Climate change and automotive technology

The impact on the aftermarket and roadside service

DR ROSALYN DE VRIES AND PAUL HUNT

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Introduction

The risk of large-scale climate change is one of the central issues facing the world. There is widespread consensus amongst the scientific community that the Earth is warming[1], that this warming is caused by human emissions of greenhouse gases (GHGs), and that the consequences of continued warming are likely to be severe. As a result, the risks of climate change - and the costs that these risks might drive – are emerging as central issues for the private sector. Some business leaders see climate change as a threat to their firms' viability. Others see opportunity in promoting technologies that will mitigate the risk of climate change or help the world adapt to its effects. This paper attempts to summarise the impact climate change is having on the automotive sector and the automotive aftermarket, and within that context, what impact it may have on the Automotive Clubs and their members in Australia.

A brief overview of climate change

The Earth's average temperature has been increasing since the Industrial Revolution. Between 1880 and 2015, average global surface temperatures rose by 0.9°C[2]. In 2016, the Earth experienced its third consecutive hottest year since recordkeeping began[3]. There is broad consensus in the scientific community that this warming has been largely driven by increases in atmospheric GHGs, particularly carbon dioxide, methane, and nitrous oxide. GHG emissions have been growing since the Industrial Revolution and were 60% higher in 2014 than they were in 1990[4].

The primary sources of year-on-year GHG emissions are the "burning of fossil fuels (coal, oil, and gas) with important contributions from clearing of forests, agricultural practices, and other activities."[5] Specifically, fossil fuel consumption for electricity and heat production generates about 25% of total GHG emissions; industry 21%; transportation 14%; other energy 10%; and buildings 6%; while agriculture, forestry, and other land uses contribute the remaining 24% of total GHG emissions. In 2016, fossil fuels provided 81% of global energy supply – a trend that is expected to continue.

Higher levels of atmospheric GHGs raise temperatures by increasing *radiative forcing*, or the amount of energy arriving on Earth's surface. Higher GHG concentrations increase the amount of radiation caught by the atmosphere and redirected back toward the surface. By 2016, carbon dioxide concentrations in the atmosphere were the highest levels in 400,000 years and up almost 7% since 2007[6]. The Intergovernmental Panel on Climate Change (IPCC), convened in 1988, states that, if no additional efforts are taken to mitigate the effects of climate change, carbon dioxide concentrations are likely to increase from 404ppm to 1,300ppm by 2100. If this occurs, by 2100 the planet may experience mean surface area temperature increases of 3.7°C to 7.8°C.

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[1] The Garnaut Review 2011

[2] NASA's Goddard Institute for Space (GISS), "Global Temperature," NASA website, http://climate.nasa.gov/vital-signs/global-temperature/, accessed April 2019.

[3] Nell Greenfieldboyce, "2016 was the hottest year yet, scientists declare," NPR, January 18, 2017, http://www.npr.org/sections/thetwo-way/2017/01/18/510405739/2016-was-the-hottest-year-yet-scientists-declare, accessed March 2019.

[4] "Turn Down the Heat: Confronting the New Climate Normal," World Bank, 2014, p.xviii, available at http://documents.worldbank.org/curated/en/2014/11/20401287/turn-down-the-heat-confronting-new-climate-normal-vol-2-2-main-report, accessed April 2019.

[5] U.S. Global Climate Change Research Program, "Climate Change Impacts in the United States," Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson (eds.), 2014, p.9, https://downloads.globalchange.gov/usimpacts/pdfs/climat-impacts-report.pdf, accessed April 2019.

[6] NOAA, "Carbon Dioxide," NASA website, http://climate.nasa.gov/vital-signs/carbon-dioxide/, accessed April 2019.

In Australia the surface air temperature for 2018 was 1.14°C above the 1961-1990 average, making 2018 the third hottest year on record[7]. While globally the 20 hottest years on record have been in the past 22 years, in Australia, nine of the 10 hottest years on record have occurred since 2005.

In Australia the extreme weather events of 2018 were the latest in a long term trend of worsening extreme weather (bushfires, heatwaves, Tropical Cyclone Kelvin, Marcus, Nora and Owen, supercell storms in Queensland, drought and flooding). Over the past several decades, heatwaves in Australia have increased in duration, frequency and intensity and in southern Australia rainfall decline has been recorded in cooler months. So far this year, 2019 has been reported as the driest start to a new year in Victoria since 1898.

Clearly action needs to be taken to prevent the worsening of extreme weather. In general, reducing emissions requires action on three fronts: greatly increasing the efficiency with which energy is used; “decarbonising” the world’s energy system through the use of renewable energy or carbon capture; and changing land use and management.

Mitigation and adaptation: the automotive sector

The challenge of climate change presents both wide-ranging threats and opportunities for the private sector. For the purpose of this paper we will focus on the impact climate change and emissions regulations have had on the automotive sector, particularly the aftermarket.

The European automotive market is regarded as the industry leader in innovative technologies as a result of strict European emissions regulations. Since 1992, European Union emission regulations have been imposed on all new cars being released into the market. The regulations – which are designed to become more stringent over time (Euro 1 to Euro 6) – define acceptable limits for exhaust emissions of new light duty vehicles sold in EU and EEA (European Economic Area) member states. According to the EU, “the air pollutant emissions from transport are a significant contribution to the overall state of air quality in Europe”[8], with industry and power generation being the other major sources.

To meet the emissions standards, OEMs have had to improve vehicle efficiency by using innovative solutions that range from idle stop-start (ISS), mild hybrids and full hybrids, through to plug-in hybrids and battery electric vehicles. The following section will briefly explore the differences between each of these types of vehicles so that the impact of these powertrains on the aftermarket is understood, particularly the impact on battery fitment requirements, which is relevant to the Automotive Clubs and their service proposition to members.

Idle Stop Start (ISS)

A basic ISS system works by shutting off the engine whilst the vehicle is stationary. For more advanced ISS systems, the vehicle may also incorporate recuperative braking or engine power assistance technology. This technology has the ability to switch off the engine when the vehicle is coasting or braking as well as whilst stationary. The battery, alternator, and starter motor are designed to withstand the increased starting and electrical demands.

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[7] Weather Gone Wild: Climate Change – Fuelled Extreme Weather in 2018, http://www.climatecouncil.org.au

[8] Euro 1 to Euro 6 guide – find out your vehicle’s emissions standard, RAC UK, https://www.rac.co.uk/drive/advice/emissions/euro-emissions-standards/, Accessed April 2019.

In constant ISS environments, the vehicle may stop and start the engine as least once per kilometre. This places increased demands on the battery, alternator and starter motor. Conventional batteries are not designed to handle the cycling requirements of ISS systems - these vehicles require either an Enhanced Flooded Battery (EFB) or an Absorbent Glass Mat (AGM) battery.

Mild Hybrid (MHEV)

A mild hybrid is generally an internal combustion engine (ICE) equipped with an electric machine allowing the engine to be turned off whenever the car is coasting, braking or stopped and then re-start quickly. Mild hybrids may employ recuperative braking and some level of power assist to the ICE but they do not have an exclusive electric-only method of propulsion. A mild hybrid has both a 12V lead-acid battery for SLI (starter, lights, and ignition) functions as well as a 42V or 48V battery pack (Lithium or NiMH).

Hybrid (HEV)

The main difference between a mild hybrid and full hybrid is that the motor in a mild hybrid cannot actually propel the vehicle on its own. The gasoline engine in a mild hybrid is the piece of machinery doing the propulsion work and the electric motor only serves to assist. In a hybrid vehicle however, pure electric driving is possible for short distances. Typically, the vehicle is powered in one of three ways: either directly by the engine, by the electric motor alone, or by both power sources working together. These vehicles feature two batteries: a Lithium or NiMH battery pack (i.e. in a Camry Hybrid this is a 245V NiMH battery pack) and a 12V lead-acid auxiliary battery which power's the vehicle's electrical systems.

Plug-in Hybrid (PHEV)

Plug-in HEVs combine the advantages of an electric vehicle with those of a vehicle using an ICE. Although they have a conventional ICE, they also have larger batteries than regular hybrids and can drive longer distances on electric power alone. The battery in a PHEV can be recharged by plugging it into an external source of electric power, as well as by its on-board engine and generator. A PHEV uses a Li-ion battery pack (i.e. Mitsubishi Outlander PHEV contains a 300V Lithium battery pack) as well as a 12V auxiliary AGM battery to initiate the drive system.

Battery Electric Vehicle (BEV)

Battery electric vehicles are operated with electrical power only. EVs are recharged by plugging into an electrical outlet which restores the on-board battery. As with other electrified vehicles, the EV contains a high voltage battery system (typically a Lithium battery) as well as a 12V auxiliary battery (which can be either a Calcium fitment or AGM) to power the car's accessories.

Fuel Cell Vehicle

The Fuel Cell Vehicle (FCV) is another type of electric vehicle which uses a fuel cell, instead of a battery, or in combination with a battery or super capacitor, to power its electric motor. Fuel cells in vehicles generate electricity to power the motor, generally using oxygen from the air and compressed hydrogen. Most fuel cell vehicles are classified as zero emissions vehicles that emit only water and heat. Even a fuel cell vehicle however, such as the Toyota Mirai, uses a 12V lead-acid auxiliary battery to power the car's accessories.

The chart below depicts the mix of these vehicles currently in the car parc and a prediction for the evolution of the mix moving towards 2025.

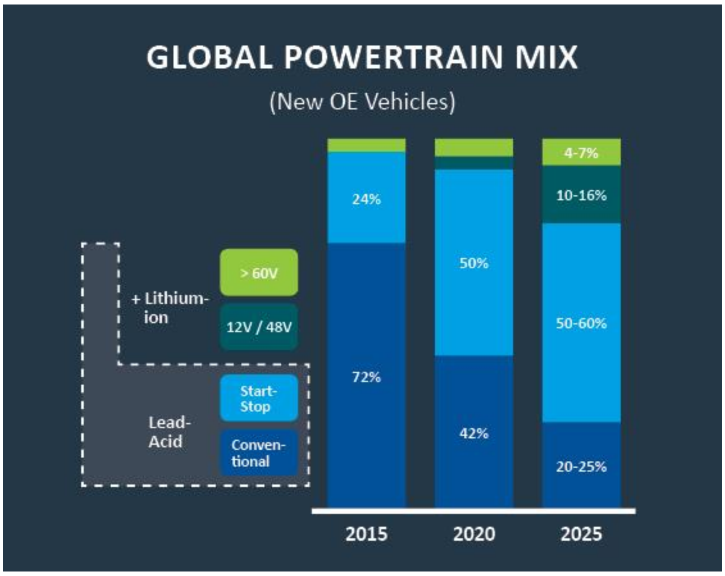


Chart 1: [9]

Impact of climate change on lead acid battery sales

Climate change, and particularly the efforts to mitigate it, have impacted the automotive aftermarket in two distinct ways. Firstly, through the flow-on effects of changing powertrain design in parts and servicing, and secondly, through the impact greater extremes of temperature will have on parts such as batteries, which are susceptible to the influence of extreme heat on their operation.

Powertrain design and impact on battery mix

The clear take-away from the overview of the increasing electrification of powertrain design is that lead acid battery technology still has an important role to play. Clarios (previously Johnson Controls Power Solutions), one of the world's largest battery manufacturers, stated in 2017 that 13 to 18 percent of all vehicles sold in 2025 will be mild hybrids utilising a 48V powertrain design[10]. Forty-eight-volt systems typically feature a 12-volt starter battery (an AGM) plus a small lithium ion battery to handle the demands of regenerative brakes and stop-start systems. JCI has backed this with an investment of $780 million by 2020 to expand its global AGM production.

Chart 2 highlights JCI's predictions for battery volumes through 2030 and their view is that lead acid will continue to dominate for the foreseeable future.

[9] Source: Johnson Controls (2016), Powering the Future, Johnson Controls Power Solutions Analyst Day June 13, 2016.
[10] David Sedgwick, 2017, JCI see big role for lead acid batteries, https://www.autonews.com/article/20170801/OEM10/170809943/jci-sees-big-role-for-lead-acid-batteries, accessed April 2019.

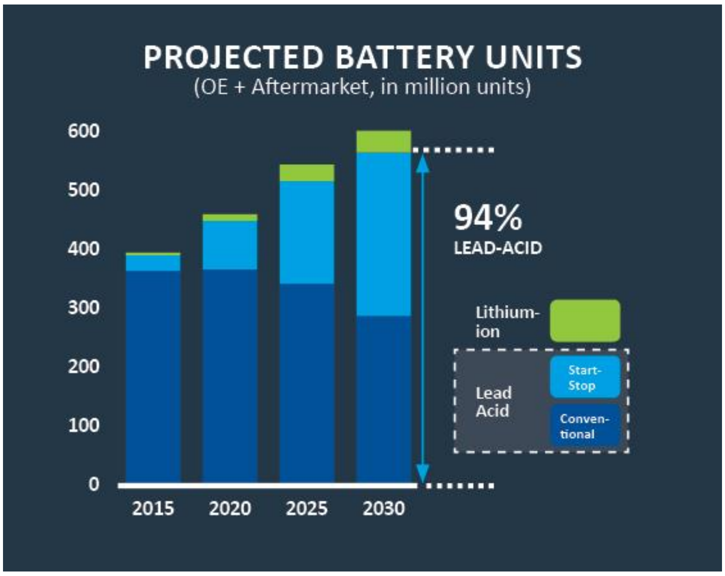


Chart 2[11]

That said, the product mix of lead acid batteries will slowly transition from an aftermarket mix of 95% flooded batteries and 5% EFBs and AGMs to a greater proportion of AGMs and EFBs as seen in Chart 2 (above). ISS vehicles were first commercially introduced (at scale) in Australia in 2010 and the batteries from these vehicles are just beginning to be replaced in the aftermarket. Recent scrap surveys validate these numbers with approximately 6% of the enhanced batteries used in these vehicles appearing in Club Assist sales and scrap figures.

Battery life of enhanced batteries

The impact of the changing product mix may be significant in terms of predicting future sales volumes as recent research conducted by Club Assist indicates the EFB and AGM batteries collected from European OEs have a significantly improved lifespan compared to conventional flooded batteries used in Japanese, Korean and North American light vehicle imports. The scrap survey conducted in October 2018 (sample size 300) consisted of 95% flooded batteries with a median age of 4.9 years. A scrap survey conducted in March 2019, which focused on European OEMs (and therefore included a mix skewed toward AGMs and EFBs), recorded the AGMs as having a median age of 7 years and the EFBs 5.4 years. Interestingly, even Calcium fitments being managed by European Battery Management Systems achieved a median age of 7.9 years.

There are a couple hypotheses for the extended median age of these European OE batteries. Firstly, they are often located in low-heat areas of the vehicle, such as the boot or behind a heat shield in the engine. Secondly, the construction of AGMs in particular, frustrates the process of sulfation and eliminates susceptibility to stratification as the electrolyte is held in the glass mat, constantly in contact with the active material on the plates. Compared to flooded cell batteries, AGM batteries have a lower internal resistance, which makes them capable of charging faster, as well as delivering high current on demand and a longer service.

Finally, as previously mentioned, the European OEs have always been leaders in automotive technology designed to improve the efficiency of powertrains to ensure vehicles meet stringent European emissions standards. These

[11] Source: Johnson Controls (2016), Powering the Future, Johnson Controls Power Solutions Analyst Day June 13, 2016.

improvements in powertrain efficiency directly impact the management of the electrical system and, consequently, the battery.

Battery registration

An example of this exceptional electrical system management is seen in the introduction of the requirements for battery registration following replacement for many European OE vehicles. As an example, in BMW vehicles, the registration process completes the following operations:

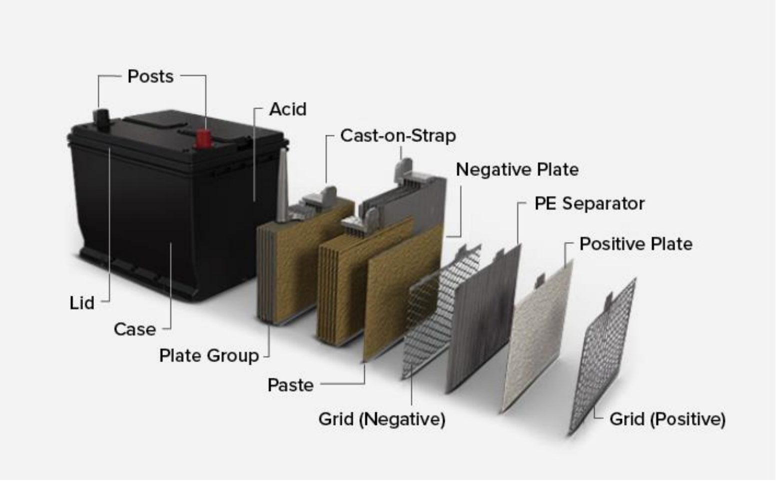
1. Stored battery statistics (battery charge level, current, voltage, temperature) are deleted.
2. Battery capacity is set to 80% and energy management system initiates 'learning mode'.
3. Current odometer reading is stored along with readings of previous battery replacements.

According to BMW Technical Training (BMW have been registering batteries for more than 10 years), "If the battery change is not registered, the power management will not function properly, with the result that Check Control messages may be displayed and functions limited by individual electrical consumers being switched off or having their power consumption reduced."

Impact of heat on batteries

One of the key factors that impacts the longevity of a battery is heat. Over the past several decades heatwaves in Australia have increased in duration, frequency and intensity as a result of climate change. In January 2018 temperatures in Sydney soared to 47°C the hottest day the city has experienced in 80 years. For Christmas Day 2018 across southern Australia temperatures of 6C to 12C above average for the daily maximum were experienced. Both Wagga and Mildura had five consecutive days above 40°C in December 2018. These examples simply illustrate the increasing likelihood of these intense heatwave events.

While these heatwaves impact on human wellbeing, they also impact battery wellbeing. A battery consists of a series of positive and negative plates (positive plate covered by lead dioxide and negative plate comprised of sponge lead), surrounded by electrolyte (water and sulphuric acid). Separators sit between each of the negative and positive plates allowing the electrolyte and the ions into it to enable conduction without the two plates touching (see image below).



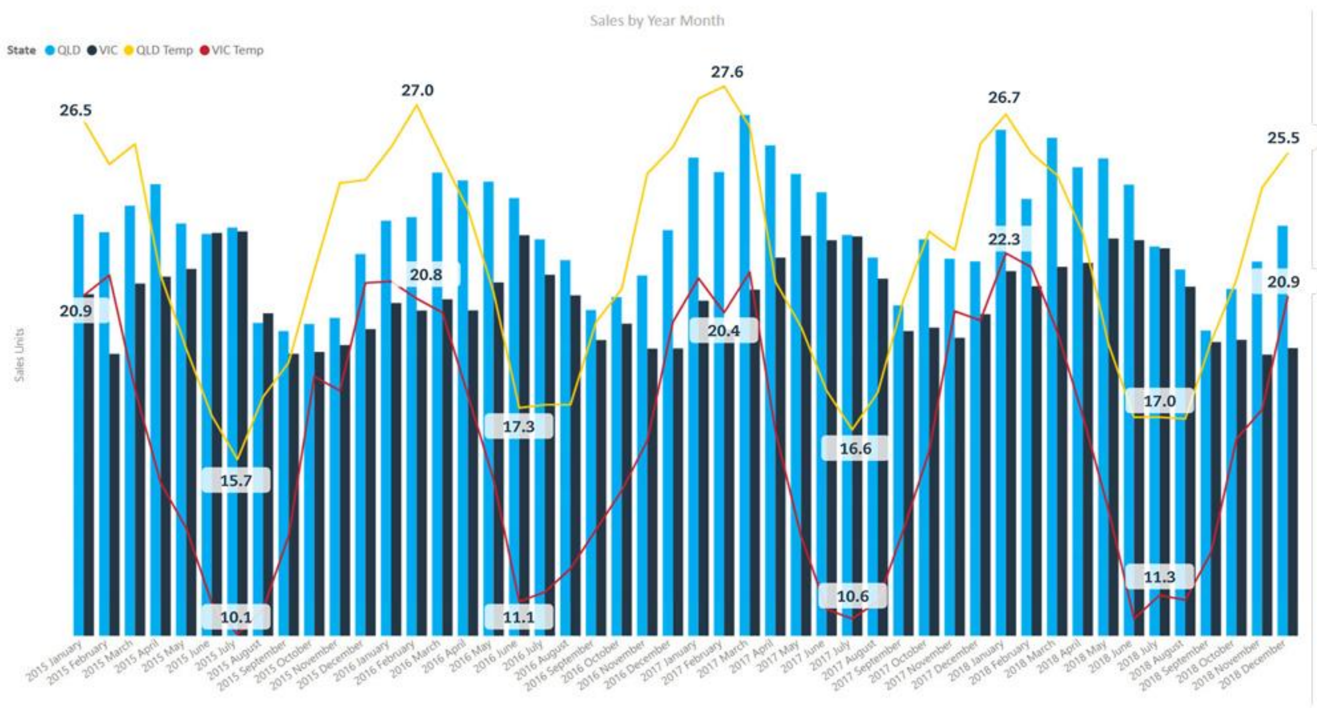
As with most chemical reactions, the chemical reaction that generates energy in a battery is affected by heat and cold. Molecules can only react when they collide. If you heat a substance, the molecules move faster and so collide more frequently. That will speed up the rate of reaction.

For every 10°C over 25°C, battery life is reduced by half. This is because the reaction of the electrolyte and lead doubles for every 10°C increase in temperature. This increasing rate of reaction leads to an expansion of the plate, causing the grid to start to corrode as the plate mass breaks down. As the grid corrodes and the plate mass breaks down the plates lose their ability to store and deliver power, causing the battery to fail.

It therefore stands to reason that as heatwaves in Australia become a more enduring problem (in terms of intensity and duration) we could expect to see an increasing failure rate of batteries as they are expected to perform in these high-heat conditions.

Heat and batteries a state-by-state comparison

By using existing sales data it is possible to compare the differences in the pattern of battery sales activity between a state with a moderate oceanic climate (Victoria) and a state with a sub-tropical climate (Queensland). The graph below was created using four years of monthly battery sales data overlaid with Bureau of Meteorology average monthly temperature data.



The graph clearly depicts the wave-like sales trend moves with the temperature trend, particularly in Queensland. The temperature always moves slightly ahead of sales in both states, but the curves travel proportionately to one another. That is, the intensity of the temperature curve mirrors the sales curve. Interestingly, it's the extremes in temperature (or the magnitude of the change from the mean) that appear to trigger battery events.

Highest temperatures for the year are experienced in Queensland in January, February and March, followed by highest battery sales in March, April and May. In Victoria this trend is similar, with highest temperatures experienced in January and February but highest sales following in June, July and August after the temperatures have drastically reduced to their lowest point experienced in the year.

The peaks and troughs of sales in Victoria appear to be smoother and less volatile than those in Queensland, likely as a result of more moderate temperatures.

The hypothesis for battery sales, in a world increasingly affected by climate change, is that more intense, sustained heatwaves will drive greater volume in sales, as will the experience of more extreme changes in temperature.

Climate change and the automotive aftermarket

This paper has highlighted a number of changes that automotive manufacturers have introduced over the 15 years to increase the efficiency of ICEs and reduce emissions. The range of vehicles and the increasing electrification of powertrains is a direct result of increasingly stringent emissions standards, particularly in Europe.

With the change in powertrain design, new battery technology (EFBs and AGMs), and the tools to support the installation of those batteries, have made their way into the aftermarket. As one of the leading aftermarket suppliers of automotive batteries and a leader in introducing these new batteries as the cars entered the car parc, these batteries now make up approximately 5% of the aftermarket sales mix. The associated battery registration technology is also a key component of the service offer as Club Assist's value proposition has always been 'OE or better' in terms of its fitment solutions.

The number of cars with electrified powertrains will continue to increase as a percentage of the market and consequently the demand for these new technology batteries and their associated tools will also continue to increase. Mercedes-Benz, for example, wants 50% of its news car sales to be full electric or plug-in hybrid by 2030, and by 2025 it won't sell any internal combustion vehicles without mild hybrid systems[12]. Fortunately for businesses involved in the battery aftermarket, all of the vehicles in that future vision need a lead-acid auxiliary battery.

While the impact of increasingly extreme weather events on battery sales is harder to predict, the data analysed for this paper shows a strong correlation between battery failure and temperature change. The one thing we can predict with certainty is that lead-acid is here to stay for a number of years yet as powertrain designers are still incorporating this highly recyclable, reliable technology into their new vehicle designs, even their most emission-friendly ones.

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[12] https://www.drive.com.au/review/2019-mercedes-benz-eqc-400-international-drive-121382?trackLink=homePageReviews1, Accessed 15 May 2019