ACIL ALLEN CONSULTING

REPORT TO
AUSTRALIAN ENERGY MARKET OPERATOR

11 APRIL 2014

EMISSION FACTORS

REVIEW OF EMISSION FACTORS FOR USE IN THE CDEII

ACIL ALLEN CONSULTING PTY LTD
ABN 68 102 652 148

LEVEL FIFTEEN
127 CREEK STREET
BRISBANE QLD 4000
AUSTRALIA
T+61 7 3009 8700
F+61 7 3009 8799

LEVEL TWO
33 AINSLIE PLACE
CANBERRA ACT 2600
AUSTRALIA
T+61 2 6103 8200
F+61 2 6103 8233

LEVEL NINE
60 COLLINS STREET
MELBOURNE VIC 3000
AUSTRALIA
T+61 3 8650 6000
F+61 3 9654 6363

LEVEL ONE
50 PITT STREET
SYDNEY NSW 2000
AUSTRALIA
T+61 2 8272 5100
F+61 2 9247 2455

SUITE C2 CENTA BUILDING
118 RAILWAY STREET
WEST PERTH WA 6005
AUSTRALIA
T+61 8 9449 9600
F+61 8 9322 3955

ACILALLEN.COM.AU

1 Introduction

AEMO's planning functions rely on an underlying set of input assumptions that characterise the behaviour of existing generation assets, and the economics/location of future investment and retirement decisions. The dataset includes projections of fuel and technology costs for both existing and emerging generation technologies. The dataset also encompasses the technical operating parameters of these units. For emerging technologies the dataset specifies location incentives/limits, construction lead-times, and earliest commercial viability dates.

The data is used by AEMO to conduct market simulation studies for medium and long-term planning purposes; in particular the analysis underlying the annual National Transmission Network Development Plan (NTNDP). Emissions factor data provided/validated through this review will also be used operationally in calculation of the Carbon Dioxide Equivalent Intensity Index (CDEII).

ACIL Allen has been engaged by the Australian Energy Market Operator (AEMO) to undertake an update of the technology costs, fuel costs and technical parameters contained within the NTNDP assumptions database.

The first part of this assignment involves the review and update of Emission factors which are used in the calculation of the CDEII. This is to be informed by the recent release of facility-level emission intensity data (Scope 1 & 2 emissions) by the Clean Energy Regulator (CER).

However, there is a concern that any updates to fuel emission factors at this early stage in the project will later be invalidated by subsequent input changes to thermal efficiencies and auxiliaries. For this reason ACIL Allen has focused on the resulting Emission Intensity values, which are likely to remain static throughout the remainder of the project. This is because any changes to thermal efficiencies and auxiliary factors in stage 2 of the project can be offset by changes to fuel Emission Factors such that the Emission Intensity values remain the same and therefore do not affect the results of the CDEII.

This paper sets out the methodology and results from ACIL Allen's review and compares current values with those derived from the CER data and new proposed values.

2 Methodology

This section outlines the proposed approach in estimating the emission factors for each scheduled, semi-scheduled and non-scheduled generator in the NEM.

2.1 Measurement of emissions

Greenhouse gas emissions are measured in carbon dioxide equivalence (CO_2-e). These are comprised of the following emissions to the atmosphere:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O), or
- perfluorocarbons specified in the NGER Regulations and that are attributable to aluminium production.

The equivalence measure allows the global warming potential of each greenhouse gas to be standardised relative to carbon dioxide.

2.2 Emission factors and intensities

In the context of an electricity generator an ***Emission factor*** relates the amount of greenhouse gas emitted per unit of fuel consumed (expressed in units of CO_2-e per unit of fuel consumed).

When combined with the power stations' thermal efficiency, one can calculate the ***Emissions intensity*** of the station, expressed in unit of CO_2-e per unit of electricity produced (either sent-out or as generated).

For the purpose of this work, we have been tasked with providing estimates of stations emission factors and thermal efficiencies separately. This allows AEMO to calculate emission intensity values for each power station.

Note that these definitions align with the NGA Factors workbook which provides estimates of Emission factors for various fuel types in kg CO_2-e/GJ.

In contrast, AEMO in its procedure for calculation of the Carbon Dioxide Equivalent Intensity Index[1] refer to Emission factors as being both defined on a per GJ and on a per MWh basis.

2.3 Emissions scope

In the language of carbon accounting, for example as set out in the Australian Government's National Greenhouse Accounts (NGA) Factors publications, there are a number of different emission 'scopes'. These are defined in Box 1.

[1] AEMO, Carbon Dioxide Equivalent Intensity Index Procedure, August 2013

Box 1 **Types of emission factors**

Firstly, it is important to note that an emission factor is activity-specific. The activity determines the emission factor used. The scope that emissions are reported under is determined by whether the activity is within the organisation's boundary (direct—scope 1) or outside it (indirect—scope 2 and scope 3).

Direct (or point-source) emission factors give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate scope 1 emissions.

Indirect emission factors are used to calculate scope 2 emissions from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.

Various emission factors can be used to calculate scope 3 emissions. For ease of use, this workbook reports specific 'scope 3' emission factors for organisations that:

a) burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
b) consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

Source: Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Australian National Greenhouse Accounts: National Greenhouse Accounts Factors, July 2013, p7

In simple terms for electricity generators:

- Scope 1 emissions relate to emissions associated with combustion of fuels on-site or other emissions associated with the power station facility
- Scope 2 emissions relate to indirect emissions from any electricity purchased from the grid
- Scope 3 relate to indirect emissions associated with the extraction, production and transport of fuel to the power station.

It should be recognised that this definition does cause an issue for renewable generators which do not consume fossil fuel in generating electricity, despite some of these entities reporting scope 1 emissions under the NGER scheme. For renewable plant an Emission factor of zero will be set, despite them possibly having a non-zero Emission intensity value.[2]

2.4 AEMO carbon dioxide intensity index

The following is an extract from AEMO's procedure for calculating the Carbon Dioxide Equivalent Intensity Index (CDEII).

The calculation requires 2 discrete sets of data:

1. The total Sent Out Energy (MWh) generated from each generator; and
2. The carbon dioxide equivalent emissions per unit of electricity (t CO2-e /MWh) generated by each generator (generator specific Emission Factor).

[2] In most cases, the actual Emission intensity values for renewable generators are very close to zero in any case.

The following formula is used to convert the Emissions Factor for an individual generator from t CO2-e/GJ to t CO2-e /MWh:

$$EF_i = \left(\frac{3.6}{TE_i}\right) \times \frac{ef_i}{(1 - A_i)}$$

Where:

EF = Emission Factor for individual generator (t CO2-e /MWh)

i = Generator with available energy data & Emission Factor

TE = Thermal Efficiency (MWh(Gen)/MWh(Fuel))

ef = Emission Factor for individual generator (t CO2-e /GJ)

A = Auxiliaries (% value)

3.6 = Conversion factor (1 MWh = 3.6 GJ).

The following formula is used to calculate the carbon dioxide equivalent emissions (CDE) for an individual generator:

$$CDE_i = EF_i \times E_i$$

Where:

CDE = Carbon Dioxide Equivalent emissions (t CO2-e) from a generating unit

EF = Emission Factor for individual generator (t CO2-e /MWh)

E = Sent Out Energy (MWh) generated from a generating unit

i = Generator with available energy data & Emission Factor.

The Carbon Dioxide Equivalent Intensity Index (CDEII) for the NEM is then calculated by:

$$CDEII = \frac{\sum_i CDE_i}{\sum_i E_i}$$

Where:

CDEII = Carbon Dioxide Equivalent Intensity Index for the NEM (t CO2-e /MWh).

2.5 NGER reporting

In 2007 Australia introduced a single, national framework for corporations to report on greenhouse gas emissions, energy use and energy production. That framework, known as the National Greenhouse and Energy Reporting (NGER) Scheme, operates under the National Greenhouse and Energy Reporting Act 2007. The Clean Energy Regulator administers the NGER Scheme and the Department of the Environment is responsible for NGER-related policy development and review.

Under the NGER Scheme, companies which meet the threshold criteria[3] are required to report annually ‘Scope 1’ emissions, ‘Scope 2’ emissions, energy production and energy consumption.

The *National Greenhouse and Energy Reporting Regulations 2008* define ‘Scope 1’ and ‘Scope 2’ emissions as follows:

> ‘Scope 1’ emission of greenhouse gas, in relation to a facility, means the release of greenhouse gas into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility.

[3] The threshold criteria at facility level are currently set at 25 kt CO_2-e or more of greenhouse gases; production of 100 TJ or more of energy, or consumption of 100 TJ or more of energy. Corporate facility thresholds also apply for aggregate volumes of 50 kt CO_2-e or more of greenhouse gases; production of 200 TJ or more of energy or consumption of 200 TJ or more of energy.

> 'Scope 2' emission of greenhouse gas, in relation to a facility, means the release of greenhouse gas into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

For electricity generators, 'Scope 1' emissions generally relate to greenhouse gas emissions associated with combustion of fuel in the electricity generation process. 'Scope 2' emissions would also accrue due to any purchased electricity sourced from the grid or from heat/steam acquired from an external source which is then used to generate electricity by the facility.

It is important to note that under the *Clean Energy Act 2011*, liability for covered emissions only include 'Scope 1' emissions under the carbon pricing mechanism. **Entities are not liable for 'Scope 2' emissions.**

For the reporting year 2012-13, the Clean Energy Regulator has for the first time made public reported energy production and scope 1 & 2 emission values at facility level.[4] Information reported by designated generation facilities is published for facilities where the principal activity is electricity generation and where the facility is not part of a vertically-integrated production process. Facilities generating electricity for their own use or as a secondary activity do not have their emissions and electricity production data published.

2.6 Approach in estimating emission factors

The proposed approach in estimating emission factors for this exercise is as follows:

1. Review CER data for NEM market generators (scheduled, semi-scheduled and non-scheduled generators)
2. Verify the basis of the Electricity Production (GJ) value in the CER data (i.e. whether it's sent-out or as generated). This should be obtainable from the NGERs Act and/or reporting guidelines for companies published by the CER
3. From this data, calculate Emission intensity values for each generator based on Scope 1 emissions only on a tonnes CO_2-e/MWh sent-out basis
4. Calculate Emission intensity values from existing AEMO NTNDP input assumptions (using the emission factors termed 'Combustion' only as the CER values do not contain Scope 3 components)
5. Calculate Emission intensity values from current ACIL Allen internal database values
6. Undertake a comparison of the actual CER values obtained against existing NTNDP and ACIL Allen estimates and between like for like plant.
7. Consider the plants running regime and other operational parameters (such as coal quality) through 2012-13 a decide whether this represents its typical running state
8. Settle on any appropriate adjustments to existing values and clearly state the rationale for the proposed change.

This will result in a recommended Emissions intensity value (Scope 1 only) for each generator (in tonnes CO_2-e/MWh either sent-out or as-generated depending upon result of Step 2 above).

To this we can add an estimate of the Scope 3 emission intensity values (to be estimated separately based on non-CER data) to yield a Scope 1 & 3 Emission intensity value which

[4] See http://www.cleanenergyregulator.gov.au/National-Greenhouse-and-Energy-Reporting/published-information/greenhouse-and-energy-information/Greenhouse-and-Energy-information-2012-2013/Pages/default.aspx

corresponds with the current values used in the CDEII. Scope 3 values will principally be sourced from the NGA factors workbook (July 2013)[5].

This approach essentially involves estimating the final Emission intensity figure, rather than its component parts which make up the calculation. **This will allow us to modify thermal efficiencies, emission factors (and auxiliary use factors if relevant) at a later stage in the project, with the overall constraint being that the Emission intensity value matches those set in this early stage.**

We note that AEMO's emission factors as used in the CDEII use the sum of 'Combustion' emission factors and 'Fugitive' emission factors in the calculation of the index. We propose to amend the terms used as follows:

— Replace 'Combustion' emission factor with 'Scope 1' emission factor. This is a more correct term as liability for emissions from a facility can relate to more than combustion of fossil fuels in the generation process (e.g. wind farms report a small amount of scope 1 emissions presumably due to vehicle use or other ancillary operations associated with the farm)

— Replace 'Fugitive' emission factor with 'Scope 3' emission factor. This is also a more correct term as Fugitive emissions solely relate to unintended leakages. The term 'Scope 3' emissions, on the other hand, includes all emissions associated with the extraction, production and transport of fuels to the power station which is the intended purpose of the measure.

Whilst inclusion of the Scope 3 emission factors is useful when conducting market modelling (it saves amending fuel price series each time the carbon price changes), in ACIL Allen's opinion, it is not a useful measure for estimating emissions from the electricity sector. Scope 3 emissions occur elsewhere throughout Australia and potentially even overseas when imported fuels are used (e.g. diesel). It also overstates the direct carbon emission liability for generators as they are only liable to pay for Scope 1 emissions. However considerations of modification to the CDEII are outside our scope of work and are mentioned here only for discussion purposes.

[5] Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education, Australian National Greenhouse Accounts: National Greenhouse Accounts Factors, July 2013

3 Results of analysis

3.1 Initial review of auxiliary factors

As the analysis of the CER data required comparisons to be done on 'as generated' basis, yet AEMO's Emission intensity values are required on a 'sent-out' basis, there was concern that translation from one to the other would later be invalidated if auxiliary factor values assigned to generators at a subsequent stage in the project. It was decided that an initial review of auxiliaries was necessary at the outset. This was particularly relevant, given AEMO had already communicated the some known discrepancies between assumptions contained in the NTNDP dataset and results at an aggregate regional level.

Table 1 summarises the proposed changes to auxiliary factors by power station, showing the original value and the proposed new one.

Table 1 **Proposed changes to Auxiliary use**

Station	Original NTNDP Auxiliary load (%)	Revised NTNDP Auxiliary load (%)	Change
Bairnsdale	3.0%	1.0%	-2.0%
Barcaldine	3.0%	1.0%	-2.0%
Colongra GT	3.0%	1.0%	-2.0%
Dry Creek	3.0%	1.0%	-2.0%
Hunter Valley	3.0%	1.0%	-2.0%
Ladbroke Grove	3.0%	1.0%	-2.0%
Mackay	3.0%	1.0%	-2.0%
Mintaro	3.0%	1.0%	-2.0%
Mortlake	3.0%	1.0%	-2.0%
Mt Stuart	3.0%	1.0%	-2.0%
Oakey	3.0%	1.0%	-2.0%
Roma	3.0%	1.0%	-2.0%
Uranquinty	3.0%	1.0%	-2.0%
Valley Power	3.0%	1.0%	-2.0%
Braemar	2.5%	1.0%	-1.5%
Braemar 2	2.5%	1.0%	-1.5%
Hallett	2.5%	1.0%	-1.5%
Somerton	2.5%	1.0%	-1.5%
Tamar Valley OCGT	2.5%	1.0%	-1.5%
Eraring	6.5%	6.0%	-0.5%
Munmorah	7.3%	7.0%	-0.3%
Wallerawang C	7.3%	7.0%	-0.3%
Vales Point B	4.6%	5.0%	0.4%
Bell Bay Three	2.5%	3.0%	0.5%
Laverton North	2.5%	3.0%	0.5%
Loy Yang B	7.5%	8.0%	0.5%
Kogan Creek	8.0%	9.0%	1.0%
Tarong North	5.0%	6.0%	1.0%
Yallourn	8.9%	10.0%	1.1%
Callide Power Plant	4.8%	6.0%	1.2%
Millmerran	4.5%	6.0%	1.5%
Callide B	7.0%	9.0%	2.0%
Stanwell	7.0%	9.0%	2.0%

Collinsville	8.0%	10.0%	2.0%
Playford	8.0%	10.0%	2.0%
Gladstone	5.0%	8.0%	3.0%
Northern	5.0%	10.0%	5.0%

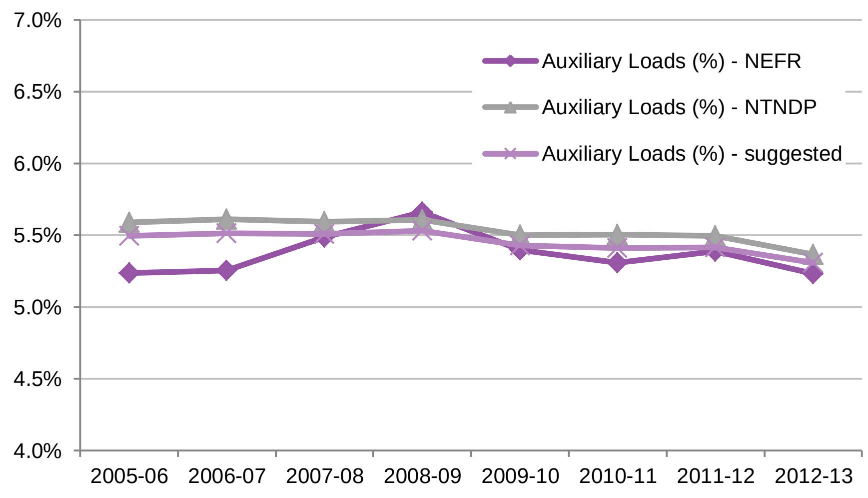
Source: ACIL Allen analysis

Based on a review of historical regional auxiliary use compared with values presented in the NEFR, suggests that in aggregate the new values are significantly closer to actuals than the original assumptions.

Figure 1 through to Figure 5 shows the resulting aggregate auxiliary use based on the original NTNDP values, the proposed new auxiliary factors and auxiliary use as reported in the 2013 NEFR.

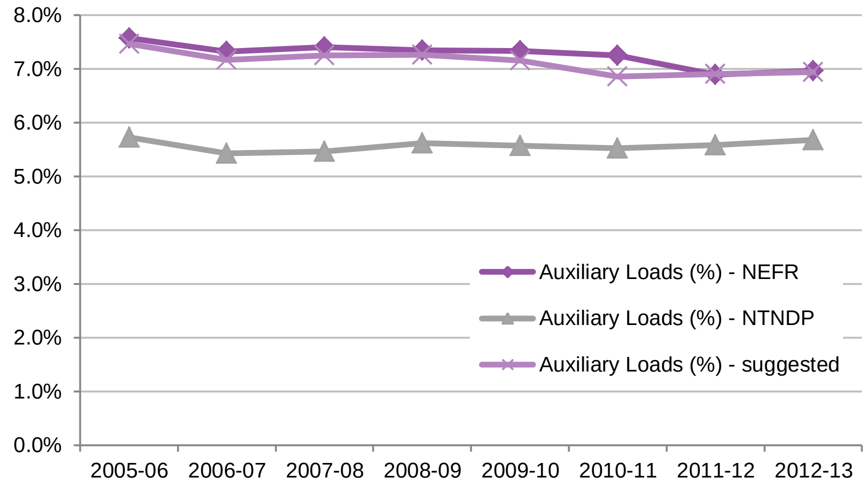
A material improvement is seen in Queensland and South Australia which were both out by around two percentage points in aggregate against actuals. Smaller improvements are seen in NSW and Victoria and virtually no change to Tasmania.

Figure 1 **Aggregate auxiliary use: NSW**



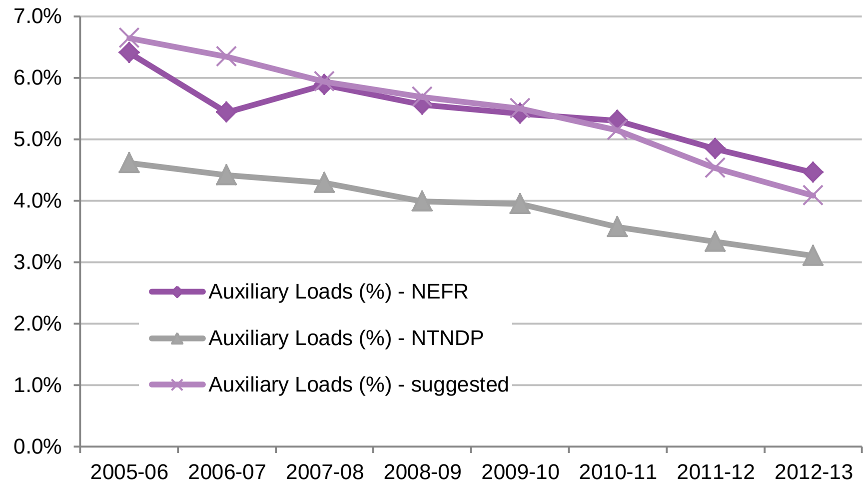
Source: ACIL Allen, AEMO NEFR 2013

Figure 2 **Aggregate auxiliary use: QLD**



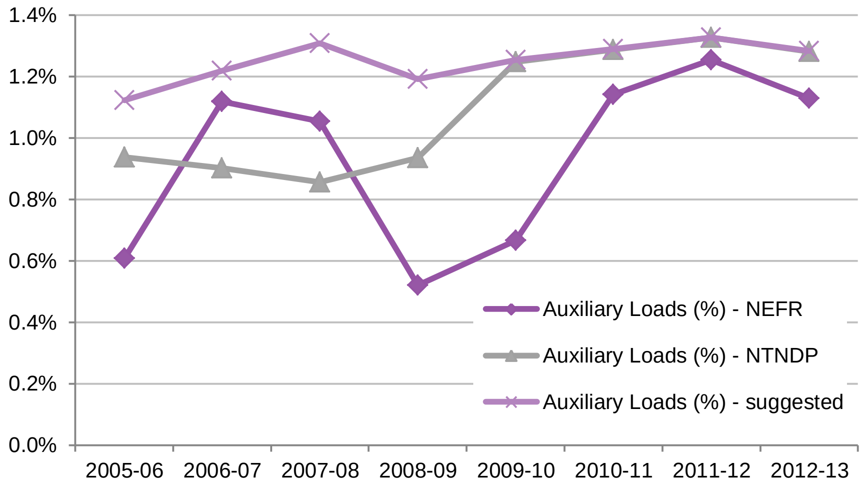
Source: ACIL Allen, AEMO NEFR 2013

Figure 3 **Aggregate auxiliary use: SA**



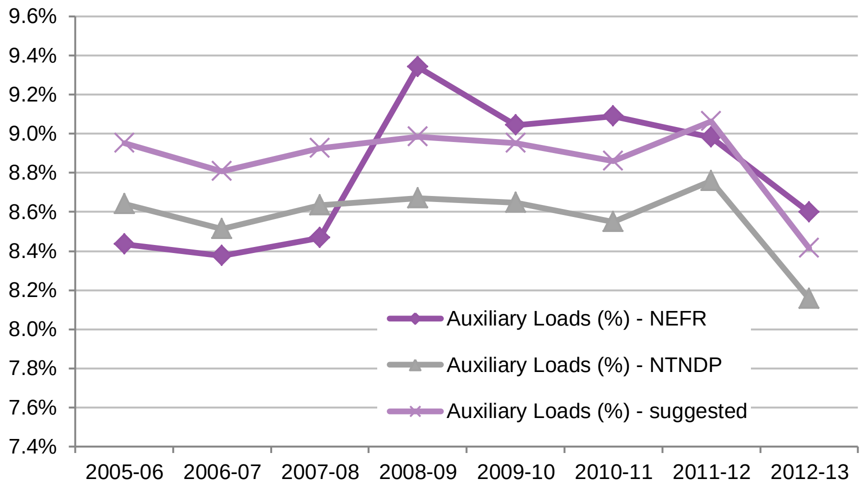
Source: ACIL Allen, AEMO NEFR 2013

Figure 4 **Aggregate auxiliary use: TAS**



Source: ACIL Allen, AEMO NEFR 2013

Figure 5 **Aggregate auxiliary use: VIC**



Source: ACIL Allen, AEMO NEFR 2013

3.2 Scope 1 emission intensities

The following charts provide comparisons of emission intensity values (presented on a tonnes CO2-e/MWh as generated basis) calculated from previous NTNDP dataset, the Clean Energy Regulator actual data for 2012-13 and those proposed for use for future NTNDP modelling. Comparisons are undertaken on an ‘as generated' basis as this is the basis of reporting “Electricity production (GJ)” from the CER data.

Each chart represents a fuel type/generation type so comparisons can be made across generators of the same fuel/type. Emission intensity values are not provided for wind and hydro as these values are all zero.

In most cases the emission intensity values have been aligned with the actual CER data with a few exceptions as follows:

— Energy Brix Complex: the calculated CER value was 2.93, however output from this station was extremely low during this period. We have adopted a value of 1.4 (the same as Hazelwood)

— Callide C: the CER value of 0.9 was not adopted – we have used the previous NTNDP value of 0.86 due to lower output from the station as a result of coal supply constraints. We would also expect Callide C to have a lower emission intensity than Callide B (0.9) given its higher efficiency.

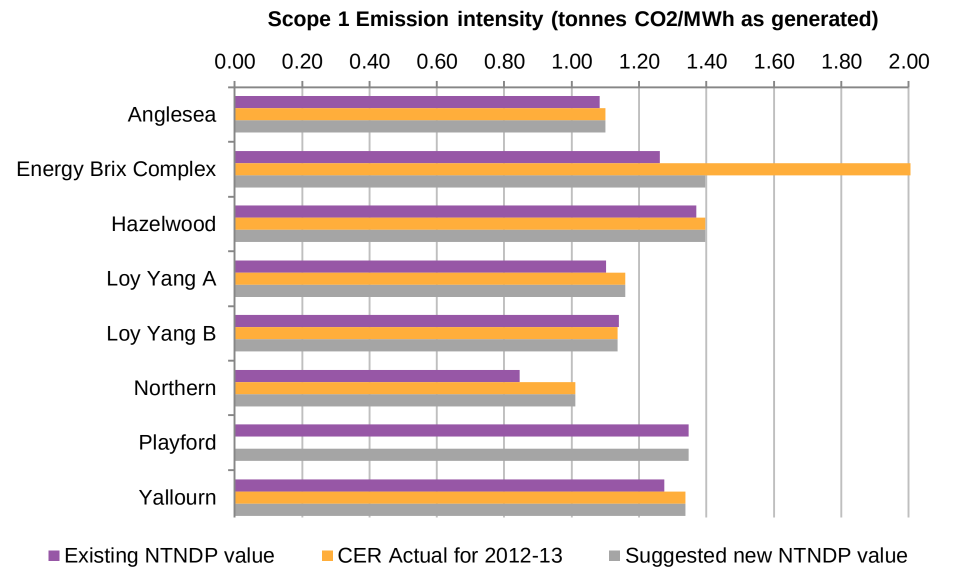
— Collinsville; the CER value of 14.47 was rejected and the original NTNDP value used (1.07). Collinsville has since been decommissioned so this change is rather academic.

For peaking plants which run infrequently, some of the CER values appear well above expected values from the NTNDP inputs. This is due to a level of fixed emissions which occur at such stations which is not related to generation activities. Where output from a station is particularly low, these other auxiliary emissions can account for a material proportion of total emissions and hence result in an inflated intensity value. In the context of the calculation of the CDEII, the intensity of such plants is immaterial given their low dispatch levels. In a few cases where it is obvious this has occurred, we have not adopted the emission intensity value calculated from the CER data, but instead retained the existing NTNDP value.

Also, where the CER data only provided a value for a combined station (e.g. Tarong/Tarong North) we have split out estimated emission intensities for each based on their relative thermal efficiencies and generation shares during 2012-13.

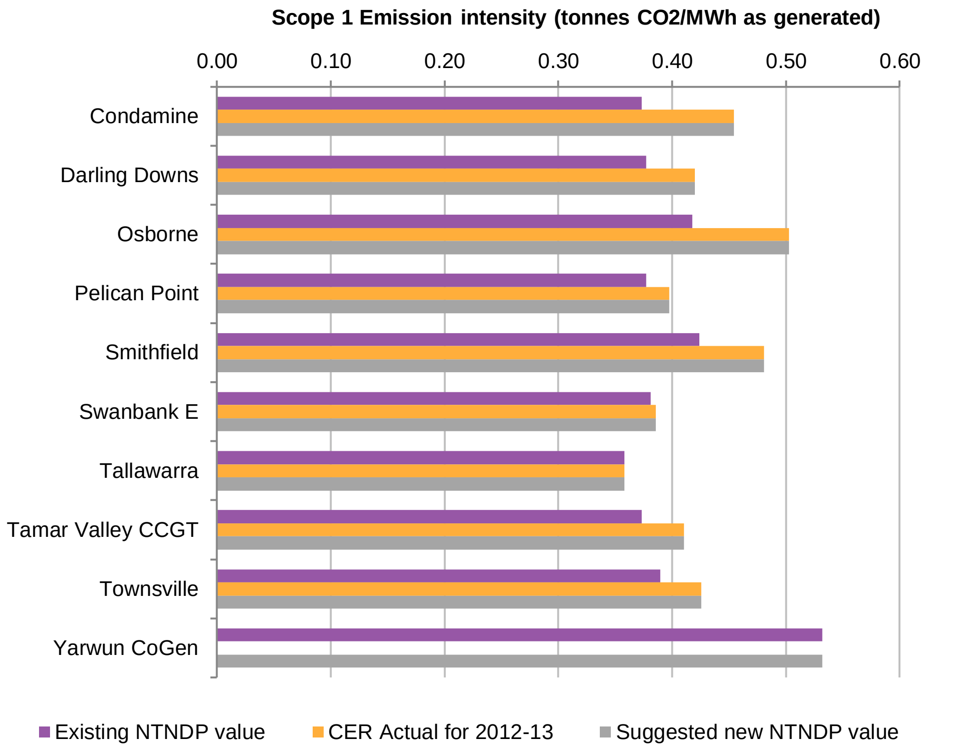
For a few selected stations, no CER data was reported and in these cases the previous NTNDP value was adopted.

Figure 6 **Scope 1 emission intensity values: Brown coal**



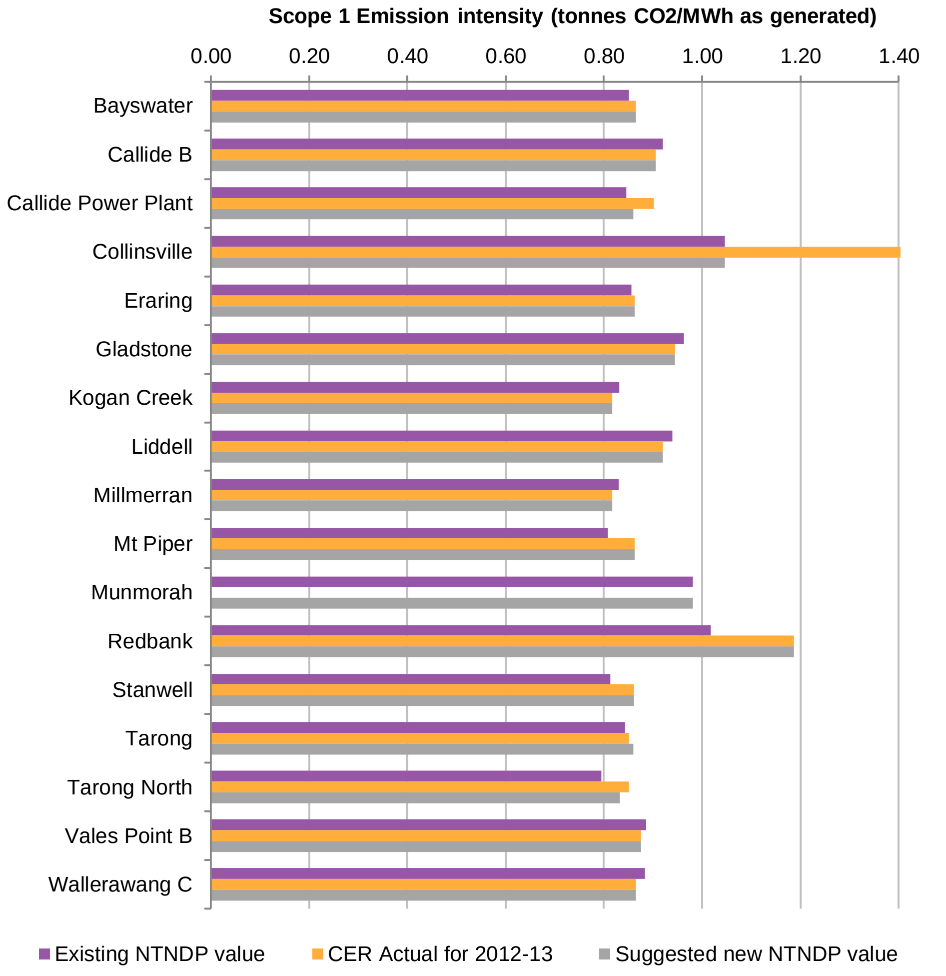
Source: ACIL Allen estimates

Figure 7 **Scope 1 emission intensity values: Gas-fired CCGT/cogeneration**



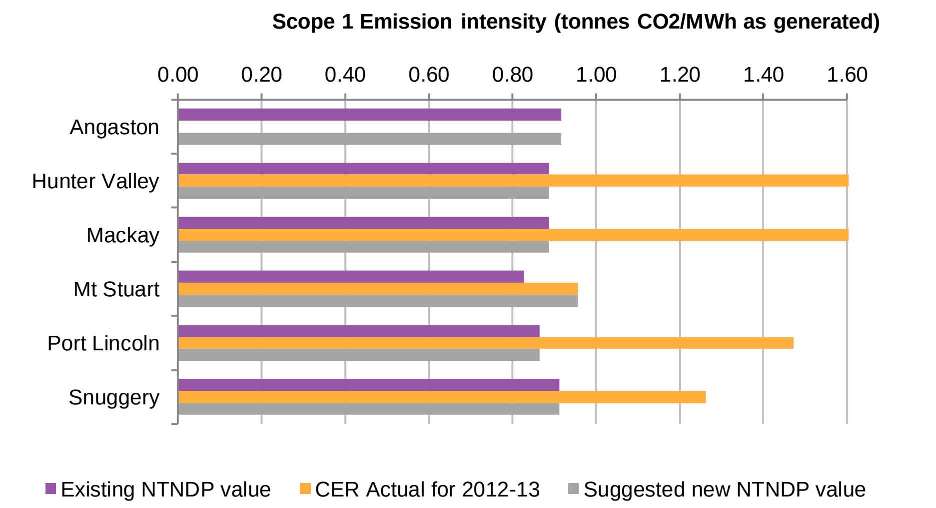
Source: ACIL Allen estimates

Figure 8 **Scope 1 emission intensity values: Black coal**



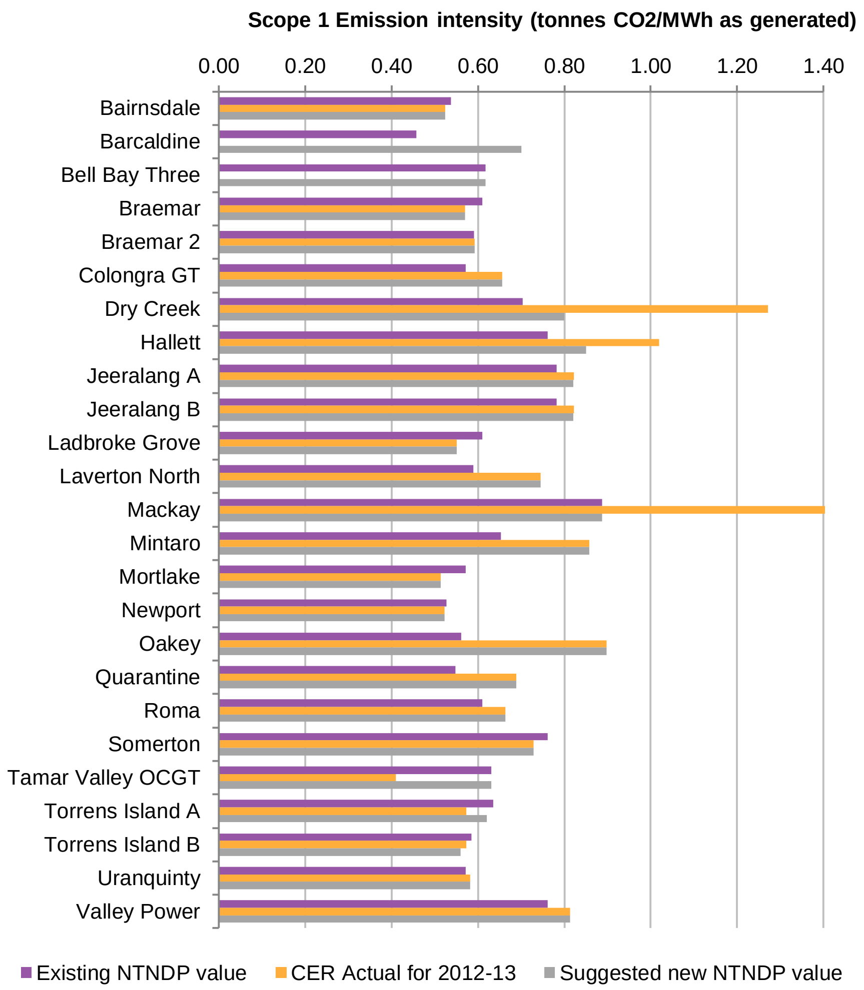
Source: ACIL Allen estimates

Figure 9 **Scope 1 emission intensity values: Liquid fuelled OCGT**



Source: ACIL Allen estimates

Figure 10 **Scope 1 emission intensity values: Gas-fired OCGT**



Source: ACIL Allen estimates

3.3 Scope 3 emission intensities

There are no corresponding Scope 3 values published by the CER to compare the NTNDP values against.

Scope 3 emission values were updated based on the latest NGA factors workbook published by the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education in July 2013.

The report contains generic Scope 3 emission factors by fuel type which are summarised in Table 2. While these are these are official figures, it should be noted that these values are averages for the entire industry and impossible to attribute accurately to specific generators.

As there is only a single value for black coal[6], we have differentiated between Queensland and NSW by halving the value for Queensland, and doubling the value for NSW. This appears to align resulting values with the practice already contained within the NTNDP dataset. We assume that the logic behind this modification is that Scope 1 emissions from coal mining in NSW are much larger than for QLD[7] and it is more common for coal to be railed to power stations in NSW than in QLD. The estimation of Scope 1 emissions from mining and delivery of coal to power stations would be a very large undertaking as separate estimates would be required for each coal mine.

Table 2 **Scope 3 emission factors by fuel**

Fuel	EF (kg CO2-e/GJ)
Black coal	4.6
Brown coal	0.4
Liquid fuel	5.3
Natural gas	
NSW	13.5
VIC	3.9
QLD	7.6
SA	10.2
TAS	0

Source: NGA factors workbook, July 2013

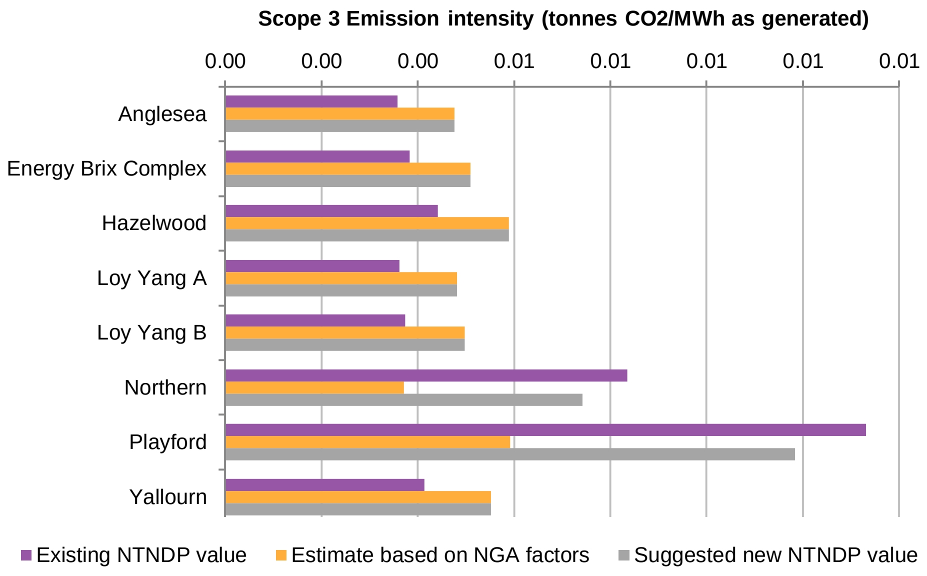
The charts in the following sections shows a comparison of the proposed new value against the original 2013 NTNDP value and that calculated directly from the NGA factors workbook.

Aside from black coal, the other group which see a major revision compared with the existing NTNDP data points is gas-fired generation – particularly for South Australia. This large downward revision is due to the scope 3 NGA emission factor falling from 18.6 in the 2008 version down to its current level of 10.2 in the 2013 edition.

[6] We note that the NGA Factor workbook states that this value is "for uses other than for electricity and coking", although there is no other substitute value available for use.

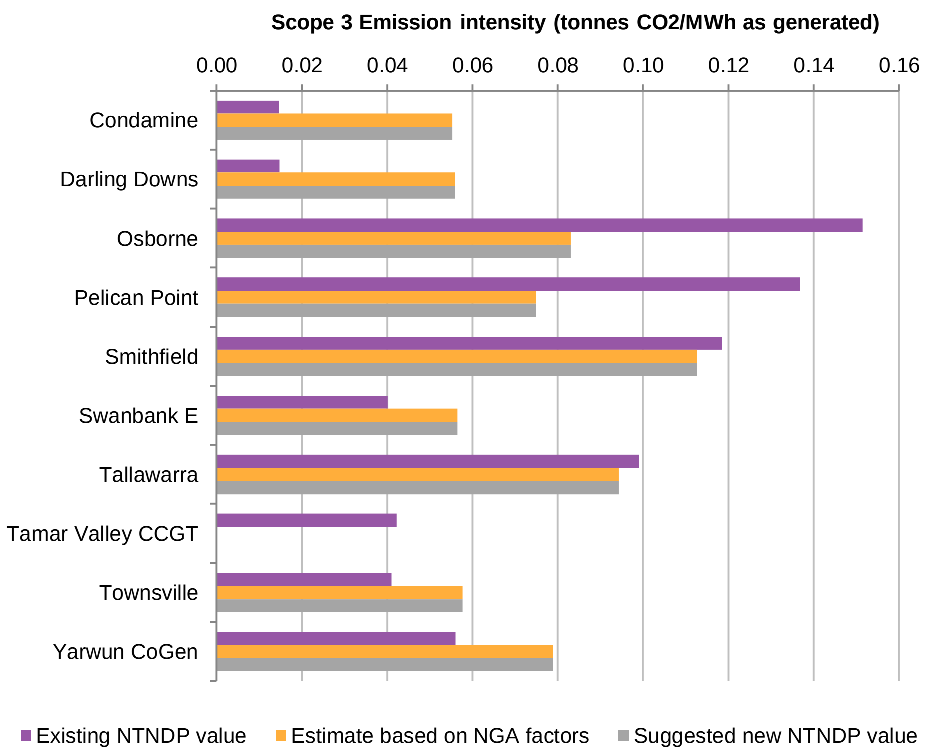
[7] For example, current fugitive emission factors for open cut coal mining in NSW are 0.045 tonnes CO_2-e/ tonne raw coal, compared with QLD at 0.017 tonnes CO_2-e/ tonne raw coal.

Figure 11 **Scope 3 emission intensity values: Brown coal**



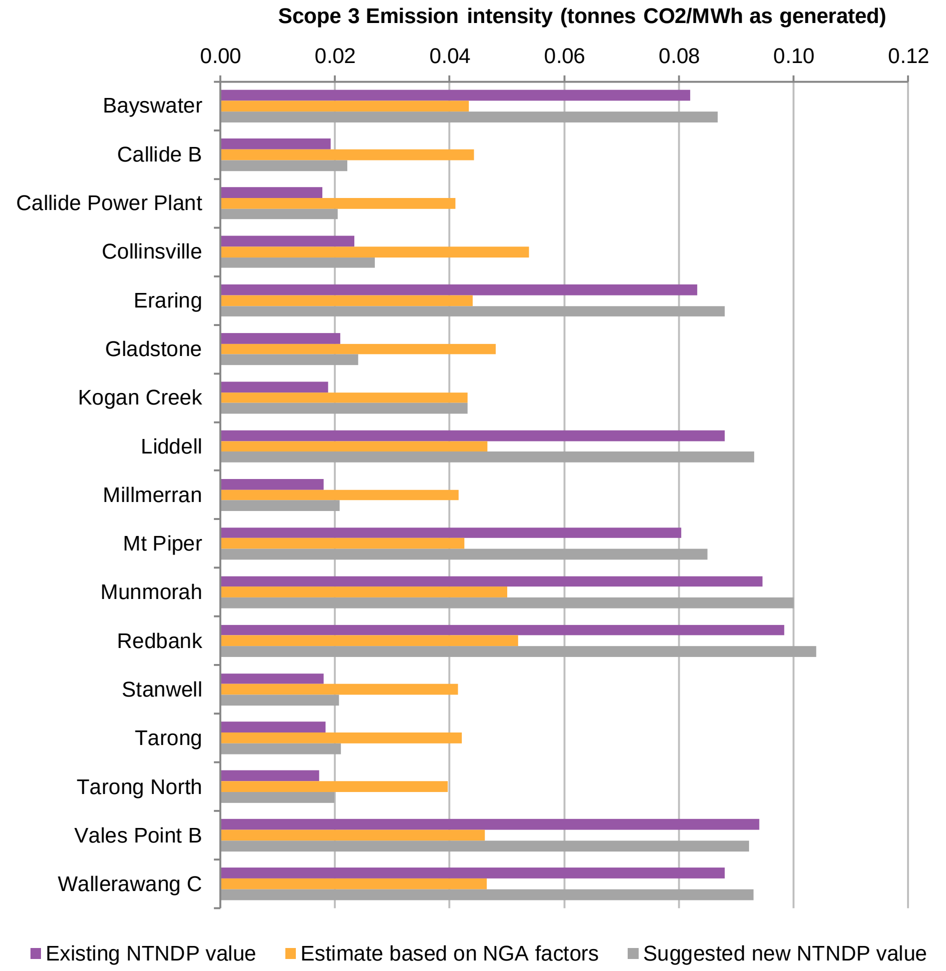
Source: ACIL Allen estimates

Figure 12 **Scope 3 emission intensity values: Gas-fired CCGT/cogeneration**



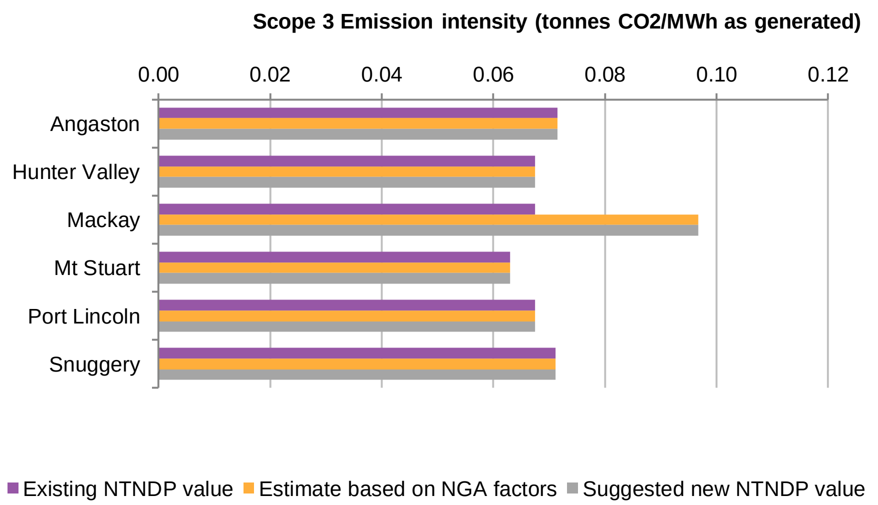
Source: ACIL Allen estimates

Figure 13 **Scope 3 emission intensity values: Black coal**



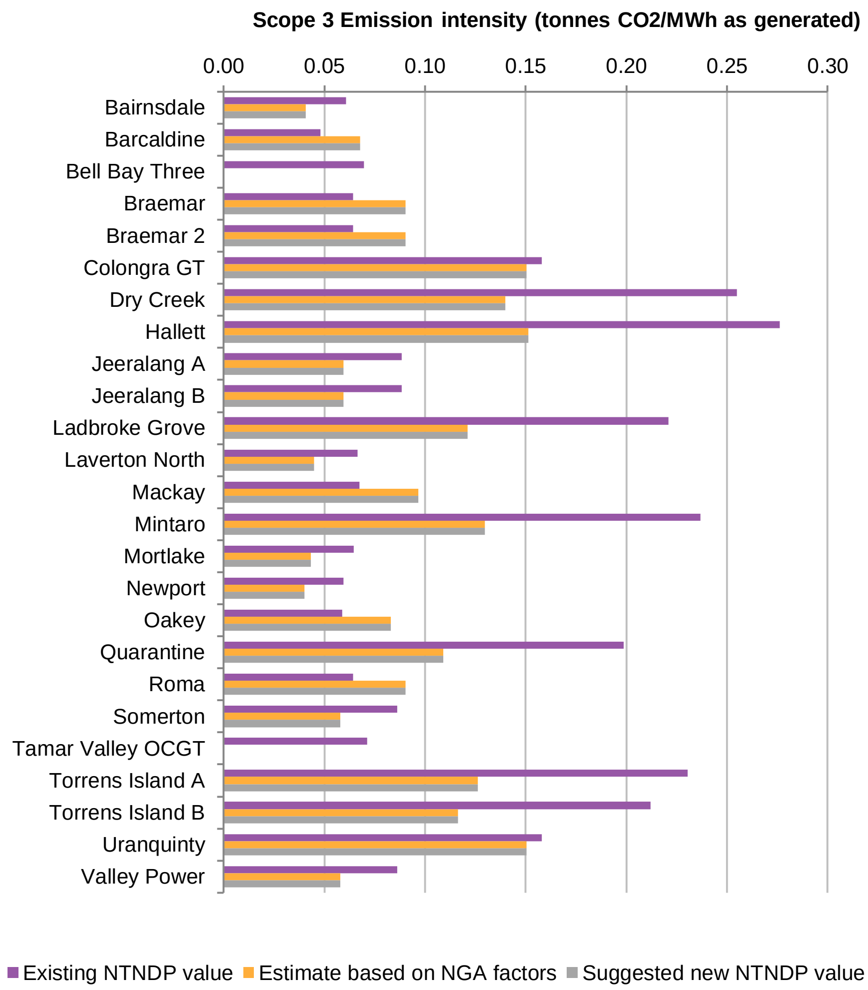
Source: ACIL Allen estimates

Figure 14 **Scope 3 emission intensity values: Liquid fuelled OCGT**



Source: ACIL Allen estimates

Figure 15 **Scope 3 emission intensity values: Gas-fired OCGT**



Source: ACIL Allen estimates

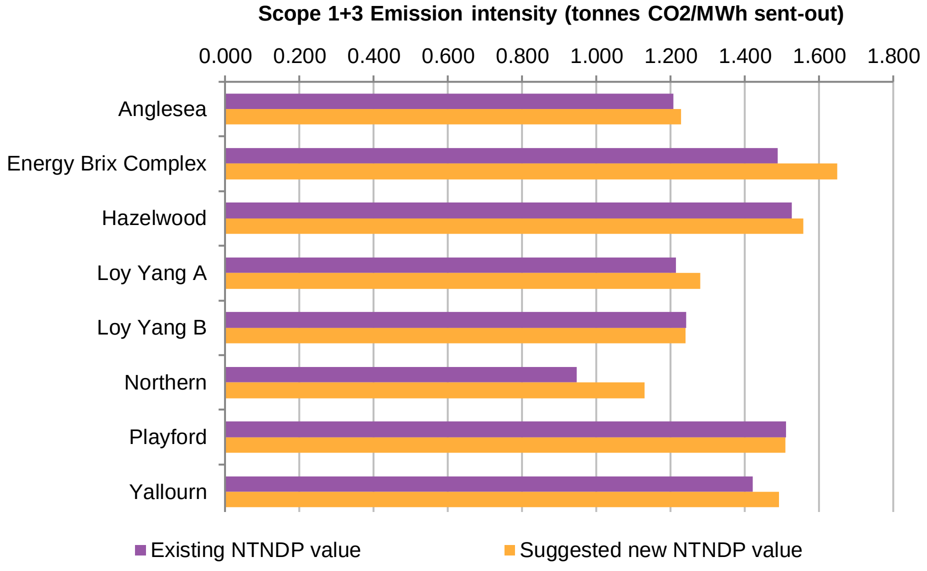
3.4 Summary of changes

This section provides a summary of the changes to Emission intensity values (Scope 1+3, expressed as tonnes CO2-e/MWh sent-out) by fuel type.

We recommend AEMO alter the emission intensity values to these in the interim, while the other input assumptions which make up the components are reviewed. Any subsequent changes to thermal efficiency or auxiliary factors can be offset by changes to the fuel emission factors which will result in the emission intensity value remaining unchanged.

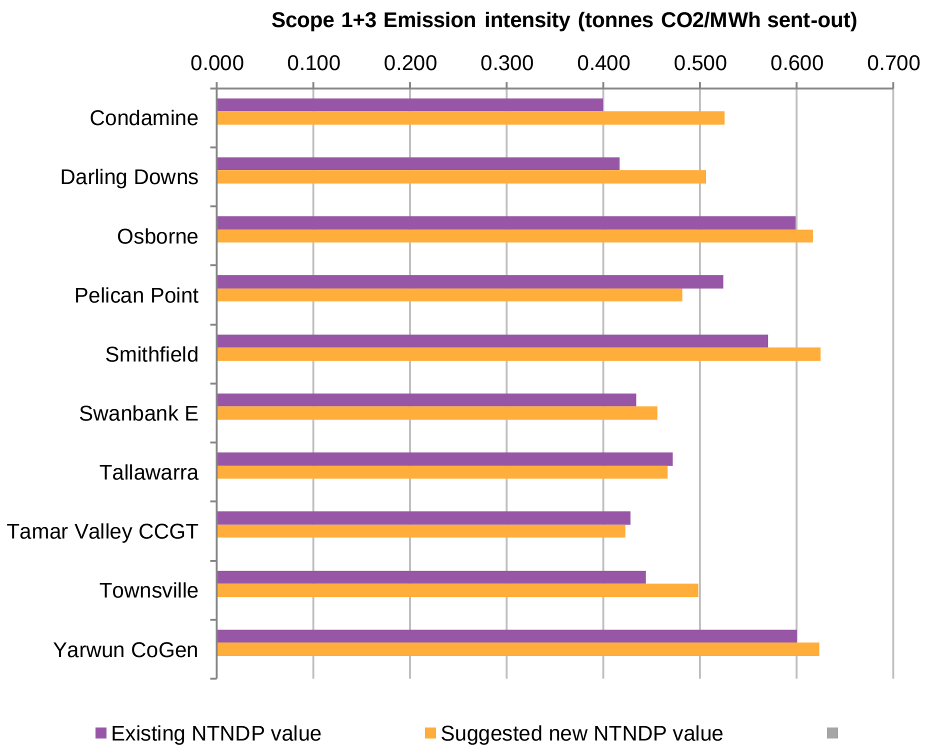
All values for renewable plant (hydro and wind) have zero values and hence are not shown.

Figure 16 **Scope 1+3 emission intensity values: Brown coal**



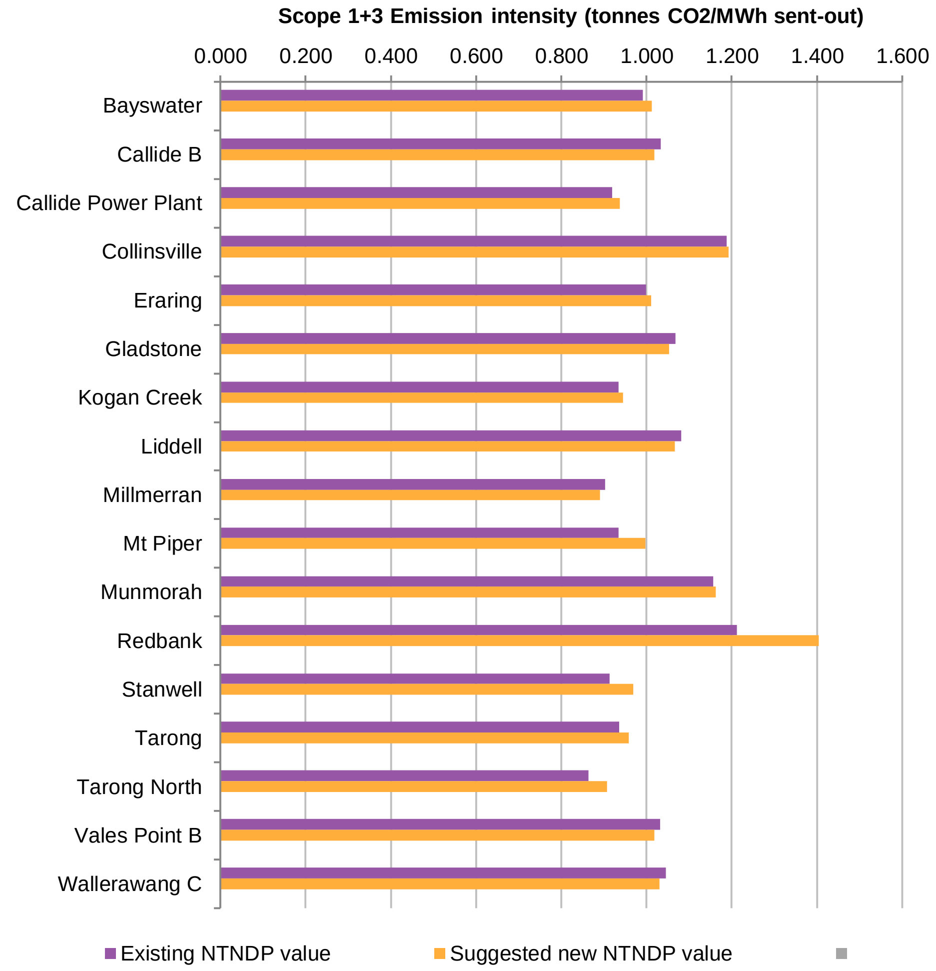
Source: ACIL Allen estimates

Figure 17 **Scope 1+3 emission intensity values: Gas-fired CCGT/cogeneration**



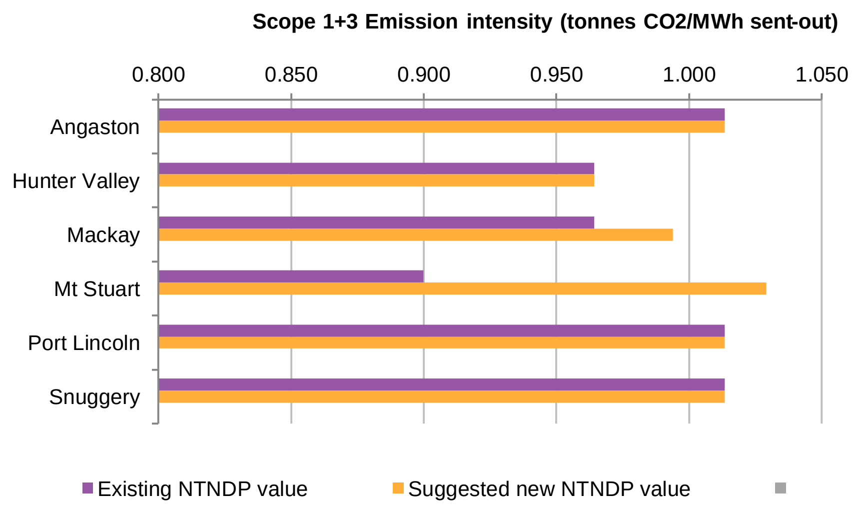
Source: ACIL Allen estimates

Figure 18 **Scope 1+3 emission intensity values: Black coal**



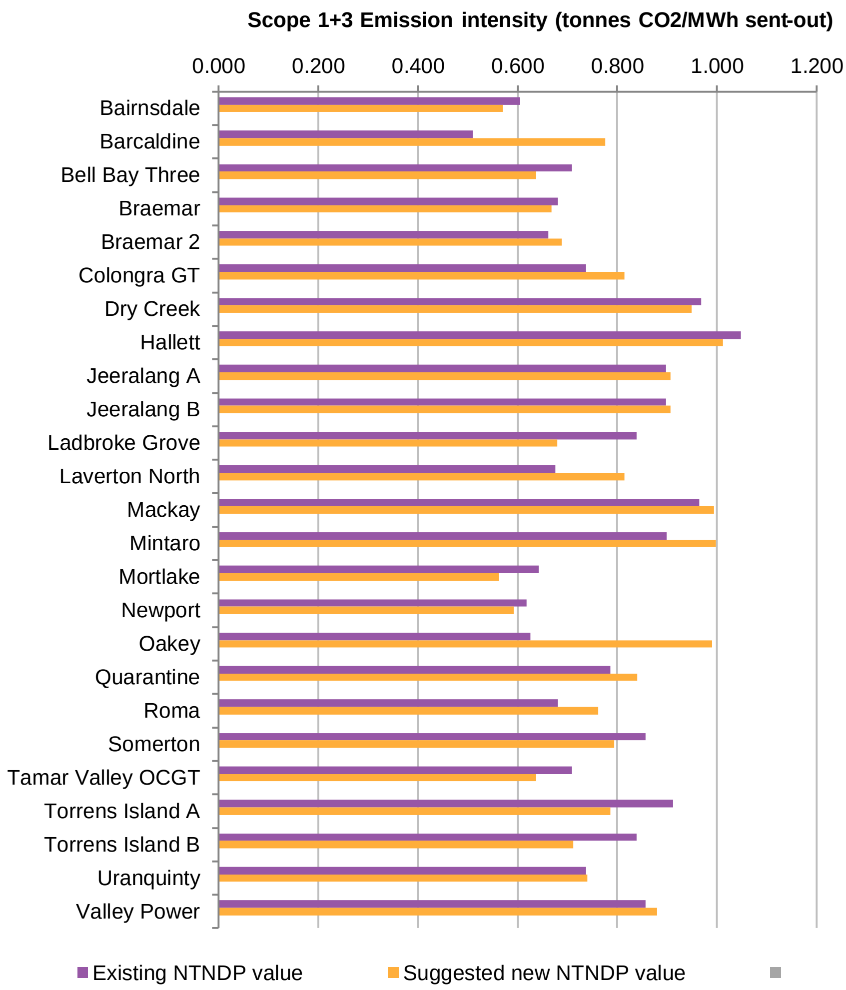
Source: ACIL Allen estimates

Figure 19 **Scope 1+3 emission intensity values: Liquid fuelled OCGT**



Source: ACIL Allen estimates

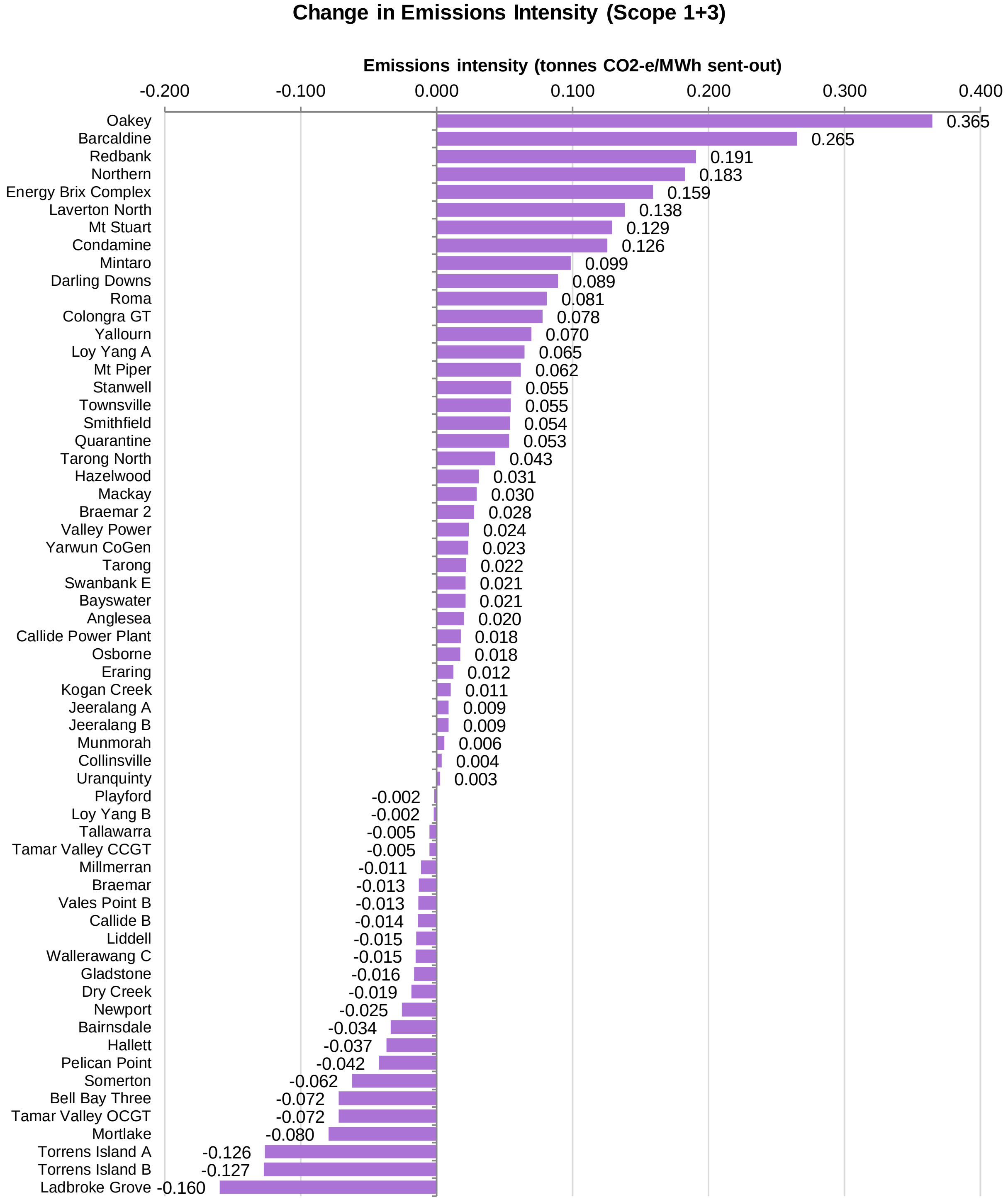
Figure 20 **Scope 1+3 emission intensity values: Gas-fired OCGT**



Source: ACIL Allen estimates

Figure 21 provides a summary of changes for plant that have had a change to the recommended Emission intensity value only, ordered by the largest increase to the largest decrease.

Figure 21 **Summary of changes in Emission intensity from 2013 NTNDP calculated values**



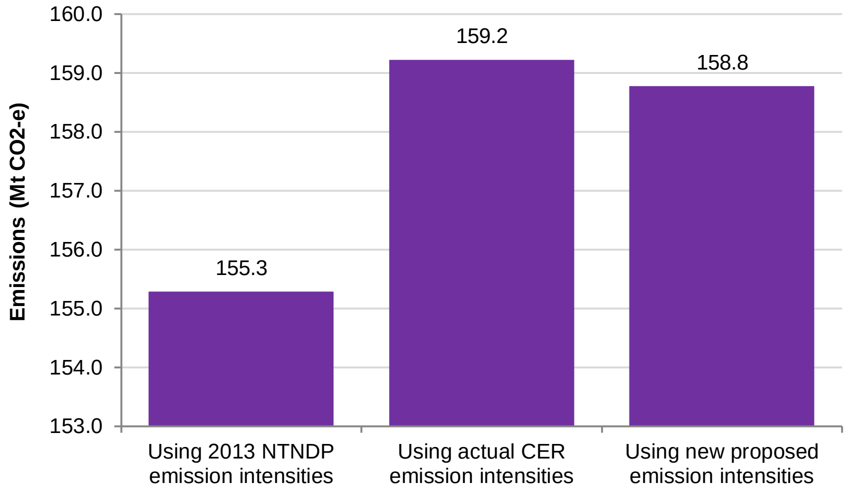
Note: Stations not shown have had no change

Source: ACIL Allen analysis

Figure 22 shows the calculated aggregate emissions for the NEM in the 2012-13 year using, the old, actual and new proposed emission intensity values. The previous 2013 NTNDP emission intensity values would results in estimated emissions around 2.5% below the actual reported level by the CER (Scope 1 only). Using the new proposed emission intensity values for each power station would results in aggregate emissions being around 0.3% below the actual 2012-13 level. This is largely attributable to not assigning the calculated

CER value to some stations in which the value was not assessed to be representative of a long-term average.

Figure 22 **Calculated aggregate emissions for 2012-13**



Note: Calculation excludes non-scheduled generators
Source: ACIL Allen analysis

3.5 Non-scheduled generators

As per the scope of work, Emission factors are also required for non-scheduled generators. For these stations, we have sourced the majority of the data requirements from the Energy White Paper input assumptions (which were developed by ACIL Tasman in 2010).

Within this dataset the majority of non-scheduled stations are represented, with values for thermal efficiency and auxiliaries. Where input values were not available, a generic representative figure was adopted based on the technology and fuel source for the plant.

Table 3 provides estimated values for emission intensity for each of the non-scheduled generators.

Table 3 **Estimated emission intensity values for NEM non-scheduled generators**

Station Name	Region	Fuel Source - Descriptor	Thermal efficiency HHV (%) sent-out	Auxiliaries (%)	Thermal efficiency HHV (%) as generated	Scope 1 emission factors (kg CO2-e/GJ of fuel)	Scope 3 emission factors (kg CO2-e/GJ of fuel)	Scope 1 intensity (tonnes CO2-e/MWh sent-out)	Scope 3 intensity (tonnes CO2-e/MWh sent-out)	Scope 1+3 intensity (tonnes CO2-e/MWh sent-out)
Daandine Power Station	QLD1	Coal Seam Methane	36.0%	2.5%	36.9%	51.3	7.6	0.51	0.08	0.59
Glennies Creek Power Station	NSW1	Coal Seam Methane	35.0%	2.5%	35.9%	51.3	13.5	0.53	0.14	0.67
Moranbah Generation Project	QLD1	Coal Seam Methane	33.0%	2.5%	33.8%	51.3	7.6	0.56	0.08	0.64
Oaky Creek Power Station	QLD1	Coal Seam Methane	29.0%	5.0%	30.5%	51.3	7.6	0.64	0.09	0.73
Teralba Power Station	NSW1	Coal Seam Methane	29.0%	2.0%	29.6%	51.3	13.5	0.64	0.17	0.80
Wilga Park Power Station	NSW1	Coal Seam Methane	26.0%	2.5%	26.7%	51.3	13.5	0.71	0.19	0.90
Amcor Glass, Gawler Plant	SA1	Diesel	29.0%	2.0%	29.6%	69.7	5.3	0.87	0.07	0.93
Angaston Power Station	SA1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Bankstown Sports Club Plant Units	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Blue Lake Milling Power Plant	SA1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Eraring Power Station	NSW1	Diesel	29.0%	2.0%	29.6%	69.7	5.3	0.87	0.07	0.93
Hunter Economic Zone	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Lonsdale Power Station	SA1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Nine Network Willoughby Plant	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Port Stanvac Power Station 1	SA1	Diesel	29.0%	2.5%	29.7%	69.7	5.3	0.87	0.07	0.93
Port Stanvac Power Station 2	SA1	Diesel	29.0%	2.5%	29.7%	69.7	5.3	0.87	0.07	0.93
Southbank Institute Of Technology Unit 1 Plant	QLD1	Diesel	29.0%	2.0%	29.6%	69.7	5.3	0.87	0.07	0.93
St George Leagues Club Plant	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Tatiara Bordertown Plant	SA1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
West Illawarra Leagues Club Plant	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Western Suburbs League Club (Campbelltown) Plant	NSW1	Diesel	26.0%	2.5%	26.7%	69.7	5.3	0.97	0.07	1.04
Eastern Creek Power Station	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Grange Avenue Power Station	NSW1	Landfill Methane / Landfill Gas	29.0%	2.5%	29.7%	4.8	0.0	0.06	0.00	0.06
Lucas Heights 2 LFG Power Station	NSW1	Landfill Methane / Landfill Gas	26.0%	2.5%	26.7%	4.8	0.0	0.07	0.00	0.07
Mornington Waste Disposal Facility	VIC1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Rochedale Renewable Energy Facility	QLD1	Landfill Methane / Landfill Gas	30.0%	5.0%	31.6%	4.8	0.0	0.06	0.00	0.06
Veolia Ti Tree Bio Reactor	QLD1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
West Nowra Landfill Gas Power Generation Facility	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Whitwood Road Renewable Energy Facility	QLD1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Woodlawn Bioreactor Energy Generation Station	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06

Station Name	Region	Fuel Source - Descriptor	Thermal efficiency HHV (%) sent-out	Auxiliaries (%)	Thermal efficiency HHV (%) as generated	Scope 1 emission factors (kg CO2-e/GJ of fuel)	Scope 3 emission factors (kg CO2-e/GJ of fuel)	Scope 1 intensity (tonnes CO2-e/MWh sent-out)	Scope 3 intensity (tonnes CO2-e/MWh sent-out)	Scope 1+3 intensity (tonnes CO2-e/MWh sent-out)
Wyndham Waste Disposal Facility	VIC1	Landfill Methane / Landfill Gas	35.0%	2.0%	35.7%	4.8	0.0	0.05	0.00	0.05
Ballarat Base Hospital Plant	VIC1	Natural Gas	29.0%	2.0%	29.6%	51.3	3.9	0.64	0.05	0.69
Shepparton Wastewater Treatment Facility	VIC1	Sewerage/Waste Water	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Tatura Biomass Generator	VIC1	Sewerage/Waste Water	30.0%	5.0%	31.6%	4.8	0.0	0.06	0.00	0.06
German Creek Power Station	QLD1	Waste Coal Mine Gas	36.0%	3.0%	37.1%	55.6	0.0	0.56	0.00	0.56
Broken Hill Gas Turbines	NSW1	Diesel	29.0%	2.0%	29.6%	69.7	5.3	0.87	0.07	0.93
Eastern Creek 2 Gas Utilisation Facility	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Remount Power Station	TAS1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Longford Plant	VIC1	Natural Gas	29.0%	2.0%	29.6%	51.3	3.9	0.64	0.05	0.69
Tarong Power Station	QLD1	Natural Gas	29.0%	2.0%	29.6%	51.3	7.6	0.64	0.09	0.73
Yarwun Power Station	QLD1	Natural Gas	34.0%	2.0%	34.7%	51.3	7.6	0.54	0.08	0.62
Brooklyn Landfill Gas Power Station	VIC1	Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Claytons Landfill Gas Power Station	VIC1	Landfill Gas	26.0%	2.5%	26.7%	4.8	0.0	0.07	0.00	0.07
Appin Power Plant	NSW1	Coal Seam Methane	26.0%	2.5%	26.7%	55.6	13.5	0.77	0.19	0.96
Moranbah North Power Station	QLD1	Coal Seam Methane	29.0%	2.0%	29.6%	55.6	7.6	0.69	0.09	0.78
Tower Power Plant	NSW1	Coal Seam Methane	26.0%	2.5%	26.7%	55.6	13.5	0.77	0.19	0.96
Awaba Power Station	NSW1	Landfill Methane / Landfill Gas	30.0%	5.0%	31.6%	4.8	0.0	0.06	0.00	0.06
Berwick Power Plant	VIC1	Landfill Methane / Landfill Gas	26.0%	2.5%	26.7%	4.8	0.0	0.07	0.00	0.07
Broadmeadows Power Plant	VIC1	Landfill Methane / Landfill Gas	26.0%	2.5%	26.7%	4.8	0.0	0.07	0.00	0.07
Browns Plains Land Fill Gas Power Station	QLD1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Corio Landfill Gas Power Station	VIC1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Grange Avenue Landfill Gas Power Station	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Hallam Road Renewable Energy Facility	VIC1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Highbury Landfill Gas Power Station Unit 1	SA1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Jacks Gully Landfill Gas Power Station	NSW1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Pedler Creek Landfill Gas Power Station Units 1-3	SA1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Springvale Landfill Gas Power Station	VIC1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Tea Tree Gully Landfill Gas Power Station Unit 1	SA1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Wingfield 1 Landfill Gas Power Station Units 1-4	SA1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Wingfield 2 Landfill Gas Power Station Units 1-4	SA1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Wollert Renewable Energy Facility	VIC1	Landfill Methane / Landfill Gas	29.0%	2.0%	29.6%	4.8	0.0	0.06	0.00	0.06
Taralgon Network Support Station	VIC1	Natural Gas	29.0%	2.0%	29.6%	51.3	3.9	0.64	0.05	0.69

Station Name	Region	Fuel Source - Descriptor	Thermal efficiency HHV (%) sent-out	Auxiliaries (%)	Thermal efficiency HHV (%) as generated	Scope 1 emission factors (kg CO2-e/GJ of fuel)	Scope 3 emission factors (kg CO2-e/GJ of fuel)	Scope 1 intensity (tonnes CO2-e/MWh sent-out)	Scope 3 intensity (tonnes CO2-e/MWh sent-out)	Scope 1+3 intensity (tonnes CO2-e/MWh sent-out)
Broadwater Power Station Units 1 and 2	NSW1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Condong Power Station Unit 1	NSW1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Victoria Mill	QLD1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Invicta Sugar Mill	QLD1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
ISIS Central Sugar Mill Co-generation Plant	QLD1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Pioneer Sugar Mill	QLD1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Racecourse Mill	QLD1	Bagasse	30.0%	5.0%	31.6%	1.5	0.0	0.02	0.00	0.02
Rocky Point Cogeneration Plant	QLD1	Bagasse	30.0%	5.0%	31.6%	1.8	0.0	0.02	0.00	0.02
Roghan Road LFG Power Plant	QLD1	Bagasse	29.0%	2.0%	29.6%	1.5	0.0	0.02	0.00	0.02
Callide A Power Station	QLD1	Black Coal	27.0%	7.0%	29.0%	95.0	4.6	1.27	0.06	1.33
Anglesea Power Station	VIC1	Brown Coal	27.2%	10.0%	30.2%	92.0	0.4	1.22	0.01	1.22
Suncoast Gold Macadamias	QLD1	Macadamia Nut Shells	30.0%	5.0%	31.6%	1.8	0.0	0.02	0.00	0.02
Midlands Power Station	TAS1	Hydro	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Banimboola Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Brown Mountain	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Burrendong Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Burrinjuck Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Butlers Gorge Power Station	TAS1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Clover Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Cluny Power Station	TAS1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Copeton Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Glenbawn Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Jindabyne Small Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Jounama Small Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Keepit Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Paloona Power Station	TAS1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Pindari Hydro Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Repulse Power Station	TAS1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Rowallan Power Station	TAS1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Rubicon Mountain Streams Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
South East Water - Hallam Hydro Plant	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Terminal Storage Mini Hydro Power Station	SA1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00

Station Name	Region	Fuel Source - Descriptor	Thermal efficiency HHV (%) sent-out	Auxiliaries (%)	Thermal efficiency HHV (%) as generated	Scope 1 emission factors (kg CO2-e/GJ of fuel)	Scope 3 emission factors (kg CO2-e/GJ of fuel)	Scope 1 intensity (tonnes CO2-e/MWh sent-out)	Scope 3 intensity (tonnes CO2-e/MWh sent-out)	Scope 1+3 intensity (tonnes CO2-e/MWh sent-out)
Wyangala A Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Wyangala B Power Station	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Yarrawonga Hydro Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Capital East Solar Farm	NSW1	Solar PV	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Eildon Pondage Hydro Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Glenmaggie Hydro Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Kareeya Power Station	QLD1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
The Drop Hydro Unit 1	NSW1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
William Hovell Hydro Power Station	VIC1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Wivenhoe Small Hydro	QLD1	Water	100.0%	1.0%	101.0%	0.0	0.0	0.00	0.00	0.00
Canunda Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Capital Wind Farm	NSW1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Cathedral Rocks Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Challicum Hills Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Codrington Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Cullerin Range Wind Farm	NSW1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Hepburn Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Lake Bonney Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Mortons Lane Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Mt Millar Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Portland Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Starfish Hill Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Toora Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Wattle Point Wind Farm	SA1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Waubra Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Windy Hill Wind Farm	QLD1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Wonthaggi Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Woolnorth Studland Bay / Bluff Point Wind Farm	TAS1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00
Yambuk Wind Farm	VIC1	Wind	100.0%	0.0%	100.0%	0.0	0.0	0.00	0.00	0.00

Source: ACIL Allen analysis

ACIL ALLEN CONSULTING PTY LTD
ABN 68 102 652 148

LEVEL FIFTEEN
127 CREEK STREET
BRISBANE QLD 4000
AUSTRALIA
T+61 7 3009 8700
F+61 7 3009 8799

LEVEL TWO
33 AINSLIE PLACE
CANBERRA ACT 2600
AUSTRALIA
T+61 2 6103 8200
F+61 2 6103 8233

LEVEL NINE
60 COLLINS STREET
MELBOURNE VIC 3000
AUSTRALIA
T+61 3 8650 6000
F+61 3 9654 6363

LEVEL ONE
50 PITT STREET
SYDNEY NSW 2000
AUSTRALIA
T+61 2 8272 5100
F+61 2 9247 2455

SUITE C2 CENTA BUILDING
118 RAILWAY STREET
WEST PERTH WA 6005
AUSTRALIA
T+61 8 9449 9600
F+61 8 9322 3955

ACILALLEN.COM.AU