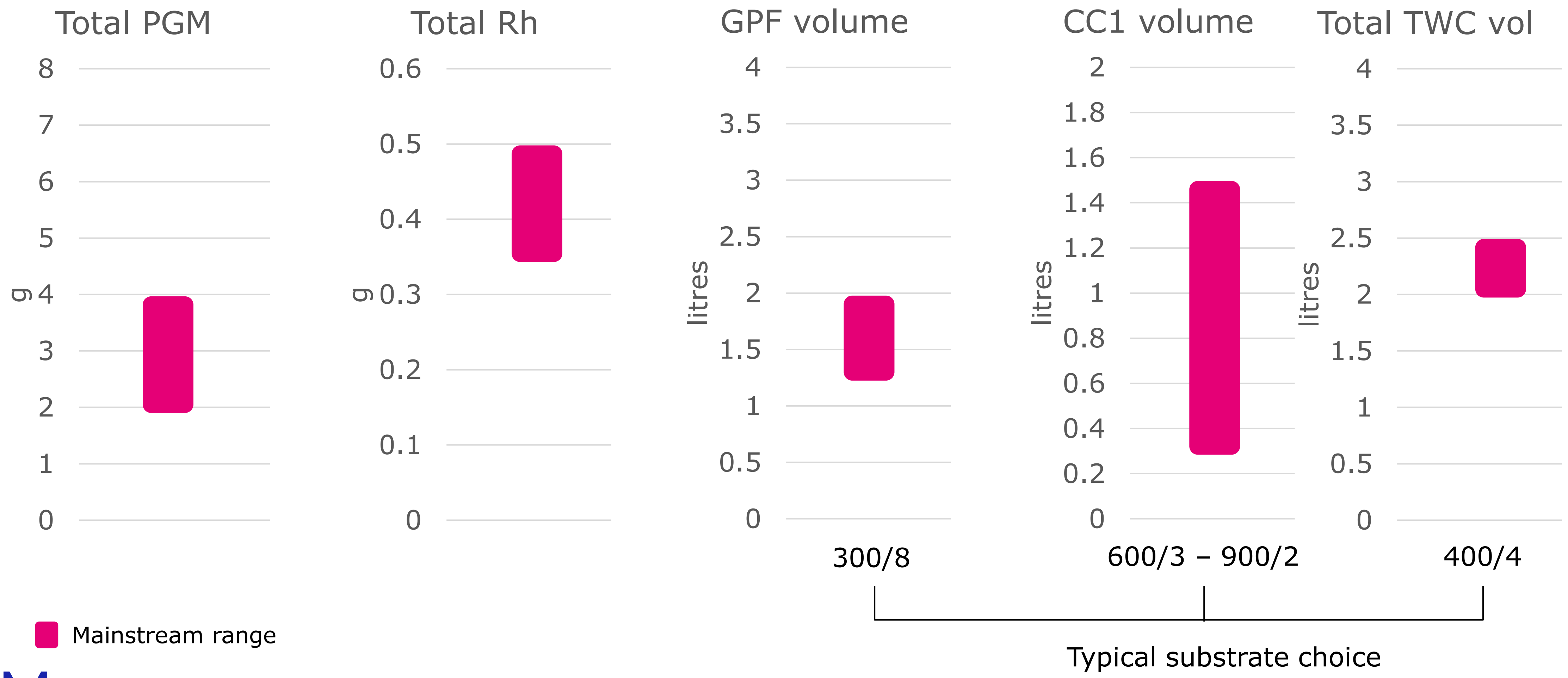
CANCELLED

- Technology pushed to limit
- New tech (ASC / EHC)
- Pt introduced
- Higher PGM (>120g/cu ft)

- **Build on today's technology**
- **TWC / TWF type technologies**
- **Pd/Rh focussed**
- **Low PGM (< 80g/cu ft CC1)**
- **Optimise system costs**
- **Consider more hybrids**

System trends for Eu6e/7

Mainstream ranges up to 2L engine volume



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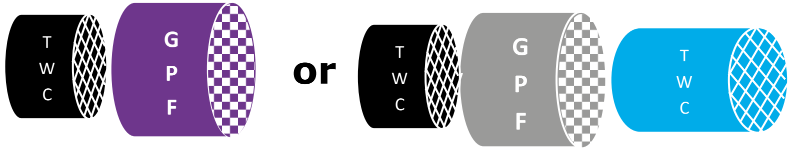
Main Legislation areas and for product / system designs / Technology Focus

Key Technology Focus

NOx **60mg/km**, continuing with Eu6e framework (inc RDE)

Eu6e to Eu7



coated

uncoated

For Eu7 typically 2-3 bricks per exhaust bank

Focus on PGM reduction / optimisation through improved technologies (Pd/Rh)
OSC on CC1 (monitored section) for diagnostic
ΔP
Low cost design for UF sections

BSVI Expected to draw on Eu7 framework

Mainly CC installations

BS VI to BS VII

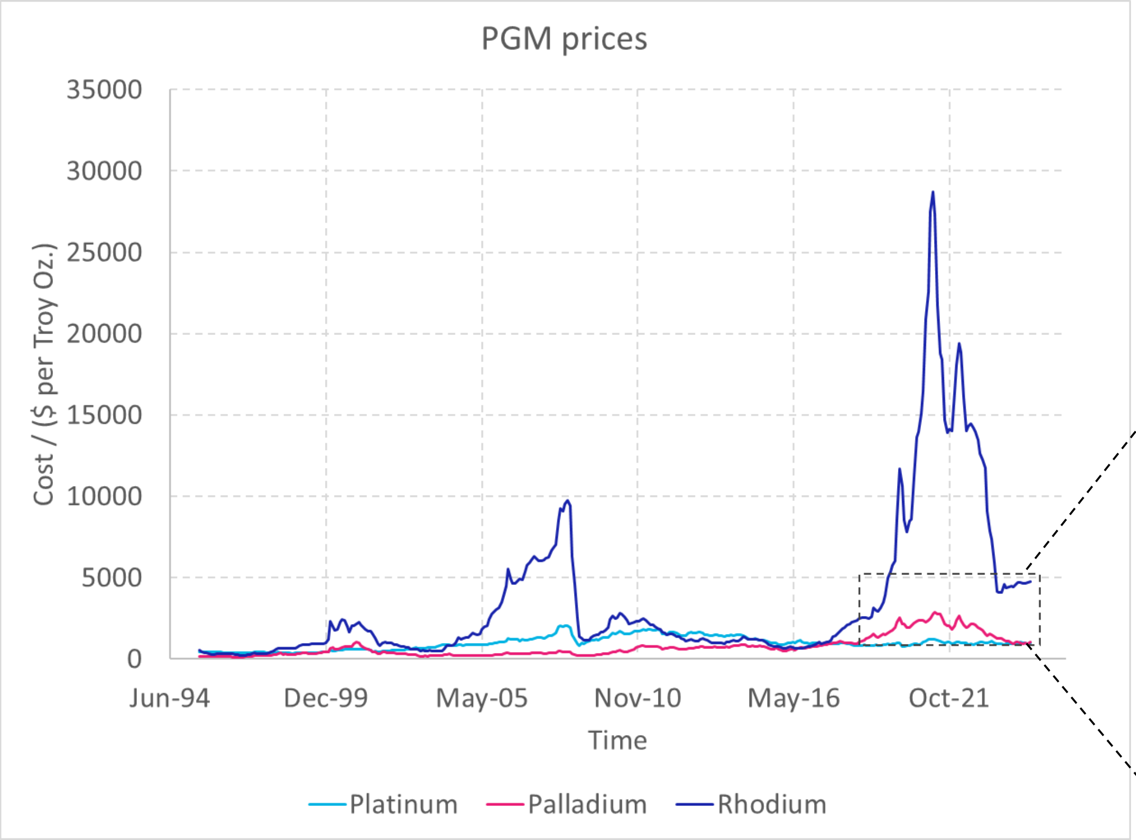
coated

uncoated

Value proposition
High Temp (NA >1000ºC) min OSC loss
Low-cost design for rear brick sections
ΔP / LO / FE sensitive
Higher prevalence of CHG

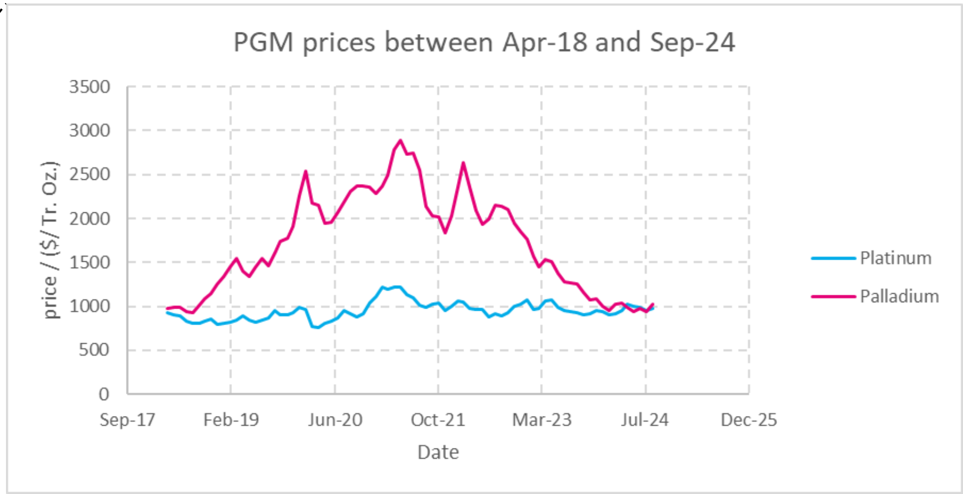
PGM prices (Jun 94 – Sept 2024)

Historic PGM fluctuations – today Pt ~= Pd, Rh still high but has fallen



World leader
largest recycler of PGMs by volume

c.a. 70% recycled PGMs
used to manufacture our products

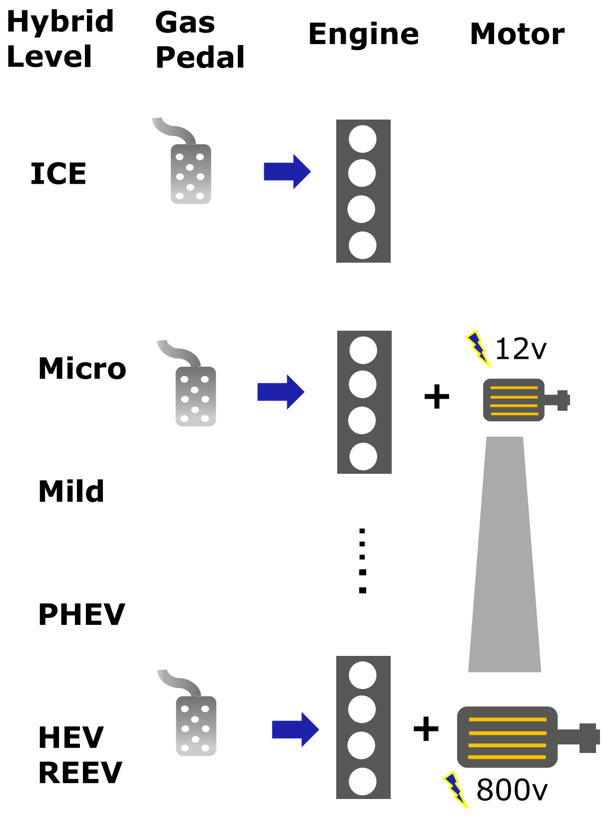


General trend to keep with Pd/Rh or **move back from Pt to Pd** as metal prices reach parity
Rh still at a relative historical high

ICE and Hybrids

Impact on emission systems and catalyst design

Powertrain Options



Impact on engine

Increasing hybridisation decouples driver from powertrain

Different engine duty cycle

Impact on ATS

General trend of using same architecture with higher PGM (+20%) with stronger hybrids, and bigger engines

Lowest possible light-off to avoid re-heat and longer electrical running

Revised (downward) temperature limits with stronger hybrids

Opportunity to simplify diagnostic

Soot control opportunities

Sharing information with OEM and designing to specific targets will give optimised system

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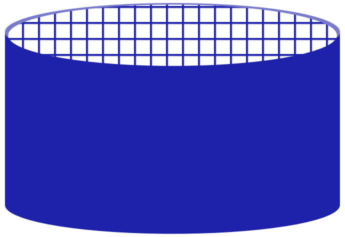
Gasoline Product portfolio

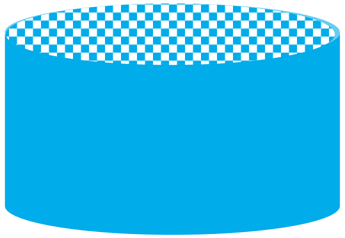
Technology Summary

TWC



Supplying Automotive industry for > 50 years
High temperature resistant technology ready for Eu7 deployment
Global presence with market leading technology
Working to supply the industry with **lowest possible PGM** levels
Development for alternative fuel (**CNG / Ethanol**) catalysts continues

TWF®



Supplying Automotive industry since Euro 6d (2017)
High filtration technology ready for Eu7 deployment
Global presence with market leading technology


JM
Johnson Matthey
Inspiring science, enhancing life