22 Greenhouse gas

This chapter outlines the legislative and policy framework for the control of greenhouse gas emissions. It provides an assessment of greenhouse gas emissions anticipated to be generated during the construction and operation stages of the M4-M5 Link project (the project) and provides recommended mitigation measures to reduce greenhouse gas emissions. There are no requirements of the Secretary of the NSW Department of Planning and Environment (DP&E) for this environmental assessment that are specific to greenhouse gas emissions. The assessment of greenhouse gas emissions for the project environmental impact statement (EIS) follows a similar approach adopted for the M4 East EIS and New M5 EIS.

Greenhouse gases (GHGs) are gases in the atmosphere that absorb and re-radiate heat from the sun, thereby trapping heat in the lower atmosphere and influencing global temperatures. Emissions of GHGs into the atmosphere are caused by both natural processes (eg bushfires) and human activities (eg burning of fossil fuels to generate electricity).

Since the industrial revolution there has been an increase in the amount of GHGs emitted from human activities, which has increased the global concentration of GHGs in the atmosphere. This has led to an increase in the Earth's average surface temperature (Intergovernmental Panel on Climate Change (IPCC) 2013). Further discussion on climate change, including the identification and assessment of climate change risks to the project, is provided in **Chapter 24** (Climate change and risk adaptation). Potential impacts of the project on air quality are assessed in **Chapter 9** (Air quality) and **Appendix I** (Technical working paper: Air quality).

22.1 Assessment methodology

The methodology for this GHG assessment has been based on relevant GHG reporting legislation and international reporting guidelines, including:

- *Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard* (World Council for Sustainable Business Development and World Resources Institute 2005)
- *National Greenhouse and Energy Reporting Act 2007* (Commonwealth)
- AS/ISO 14064.1:2006 *Greenhouse Gas Part 1: Specification with guidance at the organisational level for quantification and reporting of greenhouse gas emissions and removals*
- The current *Australian National Greenhouse Accounts: National Greenhouse Accounts Factors* (NGA Factors) (Department of the Environment 2016)
- *Greenhouse Gas Assessment Workbook for Road Projects* (the TAGG Workbook) (Transport Authorities Greenhouse Group (TAGG) 2013).

The TAGG was formed by Australian state road authorities, including NSW Roads and Maritime Services (Roads and Maritime), and the New Zealand Transport Agency as a collaborative effort to share information regarding the estimation, reporting and minimisation of GHG emissions. The TAGG Workbook provides a consistent methodology for estimating the GHG emissions from activities that may contribute significantly to the overall emissions associated with the construction, operation and maintenance of road projects. The TAGG Workbook has been adopted for the project.

To calculate the potential GHG emissions associated with the project, the following steps were followed:

1. Define the assessment boundary and identify potential sources of GHG emissions associated with the project
2. Determine the quantity of each emission source (fuel and electricity consumed, vegetation cleared, construction materials used and waste produced)
3. Quantify the potential GHG emissions associated with each GHG source, using equations and emission factors specified in the NGA Factors and the TAGG Workbook
4. Present the potential GHG emissions associated with the project.

Appendix W (Detailed greenhouse gas calculations) provides a detailed description of the GHG assessment methodology, including the emissions factors used for all emission sources, and detailed calculation methods used to estimate the GHG emissions from fuel combustion, electricity consumption, vegetation removed, materials use and waste.

GHG emissions are reported in this assessment as tonnes of carbon dioxide equivalent (t CO_2-e). While there are numerous GHGs, this standard metric takes account of the different global warming potentials of different GHGs, and expresses the cumulative effect in a common, universal unit of measurement. This allows for all GHGs associated with the project to be combined into one emissions calculation.

22.1.1 Greenhouse gas assessment boundary

The assessment boundary defines the scope of GHG emissions and the activities to be included in the assessment. The assessment boundary includes all emissions sources that can be influenced by decisions made by designers, constructors, managers or operators of the project and accounts for emissions anticipated to be generated during the construction and operation stages of the project. The guiding principles for GHG accounting and reporting, including an assessment of materiality, are provided in **Appendix W** (Detailed greenhouse gas calculations).

Emissions sources are categorised into the following three 'scopes':

- Scope 1 – direct emissions: GHG emissions generated by sources owned or controlled by the project, for example emissions generated by the use of diesel fuel in project-owned construction plant, equipment or vehicles
- Scope 2 – indirect emissions: GHG emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These GHG emissions are generated outside the project's boundaries, for example the use of electricity purchased from the grid
- Scope 3 – indirect upstream/downstream emissions: GHG emissions generated in the wider economy due to third party supply chains and road users as a consequence of activity within the boundary of the project, for example GHG emissions associated with the mining, production and transport of materials used in construction (referred to as the embodied energy of a material).

Table 22-1 summarises the emission sources and activities considered within the project's GHG assessment boundary for construction and operation, according to scope.

Table 22-1 Emission sources and activities included in the assessment

Emission source category	Emission source	Emission scope		
		Scope 1 (direct)	Scope 2 (indirect)	Scope 3 (indirect upstream/ downstream)
Construction				
Fuel use	Mobile construction equipment	✓		✓
	Site vehicles	✓		✓
	Delivery of plant, equipment and construction materials			✓
	Spoil and waste removal			✓
Electricity consumption	Electricity used to power construction plant (road headers, ventilation, lighting towers etc) and site offices		✓	✓
Vegetation removal	Clearance of vegetation as a result of the project	✓		
Materials	Embodied energy of construction materials			✓

Emission source category	Emission source	Emission scope Scope 1 (direct)	Scope 2 (indirect)	Scope 3 (indirect upstream/ downstream)
Waste	Decomposition of waste generated during project construction			✓
Operation and maintenance				
Electricity consumption	Electricity used to power tunnel lighting and ventilation, project offices and other electrical systems		✓	✓
Fuel use	Operational road use by light and heavy vehicles			✓
	Mobile construction equipment used for maintenance activities	✓		✓
Materials	Materials used for maintenance activities			✓

Some emissions sources are categorised into two scopes; for example, the use of fuel by mobile construction equipment onsite would generate Scope 1 direct emissions from the combustion of fuel as well as Scope 3 indirect upstream emissions associated with the extraction, production and transport of the purchased fuel. Consumption of electricity purchased from the grid would generate Scope 2 indirect emissions from the use of electricity to power project equipment and facilities, as well as Scope 3 indirect upstream emissions associated with transmission and distribution losses within the electricity network.

22.2 Existing environment

22.2.1 International policy setting

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (the Kyoto Protocol) (UNFCCC 1998) was signed in 1997 and Australia ratified the protocol in December 2007. The Kyoto Protocol serves to give effect to the UNFCCC's objective of reducing global GHG emissions by setting reduction targets and reporting requirements for certain ratifying countries. These targets are set using the relevant ratifying countries' 1990 baseline emissions. Australia committed to a target of 108 per cent of its 1990 GHG emission levels by the end of 2012. In December 2012, Australia signed the Doha Amendment to the Kyoto Protocol (UNFCCC 2012), agreeing to a second commitment period, from 1 January 2013 until 2020.

In 2015 the Australian Government announced its commitment to a target of reducing GHG emissions by 26 to 28 per cent below 2005 levels by 2030, building on its previous target of five per cent below 2000 emission levels by 2020, irrespective of what other countries do. The Australian Government submitted this new target as its intended nationally determined contribution to the UNFCCC for negotiation at the 21st Conference of the Parties (COP21) held in Paris in December 2015.

A global climate agreement was reached by all 197 countries in Paris on 12 December 2015. The Paris Agreement provides a framework for all countries to take action on climate change post 2020. Key outcomes of the Paris Agreement include (Department of Foreign Affairs and Trade (DFAT) 2016):

- A target to keep global temperature increase to well below two degrees Celsius (°C) and pursue efforts to keep warming below 1.5°C above pre-industrial levels
- All countries to set emissions reduction targets from 2020, with an agreement to review and strengthen targets every five years
- Transparency and accountability rules to provide confidence in countries' actions and track progress towards targets
- Promoting action to adapt and build resilience to climate impacts

- Financial, technological and capacity building support to help developing countries implement the Agreement.

The Australian Government ratified its commitment to the Paris Agreement on 9 November 2016.

22.2.2 National and State policy setting

The Australian Government's Direct Action Plan sets out how the 2030 emissions reduction target will be achieved. The Emissions Reduction Fund, as part of the Direct Action Plan, aims to reduce Australia's GHG emissions by creating positive incentives to adopt better technologies and practices to reduce emissions. The Australian Government will consider the 2030 target policy framework in detail in 2017-2018.

In 2016 the NSW Government released a new Climate Change Policy Framework, which includes a *Draft Climate Change Fund Strategic Plan 2017-2022* and *A Draft Plan to Save NSW Energy and Money*. The *Draft Plan to Save NSW Energy and Money* is proposed to meet the NSW Government's energy efficiency target of 16,000 gigawatt hours of annual energy savings by 2020 and contribute to the Climate Change Policy Framework's aspirational target of NSW achieving net-zero emissions by 2050. The draft plan summarises the preferred options for achieving the State's energy savings target, which include opportunities for implementing energy standards for State significant developments and major infrastructure projects such as road tunnels.

The NSW Government *Resource Efficiency Policy* (NSW Office of Environment and Heritage (OEH) 2014) aims to 'drive resource efficiency by NSW Government agencies in three main areas – energy, water and waste – and also reduce harmful air emissions from government operations'.

The *NSW Long Term Transport Master Plan* (Transport for NSW 2012) (Transport Master Plan) includes an objective to 'Improve sustainability – by maintaining and optimising the use of the transport network, easing congestion, growing the proportion of travel by sustainable modes such as public transport, walking and cycling, and becoming more energy efficient.' An action of the Transport Master Plan is also to 'continue to explore opportunities to reduce vehicle emissions, improve air quality and lower GHG emissions from the NSW transport sector.'

In addition, the *Transport Environment and Sustainability Policy Framework* (Transport for NSW 2013) includes an energy management objective 'to use Transport's energy sources more efficiently and reduce its greenhouse gas emissions'. The Roads and Maritime *Environmental Sustainability Strategy 2015-2019* (2016) aligns with the *Transport Environment and Sustainability Policy Framework* and includes energy and carbon management as one of the focus areas for integrating sustainability into Roads and Maritime operations and services. The *Environmental Sustainability Strategy* outlines the Roads and Maritime objective to minimise energy use and reduce GHG emissions without compromising the delivery of service to customers, and identifies the following management hierarchy to achieve this objective:

- Avoid – minimise the need for energy use
- Efficiency – implement energy efficiency measures such as light-emitting diode (LED) lighting and signalling
- Substitute – source electricity from renewable energy.

The WestConnex Sustainability Strategy (the Sustainability Strategy) (Sydney Motorway Corporation 2015) describes how sustainability will be integrated into the planning, construction and operation of WestConnex. The Sustainability Strategy includes objectives to optimise resource efficiency and outlines requirements for construction contractors to develop and implement an Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan. Further detail regarding the Sustainability Strategy objectives and targets is provided in **Chapter 27** (Sustainability).

22.2.3 GHG emissions reporting

The Clean Energy Regulator and the Department of the Environment and Energy are responsible for administering the Australian Government's GHG emission policies, regulations and initiatives. The National Greenhouse and Energy Reporting (NGER) Scheme is a national framework for obligated corporations to report on GHG emissions, energy use and energy production. The NGER Scheme operates under the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth) (NGER Act).

The most recently published Australian National Greenhouse Accounts estimate Australian GHG emissions for the year March 2016 to March 2017 to be 550.1 million tonnes of carbon dioxide equivalent (Mt CO_2-e) as reported under the Kyoto Protocol (Australian Government Department of the Environment and Energy 2017a). This figure is 0.8 per cent below 2000 levels, and demonstrates progress towards achieving Australia's targets for 2020 of five per cent below 2000 emissions levels. For 2015, annual NSW GHG emissions totalled around 133.4 Mt CO_2-e (Department of the Environment and Energy 2017b). Despite an increase of emissions in the transport sector for NSW, total emissions for the State decreased in 2015, with a 11.6 per cent reduction on 2000 levels.

The transport sector contributes about 18 per cent of Australia's total GHG emissions (Australian Government Department of the Environment 2016a). Around 90 per cent of these emissions are considered to be attributed to the combustion of fuel for road transport (Climate Change Authority 2014; Maddocks et al. 2010). Reducing the contribution of emissions from road transport would therefore have a significant impact on emissions reduction for the transport sector, and for Australia's overall emissions profile.

22.3 Assessment of potential construction impacts

The data used to estimate the GHG emissions associated with construction of the project is provided in **Appendix W** (Detailed greenhouse gas calculations). Assumptions have been made based on industry default factors and experience with similar road tunnel projects, where necessary, to provide a quantitative estimate of emissions.

Twelve construction ancillary facilities are described in this EIS. To assist in informing the development of a construction methodology that would manage constructability constraints and the need for construction to occur in a safe and efficient manner, while minimising impacts on local communities, the environment, and users of the surrounding road and other transport networks, two possible combinations of construction ancillary facilities at Haberfield and Ashfield have been assessed in this EIS. The construction ancillary facilities that comprise these options have been grouped together in this EIS and are denoted by the suffix a (for Option A) or b (for Option B).

The construction ancillary facilities required to support construction of the project include:

- Construction ancillary facilities at Haberfield (Option A), comprising:
  - Wattle Street civil and tunnel site (C1a)
  - Haberfield civil and tunnel site (C2a)
  - Northcote Street civil site (C3a)
- Construction ancillary facilities at Ashfield and Haberfield (Option B), comprising:
  - Parramatta Road West civil and tunnel site (C1b)
  - Haberfield civil site (C2b)
  - Parramatta Road East civil site (C3b)
- Darley Road civil and tunnel site (C4)
- Rozelle civil and tunnel site (C5)
- The Crescent civil site (C6)
- Victoria Road civil site (C7)
- Iron Cove Link civil site (C8)

- Pyrmont Bridge Road tunnel site (C9)
- Campbell Road civil and tunnel site (C10).

The following sections provide estimated GHG emissions for construction of the project for Option A and Option B, respectively. The remaining construction ancillary facilities (C4 to C10) are included in the assessment for each option.

22.3.1 Construction ancillary facilities: Option A

It is estimated that the project would generate about 528,000 t CO_{2}.e where Option A is selected as the preferred construction option at Haberfield. The breakdown of emissions by scope is shown in **Figure 22-1** and summarised (with numbers rounded to the nearest hundred tonnes) as:

- 132,500 t CO_{2}.e of Scope 1 (direct) GHG emissions
- 86,000 t CO_{2}.e of Scope 2 (indirect) GHG emissions
- 309,500 t CO_{2}.e of Scope 3 (indirect upstream/downstream) GHG emissions.

Key emissions sources during project construction are shown in **Table 22-2** and **Figure 22-1**. Detailed GHG emissions results are provided in Table 3-1 of **Appendix W** (Detailed greenhouse gas calculations).

Table 22-2 Construction GHG emissions results for Option A

Emissions source		GHG emissions (t CO_{2}.e)				% of total
		Scope 1	Scope 2	Scope 3	Total	
Fuel use (diesel) – mobile plant and equipment		32,336	-	2,455	**34,791**	6.59
Fuel use (diesel) – transport of materials, spoil and waste to/from site		90,392	-	6,863	**97,255**	18.42
Fuel use (petrol) –plant and equipment		69	-	5	**74**	0.01
Fuel use (petrol) – project light vehicles		8,483	-	671	**9,154**	1.73
Electricity consumption		-	86,017	13,003	**99,020**	18.75
Vegetation clearance		1,188	-	-	**1,188**	0.23
Construction materials	Concrete	-	-	154,097	**154,097**	29.18
	Cement	-	-	100,040	**100,040**	18.95
	Steel	-	-	16,223	**16,223**	3.07
	Aggregate	-	-	140	**140**	0.03
	Asphalt	-	-	4,060	**4,060**	0.77
	Water	-	-	2,000	**2,000**	0.38
Waste	Construction and demolition waste	-	-	10,000	**10,000**	1.89
Total		**132,468**	**86,017**	**309,557**	**528,042**	**100%**
% of total		25%	16%	59%	**100%**	

Notes:

Results may not add up to totals due to rounding of emissions to the nearest whole number.

Assumptions for how these figures were calculated are presented in Appendix W (Detailed greenhouse gas calculations).

22.3.2 Construction ancillary facilities: Option B

It is estimated that the project would generate about 516,400 t CO_2-e where Option B is selected as the preferred construction option at Haberfield/Ashfield. The breakdown of emissions by scope is shown in **Figure 22-1** and summarised (with numbers rounded to the nearest hundred tonnes) as:

- 125,100 t CO_2-e of Scope 1 (direct) GHG emissions
- 82,800 t CO_2-e of Scope 2 (indirect) GHG emissions
- 308,500 t CO_2-e of Scope 3 (indirect upstream/downstream) GHG emissions.

Key emissions sources during project construction are shown in **Table 22-3** and **Figure 22-1.** Detailed GHG emissions results are provided in Table 3-2 of **Appendix W** (Detailed greenhouse gas calculations).

Table 22-3 Construction GHG emissions results for Option B

Emissions source		GHG emissions (t CO_2-e)				% of total
		Scope 1	Scope 2	Scope 3	Total	
Fuel use (diesel) – mobile plant and equipment		32,336	-	2,455	**34,791**	6.74
Fuel use (diesel) – transport of materials, spoil and waste to/from site		83,218	-	6,318	**89,536**	17.34
Fuel use (petrol) –plant and equipment		69	-	5	**74**	0.01
Fuel use (petrol) – project light vehicles		8,277	-	655	**8,932**	1.73
Electricity consumption		-	82,775	12,513	**95,288**	18.45
Vegetation clearance		1,188	-	-	**1,188**	0.23
Construction materials	Concrete	-	-	154,097	**154,097**	29.84
	Cement	-	-	100,040	**100,040**	19.37
	Steel	-	-	16,223	**16,223**	3.14
	Aggregate	-	-	140	**140**	0.03
	Asphalt	-	-	4,060	**4,060**	0.79
	Water	-	-	2,000	**2,000**	0.39
Waste	Construction and demolition waste	-	-	10,000	**10,000**	1.94
Total		**125,088**	**82,775**	**308,506**	**516,369**	**100%**
% of total		24%	16%	60%	**100%**	

Note:

Results may not add up to totals due to rounding of emissions to the nearest whole number.

22.3.3 Construction GHG emissions results

The results demonstrate a marginal difference in emissions between construction ancillary facilities Option A and Option B, with Option A estimated to generate around two per cent (11,673 t CO_2-e) higher emissions compared with Option B. This difference is attributed to a larger fuel consumption and larger electricity consumption for Option A, associated with the two tunnelling sites at Haberfield compared to one site for Option B, and the additional requirements to support tunnelling activities at this additional site (eg vehicle movements, temporary ventilation and water treatment ancillary works).

The results demonstrate that the majority of GHG emissions associated with the construction of the project are attributed to indirect Scope 3 emissions (59 and 60 per cent for Option A and Option B respectively), followed by direct Scope 1 emissions (25 and 24 per cent for Option A and Option B respectively).

The embodied energy associated with the offsite mining, production and transport of materials that would be used for the construction of the project contributes the largest proportion of indirect Scope 3 emissions, accounting for around 89 per cent of these emissions for both Option A and Option B (see **Figure 22-1**). The use of concrete, cement and, to a lesser extent, steel would contribute significantly to Scope 3 emissions. The high proportions of emissions associated with these materials are attributed not only to the quantity required for the construction of the project, but also the emissions-intensive processes involved in the extraction and production of these materials.

Figure 22-1 illustrates the breakdown of construction emissions by emission source and scope. The consumption of diesel fuel associated with heavy vehicle movements for the haulage of spoil, construction materials and waste contributes the largest proportion of Scope 1 emissions (68 and 67 per cent for Option A and Option B respectively), followed by the consumption of fuel for the operation of mobile construction plant and equipment (24 and 26 per cent for Option A and Option B respectively). Indirect Scope 2 emissions from the use of electricity are estimated to account for around 16 per cent of total emissions during construction for both Option A and Option B.

Mitigation and management measures to reduce GHG emissions during construction of the project are provided in **section 22.7**.

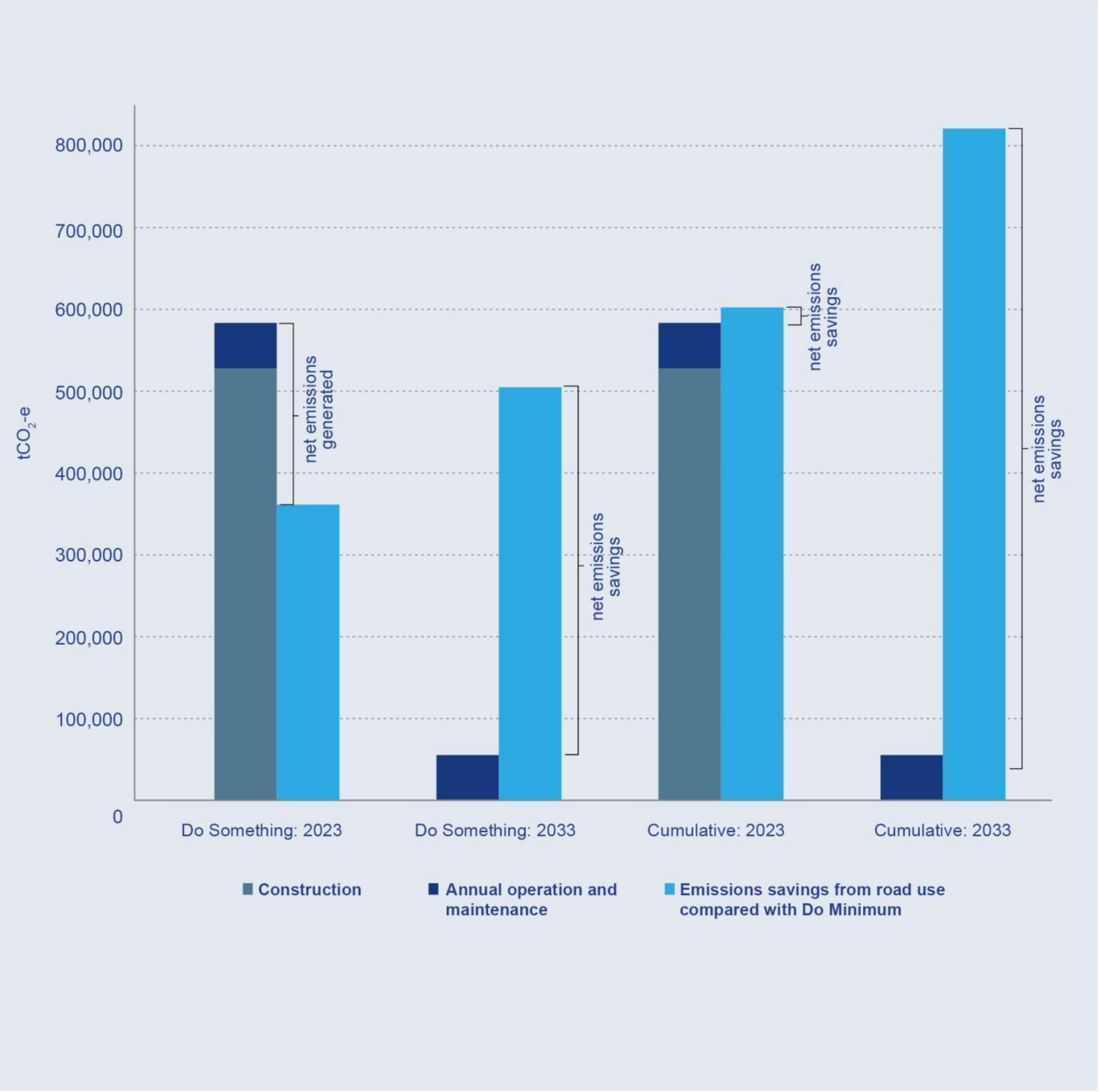

Figure 22-1 Construction GHG emissions by scope and emissions source

22.4 Assessment of potential operational impacts

Activities that would generate GHG emissions during operation and maintenance of the project include:

- Road infrastructure operation: the use of electricity for powering tunnel lighting and ventilation, operation of ventilation facilities, the operations and maintenance facility, water treatment, substation cooling, street lighting, electronic signage and other associated electrical systems
- Road infrastructure maintenance: diesel fuel use for the operation of maintenance equipment and the use of materials for maintaining road pavement
- Vehicles using the M4-M5 Link during operation: use of the M4-M5 Link during operation and the change in traffic volumes and traffic performance on alternative routes within the GHG assessment study area.

The GHG assessment results are presented in the following sections. The emission source data, and any assumptions used to estimate the GHG emissions associated with operation and maintenance of the project, are provided in **Appendix W** (Detailed greenhouse gas calculations).

22.4.1 Emissions from road infrastructure operation and maintenance

The estimated GHG emissions that would be generated by road infrastructure operation and maintenance activities are presented in **Table 22-4**. Annual operational emissions and emissions from major maintenance have been calculated according to the GHG assessment methodology summarised in **section 22.1** and the assumptions and inputs provided in **Appendix W** (Detailed greenhouse gas calculations).

Table 22-4 Road infrastructure operation and maintenance GHG emissions results

Emission source		GHG Emissions			
		Scope 1	Scope 2	Scope 3	Total
Annual operation emissions (t CO_2-e per year)					
Electricity consumption		-	42,621	6,088	48,709
Total maintenance emissions (50 year major maintenance) (t CO_2-e)					
Fuel use (diesel) – mobile plant and equipment		3,271	-	248	3,519
Maintenance materials	Cement	-	-	44	44
	Steel	-	-	406	406
	Aggregate	-	-	2,500	2,500
	Bitumen	-	-	264	264
Total maintenance emissions		3,271	-	3,462	6,733

Annual use of electricity for powering tunnel lighting and ventilation, building services, heating, ventilation and air conditioning (HVAC) systems, surface plants, wastewater treatment, pumps and drainage, communications systems, control systems, computer and safety systems, the emergency response system, operations and maintenance facility, electronic signage and other associated electrical systems would incur 42,621 t CO_2-e indirect Scope 2 emissions and 6,088 t CO_2-e indirect Scope 3 emissions per year.

Emission estimates for the use of fuel and materials for the maintenance of the road pavement are based on one major rehabilitation of asphalt pavement with the top 150 millimetres replaced and five per cent of pavement replaced for patching/repair every 50 years, and five per cent of concrete pavement replaced with only the top layer requiring replacement every 50 years (in accordance with ‘typical’ maintenance activities given in the TAGG Workbook).

The use of fuel and materials to undertake maintenance activities would result in around 3,271 t CO_2-e direct Scope 1 emissions and around 3,462 t CO_2-e indirect Scope 3 emissions. The total quantity of GHG emissions associated with the above road maintenance activities would be about 6,733 t CO_2-e. Averaged over the 50 year period from the commencement of operation, this would generate around 135 t CO_2-e of maintenance emissions per year.

22.4.2 Emissions from vehicles during operation

GHG emissions generated from the operation and maintenance of road infrastructure are relatively small in comparison with the indirect emissions associated with the fuel consumed by vehicles using the road network.

To assess the Scope 3 (indirect downstream) emissions associated with fuel consumed by vehicles using the project, and to evaluate any potential GHG emissions savings as a result of the project, the following operational scenarios, as presented in **Table 22-5**, were considered. Further description of these scenarios is presented in **Appendix W** (Detailed greenhouse gas calculations).

Table 22-5 Traffic modelling scenarios (describing components in the road network for each scenario)

Scenario	Year	Existing road network	WestConnex projects				Sydney Gateway*	NorthConnex	Western Harbour Tunnel (to North Sydney)	Beaches Link (to Seaforth)	F6 Extension
			M4 Widening	M4 East	New M5	M4-M5 Link					
‘Do minimum’ (without project)	2023	✓	✓	✓	✓			✓			
‘With project’		✓	✓	✓	✓	✓		✓			
‘Cumulative’		✓	✓	✓	✓	✓	✓	✓	✓		
‘Do minimum’ (without project)	2033	✓	✓	✓	✓			✓			
‘With project‘		✓	✓	✓	✓	✓		✓			
‘Cumulative’		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Note:

* While the proposed future Sydney Gateway project is not part of the WestConnex program of works, it is considered for the ‘cumulative’ scenarios only as the project is in the early planning stages, with no detailed information available to inform the GHG assessment.

Traffic volumes were modelled for 2023 and 2033 in line with **Appendix H** (Technical working paper: Traffic and transport). These future years were chosen as they provide an indication of road network performance at project opening (2023), and 10 years after opening (2033).

The analysis is based on the vehicle kilometres travelled (VKT) and the average speed of vehicles travelling on key alternative routes within the GHG assessment study area, as generated by the WestConnex Road Traffic Model version 2.3 (WRTM v2.3) ie the strategic traffic model developed and operated by Roads and Maritime.

WRTM v2.3 provides a platform to understand changes in future weekday travel patterns under different land use, transport infrastructure and toll pricing scenarios. Further detail on WRTM v2.3 is provided in **Chapter 8** (Traffic and transport).

The GHG assessment for operational road use involved calculation of the following inputs, using WRTM v2.3 model outputs, industry default factors, current vehicle statistics and fuel intensity projections as detailed in **Appendix W** (Detailed greenhouse gas calculations):

- Average speed for each road link
- VKT for both light and heavy vehicles
- Rate of fuel consumption
- Total fuel quantity
- Fuel quantity by fuel type (eg petrol, diesel, liquid petroleum gas (LPG)).

These inputs were then used to estimate the GHG emissions associated with a change in traffic volumes on the road network within the study area as a result of the project, under different future timeframes and project scenarios as identified in **Table 22-5**. Further detail regarding the calculation of fuel use and GHG emissions is presented in **Appendix W** (Detailed greenhouse gas calculations).

As the project does not replace a single existing route within the road network, the GHG assessment study area boundary was selected to include key routes which currently serve as alternative routes to the project as well as roads within the vicinity that were considered to be influenced by the project.

Key alternative routes within the GHG assessment study area boundary include:

- Parramatta Road between Five Dock and Broadway
- City West Link and Anzac Bridge/Western Distributor
- Victoria Road between Lyons Road and Anzac Bridge
- The Sydney Harbour Bridge and Sydney Harbour Tunnel
- Cahill Expressway and Southern Cross Drive
- The eastern extent of the M4 East Motorway, between Five Dock and the Wattle Street interchange
- The existing M5 East Motorway and New M5 Motorway, between the Princes Highway and General Holmes Drive
- Princes Highway, King Street and City Road, between Rockdale and Ultimo
- Roads surrounding the Wattle Street interchange, the Rozelle interchange, and the St Peters interchange.

Appendix W (Detailed greenhouse gas calculations) provides further detail regarding the GHG assessment study area.

Results of the operational road use assessment are provided in **Table 22-6** and **Appendix W** (Detailed greenhouse gas calculations). **Table 22-6** shows the difference between the total GHG emissions generated in the 'do minimum' (without project) and 'with project' scenarios for both 2023 and 2033. The final column in **Table 22-6** shows the difference between the total GHG emissions generated in the 'do minimum' (without project) and the 'cumulative' scenarios for 2023 and 2033.

Table 22-6 Scope 3 operational road use GHG emissions results

Route	GHG emissions (t CO2-e)						Difference between scenarios (t CO2-e)			
	'Do minimum' (without project)		'With project'		'Cumulative'		'With project' – 'Do minimum'		'Cumulative' – 'Do minimum'	
	2023	2033	2023	2033	2023	2033	2023	2033	2023	2033
Existing road network (within the study area)	9,891,755	11,687,799	9,491,704	11,140,131	9,242,368	10,811,985	-400,052	-547,668	-649,387	-875,814
M4-M5 Link	N/A	N/A	38,471	42,917	46,886	54,686	38,471	42,917	46,886	54,686
Totals	**9,891,755**	**11,687,799**	**9,530,175**	**11,183,048**	**9,289,254**	**10,866,671**	**-361,581**	**-504,751**	**-602,501**	**-821,128**

Note:

Negative values indicate a savings in GHG emissions for the 'with project' and 'cumulative' scenarios compared with the 'do minimum' (without project) scenario.

N/A = not applicable (the 'do minimum' scenario does not include the project).

The results demonstrate the benefits of road tunnel usage in urban areas, where travel along a more direct route at higher average speeds results in fewer GHG emissions being generated by road users, as reduced congestion and stop-start driving reduces the fuel used by vehicles. Despite increases to overall daily VKT on motorways and a reduction in performance of some non-motorway roads (as discussed in **Chapter 8** (Traffic and transport)), a reduction in GHG emissions is estimated as a result of the project compared with the 'do minimum' scenario.

The results for 2023 indicate that the project is forecast to reduce annual GHG emissions by around 361,600 t CO_2-e for the 'with project' scenario and around 602,500 t CO_2-e for the 'cumulative' scenario, within the study area assessed, when compared with the 'do minimum' scenario for 2023. Over time, it is anticipated that the road network performance would improve, as traffic becomes accustomed to changes brought about by the project.

The assessment results indicate that the project is forecast to reduce annual GHG emissions by around 504,750 t CO_2-e in 2033 for the 'with project' scenario and around 821,100 t CO_2-e in 2033 for the 'cumulative' scenario, within the study area assessed, when compared with the 'do minimum' scenario. The predicted reduction in GHG emissions as a result of the project would be due to an improvement in vehicle fuel efficiency for some links within the study area as well as the operational efficiency of the project tunnels.

The magnitude of GHG emissions savings for the 'cumulative' scenario is attributed to, not only an increase in average speeds, but an increase in the number of vehicles shifting off non-motorway roads within the study area as alternative routes become available through the completion of projects such as the proposed future Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

Vehicle fuel efficiency is anticipated to improve as part of the project based on:

- An overall increase in daily VKT and a reduction in daily vehicle hours travelled (VHT) on the road network, with more trips able to be made on the network in a shorter time, primarily associated with traffic using the new motorway
- A decrease in VKT and VHT on key alternative routes and non-motorway roads
- Increased average speeds as a result of the operational efficiency of the M4-M5 Link, which would reduce the number of intersections and the frequency of stopping
- Increased average speeds on key alternative routes (non-motorway roads) within the study area due to reduced congestion.

Mitigation and management measures, including efficiencies incorporated into the project design to reduce energy and resource requirements, and therefore GHG emissions, are provided in **section 22.7**.

22.5 Combined project GHG emissions

The GHG emissions saving for the project of around 361,600 t CO_2-e in 2023 would represent around 0.07 per cent of the Australian national inventory for the year March 2016 to March 2017, and 0.27 per cent of the NSW inventory for 2015, as discussed in **section 22.2.3**.

The GHG emissions saving for the project of around 504,750 t CO_2-e in 2033 would represent around 0.09 per cent of the Australian National inventory for the year March 2016 to March 2017, and 0.38 per cent of the NSW inventory for 2015.

Figure 22-2 shows the nett emissions profile for the project for the assessment years of 2023 and 2033, comparing the emissions estimated to be generated by the project's construction, operation and maintenance with the emissions savings for the 'with project' and cumulative scenarios compared with the 'do minimum' scenario.

Figure 22-2 demonstrates that emissions estimated to be generated during construction and the annual emissions from the operation and maintenance of road infrastructure would result in a nett increase of emissions generated for the project in 2023 for the 'with project' scenario. However, under the 'cumulative' scenario for 2023, emissions generated in construction and annual operation and maintenance would be offset against emissions savings as a result of improved road performance within the study area boundary. Similarly, annual operation and maintenance emissions estimated to be generated in 2033 would be offset against emissions savings for the 'with project' and 'cumulative' scenarios.

Emissions were not able to be extrapolated beyond the operational traffic impact footprint for the project, which was assessed up to 2033. However, it is expected that the savings in emissions from improved road performance would reduce over time as traffic volumes increase.

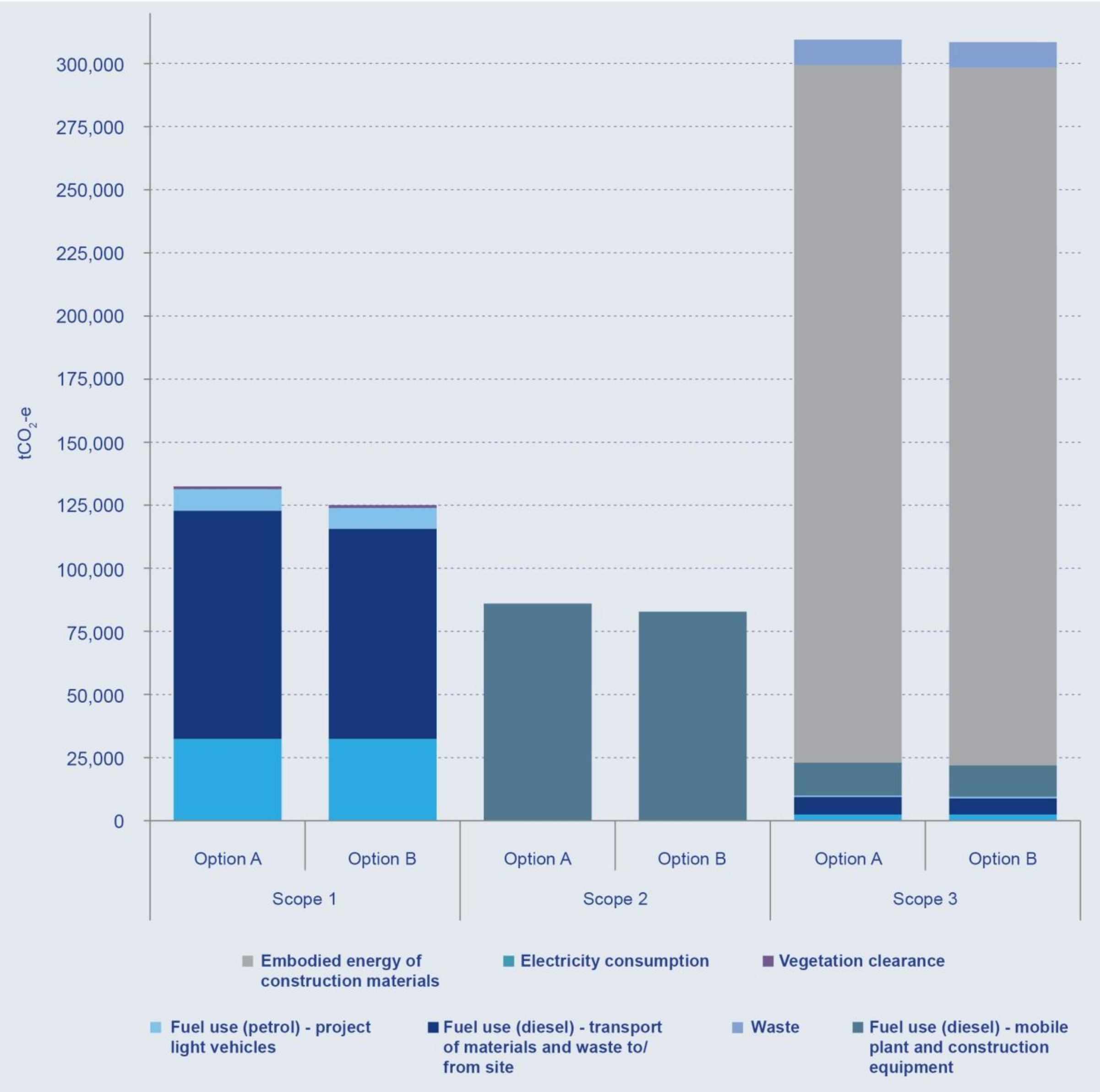

Figure 22-2 Combined GHG emissions profile: construction, operation and maintenance emissions offset against emissions savings

As discussed, the magnitude of GHG emissions savings for the 'cumulative' scenario is likely to be attributed to the reduction of traffic using the existing road network within the study area as alternative routes become available through the completion of projects such as the proposed future Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

22.6 Assessment of cumulative impacts

22.6.1 Cumulative construction emissions

Estimated construction emissions for each WestConnex component project are presented in **Table 22-7**, with a summary of the cumulative emissions for each scope.

Table 22-7 Estimated construction emissions for each WestConnex component project

WestConnex project	GHG emissions (t CO_2.e)			
	Scope 1	Scope 2	Scope 3	Total
M4 Widening	10,195	-	477,340	487,540
M4 East	92,271	65,651	224,157	382,079
New M5	83,709	109,200	280,249	473,158
King Georges Road Interchange Upgrade	2,261	-	7,825	10,085
M4-M5 Link*	132,468	86,017	309,557	528,042
Total	**320,904**	**260,868**	**1,299,128**	**1,880,904**

Note:

* Construction estimate for M4-M5 Link using Option A of construction ancillary facilities at Haberfield (the larger estimate).

Mitigation and management measures would be implemented during each project to reduce GHG emissions during construction. Ongoing monitoring and reporting of project emissions would also be undertaken in accordance with the WestConnex Sustainability Strategy (Sydney Motorway Corporation 2015), as discussed in **Chapter 27** (Sustainability).

22.6.2 Cumulative operational emissions

The assessment of operational road use emissions for each component of the WestConnex program of works was undertaken for a discreet study area as relevant to each project component. The individual study areas were assessed for differing operational timeframes and assesses the changes in traffic performance brought about by each project component within their respective GHG study area boundaries. As a result, it was not appropriate to add these together to quantitatively assess the cumulative emissions of the WestConnex program of works as a whole.

However, results for each of the GHG assessments undertaken for EISs of the individual WestConnex component projects show greater emissions savings in the ‘cumulative’ scenario compared with the ‘project only’ scenario within their respective study area boundaries. This is associated with WestConnex’s contribution to improved traffic flow on the motorway network and additional network capacity and improvements proposed as part of future projects such as Sydney Gateway, Western Harbour Tunnel, Beaches Link and the F6 Extension.

These results align with the cumulative assessment presented in **Appendix H** (Technical working paper: Traffic and transport), which shows greater reductions in daily VKT and VHT for the ‘cumulative’ scenario compared with the ‘with project’ and ‘do minimum’ scenarios for key alternative routes and non-motorway roads, and a reduced daily VHT for the ‘cumulative’ scenario for motorways.

Despite increases to overall daily VKT on motorways, improvements to traffic flow and congestion are achieved through increased speeds and reduced frequency of stopping, as well as reduced daily VKT and VHT on alternative routes and non-motorway roads, which results in improved fuel efficiency and subsequently reduced GHG emissions associated with road use. Future improvements in vehicle fuel efficiency are also taken into account, as described in **Appendix W** (Detailed greenhouse gas calculations). It is expected that savings in emissions from improved road performance would reduce over time as traffic volumes increase.

22.7 Management of impacts

22.7.1 Management of emissions through design

The design of the project has been optimised such that measures to reduce energy and resource requirements, and therefore GHG emissions, are inherent in the design. Design development from the M4-M5 Link preliminary design, as discussed in **Chapter 4** (Project development and alternatives), has been optimised to include:

- Refinement and revision of the alignment of the mainline tunnels, reducing the length of the mainline tunnels between the Wattle Street interchange and the St Peters interchange, thereby reducing the volume of spoil generated, materials used, lighting and ventilation required, and emissions generated from operational road use by vehicles
- Reduced energy and resource consumption, and spoil generation, during tunnel excavation, through selection of roadheaders and drill and blast for excavation, as opposed to the use of a tunnel boring machine. The latter option consumes more electricity, potable water and concrete, and generates more spoil
- Reduced energy and resource consumption through an LED lighting design. The design significantly reduces the number of fittings required in comparison to similar existing NSW tunnels which use end-to-end fluorescent fittings or high-pressure sodium lights. When compared to interior zone tunnel high-pressure sodium lights, as used on the East Link and Airport Link, the number of fittings can be reduced with LED lights as they can be oriented to spread the light evenly whilst meeting lighting standards. LED light banks also have a longer operational life and lower operational power demand
- Reduced power consumption through the design of the ventilation system, which incorporates low pressure fans that consume about 50 per cent less energy compared with a high pressure fan solution. These low pressure fans are oriented vertically which also reduces the total ventilation structural footprint by 20 to 30 per cent, reducing the amount of embodied energy associated with construction materials used
- Optimal tunnel ventilation power consumption by locating the ventilation facilities close to the main alignment tunnel portals, thereby optimising the piston generated vehicle effect
- Mainline tunnels and the associated surface road network designed for long term performance and durability of materials, increasing asset design lives and reducing the frequency of maintenance activities
- The project would facilitate improvements to pedestrian and cyclist paths, linking existing active transport networks with new connections at Rozelle and St Peters, and reducing the need for reliance on road transport between these communities.

22.7.2 Next steps for emissions reduction

Table 22-8 provides a list of mitigation measures to be incorporated during the construction and operation of the project, in accordance with the WestConnex Sustainability Strategy, to further reduce the GHG emissions generated by the project.

Table 22-8 Environmental management measures - GHG

Impact	No.	Environmental management measures	Timing
Construction			
Emission of greenhouse gases during construction	GHG1	An Energy Efficiency and Greenhouse Gas Emissions Strategy and Management Plan will be prepared for the project as part of the project's Sustainability Management Plan and will be implemented to assist in achieving 'Design' and 'As Built' ratings of Excellent under the Infrastructure Sustainability Council of Australia infrastructure rating tool.	Construction

Impact	No.	Environmental management measures	Timing
	GHG2	Undertake an updated GHG assessment based on detailed design for ongoing monitoring and review of emissions during construction.	Construction
	GHG3	Opportunities to use low emission construction materials, such as recycled aggregates in road pavement and surfacing, and cement replacement materials will be investigated and incorporated where feasible and cost-effective.	Construction
	GHG4	Construction plant and equipment will be operated and maintained to maximise efficiency and reduce emissions, with construction planning used to minimise vehicle wait times and idling onsite and machinery turned off when not in use.	Construction
	GHG5	Locally produced goods and services will be procured where feasible and cost effective to reduce transport fuel emissions.	Construction
	GHG6	At least 20 per cent of construction energy required for the project will be sourced from an accredited GreenPower energy supplier, where possible. Six per cent of construction electricity requirements will be offset, with any offset undertaken in accordance with the Australian Government National Carbon Offset Standard	Construction
Operation			
Emission of greenhouse gases during operation	OGHG7	The tunnel will be designed with appropriate vertical alignments and grades to allow vehicles to maintain constant speeds and minimise fuel use to reduce potential greenhouse gas emissions.	Construction and operation
	OGHG8	Energy efficiency will be considered during the design of mechanical and electrical systems such as the tunnel ventilation system, tunnel lighting, water treatment systems and electronic toll and surveillance systems. Energy efficient systems will be installed where reasonable and practicable.	Operation
	OGHG9	At least six per cent of operational energy required for the project will be sourced from an accredited GreenPower energy supplier and/or through renewable energy generated onsite. Opportunities for operational energy offset, in accordance with the Australian Government National Carbon Offset Standard, will be considered during detailed design.	Operation