Submission on 'Clean Air for All Victorians' Victoria's Air Quality Statement

Authorship:

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Melbourne Energy Institute

The University of Melbourne is a national leader in energy research, with over 300 experts engaged across science, technology, economics and policy of energy. The Melbourne Energy Institute provides a focal point for the University's energy researchers and government and industry partners. Since the Institute launched in 2010, it has developed many interdisciplinary research programs across economics, engineering, health, the humanities, law and the sciences.

Clean Air and Urban Landscapes Hub

The Clean Air and Urban Landscapes Hub (CAUL) is a consortium of four universities: The University of Melbourne, RMIT University, the University of Western Australia and the University of Wollongong. The CAUL Hub is funded under the National Environmental Science Program (NESP) of the Australian Government's Department of the Environment. The task of the CAUL Hub is to undertake research to support environmental quality in our urban areas, especially in the areas of air quality, urban greening, livability and biodiversity, and with a focus on applying research to develop practical solutions.

NHMRC Centre for Air pollution, energy and health Research (CAR)

The Centre for Air pollution, energy and health Research (CAR) is a Centre of Research Excellence funded by the National Health and Medical Research Council. The CAR brings together over 30 researchers at the forefront of their fields to investigate how air pollution and new forms of energy affect our health. The Centre's vision for a healthier community is the driving force behind its research. The CAR supports teams of researchers in the fields of epidemiology, exposure assessment, toxicology, chemistry, biostatistics and clinical respiratory medicine to pursue collaborative projects and to develop their capacity. The Centre is based in seven of Australia's leading universities.

Lung Health Research Centre

The Lung Health Research Centre (LHRC) of the University of Melbourne aims to improve lung health through excellence in basic and translational research and represents combined expertise in respiratory biology, respiratory medicine, epidemiology, public health, pharmacology and oncology. The Centre capatilises on the strong existing partnership between lung researchers in the Department of Pharmacology (Faculty of Medicine, Dentistry and Allied Health Sciences), and leading clinical research groups at the Departments of Respiratory Medicine and Clinical Immunology at Royal Melbourne Hospital to foster research of the highest scientific standard and closest alignment to patient needs.

Australian Meteorological and Oceanographic Society

The Australian Meteorological and Oceanographic Society (AMOS) is an independent society representing the atmospheric and oceanographic sciences in Australia. It currently has over 500 members drawn from the Bureau of Meteorology, CSIRO, the university sector, other State and Federal agencies, as well as the private sector. The AMOS provides support for and fosters interest in meteorology and oceanography through its publications, meetings, workshops, public events, grants and prizes. The AMOS also has an important role as a credible, independent voice for the profession. As part of this role it has established Expert Groups in areas such as climate variability, weather forecasting and physical oceanography and regularly represents the views of its members to Government, institutes and the public.

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Executive summary

We welcome the opportunity to provide a vision for "Clean Air for all Victorians" drawing upon our wide expertise across the University of Melbourne, MEI, CAUL and CAR. The authors and groups represented have knowledge and expertise in several areas relevant to the air quality statement including atmospheric chemistry measurement and modelling, exposure modelling, impact on health and translation of knowledge to policy and practice and would welcome further discussions with the Victorian State Government should this be of interest.

Our submission sequentially answers each of the seven questions raised in the statement regarding actions to improve air quality. Based on the current evidence, we have proposed numerous tangible actions of varying difficulty and urgency for the State Government to consider to improve Victoria's air quality and to lower exposure to air pollutants of all Victorians.

Our first recommendation is a significant reduction of fossil fuel power generation and internal combustion engine transport, with careful planning, evaluation and implementation of alternatives to ensure that overall health, social and environmental gains are achieved. We accept that a total phase-out of fossil fuel electricity and internal combustion engine transport will require careful and strategic planning and will take time. We have provided a number of suggestions on other actions that can be taken to reduce air pollution in the meantime, including anti-idling regulations, stricter fuel and vehicle standards, and urban design measures. We suggest the phasing out of diesel-based emissions be a priority. Further, rapid gains in air quality and health can be achieved by reducing emissions from domestic wood heaters through government subsidies for households to switch to non-combustion sources of heating.

Secondly, we recommend to substantially increase capabilities in real-time measurement of air pollutants. This information is essential to inform decisions on what actions to take and when, and ensure that any action taken is effective and in a timely manner. Additionally, real-time measurements can advance model development to eventually provide forecasts and warnings for Victorians and emergency care agencies. This is a key component of reducing exposure to poor air quality in the wider population as such information can empower the community to streamline services, which we see as an urgent matter. We suggest the development of a network of internationally recognized particulate matter measurement sites and collaboration with the international community to improve the estimates of particulate matter exposure from satellites.

Our final recommendation is a widespread education campaign that transcends sectors and demographics to inform Victorians about the health risks of air pollution. This should include what people can do to reduce individual exposures, how they can obtain reliable information and what actions they can take to protect health of their own and the community. We suggest that the education of the public begins as soon as possible as there is no known safe level of air pollution exposure for human health. Any decrease of pollution levels can have large health benefits and reduce health care costs.

Chemical definitions

$PM_{2.5}$	Particulate Matter with diameters less than 2.5 μm
PM_{10}	Particulate Matter with diameters less than 10 μm
Ultrafine ($PM_{0.1}$)	Particulate Matter with diameters less than 0.1 μm
NO_x	A general term of Nitrogen Oxides, NO and NO_2.
SO_x	A general term of Sulfur Oxides, including SO, SO_2, SO_3, S_7O_2, S_6O_2 and S_2O_2.
VOC	Volatile Organic Compound

1. What do you think are the best value actions listed above that are likely to help improve future air quality?

Defining value

A Marginal Abatement Cost Curve analysis that considers air quality action values for CO_2, CO, $PM_{2.5}$, PM_{10}, NO_x, SO_x, Hg concurrently for Metropolitan Melbourne, Latrobe Valley and regional Victoria.

In order to determine the 'best value' action, the term 'value' must first be defined. Value can consider monetary cost, environmental and human health and wellbeing, productivity, livability, and many other measures. **A comprehensive and consistent study should be performed to assess the cost of air pollution for Victoria, including the cost of source-sector emissions, health costs and the cost of abatement (by source and as a whole).** The reports developed for the New South Wales Government provide a good example analyzing the cost of air pollution on health[1], the cost on air quality from transport emissions[2] and the cost/benefit of air quality abatement[3].

The best value actions to improve air quality found in the NSW cost abatement report[3] were those that have an associated negative economic cost, which include cycling initiatives and the SmartWay[4] program. After these actions reducing NO_x pollution from coal-fired power stations was the highest priority for the Greater Metropolitan Region. For Sydney and Wollongong, reducing heavy vehicle diesel transport emissions was identified as the highest priority for NO_x (including locomotive replacement and truck, train and bus retrofitting) whilst for particulate matter, reductions in wood-fired heaters were identified[3].

Best value action

Incentives to fast track a net zero emissions pathway for Victoria: green transport, educational tools and air quality information to help the public develop individualized air action plans.

Short term

Incentives for green transport, low pollution home heating and educational campaigns are suggested as the best value short term action to improve air quality in Victoria. Green transport includes walking, cycling and using electrified public transport or personal vehicles (though a caveat to this is discussed under Question 7). The use of pellet heaters (or ideally non-combustion heaters) can significantly reduce both indoor and outdoor particulate pollution compared to solid wood heaters. **We suggest the provision of infrastructure, opportunity and incentive for Victorians to reduce their use of and reliance on fossil-fuel based vehicles, and solid wood heaters.** Reducing the use of diesel vehicles is seen as a priority. Initiatives such as walkable cities, tax concessions, subsidies and access restrictions are discussed in more detail under Question 2. These initiatives must be coupled with changes in regulations and an education campaign to be effective.

An educational campaign across the state to raise awareness of the risks of air pollution and what every day Victorians can do to limit individual exposure should be undertaken in the near future. Experts are now showing that exposure to poor air quality can have similar effects to smoking on lung health, with an increase of lung cancer in populations who have never smoked[5]. Children living or going to school in proximity to major transport routes have been linked to a 1.5 fold increase of new onset asthma[6]. These results are concerning and should be made accessible to the public, especially for vulnerable populations. Furthermore, the higher respiration rate during active transport (walking, riding) entails that air pollution exposure delivers a higher effective dose to those involved; models for finding low-exposure transport routes have been developed elsewhere[7] and could be applied within Victoria to reduce exposure. We suggest learning from heat-stress plans to raise awareness, provide decision tools for schools and emergency workers, encourage community action and support individual self-management of air pollution exposure. This should be coupled with changes in local and state government regulations to reduce idling time in vehicles, especially near child care facilities, schools, aged care facilities and hospitals, incentivise choosing green or active transport over internal combustion engine transport, especially diesel, reduce wood-burner use and encourage switching to renewable energy. These actions are discussed in greater detail under Question 2.

Long term

We submit that the best value action for Victoria to improve air quality over the long term is to fast track the transition away from combustion electricity generation and transport. Victoria has committed to net zero CO_2 emissions by 2050[8], which should include a phasing out of coal fired power and fossil-fuel driven transport. The improvement of air quality and the reduction of CO_2 emissions should be considered concurrently to achieve the best outcome for health and the environment in the most efficient way possible. In transitioning away from fossil fuels, rigorous evaluation of the health impacts of alternative sources of energy should be conducted. These recommendations are not game-changing or in any way unique to Australia. The banning of petrol and diesel vehicles from cities is in line with commitments around the world[9] to tackle air pollution, as is the phasing out of coal fired power generators[10]. While purely electric vehicles still emit primary PM via, for example, brake dust and tire wear[11], a considerable reduction in secondary PM can be expected due to the elimination of NO_x, SO_x and VOC emissions. Australia risks a large health burden due to air quality issues with delays in our energy transition away from fossil fuels. The costs of delay should be established.

2. How would you build or vary these actions?

Providing the Victorian public with high spatial and temporal air quality data in real-time and as forecast products so they can make informed decisions about personal and community health actions.

When and where

Direct observations

In Question 1 above (and more specifically below) we have called for a systematic improvement in air quality using a series of measures. However, currently there is insufficient data or modeling to support the best pathway forward. A sensor network or specific high-quality instruments can provide the necessary data to develop, validate and verify not only what actions should be taken but also whether the actions taken are effective. Existing sensors have been placed to estimate “urban background”

concentrations and will only reflect to a limited extent the concentrations to which many people are exposed (e.g. in urban "high street" shopping areas, with large volumes of slow-moving traffic).

Small, deployable particulate matter sensors have become more sophisticated, less expensive and highly popular. Sensors for toxic gases are following suit. These sensors provide an opportunity for greater data coverage of cities and air pollution hot spots. Their use in conjunction with Smart Cities[12] can revolutionize the way cities mitigate and react to air pollution sources and events. However, while these sensors are improving, they are unable to provide quantitatively accurate measurements. Their primary use is qualitative: limited to identifying trends and potentially dangerous exposure levels (as early warning). For this reason, investment in greater real-time data coverage needs to consider two things, the accuracy of the data required and the deployability of the sensors. Less deployable, but highly accurate instruments are costly, but provide in-depth information necessary for understanding the full atmospheric characteristics relevant to air pollution. These high-quality instruments are essential for studies looking at source apportionment, how pollutants are interacting with the local environment and for satellite calibration. **Careful and strategic planning should be conducted in order to determine the placement and capability requirements of different types of sensors.**

Remote sensing

Improving the retrieval of aerosol optical depth from satellites and the ability to use this information to estimate $PM_{2.5}$ concentrations, is a potentially powerful component to a better understanding of air quality trends, variability and human exposure for health studies. Current satellite products are not able to provide information of sufficient quality to be of use for modelling studies or regulating authorities over Australia. To improve satellite products, more accurate retrieval methods must be developed in conjunction with a network of high quality, ground based measurements, calibrated to the same, preferably international, standard (see Question 3). No such network exists in Australia, and there are very few sites with this capability in the Southern Hemisphere[13]. Retrieval methods are improving as new methods (combining traditional satellite retrieval as well as more statistical approaches) are being developed, for example for NO_2 over Australia[14] and $PM_{2.5}$ over China[15]. Improved satellite estimation of particulate matter exposure is a global initiative[13] and Australia's involvement would be of great benefit to the Global Atmospheric Watch's Urban program. The launch in 2015 of the geostationary Himawari-8 weather satellite, which images Australia at 1-2km resolution every 10 minutes, creates many new opportunities for high-resolution exposure estimates and near real-time monitoring. As discussed in Question 6, we consider ourselves experts in this field and would be pleased to provide further information about the feasibility of a calibration site and the process towards improved satellite retrievals of particulate matter.

Modelling

One of our main recommendations in this submission is an education campaign to inform the community of the risks of air pollution and how they can reduce individual exposure. In order to fulfill this recommendation, we must have better knowledge of the sources, trends and variability of air pollution (as discussed above), as well as the modelling capability to predict it and provide warning (this is discussed in the next section 'Empowering Communities').

Great effort and investment has been made to improve modelling of air quality, including smoke plumes from bushfires and planned burns[16] and pollen dispersion[17,18]. This includes traditional atmospheric transport modelling, along with blended methods using real-time satellite and in situ measurements,

combined with deterministic models. With the groundwork of understanding processes and methodology established, more investment is needed to help transition what is currently 'research and development' to a fully operational forecast system. **The Victorian Government should provide resources to the relevant organizations to build, test and operationalize high quality, high resolution air pollution models.** This will require close collaboration between agencies, including the EPA, the Bureau of Meteorology, the CSIRO and the Universities to meet the greater demand for real-time measurements, both on the ground and crucially from remote sensing, with significant computing expense and research required.

Empowering Communities

Before a community can be empowered, they must first be educated. Without the knowledge (and resultant motivation) of the risks of air pollution, and its main sources, a community has little hope of being able to 'identify and address local air quality challenges'. **We suggest an education campaign that highlights the risks to health, the main sources of air pollution (indoor and outdoor) and the actions communities can take to improve air quality.** With air quality beginning to draw comparisons to smoking in terms of impact on lung and respiratory health, we recommend a campaign of similar magnitude to the anti-smoking campaign, which has been highly successful in educating the public and improving health and well-being. Below are some recommendations of educational campaigns and strategies for information dissemination.

Air pollution information, forecasts and warnings

The Bureau of Meteorology now provides a forecast of the pollen count to inform at-risk people (with asthma, allergies, or respiratory problems) of days in which it may be adverse to their health to be outdoors. These forecasts are widely disseminated and trusted and provide an essential pathway to inform communities about severe weather conditions. **Air pollution levels should be included in the Bureau of Meteorology's regular forecasts to help inform Victorian's of their individual risk.** High-risk individuals (such as those with asthma) can be strongly affected by increased background pollution well before it reaches concentrations considered to be hazardous the general population (and prompting public health warnings). For this reason, the real time air pollution levels and forecasts should implemented.

Hazardous air pollution days usually occur when very stable atmospheric conditions occur over multiple days allowing for a build-up of pollution. Forecasters are easily able to predict these atmospheric conditions; however, the source of the air pollution is much harder to model and high-quality, state-wide observations are not yet available. As discussed in above, significant effort has already been made on this front, however ensuring that the relevant agencies have the resources to turn this research into an operational product is important. We can learn from the devastating thunderstorm asthma event of 2016 that triggered a cascade of research and collaboration to result in operational forecasts for the pollen season and warnings to be issued through VicEmergency and the Bureau of Meteorology[19]. We cannot wait for a severe air pollution event to claim multiple lives in a short time period (noting that 3071 premature deaths were attributed to $PM_{2.5}$ in 2016[20]) before Victoria acts upon providing real time data, forecasts and a warning system for the public.

Schools campaign

One of the most effective ways to educate a community is to educate schools, including the children, teachers and parents. The SunSmart campaign and recycling campaigns provide strong evidence of this

being successful. **An educational campaign disseminated through schools about the risks of air pollution on children (and other vulnerable populations) must be a high priority for state and local governments to reduce exposure.** We would like to highlight diesel emission exposure as particularly hazardous and preventable for school groups. Measures such as switching car air-conditioners to recirculation, anti-idling (switching off your car when stopped) and having playing fields as far from major transport routes as possible, or alternative indoor playing fields can make a large impact on children's exposure to pollution. We again highlight that high-risk individuals will be severely affected by a rise above background pollution well before it reaches concentrations deemed hazardous to the general population. Education must include measures that can be tailored to personal risk (similar to allergy plans) and schools and other organisations must have the information (real time air pollution data), understanding and training to help these individuals. Furthermore, access to information about current air quality should be available so that on hazardous days, schools, vulnerable individuals and facilities caring for people at higher risk (e.g. aged care) can make proactive decisions based on their air action plans to limit the amount to expose to all or at-risk individuals. Such proactive decisions would include moving activities indoors, reducing physical activity outdoors and the use of portable air cleaners. As recent studies have noted, there is no known safe level of air pollution for anyone[21] and reductions in air pollution even when pollutant levels are considered 'safe' or under a threshold can have significant health benefits[22]. With children being one of the most at-risk populations from air pollution exposure, our schools must be informed and have strategies to protect them. We can draw much experience from the SunSmart campaign, which has a similar disease burden attribution to air pollution (0.8% compared to 0.6%[23]) yet significantly more public awareness. This program has changed how schools are designed, has implemented strategies for 'heat days' and has been highly successful in educating children and their parents.

Media

The recent ABC television series War on Waste has revolutionized Australia's waste problem, empowered people to take action and change habits[24]. Not only have individual citizens paid attention to this documentary series, but the sources of the pollution too, for example supermarket chains Coles and Woolworths have banned single use plastic bags nationally. A well-researched and presented series such as this is a highly effective tool of educating the community. **We suggest the Victorian Government explores options as to how the media can be used to educate the public on air pollution in an effective and motivational way, similar to the ABC's War on Waste.**

Traffic and weather news reports

A simple yet effective media to provide information about air pollution levels, sources and warnings are the regular traffic and weather updates on radio, television, digital and printed media. **We recommend that pollution levels and risk of elevated pollution events are included in regular weather and traffic reports that capture a large audience.** This strategy already exists in many Chinese cites and a similar method has been used for pollen forecasts and warning in Victoria.

Engagement with VicRoads

$PM_{2.5}$, a major urban air pollutant, has been linked to more deaths than the road toll[20]. **Engagement of VicRoads to help change the way we drive should occur**. Changes to license testing and what learner drivers are taught, new anti-idling signs outside vulnerable areas and simple information campaigns would be very effective.

Reducing Pollution

Here we present our recommendations to reduce air pollution in the same structure as risk avoidance, namely the hierarchy of risk control. We believe the thinking in this case is one in the same; by reducing air pollution we are reducing the health risk to the population it presents. No known level of pollution is safe[21], and risk control is a necessary action. Below we provide a (non-exhaustive) list of measures that should be taken to improve air quality.

Elimination

> Elimination of combustion-based air pollution sources is the most effective action to reduce the impacts on human and environmental health.

Walkable city initiatives such as those submitted to the Melbourne Metropolitan Planning Strategy[25] are an achievable and simple way to reduce reliance on private and public transport and their emissions. Walkable cities are already seeing an uptake in many local councils (for example the City of Moreland) and has many co-benefits for improving health and fitness, as well as an enhanced sense of community. Similarly, **improved bicycle infrastructure** including segregated bike lanes / highways, end of trip facilities and 'Share the Road' campaigns will again reduce the reliance on emissions generating transport and improve public health.

Some cities worldwide are now **banning diesel and petrol vehicles** in the city centres in a bid to reduce air pollution, with some countries taking measures further and proposing complete bans of fossil-fuel vehicles in the future[9]. These bans act as an incentive for the public to reduce their reliance on private vehicles or to switch to electric based vehicles and provides an immediate improvement to air quality. For example, air pollution in the Chinese cities tracked by the World Health Organisation have recorded a 30% decline over 2013-2016 after introducing aggressive emissions controls including vehicle bans[26].

In both urban and regional areas one of the most effective measures to improve air quality is to **change from wood heaters to low polluting forms of home heating such as pellet stoves or electricity**. Wood heaters are a significant source of air pollution in autumn and winter in regional areas and disproportionately contribute to reduced air quality in major cities e.g. in Sydney wood heaters in just 4.4% of houses contribute more to the winter PM concentrations than vehicle emissions[27,28]. Many regional or local councils around the world already have bans in place, including bans on particular types of wood heaters (Christchurch, New Zealand) or bans on new installation of wood heaters (Waverly and Holroyd local governments in Sydney), or outright bans (Montreal, Canada).

Substitution

> Substituting fossil fuel electricity generation and internal combustion engine transport to renewable energy (noncombustible) will have significant impact on air quality improvement.

Substituting internal combustion engine public and mass transport including buses, trains, ships for electric transport has clear benefits on air quality (see caveat under Question 7). This transformation is underway in many cities around the world. As a role model, **government owed vehicle fleets and machinery should be switched to electric power**, including investment in the necessary charging infrastructure. Many city councils in Victoria are already doing this (for example Moreland and Darebin), however a State-wide policy is necessary (i.e. currently the acceptable vehicle procurement for Victoria precludes fully electric vehicles and supports diesel[29]). For the switch of vehicles to electric to deliver truly

effective air quality returns, **all government buildings and infrastructure should also be switched to renewable energy (noncombustible)**.

In the private sector, **incentives from the State government for private vehicles to be switched to electric** should be provided. The uptake of electric vehicles will require **greater charging infrastructure and updated planning laws** (e.g. charging requirements in apartments, businesses). Similar to above, **motivations for private households and business to switch to renewable energy (noncombustible) or install solar and battery systems** should also be provided if the equitable reduction of air pollution is to be effectively achieved. Incentives may include tax concessions, grants or rebates.

Reduction

Shorter term measures to reduce air pollution will be necessary before a total phase out of large emitters such as fossil fuel power generation and fossil-fuel transport can be achieved.

Reducing engine idling time can result in fuel savings of up to 15% in light commercial vehicles, whilst reducing idling time by three hours a week across all light commercial vehicles nationally could equate to a $12B saving[30]. **Introducing anti-idling technology**, **training and regulation** could reduce urban air pollution exposure in depots, warehouses, and sidewalks [30]. Anti-idling regulation should be particular focused on areas near vulnerable populations (for example, the school-children pick-ups). Idling in many countries and cities around the world attracts heavy penalties, including fines and even jail time[31]. This could be implemented through commercial and private vehicle licensing tests, road signage and enforcement.

Greater regulation on fuel standards, engine technology such as catalytic converters and more strict emission controls should be introduced across all sectors of transport. The recent Australian Fuel Standards inquiry received over 70 submissions earlier this year. We recommend careful reading of our own submission[31] and adoption of the most stringent standards in Victoria.

Urban planning should also play a key role in reducing air pollution. For example, **preventing bus stops or taxi ranks within 50m of major intersections** can considerably reduce exposure[32], as can **careful design of tunnels and major transport hubs** (see Question 5 for more). Similarly, the **use of green walls, roofs and vegetation in streetscapes can reduce exposure**[33] (but can also increase it if poorly designed). Consideration must also be taken when designing new facilities for vulnerable populations[34]. For example, the design of the proposed Alphington senior high school campus is currently suggesting the outdoor play area be on the busy Heidelberg Road, at a height similar to the truck exhaust. This current design will have serious implications for the air quality and noise pollution of the high school playing field. Similar considerations must be taken when planning all future childcare, school and nursing homes, or when major transport routs are developed or shifted (for example the new West Gate Tunnel Project). The Californian EPA is considered a world leader in this field and many of their best practices are summarized in their report on reducing road pollution at schools[34], for example the legislated distance for a new school or childcare centre is a minimum of 300m from truck traffic emissions.

Emerging Challenges

Future decisions on Victoria's air quality strategy should consider what the most equitable actions are and what possible unintended consequences may arise.

Here we highlight the challenge of equity when trying to reduce air pollution. Measures to improve air quality should consider population equity. Vulnerable people, and people who live in lower socio-economic regions, often near industrial parks and major transport hubs are at higher risk of poor air quality than others, and often less able to make changes themselves. **It is essential that the decisions made by government aim to be of equal benefit to all populations across the state.** Take for example the challenge of converting internal combustion engine vehicles to electric vehicles; unless the electricity powering these vehicles is from renewable sources, there is simply a shift in the source of air pollution from the roads to fossil fuel electricity generation, which will place further disadvantage on populations affected by emissions from power generation (e.g. the Latrobe Valley). This is inequitable and does not effectively improve air quality across the State.

Furthermore, in transitioning away from fossil fuels, there should be rigorous evaluation of the health and environmental impacts of alternative sources of energy. While bioenergy sources including wood heating, newer biodiesels, and energy from waste initiatives are potentially renewable, they rely on combustion. These sources risk increasing population exposure to combustion emissions and worsening air quality and health outcomes. Equally a shift to electric vehicles and solar needs to be accompanied by careful evaluation and planning around the full life cycle impacts and potentially new forms of population health risks from, for example, battery storage. **New solutions and approaches to meeting the energy needs of Victoria all need thorough evaluation of environmental, social and health impacts to avoid introducing new problems as unintended consequences of solving existing problems.** This requires substantial funding for ongoing research and evaluation of the impacts of newer energy sources.

3. Do you have any suggestions for further actions?

Development of an effective national emission inventory, detailed studies into indoor air quality and investment in an internally recognized measurement site

National emission inventory

An "emission inventory" is a database of emitted pollutants, including the type, source, location, time, magnitude and height. Emission inventories are used as the basis for tracking trends in emissions, modelling current air pollution, simulating potential air quality scenarios arising from different emission control pathways and help to assess and minimise the health impacts of air pollution. Thus, emission inventories are an essential foundation to developing scientifically justified air pollution policies.

Australia is an outlier among developed nations in lacking a comprehensive, national emission inventory. The National Pollutant Inventory[35] , an inventory of emissions from mostly industrial point sources, represents only one component of what an emission inventory should ideally contain. It does not capture domestic emissions (e.g. gas and wood combustion), area sources (e.g. from agriculture) and has very limited data on line sources (e.g. road traffic). Domestic, point and area emissions are, however, captured by some state-based metropolitan emission inventories (e.g. for the NSW Greater Metropolitan Region[36]), compiled by the State EPAs. Such regional emission inventories typically do not cover a whole State or Territory, have not been compiled for all States and Territories, are inconsistent in their methodologies,

what has been included and for which years they are valid. Consistency matters, as to model a region properly one must also consider the relative contributions of local emissions versus long-range transport; the atmosphere does not stop at the state border, nor does it stop at the edge of a regional emission inventory domain. Given that the EPAs are State agencies, a consistent and national emission inventory can only be achieved by coordination and cooperation, with Agencies from larger states providing supporting methodology to less well-resourced Agencies. **We encourage the Victorian EPA to engage with the corresponding agencies in other States and Territories to develop cooperatively a national, comprehensive and consistent emission inventory that is updated on a regular cycle** (e.g. every 3-5 years).

Indoor air quality

Australians, especially in urban areas, spend up to 90% of their time indoors, where they can be exposed to pollutant levels often several times higher than that of outdoors[37]. This can cause significant impacts to health, environment and the economy, with an estimated cost of $12B due to loss of productivity and illness in Australia[38]. Whilst we have good knowledge of outdoor ambient air quality (as demonstrated by this report), relatively little is known about indoor air quality. Reflecting this, there are currently no regulations or standards, and indoor air quality is not routinely monitored, and not in a consistent manner[39]. Major sources of indoor air pollution are building materials, fragranced consumer products, both of which emit VOCs, and unflued gas heaters that produce VOCs and other air toxics. New or recently renovated buildings, as well as those that are tightly sealed or energy efficient tend to have the poorest indoor air quality[37]. **We recommend that significant investment is made to develop and enforce indoor air quality standards, including a standard measurement technique.** This is essential in order to develop regulations that ensure Australians are not routinely exposed to hazardous air pollutants in their homes or workplaces.

Internationally recognized measurements

High-quality, high-resolution observational data is a key requirement in understanding the sources, trend, variability and prediction of air quality, as discussed above. This is essential knowledge to ensure any actions to improve air quality and reduce exposure to pollution are practical and effective. Whilst the EPA, the CSIRO and the Bureau of Meteorology take routine, trusted measurements of some air characteristics, Australia currently does not have an internationally recognized calibration site for total column aerosol optical depth and ground-level $PM_{2.5}$ measurements[13]. This makes improvement of remote sensing techniques difficult and can limit Australia's ability to be involved in international campaigns to improve air quality modelling and prediction. **We recommend investment in an internationally recognized $PM_{2.5}$ measurement site.** This should include instrument calibration to an internationally approved methodology and machine. Take for example ozone measurements. Measured by a Dobson instrument, all Dobson instruments worldwide (including Bureau of Meteorology instruments) are calibrated to one individual machine. This ensures an international standard for all ozone measurements and means comparisons to other instruments and remote sensing are legitimate and trusted. For $PM_{2.5}$ one international activity under the International Global Atmospheric Chemistry project is SPARTAN[13] and their aim is to relate remote sensing of $PM_{2.5}$ and source apportionment to population exposures in urban environments. New methods are allowing the estimation of exposure to air pollutants from satellite measurements[14,15]; however this could not be possible without international collaboration. Victoria, Australia and the broader international community would benefit hugely from a network $PM_{2.5}$

measurements and their compositional source apportionments. We consider ourselves experts in this field and would be pleased to offer our advice on the feasibility of such a monitoring site.

4. Are there any air quality actions you believe should be avoided? Why?

Inaction on air quality will carry a significant health, environment and economic burden as Victoria grows

Australia cannot afford inaction allowing air pollution to worsen. Many of Australia's air pollution regulation failures can be attributed to no national body with the power to implement, regulate and enforce air pollution legislation[40]. The National Environment Protection Measures are outdated in terms of thinking and knowledge and have failed multiple times in their history to make important decisions about air quality standards. Because of these failures, Australia is significantly lagging behind most developed nations and many developing nations in terms of policy, technology and education.

Victoria's population is expected to increase to 10.1 million people by 2051, with the majority of that growth forecast for the Greater Melbourne region[41]. Inaction by federal and state governments to consider the increased burden of population, transport, infrastructure and energy upon air quality will have significant environmental, health and economic consequences. Melbourne is currently ranked as the Global Livability Report's most livable city for 2017[42]. This report considers many metrics relating to livability including climate comfort, transport, energy and health. Increased air pollution, due to increased transport and energy demands, is likely to put the city's future livability status at risk. Recommendations from Infrastructure Australia to maintain Melbourne's livability status include increased accessibility to public transport, disincentives for road users, reducing the carbon footprint of the city, investing in green infrastructure and having effective and transparent policy, planning and delivery[43].

5. Are there particular areas of air quality (either pollution sources or geographic locations) you think the government should target for air quality improvement? Why?

Reduction, monitoring and increased regulation of point source emissions, greater monitoring of vehicle emissions and capturing fugitive emissions.

We provide below several recommendations of areas to be targeted for air quality improvement. This is in addition to greater monitoring if air quality over vulnerable geographic locations already identified (schools, childcare facilities, aged care facilities, hospitals, lower socio-economic regions in the vicinity of industry estates, airports, major transport hubs and routes etc.).

Point source emissions

Coal fired power stations

The updated National Pollution Inventory shows electricity generation account for 92% of sulfur dioxide and NO_x pollution, and 97% of $PM_{2.5}$ in the Latrobe Valley[35]. Whilst there was no change in $PM_{2.5}$ emissions in the Latrobe Valley between 2015/2016 and 2016/2017, there was a 40% increase in mercury emissions[35], which will be discussed below.

Whilst ultimately, we are suggesting a complete phase out of fossil fuel power generation, we accept that this is a long-term goal and cannot be implemented quickly for numerous reasons. We suggest therefore,

that interim action should be taken to quickly reduce toxic emissions from power generation (and transport). **We suggest measures that require the upgrading of coal-fired power generation equipment with pollution reducing technology such as flue-gas desulfurization units and catalytic converters.**

Currently point source emissions from major coal fired power stations are only provided on a yearly basis and are not directly measured[35]. There is no regulated technique in how these emissions are reported. This leads to inconsistency across the inventory, as well as within individual emitters themselves. For example, in the most recent National Pollutant Inventory the fine particulate matter emitted from the Yallourn power station over the last two years (2015/2016 and 2016/2017) was reported to be only 30% of what it was in previous years (2013/2014 and 2014/2015), despite no new equipment being installed to reduce emissions between 2015/2016 and 2016/2017[35], therefore a dubious reduction. **Victoria needs strict, consistent and independent monitoring and regulation of point source emissions at active coal fired power stations to ensure the emissions are accurate, are kept under the recommended standard, and that emission reduction goals are being met.**

The health costs of coal fired power in Australia are estimated to be approximately AUD$2.6 billion per year (not including the contributed effects to climate change)[44]. In situ monitoring of the air quality of communities near these point sources will allow for greater understanding of health impacts and drive interventions for continual improvement in air quality. **Air quality monitoring should take place at population centres near major coal-fired power generators in order to provide effective and timely health information to the local community.**

Transport

Major transport tunnels can also be a significant source of air pollution, both within the tunnels and at their exhaust points. Currently in Australia, only one tunnel is fitted with some form of filtration (Sydney's M5 East tunnel) to reduce pollution, and the use of filtrations systems is not included in future transport planning (which leads to costly and avoidable court actions). Filtration systems such as the Aigner tunnel technology can significantly reduce the particulate matter and carcinogenic diesel emissions[45]. **We suggest that all future transport tunnels are fitted with appropriate filter systems.** A similar problem exists at major train stations, in which diesel emissions from trains can accumulate. For example, Victoria's Southern Cross Station has routinely been identified as having poor air quality due to fumes, with large extractor fans having to be installed to help mitigate the problem. **Transitioning to electric trains, retrofitting of the current engines, better fuel standards and regulations to stop trains from idling whilst stopped (provision for plug-in technologies) should be introduced to improve the air quality of the State's major transport hubs.**

Wood heater emissions

Wood heaters disproportionately contribute to health harms from air pollution for many reasons. They emit extremely high concentrations of many air pollutants, including particulate matter, compared with other distributed sources such as motor vehicles, and they are widely distributed throughout communities. Further, despite increasingly stringent emissions standards since the 1980s in Australia, there has not been an associated documentation of improvements in air quality[46]. This is likely to be because their emissions depend on heater operation and community education campaigns about efficient lower-emissions burning have rarely been successful in improving ambient air quality[47].

Rapid gains in air quality and health can be achieved by reducing emissions from this source through actions such as government subsidies for households to switch to non-combustion sources of heating such as electricity[48] or to use less polluting alternatives, such as pellet or secondary combustion (dual chamber) stoves. Neither of these specialized biomass stoves are dependent on user operation to achieve emissions an order of magnitude lower than the most efficient wood heaters currently available. In some locations, outright bans could be appropriate.

Shipping emissions

Over 80% of Victorians live within 50km of the coast[49], and coastal activities (fishing, recreation, tourism, goods transport) is associated with considerable economic revenue for the nation[50]. Emissions of sulfur dioxide from shipping lead to down-stream formation of additional particulate matter. The United Nations' International Maritime Organisation (IMO) recently lowered the world-wide sulfur content limit for shipping fuel from 3.5% to 0.5%, and Australia as a member nation must comply; these regulations come into force in 2020[51]. Tighter regulation exists around North American and Northern European coastal areas, limiting the sulfur content of shipping fuel to 0.1%[52,53]. Modelling work estimates that these changes lead to a reduction in premature deaths by tens of thousands of thousands globally[54]. Given the significant economic benefit associated with maritime activities, the well-documented health impacts of secondary particulate matter (e.g. in NSW[55]) and the demonstration that such large-scale emissions control is possible in coastal regions, **we suggest that the Victorian Government implement a low sulfur emission control area around populated coastal areas**. This would lead to a reduction in CO_2, NO_2 and SO_x emissions overall and particularly around the coastal environment[54]. Another potential area of emissions control is the use of plug-in electricity supply (instead of burning diesel) at port, especially for large cargo and cruise ships.

Landscape fires

Greater coordination between agencies when burning off or when natural fires are occurring near populated regions is required. Fires, including prescribed fires, are a major source of particulate matter pollution for Victoria (and New South Wales[56,57]) and significantly reduce air quality. Prescribed fires are often conducted during cool, low wind conditions, which can mean that smoke is not being transported and mixed throughout the atmosphere and instead accumulates. A particularly good example of this occurred on May 1st 2018, where still weather over a couple of days and prescribed burns on the outskirts of Melbourne resulted in $PM_{2.5}$ levels of over 90$\mu g/m^3$. **Coordination between fire agencies, weather forecasters and health professionals should be improved to ensure the public is warned when hazardous levels of particulate matter due to biomass burning may occur.**

'Real' vehicle emissions

Diesel vehicle emissions of NO_x and $HC+NO_x$ measured in the 'real world' (on Australian roads) have recently been found to be 370% and 292% higher than those provided by laboratory tests and use 23% more fuel[58]. Making direct measurements of on-road vehicle emissions in the real world is now possible using remote sensing technologies[59,60]). Air quality sensor networks in Victoria, and elsewhere in Australia, have generally avoided road-side monitoring, which is a key element of air pollution monitoring in other industrial nations (e.g. the EU[61]); roadside monitoring would support estimation of real-world vehicle emission estimates and improve our understanding of the actual exposure to motorists, pedestrians and cyclists on or near Victorian roads. **Investment in roadside monitoring and improving remote sensing of**

air pollution, as supported by the Victorian Automobile Chamber of Commerce[62], is a key action in effective monitoring and regulation of real vehicle emissions.

Bowser emissions

Fugitive emissions at fuel bowsers can significantly worsen local air pollution. VOCs escape from petrol stations, are carcinogenic in their own right, but also go on to react with sunlight and NO_x to form ozone and contribute to photochemical smog. Currently, Victoria has no regulation for vapour recovery systems[63], whilst NSW has recently implemented stricter regulations upon fuel outlets[64]. The Victorian Automobile Chamber of Commerce has recommend the fitting of Onboard Refueling Vapour Recovery technology to vehicles to reduce fugitive emissions from both refueling and diurnal venting sources[62]. **Regulation to install vapour recovery technology at the fuel outlet and onboard vehicles should be introduced to reduce the occurrence of VOC and ozone pollution.**

6. Are you able to provide any data or information that will help government assess the feasibility and cost-effectiveness of air quality management actions?

The authors of this report consider themselves experts in air quality, atmospheric chemistry and health impacts.

We are willing to provide research expertise on the feasibility and cost-effectiveness of future measurement campaigns or long-term measurement sites, we have the tools and knowledge to perform detailed air quality measurements and modelling and can offer infrastructure support as detailed below.

AIRBOX

The mobile air chemistry laboratory AIRBOX (Atmospheric Integrated Research facility for Boundaries and Oxidative Experiments) is an Australian Research Council (ARC) and University-led facility that aims to understand the aerosol and atmospheric composition[65]. It is a custom-built shipping container which can be deployed anywhere from the Great Barrier Reef to the Southern Ocean. It has nine in-house instruments (including spectrometers, nephelometer, particulate sampler, lidar, meteorological instruments) and capacity for guest instruments (for example NOx and Ozone measurements). AIRBOX is the ideal facility to perform high quality air composition measurements at any given place. It can provide detailed information about air chemistry and aerosol composition and concentration, and how these are interacting with local weather. Observations such as these are beneficial in determining source apportionment and pollution trends and variability. This can aid decision making on the most effective action to reduce air pollution.

Health impact assessment

CAR researchers and collaborators have specific expertise in applying health impact assessment methods to quantify the health burden due to air pollution and quantifying the health benefits of future changes to air pollution under policy relevant scenarios. The results of these health impact assessments can then be use to estimate the health costs due to air pollution. Examples of CAR's work in this area include quantifying the health burden due to air pollution in Sydney[66], the health impacts of shipping emissions in Sydney[55] and the health impacts of fire smoke pollution in Sydney[56,57].

7. Do you have any other suggestions on how to secure a clean air future?

Increased regulation of individual pollutants, consideration of the co-benefits of phasing out fossil-fuel based power and transport and planning for increased intensity and occurrence of extreme weather.

Regulation of pollutants

Ultrafine particle removal

Ultrafine particles (particulate matter less than 0.1μm) are predominantly released by vehicle emissions, in particular diesel emissions. Whilst ultrafine particles make up only a small fraction of the total mass of particulate matter measurements, they can make up large fractions of the total number of particulate matter on busy transport routes. The small size of ultrafine particles make measurement difficult, however, their size has significant adverse health impacts as they can penetrate deep into the lungs and cross into the blood stream even more effectively compared to $PM_{2.5}$[67]. The most appropriate action to curtail ultrafine particle emissions is to reduce diesel fuel use. As mentioned, diesel vehicles have experienced a rapid increase in popularity in the last decade. **Victoria should act to remove diesel vehicles from cities and freight and provide disincentives for their further uptake to reduce ultrafine particle exposure.** Removing light passenger diesel vehicles from approved vehicle procurement lists for the state-owned vehicle fleets is a tangible action that Victoria can make to ensure that the growth of diesel in fleets[68] is not supported by the State Government. As diesel emissions are class 1 carcinogens, actions that support the growth of diesel emissions could be seen as a violation of duty of care that employers have to the community and employees. Further actions can also include reducing the sulfur content in fuel[69], which will be discussed below, octane rating, combustion efficiencies, catalytic converter efficiency, and driving behaviours.

Sulfur removal

Lowering of the sulfur content in fuel can have many co-benefits including the reduction of sulfur, the reduction of ultrafine particles, improved performance of the catalytic converter over a longer time span and subsequent reductions in other pollutants including CO, NOx and UHCs. It is clear by lowering sulfur content, numerous health benefits are achieved, as well as increased vehicle performance[70]. Currently, 10 ppm is the legislated limit of sulfur in petrol sold in the US, EU, Japan and South Korea. Australia's standard petrol has 15 times that amount[71]. Victoria and Australia should aim to meet these targets in order to improve air quality. Australia now relies on imported cars, predominately from the regions mentioned above, and hence the emissions technology requires reduced sulfur petrol to perform optimally. **The Victorian government should support a national standard for low sulfur content of petrol of 10 ppm or less.** Without these actions, Australia risks being left behind by advancing international motor industries[71].

Mercury removal

In 2013 the global Minamata Convention on Mercury was agreed upon[72], of which Australia is a signatory. Despite the convention coming into place in 2017, Australia is yet to ratify the agreement and is the world's 16th largest emitter of mercury[73]. Mercury is released into the atmosphere predominantly via coal fired power stations and non-ferrous metal manufacturing, as well as biomass burning and to a lesser extent vehicle and refinery emissions. In the atmosphere mercury is long lasting and can be transported around the globe. Mercury is able to enter the food web via rainfall and deposition, particularly over oceans, streams and lakes, including remote locations such as the Antarctic sea ice region. Once in the

food web, mercury bioaccumulates at the top of the food chain (for example in tuna) and can cause serious health issues when consumed in large quantities.

Currently, Victoria has no specific mercury legislation[74] whilst its brown coal fired power stations Yallourn and Loy Yang B (and Hazelwood prior to its closure) are the largest single emitters nationally[75]. Many of the technologies that remove sulfur and particulate matter are able to simultaneously remove mercury. Reducing sulfur content in fuel can also reduce mercury emission. **Installing sulfur scrubbers at coal-fired power stations and lowering the sulfur content of fuel can reduce Victoria's and Australia's mercury emissions in line with the Minamata Convention.**

$PM_{2.5}$ Standards

Victoria has in place targets to reduce the acceptable $PM_{2.5}$ concentrations to 20 $\mu g\ m^{-3}$ over 24hr period (down from 25 $\mu g\ m^{-3}$) and 7 $\mu g\ m^{-3}$ over one year (down from 8 $\mu g\ m^{-3}$) by 2025[74]. With expected population and transport increases and the current uptake of diesel vehicles, the **actions discussed in this report must be strong enough to reduce particulate matter pollution in line with the future $PM_{2.5}$ targets**, to ensure these levels are not routinely exceeded.

CO_2 reduction co-benefits

Particles in the atmosphere (aerosols) interact with the climate in two ways, known as the direct and indirect effects. The direct effect is where aerosols physically block sunlight from reaching the surface of the Earth, having a cooling effect. The indirect effect is where aerosols interact with clouds; more aerosols make clouds brighter and longer lasting, which can also have a cooling effect. In addition, aerosols can also act to suppress precipitation. Aerosol pollution has played an opposing role (cooling) to greenhouse gas warming in the industrial period[76]. **As air quality actions reduce aerosols in our atmosphere, we can expect to see an acceleration of global warming due to greenhouse gases if they are not concurrently reduced. For this reason, removal of aerosol pollution from energy generation and transport should be performed in conjunction with a reduction of CO_2 emissions in order to further limit global warming.** Many of the co-benefits of doing so are described below.

Renewable energy generation

A more efficient and environmentally beneficial means of improving air quality and human and environmental health is to phase out the use of coal-fired power generation, rather than modifying the power stations to only reduce toxic emissions. This has the co-benefit of reducing CO_2 emissions, which unmitigated will lead to dangerous climate change. Electricity generation in Victoria currently makes up 72% of CO_2 emissions[77] and 90% of the State's electricity comes from brown coal[78]. Victoria's total CO_2 emissions have seen little change since 1990[77]. Significant change must occur if Victoria is to meet its 2050 target of net zero emissions[8]. Whilst Australia's power generated CO_2 emissions declined in the first quarter of 2018 this was primarily due to the closure of the Hazelwood coal-fired power station[68]. Victoria aims achieve an interim target of 25% renewable energy by 2020 (currently at 14%)[79] and CO_2 emissions 15-20% below 2005 levels (currently achieving an 11% decrease[77]). **The State should act to rapidly increase renewable energy and phase out coal-fired power generations if they intend on meeting their future emission and energy commitments.** This will have the dual benefit of avoiding dangerous climate change and reducing air pollution in power-generating communities.

Reduce or end the use of internal combustion engine vehicles

Regulation to reduce or end the use of internal combustion engine vehicles is essential not only to reduce air pollution but also CO_2 emissions. Total transport CO_2 emissions have risen by approximately 10% from 2005 to 2016 in Victoria[77], with no clear end in sight. In the first quarter of 2018 alone, Victorian (and Australian) diesel CO_2 emissions have seen an increase[68]. Diesel fuel produces 17% more greenhouse gases than petrol, and across Australia now makes up to half of all petroleum carbon emissions[68]. Diesel is particularly toxic and even Euro 6 technology vehicles produces high NOx levels.

A staged and planned outright ban on internal combustion engine vehicles (including public transport) will be the most effective way to reduce air pollution in cities and will produce co-beneficial CO_2 emissions reductions. This should be coupled with incentives for electric car uptake and investment in the infrastructure to support them. However, transitioning to electric cars is not enough. Unless electric cars can be charged with net zero carbon electricity, the air pollution, including CO_2 production, is transferred to power generation areas, such as the Latrobe Valley. This can actually be more carbon intensive than an internal combustion engine vehicle[80] and increases energy demands across on the grid. A similar argument can be made for electrified public transport. **An uptake of electric vehicles, including public transport, should be encouraged in conjunction with a transition to net zero carbon emissions of the energy sector to avoid the transfer of toxic emissions from vehicles to coal power generator regions.** As stated in the National Energy Emissions Audit, until Australian Governments take action, transport emissions will continue to rise as Australia is left with one of the least efficient, highest emission vehicle fleet in the world[68].

Climate change challenges

Anthropogenic global warming will present further challenges for Victoria's air quality. Under warming trends and increased population, summertime smog (NO_x, VOCs and ozone) has been identified as a concern for cities by the Victorian EPA[81]. In addition to this the EPA identified the increased occurrence of droughts (and therefore dust) and bushfires as potential risks to Victorian air quality[81]. We would like to emphasize the importance of understanding extreme weather events, including extreme heat waves and extreme wind events, both of which can exacerbate drought and fire conditions. Of particular importance in these events is the communication of real-time information. **A warning system communicating to the relevant populations the risks of smoke exposure due to fires or particulate matter from dust storms should be in place as extreme weather events become more frequent and severe in the future.** These actions require detailed forecasting capabilities of extreme weather events and established communication systems, such as those now in place for bush fire risk in Victoria. Investment in remote sensing of air pollution and greater modelling capabilities should be a priority to better inform authorities and the community of the risk posed to air quality by increased extreme weather under climate change.

Summary of recommendations

Reduce emissions

- Conduct a comprehensive and consistent study to produce a marginal abatement cost curve for all actions that may be taken to improve air quality to enable their prioritization, taking into account air inequity issues
- Provide subsidies for households with wood heaters and unflued gas heaters to switch to non-combustion methods of home heating.
- Support national and state regulations to reduce the allowable sulfur content in petrol to 10 ppm or less, for both road, or rail transport and shipping
- Provision of disincentives to curb diesel vehicle uptake and use
    - Remove diesel vehicles from procurement lists for government fleet purchasing
    - Transition away from diesel use: vehicles and machinery that are government-owned
    - Consider banning diesel vehicles from urban areas
    - Switch diesel trains to renewable electricity and retrofit current engines to electric drive trains
    - Introduce regulations to stop trains from idling whilst stopped at stations by providing plug-in technologies
- Provision of infrastructure and incentives to reduce fossil-fuel vehicle use
    - Accelerate transition to zero-carbon transport fleets for all levels: private, public and business
    - Provide zero-carbon electric vehicle charging infrastructure in public spaces
- Engage with VicRoads to change driver behaviour
    - Educate public on wasteful idling / create anti-idling zones
    - Enforce anti-idling zones near sensitive population groups
    - Make anti-idling part of licensing process
- Upgrade coal-fired power generation equipment with pollution reducing technology such as flue-gas desulfurization units and catalytic converters.
- Support large-scale observational study into Victoria's indoor air quality

Observe air quality and disseminate information

- Support observational products from ground-based and satellite platforms to provide real-time air quality data to the public
    - Report aerosol number density, aerosol composition and air toxic concentration observations to international bodies such as Global Atmospheric Watch – Urban.
    - Support retrieval of aerosol products from satellites as a means of determining air quality trends, variability and human exposure for health studies
    - Include current air quality information in media's weather and traffic updates
    - Support the installing and reporting of in situ monitoring at major coal-fired power generators in order to provide effective and timely health information to the local community.

Empower the public to take action

- Support, build, test and operationalize high resolution air quality forecast modelling of personal exposures

  - Include air quality forecasts in conjunction with the Bureau of Meteorology's regular weather forecasts
- Support the coordination between fire agencies, weather forecasters and health professionals to ensure the public is warned when hazardous levels of particulate matter due to biomass burning may occur
- Support development of air action plans for schools, sports events, health, child and age care facilities and other sensitive population groups

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