NSW Environment Protection Authority

Review of Coal Fired Power Stations Air Emissions and Monitoring

NSW EPA

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1. Context

There are currently five black coal base load power stations operating in NSW. These power stations have a collective installed generating capacity of 10,160 megawatts (MW), representing 66% of the 15,405 MW of in-service scheduled and semi-scheduled generating capacity in NSW[1]. All five power stations use 'steam sub-critical' generation technology. A summary of the power stations is provided in Table 1.

Coal fired power stations are a significant source of air emissions. Provisional data from the Environment Protection Authority's (EPA) Air Emissions Inventory for the Greater Metropolitan Region in New South Wales - 2013 calendar year (GMR AEI) estimates that generation of electrical power from coal contributed 88% sulfur dioxide (SO_2) emissions, 51% oxides of nitrogen (NOx) emissions and 4% particulate matter <2.5 µm ($PM_{2.5}$) to anthropogenic emissions in the GMR.

Electricity Generation – General Electricity Works (capacity to generate more than 30 megawatts (MW) of electrical power) is a scheduled activity under the *Protection of the Environment Operations Act (1997)* (the Act). The EPA uses Environment Protection Licences (EPLs) to regulate each power station, including their emissions to air. The EPA has conducted a review of existing air pollutant regulatory requirements, emission monitoring and estimation and reporting practices for the coal fired electricity generation sector in NSW.

Table 1: Summary of NSW coal fired power stations

Facility name	EPL No	Licensee Name	Local Government Area (LGA)	Number of units	Installed capacity
Bayswater	779	AGL Macquarie Pty Ltd	Muswellbrook	4	2640 MW
Liddell	2122	AGL Macquarie Pty Ltd	Singleton	4	2000 MW
Mount Piper	13007	Energy Australia NSW Pty Ltd	Lithgow	2	1320 MW
Eraring	1429	Origin Energy Eraring Pty Ltd	Lake Macquarie	4	2880 MW
Vales Point	761	Sunset Power International Pty Ltd	Wyong	2	1320 MW

[1] Australian Electricity Market Operator Regional Generation Information - NSW (5 June 2017)

https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information

2. Purpose

The purpose of this review is to investigate point source air emissions and associated regulatory requirements applicable to base load coal fired power stations in NSW. The review additionally investigates emission estimation and reporting, under requirements of the National Pollutant Inventory (NPI). It should be noted that the EPA does not regulate power stations via the NPI program.

Information used in this report was collected through notices to provide information and records issued by the EPA under section 191 of the Act (Notice 1). The EPA reviewed the information provided by all five power stations in response to Notice 1 and subsequently issued a follow-up notice to provide additional information and records (Notice 2). A copy of the notices is included as Attachment A. The review was also informed by publicly available information, including power station Environment Protection Licences (EPLs) available on the EPA's Protection of the Environment Operations (POEO) public register[2].

The purpose of this report is to summarise analysis undertaken for the review and present key findings and recommendations.

This report comprises two parts:

A. Power station regulatory requirements

    1. What emission limits apply to the power stations?
    2. Are the power stations compliant with their air emission monitoring conditions?
    3. Is the monitoring representative?
    4. Are the power stations compliant with their air emission limits?
    5. Are the power stations compliant with their reporting obligations?
    6. Are emission controls being operated in a proper and efficient manner?

B. National Pollutant Inventory requirements

    1. Did each power station calculate their reported emission load using an approved NPI method and did they apply the method correctly?
    2. Did the power stations estimate reported NPI emissions using a consistent method?

This review does not investigate ambient air quality, including ambient monitoring data or modelling. Emissions discussed in this report are emissions from stacks and are not equivalent to community exposure to air pollution. The NSW Government separately publishes ambient air quality monitoring data via the Office of Environment and Heritage website.[3]

[2] http://www.epa.nsw.gov.au/licensing-and-regulation/public-registers/about-prpoeo

[3] http://www.environment.nsw.gov.au/AQMS/search.htm

3. Summary of Key Findings

3.1 Key findings relevant to regulation of power stations

1. EPL conditions are generally consistent between each of the power stations, however some limited and unnecessary variation was identified.

2. The review identified extensive compliance with few instances of non-compliance with EPL monitoring conditions, by all coal fired power stations.

3. Air emission testing at all power stations was conducted in accordance with EPL conditions and the Approved Methods for the Sampling and Analysis of Air Pollutants in NSW.

4. Monitored emissions, reported by the power stations, may be considered generally representative of power station environmental performance. However, there are opportunities for improvement in the application of periodic and continuous emission measurement at all power stations.

5. The review found no evidence that coal blending has been used to purposely lower emissions during testing periods and produce unrepresentative test results.

6. The review found extensive compliance with few instances of non-compliance with EPL air emission limits. Some pollutant concentrations consistently trend well below the specified limits.

7. The review found extensive compliance with regulatory reporting requirements. However, specific incidents of failure to report exceedances and publish monitoring data were identified.

8. The review found pollution control equipment at each power station is being operated and maintained in a proper and efficient manner, and achieving greater than 99% control efficiency. Some variability informal quality assurance and quality control procedures was identified between power stations.

3.2 Key findings relevant to National Pollutant Inventory

9. The review found all power stations used approved methods for estimating all NPI stack emissions in the last four years. No evidence of deliberate misreporting was found.

10. Minor errors were found in most power stations emission estimations in most years. The errors displayed no bias towards lower reporting of emissions.

11. Reported particle emissions were found to directly follow the annual stack test results.

12. Calculated filter efficiency for all power stations was greater than 99%.

13. Power stations used broadly consistent methods for emission estimation, other than methods used to estimate metals emissions which vary between power stations and across years.

4. Summary of Recommendations

4.1 Recommendations relevant to regulation of power stations

1. The EPA investigate practicability of implementing standardised EPL conditions, relating to air emissions, across all power stations in NSW. Development of standardised conditions will have regard for individual site and plant characteristics.

2. The EPA consider an appropriate response to the limited incidents identified of failure to complete emission monitoring in accordance with EPL requirements.

3. The EPA work with the power stations to investigate options to refine particle sampling.

4. The EPA review required parameters to be included with emission monitoring reports.

5. The EPA take action to develop and improve Continuous Emission Monitoring Systems (CEMS) protocols and monitoring guidance, including working with stakeholders such as monitoring experts and licensees.

6. The EPA investigate the potential for reducing EPL emission limits where there is a demonstrated history of compliance by an appreciable margin.

7. The EPA consider an appropriate response to those identified incidents of failure to publish or report emission monitoring data, and exceedances of limits.

8. The EPA investigate options to harmonise air emission reporting obligations across all power station EPLs.

9. The EPA engage with licensees to discuss the potential for improved and formalised emission control maintenance and fault response procedures.

4.2 Recommendations relevant to National Pollutant Inventory

10. The EPA work with industry to facilitate improved emission estimation quality assurance procedures.

11. The EPA engage with the Commonwealth NPI review to investigate and develop improved emission estimation techniques.

12. The EPA initiate a process with industry to implement consistent emission estimation techniques for all power stations for all pollutants, where practical.

13. The EPA engage with industry to investigate NSW power station specific $PM_{2.5}$ particle fractions and methods that could improve particle estimation representativeness and consistency.

5. What emission limits apply to the power stations?

The *Protection of the Environment Operations (POEO) Act* 1997 (the Act) is the principal piece of environment protection legislation administered by the EPA. It establishes the NSW environmental regulatory framework including licensing.

Section 128(1) of the Act prescribes that:

> *The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of:*
>
> *(a) the standard of concentration and the rate, or*
>
> *(b) the standard of concentration or the rate,*
>
> *prescribed by the regulations in respect of any such activity or any such plant.*

Section 38 of the *Protection of the Environment Operations (Clean Air) Regulation 2010* (the Regulation) prescribes that:

> *For the purposes of section 128 (1) of the Act, the prescribed standards of concentration for emissions of air impurities are:*
>
> *(a) in relation to any plant referred to in Schedule 2, the standards of concentration specified in that Schedule in relation to that plant, and*
>
> *(b) in relation to any activity or plant specified in Schedule 3 in respect of a particular purpose, the standards of concentration specified in Schedule 3 in relation to that activity or plant and that purpose, and*
>
> *(c) in relation to any activity or plant specified in Schedule 4 (other than those covered by Schedule 2 or 3), the standards of concentration specified in Schedule 4 in relation to that activity or plant.*

Regulation limits for plant and equipment differ according to the general grouping of the activity and plant. Grouping is classified according to the plant vintage, with Group 1 plant being the oldest and Group 6 being the newest. The Regulation prescribes more stringent limits for newer activities and plant.

Table 2 summarises the regulatory grouping of NSW power stations.

Table 2: POEO Clean Air Regulation (2010) groupings for NSW coal fired power stations

Station	EPL No.	Commission Date	POEO Grouping
Bayswater	779	1985 - 1986	Group 3
Liddell	2122	1971 - 1973	Group 5*
Mount Piper	13007	1993	Group 4
Eraring	1429	1982	Group 3
Vales Point	761	1978	Group 5*

*In accordance with clause 35 of the Protection of the Environment Operations (Clean Air) Regulation 2010, any activity or plant that, prior to 1 January 2012, belonged to Group 2 (including any activity or plant previously in Group 1) is taken to belong to Group 5. In accordance with clause 35 Liddell and Vales Point were granted an exemption from Group 5 for the emission of nitrogen oxides.

The Regulation sets emission limits as standards of concentration, typically expressed as milligrams per cubic metre (mg/m3), based on reasonably available control technology applicable to the vintage of the plant and equipment. Limits for electricity generation are prescribed in Schedule 3 of the Regulation.

Activity specific limits for coal fired electricity generation are prescribed for oxides of nitrogen (NOx), solid particles, total fluoride, and smoke. Additionally, Schedule 4 of the Regulation prescribes concentration limits for general activities and plant, for pollutants including metals, chlorine and sulfuric acid. The Regulation also restricts the use of high sulfur liquid fuels.

The EPA issues Environment Protection Licences (EPLs) under the POEO Act. Section 45 of the POEO Act sets out matters to be take into consideration in licensing functions, including Section 45

> *(c) the pollution caused or likely to be caused by the carrying out of the activity or work concerned and the likely impact of that pollution on the environment,*
>
> *(d) the practical measures that could be taken:*
>
> *(i) to prevent, control, abate or mitigate that pollution, and*
>
> *(ii) to protect the environment from harm as a result of that pollution*,

It is EPA policy, as published in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2016)*[4], to set EPL emission limits that:

- reflect reasonably available technology and good environmental practices (informed by the Regulation)
- reflect proper and efficient operation
- protect the health and amenity of the surrounding community.

By using the above three criteria, emission limits in an EPL can be more stringent than the requirements of the Regulation. Importantly, emission limits in EPLs cannot be less stringent than the limits specified in the Regulation.

Emission limits applicable to NSW power stations are summarised in Table 3 (below). All applicable regulatory emission limits are detailed in Table 3 of Attachment C.

Table 3: Summary of applicable emission limits for NSW Coal Fired Power Stations

NSW Coal Fired Power Stations – Concentration Limits													
	Solid particles (Total) (mg/m^3)	Total Fluoride (mg/m^3)	Type 1 & 2 Substances (Metals) (mg/m^3)	Cadmium (mg/m^3)	Mercury (mg/m^3)	NOx as Equivalent NO_2 (mg/m^3)	Dioxins & Furans (ng/m^3)	Volatile Organic Compounds (mg/m^3)	Sulfuric Acid Mist (H_2SO_4 as SO_3) (mg/m^3)	Hydrogen Chloride (mg/m^3)	Chlorine (mg/m^3)	Coal Sulfur Content Limit (% weight)	Opacity (%)
Bayswater	100	50	5	1	1	1500	-	-	100	100	200	-	20
Liddell	100	50	5	1	1	1500	-	-	100	100	200	1.0	20
Eraring	50	50	1	0.2	0.2	1100	-	-	100	100	200	0.5	20
Mount Piper	50	50	1	1[1]	0.2	1500	0.1	40	100	100	200	-	20
Vales Point	100	50	5	1	1	1500	-	-	100	100	200	0.5	20

1. Cadmium is included in Type 1 and Type 2 Substances

[4]Approved Methods Modelling: https://www.epa.nsw.gov.au/your-environment/air/industrial-emissions/modelling-assessing-air-emissions

In addition to the concentration limits listed in Table 3 (previous page), some EPLs also include reporting limits. The reporting limits are compared with results from Continuous Emission Monitoring (CEM) and provide a benchmark for process management and variability. The EPL reporting limits are summarised in Table 4 below.

Table 4: Environment Protection Licence - reporting limit requirements

Environment Protection Licence - Reporting Limit Requirements			
	SO_2 [1]	NO_X [2]	Opacity
Bayswater (Boiler 1 Only)	1760 mg/m^3	-	-
Liddell	1760 mg/m^3	1438 mg/m^3	20% Opacity
Eraring	1760 mg/m^3	-	-
Mount Piper	-	-	-
Vales Point	1760 mg/m^3	-	-

1. SO_2 concentration converted based on 1 ppm (SO_2) = 2.86 mg/m^3

2. NOx concentration converted based on 1 ppm (NO_2 equivalent) = 2.05 mg/m^3

Attachment B contains a review conducted by the EPA Intelligence Unit. The review focuses on EPL conditions applicable to air emissions for the five-operating coal fired power stations in NSW. The review found EPL conditions are generally consistent between each of the power stations, however some limited variation was identified, including:

- instances of inconsistent monitoring requirements between the power stations
- instances of variability in emission limits between the power stations, but noting there are differences between individual power station plant and site characteristics
- instances where limits are specified with no corresponding monitoring requirements
- some inconsistency in prescribed sampling methods
- some inconsistency in the reference basis/conditions for emission limits between the power stations

The review also compared the non-standard licence conditions and identified variation between licence requirements regarding the regulation of point source air emissions for the five premises.

Key Findings

- EPL conditions are generally consistent between each of the power stations, however some limited and unnecessary variation was identified.

Recommendations

- The EPA investigate practicability of implementing standardised EPL conditions, relating to air emissions, across all power stations in NSW. Practicability of standardised conditions will have regard for individual site and plant characteristics.

6. Are the power stations compliant with their air emission monitoring conditions?

Each power station is required to monitor, by sampling and obtaining results by analysis, the concentration of each pollutant specified in their EPL. Sampling frequency and units of measure are also prescribed. Each EPL has the following condition:

> *Monitoring for the concentration of a pollutant emitted to the air required to be conducted by this licence must be done in accordance with:*
>
> > *a) any methodology which is required by or under the Act to be used for the testing of the concentration of the pollutant; or*
> >
> > *b) if no such requirement is imposed by or under the Act, any methodology which a condition of this licence requires to be used for that testing; or*
> >
> > *c) if no such requirement is imposed by or under the Act or by a condition of this licence, any methodology approved in writing by the EPA for the purposes of that testing prior to the testing taking place.*

The Protection of the Environment Operations (Clean Air) Regulation (2010) requires monitoring to be conducted in accordance with test methods contained in the publication *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (2007)* (Approved Methods Sampling)[5].

The Approved Methods Sampling requires that analysis be carried out by a laboratory accredited to perform the procedures. The accreditation body must be independent, and acceptable to the EPA, such as the National Association of Testing Authorities (NATA).

6.1 Periodic Sampling

Periodic stack samples are generally collected over a three-to-four-hour period, ideally when the boiler is operating at representative and stable conditions.

To determine if the power stations are compliant with their periodic sampling requirements, five consecutive years (2011-2016) of stack test reports, for each power station, have been reviewed – totalling 108 reports. The review found widespread compliance with the periodic testing requirements and evidence of additional testing, over and above the EPL requirements, having been conducted.

Table 5 provides a summary of periodic stack test requirements for each power station, including pollutants to be measured and frequency of testing.

The review identified two instances of failure to complete required testing:

1) Liddell Power Station did not perform sampling on Unit 1 in 2014 – occurred due to unplanned boiler outages.
2) Liddell Power Station did not sample for VOC emissions between 2011 and 2014 – occurred due to an oversight in the sampling program.

[5] ***Approved Methods Sampling:*** **https://www.epa.nsw.gov.au/your-environment/air/industrial-emissions/sampling-analysing-air-emissions**

Table 5: Summary of EPL periodic sampling requirements for NSW power stations

	Bayswater	Liddell	Mount Piper	Eraring	Vales Point
	10: Boiler 1 11: Boiler 2 12: Boiler 3 13: Boiler 4	1: Boiler 1 2: Boiler 2 3: Boiler 3 4: Boiler 4	2: Boiler 1 3: Boiler 2	11: Boiler 1 12: Boiler 2 13: Boiler 3 14: Boiler 4	11: Boiler 5 12: Boiler 6
Pollutant	**Sampling Frequency**				
Cadmium	Yearly	Yearly	-	Yearly	Yearly
Carbon dioxide	Yearly	Yearly	Yearly	Yearly	-
Carbon monoxide	Yearly	-	-	Yearly	-
Chlorine	Yearly	Yearly	Yearly	Yearly	Yearly
Copper	Yearly	Yearly	Yearly	Yearly	Yearly
Dioxins & Furans	-	-	Yearly	-	-
Hydrogen chloride	Yearly	Yearly	Yearly	Yearly	Yearly
Mercury	Yearly	-	Yearly	Yearly	Yearly
Nitrogen Oxides	Yearly [2]	Yearly	Quarterly	-	-
Oxygen (O_2)	Yearly	Yearly	Yearly	-	-
Sulfuric acid mist (as SO_3)	Yearly	Yearly	Yearly	-	Yearly
Sulfur dioxide	Yearly [2]	Yearly	Quarterly	-	-
Total Fluoride	Yearly	Yearly	Yearly	Yearly	Yearly
Solid Particles	Yearly	Yearly	Yearly	Yearly	Yearly
Hazardous substances [1]	Yearly	Yearly	Yearly	Yearly	Yearly
Volatile organic compounds		Yearly	Yearly	Yearly	Yearly

1. Hazardous Substances means the aggregate of Type 1 and Type 2 substances, as defined by the Protection of the Environment Operations (Clean Air Regulation) 2010.

Type 1 substance means the elements antimony, arsenic, cadmium, lead or mercury or any compound containing one or more of those elements.

Type 2 substance means the elements beryllium, chromium, cobalt, manganese, nickel, selenium, tin or vanadium or any compound containing one or more of those elements.

2. Yearly sampling on Bayswater boilers 2,3 and 4.

6.2 Continuous Emission Monitoring

Continuous Emission Monitoring Systems (CEMS) are used to demonstrate ongoing regulatory compliance; ensure proper and efficient operation of pollution control equipment; and evaluate operating and emission variability.

To determine compliance with continuous monitoring requirements, hourly CEMS data, historical calibration and maintenance logs, work procedures and instructions were reviewed for the period 2011-2016. Attachment D includes an overview of the continuous monitoring equipment and practices at each power station.

Table 6 summarises the continuous monitoring requirements for each of the five power stations.

Table 6: Continuous monitoring requirements for NSW coal fired power stations

NSW Coal Fired Power Station - Continuous Monitoring Requirements			
	Sulfur Dioxide (SO_2)	Oxides of Nitrogen (NO_x)	Undifferentiated Particulates (Opacity)
Bayswater	Boiler 1	Boiler 1	All Boilers
Liddell	All Boilers	All Boilers	All Boilers
Mount Piper	-	-	-
Eraring	All Boilers	All Boilers	All Boilers
Vales Point	All Boilers	All Boilers	All Boilers

Continuous measurement of pollutants must be performed using methods stipulated in EPLs, and in accordance with the Approved Methods Sampling.

EPL prescribed CEM monitoring methods reference United States Environmental Protection Agency (USEPA) performance specifications. These standards are used for evaluating the acceptability of CEMS at the time of installation or soon after. The licensee is responsible for calibrating, maintaining, and operating installed CEMS properly.

NSW EPA does not currently have published guidance for operating and maintaining CEMS. As such, each operator has adopted their own approach for demonstrating proper and efficient operation of monitoring systems.

A best practice approach, for the ongoing evaluation of CEMS, should include well defined, rigorous quality assurance procedures coupled with regular Relative Accuracy Audits (RAAs), such as those described in USEPA Procedure 1. RAAs determine the difference between pollutant concentrations measured by a CEMS and concentrations measured using a reference method (RM).

NSW regulation requires power stations to operate and maintain [CEMS] equipment in a proper and efficient manner and condition. Proper and efficient operation of the installed CEMS was adequately demonstrated through documented records and procedures including:

- calibration records
- maintenance records
- equipment fault logs
- equipment manuals
- standard operating procedures

Key Findings

- The review identified extensive compliance with EPL monitoring conditions, by all coalfired power stations.
- Air emission testing at all power stations was conducted in accordance with EPL conditions and the Approved Methods for the Sampling and Analysis of Air Pollutants in NSW.

Recommendations

- The EPA consider an appropriate response to the limited incidents identified of failure to complete emission monitoring in accordance with EPL requirements.
- The EPA take action to develop and improve CEMS protocols and monitoring guidance, including working with stakeholders such as monitoring experts and licensees.

7. Is the monitoring representative?

Power station EPLs do not include a specific requirement to demonstrate if periodic sampling is being conducted at times considered representative of routine process conditions. The Approved Methods Sampling requires emission monitoring reports to include details of source or process operating conditions during sampling and a statement about the representativeness of the sample taken.

Power station emission test reports were found to include the minimum information required to meet the Approved Methods Sampling requirement, as such additional information was requested from each of the power stations to inform the analysis. To investigate whether monitoring being conducted by each power station is representative, the EPA reviewed and analysed data for the five-year period 2011 to 2016 including:

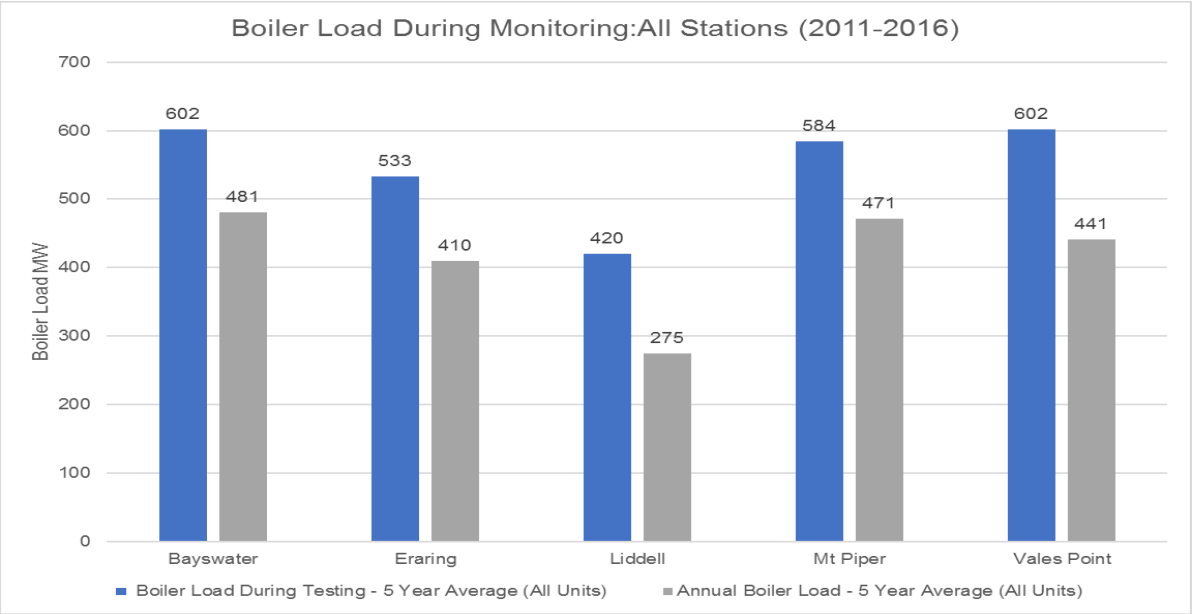
- hourly CEMS data for SO_2, NOx, opacity
- daily coal quality analysis results for calorific value, sulfur and ash content
- hourly boiler loads (MW) and coal usage (t/hr)
- periodic (stack test) reports

Periodic sampling (stack test) results for sulfur dioxide and nitrogen oxides were compared to CEMS data and hourly load data to determine if periodic sampling is being conducted at times that are generally representative of normal operations. A summary of the review and a sample of the analysis used to determine the representativeness is presented in Attachment D.

A review of SO_2 and NO_X hourly average CEMS data and periodic test results found the two sets of measurements trend well, at the time of sampling, and may be considered representative of emissions. Greater variability was observed when periodic tests were compared with monthly average and yearly average CEMS data trends, as discussed in section 3.4 of Attachment D.

The variability observed in longer term averaging periods is partly attributed to periodic testing typically being conducted when boiler loads are above average, as shown in Figure 1. The graph compares the 5-year average boiler load, during periodic sampling (blue columns), with the 5-year average boiler load (grey columns), during all times of in-service operation. Figures 3 to 7 of Attachment D provide annual comparisons for each power station and each individual boiler.

Figure 1: Average boiler load at the time of periodic testing - All power stations (2011-2016)



Stack test results tend to be equal-to or greater than monthly CEMS averages (94% for SO_2 and 90% for NOx)[6].

The review found the approach employed at each power station, to measure particles, may affect the representativeness of measured particle concentrations (refer section 1 of Attachment D). Particle monitoring is a very challenging aspect of emission monitoring. Non-ideal sampling locations, large diameter stacks and multiple exhaust ducts can impact particle distribution and emission concentrations, originating from a single boiler.

To investigate if periodic stack sampling is being undertaken at times representative of normal process conditions, daily as-fired coal data was reviewed for consistency of quality and composition during testing periods. Figures 28 to 40 of Attachment D show that the average calorific value, sulfur and ash content of the coal were consistent during and excluding stack test time periods.

The EPA reviewed CEMS data and periodic test results from Bayswater Power Station to investigate if SO_2 concentrations, being continuously monitored from a single boiler, are representative of all four boiler units. Periodic test results were compared for each boiler for the period 2011-2016. The SO_2 concentrations measured from Unit 1 boiler were found to be representative of the average emissions of all four boilers, for the 5-year period, as shown in Table 12 of Attachment D.

Key Findings

- Monitored emissions, reported by the power stations, may be considered generally representative of power station environmental performance. However, there are opportunities for improvement in the application of periodic and continuous emission measurement at all power stations.
- The review found no evidence that coal blending has been used to purposely lower emissions during testing periods and produce unrepresentative test results.

Recommendations

- The EPA work with the power stations to investigate options to refine particle sampling.
- The EPA review required parameters to be included with emission monitoring reports.
- The EPA take action to develop and improve CEMS protocols and monitoring guidance, including working with stakeholders such as monitoring experts and licensees.

[6] Refer to Table 8 of Attachment D.

8. Are the power stations compliant with their air emission limits?

The reported air emissions from each power station, for the period 2011-2016, have been reviewed and compared against their applicable emission limits. A summary of the review is presented below.

8.1 Periodic Tests

Periodic test results were compared to the concentration limits specified in the Regulation and each power station EPL. As the EPL cannot be less stringent than the Regulation, EPL limits were used for the comparison, unless the EPL did not prescribe a limit for a pollutant listed in the Regulation.

Table 7 provides an abbreviated summary of stack test results for select pollutants, reviewed for the period 2011-2016. A full summary table of results is included in section 3 of Attachment C.

Table 7: Maximum and average reported results of air pollutants from stack sampling reports (2011-2016)

		Solid Particles (Total) (mg/m^3)	Total Fluoride (mg/m^3)	Sulfuric Acid Mist (H_2SO_4 as SO_3) (mg/m^3)	Mercury (mg/m^3)	NOx (as Equivalent NO_2) (mg/m^3)	Hydrogen Chloride (mg/m^3)	Chlorine (mg/m^3)
Bayswater	Licence Limit	*100*	*50*	*100*	*1*	*1500*	*100*	*200*
	Average	15	13	13	0.0014	659	13	19
	Max	68	**54**	55	0.0053	940	24	200
Liddell	Licence Limit	*100*	*50*	*100*	*1*	*1500*	*100*	*200*
	Average	24	11	9	0.0004	724	14	0.04
	Max	58	17	58	0.0015	930	28	0.20
Mount Piper	Licence Limit	*50*	*50*	*100*	*0.2*	*1500*	*100*	*200*
	Average	11	6	21	0.0010	767	1	1.3
	Max	39	11	**120**	0.0019	1200	2	13
Eraring	Licence Limit	*50*	*50*	*100*	*0.2*	*1100*	*100*	*200*
	Average	9	10	11	0.0010	415	4	0.40
	Max	19	32	68	0.0022	593	13	1.8
Vales Point	Licence Limit	*100*	*50*	*100*	*1*	*1500*	*100*	*200*
	Average	2	3	15	0.0012	881	4	1.1
	Max	7	12	42	0.0078	1099	8	3.8

Notes:

- **Cells in bold text exceeded the EPL concentration limit.**
- **Emission limits in italics.**

The review identified two exceedances of EPL limits:

1) Bayswater Power Station had a single exceedance of its concentration limit for fluoride in June 2012. The reported concentration was 54 mg/m^3, the EPL limit is 50 mg/m^3.
    - Retests were conducted in July 2012 and reported an average result of 8 mg/m^3.
2) Mount Piper Power Station had a single exceedance of its concentration limit for sulfuric acid in April 2014. The reported concentration was 120 mg/m^3, the EPL limit is 100 mg/m^3.
    - A retest was conducted in July 2014 and returned a result of 2.2 mg/m^3.

A review of the two identified exceedances is included in section 3 of Attachment C. The review concluded:

1) Analysis of fuel burnt at Bayswater for the sampling period was inconclusive in determining the cause of the fluoride exceedance.
2) The exceedance of sulfuric acid from Mount Piper was likely an error in emission testing or sample analysis.

8.2 Continuous Emission Monitoring

Continuous Emission Monitoring (CEM) data was reviewed to determine if limits had been exceeded. The review found compliance with applicable EPL and Regulation limits at each of the power stations, for all monitored pollutants, with the following exception:

- Liddell Power Station exceeded its 20% opacity limit on 19 occasions between 2011 and 2016. Seventeen (17) of the exceedances occurred prior to 2014 when the generator was sold and a new licensee appointed. The EPA has records of being notified, via annual returns, about three of the exceedances.

Key Findings

- The review found extensive compliance with EPL air emission limits, with some pollutant concentrations consistently trending well below the specified limits and few instances of non-compliance.

Recommendations

- The EPA investigate potential for reducing EPL emission limits where there is a demonstrated history of compliance by an appreciable margin.

9. Are the power stations compliant with their reporting obligations?

9.1 Annual Returns

All NSW power stations are required to submit an Annual Return form including a statement of compliance with regulatory conditions. All power stations have completed and submitted an Annual Return for each year of the review period.

For the period of review (2011-2016), Liddell reported six non-compliances related to air emissions. No other power station reported non-compliances, relating to air emissions, in their Annual Returns for the review period.

Liddell reported non-compliances including failure to monitor volatile organic compounds due to oversight, an opacity exceedance due to operational failure, and failure to report an exceedance of its sulfur dioxide reporting limit within the timeframe specified in its EPL. Further details of the reported events can be found in Table 20 of Attachment C.

As part of their Annual Return, Mount Piper must include a report that plots the quarterly NOx sampling results against a historical NOx CEMS data curve for boiler Units 1 and 2. Mount Piper has included this report in each Annual Return for the review period.

9.2 Published Monitoring Data

Section 66(6) of the Act obliges coal fired power stations to publish results of monitoring required specified in the EPL on their website. This requirement was enacted in 2012.

> *The holder of a licence subject to a condition referred to in subsection (1) (a) must, within 14 days of obtaining monitoring data as referred to in that subsection:*
>
> > *(a) if the holder maintains a website that relates to the business or activity the subject of the licence—make any of the monitoring data that relates to pollution, and the licensee's name, publicly and prominently available on that website in accordance with any requirements issued in writing by the EPA, or*
> >
> > *(b) if the holder does not maintain such a website—provide a copy of any of the monitoring data that relates to pollution, to any person who requests a copy of the data, at no charge and in accordance with any requirements issued in writing by the EPA.*

Each power station is required to publish monitoring data on the licensee's website. A review of reporting years 2015 and 2016 identified the following:

- Mount Piper did not publish all requisite monitoring results[7] and some published data was in error:
  - Quarterly NOx and SO_2 data for Q4 2015 and Q1 & Q2 2016 was not published.
  - Annual mercury data for 2015 and 2016 was not published.
  - The published particle data in 2016 for generating Unit 1 was the result of a single total particle test of 2.2 mg/m^3 from Duct A. Published data should have included tests for all ducts associated with the licenced discharge point. A test result from Duct B of 5.8 mg/m^3 was not published. Additionally, a second test from duct A of 39 mg/m^3 was not published.
  - Test data for solid particles from generating Unit 2 was not published for 2016.
  - Annual test data for all other monitored pollutants from Units 1 and 2 was not published for 2016.

[7] EPA sourced published monitoring data from Energy Australia's website page -https://www.energyaustralia.com.au/about-us/energy-generation/mt-piper-power-station/mt-piper-epa-reports. EPA was not able to access historical published data records from website, http://www.de.com.au/Environment/Environmental-Licences---Monitoring/Mt-Piper-Power-Station-Monitoring-Data/default.aspx

- Eraring and Vales Point power stations have published all requisite monitoring data.
    - The review additionally confirmed that published data is consistent with stack test reports held by the EPA.
- Bayswater and Liddell power stations have published all requisite monitoring results.
    - Errors in data transcription, presentation and consistency were identified. Issues include; rounding of some data to zero; variable rounding from month to month; poor labelling of sampling dates and discharge points; and transposing of mean and maximum data.

9.3 Air Emissions Exceedance Reports

Power station EPLs include various 'reporting limits' and 'trigger values' (collectively referred to below as 'reporting limits') as detailed in Table 4, page 11. If a reporting limit is exceeded, the licensee must provide an exceedance report to the EPA within the timeframe specified in the EPL. The exceedance report must include the following information:

- details of the date and times of the exceedance
- the duration of the exceedance
- the reason(s) for the exceedance
- actions to be taken to address any future exceedance(s)

Table 8 provides a summary of instances where CEMS data at each power station indicated an exceedance of reporting limits. Attachment C provides a more detailed review of the reporting limit exceedances.

Table 8: NSW coal fired power station Environment Protection Licence - reporting limit exceedances

	Environment Protection Licence - Reporting Limit Exceedances
Bayswater	No exceedances
Liddell	**SO_2** exceeded 1760 mg/m^3 on 3 separate occasions between 2011 and 2016. **Opacity** exceeded 20% opacity on 17 separate days between 2011 and 2013, and 2 days between 2014 and 2016. Total of 19 exceedances
Mount Piper	No continuous monitoring requirements
Eraring	No exceedances
Vales Point	No exceedances

Liddell has self-reported some, but not all, exceedances of their reporting limits since 1 January 2011.

Key Findings

- The review found extensive compliance with regulatory reporting requirements. However, specific incidents of failure to report exceedances and publish monitoring data were identified.

Recommendations

- The EPA consider an appropriate response to those identified incidents of failure to publish or report emission monitoring data, and exceedances of limits.
- The EPA investigate options to harmonise air emission reporting obligations across all power station EPLs.

10. Are emission controls being operated in a proper and efficient manner?

All NSW power stations use bag filters to control particle emissions, including particulate metals. The filter plant (baghouse filters) comprise banks of individual bags that require maintenance and periodic replacement. In the case of the power stations, the baghouses contain thousands of individual bags.

10.1 Proper and Efficient Operation

The EPA reviewed five years (2011-2016) of baghouse maintenance records, including operational monitoring; preventative maintenance; corrective repairs/responses; bag replacement; records management; and continual improvement actions to determine whether emission controls at the power stations are being operated in a proper and efficient manner.

Operational Monitoring

All power stations use opacity meters to provide an indicative measure of dust levels at the outlets of the baghouse filters. The number and type of monitors varies between each station. A combination of either digital camera monitoring or visual inspections, and opacity alarms are used to monitor visible dust emissions, bag conditions and performance.

Preventative Maintenance

The level of preventative maintenance employed by each station varies from daily inspections and routine tests to as required inspections and random bag testing. The level of maintenance required is dependent on a number of factors including: age of the plant and equipment; filter fibre material used for the bags, dust composition and concentration; and historical data for each baghouse unit.

Corrective Repairs/ Response

All power stations have a protocol in place to respond to alarms or reports of failed bags. Some operators use trigger point flow charts to decide on appropriate action, while others either respond on a case-by-case basis – in accordance with standard operating procedures, or have management decide the course of action. Most response actions include:

- assessing the opacity monitor to ensure it is operating correctly
- assess bag cleaning processes and perform visual inspections
- removing baghouse cells from service (isolating it from the gas flow)
- reducing boiler load, reducing flow rate or shutting down a unit if required
- reporting to management or recording in operational logs

Bag Replacement

Each of the power stations track and record in-service filter hours and proactively replace bags according to expected lifespan – typically around 30,000(+) hours. Bag failure, capping and replacement is also tracked.

Records Management

Records are maintained by each operator including baghouse maintenance, inspections and repairs. Hard copies of reports were included with the information provided to the EPA under Notices 1 and 2. The records reflect the procedures used by each licensee for maintenance and repairs.

Continual Improvement

Most power stations have undertaken actions to change the type of filter material used for the bags in an effort to improve bag life and control efficiency.

10.2 Dust Capture and Control Efficiency

The average control efficiency of the dust collection systems operated at each power station was calculated by the EPA. As detailed in Table 9 below, the level of Total Solid Particles (TSP) control efficiency is very high, 99.93% - 99.98%, indicating proper and efficient operation of the baghouse filters.

Table 9: Calculated baghouse Total Solid Particle (TSP) control efficiency

Station	Year	5-Year Average TSP Control Efficiency %	5-Year Average TSP Emission %
Bayswater	2011-16	99.948%	0.052%
Liddell	2011-16	99.927%	0.073%
Mount Piper	2011-16	99.960%	0.040%
Eraring	2011-16	99.957%	0.043%
Vales Point	2011-16	99.979%	0.021%

Key Findings

- The review found pollution control equipment at each power station is being operated and maintained in a proper and efficient manner, and achieving greater than 99% control efficiency. Some variability in formal quality assurance and quality control procedures was identified between power stations.

Recommendations

- The EPA engage with the licensees to discuss the potential for improved and formalised emission control maintenance and fault response procedures.

Part B - National Pollutant Inventory

The National Pollutant Inventory (NPI) is established under the National Environment Protection (National Pollutant Inventory) Measure 1998 (Cth). The NPI is a database which provides the community, industry and governments with information about the emission of 93 substances across Australia.

In NSW, the EPA administers the NPI on behalf of the Commonwealth. The EPA collects information from NPI industry reporters, including coal fired power stations, and provides that information to the Commonwealth. The Australian Government Department of Environment and Energy compiles and publishes the NPI data on the National Pollutant Inventory (NPI) website[8].

In 2016 the Commonwealth commenced a substantive review of the NPI program, including the National Environment Protection (National Pollutant Inventory) Measure. The review will be principally managed by the Commonwealth, with contribution from the states, including the NSW EPA.

The NSW EPA does not regulate emissions from power stations based on the NPI.

[8] National Pollutant Inventory website: http://www.npi.gov.au/

11. Did each power station calculate reported emission loads using an approved NPI method and did they apply the method correctly?

The NPI emission calculation workbooks for the five operating NSW coal fired power stations were reviewed for the five NPI reporting periods 2011/12 to 2015/16. The review addressed the following points:

- Were the stack test results transcribed to the workbooks correctly and applied correctly?
- Did the calculation of emissions for each substance follow an approved methodology and was the methodology implemented correctly?
- Were the emissions calculated by the workbooks accurately reported to the NPI?

11.1 Emission Estimation Methods Used

Each power station applied emission estimation techniques that followed an approved method with the following exceptions (see Table 1 in Attachment E for a list of methods used):

- Bayswater, Eraring and Mount Piper Power Stations used a calculated flue gas volume (FGV) to estimate emissions using the direct measurement method for some pollutants in the 2011/12 reporting period, prior to approval of the calculated FGV method for those pollutants in December 2012. The calculated FGV is typically lower than the measured FGV but can be more representative as it accounts for the actual generation load rather than assuming the load during the stack test is representative of all hours of operation.

11.2 Implementation of Emission Estimation Methods

The review found that the calculation methodologies were generally applied correctly, although some minor errors and issues were identified including:

- some inconsistent reference basis between the measured or calculated FGV and the stack test concentration in direct measurement method calculations
- an incorrect factor used to calculate the $PM_{2.5}$ fraction from the stack test based PM_{10}
- cases of incorrect transcription of stack test concentrations and/or measured FGV and test conditions
- incorrect rounding and reporting to the minimum two significant figures required by the NPI
- a case of incorrectly doubling of test concentrations measured on one duct to represent the two ducts per boiler unit, rather than doubling the duct flow
- stack test results that are less that the practical quantification level (<PQL) are variously applied as PQL, 50% of PQL, or where two or more tests are <PQL, set to zero (PQL is generally < 1% of relevant concentration limits)
- using periodic test results from the one boiler tested in the quarter year period to calculate emissions from all boilers for that quarter
- use of historical coal trace element concentration data for emission estimation by the NPI emission factor method.

11.3 Particle Emissions

The EPA has considered observed year to year variation in reported particle emissions (Attachment E, Figure 1). The review found that the variation in reported annual emissions is in direct proportion to the annual stack test particle concentration results. In Figure 2 of Attachment E, reported annual PM_{10} emissions, as kg per MWh of electricity generated, are plotted against average stack test particle concentrations for each power station. The particle concentrations were extracted from the original stack test reports held by the EPA.

The observed variation in the annual average stack test concentrations is considered to be a function of the baghouse efficiency at the time of testing and the measurement uncertainty in the stack test method, particularly where low concentrations are observed. Total solid particle baghouse control efficiency, across all power stations, is calculated to be 99.883% to 99.998% (Table 2 Attachment E) for the five years of data reviewed. Hence, a very small change in the absolute baghouse efficiency results in large changes in absolute emission loads (kg/year).

11.4 Accuracy of Reporting

The review found no evidence of deliberate misreporting. The calculation errors found appear to be human error and a result of potentially inadequate quality assurance procedures. The errors displayed no bias towards lower reporting, and where the emissions of a substance was estimated by two methods (e.g. direct measurement and the NPI emission factor method for metals) the reported emission was more often the larger. The impact of the calculation errors was often relatively minor (~±10%). Some of the largest errors resulted in significant over-estimation of annual emissions. (eg. incorrectly doubling stack test concentrations).

Key Findings

- The review found all power stations used approved methods for estimating all NPI stack emissions in the last four years. No evidence of deliberate misreporting was found.
- Minor errors were found in most power stations emission estimations in most years.
- Reported particle emissions were found to directly follow the annual stack test results.
- Calculated filter efficiency was greater than 99% for all power stations.

Recommendations

- The EPA work with industry to facilitate improved emission estimation quality assurance procedures.
- The EPA engage with the Commonwealth NPI review to investigate and develop improved emission estimation techniques.

12. Did the power stations estimate reported NPI emissions using a consistent method?

12.1 Consistency Between Years

Table 1 of Attachment E summarises the Emission Estimation Technique (EET) used by each NSW power station for the five NPI reporting periods reviewed.

Eraring - used consistent EET for all major reported substances for the last four reporting periods (2012/13 – 2015/16), and used a calculated FGV for those pollutants estimated using direct measurement (i.e. stack test results).

Mount Piper - used consistent EET for all major reported substances for the last four reporting periods (2012/13 – 2015/16), and used a calculated FGV for those pollutants estimated using direct measurement (i.e. stack test results).

For the 2011/12 reporting period Mount Piper applied the calculated FGV for particle and metal emissions prior to the approval of the calculated FGV method for these substances.

Vales Point - used consistent EET for all major reported substances for the last four reporting periods (2012/13 – 2015/16), and used a calculated FGV for those pollutants estimated using direct measurement (i.e. stack test results).

Bayswater - used consistent EET for the last three NPI reporting periods except for a change from the emission factor (EF) method to direct measurement (DM) for one or more metals.

For the 2011/12 and 2012/13 reporting periods Bayswater used the stack test measured FGV/flow rate for the direct measurement estimation of particles and used different EET for estimation of one or more metals.

Liddell - used consistent EET for the last three NPI reporting periods except for a change from the emission factor (EF) method to direct measurement (DM) for one or more metals.

For the 2011/12 and 2012/13 reporting periods Liddell used the stack test measured FGV/flow rate for the direct measurement estimation of particles and used different EET for estimation of one or more metals.

For the 2011/12 and 2012/13 reporting periods Liddell used mass balance to calculate SO_2 rather than the DM-CEMS used in the later three years.

12.2 Consistency Between Power Stations

The following summary of EET consistency is limited to the 2013/14 to 2015/16 reporting periods where each of the power stations used the calculated FGV methodology approved in December 2012.

PM_{10}

All power stations used direct measurement EET to estimate particle emissions, combining annual average stack test particle concentrations with a calculated FGV.

Mount Piper, Vales Point, Bayswater and Liddell power stations measure PM_{10} concentrations directly in the stack test and use this to estimate PM_{10}. The measured ratio of PM_{10} to TSP varies widely from around 0.3 to 0.8 and averaged approximately 0.5 (Table 2, Attachment E).

Eraring applies a factor of 0.99 to the TSP stack test concentration to estimate PM_{10} concentrations as specified in the Load Based Licencing Load Calculation Protocol. The use of the 0.99 LBL factor results in Eraring potentially reporting twice the PM_{10} emissions as the other power stations.

$PM_{2.5}$

All power stations use the NPI $PM_{2.5}$:PM_{10} factor to calculate the $PM_{2.5}$ stack emissions from the estimated PM_{10} emissions, although Vales Point incorrectly implemented the $PM_{2.5}$ to TSP factor of 0.53 rather than 0.58. In the case of Eraring, the PM_{10} estimation method would also result in reported $PM_{2.5}$ being relatively higher than other power stations.

NO_x and SO_2

Bayswater, Eraring, Liddell and Vales Point use monthly average CEMS concentrations of NO_x and SO_2 multiplied by monthly calculated FGV to estimate NO_x and SO_2 emission loads. Until 2017, Bayswater had CEMS on generating Unit 1 only and applied this to the other units to estimate the emissions. A review of the periodic stack test results from all generating units at Bayswater (Appendix D, section 5) concluded that in most years boiler 1 test was reasonably representative of the other boilers. The other power stations have CEMS on all units.

Mount Piper uses a Predictive Emission Monitoring (PEMS) method, approved under the NSW EPA's LBL load calculation protocol, to estimate NO_x emissions. SO_2 emissions are estimated by mass balance.

Metals

The power stations used EET that varied, both over the years and between power stations, to estimate emissions of metals. Direct measurement, utilising a calculated FGV, and NPI emission factor methods, based on coal trace element analysis, were used. It should be noted that the lowest emission estimate of the two methods was not always reported; conversely, often the reported emissions were the higher of the two estimates.

Key Findings

- Power stations used broadly consistent methods for emission estimation, other than methods used to estimate metals emissions which vary between power stations and across years.

Recommendations

- The EPA initiate a process with industry to implement consistent emission estimation techniques for all power stations for all pollutants, where practical.
- The EPA engage with industry to investigate NSW power station specific $PM_{2.5}$ particle fractions and methods that could improve particle estimation representativeness and consistency.

List of append analysis

1. Attachment A: Power Stations Review: S191 Notices
2. Attachment B: Power Stations Review: Environment Protection Licences - Consistency Review
3. Attachment C: Power Stations Review: Compliance with Air Emissions Limits, Monitoring and Reporting Requirements
4. Attachment D: Power Stations Review: Representativeness of Sampling Data
5. Attachment E: Power Stations Review: NPI Emission Estimation Methodology