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**RE: Vales Point Power Station Exemption Application**

I am grateful for this opportunity to provide a submission to the NSW EPA on Delta Electricity's exemption application for nitrogen oxide ($NO_x$) emissions from the Vales Point coal fired power station.

I am a Senior Lecturer in Chemical Engineering at the University of Melbourne and my research focuses on air pollution. My expertise spans the formation of pollutants during combustion, emissions reduction technology, and atmospheric chemistry. I am recognised internationally as an expert in my field; I have published over 100 peer reviewed scientific papers and have given invited talks at major international conferences.

This submission is personally significant to me because I was born and raised on the Central Coast of NSW, within view of Vales Point and the other local power stations. I understand and appreciate the role that these facilitates have played in the local community, but also care deeply about protecting the unique environment of the Central Coast and the health of its residents, which includes many friends and family. Having been educated at Central Coast schools and at the University of Newcastle I am honoured to be able to use my expertise to help inform this important decision-making process.

I believe that no exemption should be granted to the Vales Point power station for nitrogen oxide air emissions. My reasoning is explained over the following pages, and can be summarized as follows:

(i) The changes required at the power station to achieve compliance with the $NO_x$ emissions standards would substantially reduce the quantity of $NO_x$ released from this power station over the remainder of its life.

(ii) The technology to achieve these emissions reductions is available and is standard at coal fired power stations around the world, and it would be technically feasible to retro-fit it to the Vales Point power station.

(iii) Ambient air pollution creates a significant health burden in the local Central Coast community and, regionally, across Sydney's greater metropolitan area. $NO_x$ is a major component of air pollution and contributes to formation of other harmful pollutants including secondary aerosol particles and ozone.

(iv) $NO_x$ emissions from the Vales Point power station contribute to negative health impacts locally and regionally, both from primary ($NO_x$) and secondary (particle and ozone) pollutants.

(v) Implementation of the available technology required to bring the Vales Point power station into compliance with the EPA's limits for $NO_x$ emissions would result in measurable improvements to the health of many NSW residents.

These findings apply to enforcement of the existing Group 5 limit (800 $mg/m^3$) as well as to the more stringent Group 6 (500 $mg/m^3$) limit. Additional benefits to air quality and human health could be realised from tighter limits on $SO_x$ emissions which I would also like to see considered.

Finally I would like to highlight in my submission a serious flaw in the air quality modelling submitted by Delta Electricity for Sydney's greater metropolitan area, specifically that addressing the impact of revised emission limits. This modelling uses emissions scenarios that would be impossible to achieve from Vales Point in which only the high emitting days are reduced. In reality, changes required to meet revised emission limits would dramatically reduce average emissions from this power station, with air quality improvements far greater than those estimated on behalf of Delta Electricity.

Yours Sincerely,

Gabriel da Silva

**Vales Point $NO_x$ Emissions**

The NSW Clean Air Regulation applicable to $NO_x$ emissions from power plants means that $NO_x$ levels must effectively be kept below a specified concentration at all times (the 100th percentile limit; a lower 99th percentile limit also applies). For the Vales Point power station (VPPS) an exemption currently allows this limit to be set at 1500 $mg/m^3$. To satisfy this obligation the VPPS continuously monitors the emissions of $NO_x$ and other key pollutants, through its continuous emissions monitoring system (CEMS).

Hourly CEMS $NO_x$ measurements from 2015 to 2021 were analysed by Jacobs Group (Australia) for Delta Electricity (the Jacobs report).[1] The data presented in the Jacobs report demonstrate that VPPS was able to meet its $NO_x$ emission limit of 1500 $mg/m^3$ only by maintaining average $NO_x$ levels in the range of about 600 – 700 $mg/m^3$ over the 2017 – 2021 period across both units (Units 5 and 6). At these average levels, peak $NO_x$ concentrations in any given year were routinely about twice the average value (and almost always meeting the 1500 $mg/m^3$ limit).

The Jacobs report accurately describes the reasons for $NO_x$ variability at VPPS. Continuous operation of the complex equipment that constitutes each of the units, principally the coal mills and the furnace, is prone to unavoidable fluctuations. Coal fired burners are particularly sensitive to the nature of the solid fuel (pulverised coal), which inevitably changes over time due to differences in the material being mined. Plant disturbances inevitably result in unpredictable upsets to operating conditions, and wear-and-tear and other operational issues result in more gradual changes over time. $NO_x$ formation in a furnace can vary significantly from relatively small changes in operating conditions, largely because of the complex interplay between gas temperatures and oxygen content.

Variability in the operation of VPPS explains the reason that peak $NO_x$ concentrations are typically around twice the average levels. To meet a stricter peak emissions limit, changes to the plant design would be required that also reduce the average emission levels. Even though at present VPPS $NO_x$ emissions usually meet the 800 $mg/m^3$ requirement, significant changes would be required to ensure that this requirement was always met. For instance, to ensure a safe operating margin from a limit of 800 $mg/m^3$, VPPS would almost certainly need to reduce average $NO_x$ emissions to around half of what they presently are, placing them in the range of 300 $mg/m^3$.[2] Being required to meet the current 800 $mg/m^3$ limit would therefore result in a dramatic reduction of total $NO_x$ pollution from VPPS. Importantly, this is the way in which the clean air regulations that VPPS operates under are intended to work – they limit total emissions by placing hard caps on maximum pollutant levels.

**$NO_x$ Reduction Technology**

A number of measures can be taken to reduce $NO_x$ emissions from older coal fired power stations. The NSW EPA, in their request for further information on the VPPS licence variation application,[3] asked for detailed evaluation of $NO_x$ emissions controls including (i) combustion optimisation, (ii) low $NO_x$ burners, (iii) selective non-catalytic reduction (SNCR), and (iv) selective catalytic reduction (SCR). The Jacobs report outlines these various classes of $NO_x$ reduction technology, within the context of VPPS, and I comment on this material below.

Efforts to optimise the combustion process have been ongoing at VPPS, including measures such as switching the burner tips, changes to the maintenance and overhaul routines of the furnaces, and implementation of new instrumentation. To date the effect of operational measures on $NO_x$ emissions have been modest at VPPS, and there is no indication that combustion optimisation alone could realise the emissions reductions needed to satisfy the 800 $mg/m^3$ limit. This conclusion extends to the neural network control technology considered by Jacobs, which can be classed as process optimisation and control technology.

Low $NO_x$ burners are a mature technology that is available to reduce $NO_x$ emissions from VPPS. Low $NO_x$ burners control the mixing of air and fuel to minimise the chemical reactions that produce $NO_x$ in a furnace, and are used around the world to help reduce coal fired power station $NO_x$ emissions, both on newly commissioned plants and on older retro-fitted ones. I agree with the Jacobs report that low $NO_x$ burners could be installed at VPPS and that they would reduce $NO_x$ emissions to near the level required to meet the 800 $mg/m^3$ limit. Because of the inherent variability in the solid fuel combustion process, however, it is very challenging to predict the exact reductions that would be achieved from a particular plant. Nevertheless, low $NO_x$ burners appear technically feasible at VPPS and I would recommend their installation. The Jacobs report only recommends against implementing low $NO_x$ burners because they are not financially profitable within the context of savings from load base licensing fees.

The remaining measures available to reduce $NO_x$ emissions from VPPS can be classified as post combustion processes, where $NO_x$ is reduced to inert $N_2$ by chemical reactions within the hot flue gas. Broadly speaking, this can be achieved by injection of reagents into the stack (SNCR) or by passing the flue gas and necessary reagents over a catalyst (SCR). Again, SNCR and SCR are mature technologies adopted by many power stations around the world. This international experience, as outlined by Jacobs, indicates that SNCR would very likely reduce peak $NO_x$ emissions at VPPS to below the 800 $mg/m^3$ limit, with SCR providing a higher degree of emissions reduction, closer to the Group 6 limit of 500 $mg/m^3$. I would recommend the installation of SNCR post combustion $NO_x$ control at VPPS. Jacobs also find that both SNCR and SCR are technically feasible at VPPS, and only appear to recommend against them because they can not make a business case. Note that this business case would dramatically shift within the context of an enforced 800 $mg/m^3$ $NO_x$ limit.

It is apparent that retro-fitting low $NO_x$ burners and post-combustion SNCR or SCR are technically feasible emissions control strategies at VPPS. Importantly, low $NO_x$ burners can work alongside post combustion controls. A layered strategy involving the retro-fit of both low $NO_x$ burners and SNCR technology would ensure that the 800 $mg/m^3$ $NO_x$ limit is met at VPPS. Alternatively, an SCR unit alone would likely provide a similar level of emissions reduction.

**Air Quality Improvements**

As outlined above, enforcing a $NO_x$ limit of 800 $mg/m^3$ on VPPS through the retro-fitting of mature emissions control equipment would cut the total quantity of $NO_x$ emitted by VPPS approximately in half. Similarly, $SO_x$ emissions control strategies including scrubbers and flue gas desulfurisation could also be feasibly implemented to reduce total emissions of this pollutant.[4] $NO_x$ and $SO_x$ are two of the most significant air pollutants in ambient air. In addition to their own demonstrated negative health effects, $NO_x$ plays an important role in the atmospheric oxidation of volatile compounds emitted by vehicles, industrial activity, and even trees. This chemistry is responsible for the formation of ozone and organic aerosol particles. $NO_x$ and especially $SO_x$ are also major precursors of secondary aerosol particles containing nitrates and sulfates (*e.g.*, ammonium sulfate). In total, this suite of key ambient air pollutants ($NO_x$, $SO_x$, ozone, and fine aerosol particles [PM2.5]) are primarily responsible for the degradation of air quality in urban environments. These pollutants are responsible for a range of negative health impacts, primarily involving the respiratory and cardiovascular systems. Globally, poor air quality is thought to be responsible for over seven million deaths annually.[5] In Australia, air pollution is responsible for thousands of deaths every year,[6] making it a significant cause of preventable death, a large public health burden, and a drain on national productivity.

There is no question that air pollution is a pressing public health concern. A two-fold reduction in $NO_x$ emissions from VPPS is achievable through enforcement of current regulations, which would result in a dramatic drop in the amount of this air pollutant that is released into the NSW environment. Predominantly, these benefits would be felt locally on the Central Coast and regionally across Sydney's greater metropolitan area (GMA).

**Local Air Pollution**

Air pollution from VPPS most acutely impacts the suburban areas of the Central Coast nearby to Vales Point. The NSW EPA asked VPPS to conduct an air quality impact assessment (AQIA) that focused on local air quality impacts. This AQIA was asked to include the 1500 mg/m$^3$ licensing limit as well as the 800 and 500 mg/m$^3$ levels for $NO_x$. Delta Electricity commissioned Katestone Global to prepare a report addressing, among other things, the AQIA requests (the Katestone report).[7]

Dispersion modelling carried out by Katestone indicates that the VPPS is a significant individual contributor to ground-level $NO_2$ locally, with average $NO_x$ emissions contributing up to 3.3 $\mu$g/m$^3$ of ground-level $NO_2$. Across large parts of the Central Coast typical contributions are predicted to be in the 1 to 2 $\mu$g/m$^3$ range. Because this dispersion modelling was carried out using average VPPS emission levels, this represents the typical contribution of this single point source to the background $NO_2$ in these areas. Note that there are many sources of air pollution (including vehicles and other nearby power stations), and unhealthy air typically arises from the aggregate sum of multiple polluters – the problem can rarely be solved by tackling one source alone.

The WHO sets an annual mean guideline level of 10 $\mu$g/m$^3$ to protect public health from $NO_2$. It is therefore apparent that VPPS provides a large contribution to potentially unhealthy air on parts of the Central Coast. As I have described, enforcing a $NO_x$ emissions limit of 800 mg/m$^3$ would approximately halve the production of these pollutants at VPPS. This could be expected to reduce typical ground-level $NO_2$ by up to 1.5 $\mu$g/m$^3$ across a large suburban region of the Central Coast.

The Katestone modelling considers dispersion of the pollutants from VPPS to the surrounding regions. However, it does not appear to contain a detailed chemical transport model (CTM), which would be required in order to describe how $NO_x$ (and $SO_x$) react to form harmful particulate matter (PM2.5) and ozone. Nevertheless, it is clear that $NO_x$ emissions from VPPS alone are a significant single contributor to unhealthy air on parts of the Central Coast, and that a requirement to meet an emissions standard of 800 mg/$m^3$ would improve health in the region.

**Regional Air Pollution**

Modelling available in the peer reviewed scientific literature demonstrates that air pollution from VPPS and other coal fired power stations has a measurable negative impact on air quality in Sydney and the GMA. The NSW EPA also requested that VPPS extend their AQIA to the GMA, including consideration of ground-level ozone, $NO_2$, and secondary aerosol particles under current emissions scenarios as well as for 800 and 500 mg/$m^3$ levels for $NO_x$. This is addressed to some extent in the Katestone report. However, the Delta Electricity response to the NSW EPA states that "the requirement to model impacts on the regional and inter-regional receiving environment as requested is excessive and unnecessary as already outlined by Delta",[8] and I therefore infer that Katestone were requested not to carry out this modelling under the likely emissions reduction scenarios described by Jacobs and analysed by myself above.

The Katestone report does include one section on revised emission limits (§ 7.3). This analysis is fundamentally flawed, and is inconsistent with information from Jacobs that was also commissioned by VPPS. I sincerely hope that this material and the derived conclusions can be disregarded from the licence variation application.

Because of the complex way in which a coal fired power station operates, emissions of $NO_x$ and other pollutants are variable and uncertain. As described by Jacobs, and evident from the CEMS data they present, average emissions levels must be kept at around half of the $100^{th}$ percentile cap in order to ensure that this cap is never (or in the current case of VPPS, very rarely) exceeded. Currently, VPPS operates with mean $NO_x$ emissions of just below 800 mg/$m^3$, and exceeds this value less than half of the time. However, to meet a $100^{th}$ percentile standard of 800 mg/$m^3$, available technology means that mean emissions would need to be reduced to somewhere closer to 300 mg/$m^3$. For the 500 mg/$m^3$ standard I estimate that mean emissions would need to be in the range of 200 mg/$m^3$. Note that international experience with low $NO_x$ burners and post combustion $NO_x$ reduction indicates that these levels are routinely achievable.

It would not be possible to operate VPPS at current mean $NO_x$ emissions levels with controls to prevent excursions above 800 mg/$m^3$. Likewise, the plant could not be modified to output $NO_x$ at a constant level of just below 500 mg/$m^3$. However, this is exactly the assumption that the Katestone report makes when attempting to evaluate the impact of revised emission limits. For compliance with the 800 mg/$m^3$ limit, the Katestone report states that their tests of revised emission limits use amended historic emissions data where "$NO_x$ concentrations that exceed [800 mg/$m^3$] are replaced with [800 mg/$m^3$]." This approach will dramatically underestimate the actual improvements on ground-level pollutants realised by enforcing the 800 mg/$m^3$ standard and must be disregarded. To reiterate, this comes within the context of Delta Electricity believing that comprehensive modelling of these effects would be excessive and unnecessary.

In the absence of modelling that satisfies the NSW EPA request, I turn to published scientific modelling of the impact of power station emissions on air quality in Sydney. Broome et al.[9]

examined the role that different sources have in PM2.5 pollution Sydney's GMA. Because of the chemistry leading from $NO_x$ to secondary aerosols, they found that power stations were a major contributor to Sydney's PM2.5 air pollution, estimated to be responsible for around 10 % of PM2.5. Because of the significant air quality issues impacting Sydney, this was predicted to account for thousands of years of lost life. Duc et al.[10] specifically examined ozone formation in the GMA, where again $NO_x$ chemistry plays an important role, and here power stations were again identified as a major contributor. Although there may be larger overall contributors to air pollution in the GMA, such as wood fire heaters and vehicles, it is undeniable that emissions from power stations that include VPPS play a role and that reducing their emissions would have a positive impact on the health of residents across Sydney's greater metropolitan area.

**Conclusion**

From material that has been submitted to the NSW EPA or is publicly available it is possible to demonstrate that enforcing a $NO_x$ limit of 800 mg/m$^3$ would dramatically reduce the quantity of nitrogen oxides ($NO_x$) released by the Vales Point power station. Moreover, technically feasible solutions are available that could be retro-fit to the power station and would be able to meet an 800 mg/m$^3$ limit. Air pollution from Vales Point currently degrades air quality both on the Central Coast (primarily through primary emissions of $NO_2$) and in the greater metropolitan area of Sydney (including through secondary aerosol particle and ozone formation), and in both cases harms human health. An implementation of available emissions control measures would improve air quality on the Central Coast and across Sydney with a reduction in years of life lost to disease, healthcare costs, and productivity loss. The Vales Point power station should be required to implement low $NO_x$ burners with selective non-catalytic reduction or selective catalytic reduction alone in order to achieve these outcomes.

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[1] Vales Point – Evaluation of Potential NOx Emission Controls, Jacobs Group (Australia), 6 October 2021.

[2] This makes the reasonable assumption that the ratio of peak to average $NO_x$ would remain the same due to the inherent variability described in the Jacobs report. Similarly, to ensure meeting a 500 mg/m$^3$ limit, average levels would need to be reduced to around 200 mg/m$^3$. Average $NO_x$ emissions in the range of about 200 – 300 mg/m$^3$ are routinely achieved at coal fired power stations around the world, as described in the Jacobs report. Detailed engineering calculations that are outside the scope of this submission would be required to refine the emissions reduction estimates provided here, although these quoted numbers are consistent with the information provided by Jacobs and reports from power stations globally.

[3] EPL 761 – Licence Variation Application – Further Information Requirements, NSW EPA, 10 May 2021.

[4] The NSW EPA request for further information asked VPPS to consider $SO_x$ emissions controls alongside those for $NO_x$. I do not describe them here.

[5] WHO Global Air Quality Guidelines, World Health Organization, 2021.

[6] Impact and Causes of Illness and Death in Australia, Australian Institute of Health and Welfare, 2011.

[7] Vales Point Power Station Air Quality Assessment for Group 5 Exemption Extension, Katestone Global, October 2021.

[8] RE: Vales Point EPL761 – Licence Variation Application for NOx Emission Limits, Delta Electricity, 8 October 2021.

[9] R. A. Broome, J. Powell, M. E. Cope, G. G. Morgan, The Mortality Effect of PM2.5 Source in the Greater Metropolitan Region of Sydney, Australia. Environment International, 2020, 137, 105429.

[10] H. N. Duc, L. T.-C. Chang, T. Trieu, D. Salter, Y. Scorgie, Source Contributions to Ozone Formation in the New South Wales Greater Metropolitan Region, Australia. Atmosphere, 2018, 9, 443.