Cleaner and Safer Roads for NSW

Supported by

ELECTRIC VEHICLE COUNCIL

Asthma Australia

Doctors for the Environment Australia
PUBLISHED BY THE ELECTRIC VEHICLE COUNCIL AND ASTHMA AUSTRALIA

Electric Vehicle Council

The Electric Vehicle Council is the national body representing the electric vehicle industry in Australia. As the world’s largest vehicle markets and companies set their course for a future where road transport is powered by zero emissions vehicles, the Electric Vehicle Council works to highlight the important role and opportunities for Australia in this global transition. This means overcoming the current challenges in Australia’s electric vehicle market through policy and industry development so that Australian consumers and industry can be leaders in the future of mobility.

Asthma Australia

For over 50 years Asthma Australia has been the leader in asthma health care, research and support. Asthma Australia delivers evidence-based preventative health strategies to over 500,000 people every year and provides support, training and resources to the primary health care sector. The organisation funds vital basic science and population health research contributing to national and international understandings of asthma and how best to manage the disease.

ACKNOWLEDGEMENTS

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## Contents

1. Executive Summary  
2. Summary of Recommendations  
3. Air Pollution on NSW Roads  
4. Electric vehicles will reduce NSW’s air pollution problem  
5. Noise Pollution in NSW  
6. EVs are a Noise Pollution Solution  
7. Road Safety  
8. EV Policy Recommendations  
9. Appendix  
10. References
This report summarises the health impact of air and noise pollution on NSW’s roads and explains how electric vehicle (EV) adoption can help to address these issues while improving road safety.

**THE IMPACT OF AIR AND NOISE POLLUTION**

The World Health Organisation considers air pollution to be the single largest environmental danger to public health globally. At the same time, a wealth of international evidence now shows that there is no safe level of air pollution. The existence of any air pollution at all causes negative health impacts.

The OECD estimates that approximately half of air pollution in member countries is due to motor vehicles. This is because, unlike with industrial or agricultural processes, motor vehicle pollution is pumped straight onto our streets where we live and breathe.

Australia and NSW are not exempt from this insidious global phenomenon. Air pollution from motor vehicles kills over 1,700 Australians per year. Around 650 of those deaths occur in NSW. This loss of life is 60% higher than loss of life caused by motor vehicle crashes in the state. In total, vehicle emissions are causing around 21,000 serious health impacts annually in NSW.

To make matters worse, air pollution disproportionately affects the most vulnerable members of society including unborn babies, children, the elderly, and those with pre-existing health conditions.

Using data collected by the NSW Department of Environment and Conservation, the annual health costs of air pollution from vehicles is estimated to be $3.0 billion in the Sydney-Newcastle-Wollongong region. That means that each internal combustion engine vehicle (ICEV) creates average health costs of $7,110 over a ten-year lifetime. Around half of that pollution comes from exhaust emissions while the remainder comes from non-exhaust emissions such as tyre and brake wear.

While ambient air quality in NSW has benefited from stricter exhaust emission standards over the last two decades, that improvement is now plateauing. This means that policymakers need to look at new ways of protecting citizens from air pollution.

Electric vehicles (EVs) produce zero exhaust emissions so widespread adoption of EVs would make marked improvements to NSW’s air quality. This report estimates that for each EV that replaces an ICEV, NSW will save at least $2,400 in health costs.
Given that the most recent data available on NSW health costs of air pollution is from 2005, this report makes recommendations as to the frequency and type of data that should be recorded and analysed by the NSW Government in order to better inform decisions made about health, environment, and transport policies.

Conventional vehicles are also responsible for significant noise pollution. In fact, noise pollution from road traffic is estimated to cause $1.4 billion in social costs per year in NSW. Electric vehicles, particularly heavy electric vehicles, are much quieter than their combustion engine counterparts and would help reduce this harm.

SAFETY BENEFITS OF EVS

The Australasia New Car Assessment Program (ANCAP) has found that electric vehicles achieve equivalent safety results to internal combustion vehicles. Every electric vehicle tested in the last five years has received a 5-star ANCAP safety rating. EVs are actually likely to be safer than conventional vehicles. The US National Highway Traffic Safety Administration (NHTSA) found that EVs are less likely to roll over during crashes due to a lower centre of gravity.¹ ANCAP does not currently undertake rollover testing despite rollovers being involved in one in every three to four vehicle fatalities in Australia.¹²

EVs are also less likely to suffer potentially dangerous mechanical failures because they have far fewer moving parts and, importantly, don’t have any dangerous powertrain components such as the gearbox and engine which makes intrusion less likely in a crash.

Fire & Rescue NSW do not consider EVs as more dangerous than ICEVs. A report prepared for the NHTSA concluded that the propensity and severity of EV battery fires was equal or less than conventional liquid fuel fires.¹³

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² Bambach, Mitchel, Mattos, Crzebieta & McIntosh (2014).
650 people in NSW die each year from vehicle emissions, ICEVs cause 21,000 serious health impacts annually.

If EVs make up 10% of new car sales for a year, 27 deaths are prevented and 910 significant health impacts are prevented.

If EVs make up 10% for another year, that’s another 27 deaths prevented, another 910 significant health impacts prevented.

If EVs make up 50% of new car sales for a year, 137 deaths prevented, 4551 significant health impacts prevented.

Each EV on NSW roads will save $2,400 in health costs.

Every EV tested in the last five years has a 5-star ANCAP safety rating.

60% more people die from vehicle emissions than from car crashes.

Noise pollution costs NSW $1.4 BILLION per year.

$3 BILLION
The annual health costs of air pollution from vehicles in the Sydney-Newcastle-Wollongong region.

Figure 1: Infographic.
Summary of Recommendations
This report makes two sets of recommendations to the NSW Government: first, measures to improve our understanding of health and safety issues in NSW; and second, measures to support EV adoption and industry development in NSW.

### HEALTH AND SAFETY RECOMMENDATIONS

1. Include deaths due to vehicle emissions in the NSW road toll.
2. Increase availability of data regarding health impact of motor vehicle noise and air pollution in NSW.
3. Enable ANCAP to perform rollover testing.

### EV RECOMMENDATIONS

1. Transition the NSW Government fleet to be electric with a staged target of 50% electrification by 2025 and 100% by 2030 (where appropriate).
2. Provide short-term financial incentives to NSW residents and businesses to decrease the upfront cost of purchasing electric vehicles.
3. Support the rollout of charging infrastructure.
3. Air Pollution on NSW Roads
Air pollution has been declared the single largest environment risk to global health by the World Health Organisation.\textsuperscript{12}

Exposure to air pollutants can result in a wide range of serious health effects including asthma, heart disease, stroke, lung cancer, and chronic obstructive pulmonary disease.

Air pollution is a serious and consistent concern in NSW, particularly in metropolitan areas where population density is higher. Each year air pollution is responsible for hundreds of deaths and thousands of hospital admissions in Sydney alone.\textsuperscript{13}

At the same time, the myth that there can exist a ‘safe’ level of pollution has been well and truly debunked.\textsuperscript{14} It is now established that the existence of any pollution in the air we breathe will increase health effects. Given that there is no safe level of air pollution, air pollution reductions are necessary. Such reductions work: documented examples have consistently shown that when air quality improves, so does population health.\textsuperscript{15}

According to the NSW Government, motor vehicles are a “significant contributor” to air emissions in NSW.\textsuperscript{16} More importantly, pollution from motor vehicles has a disproportionate health impact. This is because, unlike industrial or agricultural sources, vehicles produce their pollution in heavily populated areas. A relatively small reduction in pollution from vehicles therefore yields greater health benefits than similar reductions in other areas.

\textbf{VEHICLE EMISSIONS MORTALITY AND MORBIDITY}

According to the National Environment Science Programme, air pollution from vehicle emissions caused the deaths of 1,715 Australians in 2015.\textsuperscript{17} Using mortality data from a NSW Department of Environment and Conservation report, it is estimated that vehicle emissions are responsible for around 650 deaths in the state annually.\textsuperscript{18} This is 60% higher than the number of deaths from motor vehicle crashes in NSW.\textsuperscript{19} In fact, in NSW, vehicle emissions are responsible for four times the number of deaths as crashes where speeding is a factor, and over ten times as many deaths as crashes where alcohol is involved. Vehicle emissions also have serious morbidity impacts. Each year, vehicle emissions in NSW are estimated to be responsible for over 21,000 significant health consequences such as restricted activity days, hospitalisations and chronic diseases.\textsuperscript{20}

\begin{itemize}
\item \textsuperscript{12} World Health Organisation Regional Office for Europe (2017).
\item \textsuperscript{13} NSW Government (2016).
\item \textsuperscript{14} Barnett (2014).
\item \textsuperscript{15} State of Global Air (2017), p. 1.
\item \textsuperscript{16} NSW Government (2017).
\item \textsuperscript{17} Schofield et al. (2017).
\item \textsuperscript{18} Based on data from NSW Department of Environment and Conservation (2005). This figure is for the Sydney-Newcastle-Wollongong region only. The figure across NSW will be higher. See appendix for further calculation data and explanations.
\item \textsuperscript{19} Transport for NSW (2017).
\item \textsuperscript{20} Based on data from NSW Department of Environment and Conservation (2005). This figure is for the Sydney-Newcastle-Wollongong region only. The figure across NSW will be higher. See appendix for further calculation data and explanations.
\end{itemize}
“Deaths from vehicle emissions in NSW are 60% higher than the number of deaths from motor vehicle crashes.”

Figure 2: Crash deaths in NSW in 2017 where alcohol, fatigue, and speeding were a factor and total crash fatalities compared to estimated deaths from vehicle emissions.\textsuperscript{21} Vehicle emissions deaths calculated based on NSW Department of Environment and Conservation report.\textsuperscript{22}

\textsuperscript{21} Transport for NSW (2017).

\textsuperscript{22} See appendix for further calculation data and explanations.
Include deaths due to vehicle emissions in the NSW road toll.

The road toll is a measure of the effectiveness of government policy at keeping people safe on NSW roads. The distinction between a death due to a car colliding with someone and a death due to a car poisoning their body is arbitrary and outdated. The NSW Government has a responsibility to do all it can to keep people safe from vehicle emissions just as it has a responsibility to do what it can to keep people safe from vehicle crashes. Given the parity between these harms, the annual road toll should be updated to include deaths due to vehicle emissions.

RECOMMENDATION 1:

VEHICLE EMISSIONS FINANCIAL HEALTH COSTS

In 2005, the NSW Department of Environment and Conservation estimated the annual health costs of air pollution in the Sydney-Newcastle-Wollongong region to be $6.9 billion. Since that report, there has been no data released estimating the health costs of air pollution in NSW, so this is the best available data.

In that report, the estimation was made by examining the health impact of particulate matter measuring 10 micrometres or less in diameter, known as PM10. PM10 has numerous health effects including irritation of mucous membranes, infections, allergic effects, toxic effects, respiratory problems, and cancer. Recent epidemiological research also indicates that there is no threshold at which health effects do not occur.

According to the Bureau of Infrastructure, Transport and Regional Economics (BITRE), 43% of annual average PM10 exposure is due to motor vehicles. Using the Department of Environment and Conservation’s figure of $6.9 billion for all air pollution health costs in the Sydney-Newcastle-Wollongong region, it is estimated that 43% of that cost – $3.0 billion per annum – is due to PM10 exposure from motor vehicles. Given that there are approximately 4.2 million internal combustion engine vehicles (ICEVs) in that region, each ICEV is therefore responsible for PM10 exposure resulting in health costs around $7,100, assuming a vehicle lifetime of ten years.

“The air pollution from each ICEV on the road has an average health impact of $7,100.”

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23 NSW Department of Environment and Conservation (2005). Figures have been adjusted to 2018 Australian dollars to account for inflation.
26 The average age of a vehicle on NSW roads is 9.5 years, see Australian Bureau of Statistics (2018c). This means that an average vehicle lifetime can reasonably be estimated to be at least 10 years if not longer. See appendix for further calculation data and explanations.
THE TRUE HEALTH COSTS OF ICEVS IS LIKELY WORSE THAN ESTIMATED

The calculations of mortality, morbidity, and the associated financial costs within this report are likely to be underestimations. There are several reasons for this.

First, these estimates are based on a report by the NSW Department of Environment and Conservation and that report itself noted that its approach would “probably underestimate the impact of air pollution.”27 The study used PM10 as the single indicator of the health impacts of common ambient air pollutants but combustion engines emit many other pollutants including hydrocarbons, carbon monoxide, and sulphur dioxide that are recognised as causing respiratory and cardiovascular problems.28 Combustion engines also emit chemicals such as nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs) that react with sunlight to form ozone. When this occurs at ground level, that ozone can create toxic smog.29 Further, the study did not quantify a number of significant PM10-related health effects – such as extra cancer cases – and only estimated the impact of PM10 above a defined baseline microgram concentration thus excluding the impact of some finer particles which may have an even greater health impact than PM10.30, 31

Second, since that report was released, stronger vehicle emission restrictions have been introduced but recent data from the NSW Office of Environment and Heritage shows that levels of PM10 have not declined.32 Meanwhile, population density in NSW has increased such that the same levels of particulate pollution are likely to impact more people, causing higher mortality, morbidity, and health costs.33

Third, as new and more accurate, research methods are developed, the extent of air pollution health impacts continues to grow.34 Evidence also suggests that there are many air pollution health impacts that are still currently unquantifiable.

As such, these calculations are likely to be significantly under-estimating the actual impact of vehicle air pollution. More recent and thorough data and reporting of the health impact of ICEVs are necessary so that this issue does not continue to be ignored. 

“More thorough data and reporting of the health impact of ICEVs are necessary so that this issue does not continue to be ignored.”

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27 NSW Department of Environment and Conservation (2005), ‘Summary’.
28 PM10 was used as the single indicator emission in that report in order to avoid double counting where the health impacts of separate emissions overlap. However, this does mean that some health impacts are overlooked, leading to underestimation.
29 Australian Government Department of the Environment and Heritage (2009).
30 Doctors for the Environment Australia (2016).
31 NSW Department of Environment and Conservation (2005), ‘Summary’.
34 Schofield et al. (2017).
Increase availability of data regarding health impact of motor vehicle noise and air pollution in NSW.

— Estimate deaths and morbidity due to vehicle air pollution in NSW annually.
— The EPA should complete a report assessing the health costs of air pollution in the Greater Sydney Metropolitan Region. Such a report has not been completed since 2005.
— Commit EPA to publishing ‘Air Emissions Inventory for GMR’ every four years. 2013 data was meant to be released at the beginning of 2018 but, as of May 2019, the latest available data is still from 2008.
— Investigate potential differences between the health impact of exhaust and non-exhaust emissions of particulate matter to better inform policy prioritisation.
— Measure street level concentrations of NOx and PM$_{2.5}$ throughout NSW. This would help estimate health costs and create a map of pollution hotspots that could then be focused on.
— Investigate social costs due to vehicle noise pollution in NSW.

VULNERABLE POPULATIONS

Vehicle air emissions disproportionately impact the health of already vulnerable people. According to NSW Health, children are particularly harmed by air pollution. This is because children’s respiratory, immune, and cardiovascular systems are underdeveloped and they suffer from frequent respiratory infections that are exacerbated by pollution.\(^\text{35}\) In addition, children spend more of their lives outdoors exposing them to outdoor pollution for longer periods of time. Vehicle pollution is even more significant in the case of children’s health because schools are often built near main roads to increase accessibility. Such exposure can have lifelong effects; children living within 75 metres of a major road have a 29% increased risk of lifetime asthma.\(^\text{36}\) In Melbourne’s City of Maribyrnong – where 21,000 trucks pass through each day – the asthma incidence for children is double the national rate.\(^\text{37}\) According to a recent cross-sectional study of 2,000 Australian children, adverse respiratory health effects occur even when exposure is relatively low.\(^\text{38}\)

Vehicle pollution can begin harming children even before they are born. Unborn babies whose mothers are exposed to high levels of air pollution for long periods of time may suffer adverse pregnancy outcomes such as reduced birth weight or preterm birth. Anthropogenic PM$_{2.5}$ has been associated with 12-24% of pre-term births.\(^\text{39}\) Exposure to such ultrafine particles can also lead to neurodevelopmental harm such as ADHD and reduced cognition and IQ.\(^\text{40}\)

At the other end of life, the elderly also suffer from air pollution more than others because of their relatively poor health.\(^\text{41}\) Indeed, anyone with pre-existing medical conditions such as asthma, lung disease, or cardiovascular disease is more susceptible. Such people suffer more frequent and more serious symptoms when exposed to air pollution. Middle-aged people are also not exempt; people in their 40s and 50s living less than 200 metres from a major road were found to have higher rates of asthma and reduced lung function.\(^\text{42}\)

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\(^{35}\) NSW Health (2013).
\(^{36}\) McConnell et al. (2006).
\(^{37}\) Australian Commission on Safety and Quality in Health Care (2015), Chapter 6.4.
\(^{38}\) Knibbs et al. (2018).
\(^{39}\) Malley et al. (2017).
\(^{40}\) Canfield, Henderson, & Cory-Slechta (2003).
\(^{41}\) NSW Health (2013).
\(^{42}\) Bowatte et al. (2017).
“There is little that these vulnerable populations can do to mitigate their exposure to vehicle pollution while still leading a normal life.”

There is evidence that some of these health impacts are epigenetic, causing changes to gene expression that are passed on to future generations. In this way, the effects of vehicle pollution today will likely be felt for many years into the future by people who are not even alive yet.

There is little that these vulnerable populations can do to mitigate their exposure to vehicle pollution while still leading a normal life. This places a particular obligation on the government to step in and minimise that harm.

**AMENITY**

The NSW Government has recognised that air pollution also impacts amenity. Given the proximity of most of the NSW population to traffic-related air pollution, reducing vehicle emissions is one clear way to directly improve the liveability of NSW.

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44 NSW Office of Environment and Heritage.
Electric vehicles will reduce NSW’s air pollution problem
Despite increasingly tight vehicle emission standards over the last 40 years, the EPA says the situation is currently set to get worse.

Within the Sydney-Newcastle-Wollongong region, historical government policies of ‘urban consolidation’ have long been recognised as resulting in increased traffic emissions. Further pressures on future air quality include population growth, urbanisation, and climate change-related dust storms and bushfires.

These pressures explain why levels of air pollution are no longer improving. New policy approaches are required in order to improve health outcomes for people across the state. Electric vehicles are an important part of a multi-faceted solution that also includes encouraging active and public transport, improving vehicle emission standards, and promoting renewable energy production.

The OECD estimates that approximately half of the health impact of air pollution is due to motor vehicles. This is because, unlike with industrial or agricultural processes, motor vehicle pollution is pumped straight onto our streets where we live and breathe. As such, electric vehicles are one of the best ways of significantly and cost-effectively reducing the health impact of air pollution.

**THE ELECTRIC VEHICLE REVOLUTION**

Around the world, the EV industry is booming. In 2015, total EV sales hit one million. In December last year, they hit five million, with one million of those added in only six months. In China, 5% of 2018 new car sales were EVs. In California, it’s 7%. In Norway, it’s 50%. Uptake in Europe is expected to increase sharply in the coming years due to the EU’s combined EV target which will put around eight to nine million EVs on the road by 2020.

This overseas success has been driven by forward-thinking government policy that is helping to kickstart this revolutionary industry. In Australia, however, a lack of EV policy leadership has meant that our nation is lagging behind – EVs account for only 0.1% of new car sales compared to the global average of 1.3%. Without government action, market uncertainty prevents automakers from bringing more and cheaper EVs to Australian shores, preventing many consumers from taking part in this technological shift. This means that people in NSW and the rest of Australia are missing out on the substantial benefits that EVs offer, particularly in regard to improving the quality of our air.

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ELECTRIC VEHICLE EXHAUST EMISSIONS

Unlike ICEVs, EVs produce no exhaust emissions at all. This means that EV adoption has the potential to eliminate a significant portion of harmful air pollution. In fact, mass EV adoption would eliminate all vehicle emissions of carbon monoxide and nitrogen oxide, and reduce vehicle emissions of PM_{10} and VOCs by around half. Meanwhile, vehicle PM_{2.5} emissions – thought to be one of the most harmful pollutants – would be reduced by nearly two thirds.\textsuperscript{51} The high rate of exposure to vehicle emissions – because the pollution is produced in high population areas – means that relatively small reductions in pollution from vehicles yields greater health benefits than similar reductions in other areas.

\textbf{Figure 3:} Comparison of exhaust and non-exhaust contribution to pollution of vehicles. All exhaust emissions are eliminated by replacing ICEVs with EVs.\textsuperscript{52,53}

\textsuperscript{51} United States Environmental Protection Agency (2018).
\textsuperscript{52} NSW Office of Environment and Heritage (2014a).
\textsuperscript{53} NSW Office of Environment and Heritage (2014b).
“At 10% of new vehicle sales, EVs will prevent 27 deaths and 910 significant health impacts in NSW.”

**EVS WILL PREVENT AN ENORMOUS NUMBER OF HEALTH COSTS**

The NSW Department of Environment and Conservation calculated air pollution health costs in the Sydney-Newcastle-Wollongong region to be 1,509 deaths, 50,244 significant health impacts, and $6.9 billion.\(^{34}\) It is estimated that slightly under 20% of these health costs – or approximately 312 deaths, 10,370 significant health impacts, and $1.4 billion – are a result of the exhaust emissions of ICEVs.\(^{35}\) Given that EVs do not produce exhaust emissions, the electrification of NSW’s fleet would eliminate these costs. Based on Government data, we can estimate the reduction in mortality and morbidity that would occur as EV sales increase. The following assumes that the EVs are charged with renewable energy.

<table>
<thead>
<tr>
<th>EV share of NSW new vehicle sales</th>
<th>Annual EV sales</th>
<th>Deaths prevented</th>
<th>Significant health impacts prevented</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>3,645</td>
<td>3</td>
<td>91</td>
</tr>
<tr>
<td>5%</td>
<td>18,224</td>
<td>14</td>
<td>455</td>
</tr>
<tr>
<td>10%</td>
<td>36,449</td>
<td>27</td>
<td>910</td>
</tr>
<tr>
<td>25%</td>
<td>91,122</td>
<td>68</td>
<td>2,276</td>
</tr>
<tr>
<td>50%</td>
<td>182,243</td>
<td>137</td>
<td>4,551</td>
</tr>
<tr>
<td>100%</td>
<td>364,486</td>
<td>273</td>
<td>9,103</td>
</tr>
</tbody>
</table>

**Table 1:** Deaths and significant health impacts prevented at particular EV new vehicle market shares. Note that these figures estimate deaths and significant health impacts prevented over a vehicle’s lifetime. For example, if EVs comprise 1% of new vehicle sales for a year, there will be a total of 91 health impacts prevented over the next 10 years that those vehicles are operating.

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\(^{34}\) NSW Department of Environment and Conservation (2005). See appendix for calculation data and explanations.

\(^{35}\) See appendix for calculation data and explanations.
Preventing all deaths and health impacts from vehicle exhaust emissions would result in health savings around $1.3 billion. When distributed over the number of vehicles in the Sydney-Newcastle-Wollongong region, that means that each EV sold instead of an ICEV will save NSW approximately $2,400 in health costs. It should be noted that while these calculations use the best available data, that data comes from a range of sources and years and so these calculations are intended to provide an estimation of values rather than exact amounts. It should also be noted that, as explained earlier in this report, the actual health costs of ICEVs – including mortality and morbidity – is likely to be higher than estimated. As such, the health costs prevented by a transition to EVs are also likely to be higher than estimated.

“Each EV sold instead of an ICEV will save NSW $2,400 in health costs.”

<table>
<thead>
<tr>
<th></th>
<th>Annual health costs in Sydney-Newcastle-Wollongong region</th>
<th>Health costs per vehicle over lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health costs of all air pollution</td>
<td>$6.9 billion</td>
<td>N/A</td>
</tr>
<tr>
<td>Health costs of all vehicle emissions</td>
<td>$3.0 billion</td>
<td>$7,110</td>
</tr>
<tr>
<td>Health costs of vehicle exhaust emissions</td>
<td>$1.4 billion</td>
<td>$3,420</td>
</tr>
<tr>
<td>Health costs saved if EVs replace ICEVs, adjusted for NPV</td>
<td>$1.3 billion</td>
<td>$2,400</td>
</tr>
</tbody>
</table>

Table 2: Collection of different health costs for ICEVs. Note that these health costs are based on the NSW Department of Environment and Conservation report cited earlier and only include PM10 health costs. The actual health costs are likely to be higher. NPV value is with annual discount rate of 7%.

56 When adjusted for NPV at a discount rate of 7%. See Table 2, and appendix for further calculation data and explanations.
57 The average age of a vehicle on Australian roads is around 10 years. This means that an average vehicle lifetime can reasonably be estimated to be at least 10 years if not longer. See appendix for further calculation data and explanations.
58 See appendix for calculation data and explanations.
Further, transport emissions account for 20% of NSW’s greenhouse gas emissions, making this sector the second largest contributor in the state. Emissions from electricity generation, such as carbon dioxide, can also be reduced to zero if renewable sources are used. This means that electric vehicles purchased now will continue to get cleaner as renewable energy becomes more available. ICEVs bought today will continue to produce greenhouse gases for their entire operating lifetime.

Figure 4: A comparison of health costs from exhaust emissions from ICEVs and EVs. Note that this is based on the NSW Department of Environment and Conservation report and only includes health costs for PM10 emissions. Lifetime of vehicle is assumed to be ten years. There is evidence that non-exhaust emissions would also be reduced by EV adoption but that has not been accounted for in this chart.

Further, transport emissions account for 20% of NSW’s greenhouse gas emissions, making this sector the second largest contributor in the state. Emissions from electricity generation, such as carbon dioxide, can also be reduced to zero if renewable sources are used. This means that electric vehicles purchased now will continue to get cleaner as renewable energy becomes more available. ICEVs bought today will continue to produce greenhouse gases for their entire operating lifetime.
**ELECTRIC VEHICLE NON-EXHAUST EMISSIONS**

EVs do still produce non-exhaust emissions. These emissions include tyre wear, brake wear, road surface wear, and the resuspension of road dust, and are mostly unavoidable. One study that received media attention suggested that EVs produce more non-exhaust emissions due to their greater weight. However, a correction was later published for that study noting that it had not been carried out in connection with the University of Edinburgh as the authors had claimed, and that the primary author had later disclosed that he received non-financial support from Innas B.V., a consultancy specialising in combustion engine technology. Contrary to the findings in that study, several papers have suggested that EVs actually produce less non-exhaust emissions due to their regenerative braking. There is limited experimental evidence but a range of studies suggest such technology may reduce brake wear by 50 to 95%, reducing total non-exhaust emissions to be lower than ICEVs.

In New Zealand, a number of garbage trucks operated by EnviroWaste were retrofitted by Australian company, SEA Electric, to be fully electric with regenerative brakes. One of these trucks has been operating for 12 months and is yet to have its brake linings replaced. Meanwhile EnviroWaste’s diesel trucks have brake linings replaced every three months. EnviroWaste estimates that the regenerative braking has reduced brake wear by at least 10 times. For cases like this, where heavy vehicles start and stop frequently, reducing brake wear can significantly reduce non-exhaust emissions and improve the health of people in NSW.

The Australian Government, in its 2016 State of the Environment report, said that increasing vehicle traffic and greater congestion are a pressure on future air quality unless counterbalanced by reduced emissions per vehicle. EVs provide a clear path to achieve this.
Noise Pollution in NSW
Ambient noise levels have been shown to have a significant impact on public health and amenity. In fact, road traffic noise is identified in NSW’s Road Noise Policy document as the main issue affecting neighbourhood amenity in the state.\textsuperscript{64}

A Department of Environment and Conservation report in 2004 had 46% of respondents in NSW report that they considered road traffic noise to be a problem in their neighbourhood.\textsuperscript{65}

Meanwhile, the World Health Organisation ranked noise second among environmental threats to public health, the first being air pollution. The health effects of excessive noise pollution are significant. It can cause disturbed sleep, anxiety, and increased risk of heart disease and heart attack.\textsuperscript{66-67}

There is also reliable evidence that road traffic noise can impair cognition in children and have a negative impact on school performance.\textsuperscript{68-70}

Victoria’s Environment Protection Agency estimates that social costs due to noise amount to $250 per vehicle per annum.\textsuperscript{71} By applying that figure to NSW, we can estimate the social costs from vehicle noise to be $1.4 billion annually.\textsuperscript{72} This is nearly one quarter of the social costs of smoking in NSW.\textsuperscript{73}

\begin{table}[h]
\centering
\begin{tabular}{|l|c|}
\hline
Annual social cost of noise pollution per vehicle & $250 \\
Number of vehicles in NSW & 5,618,385 \\
Annual social cost of vehicle noise pollution in NSW & $1.4 billion \\
\hline
\end{tabular}
\end{table}

“We can estimate the social costs from vehicle noise to be $1.4 billion annually.”

\textsuperscript{64} NSW Department of Environment, Climate Change & Water (2011).
\textsuperscript{65} NSW Department of Environment, Climate Change & Water (2011).
\textsuperscript{66} World Health Organisation Regional Office for Europe (2011).
\textsuperscript{67} NSW Department of Environment, Climate Change & Water (2011).
\textsuperscript{68} Institute for Environmental Health (1997).
\textsuperscript{69} World Health Organisation Regional Office for Europe (2011), p. 51.
\textsuperscript{70} Environmental Health Standing Committee (2004), p. 24.
\textsuperscript{71} Victorian Environment Protection Agency (2013).
\textsuperscript{72} Number of registered vehicles in NSW is 5,618,285, see Australian Bureau of Statistics (2018c).
\textsuperscript{73} NSW Department of Health (2010).
EVs are a Noise Pollution Solution
According to the NSW Department of Environment, Climate Change & Water, tougher noise emission limits will be less impactful than increasing EV adoption.74

Conventional buses and trucks often reach sound levels of 80 decibels, 100 times louder than a typical residential street.75 Aside from causing health problems, loud vehicles can become a safety hazard for pedestrians when they drown out the sound of other approaching vehicles. Electrified heavy vehicles, meanwhile, produce significantly less noise. Australian company, SEA Electric, produces its own heavy vehicles as well as retrofitting conventional vehicles with electric motors. In decibel testing required by the Australian Design Rules for commercial vehicles, SEA Electric’s vehicles were deemed to be effectively ‘zero noise’.

Electric passenger vehicles are also quieter than conventional counterparts, producing approximately 5 decibels less noise at speeds less than 30km/h.76 At higher speeds, the difference in sound becomes negligible. There are concerns that quiet vehicles pose their own hazards to vulnerable road users who may not hear them approach. However, heavy vehicles still come equipped with reversing sound emitters – as required by Australian regulations – and most EV passenger vehicles sold in Australia are already equipped with noise emitters that operate to alert vulnerable road users when traveling at low speed. This is because manufacturers have already begun to comply with European Parliament legislation which requires such systems on all new electric and hybrid-electric vehicles by July 2019. Around the world, automakers have signalled a clear willingness to comply with such regulations to ensure the safety of vulnerable road users.

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75 NSW Environment Protection Agency (2013), Figure 2.2.
76 Danish Road Directorate (2015).
Road Safety

7.
The safety of road users is a clear priority for manufacturers, government, and the public. The Australasia New Car Assessment Program (ANCAP), in its submission to the Senate Committee on Electric Vehicles, said that electric vehicles achieved equivalent safety results to internal combustion vehicles. Indeed, every electric vehicle tested in the last five years has received a 5-star ANCAP safety rating.  

The 5-star ANCAP ratings given to EVs include specific electrical safety testing to ensure the safety of occupants and rescuers following a crash. ANCAP’s Strategic Objectives 2018-2023 will discuss whether any further EV-specific testing provisions will be necessary.

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**ELECTRIC VEHICLE FACTS**

- **SAFER**
  - Liquid fuel is protected by millimetres of plastic while batteries are protected by centimetres of metal

- **RECHARGING**
  - No gearbox or engine means less chance of intrusion during a crash
  - Encourages drivers to stop, revive, survive

- **17 VS 2000**
  - EVs have around 17 moving parts while ICEVs have over 2000

- **LOWERING CENTRE OF GRAVITY**
  - That means better and safer handling

- **NOISE EMITTERS**
  - Standard on almost all EVs in Australia despite no regulation because manufacturers are committed to safety

- **EVs hold the top three positions in NHTSA rollover safety testing**
  - Tesla Model S
  - Chevrolet Volt
  - Tesla Model X

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77 The 5-star ANCAP ratings given to EVs include specific electrical safety testing to ensure the safety of occupants and rescuers following a crash. ANCAP’s Strategic Objectives 2018-2023 will discuss whether any further EV-specific testing provisions will be necessary.
MORE TECHNOLOGY, LESS COMPLICATED

EVs are technological flagships for manufacturers and usually come fitted with all available active safety technology. Given EVs already require sophisticated computer systems and software, the integration of these safety features is more efficient than for conventional vehicles. At the same time, EVs have simpler powertrains, requiring fewer liquids and moving parts. According to the Victorian Automobile Chamber of Commerce (VACC), EVs typically have around 17 moving parts or less, as opposed to around 2,000 moving parts in an ICEV. This makes EVs more reliable, decreasing the chance of dangerous mechanical malfunctions. A lack of major conventional powertrain components in EVs also provides safety benefits to occupants. According to ANCAP, “large solid objects, such as an engine or gearbox, cannot be crushed – and if not carefully managed can intrude into the occupant cell”. EVs have neither engines nor gearboxes, immediately eliminating some of the potentially dangerous components of conventional vehicles. Having fewer powertrain parts also affords manufacturers more design flexibility. For example, Tesla’s model X and S have increased frontal crumple space where an engine would normally be. This combination of complex safety features and simplified design goes some way to explain why EVs are surpassing all safety requirements.

LOWERED CENTRE OF GRAVITY

Most EVs have their batteries beneath the passenger cabin. The batteries, being one of the heaviest parts of an EV, therefore lower the vehicle’s centre of gravity compared to an ICEV whose engine is higher up.

The primary benefit of this is in crashes where rollovers may occur. Rollovers are involved in one in every three to four vehicle fatalities in Australia. Current ANCAP testing does not include a test to reflect vehicle safety in the case of a rollover incident. This means that the decreased risk of rollovers in EVs is easily overlooked.

Testing carried out by the National Highway Traffic Safety Administration (NHTSA) in the US showed that Tesla’s model S was the least likely to rollover out of any vehicle ever tested. Tesla’s model X and the Chevrolet Volt were equal second. Meanwhile the Nissan Leaf was less likely to rollover than either the Ford Focus or Toyota Corolla, two of the most popular passenger vehicles in Australia.

According to multiple major automakers, EVs’ lower centres of gravity also afford drivers greater traction, road handling, and control, potentially reducing the chance of crashes. Positioning the battery underneath the cabin can also allow for the cabin to sit higher, as in the case of BMW’s i models, improving driver vision on the road. These features have the potential to reduce the chance of crashes occurring in the first place.

The weight of these batteries means that EVs typically weigh more than equivalent ICEVs. According to ANCAP, increased mass may increase the possibility of intrusion but modern vehicles “typically have structural elements that manage the crash energy well”. In fact, there is some evidence that increasing vehicle weight increases occupant safety even when accounting for vehicle size.32

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78 Victorian Automobile Chamber of Commerce (2017).
79 Victorian Automobile Chamber of Commerce (2017).
80 Bambach, Mitchel, Mattos, Crzebieta & McIntosh (2014).
82 Titheridge, Tolouei, & Maher (2011).
Enable ANCAP to perform rollover testing.

Rollovers are involved in approximately one in every three vehicle fatalities in Australia. Current ANCAP testing does not include a test to reflect vehicle safety in the case of a rollover incident, unlike comparable programs such as the NHTSA in the US. The NSW Government, as a member of ANCAP, could push for or provide extra funding that would allow ANCAP to undertake this testing. This would increase the rigour of safety tests and help ensure peace of mind for Australian drivers.

**BATTERY SAFETY**

Examples of EV batteries malfunctioning have received widespread media attention as is to be expected for any new technology. However, the evidence suggests that these lithium-ion batteries are in fact as safe or even safer than conventional fuel.

A multi-year investigation undertaken by NHTSA concluded that “the propensity and severity of fires and explosions from the accidental ignition of flammable electrolytic solvents used in Li-ion battery systems are anticipated to be somewhat comparable to or perhaps slightly less than those for gasoline or diesel vehicular fuels.”

Fire & Rescue NSW do not consider EVs as more dangerous than ICEVs and say that “all vehicles have potential hazards that need to be managed properly”.

EV batteries are also better protected than fuel canisters. While batteries are often situated in the strongest part of a vehicle’s frame – where they are less likely to be impacted – and surrounded by several centimetres of metal casing, fuel tanks are usually placed at the back of vehicles and protected by only one to two millimetres of plastic. This means that when a crash occurs from behind, the fuel tank can more easily be compromised and spark plugs or headlights can ignite the fuel. Such nose-to-tail collisions are the most common type of car crash on Australian roads, with 4,204 such crashes occurring in 2017. This may help explain why Clean Technica’s analysis of NHTSA data showed fires are nearly twice as likely to occur in fatal crashes involving conventional vehicles compared to hybrid vehicles. Tesla has also claimed that fires occur in its vehicles at a rate 11 times lower than conventional vehicles.

**DRIVER FATIGUE**

Fatigue is one of the three main killers on NSW roads. From 2013 to 2017, more people in NSW died in fatigue-related crashes than drink driving incidents. EVs force drivers to ‘stop, revive, survive’ because most EVs need to recharge after three to five hours of highway driving. Charging would take only 15 minutes using super-fast chargers, such as those installed on the Queensland Government’s Electric Super Highway, but even a short rest will reduce the chance of fatigue-induced crashes.

**PEDESTRIAN SAFETY**

As mentioned previously, most EVs in Australia are already voluntarily equipped with noise emitters to alert vulnerable road users. These emitters meet the standards required by legislation already put in place by the European Parliament. Manufacturers are committed to safety and have been cooperative and supportive of such measures.

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84 Transport for NSW (2017).
85 Cleantechnica (2018).
87 Transport for NSW (2018).
EV Policy Recommendations
The electric vehicle revolution is happening around the world but government policy is still necessary to overcome the initial barriers that the industry faces.

The NSW Government announced its EV policy in January 2019 as part of the NSW Electric and Hybrid Vehicle Plan. This signalled a positive shift in attitudes towards this new technology but stronger policy commitments are still required to ensure NSW does not fall behind. With the correct policy platform, NSW can lead Australia by providing its citizens with cleaner, quieter, and safer roads. That platform needs to be as significant as the problem it aims to address. The Road Safety 2021 Plan, part of the NSW Government’s ‘Toward Zero’ campaign, is receiving $1.9 billion over five years. Given that vehicle emissions are killing nearly twice as many people as road crashes, policies that address this issue should receive at least the same attention and funding as The Road Safety 2021 Plan.

1. **EV Policy Recommendations:**

Transition the NSW Government fleet to be electric.

A staged target of 50% electrification by 2025 and 100% by 2030 (where appropriate) should be set. A complementary ‘buy electric first’ preference should also be adopted. This would mean that, where available, a suitable electric model would be purchased instead of conventional alternatives.

In January 2019, the NSW Government announced a target of 10% – including hybrid vehicles – by 2021/2022. The NSW Government needs to increase this target and lead the way in ensuring the state’s air is as clean and breathable as possible. The NSW Government’s current fleet includes 22,000 passenger and light commercial vehicles – most of which are leased – so a 50% fleet target would be a relatively simple way to provide a notable increase in market certainty. This would encourage automakers to bring more EVs to NSW while also creating a viable secondary market when government vehicles are replaced.
2. Provide short-term financial incentives to decrease the upfront cost of purchasing electric vehicles.

Provide a temporary Stamp Duty exemption for electric vehicles in NSW. While the total ownership costs of EVs are already comparable to ICEVs, up-front costs are predicted to remain higher until 2024 according to Bloomberg. A report by Energeia and the Australian Renewable Energy Agency (ARENA) found that reductions in up-front costs have the biggest influence on EV purchase decisions. As such, consumer incentives are one of the most effective tools available to policymakers hoping to increase EV uptake. This conclusion is supported by evidence from around the world where consumer incentives have consistently helped to jumpstart EV markets. As the market matures and scales of operation increase, manufacturers will be encouraged to reshape our market by providing a greater number of EV models to Australian consumers, thereby increasing choice and affordability to better reflect international vehicle markets. These incentives can then be rolled back.

3. Support the rollout of Charging Infrastructure.

The NSW Government announced in January 2019 that it would co-invest $5 million in EV chargers. This is a good start but more funding is necessary to truly impact consumers’ range anxiety. This concern could be reduced through incentives such as providing low interest loans to households purchasing home chargers and to small and medium enterprises and councils delivering electric vehicle charging infrastructure. Such a loan scheme could be provided in a similar way to the NSW Farm Innovation Fund.

Concerns about charging site availability has been identified as a major barrier to consumers considering purchasing electric vehicles. In its 2019 Infrastructure Priority List, Infrastructure Australia labelled the creation of a national network of EV chargers a “high priority”. These types of incentives are not just effective, they’re also popular with the public. A poll by The Australia Institute found that 79% of Australians supported the government building a network of charging stations.
Appendix
PRELIMINARY NOTES:

- **Lifetime of vehicles**: The average age of vehicles in NSW is 9.5 years.\(^{88}\) We can therefore easily expect an average vehicle to be driven for 10 years. This is the average lifetime used throughout this report.

- **Number of vehicles in the GMR**: There are 696 registered vehicles in NSW per 1000 population.\(^{89}\) Approximately 75\% of NSW’s population lives in the GMR.\(^{90}\) The population of NSW is approximately 7,955,000.\(^{91}\) Based on those figures, it is estimated that there are 4,152,510 or 4.15M vehicles in the GMR. This is the figure used throughout this report.

- The following calculations assume the electric vehicles are charged using renewable energy. This assumption is reasonable for several reasons. First, NSW’s energy grid is continually becoming cleaner as renewable energy becomes cheaper. Second, most public chargers are powered by renewable energy. Third, those who purchase EVs are more likely to be environmentally conscientious and use renewable energy.

- In the body of this report, the Greater Metropolitan Region is referred to as the Sydney-Newcastle-Wollongong Region for greater clarity.

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\(^{88}\) Australian Bureau of Statistics (2018c).

\(^{89}\) Australian Bureau of Statistics (2018c).

\(^{90}\) NSW Environment Protection Agency (2012).

\(^{91}\) Australian Bureau of Statistics (2018a).
A.

SUMMARY OF VEHICLE EMISSIONS DEATHS CALCULATIONS

Aim:
Calculate the number of air pollution deaths in the GMR that are due to vehicle emissions.

Method:
1. Midpoint of GMR Mortality Incidence from PM_{10} air pollution = 1,509 deaths per year\(^{92}\)
2. ICEVs responsible for 43%\(^{93}\) of annual average PM_{10} exposure levels in Sydney. Therefore, PM_{10} from ICEVs responsible for 649 deaths per year.

Aim:
Calculate the number of air pollution deaths in the GMR that are separately due to non-exhaust and exhaust emissions.

Method:
1. PM_{10} emissions from ICEVs responsible for 649 deaths per year.\(^{94}\)
2. 48%\(^{95}\) of PM_{10} on-road ICEV emissions in Sydney due to exhaust emissions as opposed to non-exhaust emissions. Therefore, ICEV exhaust emissions responsible for 312 deaths per year. ICEV non-exhaust emission account for the remainder, 337 deaths per year.

Aim:
Calculate the number of deaths due to exhaust emissions per 10,000 ICEVs.

Deaths due to ICEV exhaust emissions per year\(^{96}\) 312
Vehicles in GMR 4,152,510
Deaths due to exhaust emissions per 10,000 ICEVs, over lifetime of vehicles 7.5

Deaths prevented per 10,000 EVs replacing ICEVs, over lifetime of vehicles\(^{97}\) 7.5
Vehicle sales in NSW per year (2017)\(^{98}\) 364,486
Total deaths prevented, EVs 1% new car sales 3
Total deaths prevented, EVs 5% new car sales 14
Total deaths prevented, EVs 10% new car sales 27
Total deaths prevented, EVs 25% new car sales 68
Total deaths prevented, EVs 50% new car sales 137
Total deaths prevented, EVs 100% new car sales 273

Notes: ‘Total deaths prevented’ is calculated over a 10-year vehicle lifetime. For example, if EVs comprise 1% of new car sales for a year, there will be a total of 3 deaths prevented over the next 10 years that those vehicles are operating.

\(^{92}\) NSW Department of Environment and Conservation (2005), Table A.2. Midpoint is 1509. As discussed earlier in this report, these are the latest available estimations for NSW and at the time, the DoE acknowledged they were conservative estimates.

\(^{93}\) Australian Government Bureau of Transport and Regional Economics (2005), p. 78. ‘Sydney’ jurisdiction includes Newcastle and Wollongong, aligning well with GMR boundaries. This is also in line with more recent estimates by the OECD in 2014 that say that roughly 50% of air pollution health costs in OECD countries are attributable to motor vehicles.

\(^{94}\) As calculated above.

\(^{95}\) NSW Office of Environment and Heritage (2014b), p. 12. Note that this is for Sydney not GMR but there is little to suggest the ratio between exhaust and non-exhaust emissions would differ significantly for vehicles elsewhere in the GMR.

\(^{96}\) As calculated above.

\(^{97}\) As EVs produce no exhaust emissions, deaths due to exhaust emissions from 10,000 ICEVs will be eliminated by replacing those vehicles with 10,000 EVs.

SUMMARY OF VEHICLE EMISSIONS HEALTH IMPACTS CALCULATIONS

Method:

1. Midpoint of GMR Health Impact Incidence from PM10 air pollution = 50,244 per year

2. ICEVs responsible for 43% of annual average PM10 exposure levels in Sydney. Therefore, PM10 from ICEVs responsible for 21,605 health impacts per year.

Aim:

Calculate the number of health impacts in GMR that are separately due to non-exhaust and exhaust emissions.

Method:

1. PM10 emissions from ICEVs responsible for 21,605 health impacts per year.

2. 48% of PM10 on-road ICEV emissions in Sydney due to exhaust emissions as opposed to non-exhaust emissions. Therefore, ICEV exhaust emissions responsible for 10,370 health impacts per year. ICEV non-exhaust emission account for the remainder; 11,235 health impacts per year.

Aim:

Calculate the number of health impacts due to exhaust emissions per 10,000 ICEVs in GMR.

<table>
<thead>
<tr>
<th>Health impacts due to ICEV exhaust emissions per year</th>
<th>10,370</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles in GMR</td>
<td>4,152,510</td>
</tr>
<tr>
<td>Health impacts due to exhaust emissions per 10,000 ICEVs, over lifetime of vehicles</td>
<td>250</td>
</tr>
</tbody>
</table>

Aim:

Calculate the number of health impacts prevented once EVs reach particular new vehicle market shares.

Note: ‘Total health impacts prevented’ is calculated over a 10-year vehicle lifetime. For example, if EVs comprise 1% of new car sales for a year, there will be a total of 91 health impacts prevented over the next 10 years that those vehicles are operating.

| Health impacts prevented per 10,000 EVs replacing ICEVs, over lifetime of vehicle | 250 |
| Vehicle sales in NSW per year (2017) | 364,486 |
| Total health impacts prevented, EVs 1% new car sales | 91 |
| Total health impacts prevented, EVs 5% new car sales | 455 |
| Total health impacts prevented, EVs 10% new car sales | 910 |
| Total health impacts prevented, EVs 25% new car sales | 2,276 |
| Total health impacts prevented, EVs 50% new car sales | 4,551 |
| Total health impacts prevented, EVs 100% new car sales | 9,103 |

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99 NSW Department of Environment and Conservation (2005), Table A.2. Midpoint is 1509. As discussed earlier in this report, these are the latest available estimations for NSW and at the time, the DoE acknowledged they were conservative estimates.

100 Australian Government Bureau of Transport and Regional Economics (2005), p. 78. ‘Sydney’ jurisdiction includes Newcastle and Wollongong, aligning well with GMR boundaries. This is also in line with more recent estimates by the OECD in 2014 that say that roughly 50% of air pollution health costs in OECD countries are attributable to motor vehicles.

101 As calculated above.

102 NSW Office of Environment and Heritage (2014b), p. 12. Note that this is for Sydney, not GMR but there is little to suggest the ratio between exhaust and non-exhaust emissions would differ significantly for vehicles elsewhere in the GMR.

103 As calculated above.

104 As EVs produce no exhaust emissions, health impacts due to exhaust emissions from 10,000 ICEVs will be eliminated by replacing those vehicles with 10,000 EVs.

C.

SUMMARY OF HEALTH SAVING PER EV CALCULATION

Aim:
Calculate health cost of exhaust emissions from on-road vehicles in GMR in order to estimate approximate health cost per ICE vehicle that would be avoided if vehicle were electric (given that EVs do not produce exhaust emissions).

Method:
1. Midpoint of GMR Health Costs of PM$_{10}$ air pollution in 2018 AUD = $6.87B$\textsuperscript{106}
2. ICEVs responsible for 43%$\textsuperscript{107}$ of annual average PM$_{10}$ exposure levels in Sydney = $2.95B
3. $2.95B$ divided by 4.15M$\textsuperscript{108}$ vehicles in GMR = $711$ for total emissions per year or $7,110$ over vehicle lifetime.
4. 48%$\textsuperscript{109}$ of PM$_{10}$ on-road ICEV emissions in Sydney due to exhaust emissions as opposed to non-exhaust emissions = $1.42B$
5. $1.42B$ divided by 4.15M$\textsuperscript{110}$ vehicles in GMR = $342$ for exhaust emissions per year
6. Cost of exhaust emissions over vehicle’s lifetime = $3,420$
7. Final savings adjusted for Net Present Value$\textsuperscript{111}$ = $2,400.$

All figures in 2018 AUD. This number is indicative and not an attempt to calculate precise figures as such a calculation is impossible with the data available for NSW.

$\textsuperscript{106}$ NSW Department of Environment and Conservation (2005), Table S.1. Midpoint is $4.7B$ in 2003 AUD. Here that figure is converted to 2018 AUD. As discussed earlier in this report, these are the latest available cost calculations for NSW and at the time, the DoE acknowledged they were conservative estimates.

$\textsuperscript{107}$ Australian Government Bureau of Transport and Regional Economics (2005), p. 78. ‘Sydney’ jurisdiction includes Newcastle and Wollongong, aligning well with GMR boundaries. This is also in line with more recent estimates by the OECD in 2014 that say that roughly 50% of air pollution health costs in OECD countries are attributable to motor vehicles.

$\textsuperscript{108}$ Australian Bureau of Statistics (2018c). Number of vehicles in GMR estimated using per capita vehicle registration in NSW, see Australian Bureau of Statistics (2018c), and population of GMR, see Australian Bureau of Statistics (2018b) and NSW EPA (2012).

$\textsuperscript{109}$ NSW Office of Environment and Heritage (2014b), p. 12. Note that this is for Sydney not GMR but there is little to suggest the ratio between exhaust and non-exhaust emissions would differ significantly for vehicles elsewhere in the GMR.

$\textsuperscript{110}$ Australian Bureau of Statistics (2018c). Number of vehicles in GMR estimated using per capita vehicle registration in NSW, see Australian Bureau of Statistics (2018c), and population of GMR, see Australian Bureau of Statistics (2018b) and NSW EPA (2012).

$\textsuperscript{111}$ Calculated at 7% discount per annum. No investment from government is required so initial investment value is $0.
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