2022 APPMC, Singapore

7th June 2022

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Rhona O'Connell is a full-time employee of StoneX Financial Ltd. She does not have a personal futures trading account

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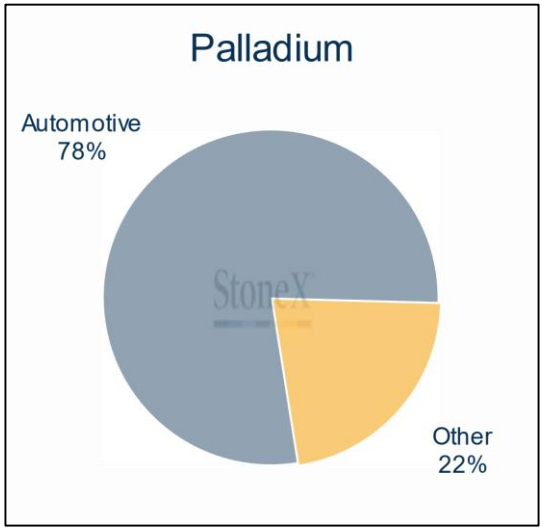
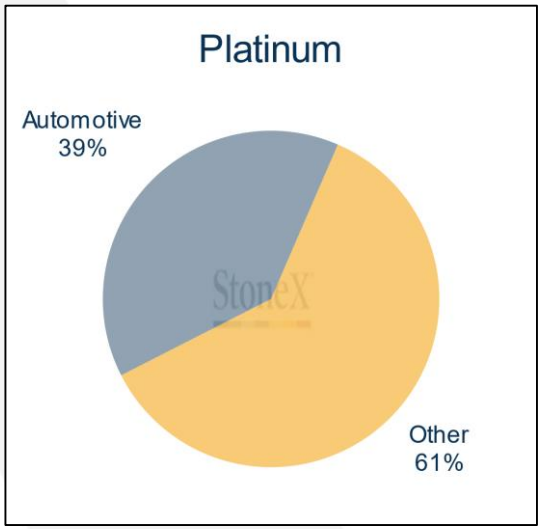
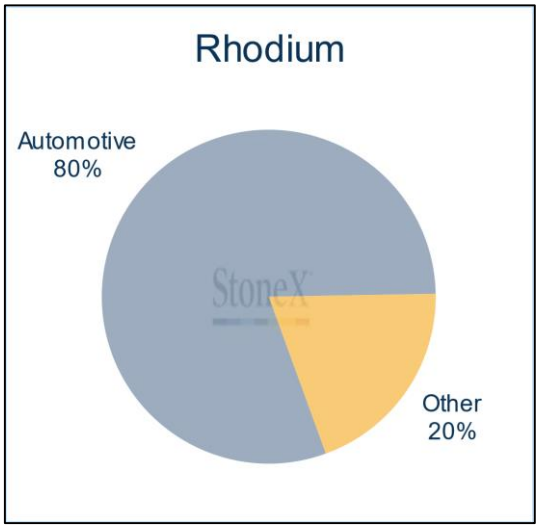
Automotive market share (gross offtake)







Sources: Pt & Pd; Metals Focus, StoneX; Rhodium - Johnson Matthey, StoneX

The path to Net Zero Emissions; vehicle electrification,

- Total global carbon dioxide emissions in 2020 amounted to approximately 34Bn tonnes.
- Of this, roughly 3Bn t came from passenger cars worldwide in 2020, meaning that the auto sector (excluding commercial vehicles) was responsible for ~10% of global CO_2 emissions in that year. The energy sector accounts for roughly 75% of total.
- The U.S. Vehicle Technologies Office estimates that shifting to a light-vehicle electric fleet could cut greenhouse gases by 30-45%.

Emission control catalysts – take out some noxious gases – but….

The Chemistry – Internal Combustion Engine (ICE) gasoline vehicles; look at the culprit by-product;

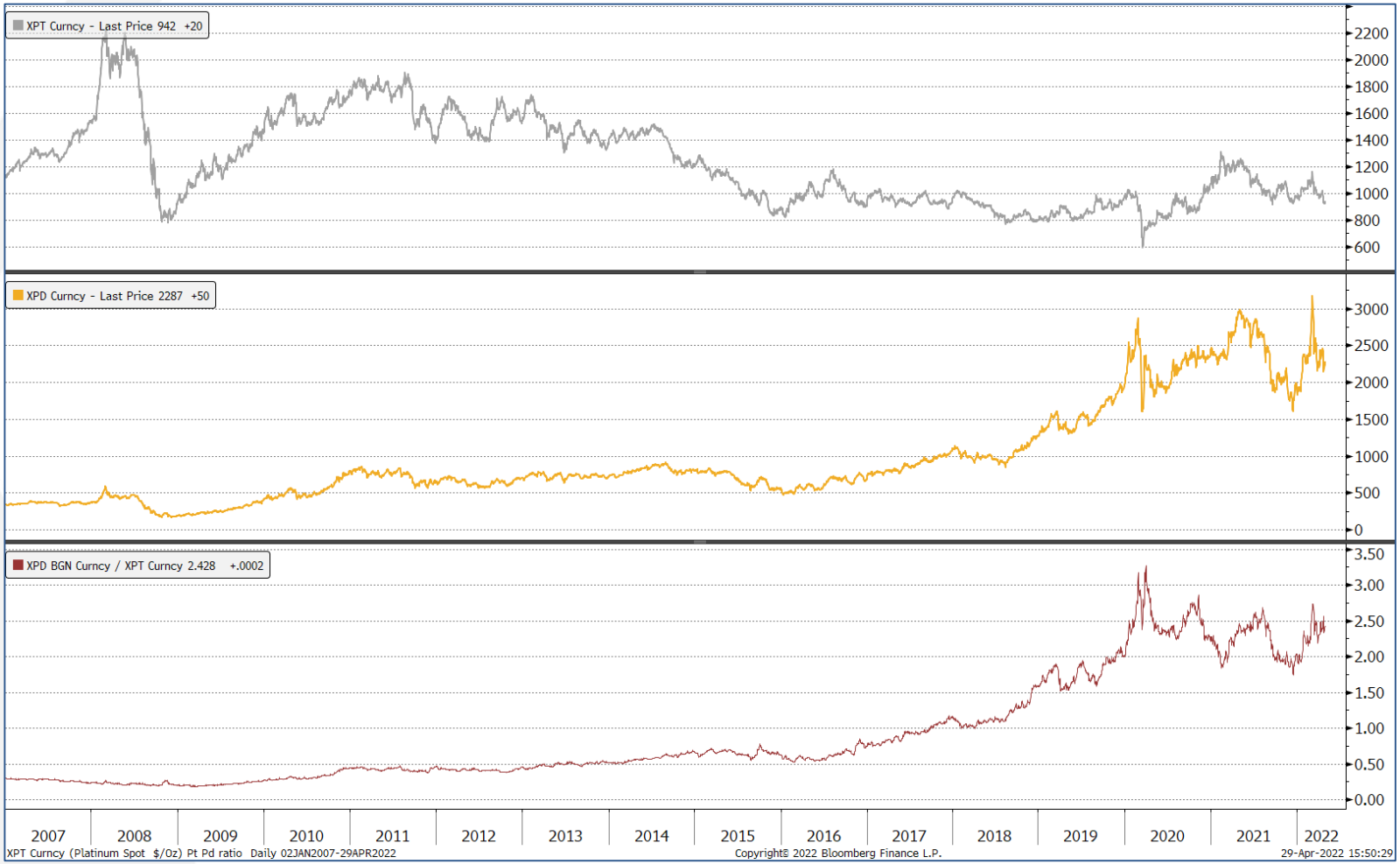
At the simplest level; these are some of the reactions involved

$C_xH_{4x} + 2xO_2 \longrightarrow xCO_2 + 2xH_2O$; main catalyst, **palladium**

$2CO + O_2 \longrightarrow 2CO_2$; main catalyst, **platinum**

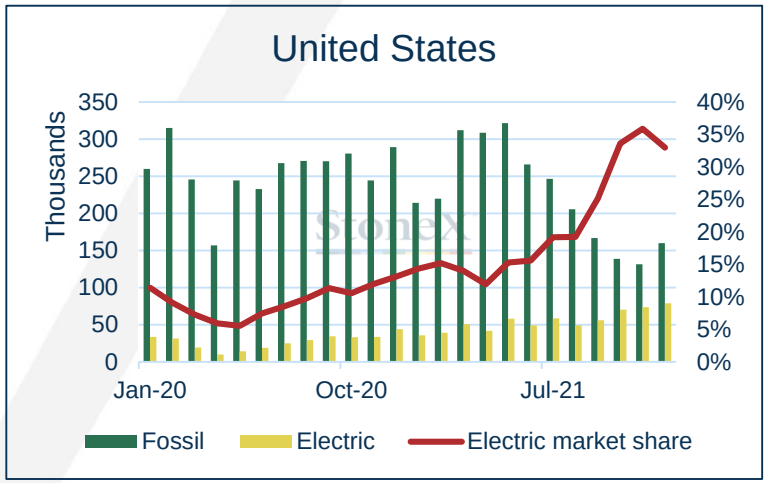
NO_x can be reduced to nitrogen gas by selective catalytic reduction (SCR); main catalyst, **rhodium**.

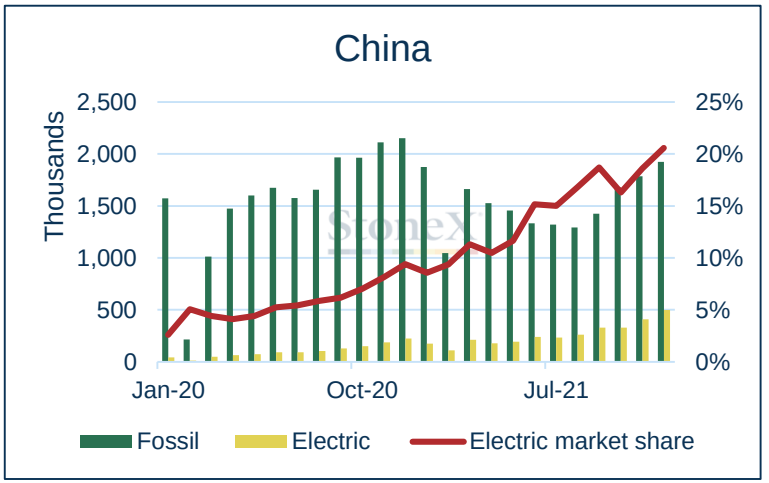
Platinum gaining in auto loadings due to relative price action

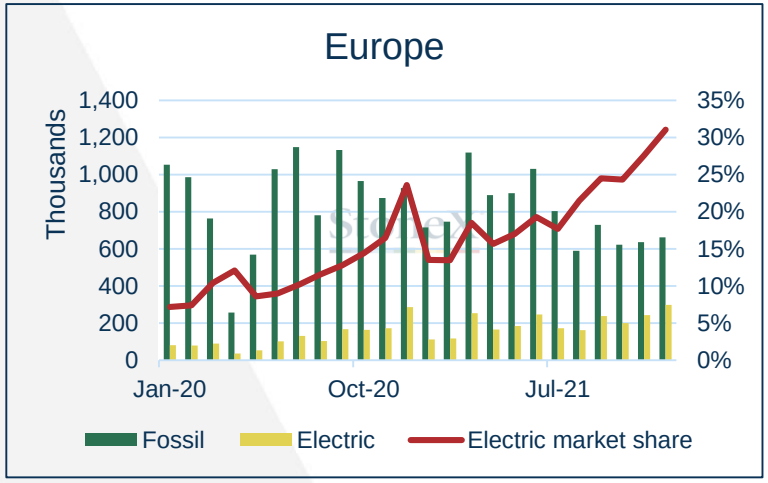


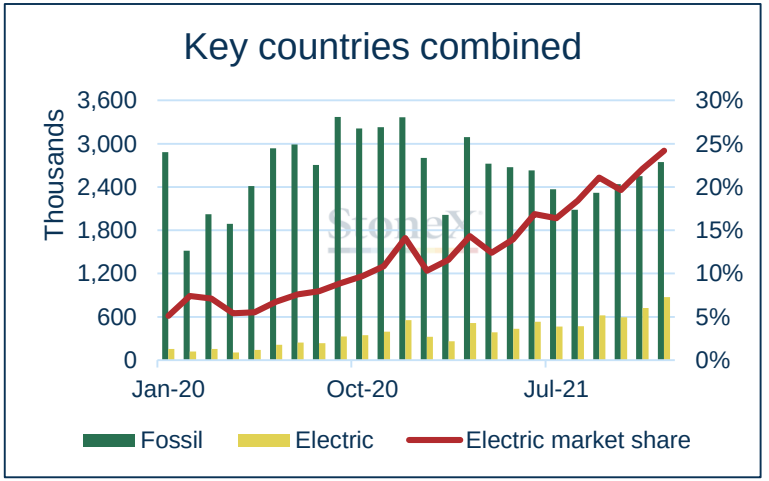
Source: Bloomberg

Light Vehicles by fuel split





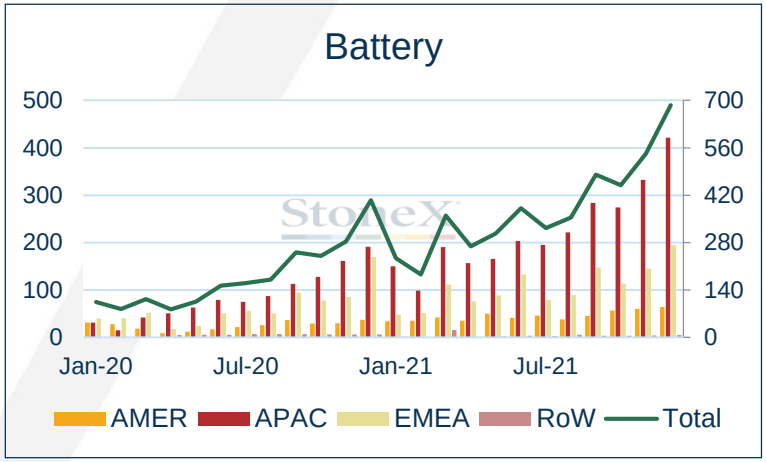


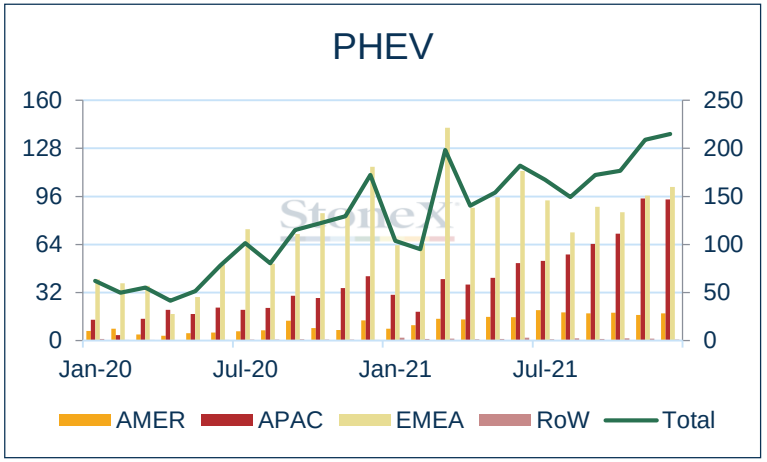


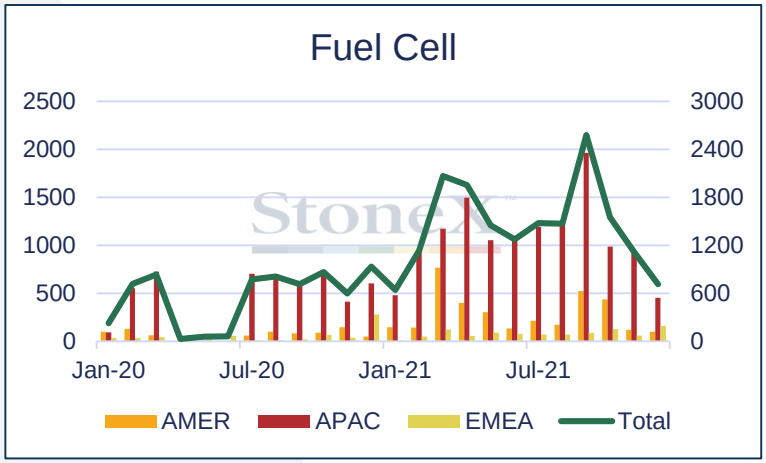
*Battery electric, Plug-in hybrid and Fuel Cell

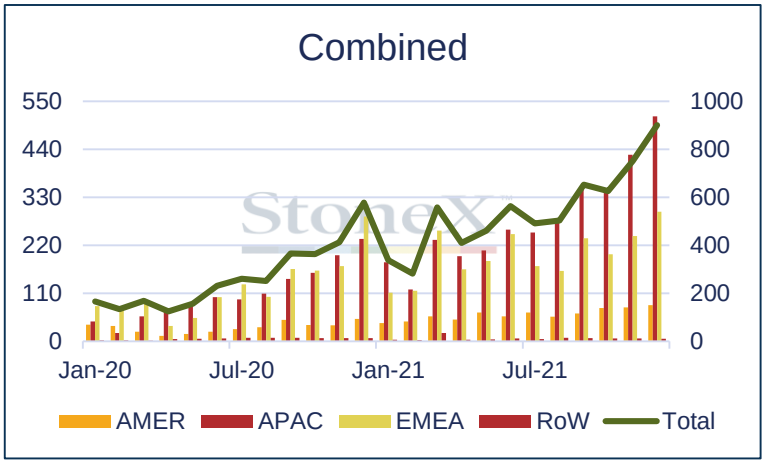
Source: BloombergNEF, StoneX

Electric vehicle sales by sector; 000s









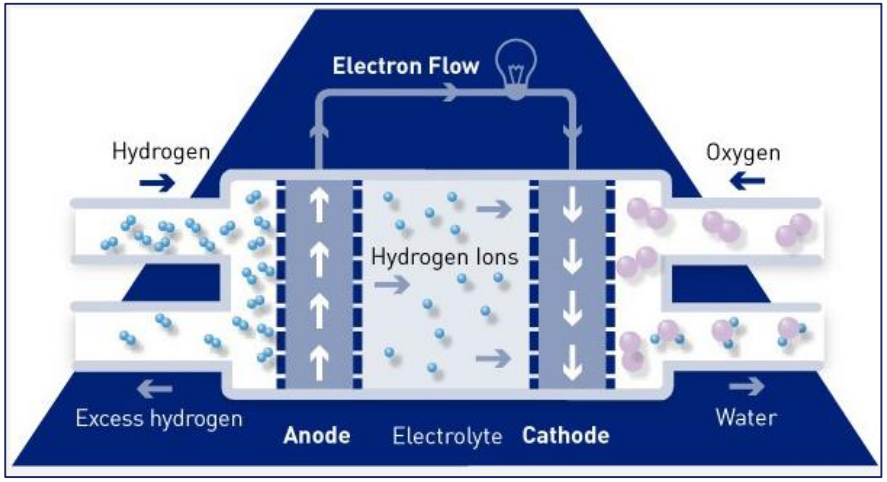
Source: Bloomberg NEF, StoneX

Battery and Plug-in hybrid vehicles – the competition; water!

The Polymer Electrolyte Membrane Electrolysis

- This involves the use of a Proton Exchange membrane and electrolyses water into hydrogen and oxygen.
- There are two reactions; firstly on the anode side the catalyst oxidises water to oxygen, and splits the hydrogen into protons and electrons (this needs **iridium**);
- Then the electrons and the protons are combined to create hydrogen. This needs **platinum** on both electrodes**.**
- A source of electricity is needed at the outset to generate the electrochemical reaction that causes electron transfer from a molecule, in this case, water.

The PEM Fuel Cell; usually a lower weight and volume than other fuel cells and is the most suitable for transport applications.



Source: Anglo American Platinum

Fuel cells; the benefits…

Twice as efficient as ICE, low or zero emissions – and no CO_2!

- Fuel cells essentially work as batteries, but don't run down or need recharging. They have a good track record dating back at last to the early 1980s as power source for stationary applications and it is only with the accelerated push to clean up the environment that governments have put their shoulder to the wheel for transport.

- The conversion of chemical to electrical energy in a fuel cell can exceed 60%, compared with just 20-40% thermal efficiency for a typical gasoline internal combustion engine (depending on engineering, air/fuel stoichiometry and other elements) and 40% for a typical diesel. It is believed that Toyota currently has the most thermally-efficient ICE, at 41%.

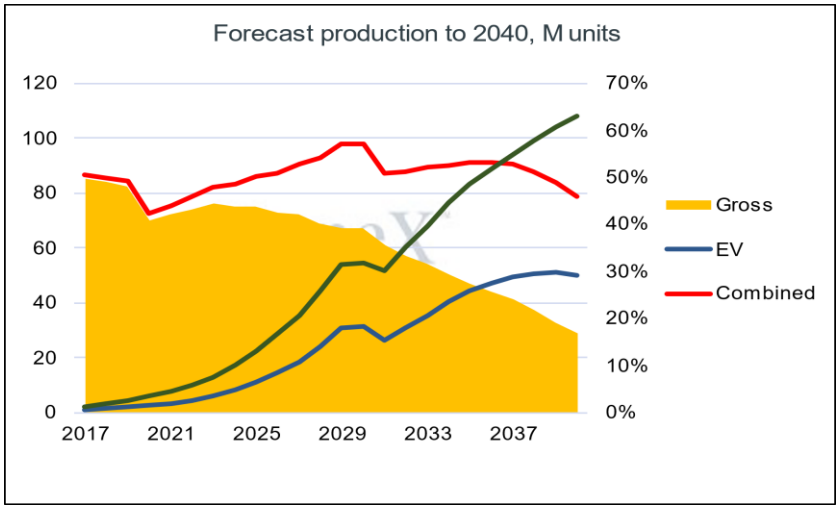
- Usage: fuel cells currently estimated to use twice as much Pt per unit as ICE light vehicles

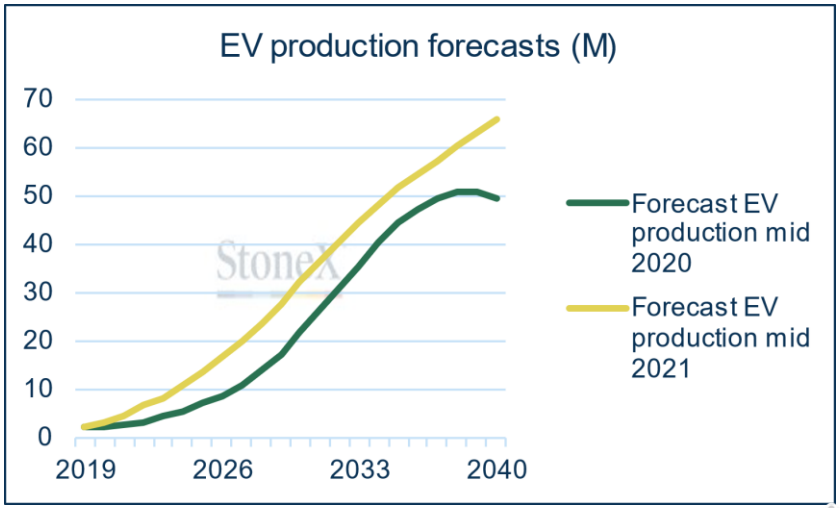
Production forecasts; ICE is peaking….

Mid-2020 forecast, 17.3% p.a. to 49.7M in 2040

Mid-2021 forecast, 18.7% p.a. to 66.1M in 2040

Meanwhile the implied light ICE production rate peaked in 2017. Post-pandemic the peak is projected at 2023 with a 2% p.a. fall to 2030 and a 7% fall thereafter.

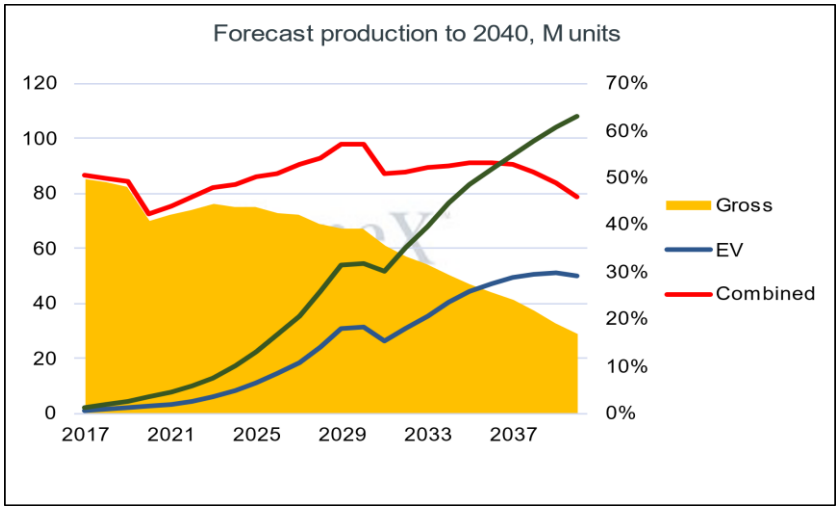


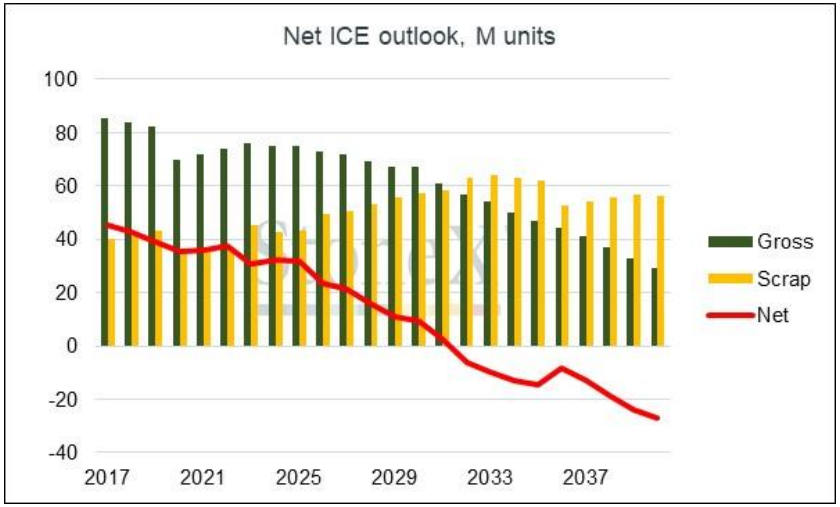


These right-hand charts include predictions/forecasts. Past performance may not be a reliable guide to future performance. Source for charts: Bloomberg NEF, StoneX

… but scrap supply has not, by any means

- Please note that these projection charts only apply to light vehicles. Platinum has a significant uplift from diesel and latterly fuel cells. Palladium does not, at present, have that safety net.
- On our current estimates for the pattern of scrapped vehicle return for the longer-term, the ICE market turns negative over the course of 2028-2030, which is not, certainly for industrial planning, very long at all.
- It is conceivable that the existing ICE fleet could contract by 150M units from 2030 to 2040.





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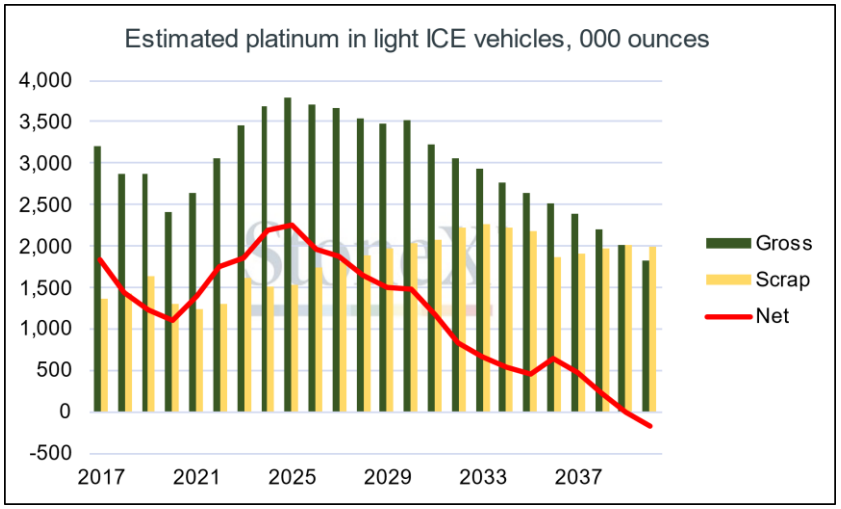
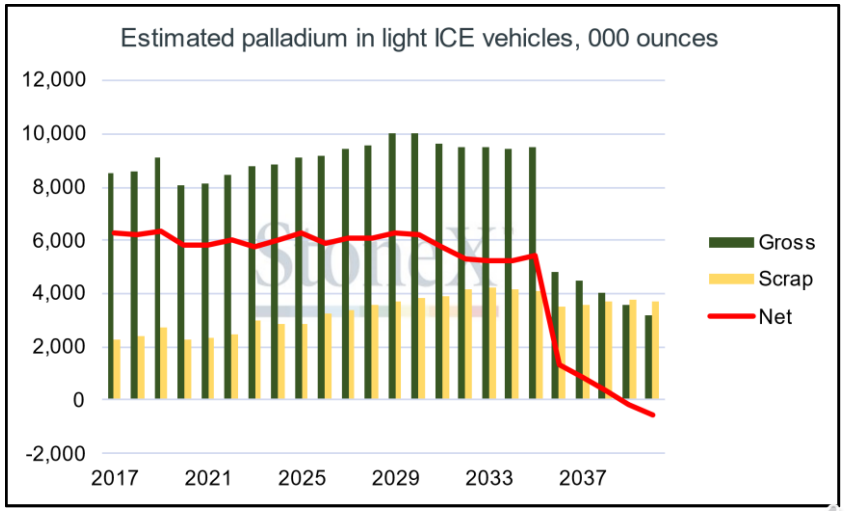
As ICE turns negative, fuel cells are platinum's likely partial salvation. Not so for palladium

- The current projections point to the auto sector, far from being 80% of the palladium market, will by 2040, likely be a net supplier.
- Platinum's outlook for light vehicles is better. At least one organisation is working on developing lithium oxygen and lithium sulphur batteries that use PGM and at least double the power:weight ratio against existing vehicle batteries, while a PGM-bearing separator may well extend the life of a lithium metal anode and which could prove to be the answer as three patents have been granted already,
- Where platinum really has the upper hand is the increasing stringency over heavy-duty vehicles, and fuel cell production could rise 60-fold between 2019 and 2030…
- … and fuel cells may also challenge PHEVs in the LV sector due to the difficulties with implementing infra-structure for the latter.
- Fuel cells in vehicles currently use twice the amount of platinum as ICE vehicles and although thrifting is inevitable, the future of platinum in the transport sector looks reasonably assured. From roughly 90t in global vehicles 2021, platinum demand in in fuel cell light vehicles alone could conceivably be up to 32-33t in 2040, partially offsetting the drop in ICE demand – and heavy duty looks likely to make up much of the shortfall.





Source for charts: Bloomberg NEF, StoneX

THANK YOU

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