The People's Clean Air Action Plan for Victoria

Authors

Bronya Lipski (Lawyer, Environmental Justice Australia)

Bruce Buckheit (former Director, Air Enforcement Division, United States Environmental Protection Authority; Member, Virginia Air Pollution Control Board; Senior Counsel, Environment and Natural Resources Division, United States Department of Justice)

Christopher James (former Director, Connecticut Department of Environmental Protection and former Principal, China Programs, Regulatory Assistance Project)

Maxwell Smith (Clean Air Campaigner, Environmental Justice Australia)

Further information

Bronya Lipski and Maxwell Smith, Environmental Justice Australia
T: 03 8341 3100
E: admin@envirojustice.org.au

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1. Introduction

There is no safe level of exposure to air pollution. Australia experiences levels of air pollution that significantly impact the health of our communities. Collective studies estimate that between 2,616 and 4,884 people die prematurely from exposure to air pollution every year in Australia.[1] The economic cost of premature death attributed to ambient air pollution in Australia has been estimated at up to AUD$24 billion per year.[2] Low levels of exposure to air pollution can cause adverse health impacts,[3] however the lower the pollution, the lower the health impacts. Driving pollution down to as low as possible therefore has significant benefits.

This Clean Air Action Plan identifies the largest sources of controllable air pollution, and the actions that the Victorian government must take to reduce controllable air pollution to best practice control standards. It has been developed in collaboration with health experts, community groups in areas impacted by air pollution, and international air regulation experts. We urge the Victorian government to adopt this plan and the actions it lists throughout.

The overwhelming industrial source of air pollution in Australia and Victoria is coal-fired power stations.[4] The most recent analysis of health impacts caused by coal-fired power stations in Australia has found that they contribute to 845 babies being born with low birth-weight, 14,434 children with asthma, and 785 premature deaths each year.[5] The health cost to the Australian economy from coal-fired power stations alone is $2.4 billion dollars annually.[6] The other major sources that contribute to health impacts are motor vehicles and smoke from wood heaters.[7] Air pollution from coal-fired power

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[1] Hanigan, I.C.; Broome, R.A.; Chaston, T.B.; Cope, M.; Dennekamp, M.; Heyworth, J.S.; Heathcote, K.; Horsley, J.A.; Jalaludin, B.; Jegasothy, E.; et al. Avoidable Mortality Attributable to Anthropogenic Fine Particulate Matter (PM2.5) in Australia. *Int. J. Environ. Res. Public Health* 2021, 18, 254: https://doi.org/10.3390/ijerph18010254; Australian Institute of Health and Welfare (AIHW) (2016). Australian burden of disease study: impact and causes of illness and death in Australia 2011, AIHW, Canberra; Begg, S. (2007). The burden of disease and injury in Australia 2003, PHE 82, AIHW, Canberra; Institute for Health Metrics and Evaluation (IHME). Global Burden of Disease Study 2017. Seattle, WA: IHME, University of Washington, 2017. Accessed 10/06/2018: http://vizhub.healthdata.org/gbd-compare.

[2] See: Australian Institute of Health and Welfare (AIHW) (2016). Australian burden of disease study: impact and causes of illness and death in Australia 2011, AIHW, Canberra; Begg, S. (2007). The burden of disease and injury in Australia 2003, PHE 82, AIHW, Canberra; Access Economics (2008). The health of nations: the value of a statistical life, Australian Safety and Compensation Council, Australian Government Department of Education, Employment and Workplace Relations, Canberra.

[3] World Health Organization. Regional Office for Europe. (2006). Air quality guidelines global update 2005: particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Copenhagen: WHO Regional Office for Europe. https://apps.who.int/iris/handle/10665/107823

[4] See: http://www.npi.gov.au/npidata/action/load/emission-by-substance-result/criteria/destination/ALL/source-type/ALL/subthreshold-data/Yes/substance-name/All/state/VIC/year/2019.

[5] Dr. Aidan Farrow, Andreas Anhäuser and Lauri Myllyvirta,, Lethal Power: How Burning Coal is Killing People In Australia (August 2020), pp 22-24. Available at: https://www.greenpeace.org.au/wp/wp-content/uploads/2020/08/GPAP-Lethal-Power-full-report.pdf.

[6] Johnson, Chris et al, 'Costs of Negative Health Outcomes Arising from Air Pollution from Coal-fired Power stations', Actuaries Institute of Australia Annual Hackathon, 19 August 2020.

[7] EPA Victoria, *Air pollution in Victoria – a summary of the state of knowledge* (March 2018) p. 18. Available at: www.epa.vic.gov.au/about-epa/publications/1709.

stations, disproportionately impacts the communities living near them, making this one of the most significant environmental justice issues in Australia. Air pollution reduction measures cannot only be undertaken primarily in larger population areas, such as metropolitan Melbourne.

The Victorian government initiated the development of an Air Quality Strategy in 2018. The Victorian population is exposed to significant amounts of air pollution each year. As one of the most populous states, reducing air pollution and lifting the health burden should be treated as a priority. As Victorians were exposed to some of the most significant impacts of bushfire smoke in the 2019-2020 summer bushfire crisis, the Victorian government must act to control air pollution wherever they can. Fortunately, the rest of the world has undertaken air pollution reduction measures that Victoria can learn from and implement to protect public health.

The devastating bushfires of the 2019-2020 summer period and the ongoing COVID-19 global pandemic have highlighted air pollution as a significant public health problem. Research published in the Medical Journal of Australia estimates that more than 400 people died from exposure to air pollution during the fires,[8] with many more likely to have developed chronic illness, or experienced serious short-term health impacts.[9] The total estimated health costs of the bushfire smoke is $1.95 billion.[10] It is a matter of when, not if, Australia will experience severe bushfires again. Without reducing existing sources of air pollution to best practice control standards, the public health consequences of air pollution from subsequent bushfires will continue to be exacerbated, especially for those communities who are already exposed to high levels of air pollution throughout the year. Air pollution can cause health problems, like heart attacks, strokes, diabetes and high blood pressure, that have been identified as the pre-existing medical conditions that raise the chances of death from COVID-19 infection.[11] By implementing this Clean Air Action Plan, pre-existing sources of air pollution will be reduced which may assist in reducing health impacts from both these crises.

[8] Nicolas Borchers Arriagada, Andrew Palmer, David Bowman, Geoffrey Morgan, Bin Jalaludin, Fay Johnston, Unprecedented smoke-related health burden associated with the 2019-20 bushfires in eastern Australia, *Medical Journal of Australia*, 12 March 2020. Available at: https://onlinelibrary.wiley.com/doi/pdf/10.5694/mja2.50545.
[9] Australian Medical Association, "AMA warns of new health threats from ongoing bushfire crisis", January 3 2020: https://ama.com.au/media/new-health-threats-escalating-bushfire-crisis
[10] Johnston, F.H., Borchers-Arriagada, N., Morgan, G.G. *et al.* Unprecedented health costs of smoke-related $PM_{2.5}$ from the 2019–20 Australian megafires. *Nature Sustainability* (2020). https://doi.org/10.1038/s41893-020-00610-5
[11] https://www.hsph.harvard.edu/c-change/subtopics/coronavirus-and-pollution/ See also: Cole, M., et al., *Air Pollution Exposure and COVID-19* (2020) available at: http://ftp.iza.org/dp13367.pdf; Liang, D., et al. *Urban Air Pollution May Enhance COVID-19 Case-Fatality and Mortality Rates in the United States* (2020) available at: https:// doi.org/10.1101/2020.05.04.20090746; Tian, H., et al. (2020). *Risk of COVID-19 is associated with long-term exposure to air pollution* (2020) available at: https://doi.org/10.1101/2020.04.21.20073700 ;

2. Air pollution

2.1 Pollutants and pollution sources

Industrial processes emit a broad range of pollutants that can impact health. It is generally accepted that there are five key pollutants released or formed in the atmosphere from numerous and diverse stationary and mobile sources that cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare. These pollutants are fine particle pollution ($PM_{2.5}$), coarse particle pollution (PM_{10}), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), and ozone (O_3). These pollutants also represent the majority of air pollutants for which standards are set in the *National Environment Protection (Ambient Air Quality) Measure*.[12] The health impacts of these pollutants are outlined below in section 2.5.

Particle pollution consists of tiny solid particles that come in a range of sizes, measured in micrometres. Coarse particle pollution is usually referred to as PM_{10} (that is, particle size of 10 micrometres in diameter), which generally forms as dust (such as coal dust) and is inhalable into the lungs. Fine particle pollution, known as $PM_{2.5}$, is much smaller, at 2.5 micrometres in diameter. Its small size means it can get deeper into the lungs and into the bloodstream, causing a deadly range of health impacts (see section 2.5 below).

NO_x and SO_2 are gases that are formed during the process of combustion. In addition to being toxic of their own accord, both SO_2 and NO_x form secondary fine particle pollution,[13] creating additional huge quantities of deadly fine particle pollution. In addition to improving reduction of fine particle emissions from industrial sources, strict control measures to drive down SO_2 and NO_x emissions must be installed to reduce the creation of secondary fine particle pollution. Nitrogen dioxide (NO_2) is the main oxide of nitrogen pollutant of concern.

Normally, ozone is not directly emitted by a source; it is formed at ground level when NO_x reacts with other chemicals in the air, including volatile organic compounds. (See more on ozone in section 6 below.)

Mercury (Hg) is well-known for its toxicity and, while not emitted by a broad range of sources, is nonetheless a pollutant of concern. Although mercury is released in much lower levels than PM, SO_2, NO_x and ozone, it is highly toxic and accumulates in both the environment and the body. Any release of mercury is significant. Specific highly toxic substances such as volatile organic compounds (VOC) are also a concern, both on their own and in the formation of ozone.

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[12] Carbon monoxide (CO) and lead (Pb) have also been listed as criteria pollutants. Improvements in mobile source fuels and technologies have significantly reduced the risk posed by these pollutants.

[13] Ewald, Ben., *The Health burden of fine particle pollution from electricity generation in NSW* (November 2018) p. 20. Available at: https://www.envirojustice.org.au/wp-content/uploads/2018/11/Ewald_B_2018_The_health_burden_of_fine_particle_pollution_from_electricity_generation_in_NSW.pdf.

2.2 Monitoring and access to information

Air quality monitoring must be improved to effectively measure the health risk for at-risk communities.

According to the Victorian Auditor General's Office (VAGO) audit of Environment Protection Authority (EPA) air monitoring obligations, the EPA does not currently produce a reliable or representative measure of ambient air quality across the state, hasn't implemented the requisite monitoring required under the NEPM, and does not collect information on air quality for most of the state despite being required to do so under air pollution law.[14]

According to power station contractors who conducted air modelling for Latrobe Valley during the 2018 power station licence review, NEPM standards for SO_2, PM_{10} and $PM_{2.5}$ are routinely breached and/or routinely reaching the standard in Latrobe Valley.[15] Yet, where exceedances are captured by industry-run monitors, nothing is done to reduce poor air quality by EPA.[16]

There is very little air pollution monitoring undertaken at roadsides in Melbourne, where traffic is heavy and causes poor air quality in front of schools, kindergartens, residential facilities, aged-care facilities and hospitals. Nor does Victoria's air quality monitoring network adequately capture air pollution data from wood-burning heaters, which are located in urban and residential environments and pose a health risk to the surrounding communities.

In addition to poor monitoring, there is poor access to information about air pollution in Victoria. The Office of Environment and Heritage in NSW provides real-time air pollution information from its monitors, including the Upper Hunter Air Quality Monitoring Network including a mechanism to download air pollution datasets with parameters chosen by the user (e.g. time, pollutant/s, monitoring station). Under their pollution licences, power stations in NSW are required to upload monitoring information on a monthly basis onto their websites. Victoria has no such thing. The EPA AirWatch displays air quality information on a 48-hour rolling average,[17] and hourly average,[18] but the data cannot be downloaded and the user cannot see information outside the 1-hour or 48-hour period. There is an historical hourly air quality table maintained by EPA which the user can scroll through hour by hour, but again none of the data is downloadable.[19] No industry in Victoria, including

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[14] See: https://www.audit.vic.gov.au/report/improving-victorias-air-quality?section=.

[15] Grey, Andrew, *Review of GHD's Modelling Assessment and Analysis of the Coal-Fired Power Stations in the Latrobe Valley* (September 2018). Available at: https://www.envirojustice.org.au/wp-content/uploads/2018/09/2018-09-18-Gray-expert-report.pdf

[16] Grey, Andrew, *Review of GHD's Modelling Assessment and Analysis of the Coal-Fired Power Stations in the Latrobe Valley* (September 2018). Available at: https://www.envirojustice.org.au/wp-content/uploads/2018/09/2018-09-18-Gray-expert-report.pdf

[17] https://www.epa.vic.gov.au/for-community/airwatch.

[18] https://www.epa.vic.gov.au/for-community/airwatch/airwatch-table-data-page#tab-standard-monitoring-sites-2.

[19] See: https://ref.epa.vic.gov.au/our-work/monitoring-the-environment/epa-airwatch/historic-air-quality-data-table.

coal-fired power stations, is legally obliged to make its stack emissions monitoring data publicly available. Access to stack emissions monitoring data is subject to a Freedom of Information request which is a lengthy and cumbersome process, subject to review, and often results in important pollution information being redacted on the basis that it is "commercially sensitive".

Action: By September 2021, develop an air quality monitoring plan that increases the level of, and access to, air quality monitoring and information, including by:

- Installing and/or increasing permanent air quality monitoring stations in every community that is near a major industrial source of pollution, such as coal-fired power stations.
- Implementing localised monitoring networks in areas with large traffic flow and with high wood-burning heater usage, including the use of low-cost monitors.
- Ensuring access to monitoring data be made available in real-time, on a single website maintained by the EPA.
- Ensuring both current and historical data be made available in downloadable datasets to coincide with the implementation of the Environment Protection Act 2018.
- Funding and implementing an *AirSmart* health promotion campaign to minimise the health impacts of poor air quality.[20]

2.3 Victoria's main sources of air pollution

According to the EPA's *Air pollution in Victoria – a summary of the state of knowledge*, the main sources of air pollution in Victoria are motor-vehicles, power generating industries, and smoke from bushfires, planned burns and wood heaters.[21]

Victoria does not have an air pollutant inventory. This section uses publicly available information from the industry self-reported National Pollutant Inventory (NPI) to identify the largest sources of PM, SO_2, NO_x, Ozone and mercury in Victoria. The NPI does not require that non-industrial emission sources be reported, however diffuse sources of air pollution including from vehicles and wood-burning heaters are prepared by the Victorian EPA and submitted to the NPI.Section 2.2 above outlines the inadequacies of air pollution monitoring in Victoria, including in urban areas with heavy vehicle traffic and where wood-burning heaters are prevalent.

According to the most recent NPI, electricity generation from coal is the largest source of $PM_{2.5}$, PM_{10}, SO_2 and Hg in Victoria, by significant amounts compared with the next largest sources. Moreover,

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[20] See: Asthma Australia, 'Now is the time to get AirSmart Australia', 1 September 2020: https://asthma.org.au/about-us/media/now-is-the-time-to-get-airsmart-australia/

[21] EPA Victoria, *Air pollution in Victoria – a summary of the state of knowledge* (March 2018) p. 18. Available at: www.epa.vic.gov.au/about-epa/publications/1709.

since both SO_2 and NO_x form secondary $PM_{2.5}$ pollution, electricity generation is an even bigger source of $PM_{2.5}$.

Table 1: Top three sources of key pollutants in Victoria from 2018/19 NPI reporting period[22]

PM_{10}	$PM_{2.5}$	NO_x	SO_2	Mercury
Electricity generation (includes coal mining) – 9,400,000kg	Electricity generation (includes coal mining) – 2,200,000kg	Motor vehicles – 100,000,000kg	Electricity generation (includes coal mining) – 85,000,000kg	Electricity generation (includes coal mining) – 1000kg
Motor vehicles – 3,500,000kg	Oil and gas extraction – 170,000kg[23]	Coal-fired power stations – 50,000,000kg	Fuel combustion (sub reporting threshold facilities) – 40,000,000kg	Windblown dust – 50kg
Windblown dust – 3,400,000kg	Petroleum and coal product manufacturing – 140,000kg	Fuel combustion (sub reporting threshold facilities) – 11,000,000 kg	Basic non-ferrous metal manufacturing – 6,500,000kg	Fuel combustion / solid fuel burning (domestic) – 27kg

Source: NPI data 2018/19 report.

Action: The Victorian EPA will complete and publicly release the Victorian air pollution inventory by September 2021, and will update it at least every 3 years.

Action: By September 2021, coal mine and coal-fired power station pollution will be reported separately in the NPI.

2.4 Where does the pollution go?

In the most recent assessment of air pollution from coal-fired power stations *Lethal Power: How Burning Coal is Killing People in Australia*,[24] international air quality modelling experts conducted

[22] Victoria does not have an up-to-date air pollution inventory (an assessment of the extent of air pollution and sources), so data from the NPI, which is self-reported by industry based on calculated estimates of their pollution, must be used to identify the largest sources of PM, SO_2, NO_x and mercury. According to the most recent NPI report from 2018/19, the largest source of $PM_{2.5}$ in Victoria, by a factor of 13, are coal-fired power stations. The largest source of PM_{10} is electricity generation, which includes coal mining. In Victoria PM_{10} emissions from coal mines and power stations are combined in reporting data.

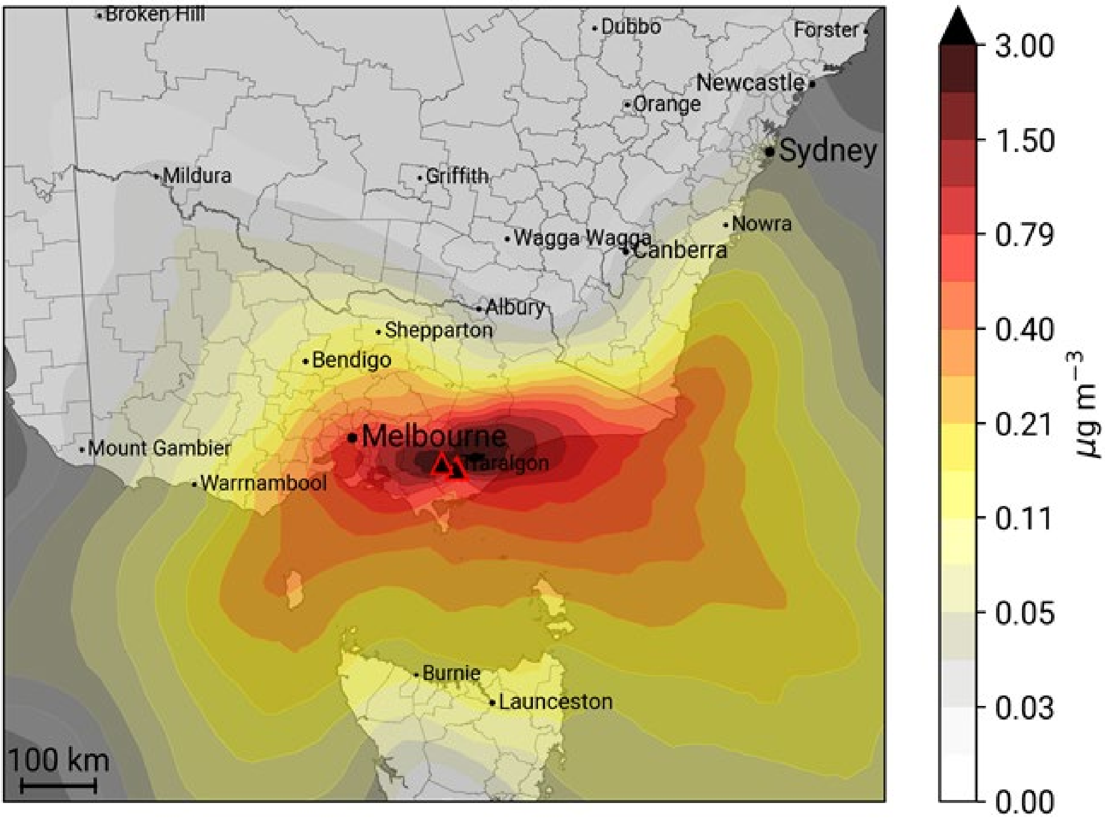
[23] Motor vehicles (especially diesel-powered motor vehicles) are generally considered to be a more significant source of $PM_{2.5}$ than oil & gas extraction, but the NPI does not include non-industrial diffuse mobile source $PM_{2.5}$. This means that domestic solid fuel burning, another significant source of $PM_{2.5}$ air pollution, is also not reported under the NPI.

[24] Dr. Aidan Farrow, Andreas Anhäuser and Lauri Myllyvirta, Lethal Power: How Burning Coal is Killing People In Australia (August 2020), available at: https://www.greenpeace.org.au/wp/wp-content/uploads/2020/08/GPAP-Lethal-Power-full-report.pdf.

industry-standard air modelling. This modelling showed that air pollution from coal-fired power stations travels far beyond a power station's location. Communities near the power station may be exposed to the highest concentrations of air pollution under certain weather conditions,[25] but transport of $PM_{2.5}$ can extend for hundreds of kilometres and affect large populations in cities.[26]

Lethal Power shows that, depending on wind direction and speed, $PM_{2.5}$ from Victoria's coal-fired power stations travels considerable distances, reducing air quality in Melbourne and as far west as Warrnambool, and as far south as Burnie in Tasmania.[27] The highest concentrations of NO_2 from coal-fired power stations is in the airshed where the power stations is located. Not only does the pollution travel far, it is most concentrated at the source, disproportionally exposing people in nearby communities.

Figure 1: Annual mean near-surface PM2.5 concentration increases due to emissions from coal-fired power stations in Victoria



Source: ***Lethal Power: How Burning Coal is Killing People in Australia***

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[25] Dr. Aidan Farrow, Andreas Anhäuser and Lauri Myllyvirta, Lethal Power: How Burning Coal is Killing People In Australia (August 2020), p. 5., available at: https://www.greenpeace.org.au/wp/wp-content/uploads/2020/08/GPAP-Lethal-Power-full-report.pdf.

[26] Dr. Aidan Farrow, Andreas Anhäuser and Lauri Myllyvirta, Lethal Power: How Burning Coal is Killing People In Australia (August 2020), p. 5., available at: https://www.greenpeace.org.au/wp/wp-content/uploads/2020/08/GPAP-Lethal-Power-full-report.pdf.

[27] Dr. Aidan Farrow, Andreas Anhäuser and Lauri Myllyvirta, Lethal Power: How Burning Coal is Killing People In Australia (August 2020), pp. 18-19., available at: https://www.greenpeace.org.au/wp/wp-content/uploads/2020/08/GPAP-Lethal-Power-full-report.pdf.

Air pollution from vehicles and wood heaters is largely localised. The heavier the traffic, the more air pollution is emitted. The most heavily impacted communities are often close to major ports and impacted by diesel-fuelled heavy vehicle movements. The City of Maribyrnong, which includes the suburbs of Footscray, Seddon, Yarraville and Kingsville, is directly impacted by the transport operations of the Port of Melbourne. Smoke from wood-burning heaters can sit in places such as the Yarra Valley for days in still weather, contributing to very poor air quality. The pervasive and widespread nature of pollution from coal-fired power stations means that even if localised sources of pollution like wood-burning and diesel trucks are reduced to zero, background concentrations of pollution will still pervade.

2.5 Health impacts of air pollution at existing concentrations

The International Agency for Research on Cancer classifies air pollution as a human carcinogen.[28] A 2019 global review of evidence found that air pollution can damage every organ and every cell in the human body.[29] In 2018, the director general of the World Health Organisation (WHO) declared air pollution a "public health emergency".[30] Children and older people are most vulnerable to the health impacts of air pollution.

The most dangerous form of air pollution is $PM_{2.5}$. There is abundant evidence that $PM_{2.5}$ exposure can cause adverse health effects and increased risk of death.[31] There is no lower threshold for these effects.[32] The science does not support that there is a safe level of exposure, so air quality standards are a reference level, not a safe level.[33] Long term exposure is particularly damaging, even at lower

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[28] World Health Organization (WHO) 2013, *Media Release No. 221, IARC: Outdoor air pollution a leading environmental cause of cancer deaths,* International Agency for Research on Cancer, World Health Organization, Lyon, France: www.iarc.fr/wp-content/uploads/2018/07/pr221_E.pdf

[29] Dean E. Schraufnagel, et al., Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 1: The Damaging Effects of Air Pollution, February 2019, Volume 155, Issue 2, Pages 409–416, Available at: https://doi.org/10.1016/j.chest.2018.10.042; Dean E. Schraufnagel, et al., (2019) Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 2: Air Pollution and Organ Systems, *CHEST Journal,* February 2019, Volume 155, Issue 2, Pages 417–426. Available at: https://doi.org/10.1016/j.chest.2018.10.041

[30] Dr Tedros Adhanom Ghebreyesus, "Air pollution is the new tobacco. Time to tackle this epidemic" *The Guardian*, October 27 2018. Available at: https://www.theguardian.com/commentisfree/2018/oct/27/air-pollution-is-the-new-tobacco-time-to-tackle-this-epidemic

[31] Dockery, Douglas W., et al., (1993) An Association between Air Pollution and Mortality in Six U.S. Cities, *New England Journal of Medicine*, 329(24): 1753-1759. https://www.nejm.org/doi/full/10.1056/NEJM199312093292401; Krewski D., et al., (2005) Reanalysis of the Harvard Six Cities Study, part I: validation and replication. *Inhalation Toxicology* 2005 Jun-Jul;17(7-8):335-42. Available at: https://doi.org/10.1080/08958370590929402U.

[32] Dockery, Douglas W., et al., (1993) An Association between Air Pollution and Mortality in Six U.S. Cities, *New England Journal of Medicine*, 329(24): 1753-1759. Available at: https://www.nejm.org/doi/full/10.1056/NEJM199312093292401; Krewski D., et al., (2005) Reanalysis of the Harvard Six Cities Study, part I: validation and replication. *Inhalation Toxicology* 2005 Jun-Jul;17(7-8):335-42. Available at: https://doi.org/10.1080/08958370590929402U.

[33] World Health Organization. Regional Office for Europe. (2006). Air quality guidelines global update 2005: particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Copenhagen: WHO Regional Office for Europe. Available at: https://apps.who.int/iris/handle/10665/107823.

levels of pollution. A recent study from Queensland found that long-term exposure to $PM_{2.5}$ was associated with increased all-cause mortality of two percent for each 1 $\mu g/m^3$ increase in annual $PM_{2.5}$, even where $PM_{2.5}$ levels were measured well-below air quality standards.[34]

Research led by the University of Sydney has found up to a four percent increased risk of out-of-hospital cardiac arrest (OHCA) associated with every 10 $\mu g/m^3$ increase in $PM_{2.5}$.[35] OHCA is a major medical emergency, with less than one in 10 people worldwide surviving these events.[36] Similarly, in Tasmania, where air pollution is mainly associated with wood-burning heaters, a 10 $\mu g/m^3$ increase in daily $PM_{2.5}$ was associated with a 29 percent increase in hospital admissions for heart failure on the following day.[37]

In 2019, the Harvard Chan School of Public Health published an analysis of more than 95 million Medicare hospital insurance claims for adults aged 65 or older in the United States from 2000 to 2012.[38] The researchers found that each 1 $\mu g/m^3$ increase in $PM_{2.5}$ was associated with 2,050 extra hospital admissions, 12,216 days in hospital, and USD$31m in healthcare costs for diseases not previously associated with $PM_{2.5}$ including sepsis, kidney failure, and urinary tract and skin infections. These associations remained even at daily $PM_{2.5}$ concentrations below the WHO guideline. As such, the researchers concluded that substantial health and economic costs were linked to small $PM_{2.5}$ short-term increases.

Children are particularly vulnerable to $PM_{2.5}$ exposure due to the adverse effects on lung development. Australia's most common cause of general practitioner presentation in children under five is asthma and allergy. A 2015 Australian meta-analysis discovered that for every 2 $\mu g/m^3$ incremental increase in chronic exposure to traffic-related particulate matter, the risk of developing subsequent asthma in childhood increased by 14 percent.[39] Reduced lung health and impaired

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[34] Yu W, Guo Y, Shi L, Li S (2020) The association between long-term exposure to low-level $PM_{2.5}$ and mortality in the state of Queensland, Australia: A modelling study with the difference-in-differences approach. PLoS Med 17(6): e1003141. https://doi.org/10.1371/journal.pmed.1003141

[35] Bing Zhao, et al.,. (2020) Short-term exposure to ambient fine particulate matter and out-of-hospital cardiac arrest: a nationwide case-crossover study in Japan. *The Lancet Planetary Health*, 4(1): 15-23. Available at: https://doi.org/10.1016/S2542-5196(19)30262-1

[36] University of Sydney. "Air pollution impacts can be heart-stopping: Biggest study of dangerously small particulate matter and cardiac arrest." *ScienceDaily*, 28 January 2020. Available at: https://www.sciencedaily.com/releases/2020/01/200128115421.htm

[37] Huynh QL, Blizzard CL, Marwick TH*, et al* Association of ambient particulate matter with heart failure incidence and all-cause readmissions in Tasmania: an observational study *BMJ Open* 2018;**8:**e021798. doi: 10.1136/bmjopen-2018-021798

[38] Wei Yaguang, et al. (2019) Short term exposure to fine particulate matter and hospital admission risks and costs in the Medicare population: time stratified, case crossover study *BMJ* 2019; 367:l6258. Available at: https://doi.org/10.1136/bmj.l6258

[39] Bowatte G, Lodge C, Lowe A, Erbas B, Perret J, Abramson M, et al. The influence of childhood traffic-related air pollution exposure on asthma, allergy and sensitization: A systematic review and a meta-analysis of birth cohort studies. *Allergy*. 2015; 70(3):245-56.

development in children holds lifelong consequences, including an increased risk of cardiovascular disease and associated mortality as an adult.[40]

$PM_{2.5}$ is not the only pollutant that adversely impacts health. At low concentrations, NO_2, SO_2 and O_3 can cause significant health problems. A number of Australian studies published in the last decade demonstrate statistically significant health impacts at pollutant concentrations well-below national standards for these pollutants.[41] Nitrogen dioxide is strongly associated with childhood asthma and impaired lung development, which can lead to lifelong adverse health effects and premature death.[42] Adverse neonatal outcomes, including preterm birth, low weight at birth and foetal growth restriction are associated with maternal exposures to NO_2, SO_2 and O_3.[43] Laboratory confirmed paediatric influenza has also been associated with ozone.[44] Middle-aged Australians exposed to nitrogen dioxide can experience exacerbations of current asthma, the incidence of new asthma, and atopy.[45] Long term exposure to SO_2, even at low concentrations, has been associated with cardiorespiratory mortality.[46] Developing but as-yet-unconfirmed evidence suggests a large effect from traffic-related air pollution damaging children's brain growth.[47] If confirmed, this would be the largest and most economically harmful health impact of current air pollution exposure.

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[40] Ryan G, Knuiman MW, Divitini ML, James A, Musk AW, Bartholomew HC. Decline in lung function and mortality: The Busselton Health Study. *Journal of Epidemiology and Community Health*. 1999;53(4):230-4; Georgiopoulou VV, Kalogeropoulos AP, Psaty BM, Rodondi N, Bauer DC, Butler AB, et al. Lung function and risk for heart failure among older adults: the Health ABC Study. *American Journal of Medicine*. 2011;124(4):334-41; Sin DD, Wu L, Man SF. The relationship between reduced lung function and cardiovascular mortality: A population-based study and a systematic review of the literature. *Chest*. 2005;127(6):1952-9.

[41] See Clare Walter, Maxwell Smith et al. (2019) Health-based standards for Australian regulated thresholds of nitrogen dioxide, sulfur dioxide and ozone: Expert Position Statement 2019: https://www.envirojustice.org.au/wp-content/uploads/2019/11/Expert-Position-Statement-PDF.pdf, pp.6-7.

[42] Knibbs, Cortés de Waterman, Toelle, Guo, Denison, Jalaludin, Williams. (2018). The Australian Child Health and Air Pollution Study (ACHAPS): A national population based cross-sectional study of long-term exposure to outdoor air pollution, asthma, and lung function. Environment International, 120, 394-403; Bowatte, G., Lodge, C., Knibbs, L., Erbas, B., Perret, J., Jalaludin, B., Dharmage, S. (2018). Traffic related air pollution and development and persistence of asthma and low lung function. Environment International, 113, 170-176; Gauderman WJ, Urman R, Avol E, et al. (2015). 'Association of improved air quality with lung development in children'. NEJM 2015;372;10:905-913.

[43] Chen, Guo, Abramson, Williams, & Li. (2018). Exposure to low concentrations of air pollutants and adverse birth outcomes in Brisbane, Australia, 2003–2013. Science of the Total Environment, 622-623, 721-726; Li, S., Guo, Y., & Williams, G. (2016). Acute Impact of Hourly Ambient Air Pollution on Preterm Birth. Environmental Health Perspectives, 124(10), 1623-1629; Pereira, G. et al., Locally derived traffic-related air pollution and fetal growth restriction: a retrospective cohort study. Occupational and environmental medicine 2012, 69 (11), 815-822.

[44] Xu, Z. W. et al., Air pollution, temperature and paediatric influenza in Brisbane, Australia. Environment international 2013, 59, 384-388.

[45] Bowatte, G., et al., (2018). Traffic related air pollution and development and persistence of asthma and low lung function. Environment International, 113, 170-176; Bowatte, Lodge, Knibbs, Lowe, Erbas, Dennekamp, Dharmage. (2017). Traffic related air pollution exposure is associated with allergic sensitization, asthma, and poor lung function in middle age. The Journal of Allergy and Clinical Immunology, 139(1), 122-129.e1.

[46] Wang, X., Hu, W., & Tong, S. (2009). Long-term exposure to gaseous air pollutants and cardio-respiratory mortality in Brisbane, Australia. Geospatial Health, 3(2), 257-263.

[47] Sunyer J, Esnaola M, Alvarez-Pedrerol M, Forns J, Rivas I, López-Vicente M, et al. (2015) Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study. PLoS Med 12(3): e1001792. https://doi.org/10.1371/journal.pmed.1001792

3. Controlling pollution from coal-fired power stations

Coal-fired power stations are the most significant controllable source of air pollution in Victoria which can be significantly reduced with best practice control standards.

This section outlines the best available technologies for pollution control and timeframe for installing those controls to protect human and environmental health. We have included NSW coal-fired power stations in this section to demonstrate that coordinated control of air pollution from coal-fired power stations in both states is possible.

3.1 Regulating emissions from coal-fired power stations

Australia's risk-based approach to air pollution regulation falls well short when compared with international counterparts.[48] For several decades the US, EU, South Korea, China, Japan and other nations have required increasingly effective controls for PM, NO_x, SO_2, and mercury.

Emissions from coal-fired power stations must be set at limits that require the installation of best available pollution control technologies (BACT) described below. Pollution licences must impose a range of obligations that, among other things, require pollution controls and power station infrastructure to be regularly maintained to ensure that operations are run as cleanly as possible. Because much of the $PM_{2.5}$ from combustion of coal is formed by subsequent reaction of SO_2 and NO_x in the atmosphere, BACT levels of SO_2 and NO_x pollution controls must be required to properly protect the public from adverse $PM_{2.5}$ health impacts.

Table 2: Emission levels that can be achieved with installation of BACT for existing coal-fired power stations[49]

	Annual Average (mg/m^3)	Short term (daily or reference test) (mg/m^3)
PM[50]	2-8	3-11
SO_2 & SO_3	10-130	25-165
NO_x (coal)	65-150	<85-165
NO_x (lignite)	<85-150	140-165
Hg (coal)	<1-4 ug/m^3	<1-4 ug/m^3
Hg (lignite)	<1-7 ug/m^3	<1-7 ug/m^3

[48] Although the Victorian regulatory frameworks require advances in pollution reduction to be made, this is not done.
[49] See: Commission Implementing Decision (EU) 2017/1442 of July 2017, establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants. *"BAT Associated Emission Levels*, *Section 2 "BAT Conclusions for the Combustion of Solid Fuels"*: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1503383091262&uri=CELEX%3A32017D1442
[50] The EU Directive assigns slightly less stringent limits (2-10 mg/m^3; 3-11mg/m^3) to plants with a heat input of less than 1000 MW of thermal input (approximately 280-320 MW electric output).

Emissions limits in other countries for existing power stations retrofitted with BACT are in Table 3 below.

Table 3: Representative emission limits for existing coal-fired power stations in other jurisdictions

	SO_2 (mg/m³)	NO_x (mg/m³)	PM (mg/m³)	Hg (ug/m³)
China[51]	35	50	10	30
Japan[52]	68.3	57.5	14.3	10
South Korea[53]	142.5.	102.5	10	50
EU[54]	130	150	8	2.0/4.0[55]
U.S.[56]	640	640	23	1.7/15.3[57]

Compare these limits to the current limits for coal-fired power stations in Victoria in Table 4 below.

Table 4: Emission limits for existing coal-fired power stations in Victoria

	SO_2 (mg/m³)	NO_x (mg/m³)	PM (mg/m³)	Hg (ug/m³)
Loy Yang A[58]	2370	677	258	No limit
Loy Yang B[59]	2692	678	149	No limit
Yallourn[60]	820	407	190	No limit

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[51] 火电厂大气污染物排放标准/Emission standard of air pollutants for thermal power plants (GB 13223-2011). Partial English translation: https://english.mee.gov.cn/Resources/standards/Air_Environment/Emission_standard1/201201/W020110923324406748154.pdf, Full English translation available at: https://www.codeofchina.com/search/default.html?page=1&keyword=GB13223-2011
See also: http://www.mep.gov.cn/gkml/hbb/bwj/201512/W020151215366215476108.pdf
[52] Compilation of actual emissions values - 90th percentile shown: http://pubs.acs.org/doi/abs/10.1021/acs.est.6b03731
[53] See Air Environment Conservation Act Enforcement Regulations: http://www.law.go.kr/%EB%B2%95%EB%A0%B9/%EB%8C%80%EA%B8%B0%ED%99%98%EA%B2%BD%EB%B3%B4%EC%A0%84%EB%B2%95%20%EC%8B%9C%ED%96%89%EA%B7%9C%EC%B9%99
[54] COMMISSION IMPLEMENTING DECISION establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants. 28 Apr 2017. http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.documentdetail&Dos_ID=14177&DS_ID=50159&Version=1. See also: Industrial Emissions Directive, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0075
[55] Higher limit is for lignite plants.
[56] See: http://www.gpo.gov/fdsys/pkg/FR-2012-02-16/pdf/2012-806.pdf; http://www.gpo.gov/fdsys/pkg/FR-2013-04-24/pdf/2013-07859.pdf; http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr60_main_02.tpl
[57] Higher limit is for lignite plants.
[58] See licence 11149 at: https://www.epa.vic.gov.au/for-business/find-a-topic/licences-works-approvals/search-for-licence
[59] See licence 3987 at: https://www.epa.vic.gov.au/for-business/find-a-topic/licences-works-approvals/search-for-licence
[60] See licence 10961 at: https://www.epa.vic.gov.au/for-business/find-a-topic/licences-works-approvals/search-for-licence

If Australian power stations were fitted with the BACTs that are widely used in other countries the emissions limits set out in Table 5 below could be achieved.

Table 5: Proposed BACT retrofit emission limits for coal-fired power stations in Australia

	Nominal Emission Limits (Subject to Revision based on individual power station operating data)	
	Annual Average (mg/m³)	Short term (daily or reference test) (mg/m³)
PMf[61]	5	8[62]
PMf+c	*NA*	40[63]
SO2 & SO3	70	100
NOx (coal)	100	120
NOx (lignite)	50	60
Hg (coal)	0.002	0.002
Hg (lignite)	0.004	0.004

NB: PMf refers to filterable fine particle pollution. PMf+c refers to filterable and condensable fine particle pollution.

Action: By September 2021, establish a comprehensive plan that sets out specific and enforceable obligations for coal-fired power station operators to achieve BACT emissions levels, including the following elements:

- BACT short and medium-term emissions limits for PM_{10}, $PM_{2.5}$, SO_2, NO_x, and Hg.
- Continuous emission monitoring (CEMS) for CO_2, $PM_{2.5}$, SO_2, NO_x, and Hg, to be installed, maintained and operated, with real-time posting on a publicly available website.
- A requirement that CEMS be maintained and operated in accordance with international best practices, including annual relative accuracy test audits and quarterly relative accuracy audits.[64]

[61] Based on emissions data reported by the operator for Vales Point Plant: https://www.de.com.au/environment/environmental-licences-and-monitoring
[62] Ibid. See also: COMMISSION IMPLEMENTING DECISION establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for large combustion plants. 28 Apr 2017. http://ec.europa.eu/transparency/regcomitology/index.cfm?do=search.documentdetail&Dos_ID=14177&DS_ID=50159&Version=1
[63] Based on ratio of condensable to filterable emissions; USEPA data in MATS proceeding. Docket Number EPA-HQ-OAR-2009-0234-3038 *"Coal PM Floor Analysis".* Available at: https://www.regulations.gov/document?D=EPA-HQ-OAR-2009-0234-3038
[64] For example, the procedures required to be followed for CEMS in the US appear in 40. CFR part 60, Appendix F. i.e., https://www.law.cornell.edu/cfr/text/40/appendix-F_to_part_60

- Use of the U.S. National Institute of Standards and Technology (NIST) “non-nulling” or the equivalent reference method to measure stack flow rate of stack gases.[65]
- A maintenance plan, with specified replacement of parts at intervals based conservatively on prior maintenance history and on-site storage of critical components affecting emissions (such as filter bags, SO_2 and NO_x reagents).
- An immediate reduction in generation to the lowest level necessary to maintain grid stability and initiation of shutdown procedures for any malfunction that cannot be resolved within a specified period of time.
- The use of the cleanest available fuels during any period where a pollution control is not operational (e.g., before the unit reaches the operating temperature needed by its selective catalytic reduction (SCR)).
- Immediate reporting of any upset conditions to the agency and the public. The agency should thereafter investigate and post the results of its review.
- Shutdown of the unit if monitoring device availability falls below acceptable levels.

3.2 Suggested installation schedule for coal-fired power stations in Victoria and NSW

Installing pollution controls in existing coal-fired power stations requires planning, both for power stations to prepare, contract, construct and test controls, and to ensure there is adequate electricity supply. This will require cooperation and scheduling between the operators and the Australian Energy Market Operator (AEMO).

In order to ensure adequate electricity supply during the “tie-in” period, that is, the time that it takes to bring pollution controls into the combustion process, specific retrofit dates should stagger installation of controls in the National Electricity Market (NEM). The schedule for taking units offline for installation and tie-in provides that this should happen in spring and autumn seasons when demand for electricity is lowest and there is (ordinarily) excess capacity in the NEM. The schedule limits installations to no more than one unit at any power station at any time and phases in the installation of those controls over several years.

There are several alternative approaches to scheduling the installation of pollution controls in Victoria and NSW. One option is to require each operator to control a set percentage of its generating capacity (nominally 25 percent) each year commencing three years after the date of regulatory or legislative changes to emissions limits. Another option is to set retrofit dates for specific plants, based on advice from AEMO, and policy preferences expressed in legislation or regulation. Among the policy choices is the issue of whether it is better to require control on the oldest or newest units. The schedule for installation below assumes that the newer units are chosen first. This is because newer units require lower maintenance, have less unplanned outages, and lower fuel costs. As such, newer units can be expected to run more and be

[65] A.N. Johnson, I.I. Shinder, B.J. Filla, J.T. Boyd, R. Bryant, M.R. Moldover, T.D. Martz & M.R. Gentry (2020) Faster, more accurate, stack-flow measurements, Journal of the Air & Waste Management Association, 70:3, 283-291: 10.1080/10962247.2020.1713249

dispatched more often, making the installation of pollution controls more effective in delivering the greatest pollution reduction.

Table 6: Suggested schedule for installation of pollution controls

State	Power Station	Coal type	Start of Operations	Capacity	Retrofit dates
NSW	Eraring	Black	1982-1984	4 x 720 MW	Spring 2024; Autumn 2025; Spring 2025; Autumn 2026
NSW	Bayswater	Black	1982-1984	4 x 660 MW	Spring 2025; Autumn 2026; Spring 2026; Autumn 2027
NSW	Liddell	Black	1971-1973	4 x 500 MW	N/A – retiring 2022
NSW	Mt Piper	Black	1993	2 x 700 MW	Spring 2024; Autumn 2025
NSW	Vales Point B	Black	1978	2 x 660MW	Spring 2026; Autumn 2027
VIC	Loy Yang A	Brown	1984-1987	3 x 560 MW 1 x 530 MW	Autumn 2025; Spring 2025; Autumn 2026; Spring 2026
VIC	Loy Yang B	Brown	1993-96	2 x 535 MW	Spring 2024; Autumn 2025
VIC	Yallourn W	Brown	1975-1982	2 x 375 MW 2 x 350 MW	Spring 2025; Autumn 2026; Spring 2026; Autumn 2027

4. Controlling pollution from vehicle emissions

Vehicle emissions contribute up to 80 percent of NO_x emissions in urban areas of Australia.[66] In the Melbourne metropolitan region alone, vehicle pollution contributes up to 70 percent of total urban air pollution.[67] Modern vehicles are much cleaner than older vehicles, but there is no systematic mechanism to remove highly polluting vehicles from the road fleet. This is a problem for people living, working or travelling on busy roads, which is potentially amplified by the growing number of road projects and tunnels.

Australia has the lowest rank out of the 35 OECD countries for fuel quality.[68] Diesel vehicles emit much higher amounts of NO_x than petrol vehicles. Many OECD countries and cities are phasing out diesel vehicles

[66] Australian Government Department of the Environment and Energy. Nitrogen Dioxide Air Quality fact sheet (2005). http://www.environment.gov.au/protection/ publications/factsheet-nitrogen-dioxide-no2. Accessed 15th June, 2019.
[67] Victorian Auditor-General's Office, *Managing the Environmental Impacts of* Transport (August 2014) P. 6. Available at: https://www.audit.vic.gov.au/report/managing-environmental-impacts-transport.
[68] Schofield, R., Walter ,C., Silver ,J., Brear ,M., Rayner ,P., Bush, M (2017), 'Submission on the "Better fuel for cleaner air" discussion paper'. Melbourne: Clean Air and Urban Landscapes Hub/Melbourne Energy Institute.

due to the health impacts associated with diesel emissions.[69] Rather than acting in a manner consistent with its OECD counterparts, Australia is increasing the amount of diesel vehicles on its roads.[70] California and other US state regulators now recognise diesel particulate matter (DPM) as a special class of particulates. More than 90 percent of fine particle pollution from diesel combustion is less than 1 micrometre in diameter, a subset of $PM_{2.5}$ that is considered even more toxic. In 2012, the WHO's International Agency for Research on Cancer (IARC) released its research assessing the health impacts of air pollution from diesel.[71] IARC's extensive literature review led to the conclusion that diesel engine exhaust is "carcinogenic to humans".[72]

In order to reduce air pollution from vehicle emissions, governments in Britain and the European Union created "Clean Air Zones", or "Low Emission Zones".[73] These Zones are established in densely populated areas, particularly near vulnerable community locations such as schools and childcare centres. Clean Air Zones implement a "polluter pays" principle by imposing a fee on polluting vehicle operators who drive within or through the Zone. The fee can be initially targeted at diesel freight trucks and be increased progressively to include other forms of vehicles. Between February 2017 and February 2020, there has been a 39 micrograms per cubic metre reduction in roadside concentrations of nitrogen dioxide in London's Ultra Low Emissions Zone (ULEZ), a reduction of 44 percent.[74] The London ULEZ scheme contains fee exemptions for residents, vehicle operators with a disability, taxis, and other not-for-profit community uses such as school transport to ensure that it is an equitable policy that does not adversely affect the everyday people whose health the scheme is designed to protect.[75]

Idling – running a vehicle's engine while it is stationary – can also lead to poor local air quality with serious health risks, particularly for vulnerable populations. In the United States, idling has been identified as a significant factor in higher pollution levels in and around schools.[76] More than 23 US

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[69] Garfield L. (2017) 13 cities that are starting to ban cars. Business Insider Australia. Available at: https://www.businessinsider.com.au/cities-going-car-free-ban-2017-8?r=US&IR=T.

[70] Cames, M. & Helmers, E. Environ Sci Eur (2013) 25: 15. https://doi.org/10.1186/2190-4715-25-159.

[71] Debra T. Silverman, Claudine M. Samanic, Jay H. Lubin, Aaron E. Blair, Patricia A. Stewart, Roel Vermeulen, Joseph B. Coble, Nathaniel Rothman, Patricia L. Schleiff, William D. Travis, Regina G. Ziegler, Sholom Wacholder, Michael D. Attfield, The Diesel Exhaust in Miners Study: A Nested Case–Control Study of Lung Cancer and Diesel Exhaust, JNCI: Journal of the National Cancer Institute, Volume 104, Issue 11, 6 June 2012, Pages 855–868, https://doi.org/10.1093/jnci/djs034; Michael D. Attfield, Patricia L. Schleiff, Jay H. Lubin, Aaron Blair, Patricia A. Stewart, Roel Vermeulen, Joseph B. Coble, Debra T. Silverman, The Diesel Exhaust in Miners Study: A Cohort Mortality Study With Emphasis on Lung Cancer, *JNCI: Journal of the National Cancer Institute*, Volume 104, Issue 11, 6 June 2012, Pages 869–883, https://doi.org/10.1093/jnci/djs035

[72] World Health Organization (WHO) 2012, *Media Release No. 213, IARC: Diesel Engine Exhaust Carcinogenic*, International Agency for Research on Cancer, World Health Organization, Lyon, France: www.iarc.fr/wp-content/uploads/2018/07/pr213_E.pdf

[73] For example, see: https://www.gov.uk/guidance/driving-in-a-clean-air-zone; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/863730/clean-air-zone-framework-feb2020.pdf.

[74] See: https://www.london.gov.uk/sites/default/files/ulez_ten_month_evaluation_report_23_april_2020.pdf.

[75] See: https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/discounts-and-exemptions

[76] J. Richmond-Bryant, L. Bukiewicz, R. Kalin, C. Galarraga, F. Mirer, A multi-site analysis of the association between black carbon concentrations and vehicular idling, traffic, background pollution, and meteorology during school dismissals, *Science of The Total Environment*, Volume 409, Issue 11, 2011, Pages 2085-2093, https://doi.org/10.1016/j.scitotenv.2011.02.024

states limit vehicle idling by some or all vehicles.[77] Eighteen US states implement schemes involving grants, loans, or tax credits to provide incentives for adopting idle reduction technologies for heavy vehicles. Significant child health improvements have been associated with the Californian EPA policies that reduced children's exposure to traffic-related air pollution (TRAP).[78] The Californian EPA policies resulted in the development of larger, healthier lungs in children, with health benefits that extend into adulthood, including a reduced risk of cardiovascular disease and associated mortality. In addition to anti-idling, the Californian policies also included buffer zones between major roads and schools. In contrast, Melbourne planning policies actively encourage the siting of childcare centres on or near major roads, thereby placing the most vulnerable subset of population (children 0– 4 years) in the areas with highest TRAP. A recent study showed over 10 percent of Melbourne metropolitan childcare centres were within 60 metres of a major road.[79]

Vehicle emissions can be reduced by other mechanisms, including by implementing Euro 6 standards for passenger and light vehicles, and Euro V1 standards for heavy vehicles. The EU has consistently reviewed its vehicle emissions standards of both petrol and diesel vehicles to drive down NO_x emissions.[80] The most recent standard imposed an emission reduction limit for light diesel vehicles of 56 percent, from 0.18 g/km (Euro 5 Standard) to 0.08 g/km (Euro 6).[81] A significant factor in the success of reducing NO_x emissions from vehicles is using fuels with very low sulfur content.[82] Europe commenced phasing-in virtually sulfur-free petrol and diesel fuels – less than 10ppm – in 2005. Australia currently implements the less-stringent Euro 5 standards for light and heavy vehicles.[83] The Ministerial Forum on Vehicle Emissions is currently undertaking a review to consider whether Australia should adopt the Euro 6 Standards for light vehicle and Euro VI standards for heavy vehicles.[84] Fuel standards are set the federal level,[85] however the Ministerial Forum on Vehicle Emissions review is a good opportunity for the Victorian government to make submissions on the necessity of adopting the Euro 6 standards.

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[77] Riley Hutchings and Kim Tyrrell, Putting the Brakes on Idling Vehicles, *National Conference of US State Legislatures* Vol . 26, No. 34 / September 2018. Available at: https://www.ncsl.org/research/environment-and-natural-resources/putting-the-brakes-on-idling-vehicles.aspx

[78] Gauderman WJ, Urman R, Avol E, Berhane K, McConnell R, Rappaport E, et al. Association of improved air quality with lung development in children. *New England Journal of Medicine*. 2015;372(10):905-13: https://www.nejm.org/doi/10.1056/NEJMoa1414123.

[79] Walter, C., Schneider-Futschik, E. and Irving, L. (2019), Traffic pollution near childcare centres in Melbourne. *Australian and New Zealand Journal of Public Health*, 43: 410-412. https://doi.org/10.1111/1753-6405.12915

[80] For a history of vehicle emissions reductions in the EU, and elsewhere, see: https://www.transportpolicy.net/topic/efficiency-and-ghg-standards/.

[81] International Council of Clean Transportation, 'A Technical Summary of Euro 6/VI Vehicle Emission Standards (2016) p.3. Available at: https://theicct.org/sites/default/files/publications/ICCT_Euro6-VI_briefing_jun2016.pdf.

[82] International Council of Clean Transportation, 'A Technical Summary of Euro 6/VI Vehicle Emission Standards (2016) p.2. Available at: https://theicct.org/sites/default/files/publications/ICCT_Euro6-VI_briefing_jun2016.pdf.

[83] *Vehicle Standard (Australian Design Rule 79/04 — Emission Control for Light Vehicles) 2011*, made under s7 of the *Motor Vehicle Standards Act 1989; Vehicle Standard (Australian Design Rule 80/03 - Emission Control for Heavy Vehicles) 2006*, made under made s7(1) of the *Motor Vehicle Standards Act 1989.*

[84] See: https://www.infrastructure.gov.au/vehicles/environment/forum/index.aspx.

[85] *Fuel Quality Standards (Petrol) Determination 2019* (Cth)*; Fuel Quality Standards (Automotive Diesel) Determination 2019* (Cth).

Action: By September 2021, develop a comprehensive plan to reduce vehicle pollution, with a focus on vehicle pollution hotspots, including the following elements:

- Low emissions/clean air zones targeting diesel freight trucks in high-traffic urban areas.
- Anti-idling regulations to require engines be stopped when a vehicle is stationary for more than 1 minute, particularly near vulnerable community locations such as schools and childcare centres.
- A levy or restricted access to the Port of Melbourne for non- Euro 6/VI compliant heavy vehicles.
- Incentives for freight operators to upgrade to Euro 6/VI compliant vehicles.
- A commitment to revise urban planning in ports areas with a view to achieving clean air outcomes.

5. Controlling pollution from domestic solid fuel burning

Solid fuel burning - that is, wood-burning heaters - significantly impacts local air quality throughout Victoria.[86] In 2018, an EPA Policy Impact Assessment quantified the total health costs of particulate matter emissions from the use of wood heaters in Victoria at over $8 billion over the next ten years, while the value of particulate matter emissions avoided by adoption of Australian wood heater efficiency standards was just $33,171,837.[87]

The principle control measures for wood heater pollution include: regulating the use of existing wood heaters, phasing out wood heaters in residential areas, and offering incentives to upgrade insulation and install clean heat pumps. Numerous states in the US have enacted regulations that phase out wood heaters, or ban solid fuel burning outright during periods of increased air pollution risk or unfavourable weather conditions.[88] Some US state building codes also prohibit the construction of homes that rely on solid fuel as a heating source.[89] These control measures are most effective when accompanied by targeted public education and communication about the health risks associated with wood smoke to drive the uptake of clean forms of heating, like heat pumps.[90]

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[86] EPA Victoria, *Air pollution in Victoria – a summary of the state of knowledge* (March 2018), pp.20-22. Available at: www.epa.vic.gov.au/about-epa/publications/1709.

[87] Regulatory Impact Solutions Pty Ltd, (2017) *POLICY IMPACT ASSESSMENT: Variation to the Waste Management Policy (Solid Fuel Heating)*, Environment Protection Authority Victoria, Carlton: https://www.epa.vic.gov.au/-/media/epa/files/about-epa/what-we-do/piawastemanagementpolicysolidfuelheating.pdf

[88] Modelling of air pollution may conclude that, if solid fuel appliances are permitted, the city or town will violate air quality standards, so the bans or restrictions are imposed as preventative measures to maintain compliance.

[89] See, for example: Washington State Energy Code, Sections R303.10.2 and R303.10.3: https://up.codes/viewer/washington/irc-2015/chapter/3/building-planning#R303

[90] See: Databuild Research & Solutions, 2016, *Upper Hunter Wood Smoke Community Research Project Final Report*, NSW Environment Protection Authority, Sydney: https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/woodsmoke/UHWSCR-consultant-report.ashx; Johnston, F., Hanigan, I., Henderson S., Morgan G., *Evaluation of interventions to reduce air*

Australia's most successful wood smoke-reduction program was in Launceston, Tasmania. The program focused on public communications about the health impacts of wood smoke pollution and replacing wood heaters with clean heating alternatives. About 2,000 households received subsidies of $500 to remove wood heaters, while many more households replaced wood heaters with clean heating alternatives at their own expense.[91] These interventions dramatically accelerated a general trend towards using heat pumps rather than wood heaters. As such, wood heater prevalence fell from 66 percent to 30 percent of all households and average particulate air pollution during winter was reduced by 40 percent (44 µg/m³ to 27 µg/m³).[92] This reduced wintertime deaths from respiratory disease by 28 percent and cardiovascular disease deaths by 20 percent.[93] Year round, for men, the reductions were 23 percent (respiratory), 18 percent (cardiovascular) and 11.4 percent (all deaths).[94]

The 2019 'Clean Air Plan for Sydney' authored by 35 expert air pollution scientists recommended legislation that works towards eliminating the use of wood heaters in urban areas.[95] One way to achieve this is to require wood heaters be removed when houses are sold. A 2011 consultancy report by AECOM Australia Pty Ltd for the NSW Government concluded that a wood heater phase out, which banned the installation new wood heaters and required existing ones to be removed when houses are offered for sale, would yield the greatest cost-benefit of all wood smoke control measures.[96]

Action: By September 2021, implement a plan to phase-out wood heaters, including the following elements:

- Progressive restrictions on the use of wood heaters during periods of increased air pollution risk and/or unfavourable weather conditions.
- Require the removal of wood heaters from homes upon sale.
- Subsidise insulation upgrades and heat pump installations for houses that remove wood heaters.

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pollution from biomass smoke on mortality in Launceston, Australia: retrospective analysis of daily mortality, 1994-2007 BMJ 2013; 346: https://doi.org/10.1136/bmj.e8446

91 Robinson, D.L. What makes a Successful Woodsmoke-Reduction Program? *Air Quality and Climate Change* 2016, 50, 20-28.

92 Johnston Fay H, Hanigan Ivan C, Henderson Sarah B, Morgan Geoffrey G. Evaluation of interventions to reduce air pollution from biomass smoke on mortality in Launceston, Australia: retrospective analysis of daily mortality, 1994-2007 *BMJ* 2013; 346: https://doi.org/10.1136/bmj.e8446

93 Johnston Fay H, Hanigan Ivan C, Henderson Sarah B, Morgan Geoffrey G. Evaluation of interventions to reduce air pollution from biomass smoke on mortality in Launceston, Australia: retrospective analysis of daily mortality, 1994-2007 *BMJ* 2013; 346: https://doi.org/10.1136/bmj.e8446

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95 Paton-Walsh, C.; Rayner, P.; Simmons, J. et al. A Clean Air Plan for Sydney: An Overview of the Special Issue on Air Quality in New South Wales. *Atmosphere* 2019, *10*, 774.

96 AECOM Australia Pty Ltd, Economic Appraisal of Wood Smoke Control Measures, *NSW Office of Environment and Heritage*, 29 June 2011. Accessed via: https://www.environment.nsw.gov.au/resources/air/WoodsmokeControlReport.pdf

- Phase out the installation of wood burning heaters..

6. Controlling ozone pollution

Ozone (O_3) is a secondary pollutant – it is ordinarily not emitted directly by industrial process such as burning coal or by vehicles.[97] Ozone is a colourless gas formed when NO_x and volatile organic compounds (VOC) react in sunlight. VOCs are a class of chemicals used across and emitted by many sources, including hydrocarbons from vehicle exhaust pipes.

Unhealthy concentrations of O_3 can form at considerable distances from direct sources of pollution, increasing the risk of unhealthy exposure to ozone in air that does not have industrial sources of air pollution or heavy traffic.

As explained above, O_3 impacts the airways and lungs, increasing susceptibility to lung infections and aggravating lung diseases. O_3 also reduces the photosynthesis and growth of certain agriculture crops and flora, increasing the risk of disease and insect damage.[98]

The best strategy to reduce ozone concentrations is to reduce NO_x and VOC emissions. Reducing NO_x emissions from large sources of NO_x emissions such as coal-fired power stations by installing SCR has the co-benefit of reducing both O_3 and $PM_{2.5}$. However, reducing NO_x alone does not automatically reduce O_3, and can in fact increase O_3. Aggressive air pollution controls have been implemented in China to reduce NO_x emissions, but significant ozone concentrations are pervasive and increasing.[99] The best way to reduce O_3 is for integrated pollution controls to be implemented that reduce NO_x and VOCs.

6.1 Reducing VOCs

There are a range of specific VOC emission control methods to reduce the diverse sources and composition of VOCs by combining several of the following:[100]

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[97] This section focuses on ground level, or tropospheric, ozone, which is distinguished from stratospheric ozone that protects us from the harmful ultraviolet effects of the sun's rays. A good mnemonic to distinguish the two types of ozone is: "Ozone in the blue is good for you. Ozone on the ground will get you down."

[98] Avnery, Shiri, et al., 'Global crop yield reductions due to surface ozone exposure: 2. Year 2030 potential crop production losses and economic damage under two scenarios of O_3 pollution' (2011) 45 *Atmospheric Science* 2297.

[99] University of Colorado at Boulder, Cooperative Institute for Research in Environmental Sciences, 2018, "China is Hot Spot of Ground-Level Ozone Pollution". Retrieved from https://cires.colorado.edu/news/china-hot-spot-ground-level-ozone-pollution; Ke Li, *et al.,* "Anthropogenic Drivers of 2013-2017 Trends in Summer Surface Ozone in China", 2019. Proceedings of the National Academy of Sciences. Retrieved from: https://www.pnas.org/content/116/2/422; [99] Clean Air Asia, "China Air 2019: Air Pollution Prevention and Control Progress in Chinese Cities". Nationally, annual average ozone concentrations increased from 149 ug/m^3 in 2017 to 151 ug/m^3 in 2018.

[100] See: U. S. Environmental Protection Agency, *Generic Chemical Rules for Stationary Sources of Air Pollution*: https://www.epa.gov/stationary-sources-air-pollution/generic-chemical-rules-stationary-sources-air-pollution; R. Avery, *"Reactivity-Based VOC Control for Solvent Products: More Efficient Ozone Reduction Strategies",* 2006.

- **Improve work practice standards** by requiring VOC capture into hood or duct work to minimise fugitive emissions.
- **Pollution prevention techniques** requiring a switch from more hazardous or reactive chemical to a less hazardous or water-based product, or requiring fewer chemicals in the manufacturing process.
- **Limit emissions for each sector** expressed as kilograms of VOC per litre or kilogram of product applied.
- **Limit vapour pressure of petrol** especially during warm summer months, to reduce evaporative losses during the filling of storage tanks and refuelling of vehicles.
- **Minimum percentage** capture and destruction efficiency in an incinerator, expressed as minimum 95 percent capture, destruction and removal efficiency of VOC emissions.

6.2 Reducing NO_x

In addition to NO_x pollution controls that must be installed in coal-fired power stations described above, other combustion processes, industrial boilers and vehicle NO_x emissions can be controlled by:

- **Improving combustion efficiency**, keeping the boiler or vehicle well maintained and tuned to optimal performance standards;
- **Reducing combustion temperature** to lower NOx emissions, ensuring that boilers are tuned to prevent increase of carbon monoxide concentrations;
- **Reducing the sulfur content in fuel** for installing catalytic devices that can effectively control NOx emissions. High sulfur poisons catalysts, rendering them less effective, decreasing their operating life, and increasing maintenance costs;
- **Installing selective catalytic reduction** in industrial facility boilers and solid waste incinerators which can reduce NOx emissions by 90 percent or higher.

Action: By September 2021, require industry emission standards for VOCs and NO_X consistent with best international practices, including the following elements:

- Requiring leak detection systems be installed on all oil refineries and gas plants to reduce VOC emissions.[101]
- VOC emissions limits and capture efficiency targets by sector.[102]
- Requiring the installation of SCR technology for all industrial boiler facilities.

Environmental Science and Technology. Volume 40, pages 4845-4850: https://pubs.acs.org/doi/pdf/10.1021/es060296u?rand=umc9039z&

[101] See: U. S. Environmental Protection Agency, *Leak Detection and Repair: A Best Practices Guide*: https://www.epa.gov/sites/production/files/2014-02/documents/ldarguide.pdf

[102] See: U. S. Environmental Protection Agency, *Generic Chemical Rules for Stationary Sources of Air Pollution*: https://www.epa.gov/stationary-sources-air-pollution/generic-chemical-rules-stationary-sources-air-pollution

7. National ambient air standards

The *National Environment Protection (Ambient Air Quality) Measure* (the NEPM) is intended to provide a nationally consistent framework for monitoring and reporting on ambient air quality. The NEPM is reflected in state law through regulations.[103] The monitoring and reporting functions of the NEPM in Victoria is carried out by the EPA. Ambient air monitors owned and operated by EPAs are largely implemented in order for states to fulfil their monitoring and reporting obligations under the NEPM.

Victoria can, and has, adopted stricter ambient air quality standards than those expressed in the NEPM.[104] After the National Environment Protection Council review of particulate matter ambient air standards, the Victorian government utilised its powers to adopt stricter $PM_{2.5}$ standards than the rest of the country - stricter than the WHO standards for ambient $PM_{2.5}$ concentrations - which will take effect in 2025.[105] Victoria can continue to lead in the adoption of stricter ambient air quality standards by adopting the standards set out in Table 8 below.

NEPM standards must be set at a level where air pollution exposure is reduced as far as possible. Australia has already adopted WHO guidelines for $PM_{2.5}$ standards, and as mentioned above in 2025 Victoria's $PM_{2.5}$ will be stricter again.[106] Ambient air quality standards for the other key pollutants that reflect a minimum adverse impact on human health as agreed on by Australian health professionals are as follows:[107]

Table 7: Recommended safe ambient air quality standards to protect health

Standard (in parts per billion)	Limit
SO_2 1-hour	60 (as 99th centile of daily worst hour)
SO_2 24-hour	8 (no exceedances)
NO_2 1-hour	72 (as 99th centile of daily worst hour)
NO_2 annual	9 (no exceedances)
O_3 1-hour	70

[103] In Victoria: State Environment Protection Policy (Ambient Air Quality).
[104] *National Environment Protection Measure (Victoria) Act 1995* (Vic) Schedule 4, cl. 19.
[105] State Environment Protection Policy (Ambient Air Quality) Schedule 2, Table 2.
[106] See: State Environment Protection Policy (Ambient Air Quality) Schedule 2, Table 2. Available at: https://www.epa.vic.gov.au/about-epa/laws/legislation-regulations-and-policies/air-legislation.
[107] Clare Walter, Maxwell Smith et al. (2019) Health-based standards for Australian regulated thresholds of nitrogen dioxide, sulfur dioxide and ozone: Expert Position Statement 2019: https://www.envirojustice.org.au/wp-content/uploads/2019/11/Expert-Position-Statement-PDF.pdf

Action: By September 2021, legislate ambient air quality standards for SO_2, NO_2 and O_3 to the values in table 7, and regulate key emissions point-sources to ensure they are met.

Action: Periodically review the ambient standards based on epidemiological data, and revise/strengthen as appropriate. At a minimum, this should be completed every 5-7 years.

8. Timeframes and targets

Timeframes and targets to achieve reduction in air pollution to best practice control standards must be set by the Victorian government. Each airshed has unique characteristics based on the source of air pollution, the geography of the area, and meteorological patterns. These characteristics inform the types of air pollution control measures that should be adopted, the emissions reduction framework that is required, and factor for the meteorological conditions that can exacerbate pollutant concentrations.

To develop the air pollution reduction target for a given airshed the following questions must be answered:

- What levels of pollution reduction are required?
- How many tonnes of pollution must be removed from the airshed in order to meet (and sustain) health-based ambient air pollution standards?
- Based on economic forecasts, how will the mix of air pollution sources change in the future?
- What do these changes suggest for the need to adopt more stringent standards and control measures in the future to maintain compliance with ambient pollution standards?
- What control measures might provide concurrent reductions of many pollutants?

The timeframe to achieve reduction targets also varies by airshed, pollutants, and the mix of sources that contribute to pollution. Pollutant concentrations that are much higher than public health standards require more time to achieve than concentrations that are just above those standards.

Establishing timeframes to reduce pollution helps to provide transparency to the public. Timeframes are important for businesses who produce air pollution to meet stronger standards by planning for the installation of pollution controls.

The two main practices for a compliance timeframe are:

1. USA: set an effective compliance date three to five years into the future.[108] Sources that indicate that this timeframe is too tight must be put on a negotiated, enforceable consent agreement that

[108] Section 110 of the US Clean Air Act requires state and local agencies to prepare new/revise existing air quality plans within three years after the adoption of a new or revised ambient air quality standard. For industrial and power plant standards, each standard (New Source Performance Standards, MACT and RACT) includes a date by which affected sources must comply with them. Sources that are unable to meet such date

provides the conditions that must be met in the interim, and which sets a final compliance date after which the requisite equipment must be installed or the source must close down.

2. EU: Typically, each Directive sets an effective compliance date three to five years into the future. Directives are implemented by each Member State. For sources who indicate that this timeframe is too tight, an individual agreement is negotiated which allows the source to operate for a designated number of hours over the three-year period, after which time the emissions standard must be met or the source must close.[109]

Either the USA or EU option is acceptable. Both options provide certainty to the public and to businesses. Both options set a compliance date for reduction in pollution or the source of the pollution must close.

Action: By September 2021, the Victorian government prepares an outline of timelines and targets for achieving reduction in air pollution to best practice control standards.

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must negotiate an individual, enforceable consent agreement that spells out the conditions that the source must meet, and the timeframe for which the source must install controls or cease operation.

[109] European Union, Industrial Emissions Directive. Overview of Directive: https://ec.europa.eu/environment/industry/stationary/ied/legislation.htm See also, frequently asked questions about the Directive: https://ec.europa.eu/environment/industry/stationary/ied/faq.htm. The three to five year derogations are negotiated between each Member State and the affected source.