Bayswater Power Station Turbine Efficiency Upgrade Project

AGL Macquarie Pty Limited

State Significant Infrastructure Application Report

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1. Introduction

1.1 Background

AGL Macquarie Pty Limited (AGL Macquarie) owns and operates the Bayswater Power Station.

Bayswater Power Station (Bayswater) was commissioned in 1985. Over recent years Bayswater has produced approximately 15,000 Gigawatt hours (GWh) of electricity a year, enough to power approximately two million average Australian homes.

Bayswater generates electricity using four generating units. AGL Macquarie proposes to replace the turbines within each of the generating units to best ensure the continued safe, reliable and efficient operation of Bayswater until its scheduled closure in 2035, and ensure that all new turbines are fully operational prior to the closure of Liddell Power Station (Liddell) in 2022.

1.2 Project Summary

The existing four generating units at Bayswater currently have a 660-Megawatt (MW) continuous maximum rating (CMR) capacity.

AGL Macquarie proposes to replace the turbines in each of the four existing generating units over a four-year period – one generating unit per year. This will increase the CMR capacity from 660 MW to 685 MW for each generating unit (overall referred to as “the project”).

The project is essentially a like for like replacement of the ageing turbines with current turbine technology. Since Bayswater was commissioned, there have been improvements in turbine technology which increase the efficiency at which the steam produced at power stations can be converted to electricity. As a result, the project will have the consequence of increasing the CMR capacity of each turbine from 660 MW to 685 MW. Approval is sought for the rated capacity increase as part of the project. This will improve the reliability, efficiency and security of electricity supply to NSW during peak demand periods without increasing coal consumption or air emissions.

Specifically, the project will:

- increase the rated capacity of each generating unit from 660 MW to 685 MW;
- increase the rated output of Bayswater from 2,640 MW to 2,740 MW and provide power for up to an additional 100,000 average Australian homes;
- achieve efficiency improvements estimated at over 4 per cent through the recovery of lost efficiency due to wear and tear since commissioning and as a result of improved turbine technology with an associated decrease in the greenhouse gas (GHG) intensity of the power station;
- involve an estimated capital investment value of approximately $150 million over a four-year period; and
- provide employment for an estimated additional 60 workers over approximately 50 days per year for four years.

Subject to approvals being obtained, the project is proposed to be carried out during planned maintenance outages which are scheduled to commence in February 2019. It is essential that the project be timed in line with these planned outages to minimise the risk of disruption to NSW's energy security.

All works proposed as part of the project will be carried out within the existing turbine hall at Bayswater with no change required to the existing footprint.

The project is part of AGL's *NSW Generation Plan* (AGL, 2017a), which has outlined new investments aimed at replacing the 1,000 MW shortfall, identified by the Australian Energy Market Operator (AEMO), that will be needed to supplement Liddell's generation capacity before its closure in 2022. Other investments identified in the *NSW Generation Plan* include a mixture of large-scale renewables, firm gas-peaking power, battery storage and demand response.

The project is limited in scope to only the replacement of existing turbines. Importantly, the application does not seek approval for any changes to the existing operations of Bayswater which will continue to be managed in accordance with the existing planning approvals and environment protection licence.

1.3 Proponent

AGL Macquarie is the owner and operator of Bayswater and is the proponent for the project. AGL Macquarie currently produces approximately 12 per cent of the electricity needed by consumers in eastern Australia. AGL Macquarie's assets include the 2,640 MW Bayswater Power Station, the 2,000 MW Liddell Power Station and 50 MW Hunter Valley Gas Turbines. AGL Macquarie acquired these assets from the former NSW Government Corporation, Macquarie Generation, in September 2014.

AGL Macquarie employs approximately 630 people, with most living in the Hunter region. The assets have been a major source of employment to the region over the last 30 years and contribute more than $1.35 billion annually to the regional economy.

AGL Macquarie is owned by AGL Energy Limited (AGL) and forms a key component of the company's generation portfolio. AGL is an integrated energy business that has been operating for more than 180 years and is committed to helping shape a sustainable energy future for Australia. AGL operates the country's largest private electricity generation portfolio, its total capacity of 10,245 MW accounting for 25 per cent of total generation within the National Electricity Market (NEM) in the financial half-year ended 31 December 2017. AGL is also the largest Australian Securities Exchange listed investor in renewable energy, an active participant in gas and electricity wholesale markets and has more than 3.6 million gas and electricity customer accounts.

1.4 Project Need

AGL will close Liddell in 2022 in accordance with its operational end of life-cycle and provided public notice of this intention in April 2015 to avoid any volatility in the NEM.

AGL recognises community and government concerns in relation to energy security, as highlighted in the Australian Energy Market Operator's 2017 *Electricity Statement of Opportunities*. AGL released a plan to replace the generation capacity of Liddell in the form of the *NSW Generation Plan*. The project application forms a critical part of the *NSW Generation Plan* to ensure the ongoing security and reliability of energy supply.

The replacement of the ageing turbines within the existing generating units will increase the generation capacity at Bayswater and improve security of supply, through improved availability and reliability. This will help contribute to the continuity of energy supply to NSW during periods of maximum hourly and daily demand and enable Bayswater to operate with reduced outage durations until its scheduled closure in 2035.

1.5 Planning and Assessment Process

The project was declared to be State significant infrastructure and critical State significant infrastructure (Critical SSI) by an amendment made to the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP) and commenced on 2 March 2018.

AGL Macquarie has accordingly lodged its application for approval for the project as Critical SSI under section 5.15 of the *Environmental Planning and Assessment Act 1979 (NSW)* (EP&A Act).

1.6 Purpose of Report

The purpose of this report is to support an application for Secretary's Environmental Assessment Requirements (SEARs) under section 5.16 of the EP&A Act. Once issued, the SEARs will set out the matters to be addressed by AGL Macquarie in the Environmental Impact Statement (EIS) to be prepared and submitted for the project under section 5.17 of the EP&A Act. This report documents the outcomes of the preliminary environmental risk analysis for the project and scopes the matters and impacts that are likely to be relevant to the project.

2. Project Context

2.1 Existing Infrastructure - Bayswater Power Station Operations

Bayswater employs technology common with other NSW coal-fired power stations using the following general process:

- coal is received and stored on site;
- coal is transferred from the storage area to the coal bunker by conveyor and is finely ground before being burned in the boiler furnace producing:
  - heat for the boiler;
  - incombustible coal residue, in the form of furnace ash and fly ash, which is collected and transported to ash disposal areas; and
  - hot gases generated from the combustion of the coal in the furnace, discharged via the fly ash collection plant through tall stacks which are continuously monitored.
- water is circulated through the boiler and heated by the boiler furnace to produce steam;
- high pressure steam from the boiler enters the turbine trains within the generating units;
- each of the generating units consist of four turbines arranged in tandem that drives a generator. The four turbines consist of one single flow high pressure (HP) turbine, one dual-flow intermediate pressure (IP) turbine and two dual-flow low pressure (LP) turbines;
- once within the generating units, the high pressure steam is expanded through stages of fixed and rotating blades within the HP turbine before being reheated and expanded through the IP and LP turbines. The turbines drive the generator rotor which produces electricity;
- steam exiting the turbine train is condensed to water and returned to the boiler with the addition of any purified water necessary to make up for losses;
- heat rejected in the condenser is carried away by the circulating water system and dissipated in the natural draught cooling towers; and
- the electricity produced by the generator is transformed to system voltage and fed to the interconnected transmission system via the station switchyard.

Bayswater includes both main plant areas and ancillary service facilities. The main plant areas and structures include the turbine hall, boilers, cooling towers, fly ash collection plant, chimneys, coal storage area, transformer yard and switchyard. The ancillary service facilities include a cooling water desalination plant, cooling water make-up reservoir, waste water treatment plant, oil storage tanks, workshops, stores, amenities and administration buildings.

Bayswater was built to utility standards of the time and has a current technical life up to 2035. Bayswater is now over 30 years old and as part of the mid-life refurbishment program, AGL Macquarie has reviewed options regarding the existing turbines to ensure they best ensure the continued safe, reliable and efficient operation of Bayswater until its planned closure.

Coal consumption and emissions at Bayswater vary in response to demand for energy. Operations are carried out in accordance with existing approvals. No changes to the existing approved operations at Bayswater are proposed other than the increase in capacity as described in Section 3.

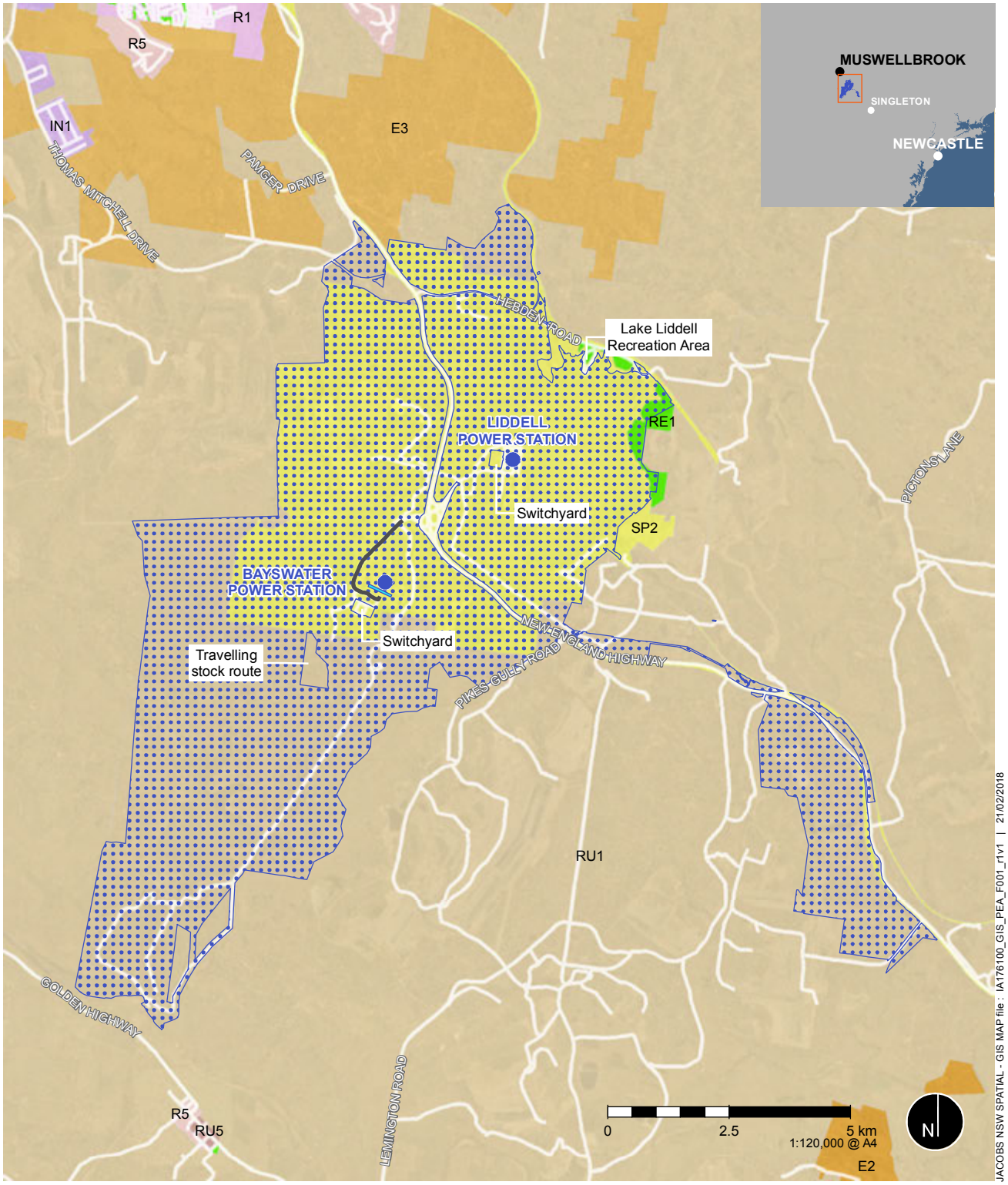
2.2 Site and Surrounds

Bayswater is located approximately 16 kilometres (km) south-east of Muswellbrook, 25 km north-west of Singleton, and approximately 165 km west-north-west of Sydney in NSW. The total area of the AGL Macquarie landholding is approximately 10,000 hectares, including Ravensworth rehabilitation area, Lake Liddell and surrounding buffer lands. Bayswater's operational area occupies approximately 300 hectares, which includes the Pikes Gully Ash Dam. The location of Bayswater and its zoning is illustrated in Figure 2.1.

The project will be wholly carried out within the existing turbine hall located at Bayswater. The turbine hall, which houses the four generating units containing the turbines proposed to be replaced, is a 38-metre-high, enclosed structure covering approximately 1.3 hectares. The turbine hall is located on Lot 2, DP327372 and Lot 2, DP1095515 within the Muswellbrook Local Government Area (LGA) to the west of the New England Highway as illustrated in Figure 2.2.

Existing development neighbouring Bayswater includes the Drayton and Liddell coal mines, as well as Liddell and the Main Northern Railway Line. The New England Highway runs parallel to Bayswater, with access from the highway provided by means of a dedicated road network designed to service the power station. Agricultural clearing for the purposes of grazing is also present within and surrounding the AGL Macquarie landholding. The closest residential area is the Antienne subdivision, which is located behind a ridge line around 5 kilometres north of the project.

The project is located within the Hunter River catchment and predominately drains to Lake Liddell, an artificial operational water body constructed for the purposes of supplying cooling water to both Bayswater and Liddell.



Legend

Turbine hall / upgrade works area — Upgrade works access — Power station — AGL owned land

LEP land zoning (DPE)

E2	Environmental Conservation	R1	General Residential	RU1	Primary Production
E3	Environmental Management	R5	Large Lot Residential	RU5	Village
IN1	General Industrial	RE1	Public Recreation	SP2	Infrastructure

Figure 2.1 | Land tenure and land use context

Figure 2.2 | Upgrade works area

3. Project Description

3.1 The Project

AGL Macquarie has identified a need to replace the existing four turbines within each of the four generating units at Bayswater, and the opportunity to use more efficient, and higher rated generating capacity turbines.

The project forms a component of AGL's *NSW Generation Plan* to meet peak demand and critical need to replace the generation capacity of Liddell before its closure in 2022. AGL Macquarie has determined that the project is the best option to increase generation capacity at Bayswater in a manner consistent with AGL's corporate policies.

The project consists of the works to replace the four turbines in each of the four generating units, increasing the rated capacity of each generating unit by 25 MW to 685 MW and increasing the overall rated capacity of Bayswater from 2,640 MW to 2,740 MW. The increased rated capacity results from the more efficient conversion of steam energy into mechanical energy provided by the improved and optimised steam paths within the selected, modern turbine technology. Once replaced, the turbines will continue to be operated and maintained as required.

The project is scheduled to commence in February 2019 to coincide with the first planned major outage in a four-year major outage program that would see one turbine replaced each year, prior to the closure of Liddell. It is critical that the project be timed in line with these planned outages to minimise the risk of disruption to NSW's energy security.

No changes are proposed to the existing approved operation of any other component of Bayswater as part of the project. In particular, coal consumption, air emissions and ash generation will not change as a result of the project and will continue to vary as the operation of Bayswater responds to market demand. However, the project will enable this continued variation in the overall operating level of Bayswater to occur at a more efficient level to meet market demand than it would have been able to in the absence of the project. The more efficient conversion of the heat energy from the boilers into mechanical energy via the turbines may result in a marginal decrease in the waste heat required to be managed through the cooling system. While not able to be confirmed until after the project is complete, this may also result in reduced water use and water treatment requirements.

3.2 Turbine Installation Works

Turbine components within each of the four generating units are currently maintained on a four-yearly basis. This involves the removal of turbine casing, inspection and maintenance of turbine components and reassembly. The project involves the replacement of the HP, IP and LP turbines during the scheduled turbine inspection and maintenance activities. The project would be completed during scheduled shutdowns of each turbine, with one turbine replacement occurring each year over a four-year period commencing in February 2019.

The project would involve the following:

- works undertaken over an expected 50 days per year within scheduled 72-day maintenance shutdown to avoid unnecessary loss of availability;
- works limited to one turbine per year to minimise loss of overall generating capacity at any one time;
- additional estimated 60 workers attending site over a scheduled 50-day period within the shutdown period;
- anticipated 11 heavy load deliveries to Bayswater per shut-down over an expected four-year period;

- all deliveries would be to the existing loading bay within the turbine hall using existing established access roads, with turbine components being lifted to the turbine floor by existing cranes located within the turbine hall;
- removal of turbine casings, extraction of HP, IP and LP turbines, replacement with new HP, IP and LP turbines and reinstatement of turbine casings; and
- categorisation and management of waste including old turbines, components and packaging. Opportunities for recycling would be explored where practicable.

Other maintenance works, consistent with the existing approved operation of Bayswater will also be undertaken during the shutdown. These maintenance works do not form part of the project which is limited to the replacement of turbines on the four existing generating units. However, where necessary to ensure full assessment of cumulative impacts, these maintenance activities will be considered and assessed.

With the exception of deliveries and dispatch of waste, all installation activities associated with the project would be contained within the fully enclosed turbine hall. No additional laydown areas, access upgrades, parking areas, temporary or permanent structures or clearing is required to facilitate the project.

3.3 Operational Implications

The project involves the replacement of the ageing existing turbines with new, more efficient and higher rated capacity turbines. As noted in Section 2.1 above, the turbines operate to convert the steam generated from the boiler to electricity and occur towards the end of the electricity generating process. No changes to the other operations, including no increase to the volume or method of coal burning or management is proposed as part of the project. As such the project would have limited operational implications.

Based on current data and specifications, the project would provide a net improvement in overall cycle efficiency of over 2 per cent compared to the original design and over 4 per cent compared to current operations reducing Bayswater's greenhouse gas (GHG) intensity (CO_2e emissions per MWh) by similar percentages (refer to Section 7.1). This is a direct result of installing newer design and technology improved turbines which provide greater heat rate efficiencies.

The increased rated capacity will require no additional coal consumption to generate 685 MW per unit compared with that currently required to generate 660 MW per unit. Therefore, there is predicted to be no increase in magnitude of environmental impacts compared to the operation of the current turbines where Bayswater's operating profile is maintained at a similar level. This will be confirmed during the environmental assessment of the project.

The replacement of the ageing turbine infrastructure proposed is anticipated to also reduce the length of future planned outages by reducing overall maintenance requirements. As a result, at the completion of the project, it is anticipated outage periods for each turbine every four years will decrease from approximately 72 days to approximately 45 days.

4. Justification and Alternatives

4.1 Consideration of Project Need

Bayswater was commissioned in 1985 and consists of four Toshiba 660 MW turbo-generating units. AGL Macquarie's asset strategy has identified that a replacement of the turbines would best ensure that safe, sustainable, reliable and cost-effective operations can continue at Bayswater through to its scheduled closure in 2035.

The project forms a key part of AGL Macquarie's asset strategy to ensure that Bayswater can continue operating without the need for major turbine outages before closure in 2035.

4.2 Consideration of Project Opportunity

Due to steam turbine blade design improvements since commissioning, the project provides two key opportunities to improve generation efficiency at Bayswater:

- to improve efficiency when continuing to operate at 660 MW (this level of operation will be able to occur with lower coal consumption and reduced GHG emissions than is currently the case once the turbines are upgraded); and
- to allow for increased output to 685 MW per unit without increasing coal consumption or GHG emissions over that currently required to generate 660 MW per unit.

4.3 Consideration of Options

As part of AGL Macquarie's overall asset strategy, five options, ranging from “Do Nothing” to replacing the plant with750 MW per generating unit, as well as their risks, benefits and costs, were assessed. Considering each generating units’ age and past operating duty, it has been identified that either ongoing extensive maintenance, or the replacement of the turbine components would be required to achieve the 2035 closure date.

Given the existing turbines would likely need significant ongoing maintenance, “Do Nothing” is not considered viable as it risks decreased reliability, lost generation, lost capacity, and significant repair cost.

While several potential options to increase capacity beyond 685 MW up to a maximum of 750 MW per unit were considered, it was determined that these would involve significant works beyond the turbines to ensure the balance of Bayswater’s capability remained “matched” with the turbines. This would delay the program start by approximately two years, add considerable complexity to design and construction, and would increase coal consumption and GHG emissions.

4.4 Justification of Recommended Option

The project was identified as the recommended option as it would allow the generating units to run at 660 MW on reduced coal consumption, or up to 685 MW at the same coal consumption as currently required to generate 660 MW per unit. The project represented the best environmental outcome of the options assessed with increased capacity. Key benefits of the project include:

- the recovery of an estimated degradation of 1.7 per cent of generation that has been lost over time through wear and tear on the turbines since original commissioning circa 1985;
- efficiency improvements at which the heat from the steam generated is converted to electricity (heat rate) by over 4 per cent compared to current operations;
- increased rated capacity of each generating unit from 660 MW to 685 MW, with an associated decrease in GHG intensity per megawatt hour; and

- an increase in the rated output of Bayswater from 2,640 MW to 2,740 MW.

The replacement of ageing turbines is also expected to result in improved security of supply, through improved availability and reliability and contribute to continuity of energy supply to NSW during periods of maximum hourly and daily demand. The project would reduce the operating risk profile and improve reliability of Bayswater enabling it to continue operating with reduced outage durations until its scheduled closure in 2035. The operating risk profile benefits resulting from the project include:

- improved reliability of the turbine plant;
- shorter and less complicated outages; and
- decreased risk of turbine failure occurring before 2035.

5. Planning framework and strategic context

5.1 Strategic Context

The project forms a key part of AGL's response to the demand in NSW and the NEM. As described below, the project responds to the identified needs of the NEM, the announced closure of Liddell and AGL's *NSW Generation Plan* aims to replace Liddell's generation capacity with reliable, dispatchable and cleaner technologies.

5.1.1 The Existing National Electricity Market

The NEM is a wholesale energy market through which energy generators and retailers trade electricity. The NEM interconnects the six eastern and southern states and territories and delivers around 80 per cent of all electricity consumption in Australia. As recognised by the *Independent Review into the Future Security of the National Electricity Market: Blueprint for the Future*, (Commonwealth of Australia, 2017):

> *"The NEM is being transformed from a 20th century grid dominated by large-scale, fossil fuel-fired synchronous generators into a 21st century grid. New and emerging generation, storage and demand management technologies are being connected into a system that was not designed for them. Older generators are reaching the end of their life, becoming less reliable and closing. These changes are placing pressure on the NEM".*

The *Final report from the Energy Security Taskforce,* prepared by the NSW Chief Scientist & Engineer and released on 19 December 2017, confirmed that "the electricity system is in a period of transition, innovation and reform" and "identified a series of risks and emerging issues for NSW" (Energy Security Taskforce, 2017). The Energy Security Taskforce (2017) identified that maintaining sufficient generation to meet demand at any given time, plus a margin for contingencies was one of the four key elements essential for reliable electricity supply. While instances of unserved energy have been rare, there are indicators that supply and demand balance are tightening and new risks are emerging, particularly with the failure of large generation plant or extreme weather events.

As the Energy Security Taskforce (2017) recognises:

- No power station can operate at its maximum capacity all the time due to outages and maintenance, and their capacity to do so tends to degrade somewhat over time; and
- The project, which the Energy Security Taskforce Final Report refers to as the efficiency upgrade at Bayswater, will increase the capacity, reliability and efficiency of Bayswater, delivering greater energy security for NSW.

The AEMO identified in its *Electricity Statement of Opportunities* (2017) that there will be a 1,000 MW generation gap following the closure of Liddell in 2022. This is not only relevant for NSW, but due to limited interconnector capacity, the AEMO report recognised that it has NEM wide impacts.

On 16 March 2018, AEMO advised the Commonwealth Government that if all three stages of proposed investment outlined in AGL's *NSW Generation Plan* are completed, the resource gap will be eliminated.

The *NSW Generation Plan* also aligns with the national energy guarantee (NEG), which AEMO has agreed will encourage competitive markets and produce the best outcome for consumers.

5.1.2 The Proposed National Energy Guarantee

In response to *the Independent Review into the Future Security of the National Electricity Market* (Commonwealth of Australia, 2017) the Energy Security Board (ESB) provided the Council of Australian Governments (COAG) Energy Council with advice on changes to the NEM and legislative framework as follows:

> *"The proposed national energy guarantee aims to support the provision of reliable, secure and affordable electricity with a focus on ensuring:*
>
> - *the reliability of the system is maintained*
> - *electricity sector emissions reductions needed to meet Australia's international commitments are achieved*
> - *the above objectives are met at the lowest overall costs.*
>
> *The NEG is a way to encourage new investment in clean and low emissions technologies while allowing the electricity system to continue to operate reliably"* (ESB, 2017).

Detail on how the NEG will function are currently being determined but it is anticipated to require retailers to contract with or invest in generators or demand response to meet a minimum level of dispatchable 'on demand' electricity while also keeping their emissions below an agreed level.

Bayswater currently supplies dispatchable electricity into the NEM. The project is focused on improving the reliability of Bayswater through to its scheduled closure in 2035. The project has been determined by AGL Macquarie as being the best option to ensure Bayswater remains as reliable and efficient while contributing to the replacement of a portion of the generation capacity misplaced through the closure of Liddell. As such, the project is consistent with the key proposed objectives of the NEG.

5.1.3 AGL Energy Strategic Objectives

The *AGL Sustainability Report 2017* | *Sustainable Business Strategy* (AGL, 2017b) recognises that about three quarters of Australia's current thermal generation fleet is currently beyond its original engineering design life, and as such there is a concurrent need to modernise and decarbonise Australia's electricity generation sector. As the generator of approximately 25 per cent of the energy within the NEM, AGL has committed to playing a leading role in this transition.

In the past five years, 12 coal fired power stations have closed in Australia, and whilst some have been mothballed, and their closure anticipated, none were closed with more than one year's notice.

In contrast, AGL has provided advanced notice of its intention to close its coal fired power stations with its strategic approach presented in its Greenhouse Gas Policy. This policy provides a public commitment that includes:

- decarbonisation of generation by 2050;
- improve the GHG efficiency of its operations and no investment in new coal fired generation in Australia without carbon capture and storage technology;
- establishment of end of life closure dates for their three operating coal plants including closure of Liddell in 2022 and Bayswater in 2035;
- renewable investment; and
- constructive engagement on energy and climate policy.

AGL is committed to investing in the generation required to meet its customers' demands. In 2016, AGL established the Powering Australian Renewables Fund (PARF), a landmark partnership to develop, own and manage approximately 1,000 MW of large-scale renewable energy infrastructure assets and projects. AGL announced QIC, on behalf of its clients the Future Fund and those invested in the QIC Global Infrastructure Fund, as its equity partner in the $2 – 3 billion PARF. AGL had sold the 102 MW Nyngan and 53 MW Broken Hill solar plants into the PARF. In 2017, AGL also announced financial close on the 200 MW Silverton and 453 MW Coopers Gap wind farms.

The project forms Stage One of AGL's *NSW Generation Plan* and is necessary to ensuring that Bayswater is best placed to address concerns about reliable, secure supply of electricity while meeting the Commonwealth Government's NEG.

5.1.4 Regional Plans

The Department of Planning & Environment's *Hunter Regional Plan 2036* includes a goal to diversify energy supply. Specifically, the *Hunter Regional Plan 2036-Implementation Plan 2016-2018* includes Direction 12 to diversify and grow the energy sector by promoting new opportunities arising from the closure of coal fired power stations that enable long term sustainable economic and employment growth in the region. With the closure of Liddell, significant local energy generation will be withdrawn from the area. The project is one of AGL's responses aimed at offsetting this loss of generating capacity in the region and provide an additional 100 MW capacity.

5.2 Statutory Context

5.2.1 Critical State Significant Infrastructure

Clause 16 of the SRD SEPP provides that:

> *Development specified in Schedule 5:*
>
> *(a) may be carried out without development consent under Part 4 of the Act, and*
>
> *(b) is declared to be State significant infrastructure for the purposes of the Act if it is not otherwise so declared, and*
>
> *(c) is declared to be critical State significant infrastructure for the purposes of the Act.*

Schedule 5 of the SRD SEPP lists:

> *Development for the purposes of the Bayswater Power Station Turbine Efficiency Upgrade project, being the replacement and upgrade of turbines on the 4 existing generating units. The development is to be carried out on the site of the Bayswater Power Station (being Lot 2, DP 327372 and Lot 2, DP 1095515).*

Accordingly, the project is Critical SSI which requires approval under Division 5.2 of the EP&A Act.

5.2.2 Zoning

The *Muswellbrook Local Environmental Plan 2009* (Muswellbrook LEP) applies to the land on which the Bayswater turbine hall is located. The subject land is zoned 'SP2 – Infrastructure: Power Station' under the Muswellbrook LEP. Development for the purposes of a 'power station' is permissible with consent under this zoning.

Similarly, clause 34 of *State Environmental Planning Policy (Infrastructure) 2007* (ISEPP) provides that 'development for the purpose of electricity generating works may be carried out by any person with consent on any land in a prescribed …special use zone'.

However, clause 16 of the SRD SEPP operates to override both the Muswellbrook LEP and ISEPP and provides that the project may be carried out without development consent under Part 4 of the EP&A Act. Rather, as the project is Critical SSI, it instead requires approval under Division 5.2 of the EP&A Act.

5.2.3 Bayswater Power Station Existing Approvals

Bayswater was originally authorised under development consent 47209 granted by Muswellbrook Shire Council on 18 September 1980. Over the operational life of Bayswater, a number of additional planning approvals have also been granted for specific aspects.

The existing planning approvals held in relation to Bayswater authorise the construction, maintenance and ongoing operation of Bayswater. The original environmental impact statement dated June 1979 describes Bayswater as consisting of "four 660 MW generating units". The project has been declared to be Critical SSI and will, if approved, increase the CMR capacity of each of the existing four turbines from 660 MW to 685 MW.

The ongoing operation of Bayswater, including coal combustion and all environmental impacts, will continue to be managed in accordance with the existing planning approvals. However, the carrying out of the project itself will, if approved, be regulated under the terms of a new Critical SSI approval granted under Division 5.2 of the EP&A Act.

5.2.4 Environmental Protection Licence

AGL Macquarie holds environment protection licence 779 (EPL 779) issued under the *Protection of the Environment Operations Act 1997 (NSW)* for Bayswater.

EPL 779 is subject to detailed conditions regulating the operation of Bayswater. This includes conditions authorising certain air emissions and discharges to water subject to emission limits and monitoring requirements.

The project will only replace the existing turbines located at Bayswater, providing a net improvement in overall cycle efficiency of over 4 per cent compared to the current operations with associated and similar percentage reduction of GHG intensity ($kgCO_{2e}$/MWh). The increased capacity results from using newer turbine design and technology improvements which provide greater heat rate efficiencies and will require no additional coal consumption at the new unit design rating of 685 MW or plant changes to the coal burning infrastructure which produces air emissions. Accordingly, Bayswater will continue to comply with all conditions currently imposed under EPL 779 and no variation to EPL 779 is required to accommodate the project.

6. Stakeholder Engagement

6.1 Engagement to Date

Engagement to date has included discussion of the assessment pathway with the NSW Department of Planning and Environment (DP&E). This has included the provision of high-level project summary and request for DP&E to consider whether the project should be treated as critical SSI that was determined by the Minister for Planning and commenced on 2 March 2018.

AGL Macquarie hosted its inaugural Community Dialogue Group meeting on 27 February 2018 where the proposed project was discussed as part of AGL's *NSW Generation Plan*. With the exception of local employment potential, no stakeholder issues were raised. It was noted AGL Macquarie would provide further details at upcoming community meetings as the project develops.

6.2 Proposed Engagement

Key stakeholders for the project include:

- Federal, state and local government representatives and agencies;
- Muswellbrook and Singleton residents, neighbours, businesses and business chambers, traditional owners, environment interest groups; and
- Other - community organisations, road users, tourism operators and emergency services.

AGL Macquarie has publicly announced its plan for the project and the outcomes of consultation will be included in the EIS. An engagement plan will ensure ongoing and effective communication with key stakeholders and the community.

6.3 Anticipated Stakeholder Issues

As the project relates to the upgrade of an existing operational coal fired power station, AGL anticipates that key stakeholder issues could include:

- Air quality impacts including greenhouse gas emissions;
- Noise impacts;
- General objection to the use of coal;
- General objections to AGL's decarbonisation policy; and
- Potential implications for power prices.

AGL Macquarie acknowledges these issues. It is important to note that the project is an efficiency upgrade that is anticipated to result in additional power being generated with no additional resource consumption or environmental impacts over the continued operation of Bayswater.

The project is essentially a like for like replacement of key components of the ageing turbines with current turbine technology. The improvements in turbine technology will increase the rated capacity of each approved and operational generating unit from 660 MW to 685 MW with no impact to air quality, noise or coal consumption.

AGL has made a commitment to transition toward a decarbonised energy generation portfolio by 2050. Given that this transition will happen over several decades, Bayswater will require maintenance as part of its mid-life refurbishment to ensure ongoing reliable performance through to its closure in 2035. At the same time, AGL is investing in renewable projects supported by fast start gas generation and some examples of this are highlighted in AGL's *NSW Generation Plan*.

Energy prices are linked to the cost of securing supply from the wholesale market, to pass on to customers. AGL, as a generator and retailer of energy, are conscious of community and customers' concerns regarding power prices. The *NSW Generation Plan* is focused on achieving the necessary replacement energy generating capacity at the lowest generation cost.

Preliminary consideration of air quality, noise and other environmental issues is provided in the following sections.

7. Consideration of Environmental Impacts

7.1 Air Quality and Greenhouse Gas

As outlined in the project description (refer to Section 3.1) the project involves the replacement and upgrade of the HP, IP and LP turbines on the four generating units, increasing capacity in each generating unit by 25 MW to 685 MW. This constitutes an increase of 100 MW without requiring changes to the existing operation of other components of Bayswater, which are approved under the existing planning approvals.

At a coal fired power station, air pollution and GHG emissions result from the combustion of coal in the boiler furnace. As outlined at section 2.1 above, the burning of coal in the boiler furnace producing:

- heat for the boiler which is used to produce steam;
- incombustible coal residue, in the form of furnace ash and fly ash, which is collected and transported to ash disposal areas; and
- hot gases generated from the combustion of the coal in the furnace discharged via the fly ash collection plant through tall stacks which are continuously monitored.

High pressure steam from the boiler enters the turbine trains within the generating units. Once within the generating units the high pressure steam is expanded through stages of fixed and rotating blades within the HP turbine before being reheated and expanded through the IP and LP turbines. The turbines drive the rotor which produces electricity.

The project is limited to the replacement of the HP, IP and LP turbines with new, more efficient modern turbines on the four generating units, increasing capacity in each generating unit by 25 MW to 685 MW via increased efficiency. The project does not include any other changes to the existing approved operations at Bayswater. In particular, the project does not include any works on the boiler furnace which generates the air emissions at Bayswater and will not require any additional coal consumption to generate at 685 MW per unit as the additional generation capacity will be achieved solely through efficiency improvements in the rate in which the turbines convert the steam from the boiler to electricity.

7.1.1 Preliminary Air Quality Assessment

This preliminary air quality assessment considers:

- power station air pollution emissions and confirms expected changes in emissions as a consequence of the Bayswater project;
- air quality criteria;
- a summary of the Hunter region ambient air quality (refer to Appendix A); and
- any expected changes in air quality associated with the project.

An overview of relevant ambient air quality criteria and a summary of the current Hunter Regional ambient air quality is set out in Appendix A.

Air Pollution Emissions from existing operations at Bayswater Power Station

The main air emission sources associated with the existing approved operations of Bayswater and associated infrastructure are:

- Boiler stack including sulphur oxides (SO_X), nitrogen oxides (NO_X), particulate matter (PM), carbon monoxide (CO), chlorine (Cl_2), various metals and fluorides; and
- fugitive dust from coal conveyors, coal stockpiles and ash dams.

Stack emissions from Bayswater are subject to regulation under the EPL and the *Protection of the Environment Operations (Clean Air) Regulation 2010*.

The EPL requires monitoring of stack emissions and sets emission limits for the key pollutants outlined above. In addition, sulphur dioxide (SO_2) is regulated by restricting the sulphur content of coals combusted in the power station.

Further, under the EPA's Load Based Licencing (LBL) Scheme, AGL Macquarie is required to pay licence fees associated with the amount of annual air pollution emissions.

Table 7.1 sets out the LBL reportable emissions for Bayswater. Also shown is the pollutant emission intensity (kg/MWh) and other key existing approved power station operating parameters.

Table 7.1 : Bayswater LBL Reported Air Pollution Emissions (Feb 2016 – Jan 2017)

Pollutant	Load (kg/annum)	Load Intensity (kg/MWh)
Coarse Particulates	9436	0.000567126
Fluorides	609196	0.036614152
Benzo(a)pyrene	0.433	0.000000026
Lead	36	0.000002164
Arsenic	24	0.000001442
Sulphur Oxides	59597849	3.581974768
Nitrogen Oxides	39838245	2.394374810
Fine Particulates	526616	0.031650894
Mercury	77	0.000004628
Power Station Parameter	**Value**	**Units**
Capacity	2640	MW
Available Output	23126400	MWh/annum
Actual Output (Feb 2016 – Jan 2017)	16638266	MWh/annum
Capacity Factor	71.9	%

Air Quality Impact Assessment

The efficiency gains generated via the project will enable Bayswater to generate 685 MW from each generating unit without increasing the level of coal consumption and consequent air emissions when compared with the current operation of each unit at 660 MW. On the basis that no change is proposed to the current approved operations, the project will not result in any increased air emissions.

As noted above, the project completion coincides with the announced Liddell closure in 2022. With no additional air pollution from Bayswater associated with the project and with Liddell emissions reducing to zero, it is estimated that that Upper Hunter airshed power station particulate emissions will reduce by 30-50 per cent, and NOx and SO_2 by approximately 30 per cent. This will result in significant overall improvements in the Upper Hunter ambient air quality.

7.1.2 Preliminary GHG Assessment

The project will increase the overall capacity of Bayswater from 2640 MW to 2740 MW without increasing coal consumption at the new rated capacity of 685 MW per unit compared with the current 660 MW. This will result in a lower GHG intensity for Bayswater.

The project is accordingly consistent with AGL's commitment to GHG mitigation as set out in AGL's Greenhouse Gas Policy which states "*AGL will improve the greenhouse gas efficiency of our operations, and those in which we have an influence."*

This preliminary environmental assessment provides the following:

- an overview of GHGs impacts on climate change;
- GHG and climate change policy; and
- project GHG emissions, intensity and impact.

Greenhouse Gases and Climate Change

Greenhouse gases (GHGs) is a collective term for a range of gases that are known to trap radiation in the upper atmosphere, where they have the potential to contribute to the greenhouse effect (global warming).

GHGs include:

- Carbon dioxide (CO_2) – by far the most abundant, primarily released during fuel combustion;
- Methane (CH_4) – from the anaerobic decomposition of carbon based material (including enteric fermentation and waste disposal in landfills);
- Nitrous oxide (N_2O) – from industrial activity, fertiliser use and production;
- Hydrofluorocarbons (HFCs) – commonly used as refrigerant gases in cooling systems;
- Perfluorocarbons (PFCs) – used in a range of applications including solvents, medical treatments and insulators; and
- Sulphur hexafluoride (SF_6) – used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

It is common practice to aggregate the emissions of these gases to the equivalent emission of carbon dioxide. This provides a simple figure for comparison of emissions against targets. Aggregation is based on the potential of each gas to contribute to global warming relative to carbon dioxide and is known as the global warming potential (GWP). The resulting number is expressed as carbon dioxide equivalents (or CO_2e).

The OEH has developed Climate Change Snapshots for NSW and each of the State Planning Regions. The Hunter region is projected to continue to warm in the near future (2020–2039) and far future (2060–2079). The warming is projected to average about 0.7°C in the near future, increasing to about 2.1°C in the far future. Other changes include increases in extreme temperatures and fire weather.

The emissions that form a GHG inventory can be split into three categories known as 'Scopes'. Scopes 1, 2 and 3 are defined by the GHG Protocol (United Nations, 1994) and can be summarised as follows:

- Scope 1 – Direct emissions from sources that are owned or operated by a reporting organisation (examples – combustion of coal for the generation of electricity, combustion of diesel in company-owned vehicles or used in on-site generators);
- Scope 2 – Indirect emissions associated with the import of energy from another source (examples – import of electricity or heat); and
- Scope 3 – Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (examples include business travel (by air or rail) and product usage).

Greenhouse Gas and Climate Change Policy

On 3 December 2007, the former Australian Prime Minister, Kevin Rudd, signed the instrument of ratification of the Kyoto Protocol. Australia has met its Kyoto Protocol target of limiting emissions to 108 per cent of 1990 levels, on average, over the Kyoto period 2008–2012. Over the five reporting years in the Kyoto period (2008 to 2012), Australia's net emissions averaged 104 per cent of the base year level (DoE, 2014). As such, Australia has committed to meeting its Kyoto Protocol long term target and has set a target to reduce GHG emissions by 60 per cent on 2000 levels by 2050.

Additionally, as a medium target, the Commonwealth Government has committed to reduce Australia's carbon pollution to 25 per cent below 2000 levels by 2020 if the world agrees to an ambitious global deal to stabilise levels of GHGs in the atmosphere at 450 parts per million CO_2 equivalent or lower. This will maximise Australia's contribution to an ambitious outcome in international negotiations. If the world is unable to reach agreement on a 450 parts per million target; Australia will still reduce its emissions by between 5 and 15 per cent below 2000 levels.

Following the 2015 Paris Climate Conference (COP21), international agreements were made to:

- keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius;
- from 2018, countries are to submit revised emission reduction targets every 5 years, with the first being effective from 2020, and goals set to 2050;
- define a pathway to improve transparency and disclosure of emissions; and
- make provisions for financing the commitments beyond 2020.

It is yet to be determined how Australia will deliver these commitments in detail.

Additional policy measures to facilitate the accounting of GHG emissions and programs for managing and reducing emissions that are relevant to AGL Macquarie and the project are the:

- *National Greenhouse and Energy Reporting Act 2007* (NGER Act);
- Emissions Reduction Fund (ERF); and
- The safeguard mechanism – Electricity sector.

AGL's Greenhouse Gas Policy is the centrepiece of its corporate commitment to managing and reducing GHG emissions.

Project GHG Emissions and Impact

The project is expected to improve greenhouse gas intensity at the operation phase.

Toshiba, who are the technology provider for the project, have confirmed that coal consumption is expected to remain essentially the same when each unit is operated at 685 MW following the upgrade compared with current operations at 660 MW (refer to Table 7.2). The increase in capacity and expected small decrease in coal consumption results from the improved efficiency (heat rate) of the turbines.

Table 7.2 : Project Technical Specification

Parameter	Units	Continuous Maximum Rating (CMR)	
		Upgrade 685 MW	Existing 660 MW
Boiler Steam Duty	MWth	1526	1533
Turbine Gross Output	MWe	685	660

The boiler steam duty is directly proportional to coal consumption remaining essentially the same.

Table 7.3 sets out Bayswater GHG emissions over the two year period 2014-15 and 2015-16.

Table 7.3 : Bayswater Power Station GHG Emissions (as reported under NGERS)

Year	Bayswater Power Station		
	Output (GWh) – sent out	GHG Emissions from Coal (tonnes CO_{2-e})	GHG Intensity – sent out ($kgCO_{2-e}$/MWh)
2014-15	17,101	14,821,284	923
2015-16	18,159	16,117,506	945

At the upgrade CMR of 685 MW the above stated GHG intensity will improve (reduce) by approximately 4 per cent. That equates to an approximate 37 kg of GHGs (as CO_{2e}) per megawatt hour (MWh) of the electricity sent out from the power station.

7.2 Traffic

The project will involve approximately an additional 11 heavy deliveries over each annual shutdown period. Up to 60 small vehicles would also attend site per day during each annual shutdown associated with workers undertaking the project. As the project is scheduled to coincide with routine maintenance shutdowns carried out as part of the current approved operations at the site, these vehicle movements would coincide with a further expected 200 light vehicles attending site per day and the typical daily staff movements associated with the ongoing operation of the power station.

There would be no ongoing change in traffic following completion of the project.

Access to and from Bayswater is provided by slip-lanes from the New England Highway and the existing road network has demonstrated capacity to accommodate annual shutdown traffic over recent years. The traffic movements related to the project are expected to be largely offset by reduced movements that would typically be related to the turbine inspection and maintenance activities.

Due to the existing capacity of the access point to receive traffic from both directions on the New England Highway there is not expected to be any reduction in performance of the intersection. The New England Highway provides for over-weight and over-size deliveries of mining equipment from the Port of Newcastle to Hunter Valley mine sites and as such would be expected to accommodate the anticipated over-size deliveries associated with the project.

Further description of the type, route and scheduling of anticipated deliveries would be provided in the EIS but no detailed traffic impact assessment is deemed warranted given the existing capacity of the relevant road network to support the small volumes of additional traffic associated with the project.

7.3 Noise

The project would be considered short term, over an approximate 50-day timeframe each year for four years and be consistent with the noise generated by routine inspections and maintenance. Due to the over 5 km separation to sensitive receptors, the project is not anticipated to result in noticeable noise impacts when compared to the approved operation of Bayswater.

The project is not expected to result in a change in operational noise levels generated by Bayswater. This is because the replaced turbines will be:

- positioned within the same location;
- housed within the same casing and within the existing enclosed turbine hall;
- rotating at the same speed (requirement of the network); and
- functioning essentially in the same manner.

Background noise levels at receiver locations, including the operation of Bayswater, were determined through the environmental assessment undertaken for the (then) proposed the Bayswater B Power Station (AECOM, 2009). Attended noise measurements undertaken by AECOM identified that only the Lake Liddell Reserve Camping Area recorded greater than negligible industrial noise contributions. Based on the location of the Lake Liddell Reserve Camping Area, this industrial noise contribution would be more likely to be associated with the operation of either Liddell or Antienne Rail unloader.

The absence of significant contributions to the ambient noise environment by industry would indicate that the continued operation of Bayswater in a manner similar to the current authorised operations, as proposed, would be unlikely to result in a noticeable change in the acoustic environment. The current acoustic environment will be described in the EIS as the best indication of future performance.

7.4 Water

The project does not involve a change in the water required to operate Bayswater. The same amount of steam would be generated from the same amount of coal being burnt. However, there is some potential for the more efficient conversion of steam energy into mechanical energy resulting from the project to result in a reduction in waste heat requiring cooling. This could potentially result in a reduction of water used in the cooling process and lost to the atmosphere through the cooling towers. A reduction in evaporation would result in improved environmental performance through a reduced need for cooling water and a consequent reduction in the amount of saline water being generated and requiring management from the evaporative process.

7.5 Waste

The project would generate waste in the form of turbine packaging and the old turbine components. Waste would be appropriately classified for off-site disposal in accordance with current waste management guidelines. It is expected that the turbine components would be predominantly recycled as scrap steel with the packaging predominantly made up of wooden pallets and containers and plastic wrapping material. All waste would be appropriately recycled or disposed of offsite to licenced waste facilities.

As no additional coal would be burnt to achieve the additional energy generation there would be no additional ash requiring disposal.

7.6 Biodiversity

The project would be entirely contained within the existing turbine hall located within the operational footprint of Bayswater. No clearing or ground disturbance and no direct or indirect impacts to biodiversity would result from the project.

No further consideration of biodiversity impacts is considered warranted.

7.7 Heritage

The project would be entirely contained within the existing operational footprint of Bayswater. In the absence of clearing or ground disturbance there would be no potential for impacts to Aboriginal heritage objects of values. Bayswater is not heritage listed and, in any event, all works associated with the project will be carried out within the existing turbine hall. As such no impacts to non-Aboriginal heritage would result from the project.

No further consideration of heritage impacts is considered warranted.

7.8 Visual

The project would be completed within the existing enclosed turbine hall of Bayswater. The turbines would be briefly stored within the existing enclosed hall until the project is carried out. As such there is no potential for changed visual amenity and no further consideration of visual impacts is considered warranted.

7.9 Social and Economic Impacts

The project would have the following economic and social impacts:

- improve security and continuity of energy supply to NSW and the NEM during periods of maximum hourly and daily demand;
- reduce operating risk profile and improve reliability of Bayswater enabling it to continue operating with decreased outage durations until its scheduled closure in 2035;
- represent a substantial investment of approximately $150 million;
- create additional capacity of 100 MW (~ 1 TWh annually) in a heightened period with energy security being a critical issue for NSW and Australia, particularly post Liddell closure in 2022; and
- create an expected 60 jobs during each outage period over four years.

Bayswater would continue to be operated in the same manner as it is currently and no change in permanent employment requirements or amenity of surrounding receivers are anticipated that could

lead to social impacts. AGL has a clearly articulated strategy that attempts to balance the needs of the communities in which they operate in relation to employment and amenity values, the energy demands of the NEM and Australia's international climate obligations. While no further assessment of social and economic consequences is proposed, AGL Macquarie will continue to engage with all stakeholders in accordance with the project stakeholder engagement plan and provide a summary of the outcomes of this consultation in the EIS.

8. Summary and Conclusions

AGL Macquarie propose to replace the ageing turbines in each of the four generating units at Bayswater and in doing so increase its capacity by 100 MW ensuring that Bayswater continues to operate and provide reliable, secure supply of electricity. The project has been declared Critical SSI and as such will be assessed under Division 5.2 of the EP&A Act.

This document provides a description of the project, existing information on environmental context and potential for environmental impacts and has been prepared in support of an application for the SEARs for the project. Once SEARs have been issued, AGL Macquarie will prepare an EIS to address the SEARs. The EIS will be placed on public exhibition in accordance with Division 5.2 of the EP&A Act.

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Appendix A. Ambient air quality criteria and summary of current Hunter Regional ambient air quality

Air Quality Criteria

Relevant air quality criteria for pollutants associated with power station emissions including PM_{10}, $PM_{2.5}$, SO_2 and NO_2 are presented in Table A.1.

Table A.1 : NSW Air quality criteria for PM10, PM2.5, SO2 and NO2 (NSW EPA, 2017)

Pollutant	Averaging Period	Concentration		Source
		Pphm	µg/m³	
PM_{10}	24 hours	-	50	DoE (2016)
	Annual	-	25	DoE (2016)
$PM_{2.5}$	24 hours	-	25	DoE (2016)
	Annual	-	8	DoE (2016)
Sulfur dioxide (SO_2)	10 minutes	25	712	NHMRC (1996)
	1 hour	20	570	NEPC (1998)
	24 hours	8	228	NEPC (1998)
	Annual	2	60	NEPC (1998)
Nitrogen dioxide	1 hour	12	246	NEPC (1998)
	Annual	3	62	NEPC (1998)

Ambient Air Quality

The Office of Environment and Heritage (OEH) operate the Upper Hunter Air Quality Monitoring Network (UHAQMN) as a regional air quality monitoring network of fourteen stations operated in partnership between the NSW Government and the Hunter region coal and power industries.

Air quality monitoring in the vicinity of Bayswater is conducted at Muswellbrook to the north-west, Jerrys Plains to the south-west and Camberwell and Singleton to the south-east. The network continuously measures:

- Particulate matter PM_{10} (particles less than or equal to 10 microns in diameter), wind speed and direction, temperature and humidity at all locations;
- Fine particulate matter $PM_{2.5}$ (particles less than or equal to 2.5 microns in diameter) at Singleton, Muswellbrook and Camberwell; and
- Gases sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) at Singleton and Muswellbrook.

Data from the past five years (2013 – 2017) from each of the four nearest locations was reviewed against the relevant air quality criteria.

Annual average, 24-hour average and 1-hour average concentrations are presented for each pollutant as follows:

- PM_{10} annual averages (Table A.2) and 24- hour averages (Figure A.1)
- $PM_{2.5}$ annual averages (Table A.3) and 24-hour averages (Figure A.2)
- SO_2 annual averages (Table A.4), 24-hour averages (Figure A.3) and 1-hour averages (Figure A.4)
- NO_2 annual averages (Table A.5) and 1-hour averages (Figure A.5)

Any exceedances of the annual criteria are highlighted.

Table A.2 : Annual average PM10 monitoring data from Muswellbrook, Singleton, Camberwell and Jerrys Plains, 2013 – 2017

Year	Muswellbrook	Singleton	Camberwell	Jerrys Plains	Annual Criterion
2013	22.6	23.3	27.8*	18.6	25*
2014	21.4	21.0	24.6	18.2	
2015	19.1	19.3	22.0	15.5	
2016	19.2	19.3	24.5	16.8	
2017	21.7	20.8	27.4	18.0	

* In 2015 the annual criteria for PM_{10} was reduced from 30 µg/m^3 to 25 µg/m^3

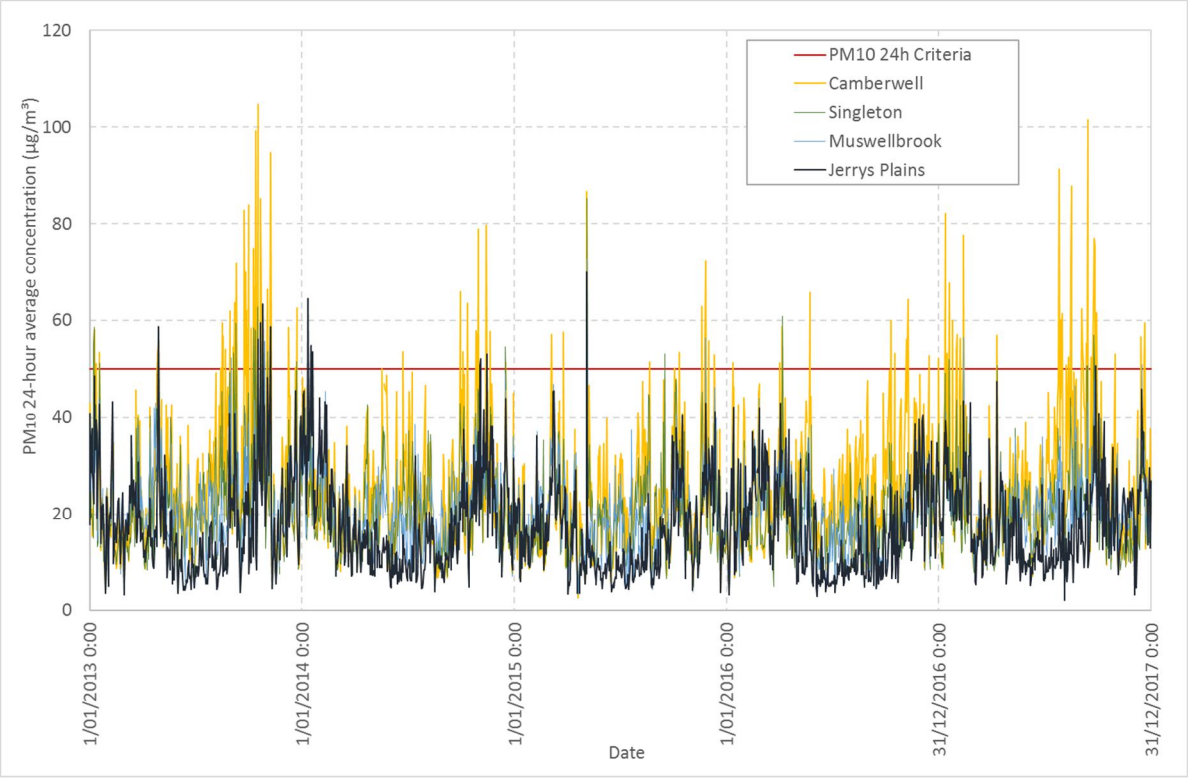

Figure A.1 : Average 24-hour PM10 (µg/m³) measured at Muswellbrook, Singleton, Camberwell and Jerrys Plains, 2013 – 2017

Table A.3 : Annual average PM2.5 monitoring data from Muswellbrook, Singleton, Camberwell and Jerrys Plains, 2013 – 2017

Year	Muswellbrook	Singleton	Camberwell	Annual Criterion
2013	9.4*	7.9	8.2*	8*
2014	9.7*	7.8	7.8	
2015	8.7	7.6	7.2	
2016	8.4	7.9	7.5	
2017	9.4	8.2	7.4	

* In 2015 the annual criterion for $PM_{2.5}$ was reduced from 30 µg/m^3 to 25 µg/m^3 and the 24-hour average from 10 µg/m^3 to 8 µg/m^3

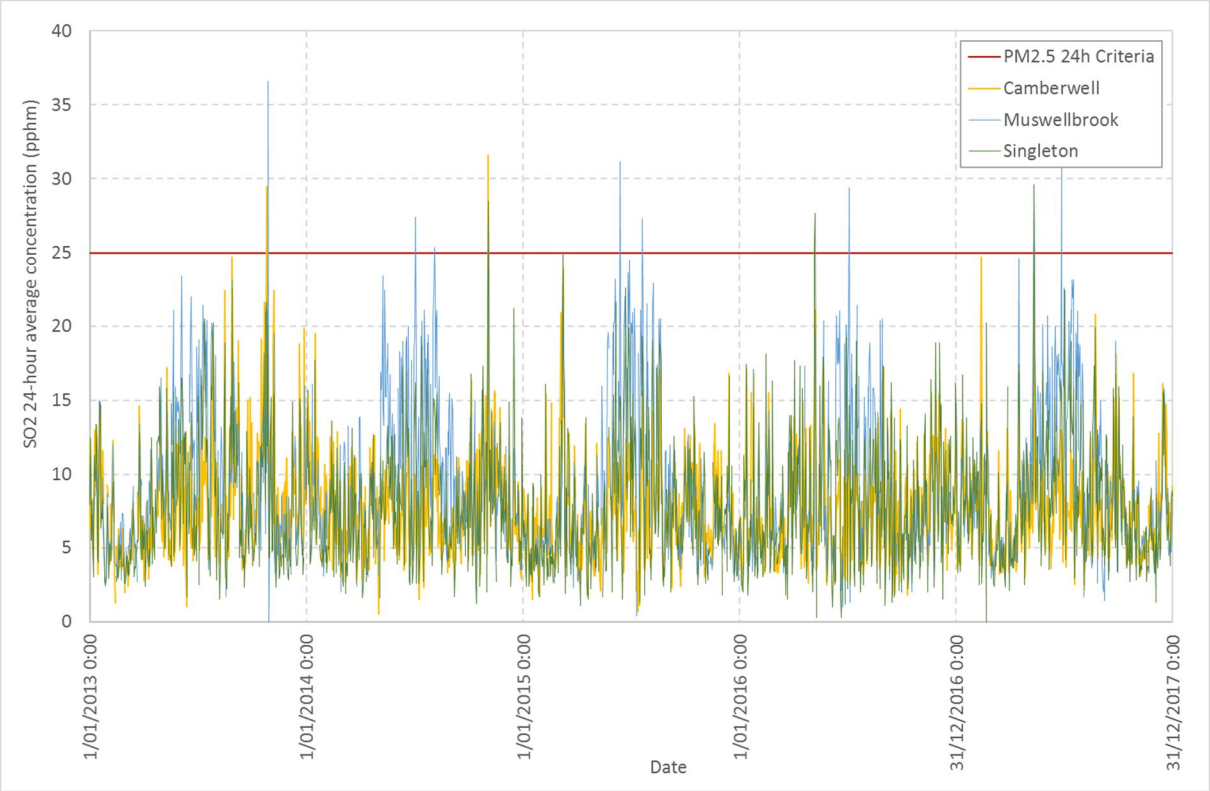

Figure A.2 : Average 24-hour PM2.5 (µg/m^3) measured at Muswellbrook, Singleton and Camberwell, 2013 – 2017

Table A.4 : Annual average SO_2 (pphm) monitoring data from Muswellbrook and Singleton, 2013 – 2017

Year	Muswellbrook	Singleton	Annual Criterion
2013	0.2	0.1	2
2014	0.3	0.1	
2015	0.2	0.1	
2016	0.2	0.1	
2017	0.2	0.1	

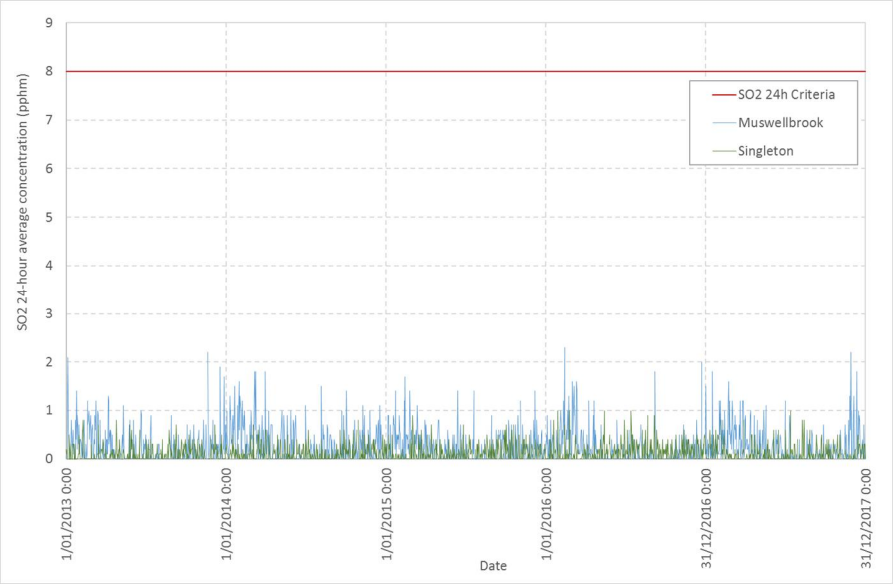

Figure A.3 : Average 24-hour SO_2 (pphm) measured at Muswellbrook and Singleton, 2013 – 2017

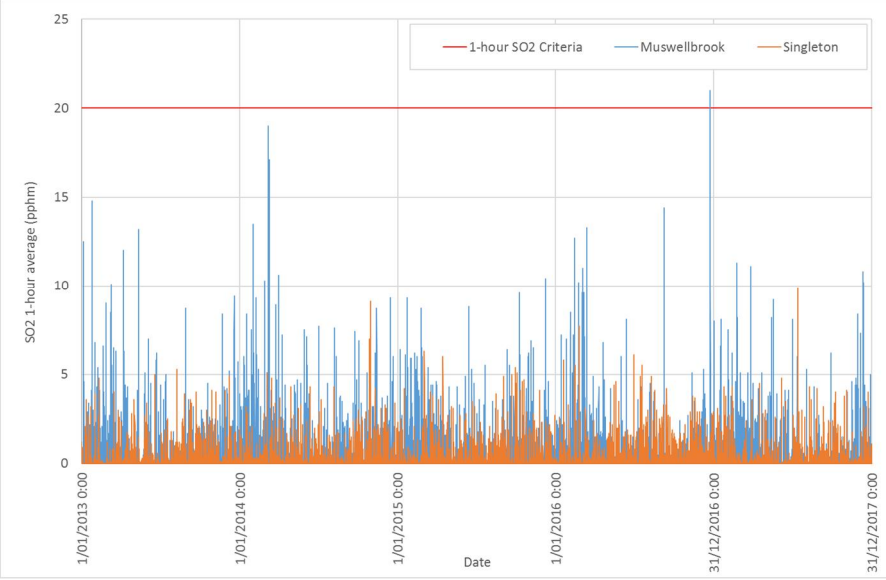

Figure A.4 : Average 1-hour SO_2 (pphm) measured at Muswellbrook and Singleton, 2013 – 2017

Table A.5 : Annual average NO_2 (pphm) monitoring data from Muswellbrook and Singleton, 2013 – 2017

Year	Muswellbrook	Singleton	Annual Criterion
2013	0.9	0.9	3
2014	1.0	0.8	
2015	0.9	0.8	
2016	0.9	0.8	
2017	1.0	0.8	

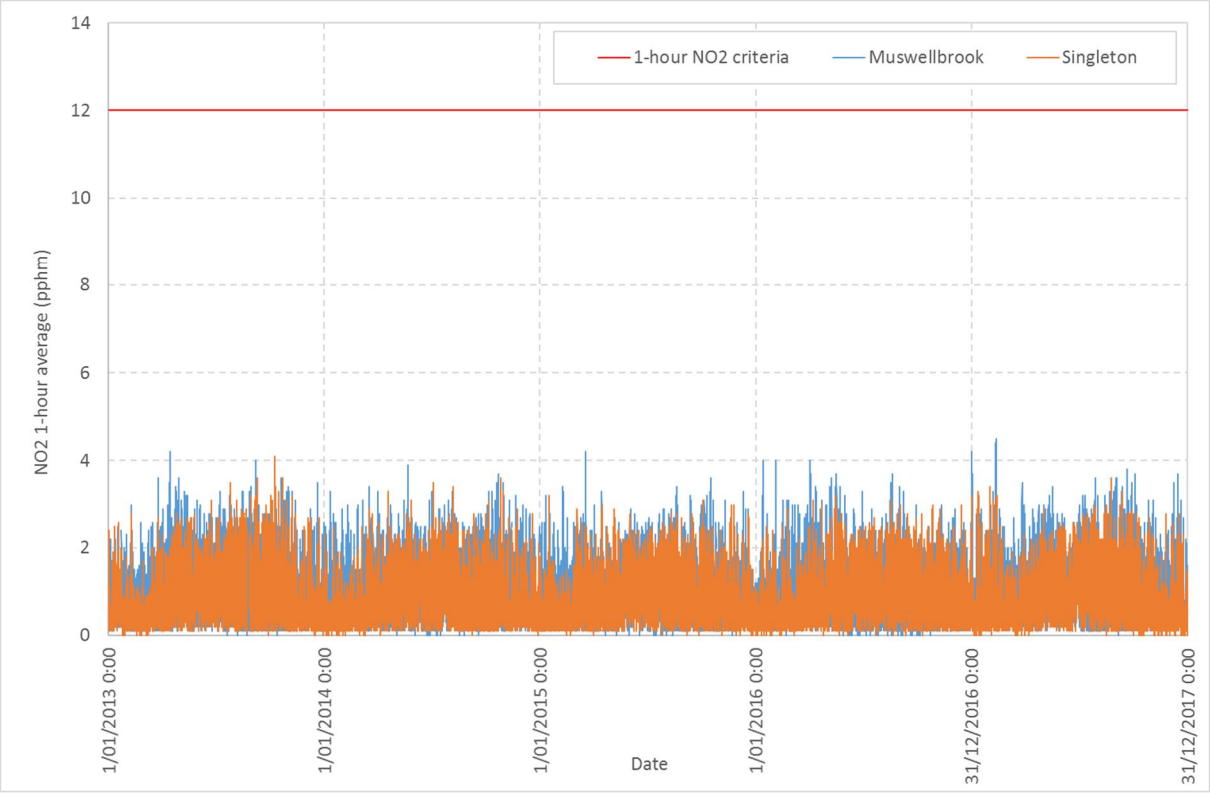

Figure A.5 : Average 1-hour NO_2 (pphm) measured at Muswellbrook and Singleton, 2013 – 2017

In summary, ambient quality in the Hunter region is considered as good, noting however, fine particle ($PM_{2.5}$) pollution exceeds annual ambient air quality criteria at the Muswellbrook monitoring station with some exceedances of 24-hour criteria (refer to Table A.3 and Figure A.2).

Acknowledging that PM_{10}/$PM_{2.5}$ and NO_X as NO_2 are common to many emission sources in the Upper Hunter including coal mines, agriculture and diesel exhausts, SO_2 is considered the best indicator of coal fired power stations impacts on local and regional air quality. As can be seen from Table A.4, Figure A.3 and Figure A.4 annual average and 24- hour ambient SO_2 concentrations are generally low. In terms of 1- hour impacts there has been one exceedance of the SO_2 criteria in the past five years, as measured at the Muswellbrook monitoring station.

In response to elevated fine particle ($PM_{2.5}$) ambient air quality concentrations the OEH and NSW Health commissioned the Upper Hunter Valley Particle Characterisation Study (Hibberd *et al*., 2013) conducted by CSIRO and ANSTO, to explore elevated $PM_{2.5}$ in Muswellbrook and Singleton during winter. Samples were collected for 24-hours, every third day during 2012 using high volume and low

volume air samplers. The samples were analysed by ion beam analysis and ion chromatography for twenty elements and black carbon, and then sources were attributed using positive matric factorisation (PMF). The results of the study are reproduced, without error estimates for simplicity in Table A.6.

Table A.6 : Contribution of PM2.5 at Singleton and Muswellbrook during 2012, and potential sources (Hibberd et al., 2013)

Factor	Contribution of factor to annual $PM_{2.5}$ mass at Singleton	Contribution of factor to annual $PM_{2.5}$ mass at Muswellbrook	Potential source
1. Wood smoke	14%	30%	Domestic wood heaters
2. Vehicle / industry	17%	8%	Vehicles, industry
3. Secondary sulphate	20%	17%	Such as power stations
4. Biomass smoke	8%	12%	Bushfires, hazard reduction burns
5. Industry aged sea salt	18%	13%	Such as sea salt and power stations
6. Soil	12%	11%	Soil dust and coal dust
7. Sea salt	8%	3%	Sea salt
8. Secondary nitrate	3%	6%	Motor vehicles and power stations

While the largest single source contributor for fine particle ($PM_{2.5}$) sources in the Upper Hunter are wood heaters, coal fired power stations also contribute to these source emissions, both as direct emissions and secondary sulphates and nitrates.

The study demonstrated the importance of secondary particles and long-range transport to $PM_{2.5}$ concentrations, and highlighted the contribution of industry to $PM_{2.5}$ concentrations in the region.