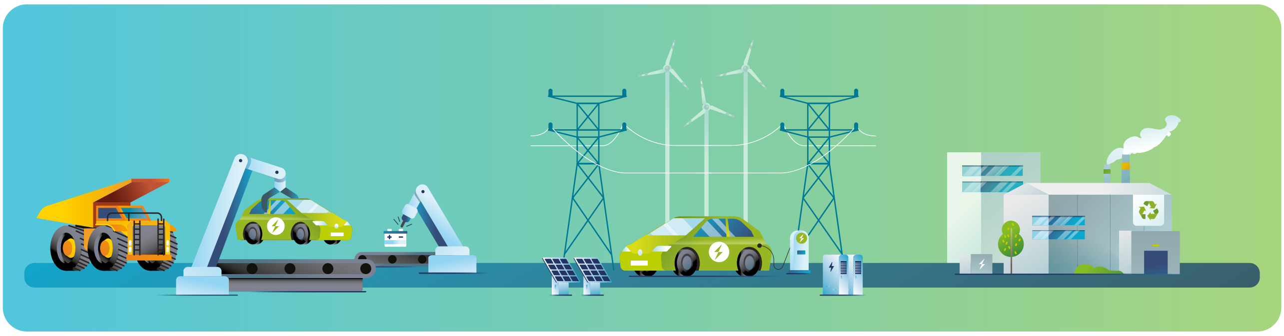
A comparison of lifecycle emissions between BEVs and ICE vehicles in Australia

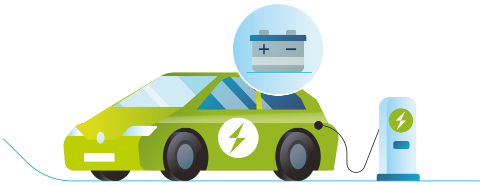
Transport accounts for 19% of Australia's carbon emissions. As the energy sector rapidly decarbonises through the increased share of renewables, attention must be directed at other sectors of the economy to ensure we can achieve legislated climate targets of a 43% reduction by 2030 and net zero by 2050.

Electric vehicles (specifically battery electric vehicles or BEVs), are going to play a key role in achieving these reductions. Not only do they produce zero tailpipe emissions, but over the lifespan of a vehicle they offer significantly lower emissions than conventional vehicles powered by petrol or diesel, as well as hybrid vehicles, all of which are classed as internal combustion engine (ICE) vehicles. What's more, unlike ICE vehicles, which maintain a consistent rate of emissions throughout their lifecycle, the emissions associated with BEVs are expected to fall progressively as the electricity grid continues to get cleaner.

There are a lot of variables that affect a vehicle's emissions. It's complex, and can be hard to understand. The Electric Vehicle Council (EVC) has worked with EU experts at **Transport & Environment** to make an easy-to-use calculator which can help you understand the differences in lifecycle emissions between BEVs and ICE vehicles. In the development of this calculator we have taken a conservative approach in order to explore the worst case scenarios for BEVs compared to ICE vehicles.



Overview of different powertrains

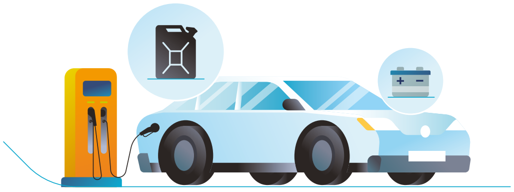


BATTERY ELECTRIC VEHICLES (BEV)

powered exclusively by electric motors, using energy stored in a battery than can be plugged in to be charged.

PLUG-IN HYBRID VEHICLES (PHEV)

powered by electric motors and usually also a combustion engine, with the ability to travel for shorter trips exclusively using energy stored in a battery that can be plugged in to be charged.



HYBRID VEHICLE

powered using an internal combustion engine, with an electric motor and small battery to improve fuel efficiency. Cannot be plugged in to be charged, and can only run on battery power for short distances at low speeds.

PETROL VEHICLE

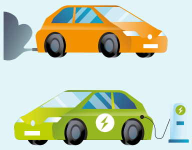
powered solely by an internal combustion engine that runs on petrol. These vehicles rely entirely on the combustion of petrol to generate power and do not use electricity.

Using the tool

To utilise the tool effectively, users are required to provide two inputs:

LOCATION

Selecting location is crucial as it helps incorporate region-specific energy emissions data into the comparison. This ensures more accurate and relevant results.



VEHICLE SELECTION

Simply select a vehicle segment. The tool then provides average lifecycle emissions for the chosen segment and fuel type, enabling easy comparisons with other vehicle segments.

From Production to Recycling:

Lifecycle emissions of EVs and ICE Vehicles

EV lifecycle

Production

- **Vehicle Production:** Use of raw materials, energy consumed in manufacturing processes.
- **Battery Production:** Extraction of minerals, energy use in battery cell manufacturing.

Fuel lifecycle

- **Electricity:** Emissions vary depending on the regional energy mix and use of renewable energy generation sources.

End of life

- **Recycling:** Processing of vehicle and battery materials for reuse.

ICE Vehicle lifecycle

Production

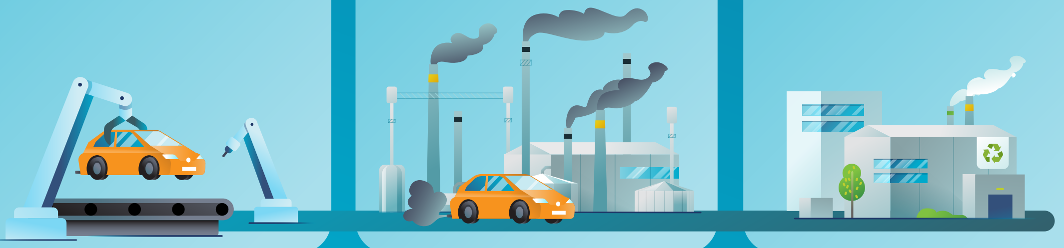
- **Vehicle Production:** Use of raw materials, energy consumed in manufacturing processes.

Fuel lifecycle

- **Fuel Production and Refining:** Processing and transformation of crude oil and associated emissions.
- **Tailpipe:** Emissions from fuel combustion in the vehicle.

End of life

- **Recycling:** Disassembly and recycling of vehicle components.



Overview of Method & Assumptions

The EVC's vehicle lifecycle emissions calculator builds on existing **analysis** conducted by Transport & Environment, a prominent European organisation with expertise on clean transportation.

It's important to note that it is difficult to directly compare the results from this tool with other reports or analyses. Every lifecycle analysis is developed using slightly different boundaries, data sources, and data processing choices.

The EVC's tool provides a snapshot comparison based on available evidence, a defined methodology, and a number of different assumptions. It covers a wide range of processes within the economy, offering valuable insights into the environmental impact of different vehicle types throughout their lifecycles. This tool does not provide definitive or absolute results on the lifecycle emissions of specific makes and models of vehicles, as it was not designed for this purpose.

Our approach to developing this tool has been intentionally conservative in order to explore the worst case scenarios for BEVs compared to ICE vehicles. We have assumed the highest emissions-intensive battery production in estimating the manufacturing emissions for batteries in BEVs driven in Australia. The tool also calculates operational or fuel lifecycle emissions for BEVs using the average generation mix for BEVs powered using the electricity grid, rather than factoring in timing of charging that would maximise utilisation of renewable energy, which would have presented a more favourable scenario.

Regarding tailpipe emissions of ICE vehicles, the tool adopts an optimistic approach using Worldwide Harmonised Light Vehicle Test Procedure (WLTP) test cycle data, which may not accurately capture real-world driving conditions. In addition, the tool also does not include extra emissions associated with manufacturing of hybrid powertrains, presenting a more favourable outlook for these vehicles.

As new data becomes available, we will continue to refine the methodogy and assumptions set out below to ensure the tool remains accurate.

Method & Assumptions

Vehicles

As noted above, this calculator considers average emissions across each vehicle segment, and the values shown are not specific to individual vehicles. To inform the development of this tool, we utilised information on vehicles available or soon to be available in the Australian market. In order to do this, we gathered information including the curb weight of new vehicles across different segments, the battery capacity, kWh/100km efficiency for BEVs, and L/100km efficiency for ICE vehicles, converted to WLTP (see below).[1] Please note that as hybrids are not available in every vehicle segment in Australia (e.g. people movers, utes, vans), the calculator does not include hybrid vehicles for these segments. The tool may be updated over time if new hybrid vehicles become available.

Segment	Petrol (L/100km WLTP)	Hybrid (L/100km WLTP)	BEV (kWh/100km)	BEV Battery Capacity (kWh)
Light	5.9	3.7	16.1	28.9
Small	7.5	4.1	15.9	49.1
Medium	7.9	4.9	18.3	73.7
Large	8.0	-	20.0	92.8
Upper Large	9.6	7.3	21.5	106.9
Small SUV	7.3	5.4	16.6	56.1
Medium SUV	8.3	6.0	17.3	70.2
Large SUV	9.1	6.5	20.9	86.9
People Mover	8.9	-	24.1	90.0
Small Van	7.8	-	16.8	44.7
Large Van	8.8	-	24.4	64.0
Ute	9.3	-	25.6	107.2

Table 1. Average fuel consumption and efficiency data by segment and powertrain

WHAT ABOUT PLUG-IN HYBRIDS?

The initial version of this tool does not include plug-in hybrids (PHEVs). Analysing the lifecycle emissions of these vehicles is more complicated because of their dual powertrains and the real-world operations of these vehicles. The fuel lifecycle emissions of PHEVs will vary significantly depending on whether the vehicle is regularly charged, or if the user instead relies on petrol for the majority of driven kilometres.[2] We intend to include PHEVs in a future iteration of this tool.

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1 WLTP refers to Worldwide Harmonised Light Vehicle Test Procedure. While these figures are standardised, it is widely recognised that they tend to significantly underestimate vehicle tailpipe emissions in real-world driving conditions.

2 Transport & Environment (2022), LCA Update, **https://www.transportenvironment.org/wp-content/uploads/2022/05/TE_LCA_Update-June_corrected.pdf.**

The below table provides indicative information on top selling models in each segment to aid in understanding of categorisation of different models:[3]

Segment	Examples of Top Selling Models
Light	MG3 , Suzuki Swift, Kia Picanto
Small	Hyundai i30, Toyota Corolla, Mazda 3
Medium	Tesla Model 3, Toyota Camry, Mercedes-Benz C-Class
Large	Mercedes-Benz E-Class, BMW 5, Kia Stinger
Upper Large	BMW 7, Audi A8, Mercedes-Benz EQS
Light SUVs	Mazda CX-3, Kia Stonic, Hyundai Venue
Small SUVs	MG ZS, Mazda CX-30, Haval Jolion
Medium SUVs	Tesla Model Y, Toyota RAV4, Mazda CX-5
Large SUVs	Isuzu MU-X, Toyota Prado, Subaru Outback
Utes	Ford Ranger, Toyota Hilux, Isuzu D-Max
People Movers	Kia Carnival, Hyundai Staria, Volkswagen Multivan
Small Van	Volskwagen Caddy Van, Peugeot Partner, Renault Kangoo
Large Van	Toyota Hiace Van, Hyundai Staria Load, LDV G10

Source: VFACTs (2023)

MILEAGE

To inform the average mileage of a vehicle in Australia, we have used survey data from the Australian Bureau of Statistics (ABS), estimating that the average Australian car travels a distance of around 12,600 kilometres a year and 189,000 kilometres over the life of the vehicle. [4]

The mileage of a particular driver does have an impact on the lifecycle emissions of a vehicle, in particular the emissions rate in grams of carbon per kilometre or g CO_2/km. In general, BEVs that travel further over their lifetime (including taxis, ride-share vehicles and vehicles used in commercial operations) deliver a better overall climate impact per kilometre driven. We are exploring additional features for future iterations of the tool to adjust lifetime distance and account for higher mileage vehicles and/or drivers.

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[3] Please note that this tool has been designed to provide an estimate of the average lifecycle emissions for different vehicle segments, depending on where they are driven in Australia. The vehicles listed in the table above are merely examples of different vehicles within distinct segments and should not be interpreted as an exhaustive list of vehicles that have been individually assessed or analysed.

[4] Australian Bureau of Statistics (2018), Survey of Motor Vehicle Use, **https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/12-months-ended-30-june-2018**.

Production

All vehicles involve energy and emissions-intensive industrial processes, from raw material extraction, through to component and vehicle production. As per Transport & Environment's analysis, the emissions involved in the production of the body of the vehicle (glider) and powertrain is modelled using the average weight of vehicles across each segment, with the production of conventional petrol vehicles 10.7% more emissions intensive than electric vehicles (excluding battery production – refer below) due to the inclusion of engine and powertrain components.

While exact figures will vary across models, global studies suggest that the upstream manufacturing emissions for hybrids are also generally higher than a conventional petrol vehicle by about 5-7% due to the inclusion of an electric motor/s and a small battery in addition to a combustion engine.[5] However, in this analysis we have assumed that manufacturing emissions for hybrids are no higher than a conventional petrol vehicle, presenting a highly optimistic scenario for hybrids.

CARBON FOOTPRINT OF BATTERY PRODUCTION

The tool calculates the carbon footprint of battery production based on upstream emissions from mining and refining, and the carbon intensity of the electricity used in manufacturing processes.

The main chemistry considered under this analysis is NMC (Nickel-Manganese-Cobalt) li-ion batteries (NMC-622) which are incorporated in the majority of EVs on the global market.[6] As manufacturers shift towards lower-cobalt batteries and chemistries like LFP (Lithium-Iron-Phosphate)-based cathodes that do not contain cobalt or nickel, the upstream emissions will also change and will need to be factored into this analysis.[7]

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[5] European Commission, Directorate-General for Climate Action, Hill, N., Amaral, S., Morgan-Price, S., et al. (2020) Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA : final report. Publications Office of the European Union. **https://data.europa.eu/doi/10.2834/91418.**

[6] International Energy Agency (2023), Global EV Outlook 2023, **https://www.iea.org/reports/global-ev-outlook-2023/trends-in-batteries.**

[7] See Transport & Environment (2021), Minviro Life Cycle Assessment, **https://www.transportenvironment.org/wp-content/.** uploads/2022/07/2022_07_LCA_research_by_Minviro.pdf

The carbon footprint of batteries can vary significantly depending on the country or region of production (see **Table 2** below). For the purposes of this analysis, we have based calculations on the assumption that the average EV battery in an Australian vehicle is manufactured in China, which accounts for the majority of the current domestic EV market.[8]

Production Location	kg CO_2/kWh
EU average	78
Sweden	64
Germany	85
China	105

Table 2. Battery production emissions in kg CO_2/kWh - 2022

It should be noted that these figures represent averages, and there is considerable variation among manufacturers, depending on specific manufacturing processes, upstream supply chain diversification, and energy sourcing. For example, some car makers are purchasing 100% renewable energy for vehicle and battery manufacturing, at facilities in Europe, Asia and North America.

Over time, it is expected that the supply chain emissions for EV batteries will reduce as the industrial processes involved in battery production are decarbonised globally – this presents a significant opportunity for improving the lifecycle emissions of EVs even further (see **Table 3**). Although not included in the current version of this tool, it is projected that emissions from battery production worldwide will improve by approximately 25% by 2030.[9]

Production Location	kg CO_2/kWh
EU average	55
Sweden	47
Germany	61
China	81

Table 3. Battery production emissions in kg CO_2/kWh - 2030

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[8] International Energy Agency (2022), Global Supply Chains of EV Batteries, **https://iea.blob.core.windows.net/assets/4eb8c252-76b1-4710-8f5e-867e751c8dda/GlobalSupplyChainsofEVBatteries.pdf**; Federal Chamber of Automotive Industries (2023), 2022 EV Report, **https://www.fcai.com.au/library/publication/fcai_zlev_report_2022.pdf.**

[9] Transport & Environment (2020), T&E's analysis of electric car lifecycle CO_2 emissions, **https://www.transportenvironment.org/wp-content/uploads/2020/04/TEs-EV-life-cycle-analysis-LCA.pdf**.

Fuel lifecycle and energy consumption

ICE vehicles, including hybrids, emit the majority of their CO_2 emissions through the direct combustion of fossil fuels, commonly known as tailpipe emissions. While hybrids are still fundamentally ICE vehicles, they achieve greater fuel efficiency by integrating an electric motor and small battery with a combustion engine, allowing for reduced tailpipe emissions compared to traditional petrol vehicles. However, it is important to recognise that hybrids, despite being more efficient, still produce considerable tailpipe emissions. In comparison, BEVs do not produce any tailpipe emissions as they operate entirely on electric power. The emissions associated with BEVs during their operational use are determined by the energy sources used to generate electricity.

ICE VEHICLES

To provide a comprehensive comparison, the tool incorporates fuel consumption data for conventional petrol and hybrid vehicles, while also considering factors such as upstream production, refining, and transportation of fuel. Our methodology aligns with that used by Transport & Environment in their model, which we have adapted to evaluate the emissions of major vehicles available in the Australian market.

Importantly, we have not used real-world fuel consumption data but instead adopted claimed test cycle figures aligned to Worldwide Harmonised Light Vehicle Test Procedure (WLTP). While these figures are standardised, it is widely recognised that they tend to significantly underestimate vehicle tailpipe emissions in real-world driving conditions.

BATTERY ELECTRIC VEHICLES

The LCA calculator considers all lifecycle carbon emissions associated with electricity generation for BEVs. The carbon intensity of electricity sources is based on realistic electricity generation mix evolution for each state and territory in Australia, including IPCC emission factors for different energy sources and consideration of average electricity grid losses. On average, losses in electricity transmission and distribution increase the carbon intensity of the grid by approximarely 5%. In addition, 10% efficiency losses in charging were added (5% from the charger equipment and 5% from battery charging efficiency).[10]

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[10] Transport & Environment (2020), T&E's analysis of electric car lifecycle CO_2 emissions, **https://www.transportenvironment.org/wp-content/uploads/2020/04/TEs-EV-life-cycle-analysis-LCA.pdf**.

Importantly, we consider the emissions from burning fossil fuels in power plants (such as coal or gas) and upstream emissions from power generation source production. For renewable energy sources, the tool considers upstream emissions from metal extraction and the manufacturing of solar panels or wind turbines. Lifecycle emissions factors are based on IPCC and World Nuclear Association figures.[11]

It is important to recognise that the fuel lifecycle emissions for EVs are improving due to the decarbonisation of electricity generation sources. Accordingly, the tool incorporates both current energy generation mix data and future energy generation scenarios to determine lifecycle emissions more accurately. This data will be iteratively updated based on the latest available data and projections.

Please note that the emissions associated with EV charging also change throughout the day (for instance, if you charge during peak solar hours), however, for the purposes of this analysis we have used the average generation mix across the electricity grid to reflect the average scenario.

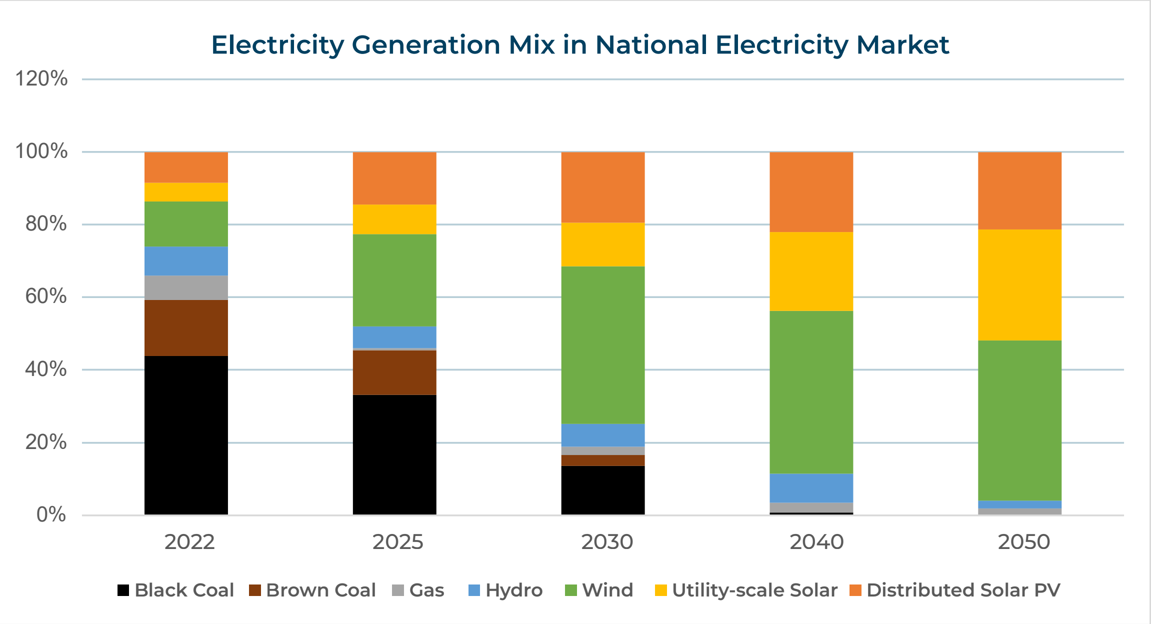

Figure 1. Electricity Generation Mix in National Electricity Market

Source: AEMO (2022), Integrated System Plan, Step Change Scenario.

For National Electricity Market (NEM) regions (including New South Wales and Australian Capital Territory, Queensland, South Australia, Tasmania and Victoria), data for the current generation mix is sourced from AEMO. Future estimates for the electricity generation mix are based on AEMO's Step-Change Scenario under the 2022 Integrated System Plan (ISP), which reflects the most likely pathway to meet net-zero policy commitments (see above).[12] We note that the scenarios are subject to change under the upcoming 2024 ISP and will

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[11] Schlömer S. et al (2014), 'Annex III: Technology-specific cost and performance parameters,' Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, **https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_annex-iii.pdf.**

[12] Australian Energy Market Operator (2022), Integrated System Plan, **https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp.**

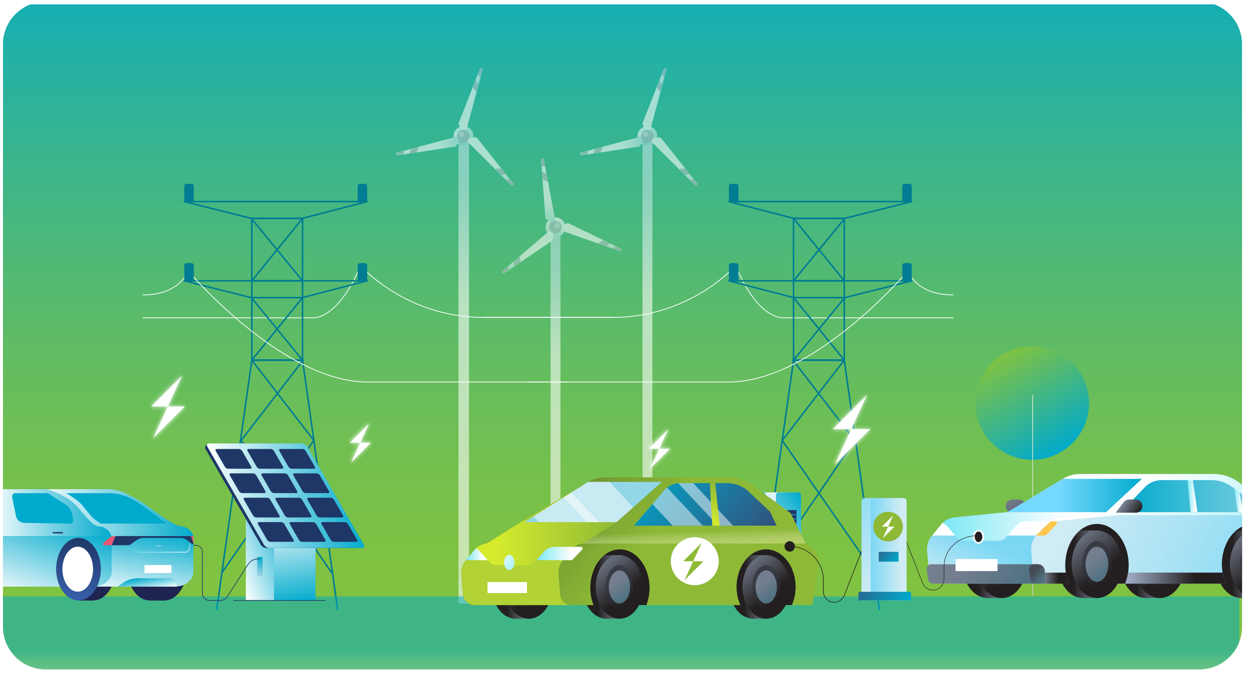
modify our underlying data at periodic intervals to account for updated information as it becomes available.

Please note that AEMO does not have separate generation data available for the ACT, with this instead encompassed in NSW data and forward scenarios. While the ACT does have contracts in place for 100% renewable energy supply, this does not account for real-time energy consumption as it is interconnected with the electricity grid in NSW. As such, ACT values correspond with the emissions intensity of the NSW grid.

For Western Australia, data is derived from recent AEMO data and the Whole of System Plan Report Techtopia Scenario, estimating 48% renewables in the system by 2030.[13] The Northern Territory data is based on the NT Government Darwin-Katherine Electricity System Plan, which presents an estimate of 45% renewable electricity by 2030.[14]

Users also have the option to select charging with 100% rooftop solar, which significantly reduces the emissions profile for EV drivers. It is important to acknowledge that even with rooftop solar there are upstream emissions. As mentioned, we calculate the lifetime emissions of rooftop solar using IPCC emissions factors. It should be noted that our assumed emissions intensity for rooftop solar PV is conservative as it remains fixed over the lifetime of the vehicle, and does not account for future improvements associated with manufacturing solar PV panels.

As supply chains for all energy technologies will continue to decarbonise, this will make a significant impact on the future sustainability of all products (including solar panels, batteries and vehicles).



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[13] Western Australian Government (2020), Whole of System Plan, https://www.wa.gov.au/government/document-collections/whole-of-system-plan.

[14] Northern Territory Government (2021), Darwin-Katherine Electricity System Plan, https://territoryrenewableenergy.nt.gov.au/strategies-and-plans/electricity-system-plans.

Recycling

Recycling enables a significant reduction in the lifecycle emissions of vehicles by reducing demand for raw material extraction to produce new vehicles. As per the methodology applied by Transport & Environment in development of their model, recycling credits have been applied to all powertrains in this calculator, reducing approximately 19% of the production carbon footprint of a vehicle. [15] This is based on a previous study commissioned by the EU Commission, which demonstrated that recycling provides for a 19% reduction in the production footprint of a vehicle in 2020, with a 22% reduction expected by 2030.[16]

Recycling of all types of vehicles in Australia is a topic currently being discussed. Importantly, EVs provide an opportunity to move closer towards a circular economy due to the high recyclability of their components, including batteries and motors.

REUSE AND RECYCLING OF EV BATTERIES

Establishing a circular economy around EV batteries will allow for the provision of critical minerals to meet future needs for clean energy technologies and achieve significant emissions reductions by reducing the use of raw materials in battery production.[17]

Global car makers have made several commitments to increase supply chain sustainability of their vehicles, including efforts to recycle spent EV batteries at end-of-life. While the volume of batteries for recycling remains relatively low, this market is expected to grow significantly over coming years. To ensure emissions involved in the recycling and manufacturing of batteries continues to improve, ongoing research and development to enhance material recovery rates and efficiency of recycling methods is crucial.

In addition, industry efforts to reuse EV batteries will have a significant impact on extending

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15 Transport & Environment (2022), Lifecycle Analysis : 2022 update, **https://www.transportenvironment.org/wp-content/uploads/2022/05/TE_LCA_Update-June_corrected.pdf.**

16 European Commission, Directorate-General for Climate Action, Hill, N., Amaral, S., Morgan-Price, S., et al. (2020) Determining the environmental impacts of conventional and alternatively fuelled vehicles through LCA : final report. Publications Office of the European Union. **https://data.europa.eu/doi/10.2834/91418.**

17 International Council on Clean Transportation (2023), Scaling Up Reuse and Recycling of Electric Vehicle Batteries: Assessing Challenges and Policy Approaches, **https://theicct.org/publication/recycling-electric-vehicle-batteries-feb-23/.**

the life of critical materials and reducing lifecycle emissions of batteries themselves. Following an average 15+ year lifespan in a vehicle, current EV batteries are expected to retain approximately 70-80% of their energy storage capacity, which importantly makes them attractive for several secondary use cases prior to recycling (see battery lifecycle below at **Figure 2**).[18]

For simplicity, the LCA calculator assumes that a typical EV and battery will be recycled at the end of its initial lifespan. This adopts a conservative approach in not factoring in the reuse and repurpose of EV batteries for a second life. It should be noted that these second-life applications are already in progress, and will contribute to a further reduction in the lifecycle emissions of EVs. This is because the emissions associated with manufacturing a battery would be distributed across its use in a vehicle and subsequent second-life powering a home or the grid.

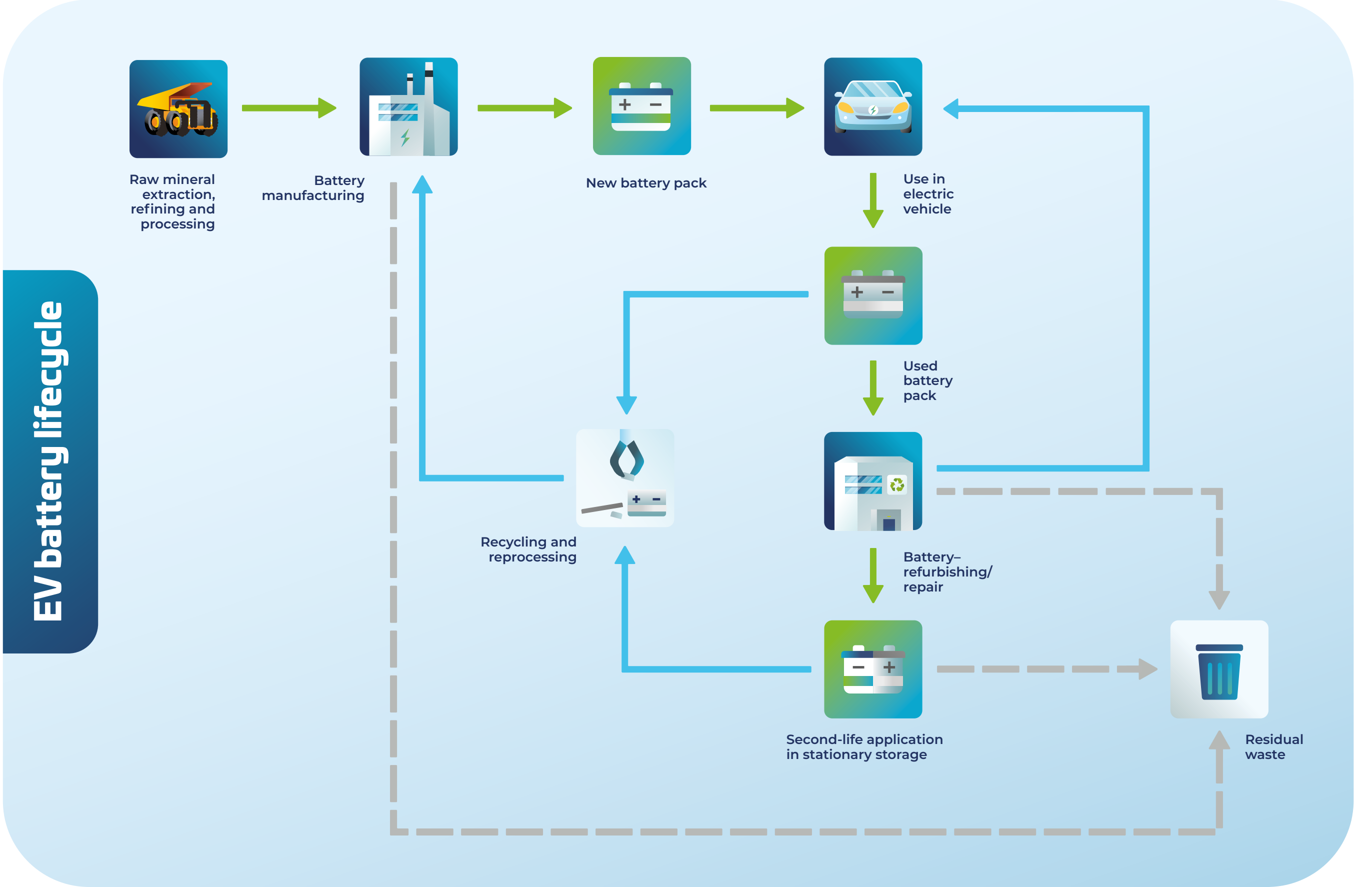

Figure 2. EV Battery Lifecycle

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[18] International Council on Clean Transportation (2023), Scaling Up Reuse and Recycling of Electric Vehicle Batteries: Assessing Challenges and Policy Approaches, **https://theicct.org/publication/recycling-electric-vehicle-batteries-feb-23/.**

Results

Considering the results of this analysis, it is evident that even when accounting for higher manufacturing emissions of EV batteries today - using conservative estimates - BEVs consistently provide increased environmental benefits in terms of lifecycle emissions compared to both petrol and hybrid vehicles, especially when paired with renewable energy.

Example: Medium Car Driven in Australia

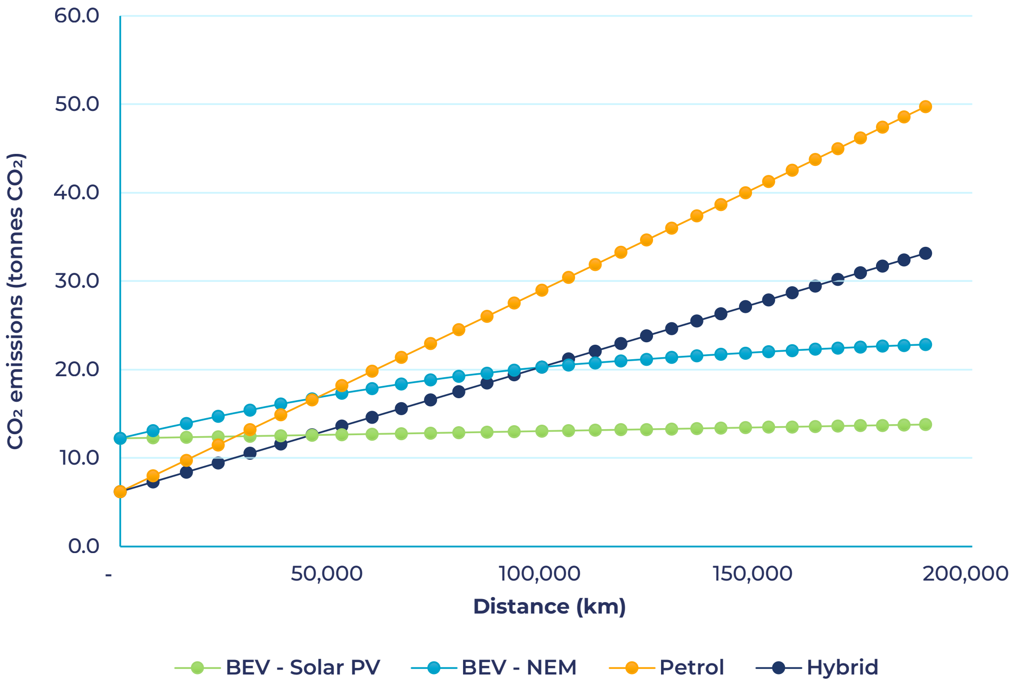

Figure 3. Lifecycle emissions of Medium Car Driven in Australia in tonnes CO_2

For an average medium-sized BEV, when powered by grid electricity from the National Electricity Market (NEM), the lifecycle emissions are 124 grams of CO_2 per kilometre, which equates to 23.8 tonnes of CO_2 over the vehicle's average lifetime (see **Figure 3**). However, when this BEV is charged using solar power, its emissions drop significantly to only 73 grams CO_2 per kilometre, or 13.8 tonnes of CO_2 over its lifetime. In comparison, an equivalent petrol car emits substantially more, at 263 grams CO_2 per kilometre, leading to 49.7 tonnes over its lifetime. A hybrid vehicle in the same category produces 175 grams CO_2 per kilometre, amounting to 33.2 tonnes over its entire lifespan.

BEV - NEM	BEV - Solar PV	Petrol	Hybrid
124 grams of CO_2 / km	73 grams of CO_2 / km	263 grams of CO_2 / km	175 grams of CO_2 / km

Figure 4. Lifecycle emissions of Medium Car Driven in Australia in grams CO_2 per kilometre

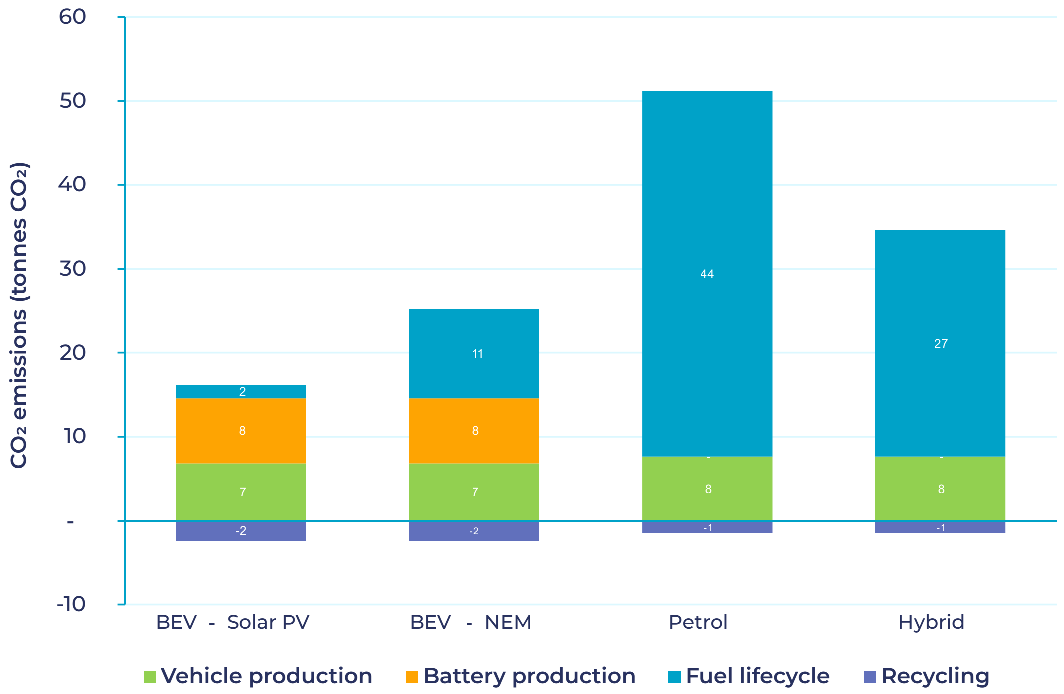

Figure 5. Lifecycle emissions of Medium Car Driven in Australia in tonnes CO_2

The average medium BEV driven on grid electricity from the NEM presents a 52.97% reduction in emissions compared to a convention petrol vehicle. This emissions saving is further increased when the BEV is powered by renewable energy, like solar, where it shows a 72.27% reduction in lifetime emissions. Even when compared with a medium hybrid vehicle in the same conditions, the average BEV still provides a notable 29.45% improvement, and this advanatage increases to 58.40% for a BEV powered by renewable energy.

Example: Medium Car Driven in Victoria

The lifecycle emissions of a BEV are significantly influenced by the emissions intensity of the electricity grid it uses. Simply put, the cleaner the grid, the lower the overall emissions of the BEV. This is important to consider in areas where the electricity grid relies heavily on coal-fired power stations, as is the case in many parts of Australia. In Victoria, the prevalence of coal power (specifically brown coal) means that the emissions associated with operating a BEV can vary from other regions. Accordingly, the average medium BEV driven in Victoria using the Victorian electricty grid emits 137 grams of CO_2 per kilometre (see **Figure 5**). Over the average lifetime of the vehicle, this equates to 25.9 tonnes of CO_2 (see **Figure 6**).

BEV - VIC Grid	BEV - Solar PV	Petrol	Hybrid
137 grams of CO_2 / km	73 grams of CO_2 / km	263 grams of CO_2 / km	175 grams of CO_2 / km

Figure 6. Lifecycle emissions of Medium Car Driven in Victoria in grams CO_2 per kilometre

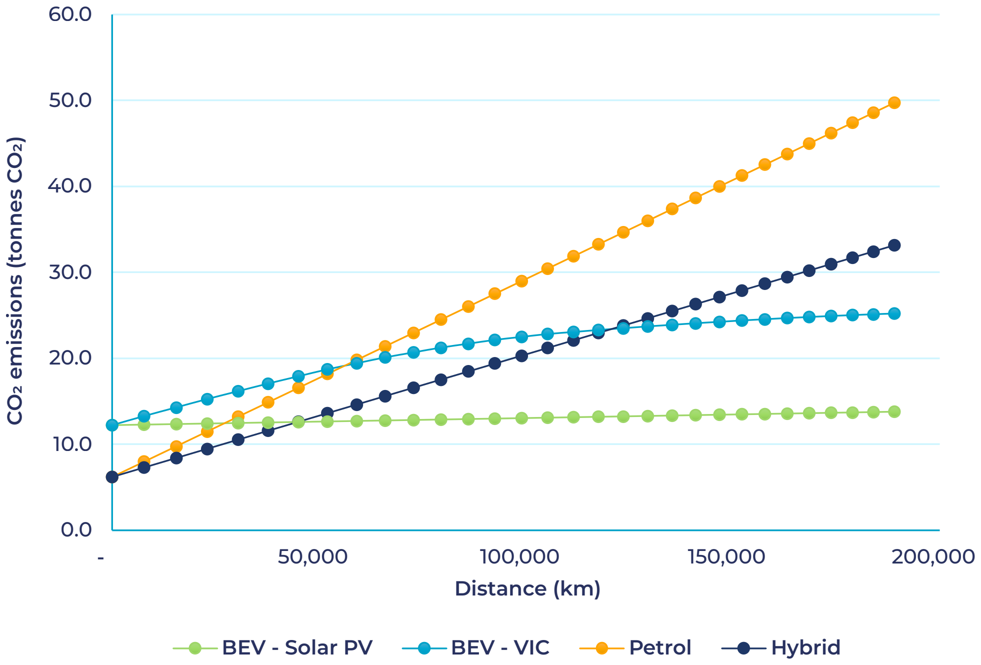

Figure 7. Lifecycle emissions of Medium Car Driven in Victoria in tonnes CO_2

Importantly, the average medium BEV driven on the Victorian grid still presents an emission saving of 47.94% compared to a convention petrol vehicle in the same segment. As noted, this increases further when access to renewable energy is considered, to a 72.27% reduction. Compared with a medium hybrid vehicle in the same conditions, the average BEV still presents a 21.91% improvement, with a BEV powered by renewable energy presenting a significantly higher saving of 58.40%.

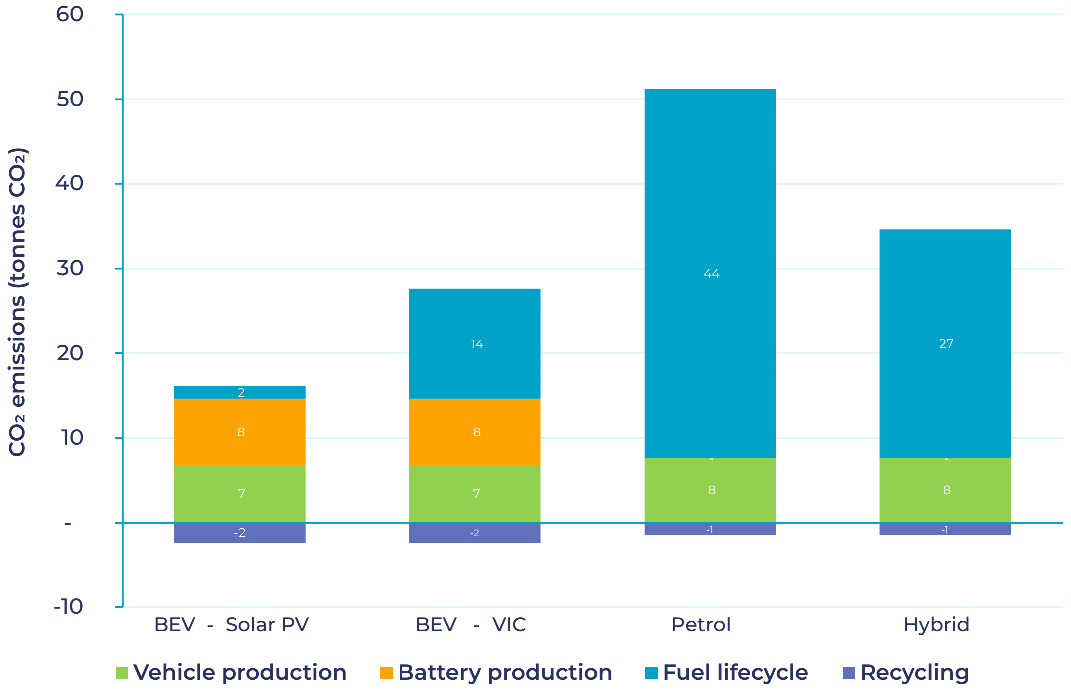

Figure 8. Lifecycle emissions of Medium Car Driven in Victoria in tonnes CO_2

Conclusion

This analysis presents a comprehensive comparison of lifecycle emissions between BEVs and ICE vehicles, including hybrids, within the Australian context. Despite adopting conservative assumptions for the manufacturing emissions of BEVs and a more optimistic outlook for hybrids and ICE vehicles, the findings consistently demonstrate that BEVs offer a substantial reduction in lifecycle emissions. This remains true even in scenarios with high emissions-intensive electricity grids. The advantage of BEVs is further increased when powered by renewable energy sources, such as solar, underscoring their potential in contributing significantly to Australia's climate targets.

While hybrids may serve as a transitional technology in the near term, they fall short as a long-term solution for deep decarbonisation, as emphasised by the International Council on Clean Transportation.[19]

Ongoing advancements in BEV technology, alongside improvements in upstream supply chains and the progressive decarbonisation of the electricity grid firmly demonstrate the role of BEVs in the transition towards a more sustainable transport system.

Access the calculator at: https://electricvehiclecouncil.com.au/lifecycle-emissions-calculator/

If you are interested in understanding more about the lifecycle emissions of battery electric vehicles compared to petrol vehicles, hybrids and PHEVs, please check out these global resources:

- **https://www.transportenvironment.org/discover/how-clean-are-electric-cars/**
- **https://unece.org/sites/default/files/2022-06/4_ICCT.pdf**
- **https://theicct.org/wp-content/uploads/2021/07/Global-Vehicle-LCA-White-Paper-A4-revised-v2.pdf**

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[19] International Council on Clean Transportation (2021), A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars, **https://theicct.org/wp-content/uploads/2021/07/Global-Vehicle-LCA-White-Paper-A4-revised-v2.pdf**