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Submission to NEPM air quality review regarding cost benefit analysis

Submission to NEPM

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Summary

The environment ministers from the Commonwealth, state and territory governments are considering changes to Australia's ambient air quality standards for ozone, nitrogen dioxide and sulphur dioxide (O3, NO2 and SO2). The standards proposed are inadequate and will likely be met with minimal abatement effort. The proposed standards appear directed towards preventing air quality from getting worse, rather than at achieving air quality that maximises the welfare of the Australian community.

The process and supporting documentation for this review of air quality standards is not fit for purpose. The benefit-cost analysis in its own words "does not necessarily provide an indication of the likely costs and benefits of meeting alternative AAQ standards."

The benefit-cost analysis does not consider the economic impacts of either the proposed draft standards or the range of standards that have been proposed by the Air Thematic Oversight Group of various government officials. Instead, it is a benefit-cost analysis of an "Abatement package" of nine potential policy measures, largely retrofitting industrial facilities. The Abatement package is not being considered for implementation by decision makers.

There is no transparency around how the Abatement package was developed. The nine measures were picked via a multi criteria analysis (MCA) in 2016. This analysis has not been released because the consultant that wrote the MCA does not want the analysis publicly released. It is not clear why this is the case, or why the rights to release the report do not lie with the National Environment Protection Council.

What is known about the MCA is that it was based on a literature review of 64 sources with an average publication date of 2009. Much of the analysis is based on material that predates commercial renewable energy, the Paris Agreement and various state policies on energy and emissions standards. This is all the more concerning as MCA is a very subjective assessment technique, not based on strong economic foundations and described by prominent economists as "a significant risk to the quality of policy formulation by Australian governments."

The benefit-cost analysis compares the costs and benefits of the Abatement package to a 'business as usual' (BAU) emissions scenario. This scenario is also based on outdated information. For example, the Victorian forecast "assumes" that in 2030 "most electrical power will be generated using natural gas, brown coal, co-generation and tri-generation … Smaller amounts of power will be generated using wind, black

coal, hydro-electric, biomass (from landfill), liquid fuels and solar." This assessment is derived from a 2006 report from the Australian Bureau of Agriculture and Resource Economics which forecast the amount of solar energy in 2019 at just $1/20^{th}$ of current levels.

To be clear, Australian decision makers are making air quality policy decisions in 2019 based, at least in part, on forecasts made in 2006 that have been shown to significantly underestimate the potential for renewable energy and other technologies that can improve air quality.

Beyond comparing two badly modelled scenarios with limited relevance to current policy decisions, the benefit-cost analysis underestimates the benefits of improved air quality while overstating the costs of the Abatement package.

On benefits, there is no attempt to quantify or meaningfully assess reductions in health impacts that would not result in hospitalisation. There is no consideration of improvements in workforce productivity, or of impacts on agriculture and ecosystems. Such estimates have been made in international studies and are usually found to be substantial, if highly variable depending on assumptions made.

Health benefits considered only relate to changes in ambient air quality. However, the Abatement package would bring considerable health benefits to the workers in and neighbours of industrial facilities and other emissions sources. These local level benefits of reduced pre-dispersal pollution are ignored.

By contrast, local level costs are included. Every megawatt of capacity in every power station that would need retrofitting attracts a cost – even of the Hazelwood power station that has already closed. Hazelwood is included in the analysis because despite announcing its closure in November 2016.

Many costs are overstated. Taking SO2 out of power station emissions is done by 'flue gas desulphurisation' (FGD). The benefit-cost analysis prices this process at AUD 1,090 per kilowatt of power station capacity, based on an extrapolation of price rises recorded in a 2010 source. The United States Energy Information Agency estimates the average installed FGD cost at AUD 150 per kilowatt in 2017.

A similar overstatement seems to be included in the assessment of NO2 reduction measure Selective Catalytic Reduction (SCR). Furthermore, the benefit-cost analysis appears to include the costs of SCR to both gas and coal fired power stations, while the air quality modelling assumes SCR is not applied to gas-fired power stations.

The result of the benefit-cost analysis is that the costs are up to 100 times greater than the benefits of air quality improvement. This result is a major outlier in the economic literature, where international studies almost always show that the benefits of air quality improvement outweigh the costs. For example, an analysis of the economics of the US Clean Air Act estimated that its benefits could have been 90 times its costs.

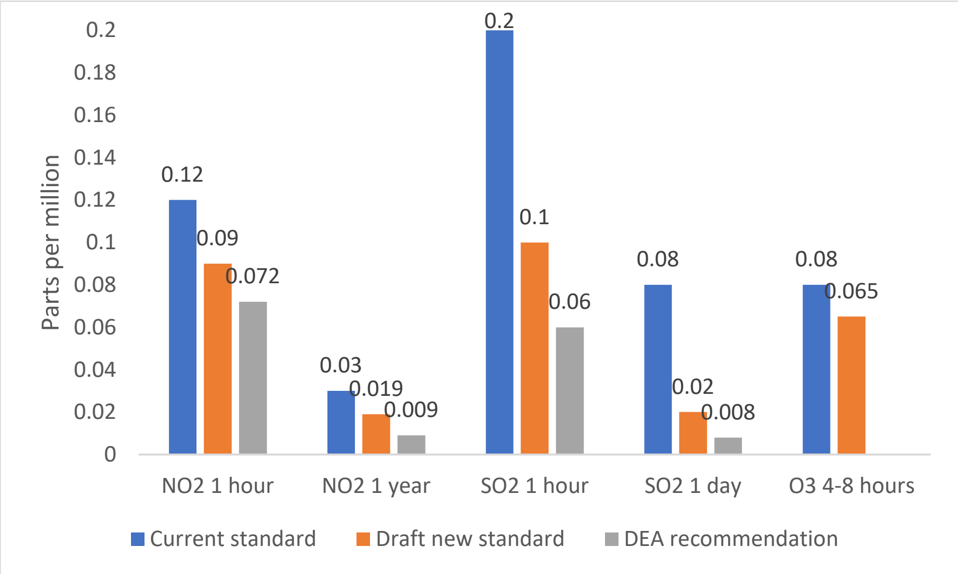
This difference is not due to unique air quality conditions in Australia, but due to the flawed process that has been employed by the authors of these studies. Decision makers should ignore this benefit-cost analysis and air quality modelling exercise and instead seek advice from independent doctors and health researchers to set ambitious air quality standards that maximise the wellbeing of the Australian community.

Introduction

PROPOSED CHANGES TO AMBIENT AIR QUALITY

The National Environment Protection Council (NEPC), consisting of the environment ministers from the Commonwealth, state and territory governments, is reviewing the National Environment Protection (Ambient Air Quality) Measure (NEPM) standards for ozone, nitrogen dioxide and sulphur dioxide (O3, NO2 and SO2). The current standards, draft standards proposed by the NEPC jurisdictional agencies (environment departments and environmental protection agencies of the states and territories) and recommendations of Doctors for the Environment Australia (DEA) are shown in Figure 1 below:

Figure 1: Current and proposed air quality standards



Sources: NEPC (2019) *Draft variation, DEA submission*. Note the standard for ozone changes from a four to an eight hour measuring period.

The first thing to note about the current standards is that they are almost never exceeded, at least for NO2 and SO2. Tables 2-2, 2-3, 2-4 and 2-5 in the air quality study of the supporting documents show that there has not been an exceedance of any current SO2 or NO2 standard in the period from 2003 to 2016.[1]

[1] Pacific Environment (2018) *Appendix A: Air quality study,* http://www.nepc.gov.au/system/files/consultations/8710bdfb-ed01-4df9-8697-bc75956991a1/files/aaq-nepm-impact-statement-appendix.pdf

The draft new standards, shown in Figure 1 above, are not likely to change this. For example, in discussing potential changes to NO2 one hour standards, the air quality study notes:

> Under existing conditions, the results indicate that for the most urbanised airsheds it will be a significant challenge to comply with the proposed 1-hour standard for NO2 of 40 ppb in future years. Compliance with the proposed standards of 80 ppb and 97 ppb should generally be possible in all airsheds. All jurisdictions would be likely to achieve continued compliance with the current 120 ppb standard.[2]

Figure 1 shows that rather than taking up the "significant challenge" of complying with tougher standards, the draft recommendations have simply recommended standards that are likely to be complied with without any abatement action.

If standards are never breached and new standards likely to be achieved without action, it is unclear what the point of them is. For this reason, the Doctors for the Environment Australia (DEA) submission recommends standards that could challenge environmental managers and, in doing so, provide health benefits to the community.

From an economic perspective, standards that cost nothing and achieve little are scarcely worth implementing or examining. The NEPM process should have included assessment of a range of possible changes to standards, including some that would be very challenging. Only through consideration and assessment of policies and standards that make a difference can good decisions be reached.

Unfortunately, the air quality modelling does not consider such scenarios and the benefit-cost analysis (BCA) that accompanies it is deeply flawed.

BENEFIT-COST ANALYSIS

As part of the review a BCA has been conducted by consultants, Aurecon. This submission focuses mainly on the BCA and related documents.

Aurecon's analysis finds benefit-cost ratios (BCR) for selected abatement measures to reduce to SO2, NO2 and O3 are estimated at 0.01, 0.07 and 0.05 respectively. In other words, they estimate that the costs of SO2 reduction are 100 times greater than the benefits, costs 14 times greater for NO2 and 20 times greater for O3.

Aurecon's results are in stark contrast to most international studies on the economics of air quality improvements. This literature consistently finds that health and other benefits of improved air quality outweigh costs. Aurecon's BCRs are remarkably low

[2] Pacific Environment (2018) *Appendix A: Air quality study*, p13.

considering that many of the measures considered by Aurecon are standard internationally. When the US EPA evaluated the 1990 Clean Air Act it found:

> Our central benefits estimate exceeds costs by a factor of more than 30 to one, and the high benefits estimate exceeds costs by 90 times. Even the low benefits estimate exceeds costs by about three to one.[3]

An EU study on its clean air strategy similarly estimated:

> Quantification of the benefits of the revised emission ceilings indicates that they will exceed costs by a large margin. Taking a conservative position on the valuation of mortality leads to benefits:cost ratios in excess of 14, taking a less conservative position pushes the ratio above 50.[4]

Many similar studies and results exist. While there are differences between the USA, the EU and Australia, and between the methodologies of these studies, two points are worth noting. Firstly, benefit-cost ratios of air quality improvements are usually far above 1:1, meaning that benefits outweigh costs and it is economically desirable to improve air quality. This is because a huge number of people benefit and even if benefits to an individual are small, the large number of people who experience them means they sum to a large number. Costs, by contrast, are often limited to a handful of polluters.

The second thing to note from many air quality economic assessments is that benefit-cost ratios vary widely depending on the assumptions. Sensitivity analysis in the above quote changes benefit-cost ratios from between 3:1 and 90:1. This is driven by the large uncertainties around the value of impacts on health and people's economic productivity as well as impacts on agriculture and ecosystems.

The contrast with Aurecon's results could not be more stark. Aurecon's sensitivity analysis is presented in Figure 2 below, showing benefit-cost ratios far below one and very little variation from changed assumptions:

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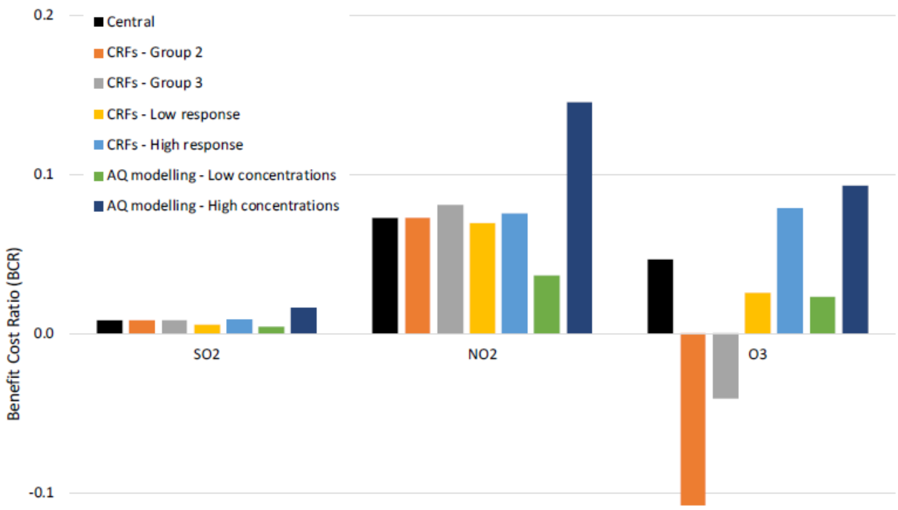
[3] Environmental Protection Authority (2019) *Benefits and Costs of the Clean Air Act 1990-2020, the Second Prospective Study,* accessed 10 July 2019, https://www.epa.gov/clean-air-act-overview/benefits-and-costs-clean-air-act-1990-2020-second-prospective-study

[4] Amann et al (2017) *Costs, benefits and economic impacts of the EU Clean Air Strategy and their implications on innovation and competitiveness*, p3, http://ec.europa.eu/environment/air/pdf/clean_air_outlook_economic_impact_report.pdf

Figure 2: Aurecon sensitivity of results to changes in technical assumptions



Source: Aurecon (2018) *Review of Ambient Air Quality NEPM for SO2, NO2 and O3.*

Figure 2 shows that Aurecon's estimates for the value of changes to SO2 pollution barely change from the extremely low ratio of 0.01, while NO2 estimates show a similar trend around 0.07. Most unusual of all is the finding that benefit-cost ratios for reducing ozone pollution could be negative. Negative cost benefit ratios suggest that benefits are negative, while costs are substantial. This suggests that under some of Aurecon's assumptions introducing ozone pollution control measures would make health outcomes worse.

To be clear, the results of Aurecon's benefit-cost analysis are a major outlier in economic assessment of air quality changes. This is partly due to the overall approach and partly due to poor execution. The analysis does not assess the policy changes that decision makers are contemplating, but instead evaluates a series of engineering measures selected in a different process. As a result, it offers decision makers little useful information in assessing the merits of the proposed policy changes. In our view Aurecon's analysis is deeply flawed and misleading, and should be excluded entirely from the NEPM process.

Flawed approach to scenario modelling and BCA

Aurecon's BCA does not actually assess the costs and benefits of potential changes to air quality standards. Instead, it estimates the costs and benefits of an 'Abatement package scenario' relative to a business as usual (BAU) scenario, as Aurecon explain:

> While the CBA estimates the costs and benefits of the 'Abatement Package scenario' at a national level, it does not necessarily provide an indication of the likely costs and benefits of meeting alternative AAQ standards.

It is worth emphasising that the BCA provides no assessment of alternative standards. This is unusual, as a range of potential values for the standards have been considered by the Air Thematic Oversight Group (Air TOG), made up of officials from all Australian jurisdictions, according to the accompanying air quality modelling report.[5] Figure 3 below reproduces the range of standards considered for SO2. Similar tables are presented for NO2 and O3:

Figure 3: Current and proposed standards for sulphur dioxide

Pollutant	Averaging period	Concentration (ppb)	Source
SO_2	1-hour	75	Air TOG
		100	Air TOG
		150	Air TOG
		200	AAQ NEPM
	24-hour	7	Air TOG
		20	Air TOG
		40	Air TOG
		80	AAQ NEPM
	Annual	10	Air TOG
		20	AAQ NEPM

Source: Pacific Environment (2018) *Appendix A: Air quality study.*

Figure 3 shows that the Air TOG proposed or considered several different standards for different measures. The CBA provides no analysis to help evaluate these different options.

Furthermore, it is not clear which of the various proposed standards the Abatement package scenario meets, if any. Pacific Environment's section on the Abatement package simply states:

[5] Pacific Environment (2018) *Appendix A: Air quality study*, http://www.nepc.gov.au/system/files/consultations/8710bdfb-ed01-4df9-8697-bc75956991a1/files/aaq-nepm-impact-statement-appendix.pdf

> Achieving compliance with the proposed air quality standard for SO2, NO2 and O3 would, in some cases, require the introduction of new abatement measures to reduce emissions from specific sectors.[6]

Nowhere is it made clear which combination of standards the Abatement package would meet. The recommendations outlined in the draft standard appear to have only been finalised in 2019 and published in May this year.[7] By contrast, the process to select abatement measures involved a literature review completed in March 2016. Modelling of BAU and Abatement package scenarios also appears to have been done in 2016 (and based on much earlier data), well before the draft recommendations had been made. Rather than modelling BAU and assessing Abatement packages or other scenarios that comply with particular standards, the approach appears to have been to simply assess if emissions would be kept at modelled BAU levels and if so, this was considered compliant, at least for SO2 and NO2:

> It was considered that, if the 2040 projected emissions with abatements were less than the calculated 2016 base load emissions, then compliance could be assumed to be achieved with the abatements applied.[8]

Nowhere in the description of the Abatement package is it made clear what standards it is aiming to reduce emissions to.

A key problem with estimating costs and benefits of the Abatement package and the BAU scenarios based on 2016 data is that unforeseen improvements in emissions reduce both the costs and the benefits in the modelling. This is spelled out by Aurecon when discussing the unforeseen closure of petrol refineries between the research for the BAU and the final publication:

> Since the publication of the inventory [used for the BAU calculations], there has been a closure of petrol refineries in NSW and QLD. Therefore, the costs and emission reductions could be lower than estimated in this CBA. This simplification is likely to result in a reduction in the magnitude of the NPV for SO_2 (i.e. both reduced costs and benefits), but not the sign.

The closure of refineries has improved Australian air quality. This provides obvious health benefits and reduces the costs of improving air quality. From the perspective of the Australian community, Aurecon is wrong to state that this reduces both costs and benefits. Only when seen through the narrow scope of the Abatement package

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[6] Pacific Environment (2018) *Appendix A: Air quality study*, p21.

[7] NEPC (2019) *Draft Variation to the National Environment Protection (Ambient Air Quality) Measure for sulfur dioxide, nitrogen dioxide and ozone Impact Statement*, http://www.nepc.gov.au/system/files/consultations/8710bdfb-ed01-4df9-8697-bc75956991a1/files/aaq-nepm-draft-variation-impact-statement-o3-no2-so2.pdf

[8] Pacific Environment (2018) *Appendix A: Air quality study*, p22.

scenario does it reduce benefits. It reduces the impact of the Abatement package because the package would no longer reduce emissions from the closed refineries.

This perverse logic pervades Aurecon's BCA and the air quality modelling it is based on. If the NEPC were making decisions relating to this specific Abatement package, the BCA could be of some use. However, the NEPC is assessing standards considered by the Air TOG and those in the draft recommendations. The approach taken by Aurecon is of little assistance for this consideration. Both the BAU and Abatement package scenarios have flaws that make them unsuitable for NEPM decision making.

BUSINESS AS USUAL

The BAU scenario overstates the likely future emissions of the assessed airsheds. While failing to foresee the closure of petrol refineries may seem a minor flaw in the assessment, the approach taken ignores technology change altogether. It ignores the community's demands for change and industries' potential to provide such changes. The obvious examples are renewable energy and electric vehicles. While Pacific Environment claim to have based projections from the 'most recent official emissions inventories', the sources are often more than 10 years old, preceding the advent of commercially viable renewable energy and a period of reduced electricity demand.[9]

New South Wales

The NSW BAU is based on a 2012 interpretation of 2008 inventory of emissions, and the associated forecasts are not publicly available.[10] Problems with the data include:

- Inclusion of coal-fired Wallerawang Power Station, which closed in 2014.
- Inclusion of coal-fired Redbank Power Station, which closed in 2014.
- Inclusion of numerous coal mines that have either closed or experienced long periods of care and maintenance, for example Awaba, Angus Place, Charbon, Berrima, Baal Bone, Invincible, West Wallsend and others.

The difficulty of using 2008 or 2012 data for the NSW BAU out to 2040 is that, at that time, major expansion of the coal industry seemed inevitable. For example, Newcastle's Port Waratah Coal Services (PWCS) planned a major new terminal. The forecast PWCS submitted to NSW planning authorities is reproduced in Figure 4 below:

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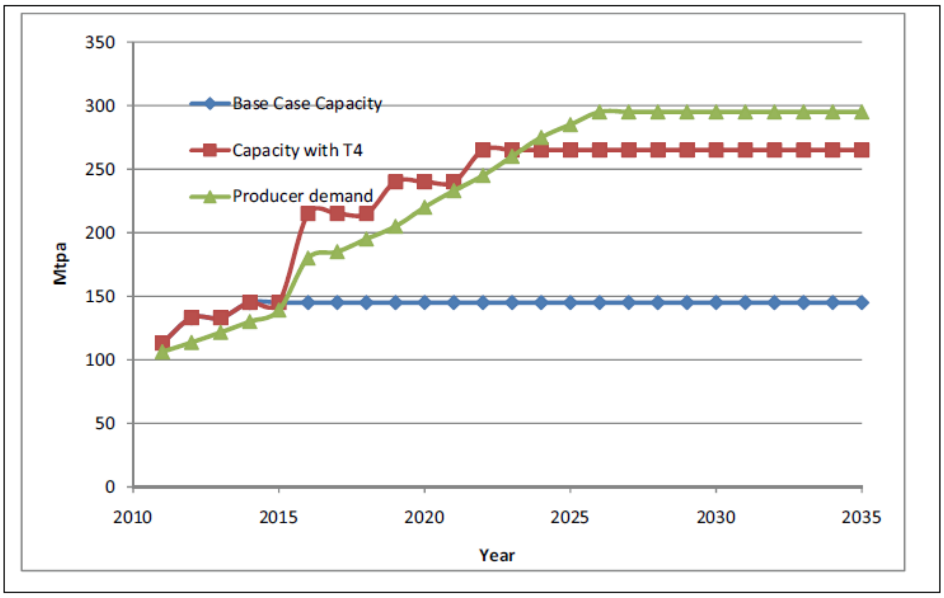
[9] Pacific Environment (2018) *Appendix A: Air quality study*, p20.

[10] EPA NSW (2012) *2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW*, https://www.epa.nsw.gov.au/your-environment/air/air-emissions-inventory/air-emissions-inventory-2008. See Technical Report No. 5, Industrial Emissions.

Figure 4: Forecast coal throughput at PWCS coal terminals at Newcastle



Source: Gillespie Economics (2012) *PWCS Terminal 4 Project Economic Assessment*.

Figure 4 shows that PWCS expected demand for coal through its Newcastle terminals to nearly triple by the mid-2020s (green line). They planned major expansions of export coal capacity (red line). Instead, coal demand has flattened since 2013 staying well below existing capacity (blue line). PWCS have abandoned their expansion plans and the many coal mines expected to feed the expanded terminals have been closed, delayed or abandoned.[11] Many of these mines are included in the BAU scenario.

Victoria

The air quality modelling for Victoria was based on a 2013 source from the Victorian EPA. A lot has changed since it claimed:

> There will be significant changes to the power generation sector by 2030. It is assumed that most electrical power will be generated using natural gas, brown coal, co-generation and tri-generation (the latter two located particularly in urban areas). Some existing large power stations are expected to be closed. Smaller amounts of power will be generated using wind, black coal, hydro-electric, biomass (from landfill), liquid fuels and solar.[12]

[11] Wakatama et al (2018) *T4 scrapped: Controversial multi-billion-dollar coal loader in Newcastle won't go ahead*, https://www.abc.net.au/news/2018-05-31/plans-for-five-billion-dollar-coal-loader-scrapped/9821890

[12] EPA Victoria (2013) *Future air quality in Victoria – Final report,* https://www.epa.vic.gov.au/~/media/Publications/1535.pdf. Note that one of the references cited in

Six years later, no new gas-fired generators are operating or being constructed in Victoria, the Hazelwood brown coal fired power station has closed and the state has a 50 percent renewable energy target by 2030.[13] Analysts expect this to be met easily.[14]

In fact, the Victorian EPA's 2013 estimates are derived from a 2006 emissions inventory applied to a 2006 report by the Australian Bureau of Agriculture and Resource Economics (ABARE).[15] ABARE forecast that wind power would provide 15 petajoules (4.2 terawatt hours, TWh) of energy in 2019-20 and solar would provide just four petajoules (1.1 TWh) this year. The latest National Energy and Emissions Audit reports approximately 29 TWh from wind in the 2018-19 year and 22 TWh from solar. Actual wind generation was seven times greater than ABARE's prediction while solar was almost 20 times greater.[16]

In 2013 the EPA's 'low impact scenario for 2030' included changes that have already happened, including a 90 per cent reduction in SO2 emissions from Anglesea power station. This power station closed in 2015. Another change was the replacement of 2-stroke lawnmowers with 4-stroke mowers. A phase out of 2-stroke engines in Victoria began in 2018.[17] Interestingly, another measure in this scenario is 50 percent electric vehicles by 2030, which appears less likely to be achieved.

Other jurisdictions and final BAU comments

It is beyond the scope of this submission to examine all sources for the BAU air quality modelling. We note, however, that all jurisdictions seem to be based on similarly out of date sources. For example:

- The 2000 South-East Queensland emissions inventory (Queensland EPA, 2004)

this quote is the Minerals Council of Australia (2009) *Vision 2020 Project: The Australian Minerals Industry's Infrastructure Path to Prosperity - An assessment of industrial and community infrastructure in major resources regions.* The other source is GHD (2005) *Latrobe Valley 2100 Coal Resource Project: Executive Summary*.

[13] Victorian Government (2019) *Victoria's renewable energy targets*, https://www.energy.vic.gov.au/renewable-energy/victorias-renewable-energy-targets

[14] Parkinson (2018) *Victoria to meet 40% renewables target five years early*, https://reneweconomy.com.au/victoria-to-meet-40-renewables-target-five-years-early-90487/

[15] See EPA Victoria (2013) *Future air quality in Victoria – Final report*, Appendix B: The most likely future emission (E2) scenario, Figure B1 and footnote 38. Their source is ABARE (2006) *Australian Energy: National and State Projections to 2029-30*, http://s3.amazonaws.com/zanran_storage/www.abare.gov.au/ContentPages/2249002001.pdf

[16] Saddler (2019) *National Energy Emissions Audit: July 2019*, http://www.tai.org.au/content/national-energy-emissions-audit-july-2019

[17] Renault (2018) *Emissions crackdown to slash sale of two-stroke lawn mowers, outboard motors*, https://www.abc.net.au/news/2018-06-29/dirty-mowers-and-chainsaw-motors-slashed-under-new-emission-laws/9885250

- The 1998/1999 Perth emission inventory (WA DEP, 2003)
- The NPI diffuse source data for Adelaide, Canberra, Hobart, Gladstone, and Darwin, which were assumed to be for 1999/2000.

Any form of forecasting is inherently difficult. Estimating a BAU emissions scenario for sectors that are changing as rapidly as electricity and transport will be fraught with difficulty. The responsible analyst's response to this should be transparency around assumptions and wide sensitivity analysis. Pacific Environment and Aurecon do not provide these important caveats to their readers. No sensitivity analysis is provided around the BAU scenario, or how variations in it might affect the results of the BCA.

Importantly, the modelling that underpins this analysis apparently contradicts numerous government policies, such as the Victorian and Queensland Government renewable energy policies and the Paris Agreement. If Australia's climate goals are reached, including likely ratcheting up of CO2 abatement ambition, emissions of other pollutants including NO2, SO2 and O3 are all likely to be significantly lower, as thermal power stations and internal combustion engines are likely to be used far less. This is not considered in the BAU scenario or elsewhere in the modelling.

ABATEMENT PACKAGE

The Abatement package scenario shares many of the problems of the BAU scenario: it is based on out-of-date sources and ignores major changes in technology.

Literature review

Pacific Environment state that the literature review for the Abatement package was completed prior to the end of March 2016 and had an 'emphasis on material published in the last five years'.[18] However, of the 64 dated sources cited by Pacific Environment on average they were published in 2009, ie based on information now more than a decade old. Just four sources were from 2016 and three from 2015. Four were from last century.

This means that the Abatement package scenario is largely based on literature that pre-dates not only current state policies on emissions and energy, but also major developments such as commercial renewable energy and the Paris Agreement. Key events such as carbon pricing and the implementation of the 2020 renewable energy target also occurred after most of this literature was published.

[18] Pacific Environment (2018) *Appendix A: Air quality study*, p79.

It is not clear what the terms of reference for the literature review were, other than that a list of measures and references were provided by EPA Victoria. The literature review did not consider closure of thermal power stations and replacement with renewable energy, storage and demand response. It does not include up-to-date sources such as the Australian Energy Market Operator's Integrated System Plan, which outlines scenarios for Australia's future energy grid and is the basis for much planning around the energy system.[19] While it is unclear what guided the literature review, it put forward 18 measures which were then subject to multi criteria analysis.

Multi criteria analysis

The literature review identified 18 abatement measures, which were then whittled down to nine measures – three for each pollutant – by multi criteria analysis (MCA). It is unclear why nine measures were selected rather than six, twelve or any other number. From an economic perspective, any measure that has benefits that outweigh its costs should be pursued.

MCA is often criticised by economists:

> Multi-criteria analysis … is fundamentally flawed in principle, and is open to abuse by special-interest groups. Its increased use poses a significant risk to the quality of policy formulation by Australian governments.[20]

MCA involves subjective decisions around the selection of criteria, their measurement and weighting. While this may be useful for some assessments where robust data is unavailable, it must be accompanied by full explanations of the various decisions made. This has not been done by Aurecon or Pacific Environment. While there is some discussion of weighting, it is entirely unclear how these weights were derived:

> The Abatement Package scenario was selected by prioritising measures on the quantum of abatement (30% weight), cost (30% weight) and to a lesser degree health benefits (10% weight). Other factors included reliability, targeting of costs to the source, timeframe for implementation, technological status, co-benefits and dis-benefits (5% weight each). These criteria were grouped into effectiveness (quantum of abatement and reliability), efficiency (targeting,

[19] AEMO (2019) *Integrated System Plan*, https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan

[20] Dobes and Bennett (2009) *Multi-Criteria Analysis: "Good Enough" for Government Work?*, https://openresearch-repository.anu.edu.au/bitstream/10440/1065/1/Dobes_Multi2009.pdf

timeframe for implementation, technological status and cost) and appropriateness (direct health benefits, co-benefits and dis-benefits).[21]

The derivation of these criteria and weighting is never discussed. Furthermore, the scores of the various abatement measures and working behind them is never discussed. For example, 'encouraging public transport' was dismissed as a measure, based on the following assessment:

Figure 5: Extract from MCA on public transport

Abatement	3. Encouraging public transport		
Description	To promote the use of public transport and change travel behaviour by providing subsidies for using public transport.		
Applicable to Regions	All		
Emission Reduction Potential	SO_2	NO_x	VOCs
	Yes	Yes	Yes
Assumptions	Control efficiency applied 1% encouraging active and public transport 2040.		
Included in final Abatement Package	No		

Source: Pacific Environment (2018), p88.

There is no transparency around what specific measures are proposed, how this subsidy is estimated or delivered, which jurisdictions this would apply to, what other benefits and costs might be involved. The Australia Institute and Environmental Justice Australia requested the full MCA report from, but were told that consultants did not want the report released. It is not clear why this is the case, or why the intellectual property of the report does not lie with the National Environment Protection Council.

Final Abatement package and modelling comments

To summarise, the Abatement package scenario is based on sources that predate a lot of important technological development, is derived via a highly subjective methodology and suffers from a complete lack of transparency. It is highly unlikely that the modelled scenario represents an estimate of future emissions changes suitable for decision making in 2019. Combined with the problems with the BAU scenario, the entire approach to the Pacific Environment/Aurecon assessment is flawed.

Not only is the approach taken flawed, but in the following sections we describe how the benefit-cost analysis of these measures has been poorly executed, understating benefits and overstating costs.

[21] Aurecon (2018) *Review of Ambient Air Quality NEPM for SO2, NO2 and O3: Cost Benefit Analysis*, p10.

Flawed execution of BCA

Aurecon's analysis is made more difficult to review because the Abatement package measures were evaluated "together rather than individually to account for the interactions between pollutants".[22] With so little transparency around how the Abatement package was selected and evaluated, and such unusual final benefit-cost ratio results, such a breakdown would help readers understand more about the Abatement package and the results. Such a summary is easily derived from Aurecon's report and is presented in Table 1 below:

Table 1: Abatement and cost summary

Abatement measure	Emissions reduction 2016-2040 (t)	Capital cost ($m)	Capital cost per tonne	Annual ongoing cost ($m)
De-SOx at power stations (using FGD)	1,963,365	$ 20,514	$ 10,448	$ 847
De-SOx at petrol refineries	290,376	$ 127	$ 437	$ 5
De-SOx at iron and steel production facilities	89,073	$ 100	$ 1,123	$ 24
De-NOx at power stations (using SCR)	792,027	$ 23,509	$ 29,682	$ 192
Non-road diesel engine standards (NOx)	282,416	$ 5,400	$ 19,121	$ 8
Industry NOx control technology	230,467	$ 37	$ 161	$ 29
On-board refuelling vapour recovery (O3)	138,531	$ 79	$ 570	-
Surface coating standards (O3)	536,872	$ 1,611	$ 3,001	-
VOC control for solvent aerosol use (O3)	628,918		NA	$ 281

Source: Aurecon (2018) *Benefit cost analysis*. Emissions reductions as published in Aurecon analysis. Capital cost based on Aurecon figures and some additional research, for example around power station capacity. Note these figures are undiscounted and so do not sum to the same amounts as in Aurecon's other results summary tables.

[22] Department of the Environment (2019) *Impact Statement for the Review of the Ambient Air Quality NEPM standards for SO2, NO2 and O3*, p vi.

Table 1 shows that the vast majority of the costs of the Abatement package come from capital costs of SO2 and NO2 reduction measures at power stations. These measures make up 85% of Aurecon's estimated costs of the Abatement package. This is particularly concerning because these estimates are based on dated sources, many times greater than more recent sources suggest, as discussed below.

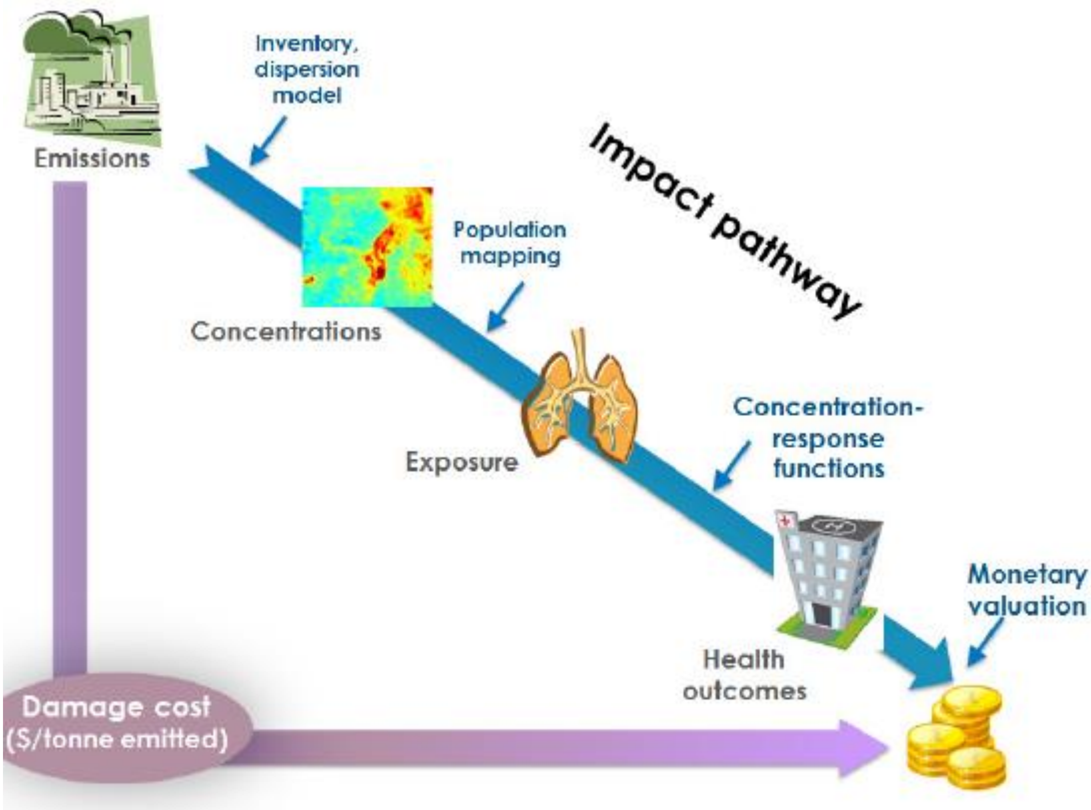
Understated benefits

Aurecon's assessment of benefits in the BCA ignores major benefits of the Abatement package.

Localised benefits

Aurecon adopt mainly an 'impact pathway' approach following the UK's Department for Environment, Food and Rural Affairs (DEFRA), explained in the Figure 6 below:

Figure 6: Impact pathway explanation diagram



Source: Aurecon (2018).

Under the approach in Figure 6 the change in emissions in tonnes is estimated first and then how this change would disperse across the relevant airshed. Then population exposure is considered and the health responses to the population's exposure to the change. Finally, a monetary value is put on the changed health response.

However, exposure to and the health impacts of pollutants begins locally before it spreads to the wider population via ambient air quality. The BCA considers abatement measures that relate to consumer cars and petrol stations and household aerosol use, as well as various industrial facilities. The impacts on health begin with the drivers of cars, workers in petrol stations, users of aerosols and the workers in and neighbours of industrial facilities; they then spread across the wider population.

For example, measures to reduce SO2 and NO2 at Yallourn power station will create health benefits in the neighbouring towns of Moe and Morwell over and above those created by a change to the overall ambient air quality of the Latrobe Valley, or wider Port Phillip region. Similarly, a change to fuel efficiency standards would bring health benefits to many people who live and work alongside busy roads, but this benefit is overlooked by assessment that focuses only on changes to ambient conditions across wide areas.

Just looking at average air quality across the wider population and ignoring localised high concentrations is like assuming you can't drown in a river that has an average depth of only 20 centimetres. That average depth may hide deep holes of many meters. Those living and working near pollution sources experience higher concentrations and may have much worse health outcomes than would be expected across an airshed with good average air quality. For this reason, Doctors for the Environment Australia (2019) recommend more air quality monitoring stations close to pollution sources. We endorse their recommendation.[23]

While the local benefits to Moe and Morwell are omitted from Aurecon's analysis, local costs are included. The cost of the abatement measure to the Yallourn Power station's owners is included as a cost, with every one of its 1,450 megawatts of capacity attracting a capital cost of $1,090,000.

This inconsistency of including local costs but excluding local benefits is an error, and one that is likely to significantly understate the benefits of better air quality standards.

Other distributional considerations

The health costs of pollution are disproportionately borne by the young, the elderly, those with respiratory conditions and those living and working close to pollution sources. These people bear these costs via their health and sometimes their life. This raises moral and ethical considerations that BCA practitioners should be aware of and discuss in their analysis, at least qualitatively. Aurecon's analysis takes the fairly standard approach to valuing human life by assuming you can put a dollar value on these people's suffering. This can then be compared that to the dollar cost borne by the whole population in removing pollutants. The absence of quantitative

[23] Doctors for the Environment Australia (2019).

distributional analysis or qualitative discussion of who bears these costs will not assist the community and decision makers consider these issues.

Many benefits ignored

Aurecon notes:

> Some authors have estimated the marginal social costs of precursor emissions that lead to the formation of secondary PM (e.g. see Heo, Adams and Gao, 2016). Heo et al (2016) estimate a range of marginal social costs of US$3,800–14,000 per tonne NOX, and US$14,000–24,000 per tonne of SOX.
>
> Using these estimates results in a very large potential benefit from reductions in secondary PM formation, through reductions in SOX and NOX emissions associated with the Abatement Package scenario, of approximately AU$20 and AU $10 billion respectively.[24]

Aurecon omit such benefits claiming they are not directly translatable to Australia and may be difficult to quantify. Such a large omission based on inability to accurately estimate recalls the quote attributed to noted economist, John Maynard Keynes, that he "would rather be vaguely right than precisely wrong", Aurecon's approach does the opposite. Not considering such benefits even in sensitivity analysis is contrary to the precautionary principle, which states there is a social responsibility to protect the public from harm when scientific investigation has found a plausible risk.

Other health benefits not included are:

- Reduction in health impacts not requiring hospitalisation. This is the vast majority of health impacts from improving air quality, such as fewer asthma attacks and reduced breathing difficulties. These individually small but widespread benefits are likely to have a very large aggregate economic value.
- Changes to worker productivity not included. This is also a potentially very large economic benefit. Aurecon claims that "US EPA (2010) estimates that the work days lost associated with exposure to PM2.5 represent around 0.2 per cent of the total monetised health benefits." The linked document was actually published in April 2011, but more importantly it does not appear to support

[24] Aurecon (2018), p19.

this claim. It may relate to Table 8-5, where worker time endowment changes between 0.15% and 0.25%, but this is different to the claim by Aurecon.[25]

- Agricultural and ecosystems impacts including higher agriculture and timber yields. These impacts are assessed as very large in overseas studies but excluded and barely considered by Aurecon.

- Fewer babies born with low birth weights.

In addition, Doctors for the Environment (2019) note the negative effects of pollution on child cognitive development and Ewald (2018) notes the links between air pollution and rates of diabetes.[26] Neither of these effects are included in the BCA.

In other cases where Aurecon has made assumptions about the economic value of certain health outcomes, those assumptions appear very low. It assumes a willingness to pay to avoid a (life-long) respiratory illness of $431.[27] As Doctors for the Environment (2019) write, 'We invite any reader to try explaining that to the parent of a child with asthma'.[28] Similarly, Aurecon assume a willingness to pay to avoid cardio-vascular illness of $584.[29]

Aurecon does detail some alternative concentration response functions (CRFs) (Group 2 and Group 3) that result in greater benefits from the Abatement package measures for SO2 and NO2. However, like the central estimate CRF that Aurecon has chosen, these alternate CRFs are based on research prior to 2013. As Doctors for the Environment (2019) note, these CRFs have become outdated as more research has been done and as such understate the health costs compared to this later research.[30]

Bizarrely, changing the CRFs for ozone results in negative benefit-cost ratios in Aurecon's sensitivity analysis. Aurecon explain that under the Abatement package scenario air quality modelling O3 concentrations "reduce on some days, but increase on other days." However, no explanation is given as to how this could occur, particularly given the O3 abatement measures relate to consumer cars, surface coating

[25] US EPA (2011) *The Benefits and Costs of the Clean Air Act from 1990 to 2020,* https://www.epa.gov/sites/production/files/2015-07/documents/fullreport_rev_a.pdf

[26] Doctors for the Environment (2019) *Submission on the proposed variation to the ambient air quality measures standards for ozone, NO2 and SO2,* p6-7 and Appendix A; Ewald (2018) *The health burden of fine particle pollution from electricity generation in NSW,* 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

[27] Aurecon (2018) Table 3-2.

[28] Doctors for the Environment (2019), p5.

[29] Aurecon (2018) Table 3-2.

[30] Doctors for the Environment (2019) p6-7 and Appendix A.

and aerosol use, all of which are dispersed sources that are seemingly unlikely to have significant daily variation. The basic logic of how these abatement measures could lead to increased ozone pollution is not clear even after extensive review of Aurecon's document and Pacific Environment's 2018 *Air quality study*. Furthermore, the inclusion of pollution increasing abatement measures suggests flaws in the multi criteria analysis used to select the measures.

Overstated costs

Studies have found that when regulators evaluate whether to introduce pollution controls they over-estimate the cost of compliance.[31] Reasons for this are the failure to account for technological innovation, errors in baseline specification, optimistic compliance assumptions, and reliance on maximum instead of mean cost information.[32] Wolverton et al (2019) quotes *seven* studies that have found that, ex-ante, the US EPA over-estimated the cost of compliance with pollution regulations.[33] Similarly, the estimated costs in this study are likely to be overstated.

In estimating the cost of introducing pollution controls, Aurecon has used desktop studies mostly from overseas. In many cases these sources are old, and were conducted when measures were only just being considered. Often, pollution controls have since been introduced, leading to improved technology and economies of scale. Costs may fall further by the time measures are introduced in Australia.

International owners

The example of Yallourn power station raises another issue of scope in Aurecon's analysis. While the scope of the assessment is defined as the airsheds for which data is available, covering a large part of the Australian population, some of the largest costs of the Abatement package fall outside of this scope and outside of Australia.

Yallourn power station is owned by Energy Australia, a company that, despite its name, is based in Hong Kong. Most of its shareholders reside outside of Australia. Costs to overseas interests from the Abatement package should be excluded from the analysis that is focused on the costs and benefits to the Australian community. Energy Australia owns at least two other facilities in the analysis which attract significant costs. International interests are likely to own significant stakes in other industrial facilities identified in the analysis.

[31] David Simpson (2011) *Do Regulators Overestimate the Costs of Regulation?* EPA Working Paper 12/2011, https://www.epa.gov/environmental-economics/working-paper-do-regulators-overestimate-costs-regulation; Wolverton, Ferris and Simon (2019) *Retrospective Evaluation of the Costs of Complying with Light-Duty Vehicle Surface Coating Requirements,* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6309231/

[32] David Simpson (2011).

[33] Wolverton et al (2019).

The issue of foreign ownership of Australian projects and how to deal with this in benefit-cost analysis has been extensively discussed in the development of NSW economic assessment guidelines.[34] These guidelines state that assessment should consider 'first round' impacts, but not secondary impacts in related markets. This is particularly the case in Australian electricity markets, where prices are often set by renewable energy and/or gas-fired facilities. Energy Australia's coal-fired power stations would have little opportunity to pass on the costs of abatement reducing retrofits, even if this was considered in benefit-cost analysis.[35]

DE-SOX OF COAL-FIRED POWER STATIONS

Aurecon assumes very high capital costs of flue gas desulphurisation (FGD), at AUD 1,090 per kW. By contrast, the American Energy Information Administration (EIA) annually surveys the capital cost of installing FGD in the US and found that in in the US in 2017 the average cost was USD 105 or AUD 150 per kw.[36] To state this plainly, Aurecon has assumed a cost of FGD installation seven times higher than the actual average cost of installations in the US in 2017.

It is unclear exactly how Aurecon estimated its cost of AUD 1,090 per kW. Aurecon quotes two source for its cost calculations. One source is Cichanowicz (2010),[37] which reported FGD costs rising from $342 per kW between 2004-07 to $407 per kW in 2010 and included some forecasts out to 2015. Cichanowicz does not forecast costs to 2019 or further into the future and does not provide a specific figure that supports Aurecon's $1,090 figure. Instead, it appears Aurecon uses Cichanowicz's prediction of further FGD cost increases to extrapolate rising FGD costs to 2019. The problem is that these increases never happened. The US cost of FGD installation has fallen every year since 2009, except 2016, as shown in Figure 7.

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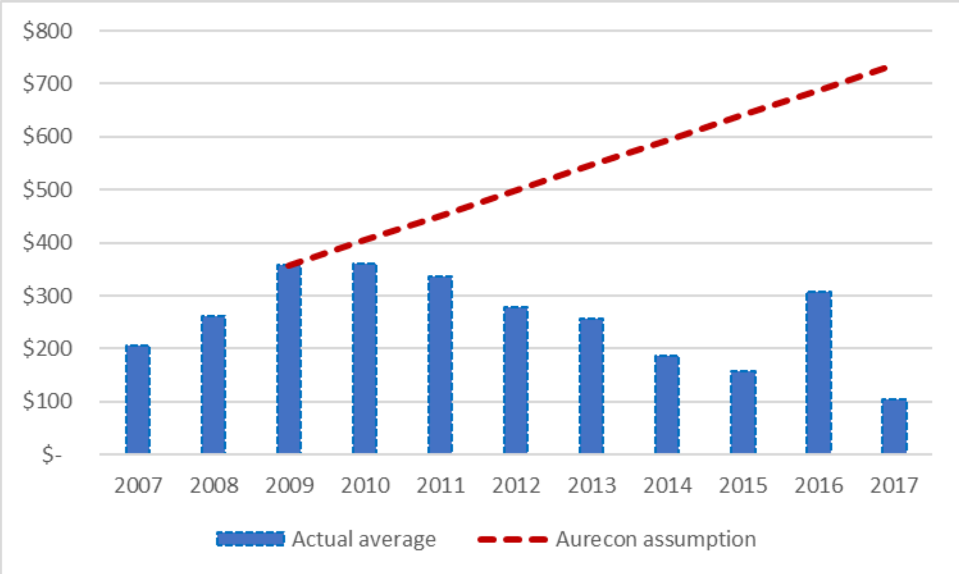
[34] NSW DPE (2015) *Guidelines for the economic assessment of mining and coal seam gas proposals*, https://www.planning.nsw.gov.au/~/media/Files/DPE/Guidelines/guidelines-for-the-economic-assessment-of-mining-and-coal-seam-gas-proposals-2015-12.ashx

[35] See also benefit cost analysis textbooks such as Boardman et al (2011) *Cost-benefit analysis: Concepts and Practice*, Prentice Hall.

[36] Energy Information Administration (2018) *Electric Power Annual 2017*, https://www.eia.gov/electricity/annual/pdf/epa.pdf. See Table 9.4. Average Costs of Existing Flue Gas Desulfurization Units, directly available at https://www.eia.gov/electricity/annual/html/epa_09_04.html; assumes an exchange rate of AUD/USD of 0.70.

[37] Cichanowicz (2010) *Current Capital Cost And Cost Effectiveness Of Power Plant Emissions Control Technologies.*

Figure 7: FGD installation costs (USD per kW)



Source: Energy Information Administration (2019) and Aurecon (2018).

We have illustrated Aurecon's assumption by taking actual 2009 EIA cost and assigning Aurecon's assumption of AUD 1,090 per kW (and an exchange rate of AUD/USD of 0.70) to 2017 and extrapolating between 2009 and 2017.

While Cichanowicz predicted increases in FGD costs at the time of publishing his paper, it is difficult to understand why Aurecon extrapolated this out to current prices without reference to more recent data.

The second source on FGD cost estimates cited by Aurecon is Electric Power Research Institute's *Australian Power Generation Technology Report*.[38] This report is largely focussed on carbon capture and storage, with only side discussion of FGD in Chapter 9. The key paragraph states:

> The FGD and SCR costs here are based on typical published US values for equipment retrofit of $400/kW for FGD and $350/kW for SCR (both before the capture derate). These estimates were adjusted to an Australian location and converted to 2015 Australian dollars.

No source is provided for these estimates. Confusingly, Table 67 of this report estimates the combined FGD and SCR costs at between $1,850 and $1,950, without explanation and without sources.

[38] EPRI (2015) *Australian Power Generation Technology Report,* http://www.co2crc.com.au/wp-content/uploads/2016/04/LCOE_Report_final_web.pdf

Neither of Aurecon's source documents are up to date or seriously intended to inform FGD investment decisions. It is difficult to understand why Aurecon would not have used sources such as *Flue Gas Desulphurization Market: Global Industry Analysis and Opportunity Assessment 2015-2025* or *Global FGD Industry Analysis, Size, Share, Growth, Trends and Forecast, 2012 – 2019*.[39] These reports are published regularly and have up-to-the-minute information about a dynamic industry. They cost money to access, but this is the point of employing consultants such as Aurecon – their global engineering operations should give them access to this kind of information.

Another publicly available source is Cropper et al (2017), which estimated the costs and benefits of desulfurization in India. Like the EIA figures, they used industry research to assume a capital cost of USD 109 per kW.[40] This cost is very similar to the EPA's 2017 figure of USD 105 per kW.

Table 2 below summarises published estimates of FGD cost data. Aurecon's estimates are by far the highest.

Table 2: FGD Capital cost per kilowatt assumed:

Source	Cost per kilowatt[41]		Basis of estimation
	AUD	USD	
Aurecon (2018)	**$1090**	$763	Reference to Cichanowicz (2010) and EPRI (2015)
EPRI (2015)	**$400**	$280	"Based on typical published US values for equipment retrofit of $400/kW for FGD and $350/kW for SCR then adjusted to an Australian location and converted to 2015 Australian dollars."
Cichanowicz (2010)	$581	**$407**	Cost estimated for Wet FGD for a 500 MW plant in the years 2008-2010. Cichanowicz noted that the cost escalated roughly by $16 a year over the previous 4 years. Estimates

[39] Future Market Insights (2019) *Flue Gas Desulphurization Market: Global Industry Analysis and Opportunity Assessment 2015-2025*, https://www.futuremarketinsights.com/reports/flue-gas-desulphurization-market; Transparency Market Research (2019) *Global FGD Industry Analysis, Size, Share, Growth, Trends and Forecast, 2012 – 2019*, https://www.transparencymarketresearch.com/flue-gas-desulfurization-systems.html

[40] Cropper et al (2017) *Costs and Benefits of Installing Flue-Gas Desulfurization Units at Coal-Fired Power Plants in India*, https://www.ncbi.nlm.nih.gov/books/NBK525204/

[41] Bold numbers are as directly from the source document. Unbold numbers have been converted to AUD or USD at a rate of AUD/USD 0.70 to allow comparison.

			based on field data. He also predicted costs would continue to rise, though the opposite has happened.
Lin et al (2018)	$650	**$455**	Cichanowicz (2010). Although Lin et al note that Cichanowicz found the capital cost escalated by $16 a year they do not appear to have escalated Cichanowicz's 2008-2010 figure of USD 407 a year by USD 16 a year.
Cropper et al (2017)	$155	**$109**	Communication with NTPC (India's largest power utility engineer). They note that "these figures are slightly lower than FGD unit prices in the United States prior to the post-2006 spike in prices".
EIA (2019)	$150	**$105**	Average installed cost for 2017 (see Figure 1).

Another point to note is that the Hazelwood power station closed in 2017. Despite this, Aurecon include it in cost estimates of de-SOx measures. Other power stations are also scheduled to close before 2040 and they appear to contribute to a significant overstatement of de-SOx costs.

Aurecon estimate an annual cost of maintaining an FGD-fitted plant of some $45/kW per year which we calculate results in an annual cost of $847 million. Aurecon does not state the sources for the estimate of $45/kW. We guess Aurecon uses costs from Cichanowicz (2010) and EPRI (2015) and increases those estimates. We note Cichanowicz (2010) in turn based his estimates on a 2006 paper. Costs are likely to have changed considerably in those 13 years and probably seen drops similar to the dramatic drops in FGD capital costs that have occurred. In contrast to Aurecon, Cropper et al (2017) use current data from field research and estimate the operating costs for an FGD unit at USD 0.47/MWh or AUD 0.67/MWh.[42] This is negligible compared to the current Australian wholesale electricity price which averages around $60-$80/MWh.

[42] Cropper et al (2017) Table 13-4.

DE-NOX OF POWER STATIONS

Coal-fired and gas-fired power stations produce NOx emissions that can be reduced with Selective Catalytic Reduction (SCR). SCR can be installed at both coal-fired and gas-fired power stations.

Throughout its analysis Aurecon states that SCR will be applied at both gas and coal fired power stations. For example, Aurecon's Table C-7 lists both the coal and gas fired power station that will be affected by SCR.

However, Pacific Environment's air quality modelling appears to include the emissions reductions from the installation of SCR only at "non-gas-fired power stations", ie coal-fired power stations only.[43] If Aurecon has calculated the costs of de-NOxing both coal and gas-fired power stations while Pacific Environment only include the benefits from de-NOxing coal-fired power stations, costs will be heavily overstated, while large benefits have been excluded.

There are other issues with SCR at gas-fired power stations that are not discussed by Aurecon and need to be considered. Gas-fired power stations often operate differently to coal-fired power stations, as their generation can be ramped up and down more quickly. It is unclear if this is accounted for by Aurecon. Coal-fired power stations provide so-called baseload power and operate 24 hours a day, 7 days a week.[44] Many gas-fired power stations often only operate intermittently to provide power at times of high demand. Capital costs to install de-NOx technology are likely to be similar regardless of whether the plant is run intermittently or around the clock.

By contrast, the benefits of SCR at a gas-fired power station are dramatically different depending on how it is run. A gas-fired power plant run only at times of peak demand emits much less NOx in the year than a gas plant run 24/7 and hence the benefits from SCR at the intermittent plant are much less. If a plant is only run intermittently then, of course, the case for requiring SCR installation at it is much weaker than a similar plant run 24/7. Aurecon does not detail how it approached applying SCR to different gas power stations.

[43] Pacific Environment (2018) *Appendix A: Air quality study,* p23, repeated on p89.

[44] Except when they break down. See The Australia Institute (2019) *Gas and Coal Watch*, http://www.tai.org.au/gas-coal-watch

As discussed earlier, Aurecon estimates a relatively low benefit from de-NOxing across all three measures it examines. For de-NOxing power stations it estimates a benefit of $1.0bn. In contrast using assumptions from Heo et al (2016), the benefit is $6 billion.[45]

As noted earlier, the US EIA has found that the cost of Flue Gas Desulphurisation has fallen at coal-fired power stations - in contrast to Cichanowicz (2010) who predicted it would rise. The cost of reducing SCR is similarly likely to have fallen since Cichanowicz wrote this paper in 2010. However, Aurecon assumes a capital cost of SCR at AUD 828 per kW or USD 601 per kW which is more than double the cost assumed by Cichanowicz of USD 270 per kW. As described earlier, technology improvement is likely to have cut the cost of SCR as it has with FGD.

We also note that a number of gas plants have closed as they have become uncompetitive due to higher gas prices, battery storage, and the increase in renewable energy and/or the plants have come to the end of their economic life. These factors, as well as demand response, will lead to further closures before the 2040 timeline.

OTHER MEASURES

Below we use Aurecon’s Appendix C to discuss each of the seven other pollution control measures in the Abatement package. Appendix C sets out the predicted emission reductions resulting from each measure. These emission reductions appear to have been estimated in the MCA making it impossible for the reader to evaluate the accuracy of the predicted reductions.

Our general comments regarding the frontloading of costs and backending of benefits, the use of old data sources which under-estimate the benefits and over-estimate the costs and ignoring the benefits of technological change and substitution apply to each measure.

[45] De-NOxing power stations accounts for 60% of the estimated reduction in nitrous oxide emissions across all three measures.

1. VOLATILE ORGANIC COMPOUND MEASURES

These three measures would reduce volatile organic compounds (VOC) that contribute to atmospheric ozone concentrations.

ON-BOARD REFUELLING VAPOUR RECOVERY

Onboard Refuelling Vapour Recovery (ORVR) would reduce VOC being released when vehicles refuel. Aurecon assumes this would be taken up gradually as the vehicle fleet is replaced over ten years. The costs of implementation are small – $18 per vehicle – and Aurecon notes a co benefit of lifetime fuel saving of $15 per vehicle, resulting in a net cost of roughly $3 per vehicle. This cost is from a 2014 source. Due to innovation the cost is likely to be even lower by the time ORVR is installed in Australia.

ORVR it is already in place in the US. A review efficiency and penetration conducted by the US EPA showed that the system is highly cost effective.[46] By contrast, Aurecon appears to arrive at a benefit-cost analysis ratio less than one.

ORVR appears a clear case where those suffering the health costs and shorter lifespan due to pollution will dramatically benefit at only a small cost to the wider population.

SURFACE COATING STANDARDS

VOC emissions result from the evaporation of solvents in solvent-based and water-based coatings. This measure would reformulate the coatings in the architectural, industrial and automotive refinishing sectors. Standards will align with international improvements in reformulation.

Aurecon assumes a capital cost of $3,000 per tonne of VOC reduced, based on California Air Resources Board (2007).[47] Other jurisdictions have since put in place surface coating standards including Europe. These legislative requirements will have driven industry to find a much lower cost to reduce VOC.

Despite the fact that costs are likely to have fallen since 2007, California Air Resources Board (2007) still found that the measures they discussed would "have no significant

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[46] Fung and Maxwell (2011) *Onboard Refueling Vapor Recovery: Evaluation of the ORVR Program in the United States*, https://theicct.org/publications/onboard-refueling-vapor-recovery-evaluation-orvr-program-united-states

[47] California Air Resources Board (2007) *2007 ARB SCM for Architectural Coatings Chapter 5-8. Technical Assessment Of Categories*, https://www.arb.ca.gov/coatings/arch/docs.htm

impact on employment; business creation, elimination or expansion; or business competitiveness in California".[48] This dramatically contrasts with Aurecon who appear to have found a very low, and possibly even negative, benefit-cost ratio.

VOC CONTROL FOR SOLVENT AEROSOL USE (O3)

This measure seeks to reduce VOC content in aerosols by implementing Californian regulations for domestic solvents and aerosols. According to Aurecon "this involves phasing out non-compliant household aerosol products from the market, which in turn incurs an additional production cost to manufacturers."

Like much of Aurecon's analysis, it is based on aging sources. The 2010 SKM study referenced by Aurecon assumes:

> each household spends A$10 per week on consumer aerosol products, 75 % of which already meet CARB, 2008 regulations. It is estimated that in each product category there is a 20 % price difference between the most expensive brands and the cheapest brands with the expensive brands meeting CARB 2008 (generally as per MSDS review) and the cheaper ones currently not in compliance.[49]

This appears to be the basis for Aurecon's $0.60 per household per week cost estimate: $10 per week, $2.50 of which would be on non-compliant products, increasing by 20% would be an extra $0.50 per week, perhaps adjusted by Aurecon for inflation.

All these assumptions are questionable. $10 per week per household appears a lot on aerosol products; this would be a full third of the average household's personal care spending.[50] If 75% of aerosol products were compliant in 2010, this is likely to have increased since then. Costs of compliance are likely to have reduced over time. The costs of this measure may be close to zero.

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[48] California Air Resources Board (2007), p7-1.

[49] SKM (2010) *Cost Abatement Curves for Air Emission Reduction Actions*, https://www.environment.nsw.gov.au/resources/air/CostCurveAirEmissionRedn.pdf

[50] ABS (2017) *6530.0 - Household Expenditure Survey*, https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/6530.02015-16?OpenDocument

2. DE-SOX MEASURES

We have discussed desulphurisation at coal-fired power stations earlier. Below we discuss the two other measures that Aurecon examine.

DE-SOX AT PETROL REFINERIES

This measure involves the installation of wet gas scrubbing (WSG) technology at petrol refineries to reduce SOX emissions. According to Aurecon "WGS technology removes particulates and SOX by intimate mixing with an aqueous scrubbing liquid in a vessel."

Aurecon estimate a capital cost of $127 million and annual maintenance cost of $5 million. These costs are over-estimated as the Queensland refineries have since closed. Aurecon finds that de-SOx at Western Australian and Queensland petrol refineries would be worthwhile for any remaining facilities. Surprisingly, Aurecon appear to find that de-SOx at Victorian refineries is not worthwhile. This is despite the two refineries at Altona and Geelong being close to large populations.

Once again, Aurecon relies on old sources from 2011 which are likely to over-estimate costs by the time de-SOxing is installed.[51]

The general problems discussed earlier, from under-estimating the benefits of SOx reduction and front-loading the costs and backending the benefits, also exist.

DE-SOX AT IRON AND STEEL FACILITIES

This measure involves the installation of wet flue gas desulphurisation (FGD) at iron and steel production facilities to reduce SOx emissions. FGD involves scrubbing flue gas released from these facilities by absorbing SOx compounds in a chemical solution. The measure is only assumed to affect NSW, and the estimated costs and emission reductions are based on the Port Kembla facility near Wollongong. Aurecon estimates this has a capital cost of $100 million and a maintenance cost of $24 million per year.

Once again, Aurecon relies on out of date sources which are likely to over-estimate costs by the time de-SOxing is installed.[52]

[51] CONCAWE (2011) *Cost effectiveness of emissions abatement options in European refineries DEFRA – Damage costs*.

[52] MACTEC (2005) *Midwest Regional Planning Organization (RPO) Iron and Steel Mills Best Available Retrofit Technology (BART) Engineering Analysis*.

The general problems discussed earlier, from under-estimating the benefits of SOx reduction and front-loading the costs and backending the benefits, also exist.

3. DE-NOX MEASURES

We have discussed de-NOxing of power stations earlier, we discuss the other two de-NOxing measures below.

NON-ROAD DIESEL ENGINE STANDARDS (NO2)

Aurecon's reported results suggest that this measure is not worthwhile to introduce. This contradicts the source that Aurecon used to estimate the costs of that measure. That source, NSW EPA (2014), found that:

> the impact analysis undertaken during the development of this report provides a strong case for action in relation to non-road diesel engine emissions in Australia.
>
> The present value of net benefits (i.e. health cost reductions less compliance costs), calculated over the 2015 to 2055 period could be in the range of approximately $1257 million to $2244 million. [53]

Despite Aurecon coming to a very different conclusion from the source it uses, the NSW EPA, Aurecon does not even remark on this.

NSW EPA (2014) also noted that:

> The International Agency for Research on Cancer (IARC), which is part of the World Health Organization, recently classified diesel engine exhaust as carcinogenic to humans, based on sufficient evidence that exposure is associated with an increased risk of lung cancer. NOx and VOC emissions from the non-road diesel sector contribute to ground level ozone formation which is used as an indicator of photochemical smog. Particulate matter and ground-level ozone concentrations still sometimes exceed national standards in some Australian cities.
>
> Despite consuming less diesel fuel than road transport nationally, the non-road diesel sector is estimated to produce higher fine particle emissions than on-

[53] NSW EPA (2014) *Reducing Emissions from Non-Road Diesel Engines,* https://www.epa.nsw.gov.au/~/media/EPA/Corporate%20Site/resources/air/140586NonrdDiesInfoRpt.ashx

road diesel vehicles. Whereas on-road diesel vehicles have been subject to increasingly stringent emission standards and state and territory emission reduction programs, non-road diesel engine emissions have remained unregulated in Australia with the exception of engines applied in underground mining.

Regulations for non-road diesel equipment have been implemented in the United States (US) and the European Union (EU) since the 1990s, and have subsequently been introduced by other jurisdictions including Canada, Japan, India, China, Brazil and Russia…

…The number of 'dirtier' (diesel) engines and equipment being sold into Australia may increase as other countries introduce or tighten regulations and manufacturers seek alternative markets.

Non-road diesel engine emissions are projected to grow significantly over the next two decades as a result of the forecast increase in fuel consumption by this sector, and given the cost impediment to the uptake of significantly cleaner non-road diesel engines and equipment. It is estimated that:

- annual NOx and PM2.5 non-road diesel engine emissions in 2012 of approximately 171,900 tonnes/year and 18,850 tonnes/year respectively will quadruple by 2050.
- associated health costs will increase from $690 million per annum in 2012 to $4.6 billion per annum by 2050, with approximately 85% of the cost being due to direct PM2.5 emissions and the remainder due to NOx emissions.[54]

INDUSTRY NOX CONTROL TECHNOLOGY (NO2)

This measure involves the installation of selective catalytic reduction (SCR) technology to reduce NOx emissions in cement and clinker, iron and steel and aluminium and alumina production plants.

Given the lack of documentation provided by Aurecon we have calculated the costs in Table 3 below in an attempt to understand their magnitude.

[54] NSW EPA (2014).

Table 3: Estimated Cost of Industry NOx control

	Annual production (million tonnes)	Capital cost ($m)	Maintenance costs per annual ($m)
Cement production			
NSW	5	20	15
SA	4	16	12
WA	2	8	6
		44	**33**
Iron and Steel			
NSW		17	5
		17	**5**
Aluminium and Alumina			
NSW (aluminium)	1	3	4
WA (alumina)	11	9	14
		12	**18**
TOTAL		37	29

Source: Calculations by The Australia Institute using Aurecon assumptions.

Again, the source data Aurecon uses is old. The source data is Economic and Social Council (2012) and MATEC (2005).[55] Economic and Social Council (2012) in turn sourced its data on aluminium and alumina capital costs (as shown in Table 38) from European Commission (2001)[56] and data on cement and clinker costs (as shown in Table 51), from European Commission (2010).[57] Costs are likely to have significantly reduced in the 9-18 years that have passed since.

Europe already requires NOx reduction in heavy industry. Armendariz (2008) found that SCR for cement kilns is cost effective based mostly on US data. He noted the benefits of SCR to simultaneously control emissions of other pollutants, including VOCs, dioxins and furans, ammonia, and mercury.[58]

[55] Economic and Social Council, Economic Commission for Europe (2012) *Guidance document on control techniques for emissions of sulphur, nitrogen oxides, volatile organic compounds and particulate matter (including PM10, PM2.5 and black carbon) from stationary sources),* https://www.unece.org/fileadmin/DAM/env/documents/2012/EB/ECE.EB.AIR.117_AV.pdf

[56] European Commission (2001) *Reference Document on Best Available Techniques in the Ferrous Metals Processing Industry: Integrated Pollution Prevention and Control*.

[57] European Commission (2010) *Reference document on Best Available Techniques in the cement, lime and magnesium oxide manufacturing industries.*

[58] Armendariz (2008) *The Costs and Benefits of Selective Catalytic Reduction on Cement Kilns for Multi-Pollutant Control,* http://www.4cleanair.org/Documents/AlsSCR08report.pdf

Conclusion

The benefit-cost analysis, air quality modelling study and multi criteria analysis that selected the "Abatement package" are not fit for purpose. The conceptual approach is flawed, and the execution of that approach has been flawed.

Aurecon benefit-cost analysis finds most of the proposed measures have very low benefit-cost ratios. We believe this is because Aurecon's methodology is flawed and because it does not incorporate the latest research; which was the very purpose of the review. Aurecon's finding is also contrary to the experience of other countries that have introduced many, if not all, of the proposed measures. The benefit-cost analysis is also poorly written, hard to follow and does not provide enough supporting documentation for a reader to verify its analysis and conclusions. In summary, the analysis does not meet its objective of incorporating the latest research and it falls short of the standard required for it to be used for major public health policy decisions. It should not be used.

We consider the poor and limited standard of the work that has been done reflects the fact that a lot of the work has been outsourced to consultants who face cost incentives to: stick to the narrow brief they are given; provide little documentation; and not question the brief they have been given.

Aurecon is an engineering, design and advisory company with revenue of over $1 billion and 7,300 employees in Australia.[59] Large industry comprises a significant section of its client base. Implementation of the Abatement package would impose significant costs on parts of Aurecon's industrial client base. It is perhaps not surprising then that Aurecon found that implementing the Abatement package would not be worthwhile. Researchers consulting to government should include input from health, community and other stakeholders which Aurecon has failed to do.

Aurecon's paper should not be used as the basis to decide on action to reduce pollutants. It appears to drastically under-estimate the benefits of reducing pollutants and over-estimate the costs.

[59] Aurecon (2019) *About,* https://www.aurecongroup.com/about; IbisWorld (2019) *Aurecon Group Pty Ltd,* https://www.ibisworld.com.au/australian-company-research-reports/professional-scientific-technical-services/aurecon-group-pty-ltd-company.html