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Kemps Creek Data Centre

Greenhouse Gas and Energy Report

SYD05-06-07_Y-R-0018

Revision 3 | 26 July 2021

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Executive summary

An assessment of the greenhouse gas (GHG) emissions due to the construction and operation of the proposal was conducted to evaluate the impact and assess the effectiveness of mitigation measures included in the design. Where possible, baseline emission sources were estimated using known proposal information and data. Below provides a summary of the baseline emissions excluding any mitigations:

Table 1: Baseline construction emissions (16 month period 2022-2023)

Scope	Emission category	Emissions (tCO_{2-e})	% of total
Scope 1	Fuel	672	2.22%
Scope 2	Electricity	2,919	9.67%
Scope 3	Materials	25,943	88.11%
	Electricity	308	
	Transport	352	
Total		**30,194**	**100%**

Table 2: Baseline operation emissions

Scope	Emission category	Emissions at first year of operation (tCO_{2-e})	Total Emissions over asset life (50 years) (tCO_{2-e})	% of total
Scope 1	Fuel	355	17,750	3.48%
	Refrigerants	13,596	679,800	
Scope 2	Electricity	1,426,571	18,269,294	91.14%
Scope 3	Electricity	133,528	1,071,593	5.37%
	Transport	274	6,745	
Total		**1,574,388**	**20,045,181**	**100%**

Operational emission account for 99.8% of total GHG emissions for construction and operation of the proposal, primarily due to the high electrical loads for the proposal. Mitigation measures have therefore been selected to target the three largest emitters during operation; scope 2: electricity, scope 3: electricity and scope 1: refrigerants. Below provides a summary of the mitigation measures included in the design, outlining the residual impact and further mitigations for consideration.

Table 3: Mitigation measures for GHG impacts

ID	Baseline Impact (first year of operation)	Development Phase	Mitigation	Residual Impact	Further Mitigations for Consideration	Responsibility
001	Scope 2 – Electricity: 1,426,571 tCO_{2-e}	Operation	Data hall is designed to run at a higher temperature than typical. Up to 35 degrees. In addition, evaporative cooling is used to cool the servers, mitigating the need for additional chillers. This has resulted in a PUE of 1.25 rather than an industry standard of 1.6.	Scope 2 – Electricity: 1,114,509 tCO_{2-e}	Off-site renewables – Enter into a power purchasing agreement (PPA) where electricity is sourced from off-site renewable energy. This has the potential to offset all scope 2 emissions.	Design Manager
002	Scope 3 – Electricity: 133,528 tCO_{2-e}	Operation	As above.	Scope 3 – Electricity: 104,318 tCO_{2-e}	None.	Na.
003	Scope 1 – Refrigerant: 13,596 tCO_{2-e}	Operation	Evaporative cooling is used instead to cool the servers, no refrigerant or compressors in areas requiring main cooling. 70,850 kg of refrigerant omitted	Scope 1 – Refrigerant: 282 tCO_{2-e}	None.	Na.

Following the above mitigation measures, the total operational GHG emissions in the first year of operation are estimated to reduce from 1,574,388 tCO_{2-e} to 1,219,802 tCO_{2-e} a saving of 23%.

Table 4 compares the total emissions in the first year of operation compared to the most recent State and National emissions figures. As shown, the proposal represents a small percentage of State and National emissions. These figures are also based on a worst-case scenario where no electricity consumption is offset. As outlined in Section 5 of the ESD Report (SYD05-06-07_Y-R-0018), the relevant organisation is targeting a 100 percent shift to renewable energy for all data centres, buildings and campuses by 2025, meaning that all electricity will be purchased through power purchase agreements for green energy. It is not unreasonable therefore to assume that by the time the proposal is operational, a significant proportion of the electricity emission, which account for over 90% of total emissions, will be offset through green energy.

Table 4 Comparing the Proposals emission to State and National emissions

Emissions at first year of operation ($MtCO_{2-e}$)	NSW & National Emissions ($MtCO_{2-e}$)		Project Emissions as % of NSW & National Emissions ($MtCO_{2-e}$)	
	NSW (Environment, n.d.)	National (Deparment of Industry, n.d.)	NSW	National
1.2	131.7	499	0.9%	0.2%

Contents

1 Introduction

1.1 Purpose of this report

The purpose of this report is to respond to the Secretary's Environmental Assessment Requirements (SEARs) by providing an assessment of the energy use of the proposal and all reasonable and feasible measures that will be implemented to minimise the proposal's greenhouse gas emissions. The report provides an assessment of greenhouse gas (GHG) emissions during the construction and operation of the proposal, identifying the largest emitters and outlining how these emissions will be mitigated.

1.2 Proposal overview

1.2.1 Site context

The identified site address that is the subject of this technical report is legally defined as 757-769 Mamre Road, Kemps Creek. The entire Site comprises a total area of approximately 17.38 hectares (ha) and is subject to the applicable provisions outlined within SEPP (WSEA) 2009. Access to the Site is currently obtained via the proposed Estate Access Roads (SSD 9522), which are accessed from Mamre Road. Access into the Site is made possible via Mamre Road, which is subject to future road widening as part of the Mamre Road Widening Project (Transport for NSW).

The Site is situated approximately 40.26 km west of the Sydney CBD, 22.11 km west of Parramatta and 11.97 km southeast of Penrith. It is within close proximity to transport infrastructure routes (predominantly the bus network), as well as sharing direct links with the wider regional road network, including Mamre Road and both the M4 & M7 Motorways. All of which provide enhanced connectivity to the Subject Site and immediate vicinity, as well as the wider locality.

Additionally, the Subject Site is located within close proximity to active transport links, such as bicycle routes, providing an additional mode of accessible transport available to the Subject Site. In its existing state, the Subject Site comprises an undeveloped land portion; however, is subject to bulk earthworks and infrastructure works under a concurrent State Significant Development (SSD) Application – SSD 9522.

The Proponent is proposing to construct and operate a Data Centre on the Subject Site. The Site is located within the Penrith Local Government Area (LGA) and is zoned IN1 General Industrial under the provisions of State Environmental Planning Policy (Western Sydney Employment Area) 2009 (SEPP (WSEA) 2009). Development for the purpose of a Data Centre is permissible with consent within the IN1 General Industrial zone pursuant to the provisions outlined with Part 3, Division 3, Clause 27 of State Environmental Planning Policy (Infrastructure) 2007 (ISEPP).

The site and surrounding context are illustrated below in Figure 1.

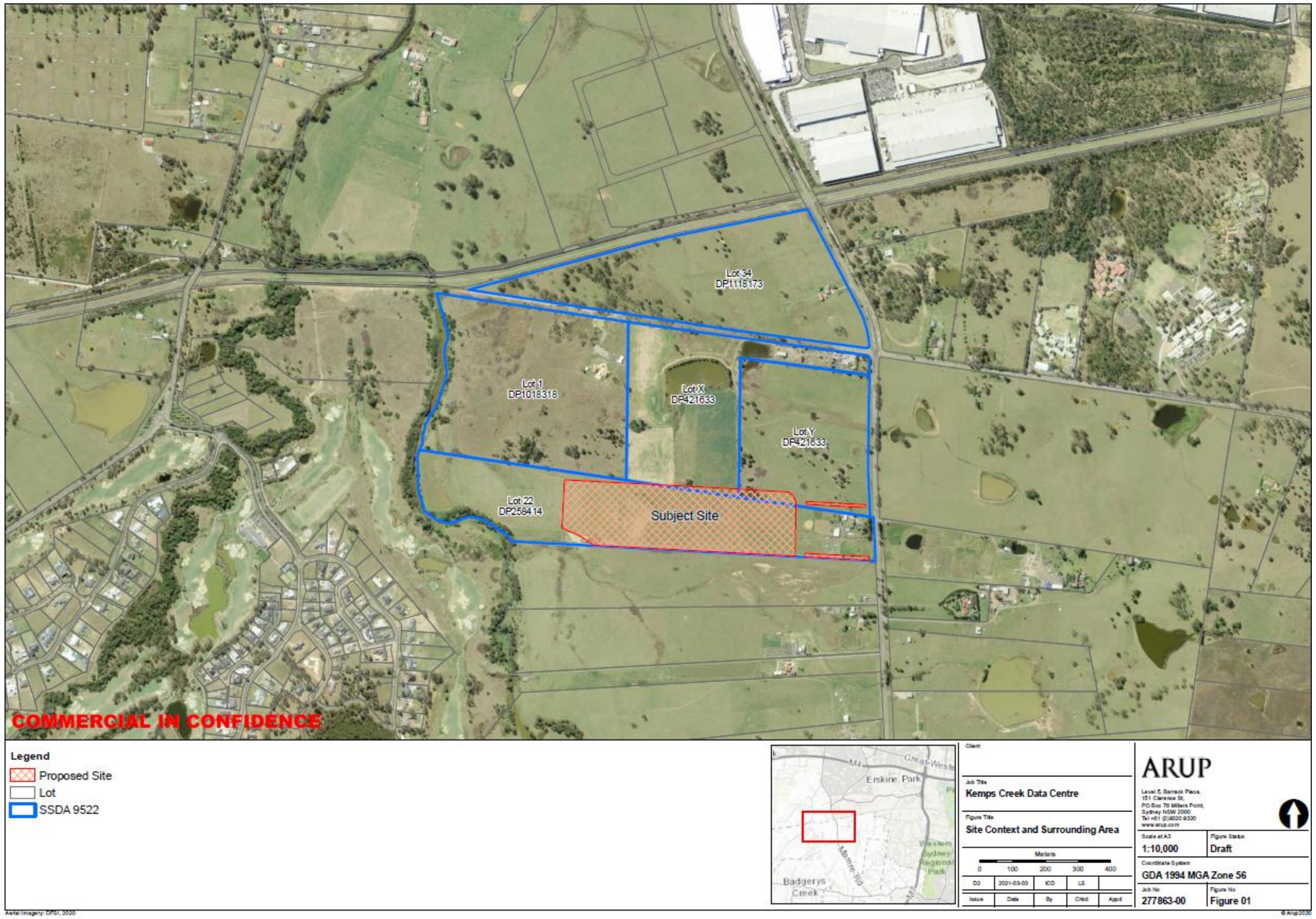

Figure 1: Site context and surrounding area (WillowTree, 2020)

1.3 Description of the proposed development

The Site will form part of the new Kemps Creek Warehouse, Logistics and Industrial Facilities Hub being developed as a joint venture between Frasers Property and Altis Property Partner under the recently approved SSD 9522 as of 21st December 2020.

The site layout has been developed for three data centres for a total of (3 x 48MW) 144MW capacity. Full detailed design is currently underway for two 48MW centres, with the third data centre being designated as a future build. The design of these which are based on the end-client's reference design as well as applicable Australian standards.

1.4 SEARs and DCP requirements relevant to this report

Table 5 identifies the SEARs and Development Control Plan (DCP) requirements which are relevant to this technical assessment.

Table 5: SEARs and DCP requirements for the GHG assessment

SEARs relevant to this technical report	Where addressed in this technical report
An assessment of the energy use of the proposal and all reasonable and feasible measures that would be implemented on site to minimise the proposal's greenhouse gas emissions.	Sections 3, 4, 4 and 5
DCP Requirements	
Developments with a construction cost of $1 million or more are to demonstrate a commitment to achieving no less than 4 stars under Green Star or 4.5 stars under the Australian Building Greenhouse Rating system (now part of the National Australian Built Environment Rating System (NABERS), where appropriate.	LEED has a data centre specific rating, which will allow a more comprehensive and targeted performance rating based on the project type. LEED is the dominant rating tool used globally and will allow easier comparison of performance with global data centres. In terms of performance the LEED v4 Energy Efficiency and CO2 emissions baseline standard is more stringent than other global tools. Green Star doesn't use a baseline standard, but sets its own standard of 110kg/CO2/m2/y and NABERS energy make a comparison of performance against the performance of 'peer' buildings. LEED and NABERS both have data centre-specific ratings which make use of 'Power Usage Effectiveness' as a measure of performance.

2 Policy and planning context

The following policies and plans are relevant to this assessment:

- A Metropolis of Three Cities – Greater Sydney Region Plan
- Western Parkland City vision
- Future Transport Strategy 2056
- Guidelines for Energy Savings Action Plans (DEUS, 2005)
- Penrith City Council Sustainability Policy, June 2020
- Penrith City Council Sustainability Strategy 2015-21
- Draft Mamre Road Precinct Development Control Plan (DCP).

The following methodologies and guidelines will be referenced for guidance for the calculation of greenhouse gas emissions for the proposal:

Table 6: Relevant methodologies and guidelines

Document	Description	Relevance
Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard (World Council for Sustainable Business Development and World Resources Institute, 2005)	Provides internationally recognised guidelines on developing a GHG emission inventory	Supports the justification of the methodology and definition of emission boundary
The current Australian National Greenhouse Accounts, National Greenhouse Accounts Factors (NGA Factors, Department of the Environment, August 2020)	Draws on the National Greenhouse and Energy Reporting (Measurement) Determination 2008 to provide methods to estimate a broad range of GHG emissions inventories	Provides methodologies for estimating scope 1, 2 and 3 emissions.
ISCA materials calculator version 2.0	Provides industry recognised embodied emission factors for materials	Supports the calculation of embodied emissions from materials

3 Methodology

This Chapter outlines the methodology used to assess the baseline GHG emissions.

3.1 Assessment methodology

The assessment methodology consisted of the following steps:

1. Defining emission boundary and sources: the emission boundary was defined identifying emission sources that are relevant to the assessment.
2. Quantifying baseline emissions sources: the quantity of each relevant emission source was estimated in its relevant units utilising proposal specific data and information where possible.
3. Calculating baseline emissions: Once the emissions sources had been estimated in their relevant units, these were then converted to CO_2 equivalent units using known emission factors and industry recognised calculation methods to estimate the GHG emissions from the identified sources.
4. Assessment of management measures: Measures included within the design which reduce the baseline GHG emissions were then assessed based on their impact. The residual GHG emissions were then estimated.

3.1.1 Guiding principles

The following best practice principles were adhered to when calculating the GHG emissions:

- Relevance: ensure the GHG emission inventory appropriately reflects the GHG emissions attributable to the proposal.
- Completeness: account for and report all GHG emissions sources within the defined boundary, justifying any exclusions.
- Consistency: use consistent data and calculation methodologies to allow for meaningful comparisons.
- Transparency: compile, analyse and document GHG information clearly so that auditors and the public may evaluate its credibility.
- Accuracy: ensure the quantification of GHG is unbiased and uncertainties are reduced as much as reasonably practical.

3.2 Defining emission boundary and sources

The first step in calculating the GHG emissions involved establishing the perimeter of the emission boundary, as this defines which emissions sources are to be either included in or excluded from the assessment. Emission sources are typically categorised into three distinct scopes in order to provide clarity and consistency:

- Scope 1: direct emissions which occur within the site boundary from owned or controlled sources e.g. emissions from site plant and equipment.
- Scope 2: indirect emissions which occur outside the site boundary from the generation of purchased energy.
- Scope 3: all indirect emissions (not included in scope 2) that occur in the value chain of the reporting body.

As previously noted, the SEARs require an assessment of the energy use of the proposal, therefore the following emissions sources were considered to be relevant for this assessment across both construction and operation.

Table 7: Emission sources considered

Scope	Emission source
Scope 1	• Liquid fuels • Refrigerants
Scope 2	• Electricity
Scope 3	• Embodied emissions from purchased goods and materials • Indirect emissions from commercial transport • Workers commuting

3.3 Quantifying baseline emission sources

Where possible, baseline emission sources were estimated using known proposal information and data. Where proposal estimates were unavailable, data from existing comparable projects was used as a proxy or to support reasonable assumptions.

While it is recognised that not every emission source attributable to the proposal has been included, those not included do not relate to energy use as required by the SEARs OR have been estimated to represent a negligible impact compared to the total GHG emissions for the construction or operational phase <1%. These include:

- Scope 1: Loss of sequestration due to vegetation clearance
- Scope 3: Indirect waste emissions
- Scope 3: Indirect emissions from fuel use
- Scope 3: Indirect emissions from water use (except water use during construction)

Table 8 below outlines the baseline emission sources and the methodology used to derive the value. *Emission sources* have been grouped into *emission categories*, below outlines the categories and what emission sources they account for.

- Scope 1 emissions categories:
  - Fuel: accounts for the use of on-site stationary and transport fuels for equipment, machinery and vehicles during both construction and operation.
  - Refrigerants: accounts for the leakage of refrigerants during operation.
- Scope 2 emission categories:
  - Electricity: accounts for the indirect emission from the generation of purchased grid electricity during construction and operation
- Scope 3 emission categories:
  - Materials: accounts for the embodied emissions released during the lifecycle of materials (including water) used during construction
  - Electricity: accounts for emissions due to electricity transmission and distribution losses during construction and operation.
  - Transport: accounts for emissions from the use of vehicles, deliveries and commuting, during construction and operation which occurs outside the site boundary.

Quantities for construction are based on a 16-month construction period.

Table 8: Quantity of baseline emission sources

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Method of estimation	Exclusions
Scope 1	Fuel	Construction	Diesel (stationary)	207	kL	Based on estimated hours of operation for stationary plant/equipment. Converted to kL using fuel consumption/hr. Includes 30kL required for standby generator commissioning. Refer to Appendix A.	Petrol, as negligible (<1%) compared to diesel usage.
			Diesel (transport)	40	kL	Based on estimated hours of operation for non-stationary machinery/equipment and on-site vehicles. Assumes all trucks run on diesel. Refer to Appendix A.	None
			Petrol (transport)	0.9	kL	Based on estimated hours of operation for on-site vehicles. Assumes all light commercial vehicles run on petrol. Refer to Appendix A.	None
		Operation	Diesel (stationary)	131	kL/year	Diesel used on site is solely to test backup generators. Amount based on 7 monthly tests at 15 minutes, 4 quarterly tests at 30 minutes and 1 yearly test at 60 minutes.	None.
	Refrigerants	Operation	Refrigerants	72,350	kg	Based on equipment selection, which is in turn based on preliminary cooling requirements (W/square metre only) for the admin area and support rooms (battery rooms, security equipment rooms, etc). The calculated figure includes the redundant system.	None.
Scope 2	Electricity	Construction	Grid electricity	3,987	MWh	Based on estimated annual usage of 1875MWh during construction and 2112MWh during commissioning.	None
		Operation	Grid electricity	2,018,304	MWh/year	IT area has an estimated peak load of 144MW. The average Power Usage Efficiency (PUE) for data centres in 2020 is 1.6 (based on Uptime Institute's Data). Reasonable to assume peak operation 24/7 365 days per year operation. Therefore, 144MW x 1.6 x 8760hrs = 2,018,304 MWh/year.	Admin area, MWh considered negligible (<1%)

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Method of estimation	Exclusions
							compared to IT load.
Scope 3	Materials	Construction	**IT Area**				
			Concrete	69,292	t	Based on latest construction drawings (SSK-005, SSK-006)	None
			Cement	13,859	t	Assumed 20% by weight	None
			Fine Aggregates	20,788	t	Assumed 30% by weight	None
			Coarse Aggregates	27,717	t	Assumed 40% by weight	None
			Mains Water	6,236	t	Assumed 9% by weight	None
			Additives	693		Assumed 1% by weight	None
			Steel roof	689	t	Based on latest construction drawings (SSK-005, SSK-006)	None
			Steel rebar	2,346	t	Based on 1.5% cross sectional area (CSA) of rebar for columns and 1% CSA for reinforced concrete	None
			Admin Area				
			Concrete (all)	6,929	t	Assumed 10% of total concrete used in IT area.	None
			Cement	1,386	t	Assumed 20% by weight	None
			Fine Aggregates	2,079	t	Assumed 30% by weight	None
			Coarse Aggregates	2,772	t	Assumed 40% by weight	None
			Mains Water	624	t	Assumed 9% by weight	None
			Additives	69	t	Assumed 1% by weight	None
			Whole Site				
			Mains water	1225	kL	Estimated based on site activities and construction duration	None

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Method of estimation	Exclusions
	Electricity	Construction	Refer to Scope 2 electricity for quantities				None
		Operation					None
	Transport	Construction	Deliveries (Diesel)	53	kL	Based on up to 10 rigid truck deliveries per day and an average travel distance of 25km from source to destination. Based on a fuel efficiency of 0.28L/km (Statistics, 2020). Refer to Appendix B.	None
			Workers trips (Petrol)	90	kL	Based on an average of 50 construction workers on any one day of which 90% are assumed to use private transport and travel an average distance of 25km from source to destination. Based on a fuel efficiency of 0.108L/km (Statistics, 2020). Refer to Appendix B.	None
		Operation	Workers trips (Petrol)	114	kL/year	Based on 79 workers of which 90% are assumed to use private transport and travel an average distance of 25km from source to destination. Based on a fuel efficiency of 0.108L/km (Statistics, 2020). Refer to Appendix B.	None
		Operation	Deliveries (Diesel)	26	kL/year	Based on an average of 6 deliveries per day and an average distance of 25km from source to destination. Based on a fuel efficiency of 0.28L/km (Statistics, 2020). Refer to Appendix B.	None
		Operation	Waste transportation (Diesel)	0.7	kL/year	Based on 1 collection per week and an average distance of 25km from source to destination. Based on a fuel efficiency of 0.28L/km (Statistics, 2020). Refer to Appendix B.	None

3.4 Calculating baseline emissions

This section details the calculation methods and emission factors that were used to convert the baseline quantity of emission sources as reported in Table 8 into tonnes of CO_2-equivalent (tCO_{2-e}). A summary of the approach taken is provided for each scope and emission source. Where emission sources exist in both the construction and operation phase, the emission factor is identical therefore has not been reported separately. Section 4 and section 5 provide a summary of the results.

3.4.1 Scope 1

3.4.1.1 Fuel

The following method was used to calculate the Scope 1 baseline emissions from the combustion of fuels (stationary) as sourced from the National Greenhouse Accounts (Environment, 2020):

$$\text{GHG emissions } (tCO_{2-e}) = ((Q \times ECF)/1000) \times (EF_{CO2} + EF_{CH4} + EF_{N2O})$$

Where:

Q is the quantity of fuel (kL)
ECF is the relevant energy content factor (GJ/kL)
EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (tCO_{2-e}/GJ)
EF_{CH4} is the relevant Methane (CH_4) emission factor (tCO_{2-e}/GJ)
EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (tCO_{2-e}/GJ)

Table 9 outlines the emission factors, which have been converted to tCO_{2-e}/kL.

Table 9: Fuel emission factors

Fuel type	ECF (GJ/kL)	EF (tCO_2-e/GJ)			EF (tCO_{2-e}/kL)	Source
		CO_2	CH_4	N_2O		
Diesel	38.6	0.069	0.0001	0.0002	2.7	(Environment, 2020)

3.4.1.2 Refrigerants

The following method was used to calculate the Scope 1 baseline emissions from the use of refrigerants as sourced from the National Greenhouse Accounts (Environment, 2020):

$$\text{GHG emissions } (tCO_{2\text{-}e}) = Q \text{ x } GWP/1000 \text{ x } LR$$

Where:

Q is the quantity of refrigerant (kg)
GWP is the Global Warming Potential of the refrigerant ($kgCO_{2\text{-}e}$/kg refrigerant)
LR is the annual leakage rate

Table 10: Refrigerant emission factors

Refrigerant type	GWP	LR	Source
R410a	2088	0.09	(Environment, 2020)

3.4.2 Scope 2

3.4.2.1 Grid Electricity

The following method was used to calculate the Scope 2 GHG emissions from the consumption of electricity as sourced from the National Greenhouse Accounts (Environment, 2020):

$$\text{GHG emissions } (tCO_{2\text{-}e}) = Q \text{ x } EF$$

Where:

Q is the quantity of purchased grid electricity (MWh)
EF is the emission factor for NSW ($tCO_{2\text{-}e}$/MWh)

The amount of emissions per MWh of grid electricity consumed is dependent on the process used in its generation i.e. the more fossil fuels used the higher the emission factor per MWh. Since the energy mix within the electricity grid is constantly changing, the electricity emission factor is also changing in response. With NSW targeting net zero emissions in 2050, the rate of uptake of renewable energy onto the grid is expected to increase in the coming years resulting in a lower emission factors moving forwards. The National Greenhouse Accounts (NGA Factors 2020) provide estimates up to 2020 however given construction is due to commence in 2022 with an operational design life of 50 years, these values must be projected forwards to capture the anticipated change.

The Climate Change Authority provides four scenarios for how electricity emission factors could change towards 2030 in its Climate Change Mitigation Scenarios (2013) report. Scenarios depend on whether a carbon price is introduced, and whether a high or low carbon price is implemented. Accurately predicting which scenario will prove to be most accurate is a difficult task, as there are many factors which can influence rate of uptake of renewable energy e.g. national and state policy/funding, levels of private investment, market performance/costs and social acceptance.

In acknowledgment of this unpredictability, and to maintain a balanced approach, the mid-range of all scenarios was selected as the preferred trajectory until 2030. This results in a pathway that is not unrealistically ambitious, in recognition of the fact that the NSW government are currently in stage 1 of their Net Zero Plan. However, beyond 2030 it is assumed that government action will begin to take greater effect therefore the high price scenario was used as the pathway towards the end of the asset life, which is around 2073. See Table 11 for a summary of resultant emission factors.

Table 11: Grid electricity emission factors

Year	Emission factor (tCO_{2-e}/MWh)	Source
2022	0.73	The emission factor for 2020 was obtained from (Environment, 2020) and the mid-range of the projected year on year change (Authority, 2013) was used to project the emission factor towards 2030. The average annual % change from the last 5 years (2025-2030) for the high price scenario was then used to project the emission factors towards 2073.
2023	0.71	
2024	0.68	
2025	0.66	
2026	0.63	
2027	0.61	
2028	0.59	
2029	0.58	
2030	0.57	
…	…	
2070	0.014	
2071	0.012	
2072	0.011	

3.4.3 Scope 3

3.4.3.1 Materials

The following method was used to calculate the Scope 3 embodied material emissions:

$$\text{GHG emissions } (tCO_{2-e}) = Qt \times EF$$

Where:

Qt is the quantity of material (tonnes)
EF is the relevant emission factor (tCO_{2-e}/tonne)

The Infrastructure Sustainability Council of Australia (ISCA) materials calculator was utilised to obtain emission factors for the relevant materials. The calculator is a nationally recognised tool, which references emission factors from reputable and reliable sources such as The Australian National Life Cycle Inventory Database (AusLCI) and in the case of specific products, Environmental Product Declaration's (EPD). These are independently verified and registered documents that communicate transparent and comparable information about the life-cycle environmental impact of products. See Table 12 for the relevant emission factors.

Table 12: Material emission factors

Material type	Emission factor (tCO_{2-e}/tonne	Source
Cement	0.984	(ISCA, 2018)
Fine Aggregates	0.004	
Coarse Aggregates	0.011	
Mains Water	0.001	
Additives	4.400	
Steel columns & roof	2.850	
Steel rebar	1.800	
Mains Water	0.001	

3.4.3.2 Grid electricity

The following method was used to calculate the Scope 3 emissions from electricity as sourced from the National Greenhouse Accounts (Environment, 2020). A reminder that scope 3 electricity emissions account for emissions from transmission and distribution losses of purchased electricity, which have not been accounted for when deriving scope 2 emissions from generation.

$$\text{GHG emissions } (tCO_{2-e}) = Q \times EF$$

Where:

Q is the quantity of purchased electricity (MWh)
EF is the scope 3 emission factor for NSW (tCO_{2-e}/MWh)

Similarly, to scope 2 grid electricity emission factors, Scope 3 grid electricity emission factors also vary with time. Values up to 2020 are provided within the National Greenhouse Accounts, therefore in order to project these values towards 2073, the average year on year reduction for the last five years was calculated and projected forwards. See Table 13 for the resultant emission factors.

Table 13: Scope 3 grid electricity emission factors

Year	Emission factor (tCO_{2-e}/MWh)	Source
2022	0.077	The emission factor for 2020 was obtained from (Environment, 2020) The average annual % change from the last 5 years (2015-2020) was used to project the emission factors towards 2072.
2023	0.073	
2024	0.070	
2025	0.066	
2026	0.063	
2027	0.060	
2028	0.057	
2029	0.054	
2030	0.051	
…	…	
2071	0.0062	
2072	0.0059	
2073	0.0056	

3.4.3.3 Transport

The following method was used to calculate the Scope 3 GHG emissions from the combustion of fuels (transport) as sourced from the National Greenhouse Accounts (Environment, 2020):

$$\text{GHG emissions } (tCO_{2-e}) = ((Q \times ECF)/1000) \times (EF_{CO2} + EF_{CH4} + EF_{N2O})$$

Where:

Q is the quantity of fuel (kL)
ECF is the relevant energy content factor (GJ/kL)
EF_{CO2} is the relevant Carbon dioxide (CO_2) emission factor (kg CO_{2-e}/GJ)
EF_{CH4} is the relevant Methane (CH_4) emission factor (kg CO_{2-e}/GJ)
EF_{N2O} is the relevant Nitrous oxide (N_2O) emission factor (kg CO_{2-e}/GJ)

When calculating future transport emissions during operation, a worst-case scenario was assumed where all cars run on petrol or diesel for the next 20 years. Emissions from electric cars were not calculated as these are assumed to be negligible compared to operational scope 2 emissions.

Table 14: Transport fuel emission factors

Fuel type	ECF (GJ/kL)	EF (tCO_2-e/GJ)			EF (tCO_{2-e}/kL)	Source
		CO_2	CH_4	N_2O		
Diesel	38.6	0.069	0.0001	0.0006	2.7	(Environment, 2020)
Petrol	34.2	0.067	0.0002	0.0002	2.3	

4 Assessment of potential construction impacts

Table 15 provides a summary of the estimated baseline GHG emissions due to construction of the proposal. These GHG emission values have been determined based on the calculation methods outlined in section 3.4, utilising the baseline emission sources provided in section 3.3.

Table 15: Baseline GHG construction emissions

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2-e})	% of total (emission source)	% of total (scope)
Scope 1	Fuel	Construction	Diesel (stationary)	207	kL	2.7	561	1.86%	2.22%
			Diesel (transport)	40	kL	2.7	109	0.36%	
			Petrol (transport)	0.9	kL	2.3	2	0.01%	
Scope 2	Electricity	Construction	Grid electricity	3,987	MWh	0.73	2,919	9.67%	9.67%
Scope 3	Materials	Construction	**IT Area**						
			Cement	13,859	t	0.984	13,637	45.16%	88.11%
			Fine Aggregates	20,788	t	0.004	83	0.28%	
			Coarse Aggregates	27,717	t	0.011	305	1.01%	
			Mains Water	6,236	t	0.001	6	0.02%	
			Additives	693	t	4.400	3,049	10.10%	
			Steel roof	689	t	2.850	2,440	8.08%	
			Steel rebar	2,346	t	1.800	4,714	15.61%	
			Admin Area						
			Cement	1,386	t	0.984	1,364	4.52%	
			Fine Aggregates	2,079	t	0.004	8	0.03%	
			Coarse Aggregates	2,772	t	0.011	30	0.10%	

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2-e})	% of total (emission source)	% of total (scope)
			Mains Water	624	t	0.001	1	0.00%	
			Additives	69	t	4.400	305	1.01%	
			Whole Site						
			Mains water	1225	kL	0.001	1	0.004%	
	Electricity	Construction	Grid electricity	3,987	MWh	0.077	308	1.02%	
	Transport	Construction	Deliveries (Diesel)	53	kL	2.7	144	0.48%	
			Workers trips (Petrol)	90	kL	2.3	208	0.69%	
Total (all scopes)							30,194	100%	

5 Assessment of potential operational impacts

Table 16 provides a summary of the estimated baseline GHG emissions due to operation of the proposal. These GHG emission values have been determined based on the calculation methods outlined in section 3.4, utilising the baseline emission sources provided in section 3.3. Total emissions have been calculated for both the first year of operation and an assumed asset life of 50 years.

Table 16: Baseline GHG operational emissions

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2-e}/year)	Emissions at first year of operation (tCO_{2-e})[1]	Total Emissions over 50 years (tCO_{2-e})	% of total (emission source)	% of total (scope)
Scope 1	Fuel	Operation	Diesel (Stationary)	131	kL/yr	2.7	355	355	17,750	0.09%	3.48%
	Refrigerant	Operation	Refrigerants	72,350	Kg	0.19	13,596	13,596	679,800	3.39%	
Scope 2	Electricity	Operation	Grid electricity	2,018,304	MWh/yr	See section 3.4.2.1	Varied	1,426,571	18,269,294	91.14%	91.14%
Scope 3	Electricity	Operation	Grid electricity	2,018,304	MWh/yr	See section 3.4.3.2	Varied	133,528	1,071,593	5.35%	5.37%
	Transport	Operation	Waste collection (Diesel)	0.7	kL/yr	2.7	2	2	38[2]	0.0002%	
			Deliveries (Diesel)	26	kL/yr	2.7	71	71	1,415	0.0071%	
			Workers trips (Petrol)	114	kL/yr	2.3	265	265	5,291	0.03%	

[1] Note that due to a changing grid carbon factor, total emission in the first year of operation will not be the same as total emission in the second year of operation. Overall emissions will drop year on year as the grid decarbonises.
[2] Assumes petrol/diesel cars will be used for the next 20 years

Scope	Emission category	Dev Phase	Emission source	Quantity	Unit	Emission factor (tCO_{2-e}/unit)	Emissions (tCO_{2-e}/year)	Emissions at first year of operation (tCO_{2-e})[1]	Total Emissions over 50 years (tCO_{2-e})	% of total (emission source)	% of total (scope)
Total (all scopes)								1,574,388	20,045,181	100%	

6 Environmental management measures

Below provides a summary of the mitigation measures included in the design to mitigate selected baseline emissions. A summary of the baseline impact, mitigation measure and residual impact is provided along with further mitigations for consideration. The below mitigations target operational emissions since these are by far the greatest contributor at 99% of total GHG emission.

Table 17: Mitigation measures for GHG impacts

ID	Baseline Impact (first year of operation)	Development Phase	Mitigation	Residual Impact	Further Mitigations for Consideration	Responsibility
001	Scope 2 – Electricity: 1,426,571 tCO_{2-e}	Operation	Data hall is designed to run at a higher temperature than typical. Up to 35 degrees. In addition, evaporative cooling is used to cool the servers, mitigating the need for additional chillers. This has resulted in a PUE of 1.25 rather than an industry standard of 1.6.	Scope 2 – Electricity: 1,114,509 tCO_{2-e}	Off-site renewables – Enter into a power purchasing agreement (PPA) where electricity is sourced from off-site renewable energy. This has the potential to offset all scope 2 emissions.	Design Manager
002	Scope 3 – Electricity: 133,528 tCO_{2-e}	Operation	As above.	Scope 3 – Electricity: 104,318 tCO_{2-e}	None.	Na.
003	Scope 1 – Refrigerant: 13,596 tCO_{2-e}	Operation	Evaporative cooling is used instead to cool the servers, no refrigerant or compressors in areas requiring main cooling. 70,850 kg of refrigerant omitted	Scope 1 – Refrigerant: 282 tCO_{2-e}	None.	Na.

Following the above mitigation measures, the total operational GHG emissions in the first year of operation are estimated to reduce from 1,574,388 tCO_{2-e} to 1,219,802 tCO_{2-e} a saving of 23%.

Table 18 compares the total emissions in the first year of operation compared to the most recent State and National emissions figures. As shown, the proposal represents a small percentage of State and National emissions. These figures are also based on a worst-case scenario where no electricity consumption is offset. As outlined in Section 5 of the ESD Report (SYD05-06-07_Y-R-0018), the relevant organisation is targeting a 100 percent shift to renewable energy for all data centres, buildings and campuses by 2025, meaning that all electricity will be purchased through power purchase agreements for green energy. It is not unreasonable therefore to assume that by the time the proposal is operational, a significant proportion of the electricity emission, which account for over 90% of total emissions, will be offset through green energy.

Table 18 Comparing the Proposals emission to State and National emissions

Emissions at first year of operation ($MtCO_{2-e}$)	**NSW & National Emissions ($MtCO_{2-e}$)**		**Project Emissions as % of NSW & National Emissions ($MtCO_{2-e}$)**	
	NSW (Environment, n.d.)	**National (Deparment of Industry, n.d.)**	**NSW**	**National**
1.2	131.7	499	0.9%	0.2%

6.1 Other Mitigations for Consideration

Below summarises mitigation measures which may be considered to address emissions from construction. The largest emitter during construction is due to embodied materials emissions (~85%) thus the following measures will be considered to reduce this impact.

- Seek to procure recycled or reused materials where the options exist, and comparable performance can be achieved. Targeting materials which have the highest impact (such as concrete) and are most easily recycled (such as steel) will result in the greatest savings.
- Review and develop the design to identify where reductions in material quantities can be made, while maintaining the design performance.
- Identify materials which can be substituted for lower embodied carbon alternatives.
- Consider the lifetime of the asset in the design, particularly with regards to decommissioning. Design for materials and construction processes which enable the recovery and reuse of materials.

7 References

Authority, C. C., 2013. *Climate Change Mitigation Scenarios* , s.l.: s.n.
Deparment of Industry, S. E. a. R., n.d. [Online]
Available at: https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-december-2020#annual-emissions-data
Environment, D. o., 2020. *The current Australian National Greenhouse Accounts, National Greenhouse Accounts Factors*, s.l.: s.n.
Environment, N. D. o. P. I. a., n.d. [Online]
Available at: https://climatechange.environment.nsw.gov.au/about-climate-change-in-nsw/nsw-emissions
Institute, W. R., 2005. *Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard*, s.l.: s.n.
ISCA, 2018. *ISCA Materials Calculator Version 2.0*, s.l.: s.n.
Office of parliamentary Council, C., 2017. *National Greenhouse and Energy Reporting (Measurement)* , s.l.: s.n.
Statistics, A. B. o., 2020. *Survey motor vehicle use.* [Online]
Available at: https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia/latest-release
[Accessed Febuary 2020].

Appendix A

Scope 1 Construction Fuel Calculations & Assumptions

Equipment	Operational plant during worst case 15 minute period.				Hours assumptions			Total hours	Fuel consumption (L/hr)	Fuel consumption (kL)	Fuel type	Fuel Consumption Source	Assumption
	Site establishment and excavation	Pavement & road works	Building construction	Plant installation and connection									
Indicative duration	1 months	3 months	10 months	2 months	Assumed time operational (months)	Time opeartional (days)	Assumed average hours per day						
Backhoe	1				1	24.0	5	120.0	25	3.0	Diesel	https://www.hawthornecat.com/sites/default/files/content/download/pdfs/Estim	Median of medium capcity
Compactor	1	1			2	48.0	5	240.0	13	3.1	Diesel	https://static1.squarespace.com/static/58877529414fb5283ed14a6b/t/5888f8df4	Median of medium capcity
Concrete Pump		1	1		5	120.0	3	360.0	5	1.8	Diesel	https://macchiaelettrodomestici.it/sjdg/concrete-pump-fuel-consumption.htm	
Concrete Truck		1	1		5	120.0	3	360.0	17	6.1	Diesel	https://www.concreteconstruction.net/concrete-production-precast/tips-for-spec	
Crane (franna crane 20t)			1		10	240.0	10	2400.0	21.7	52.1	Diesel	https://www.terex.com/docs/librariesprovider10/default-document-library/tech-t	
Crane (tower)			1		10	240.0	10	2400.0	25	60.0	Diesel	Estimated	
Excavator tracked (hydraulic) – 35t	2	1			4	96.0	5	480.0	28	13.4	Diesel	https://www.liftrite.com.au/wa-company-saving-with-fuel-efficient-kobelco-35-to	Worst case
Excavator mounted hammer	1				0.5	12.0	2	24.0	25	0.6	Diesel	Estimated	
Front end loader	1	1			2	48.0	5	240.0	15	3.6	Diesel	https://www.wph.net.au/wp-content/uploads/2016/01/966H.pdf	
Generator (diesel)	1	1	1		14	336.0	10	3360.0	18	60.5	Diesel	https://www.ablesales.com.au/blog/diesel-generator-fuel-consumption-chart-in-li	Assumed 60kW generator
Grader	1	1			2	48.0	5	240.0	15	3.6	Diesel	https://www.hawthornecat.com/sites/default/files/content/download/pdfs/Estim	Median of medium capcity
Jackhammer		1			1	24.0	5	120.0	0.6	0.1	Petrol	https://www.nicencheap.com.au/product/giantz-52cc-petrol-jack-hammer-demol	
Roller (vibratory)	2				1	24.0	3	72.0	20	1.4	Diesel	https://www.ezyquip.com.au/product/ca5000d-pd-vibratory-roller/	
Roller (smooth)		1			1	24.0	3	72.0	4.9	0.4	Diesel	https://www.hireexpress.com.au/product.view&pid=250	
Pavement layer		1			0.5	12.0	5	60.0	20	1.2	Diesel	Estimated	
Piling (impact)			1		1	24.0	3	72.0	6.5	0.5	Diesel	https://bsp-if.com/jx-piling-rig/	
Scraper	1				0.5	12.0	3	36.0	70	2.5	Diesel	https://www.hawthornecat.com/sites/default/files/content/download/pdfs/Estim	
Welder						0.0	Na (powered electrically)			0	0		

Equipment	Site establishment and excavation	Pavement & road works	Building construction	Plant installation and connection	Assumed time operational (months)	Time opeartional (days)	Assumed average hours per day	Total hours	Average speed on site (km/hr)	Distance travelled (km)	Fuel efficiency (L/km)	Fuel consumption (kL)	Fuel type	Fuel Consumption Source	Assumption
Truck (15t)	1	1			2	48.0	3	144.0	15	2160.0	0.286	0.6	Diesel	https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-v	
Truck (water cart)	2	2	1		10	240.0	2	480.0	15	7200.0	0.213	1.5	Diesel	https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-v	
Vehicle (light commercial)	2	2	2	1	10	240.0	2	480.0	15	7200.0	0.125	0.9	Petrol	https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-v	

Comissioning	Fuel consumption (kL)	Fuel type
Standby Generator for Commissioning	29.6	Diesel

Totals:

Total consumption (kL)	Fuel type
39.9	Diesel (transport)
177.0	Diesel (stationary)
0.9	Petrol

Standard construction hours:

Day	Standard construction hours
Monday to Friday	7 am to 6 pm
Saturday	8 am to 1 pm
Sunday and public holiday	No work

Appendix B

Scope 3 Transport Calculations & Assumptions

Transport type	Number of staff	Number of trips per day	Assumption	Number of working days for 16 month construction period	Assumed Distance per trip	Distance travelled (km)	Fuel efficiency (L/km)	Fuel consumption (kL)	Fuel type
Construction									
Deliveries	Na	20.0	up to 10 trucks per day (accounts for inbound and outbound trip)	370.0	25	185000.0	0.286	52.91	Diesel
Workers trips	50	90.0	90% of workers drive (accounts for inbound and outbound trip)	370.0	25	832500.0	0.108	89.9	Petrol
Operation				**Number of working days per year**					
Workers trips	79	142.2	90% of workers drive (accounts for inbound and outbound trip)	298.0	25	1059390.0	0.108	114.4	Petrol
Deliveries	na	12.0	Based on an average of six deliveries per day due to three loading docs with capacity for two vehicels (accounts of inbound and outbound trip)	298.0	25	89400.0	0.286	25.6	Diesel
		Number of trips per year							
Waste	na	52.00	1 collection per week		25	2600.0	0.286	0.7	Diesel

Fuel efficiency source

https://www.abs.gov.au/statistics/industry/tourism-and-tr

https://www.abs.gov.au/statistics/industry/tourism-and-tr

https://www.abs.gov.au/statistics/industry/tourism-and-tr

Totals:

Total consumption (kL)	Fuel type
Construction	
52.9	Diesel
89.9	Petrol
Operation	
114.4	Petrol
26.3	Diesel