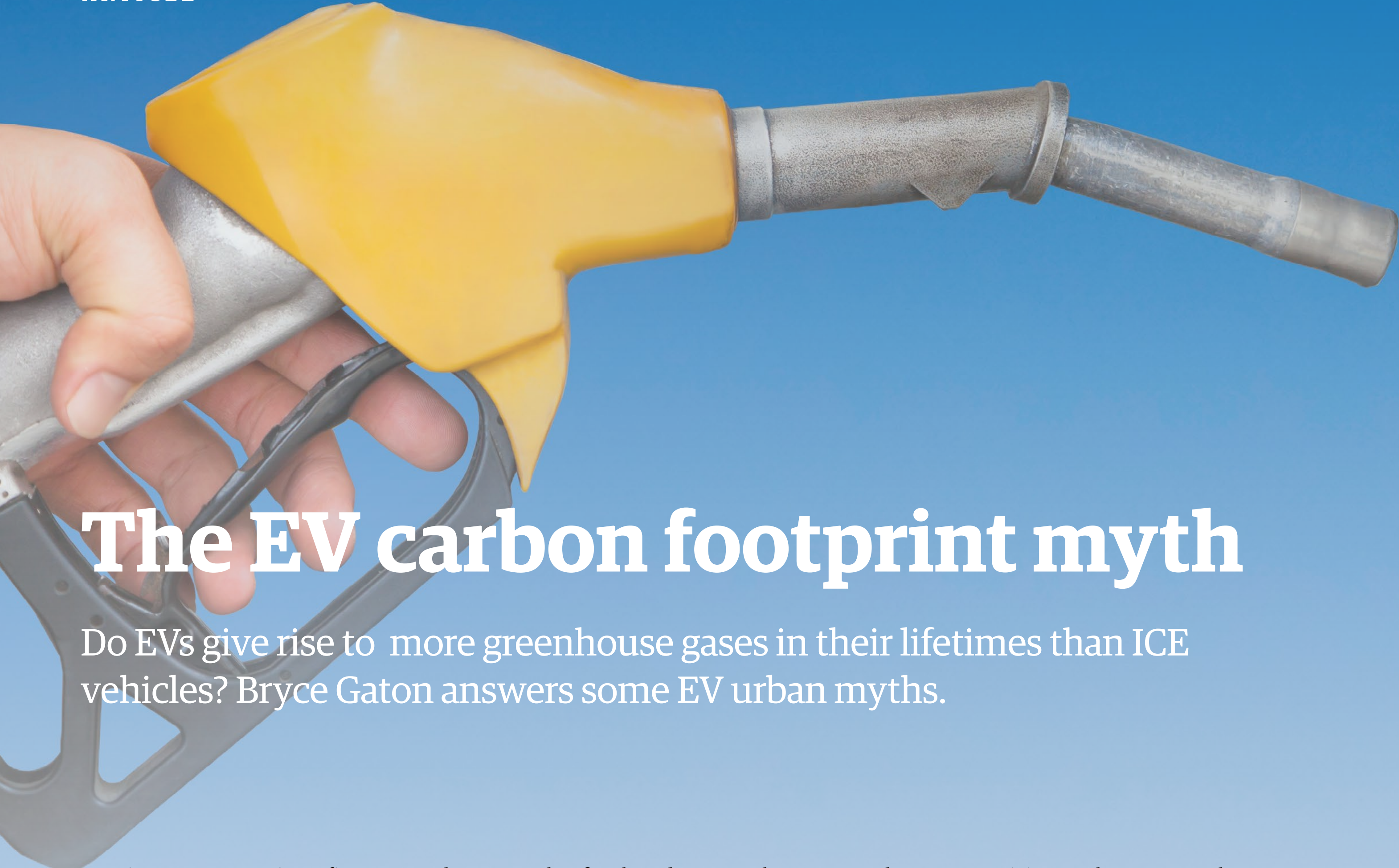

The EV carbon footprint myth

Do EVs give rise to more greenhouse gases in their lifetimes than ICE vehicles? Bryce Gaton answers some EV urban myths.

It is now ten years since I first put together an analysis for *Renew* magazine on how much greenhouse gas EVs (electric vehicles) driven in Australia cause as they drive. The initial result was that in all the states and territories (except Victoria), EVs produced fewer greenhouse emissions than those produced by driving an equivalent petrol car. (In fact, even in Victoria it was a bit less if you only drove in the city—which was all that the short-range EVs of the time were likely to do!)

A big feature of that analysis was just how much of a difference the state/territory in which you lived made. Each state and territory used a very different mix of coal types and renewable sources.

I repeated the exercise five years later for *Renew* 143. It was becoming apparent then that as each grid moved towards including more renewable energy sources, the emissions from driving an EV were declining faster than the improvements offered by the incremental improvements in ICE (internal combustion engine) design.

Since then, there has been some reasonable questioning, both here and around the world—as well as a not inconsiderable amount of disinformation—about whether the results of such analyses are robust. As a result, the last few years have seen many scientific papers and government reports on the topic written around the world. All of these have supported the claim that EVs running on almost any grid will produce fewer emissions that an equivalent ICE vehicle[1]. (See also "Resources" at the end of this article).

For this update, I will look at three questions:

> *Many scientific papers and government reports ... written all around the world [back up] the claim that EVs running on almost any grid will produce fewer emissions that an equivalent ICE vehicle.*

1. Now it is 2022, have EV greenhouse driving emissions improved any further, and how do these changes compare with the latest ICE vehicles?
2. Do the lifetime emissions of EV manufacture and use stack up against ICE vehicles?
3. How do hybrids and PHEVs compare?

How well does an EV stack up in Australian greenhouse emissions versus an equivalent ICE vehicle?

First-up: I need to make the point that it is a mistake to directly compare new car petrol/diesel windscreen sticker CO_2 emission numbers to EV electricity use emission numbers.

This is not an apples-with-apples comparison, because the windscreen stickers on petrol and diesel vehicles show only the direct CO_2 emissions from the fuel burnt in the car's engine. They do not include the emissions due to extracting, refining, transporting and delivering that fuel to the car. They also do not include the greenhouse effects of gases other than CO_2.

On the other hand, EV emissions data generally includes the warming potential of all the known greenhouse gases, plus a lot

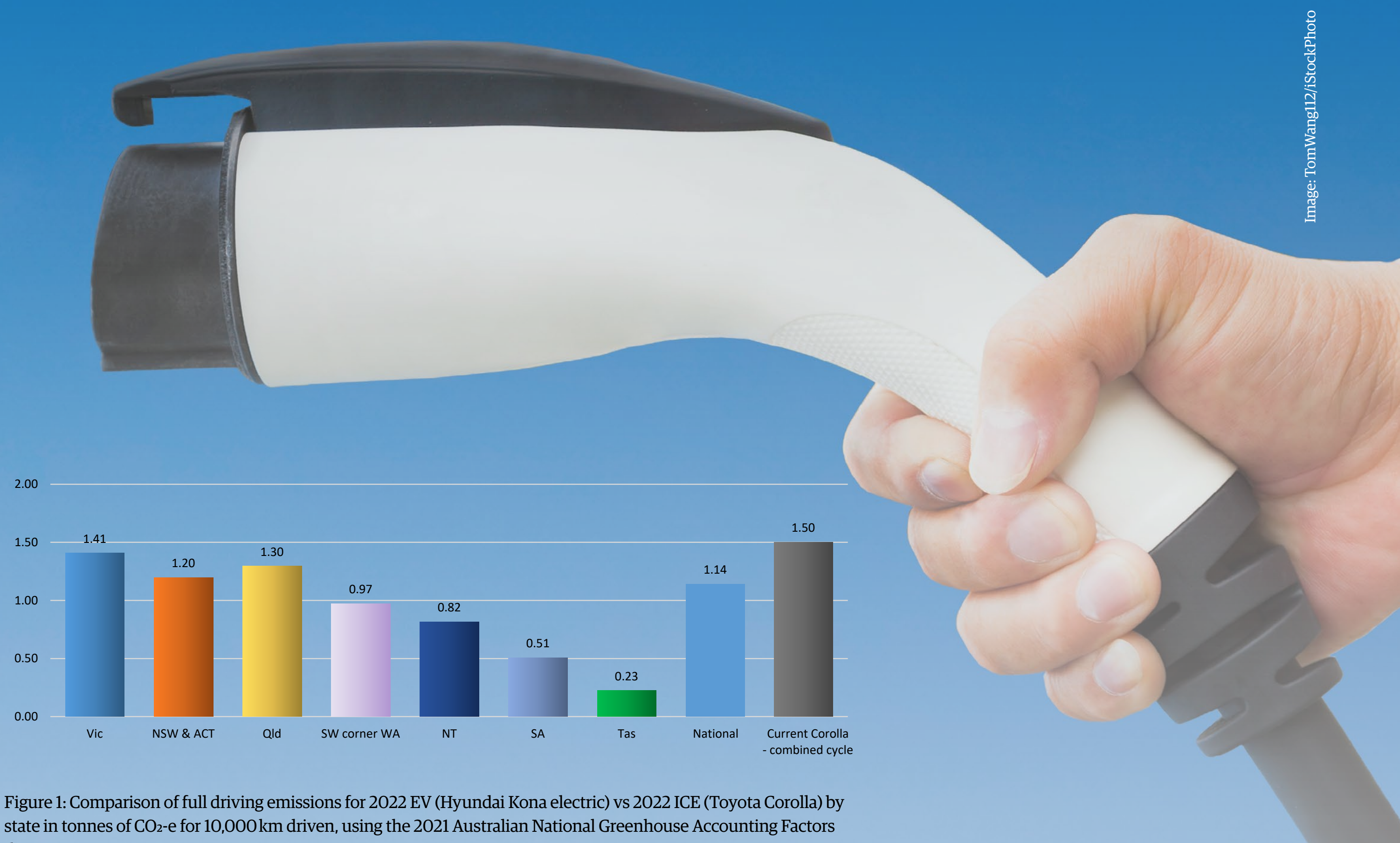

Image: TomWang112/iStockPhoto

Figure 1: Comparison of full driving emissions for 2022 EV (Hyundai Kona electric) vs 2022 ICE (Toyota Corolla) by state in tonnes of CO_2-e for 10,000 km driven, using the 2021 Australian National Greenhouse Accounting Factors data.

of the upstream grid emissions—meaning comparing the two is not a true "well-to-wheel" comparison of EV to ICE.

Figure 1 above *does* give that comparison. The data is from the Australian National Greenhouse Accounting Factors (produced annually by the department of Industry, Science, Energy and Resources) and the calculations were made using the carbon emissions accounting methodology specified in that document.

The results speak for themselves. One particularly exciting thing to note is that now that the Victorian grid has progressed in reducing its overall emissions, I can now finally say that in *all* cases, a new EV will produce fewer greenhouse emissions that an equivalent new ICE vehicle! Plus, given that ICE vehicles have improved their emissions over the years (Figure 2), replacing an older ICE with a new EV will make an even bigger difference.

The reason for this improvement in EV emissions? As can be seen from Figure 3, in the last ten years all the states and territories have reduced their grid greenhouse emissions. (Mind you, some have done better than others: Queensland is the stand-out failure, with its emissions stuck at 0.92 kg per kWh since 2015).

Do the lifetime emissions of EV manufacture and use stack up against ICE vehicles?

Having an EV produce fewer driving emissions is one thing—but does the inclusion of the emissions produced when making the EV drivetrain (battery, motor and control electronics) negate that benefit?

Again, numerous studies have now come out to say this is not the case. EVs generally repay that manufacturing "debt" within a fairly short period, depending on the annual distance travelled. In Europe, based on the average European electricity grid emissions, it has been calculated the payback period for the battery manufacture—with an overall 50% less life-cycle CO_2-e produced over the first 150,000 km—is two years of driving[2]. In the US, where cars generally do higher mileages, that payback period is around six to 16 months[3]. Figure 4 is taken from a UK study that estimated manufacturing and driving emissions as the grid moves towards being fully renewably sourced[4].

How do hybrids and PHEVs compare?

I often get asked about whether hybrid electric vehicles (HEVs) or perhaps plug-in hybrid EVs (PHEVs) are a potentially good choice in the current period before BEVs (full Battery Electric Vehicles) reach affordable prices. The debate about what improvements they offer in terms of greenhouse emissions (as well as urban air pollution) is, however, severely hampered by the lack of clear data on their actual emissions.

Unfortunately, many of the vehicle consumption figures found for HEVs and PHEVs in the Australian Green Vehicle Guide still use the older NEDC test cycle that has been superseded in Europe, where it became largely discredited and replaced by the WLTP test cycle. (For more detail on this topic, see *Renew* 155).

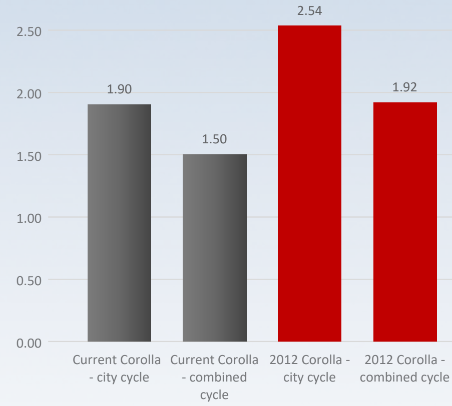

Figure 2: Full CO_2-e in tonnes for 10,000 km driven for 2012 petrol Toyota Corolla versus 2022 petrol Corolla.

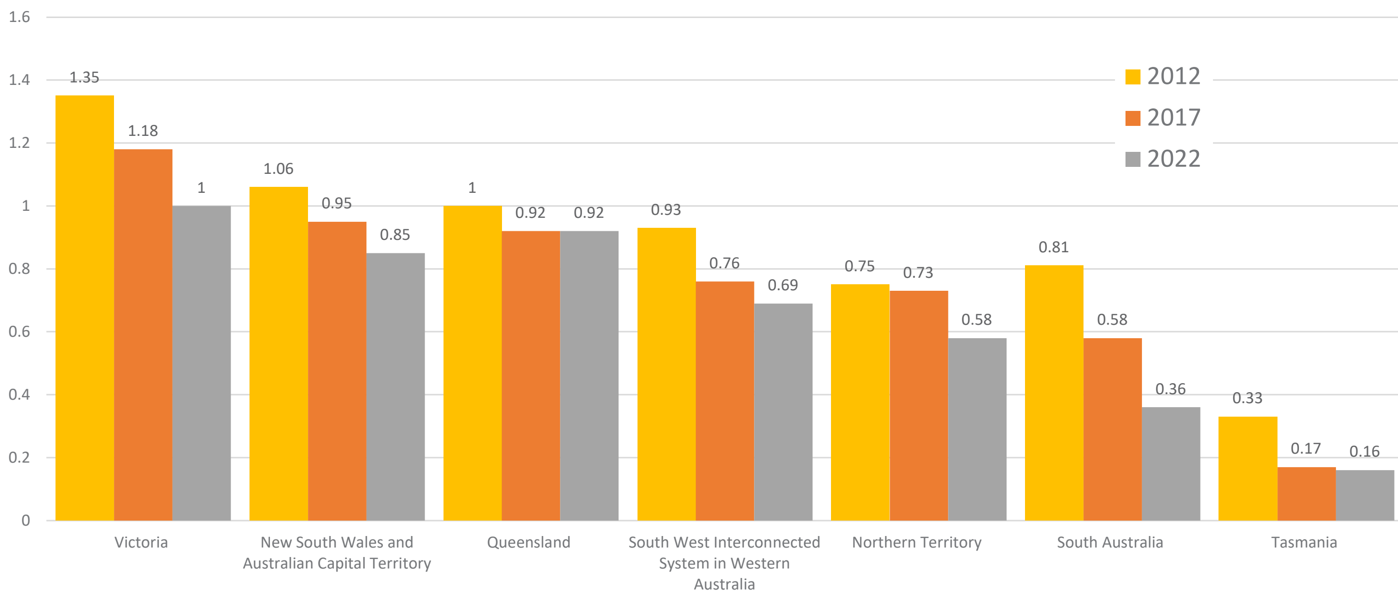

Figure 3: Full CO_2-e in kilograms per kilowatt-hour for each state over the last 10 years.
Note: data correct as of time of writing. The department does make retrospective amendments to the NGA tables, therefore the historical data given in the 2021 tables differs slightly to this graph.

As a result, the figures for HEVs and PHEVs in the Green Vehicle Guide are generally unrealistic and quite unachievable, just as the NEDC figures for EVs were. European WLTP test figures for the equivalent Corolla hybrid are more realistic, but significantly higher than NEDC. (The Green Vehicle Guide figure for the Corolla HEV is 3.5L/100km, yet the European WLTP figure is 5.3L/100km). This makes it hard to compare realistic figures for ICE and HEV as they are not being rated on the same system. Whilst it may be worth avoiding the mismatch and swap from the Australian figures to use overseas WLTP figures for the Kona electric, ICE Corolla and HEV Corolla, the ICE Corolla sold here is no longer sold in Europe as it does not meet the Euro 6C fuel and emission standards. (In fact, the one here only meets the much older Euro 5 standard—a good example of how the dumping of more inefficient and polluting older tech vehicles is already happening here). As a result, no apples-with-apples comparison is available.

Another confounding issue is these test cycle fuel economy figures are highly variable for HEVs and PHEVs, depending on how closely your trips reflect the test cycle. HEV batteries can be quite tiny (for instance, the

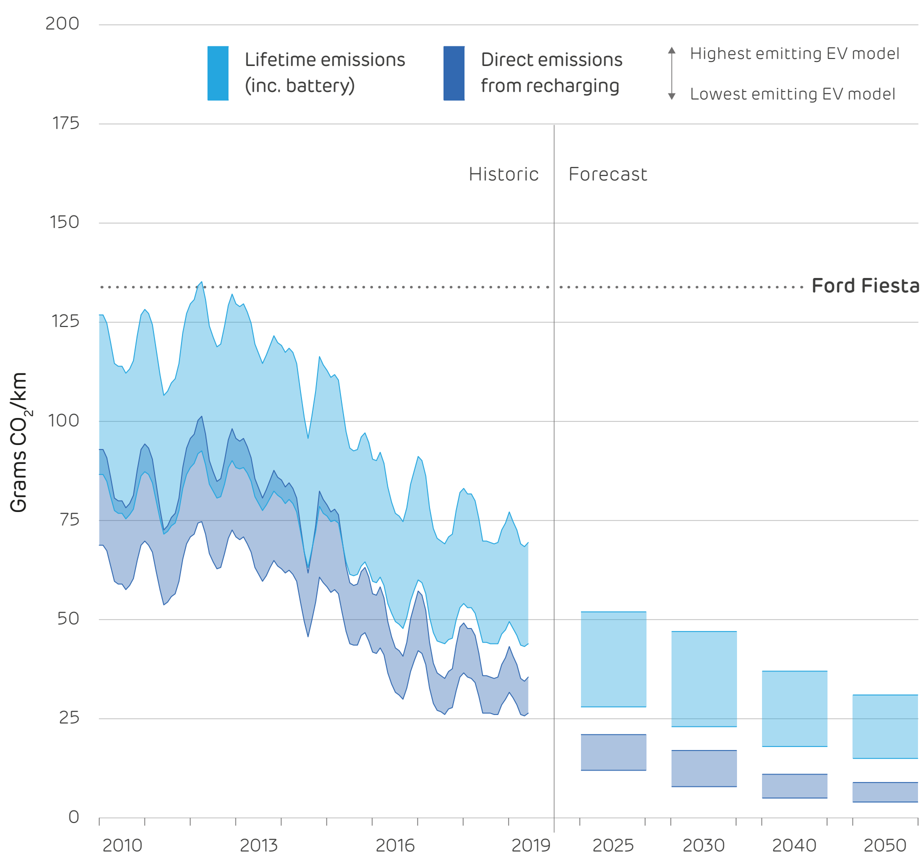

Figure 4: CO_2/km for hatchback EVs using the UK grid 2010 to 2050. Source: ICCT.

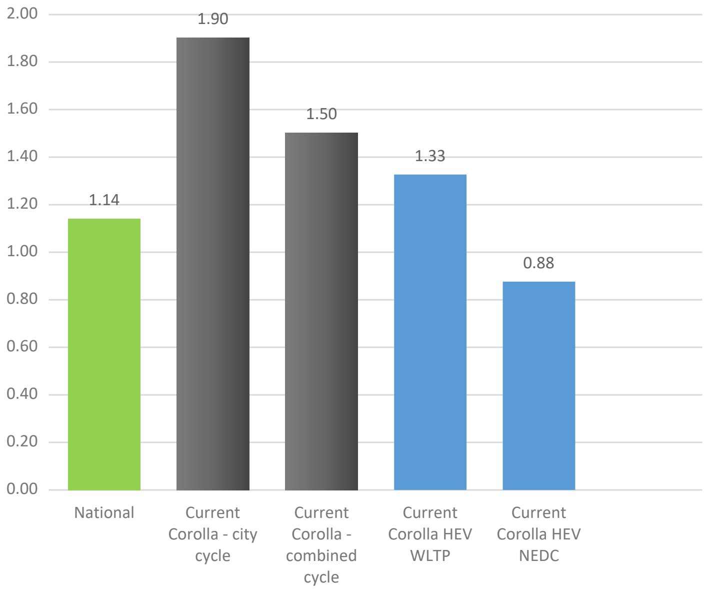

Figure 5: Tonnes CO_2-e per 10,000 km for Kona on national grid average, ICE Corolla (city and combined) and HEV Corolla.

Corolla HEV battery is only 1.4 kWh). Under the old NEDC cycle, the test distance was relatively short compared to the newer WLTP—so PHEV batteries were sometimes sized to minimise the test cycle fuel consumption figures whilst only providing a short battery-only range. Therefore, for HEVs and PHEVs, the closer your mix of driving type and length of trip matches the test cycle, the closer you will get to the test cycle fuel consumption figure. The further you are from the trip defined in the test cycle, the more fuel you will use in comparison. All-in-all, HEVs and PHEVs have a very narrow use-case (particularly PHEVs) for meeting the expectations created by the test cycle figure.

However, as there is a HEV equivalent to the Corolla available, I have attempted to add an apples-for-apples comparison of a HEV Corolla into the mix to give some idea of whether HEVs are potentially a viable alternative. This is shown in Figure 5 using the average WLTP figures for the HEV Corolla (sourced from European data) and Kona electric, but using the Green Vehicle Guide figure for the ICE Corolla. (Note, under the European WLTP test cycle, the Corolla HEV L/100 km figure is listed as varying from a low of 4.4 to a high of 6.5).

As can be seen from Figure 5, the HEV Corolla rated on the more reliable WLTP test cycle is an improvement on greenhouse emissions from the petrol version, but it is not as large as an EV already offers. This is also based on the use case for the HEV being close to the WLTP test cycle conditions. Outside of that, its greenhouse emissions figure will likely increase. On top of that, local air pollution from the HEV's tailpipe is not eliminated as it is from a BEV.

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bit.ly/UCS-ChooseEV

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bit.ly/CC-TCC

Australian Vehicle Emission Standards:
bit.ly/IGAAVES

State of electric vehicles (Electric Vehicle Council report, August 2021):
bit.ly/EVC-SEV2021

CROSSWORD SOLUTION

(From page 12)

Theme: LIGHTNING STRIKE

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