A review of the briefing note by Dr Ben Ewald, January 2021, titled:

Power station NO_2 emissions and paediatric asthma in Central Coast, Hunter Valley and Sydney Local Government Areas.

by Hugh Malfroy

Summary

Dr Ewald of the School of Medicine and Public Health, University of Newcastle, and a member of Doctors for the Environment Australia produced a briefing note in January, 2021 titled "*Power station NO_2 emissions and paediatric asthma in Central Coast, Hunter Valley and Sydney Local Government Areas"* (Ewald, 2021). The note includes a single table with estimates of the number and percentage of children in 27 Central Coast, Hunter Valley and Sydney Local Government Areas (LGAs) with asthma claimed to be caused by coal-fired power station nitrogen dioxide (NO_2) emissions[1].

Hugh Malfroy, Director of Malfroy Environmental Strategies Pty Ltd, was commissioned by Delta Electricity, owner of the Vales Point Power Station at Mannering Park (Central Coast LGA) to review the briefing note. The review focusses on the results for the Lake Macquarie and Central Coast LGAs for which the briefing note estimates that 6% and 5% of childhood asthma cases respectively are due to power station ground-level NO_2 concentrations. These percentages equate to 321 and 335 children in the two regions respectively, according to the table in the briefing note.

The purpose of the review was to attempt to understand and, if possible, reproduce the asthma results presented in the briefing note. While it has been possible to gain a general understanding of the methodology employed by Dr Ewald in producing the briefing note estimates, it has not been possible to verify or reproduce the results due to the briefing note's lack of input data used in calculating the results and the absence of supporting explanatory information relevant to the methodology employed.

In this review, the steps involved in the methodology employed by Dr Ewald, as understood by the author of the review, are examined and an attempt is made to establish reasonable values for the necessary inputs in an attempt to derive similar results to Dr Ewald. All data sources used are referenced and all assumptions made are documented.

The review arrives at estimates for the impact of power station NO_2 on children with asthma in the Lake Macquarie and Central Coast LGAs which are about an order of magnitude lower than those presented in Dr Ewald's briefing note. The review conservatively estimates that power station NO_2 may be responsible for about 0.5% of the cases of childhood asthma in the Lake Macquarie and Central Coast areas compared with the briefing note's estimates of 6% and 5% respectively.

Given the lack of data and supporting information provided in Dr Ewald's briefing paper it is not possible to explain the significantly different estimated asthma outcomes. However, as noted in the review, the estimated number of children with asthma used in the briefing paper

[1] NO_2 comprises the minor amount (5 – 10%) of the nitrogen oxides (NOx) emitted by coal-fired power stations and other combustion sources. The majority is emitted as nitric oxide (NO). Once emitted to the atmosphere, NO is converted to NO_2 at varying rates depending on prevailing atmospheric physical and chemical processes.

calculations and the numbers used in the review's calculations are similar (the review's estimates are about 8% higher), so this input does not appear to explain the differences.

The review can make no comment on how Dr Ewald applied the referenced NO_2 asthma risk estimate, as it is not discussed in the briefing paper.

It is left to conclude that a possible reason for the significant difference in estimated asthma outcomes is due to the NO_2 concentrations adopted in estimating the number of asthma cases due to all NO_2 sources and due to power station NO_2. Other than referring to dispersion modelling, the briefing paper presents no information that might enable the reader to understand how the relevant ground level NO_2 concentrations were obtained.

Given the very significant differences in the estimated outcomes presented in the briefing paper and in this review, it is suggested that a further independent review be undertaken by a suitably qualified person, with a view to clarifying the role of NO_2 in the development of childhood asthma in the Lake Macquarie and Central Coast LGAs.

1. Introduction

Dr Ewald of the School of Medicine and Public Health, University of Newcastle, and a member of Doctors for the Environment Australia produced a briefing note in January, 2021 titled *Power station NO2 emissions and paediatric asthma in Central Coast, Hunter Valley and Sydney Local Government Areas*. (Ewald, 2021). The note includes a single table with estimates of the number and percentage of children in 27 Central Coast, Hunter Valley and Sydney Local Government Areas (LGAs) with asthma claimed to be caused by coal-fired power station nitrogen dioxide (NO_2) emissions[2].

This review of the briefing note was commissioned by Delta Electricity, owner of the Vales Point Power Station at Mannering Park (Central Coast LGA). The review focusses on the results for the Lake Macquarie and Central Coast LGAs for which the briefing note estimates that 6% and 5% of childhood asthma cases respectively are due to power station ground-level NO_2 concentrations. These percentages equate to 321 and 335 children in the two regions respectively, according to the table in the briefing note.

The purpose of the review was to attempt to understand and, if possible, reproduce the asthma results presented in the briefing note.

In the following sections of the review, the steps involved in the methodology employed by Dr Ewald, as understood by the author of this review, are examined and reasonable values for the necessary inputs are presented in an attempt to derive similar results to Dr Ewald. All data sources used are referenced and all assumptions made are documented.

2. The steps involved in estimating asthma cases

The briefing paper does not provide explicit information on the methodology followed in producing the estimates of childhood asthma cases, nor does it include the data used in calculating the number of asthma cases. What follows is the author's understanding of the steps involved in the methodology and specific information on the data inputs required to make the necessary calculations.

The steps involved:

1. Obtain data on the number of children in the two regions;
2. Obtain data on the prevalence of asthma in children in the two regions;
3. Calculate the number of children with asthma in the two regions;
4. Calculate or obtain data on the ground level concentrations of NO_2 due to <u>all sources</u> of NOx in the two regions and the contribution from power station emissions.
5. Adjust the referenced NO_2 asthma risk estimates for local annual average NO_2 concentrations to calculate asthma due to all sources of NO_2 and asthma due to power station NO_2.

2.1 Number of children in the two regions

The briefing paper says that population data were obtained from the Australian Bureau of Statistics (ABS) but the paper does not include the actual data used in the analysis. The

[2] NO_2 comprises the minor amount (5 – 10%) of the nitrogen oxides (NOx) emitted by coal-fired power stations and other combustion sources. The majority is emitted as nitric oxide (NO). Once emitted to the atmosphere, NO is converted to NO_2 at varying rates depending on prevailing atmospheric physical and chemical processes.

most recent ABS data are from the 2016 census and while more recent population estimates may be available[3] the review uses ABS data to be consistent with the briefing paper.

The ABS provide the following for the number of children between 0 – 14 years of age:

- Lake Macquarie

  36,109 (18.2% of total population)

  https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA14650

- Central Coast

  60,420 (18.5% of total population)

  https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/LGA11650?opendocument.

It is noted Dr Ewald's estimates (from the table in the paper) are based on children in the 2 - 14 age group without describing from where data for the 2 - 14 years of age cohort were obtained.

2.2 Percentage of children in each region who suffer from asthma

The briefing paper says asthma prevalence was derived from "*the NSW health survey*" (Footnote 2) without providing a refence to the survey or including the actual data used in the analysis.

In this review, data from the NSW Government's Health Stats website on Asthma prevalence in children (*2 to 15 years of age*) were used (website accessed on 2nd July, 2021).

http://www.healthstats.nsw.gov.au/Indicator/res_astkid_age/res_astkid_lhn_comparison

Data are reported for children who have ever had asthma and for those that currently have asthma. In the analysis that follows the percentage of children with asthma in the latest reporting period (2017 – 2019) are used. This appears to be consistent with the briefing note (Footnote 1) which includes "*The definition for asthma is 12-month period prevalence, i.e., children who have been wheezy or required asthma medications in the last 12 months.*"

It is noted that the Lake Macquarie area is included in the Hunter and New England Local Health District (LHD), which extends as far north as the Queensland border. The most recent data (2017- 2019) indicates an asthma prevalence of about 16%.

The most recent data for the Central Coast LHD indicates an asthma prevalence of about 12%, declining from about 15% in 2014 – 2016.

Notwithstanding that the Central Coast data may be more representative of children living in the Lake Macquarie area than data from the much broader Hunter New England LHD, in the analysis that follows asthma prevalence rates of 16% for Lake Macquarie and 12% for the Central Coast have been assumed.

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[3] Lake Macquarie 205,901 (2019) https://www.lakemac.com.au/Our-Council/About-us/City-by-numbers

Central Coast 345,809 (2020) https://profile.id.com.au/central-coast-nsw

2.3 Number of children with asthma

The briefing note does not include the total number of children who have asthma in the two regions.

Table 1 provides an estimate of the number of children with asthma in the two regions based on the data presented in the previous sections.

Table 1: Data used in estimating the number of children with asthma in Lake Macquarie and the Central Coast

	Lake Macquarie	**Central Coast**
Number of children	36,109	60,420
Asthma prevalence %	16	12
Number of children with asthma	**5,777**	**7,250**

2.4 Ambient NO_2 concentrations in the two regions and the percentage of ambient NO_2 due to power station emissions

The briefing note says that modellers at the University of Exeter in the United Kingdom used dispersion modelling to estimate the proportion of ground-level NO_2 that originated from NSW coal-fired power stations (CFPS) across the LGAs.

To estimate the proportion of NO_2 due to power stations it is necessary to model or obtain data on the contribution from all sources of oxides of nitrogen (NOx = NO and NO_2) in the region[4] to ground-level NO_2 concentrations. The briefing note does not provide any detail on the numerous emission sources in the two regions, including the necessary emission parameters (location of source, height, temperature, concentration of emissions) necessary to model the contribution to ground level concentrations. The briefing note refers to coal-fired power stations generally without detailing which of the several power stations in the region (and beyond) were included in the modelling study or including relevant emission parameters.

To model ground-level NO_2 concentrations it is necessary to know or estimate the proportion of NOx that is emitted as NO_2 (a minor fraction) (Seinfeld 1977) and the proportion of NO converted to NO_2 in the atmosphere. The briefing note is lacking in any detail on how emission sources were characterised and how the atmospheric conversion of NO to NO_2 was estimated.

The briefing paper is lacking detail on the modelled outcomes or comparison with actual, monitored concentrations in the environment.

The table in the briefing paper includes a column headed NO_2 ppb (parts per billion) and includes figures of 2.5 and 2.2 for Lake Macquarie and Central Coast, respectively.

It is assumed that these are modelled annual average concentration, as the relevant averaging period, but it is unclear if the numbers refer to the total modelled NO_2 concentration (all sources) or the concentration due to power station emissions only.

[4] The National Pollutant Inventory includes 16-point sources of NOx in the Lake Macquarie and Central Coast areas. This does not include fugitive and distributed source, such as transport, domestic and commercial.

It is possible to put the numbers from the table into some context by comparison with monitoring data. Figure 1 shows the location of air quality monitoring sites operated by Delta Electricity, Origin Energy and the Environment Protection Authority (EPA) in the Central Coast-Lake Macquarie region. Table 2 includes data from the sites which monitor NO_2. In 2018 and 2019 annual average NO_2 concentrations across the region ranged between about 4 to 9 ppb. The monitoring data represents the combined contribution from all sources in the region (and beyond) and without detailed analysis it is not possible to estimate individual source contributions.

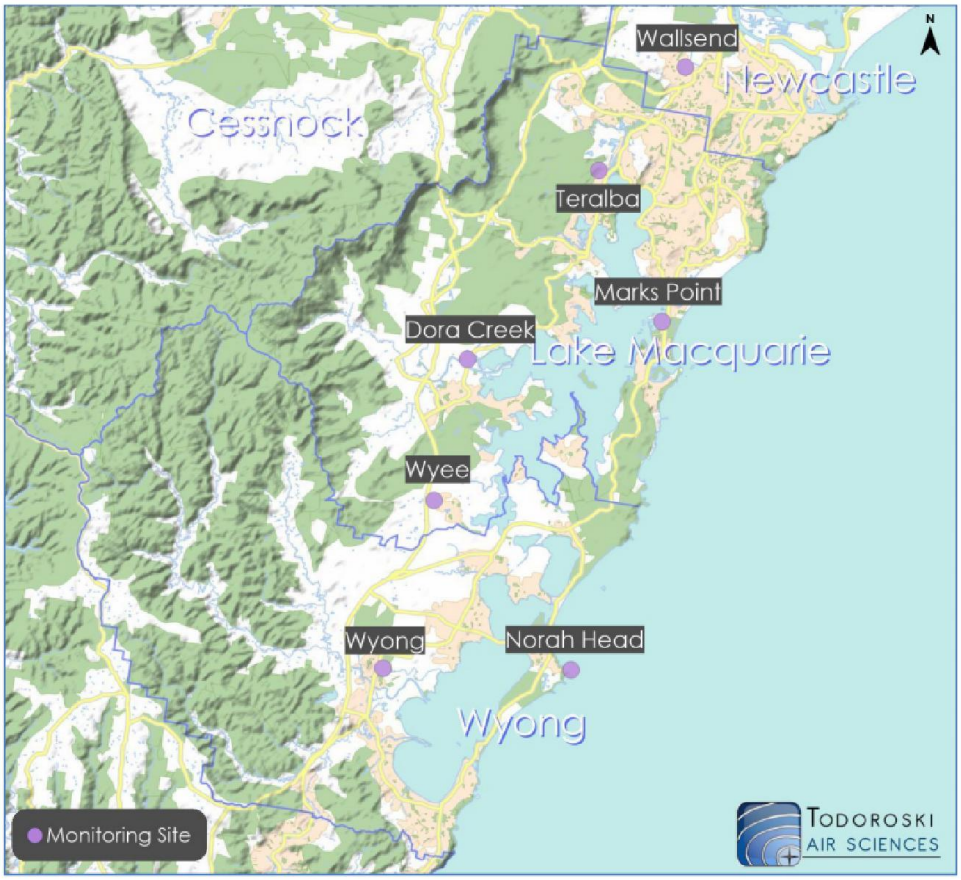

Figure 1: Air quality monitoring sites in the Central Coast Lake Macquarie region. (Source: Todoroski Air Sciences, 2020)

Table 2: Annual average NO2 concentrations, (ppb) in the Central Coast Lake Macquarie Region in 2018 and 2019 (Source: Todoroski Air Sciences, 2020)

	2018	2019
Monitoring site	**NO_2, ppb**	
Wallsend	6.9	7.0
Wyong	4.3	3.8
Dora Creek	5.1	9.4
Marks Point	5.2	5.4
Wyee	6.6	5.9

If the numbers reported by Dr Ewald of 2.5 ppb and 2.2 ppb are for all sources, they are clearly too low when compared with the monitored annual averages in Table 2[5]. It is noted that the modelling of annual average concentrations is generally reasonably accurate as long as emissions are well characterised and appropriate modelling assumptions are employed, so reasonable agreement between modelled and monitored data might be expected.

On the other hand, if the numbers reported by Dr Ewald are the power station contributions to the total ground level concentration, then it can be inferred that power stations are estimated to contribute in the order of 25 – >50% of the total NO_2 concentration. (Modelled power station contribution divided by monitored regional concentration).

A third possibility is that the NO_2 numbers in the briefing paper refer to something else not considered in the review. At the time of writing the review, Dr Ewald had not responded to an email requesting clarifying information relevant to the modelling undertaken for the briefing paper.

The 2010 Vales Point Power Station Assessment report (M_E_S 2010) included a detailed modelling study of the Central Coast – Lake Macquarie power stations (Vales Point, Eraring, Munmorah and Colongra Power Stations). The modelling was very conservative in that it assumed that the power stations were all running at full load throughout the year modelled.

Since 2010 a number of changes in power station operations in the region indicate that annual NOx emissions may have declined overall. Munmorah power station has closed, NOx emissions from Eraring have declined as part of the station upgrade[6] (National Pollutant Inventory data) and Colongra's 4 turbines have each run less than 100 hours in recent years (about 1% of the time). (Australian Electricity Market Operator, AEMO)[7]. Since 2010, Vales Point NOx emissions varied between about 16,000 – 22,000 tonnes per year, according to NPI data.

Figure 2 shows the predicted annual average NO_2 concentrations (in 2010) with an ambient background concentration of 14 $\mu g/m^3$ (~7 ppb) added to account for the non-power station sources (mainly motor vehicles). The total NO_2 concentrations are consistent with the more recent monitoring data shown in Table 2. Discounting the small, isolated area of slightly higher concentrations near Eraring, it can be appreciated that the regional power station contribution is about 0.5 ug/m^3 (0.2 ppb) or 3.4 % of the total NO_2 concentration (0.5 / 14.5) – up to 10 times lower (or more) than estimates based on data in the briefing paper.

[5] Reported concentrations in $\mu g/m^3$ have been converted to ppb to enable comparison with concentrations included in the briefing paper.

[6] National Pollutant Inventory data show NOx emissions from Eraring were estimated to be 33,000 tonnes in 2009/10 and 20,000 tonnes in 2019/20

[7] https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/market-management-system-mms-data/generation-and-load

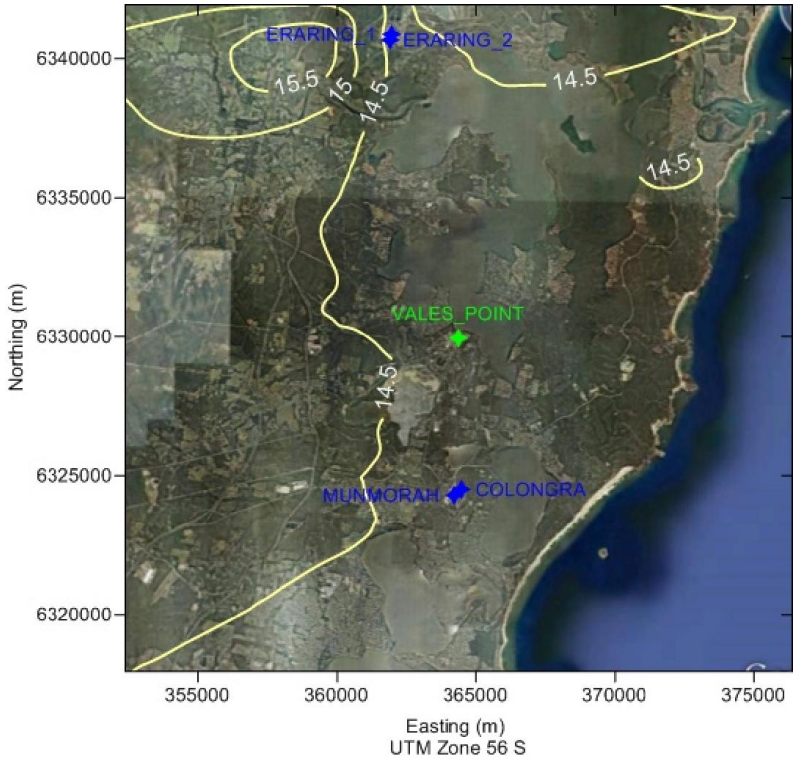

Figure 2: Annual average ground-level concentrations of Nitrogen Dioxide due to Vales Point, Eraring, Munmorah and Colongra Power Stations. An ambient background concentration of 14 µg/m^3 has been added.

2.5 The incidence of asthma due to NO_2

Having estimated the number of children with asthma and ambient NO_2 concentrations in the region, it is necessary to understand the role of NO_2 in causing childhood asthma[8]. The briefing paper references, but does not discuss a 2017 paper by Khreis, H., et. al, 2017.

This paper includes a risk estimate for NO_2 (due to traffic related emissions) of 1.05 (1.02, 1.07 95% Confidence Interval) per 4 µg/m^3.

The briefing note does not discuss the application of this risk estimate, nor does it consider possible limitations or uncertainties in its use. For example, on page 23 on the Khreis et al the passage below suggests some doubt regarding the NO_2 risk figure – (author's emphasis)

*"The results showed that the meta-analyses for NO_2, which had the highest number of studies, produced the highest heterogeneity and a relatively small effect size, which may indicate that **NO_2 may not be the putative agent in the TRAP (traffic-related air pollution) mixture,** but may act as a surrogate for example BC or PM2.5 which showed less heterogeneity."*

It is also noted that the risk factor was developed from data gathered in areas significantly more impacted by NO_2 than the two NSW LGAs considered here.

[8] Here the development, or cause of asthma, is being considered, not the conditions which may trigger an event in someone who already has asthma.
https://raisingchildren.net.au/guides/a-z-health-reference/asthma-causes

The briefing paper does not describe how the Khreis risk estimate was "factored up" from the published 4 μg/m^3 to the local NO_2 concentrations.

The table in the briefing note indicates an asthma prevalence of 321 and 335 in the Lake Macquarie and Central Coast respectively due to power station emissions which represents 6% and 5% respectively of total asthma cases in the two regions. There is not enough information provided to understand how these figures were calculated using the referenced risk estimate and total NO_2 concentrations. From the above numbers and percentages, it can be calculated that the total number of children with asthma in the two regions is estimated to be about 12,050[9] – about 8% lower than the review's estimate (Table 1).

3. Calculations

In undertaking the following calculations assistance was provided by Dr Stephen Wright, a senior biostatistician.

The methodology identified 3 scenarios relevant to the assessment:

1. Current conditions. The conditions in this scenario are defined by the existing number of children, the existing number of children with asthma (Table 2) and the existing ground level concentrations of NO_2 (from all sources) in the two LGAs of 14.5 μg/m^3 with all NOx sources included (including power stations).
2. No NO_2 emissions. This scenario uses the Khreis risk estimate, of 1.05 per 4 μg/m^3, adjusted for local NO_2 concentrations, to estimate the number of children expected to experience asthma in the absence of NO_2 emissions from all sources.
3. No power station NO_2 emissions. This scenario again uses the Khreis risk estimate, this time adjusted for local NO_2 concentrations with removal of the power station contribution of 0.5 μg/m^3, but all other NOx sources included, resulting in a ground level NO_2 concentrations of 14 μg/m^3.

The number of asthma cases due to power station NO_2 will be the numbers estimated for the Current conditions less the number of cases estimated for the No power station NO_2 conditions.

Calculation steps:

1. The number of cases in each scenario is calculated by multiplying the event rate by the population of children. The event rate is equivalent to the prevalence percentage (divided by 100), which from Table 2 is assumed to be 16% and 12% for Lake Macquarie and Central Coast LGAs respectively. These prevalence rates are relevant to the Current conditions scenario above. (All NOx sources included)
2. The event rate or prevalence must be calculated for the other two scenarios using the adjusted Khreis risk estimate (also known as an odds ratio).

[9] Lake Macquarie 321 / 6 * 100 = 5,350
Central Coast 335 / 5 *100 = 6,700

3. Scaling the Khreis risk estimate of 1.05 per 4 μg/m^3 for a local NO_2 concentration of 14.5 μg/m^3 resulted in an adjusted risk estimate of 1.93 (all NOx sources) , and scaling for an NO_2 concentration of 14.0 μg/m^3 resulted in an adjusted estimate of 1.86 (Power station emissions removed).
4. The above adjustments assume that the risk estimate can be scaled linearly with NO_2 concentration, which is considered to be reasonable for this purpose given the estimate is expressed as **per** 4 μg/m^3.
5. The adjusted risk estimates were used to calculate the event rates for the No NO_2 emissions and No power station NO_2 scenarios.
6. The predicted asthma cases were calculated by multiplying the number of children in the two LGAs by the event rates.
7. The estimated extra cases are shown in Table 3 for the two LGAs

Table 3: Estimated number of children with asthma due to NO_2 from all sources and NO_2 from power stations, Lake Macquarie and Central Coast LGAs (1)

	LAKE MACQUARIE			CENTRAL COAST		
	Current	No NO_2 emissions	No Power station NO_2	Current	No NO_2 emissions	No power station NO_2
Number of children	36,109	36,109	36,109	60,420	60,420	60,420
Event rate	0.160	0.13763	0.15918	0.12	0.10254	0.11936
Number of cases	5,777	4,970	5,747	7250	6,196	7,211
Extra cases due to All sources of NO_2(**2**)		**807**			**1,054**	
Extra cases due to power station NO_2 (**3**)		**30**			**39**	

1. There may be some small discrepancies in the table's results due to rounding of some numbers
2. Current minus No NO_2 emissions
3. Current minus No power station NO_2

4. Discussion

It is estimated that in the two LGAs combined, 1,861 children could have asthma due to exposure to NO_2. Of these 1,861 children with asthma, it is estimated that 69 could have asthma due to exposure to ground-level power station NO_2 concentrations. This represents about 0.5% of all children with asthma in the two LGAs. This is considered to be a conservative estimate given the very conservative nature of the modelling undertaken discussed in Section 2.4.

The predictions presented here are about an order of magnitude lower than those presented in Dr Ewald's briefing paper that estimated 6% and 5% of childhood asthma cases in the Lake Macquarie and Central Coast LGAs, respectively are due to power station NO_2 emissions. These percentages equate to 321 and 335 children in the two regions respectively, according to the table in the briefing note.

Given the lack of data and supporting information provided in Dr Ewald's briefing paper it is not possible to explain the significantly different estimated asthma outcomes. However, as previously noted, the estimated number of children with asthma used in the briefing paper calculations and the numbers used in the review's calculations are similar (the review's estimates are about 8% higher), so this input does not appear to explain the differences.

The review can make no comment on how Dr Ewald applied the asthma risk estimate as it is not discussed in the briefing paper.

It is left to conclude that a possible reason for the significant difference in estimated asthma outcomes is due to the NO_2 concentrations adopted in estimating the number of asthma cases due to all NO_2 sources and due to power station NO_2. Other than referring to dispersion modelling, the briefing paper presents no information that might enable the reader to understand how the relevant ground level NO_2 concentrations were obtained.

Given the very significant differences in the estimated outcomes presented in the briefing paper and in this review, it is suggested that a further independent review be undertaken by a suitably qualified person, with a view to clarifying the role of NO_2 in the development of childhood asthma in the Lake Macquarie and Central Coast LGAs.

5. References

Ewald B., 2021 *Power station NO2 emissions and paediatric asthma in Central Coast, Hunter Valley and Sydney Local Government Areas.* A briefing paper

https://www.nature.org.au/media/376419/ewald-b-2021-power-station-no2-emissions-and-childhood-asthma-in-local-government-areas-of-the-nsw-central-coast-final.pdf Accessed 10th June 2021

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