PLATINUM ESSENTIALS

Prioritising hybrid ICE technology would minimise CO_2 emissions and avoid a critical minerals shortage, versus the current "BEV first" strategy

Edward Sterck
Director of Research
+44 203 696 8786
esterck@platinuminvestment.com

Wade Napier
Analyst
+44 203 696 8774
wnapier@platinuminvestment.com

Jacob Hayhurst-Worthington
Associate Analyst
+44 203 696 8771
jworthington@platinuminvestment.com

Brendan Clifford
Head of Institutional Distribution
+44 203 696 8778
bclifford@platinuminvestment.com

World Platinum Investment Council
www.platinuminvestment.com
Foxglove House, 166 Piccadilly
London W1J 9EF

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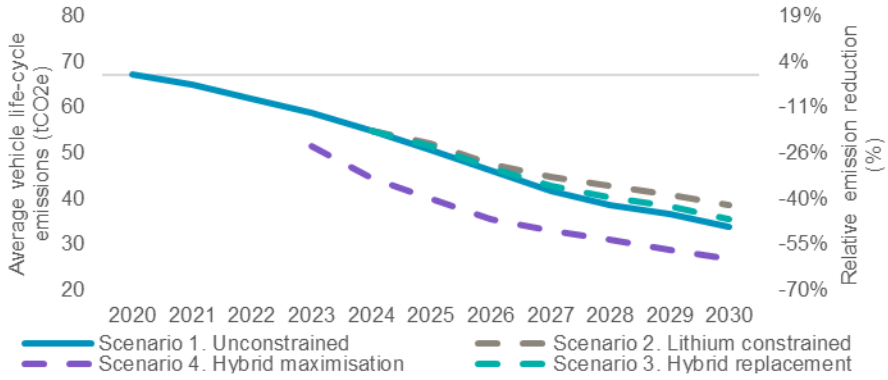
This report examines the associated raw material requirements of electrified drivetrains alongside a life-cycle analysis of their carbon emissions. A combination of blinkered policy setting, public perception, and corporate fear, appears to be pushing automakers into prioritising pure Battery Electric Vehicle (BEV) production, thereby leading to an imbalance between battery critical mineral efficiency and decarbonisation.

Our analysis indicates a BEV prioritisation strategy will lead to 8% greater average vehicle full life-cycle emissions by 2030, versus prioritisation of plug-in and mild hybrid electric vehicles ("Hybrids"). We also calculate that a BEV prioritisation strategy risks pushing battery critical mineral markets such as lithium into supply deficit, which would in itself then aggravate the CO_2 inefficiency of the BEV prioritisation strategy. A key conclusion is that in a critical mineral-constrained operating context, hybrids offer a better pathway to reducing average vehicle life-cycle emissions whilst maintaining supply demand balances within critical mineral markets. Whilst we think it is unlikely that cold logic will shift perceived 'wisdom', it is likely that hybrids will receive increased prioritisation to avoid critical mineral shortages. A hybrid focused strategy would boost autocatalyst platinum demand by an incremental ~360koz per annum in 2027f. Furthermore, we would expect "peak" Internal Combustion Engine (ICE) platinum demand to be shifted from 2025f to 2028f.

BEV production growth is likely to be capped by battery critical mineral availability which will cause a renewed focus on hybrids to continue decarbonising the automotive sector

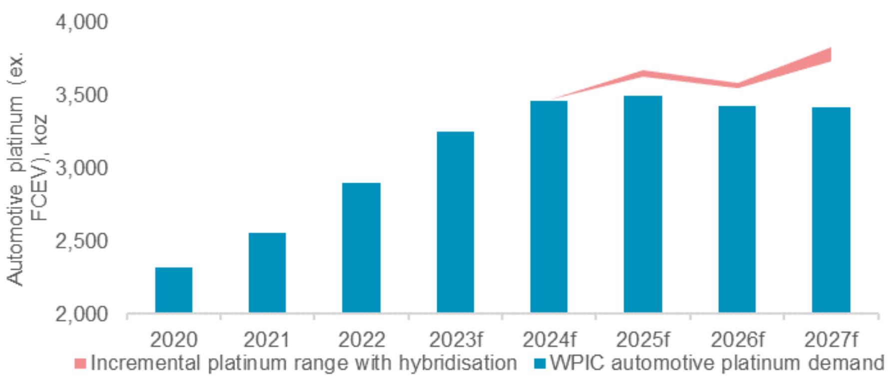
The need for ICE or hybrids to fulfil BEV supply shortfalls will support incremental platinum demand of ~360 koz pa in 2027f

Figure 1. Prioritising hybrids can ease lithium constraints whilst delivering greater reductions in average life-cycle emissions



Source: Johnson Matthey, ICCT, WPIC Research

Figure 2. Replacing BEV's with more hybrids could support incremental PGM demand



Source: Metals Focus 2020 - 2023, WPIC Research from 2024

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Figure 3. Drivetrain optimisation scenario analysis comparing the vehicle production mix, lifecycle CO_2 emissions, and relative lithium market balance

		2020	2022	2024f	2026f	2028f	2030f
Light-duty production	m units	73.1	81.5	88.3	90.9	98.3	104.1
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*Source: Metals Focus from 2020 and 2022, WPIC Research from 2024, *Hybrid vehicles include both Mild Hybrid Electric Vehicles (MHEV) and Plug-in Hybrid (PHEV)*

A LCA assessment offers a better understanding of a vehicle's full carbon impact

Manufacturing related CO_2 emissions for BEVs are typically 35% to 50% higher than for ICE vehicles

The CO_2 benefit for BEVs manifests from lower CO_2 emissions during use, assuming they are charged from a low carbon grid

Introduction

This report explores how ICE demand for platinum could remain higher for longer if supply growth of battery critical minerals for BEVs is unable to meet demand. Should BEV penetration rates become constrained due to lithium supply shortfalls, we expect greater adoption of hybrid drivetrains since hybrids are ~75% less lithium intensive than BEVs. Due to LCA data availability constraints, we define hybrids as encompassing only MHEV and PHEV in this report. Our analysis aims to optimise an emission reduction pathway, while working within a constrained mineral environment. So, whilst a BEV's life cycle CO_{2e} emissions are ~55% below an ICE vehicle, hybrids offer a ~30% reduction in life cycle CO_{2e} emissions versus ICE while maintaining lithium market balances. Assuming a greater proportion of PGM-containing hybrids relative to BEV, ICE demand for platinum will remain well supported to 2030f.

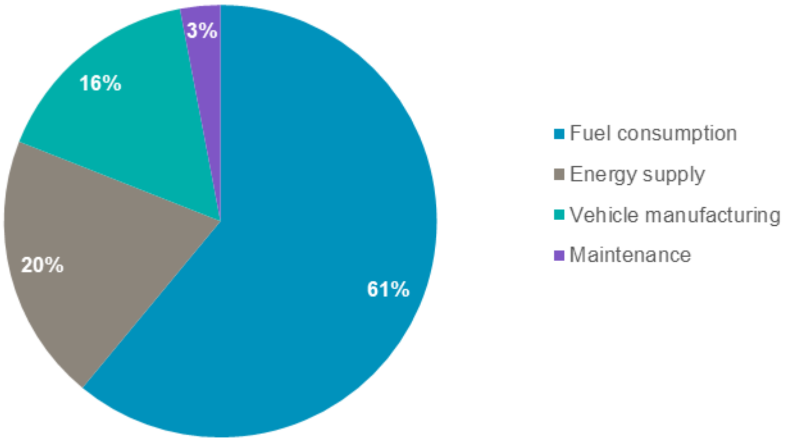
Emission reduction regulations

Regulation within the transport and specifically automotive sector is targeted towards tailpipe emission reductions. Markets such as Europe specify CO_2 emission reductions across the fleet average, implying that OEMs have freedom to adjust their drivetrain mix if average fleet wide emission reduction targets are met. Whilst hydrogen fuel cell electric vehicles (FCEV) offer a zero-emission drivetrain, zero emission BEV drivetrains appear the most practical near-term solution to reducing tailpipe emissions in light-duty and light commercial vehicles as battery technology and recharging infrastructure is better developed and more widely available than hydrogen refuelling infrastructure at present. Hydrogen powered fuel cell technology remains by far and away the best current solution to decarbonising heavy-duty, long-distance and high-capacity utilisation vehicles, especially given grid charging constraints.

Legislation focusses on CO_2 tailpipe emissions rather than life-cycle emissions

Reducing tailpipe emissions is an important component of decarbonising automotive transport. **However, the regulatory focus on tailpipe emissions ignores emissions associated with vehicle manufacturing** (including raw material procurement) and energy supply (either fossil fuel production for ICE or electricity generation for BEV). So, whilst tailpipe emissions are the largest constituent of carbon emissions of an ICE vehicle, to fully reflect the carbon impact of the automotive sector, a life-cycle assessment (LCA) of emissions may be considered more informative in determining an optimal drivetrain mix. With ICE vehicles as the de-facto benchmark, the International Council for Clean Transportation (ICCT) guides that vehicle manufacturing and maintenance account for ~20% of ICE vehicle life-cycle emissions and that energy supply accounts for another ~20% of ICE vehicle life-cycle emissions (Fig. 4).

Figure 4. Vehicle production and energy supply are large minority components of an ICE vehicle's life-cycle emissions



Source: ICCT, WPIC research

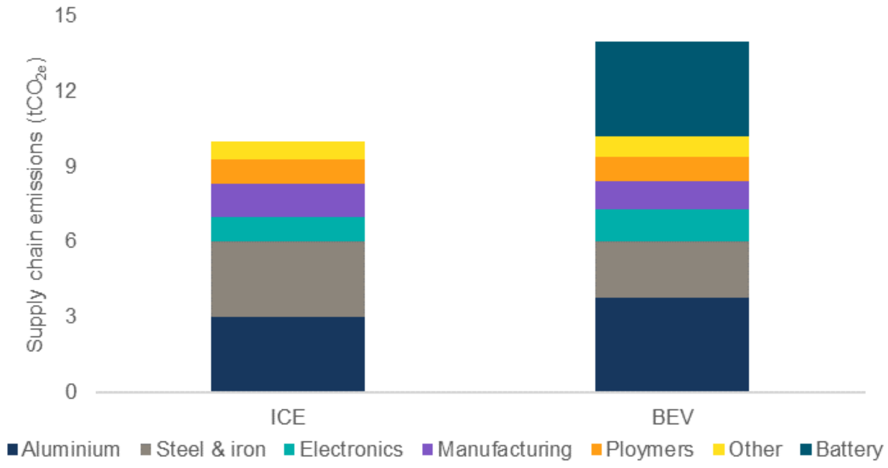
Ahead of assessing LCA data across drivetrains, we should highlight some potential drawbacks of LCA methodologies and data. LCA methodologies normalise for external factors such as driving style, terrain and ambient temperature, which can impact outcomes such as fuel consumption or battery effectiveness. Furthermore, it is not clear if LCA's take into account scrappage curves, or simply work of the basis of a 'typical' vehicle mileage of 240,000 km, although we think it is the latter. A BEV written off just after leaving the forecourt obviously has a much great CO2 burden than an ICE vehicle in the same situation. Furthermore, we believe greater LCA performance variability would result from consumer behaviour for PHEV operation as well as EV battery longevity.

Firstly, real world PHEV usage suggests that the proportion of operating time between battery and combustion engine is not aligned to emission testing standards. That is, it appears real world usage is more reliant on the combustion engine than the testing procedure which would have the implication of real world higher operating emissions (link). Secondly, batteries remain at risk of degradation over time through charge and use cycles. The ICCT utilises a 240,000km distance for its LCA analysis which could be beyond the useful life of a typical EV battery pack since the average battery warranty is 160,000km guaranteeing a minimum 70% battery capacity (link). Replacing a battery pack to reach 240,000km would weigh on comparative emission reductions.

Life cycle emissions across drivetrains

A LCA comparison between ICE and electric drivetrains has two primary differences. Firstly, the inclusion of emissions related to battery manufacturing. And secondly, the emissions associated with the mix of power generation used to charge the vehicle. Polestar, the electric vehicle manufacturer, estimates that a BEV has 35% to 50% higher emissions related to the supply chain and manufacturing process when compared to an ICE vehicle. The higher manufacturing emissions of BEV are attributable the battery's raw material supply and its production emissions (Fig. 5).

Figure 5. Supply and manufacturing emissions are currently higher for a BEV than ICE vehicle



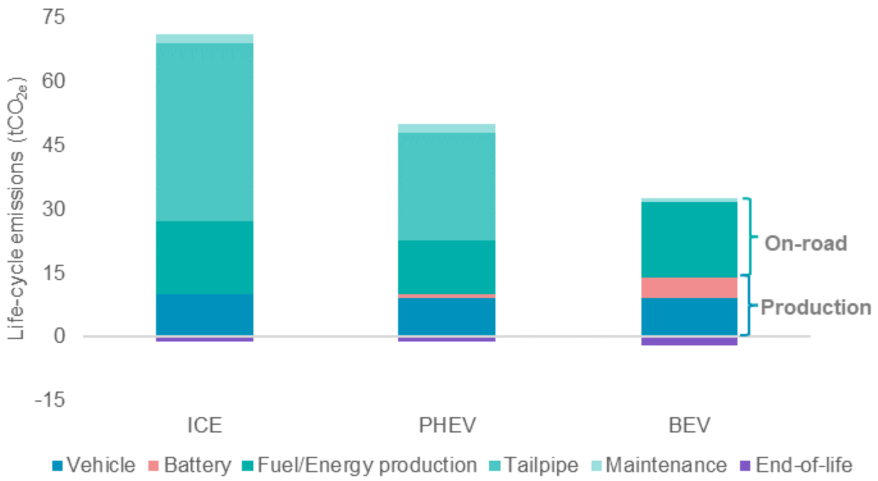
Source: ICCT, Polestar, Kearney, WPIC research

Notably, the relatively higher upfront emissions from the supply and manufacturing stage of a BEV are mitigated over time from lower on-road emissions (i.e. whilst the car is in-use). Whilst it is important to acknowledge that BEVs are only as clean as the power sources used to charge the vehicle, ICCT testing has found that life-cycle emissions of BEVs begin outperforming ICE after around 40,000 km of cumulative use (based on the German grid mix). By end-of-life (240,000 km), ICCT estimates BEV's life-cycle emissions to between 54% to 60% lower than an equivalent light-duty ICE (Fig. 6).

In time, BEVs life-cycle emissions advantage is expected to increase. Since 60% of a BEV's life-cycle emissions are related to energy generation (versus 25% for fuel production of an ICE vehicle), as grids decarbonise, BEVs benefit by a proportionally larger amount (although we note that total CO_2 emissions from electricity generation have so far continued to increase). The ICCT projects that a BEV's life-cycle emissions will reduce by ~50% between 2021 and 2030 given a greater proportion of renewables in the grid (comparatively ICE reduces by ~10%).

Whilst battery production initially increases a BEV's emissions, lower in-use emissions imply a favourable LCA compared to ICE

Figure 6. BEVs have the lowest comparative life-cycle emissions due to an advantageous use phase emission profile



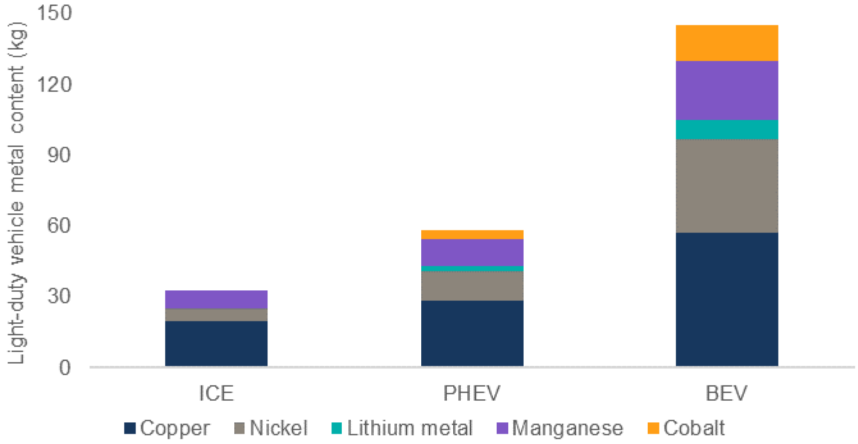
Source: ICCT, Polestar, Kearney, WPIC research, 240,000 km cumulative milage, 2021 Grid

Constrained battery raw material supply

Given favourable standalone tailpipe emission performance and life-cycle emission performance from BEV, it may appear obvious that the best route to for automakers to achieve emission reduction targets is to maximise BEV sales. In practical terms however, electric vehicles require significantly larger quantities of base metals and 'critical minerals' than ICE vehicles, estimated to be four times an ICE vehicle (Fig. 7).

BEVs are intensive users of battery critical metals and as sales increase, supply deficits in lithium are likely to materialise

Figure 7. BEVs are critical metal intensive due to their large battery packs



Source: Johnson Matthey, WPIC research

The rapid demand growth of electric vehicles coupled with their high metal intensity is pressurising critical mineral suppliers to increase output to meet the industry's requirements. Sibanye-Stillwater suggests lithium markets could enter supply deficits in the coming years (link). We estimate that lithium carbonate supply would need to quadruple between 2020 to 2030f to meet demand growth and support balanced markets. Lithium is not geologically rare. The United States Geological Survey reported an 85% increase in reserves to 26 Mt in the past five years as exploration has increased. However, "perfect" project execution is unlikely given risks associated with delayed project lead times, project financing challenges (particularly for junior miners) and increasingly stringent ESG demands for greenfield mining projects. Furthermore, there are additional processing constraints in terms of converting mine-gate lithium products to the high-grade lithium carbonate needed for lithium-ion batteries.

If project execution were perfect, we estimate lithium supply would increase by ~16% CAGR to 2,100 kt LCE by 2030f. However, due to the abovementioned risks, ~25% of projects are classified as 'medium' risk and ~5% classified as 'high' risk of deferral or cancelation. We expect 50% of medium-risk projects and 25% of high-risk projects are successfully commissioned by 2030f. Applying these risk adjustment reduction factors to lithium supply implies lithium supply growth of 12.5% CAGR between 2022 to 2030f (Fig. 8), suggesting a deferral of ~400kt LCE annual production capacity versus whether all projects are commissioned on schedule.

The projected lithium shortage could reduce BEV production by 11 million vehicles versus our base case forecasts

Figure 8. Headwinds to project implementation will likely constrain lithium capacity additions leading to supply deficits

Source: Sibanye-Stillwater, WPIC research

Optimising the fleet's life-cycle emission footprint

Between 2020 and 2021, BEV markets transitioned from the start-up phase of the product life-cycle curve to the growth phase. Underpinned by China, global BEV production increased by 118% YoY in 2021 and by 72% YoY in 2022. The increase in global light-duty BEV penetration from ~2% to ~8% over the two years to 2022 has resulted in an 8% decline in the average vehicles life-cycle emissions (based on drivetrain mix) to 62 tCO_{2e} in 2022 from 67 tCO_{2e} in 2020.

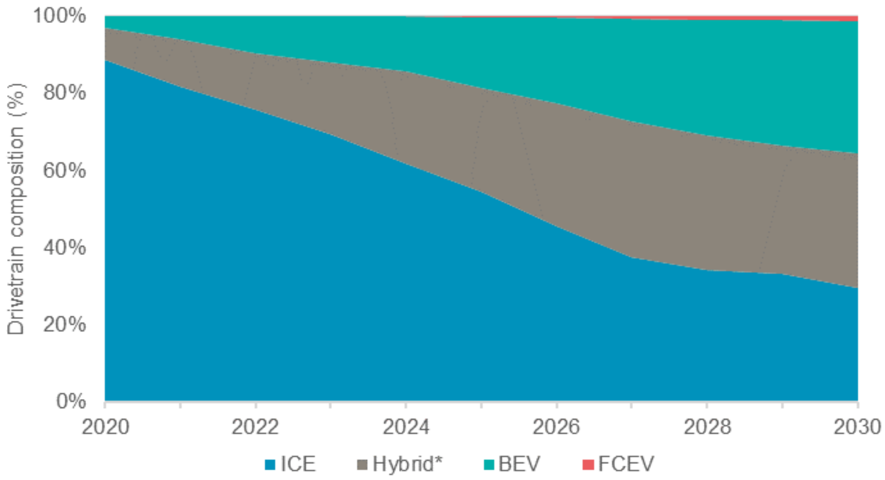
We undertake four scenarios to evaluate how life-cycle emissions evolve to 2030f when considering possible lithium supply constraints.

Global BEV penetration rates have quadrupled to 8% between 2020 and 2022

Scenario 1: Current base case automotive forecasts

Our first scenario has not considered lithium constraints, and is our base-case used for modelling our platinum autocatalyst demand forecasts. Our bottom-up forecast for the automotive sector sees ongoing growth in BEV penetration as OEMs and governments push to decarbonise the industry. We forecast BEV penetration rates of 34% in 2030f globally (Fig. 9), with China a global leader at 54% (2023 YTD: 23% penetration). Alongside rising BEV penetration, we expect the combined MHEV and PHEV to account for 35% of global vehicle production by 2030f, up from ~15% in 2022.

Figure 9. The drivetrain mix of light-duty vehicles will rapidly evolve to 2030f with greater shares of both hybrids and BEV



*Source: OICA, WPIC research, *Hybrid includes MHEV and PHEV*

Given changes in the drivetrain mix, our base-case unconstrained scenario expects blended per vehicle life-cycle emissions to decrease by 50% between 2020 to 2030f (Fig. 10). A parallel analysis of our base case automotive forecasts, highlight risks of lithium shortfalls. As BEV sales increase to 36 million units at a 34% penetration by 2030f, we forecast lithium demand growth will be 15.0% CAGR (Fig. 8). Should execution risks negatively impact lithium supply as suggested above, **we expect lithium supply deficits of ~450 kt LCE by 2030f which is equivalent to ~11 million BEVs.** Our lithium intensity forecast is 42 kg LCE per vehicle. We ignore declining lithium intensities since our assumptions are lower than several lithium intensity forecasts provided by the likes of Sibanye-Stillwater, Albemarle and SQM.

Scenario 2: Lithium shortage constrained BEV output

Acknowledging possible critical mineral shortages, our second scenario ("lithium constrained") is assessed. Setting lithium supply as a constraining factor to BEV penetration rates, lithium shortages arise from approximately 2025f. **Our analysis suggests BEV penetration could be capped to 24% or 25 million vehicles globally in 2030f which is 11 million fewer BEV vehicles** than our base-case. If ICE vehicles are used at a one for one rate to fill the BEV supply gap, global blended per vehicle life-cycle emissions will reduce by 42% between 2020 to 2030f (Fig. 10) which implies 5 tCO_{2e} more life-cycle emissions per vehicle under a lithium constrained scenario.

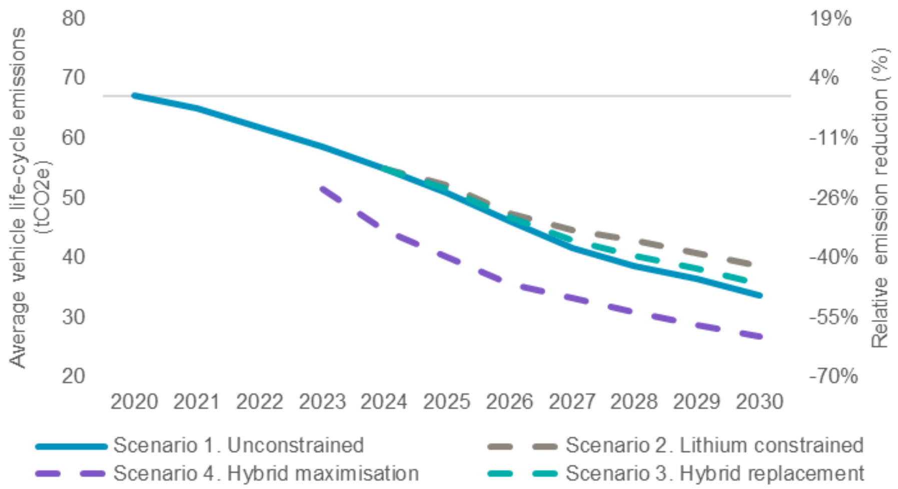
Given lower critical mineral needs, opting to prioritise hybrids over BEVs supports a faster reduction in life-cycle emissions to 2030

Scenario 3: Hybrid replacement to compensate for BEV shortfall

More practically, lithium constraints could be addressed with hybrids. While hybrids do not reduce life-cycle emissions by as much as BEV (Fig. 6), hybrids are more resource efficient, using ~75% less lithium per vehicle (Fig. 7). In other words, four hybrids could be manufactured for the same amount of lithium used for one BEV. **Therefore, with lithium being a constraining factor, we can achieve larger life-cycle emission reductions with four hybrids as opposed to one BEV and three ICE vehicles.**

In our third scenario, we aim to model the same cumulative "BEV plus hybrid" penetration rate as our base case forecasts. However, to avoid lithium supply deficits, the proportion of hybrids would increase at the expense of BEV ("hybrid replacement" scenario). Our modelling suggests a relatively better outcome for lowering life-cycle emissions when using hybrids rather than pure ICE to fulfil BEV supply gap. We expect global blended per vehicle life-cycle emissions reduce by 47% by 2030f (Fig. 10) which is an improvement over our second scenario despite a lower pure-BEV penetration rate.

Figure 10. Prioritising hybrids can ease lithium constraints whilst delivering greater reductions in average life-cycle emissions



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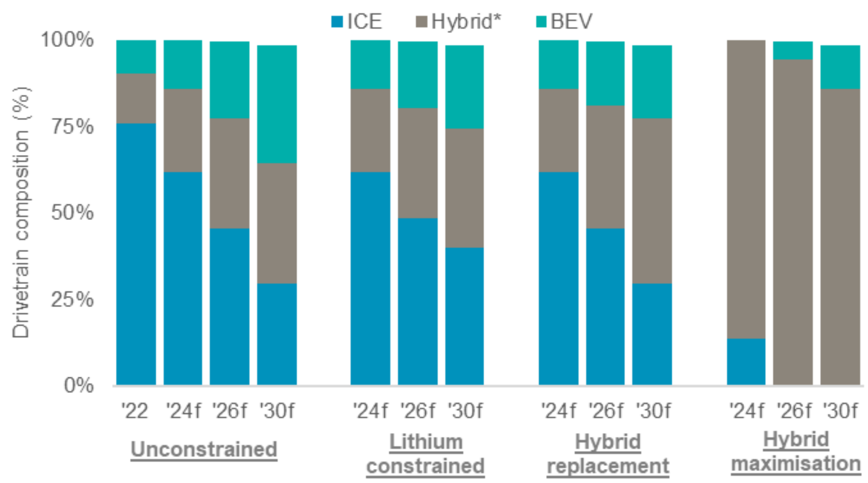
Our second and third scenarios have aimed to maximise BEV penetrations and where lithium supply constraints capped BEV output, that BEV supply shortfall was filled with either ICE vehicles (scenario 2) or hybrid vehicles (scenario 3).

Had hybrids been prioritised over BEVs, light-duty vehicles could have been completely hybridised by 2026f

Scenario 4: Minimising life cycle CO_2 emissions through hybrid prioritisation

Our fourth scenario ignores the BEV penetration rate but aims to maximise reductions in life-cycle emissions. Our analysis has shown hybrids are more effective at reducing life-cycle emissions per unit of lithium than BEVs. Hence in our fourth scenario ("hybrid maximisation"), we assume all available lithium is directed towards hybrid production. Whilst largely theoretical (given the already entrenched preference for BEV), our analysis suggests that lithium supply would be sufficient to hybridise all light-duty vehicles by 2026f (Fig. 11). Furthermore, from 2026f we estimate that there would be excess lithium supply which could then be directed to BEVs (offering greater emission reductions but at a lower lithium resource efficiency). **Our hybrid maximisation scenario materially outperforms our other scenarios and would reduce per vehicle life-cycle emissions by 60% by 2030f (Fig. 10).**

Figure 11. There is sufficient lithium supply to hybridise all light-duty vehicles by 2026f



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Too soon to conclude PGM demand decline

The current focus on prioritising mineral intensive BEVs as a result of a combination of poor policy making, public perception and corporate fear, is resulting in an inefficient drivetrain which is failing to minimise CO_2 emissions and risks engendering a battery critical minerals shortage, potentially leading to a failure of the very strategy being followed.

In contrast to perceived wisdom and collective 'group think', our analysis shows that prioritising hybrids would avoid a lithium shortage and deliver a significant 20% greater reduction to emissions than our base-case drivetrain forecasts (which is based upon the current BEV prioritisation strategy being followed by the automakers).

Critical mineral constraints will cap BEV penetration and lead to higher ICE and hybrid demand supporting incremental platinum demand

Having identified that lithium supply constraints may cap BEV penetration, we estimate that using ICE or hybrids to backfill the implied BEV supply gap (scenarios 2 and 3) could support incremental platinum demand of ~360 koz by 2027f (Fig. 12) and defer "peak" automotive platinum demand from 2025f to 2028f.

We are too far down the track, and the BEV prioritisation orthodoxy is too entrenched for the industry to pivot to our fourth scenario of minimising full-life cycle CO_2 emissions by maximising hybrids, but under that (sadly, from a decarbonisation perspective) fanciful scenario, platinum demand would increase by an incremental 920 koz per annum by 2027f.

Figure 12. Should lithium constraints cause an increase hybrid adoptions, platinum demand could increase by ~360 koz in 2027f

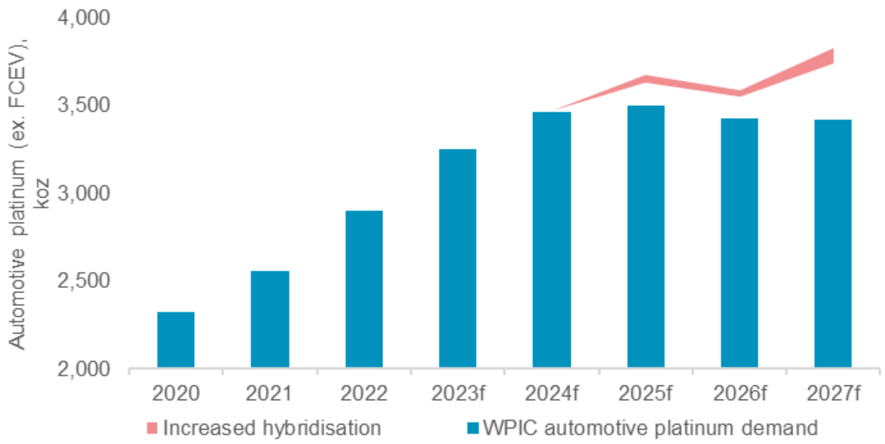

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Figure 13. Drivetrain optimisation scenario analysis comparing the vehicle production mix, lifecycle CO2 emissions, and relative lithium market balance

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