# 22 Greenhouse gas

This chapter outlines the legislative and policy framework for the control of greenhouse gas emissions. It provides an assessment of the contributions of the project to climate change, due to the release of greenhouse gas emissions during the construction and operation stages of the project and provides recommended mitigation measures to reduce greenhouse gas emissions. There are no requirements of the Secretary of the Department of Planning and Environment that are relevant for this environmental assessment.

Greenhouse gases 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 greenhouse gases into the atmosphere are caused by both natural processes (eg forest fires) and human activities (eg burning of fossil fuels to generate electricity).

Since the industrial revolution there has been an increase in the amount of greenhouse gases emitted from human activities which increased the global concentration of greenhouse gas' in the atmosphere and has led to an increase in the Earth's average surface temperature (IPCC 2013). Further discussion on climate change, including the identification and assessment of climate change risks to the project, is provided in **Chapter 25** (Climate change risk and adaptation).

## 22.1 Assessment methodology

The methodology for this greenhouse gas assessment has been based on relevant greenhouse gas 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, 2015a)
- *Greenhouse Gas Assessment Workbook for Road Projects* (the TAGG Workbook) (Transport Authorities Greenhouse Group (TAGG) 2013).

The TAGG Workbook provides a consistent methodology for estimating the greenhouse gas 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.

### 22.1.1 Greenhouse gas assessment methodology

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

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

**Appendix U** provides a detailed description of the greenhouse gas assessment methodology, including the emissions factors used for emission sources, and detailed calculation methods used to estimate the greenhouse gas emissions from fuel combustion, electricity consumption, vegetation clearing, materials use and the decomposition of waste.

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

### 22.1.2 Greenhouse gas assessment boundary

The assessment boundary defines the scope of greenhouse gas 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 and / or operators of the project and accounts for emissions anticipated to be generated during the construction and operation stages of the project. Although approval is not being sought for ongoing motorway maintenance activities likely to be undertaken during operation of the project, major maintenance activities have been included in the greenhouse gas assessment boundary for completeness. The guiding principles for greenhouse gas accounting and reporting, including an assessment of materiality, are provided in **Appendix U**.

Emissions sources are categorised into the following three ‘scopes’:

- **Scope 1** – direct emissions: greenhouse gas emissions generated by sources owned or controlled by the project. For example emissions generated by the use of diesel fuel by project-owned construction plant, equipment and/ or vehicle.
- **Scope 2** – indirect emissions: greenhouse gas emissions from the consumption of purchased electricity in project-owned or controlled equipment or operations. These greenhouse gas emissions are generated outside of the project’s boundaries, for example the use of electricity purchased from the grid
- **Scope 3** – indirect upstream / downstream emissions: greenhouse gas 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 greenhouse gas emissions associated with the offsite mining, and production and transport of materials used in construction.

**Table 22-1** summarises the emission sources and activities considered within the project’s greenhouse gas 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 | Scope 2 | Scope3 |
| **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 and site offices | | ✓ | ✓ |
| Vegetation removal | Clearance of vegetation as a result of the project | ✓ | | |
| Materials | Embodied energy of construction materials | | | ✓ |
| 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.

The project does not include ongoing motorway maintenance activities during operation as these would be subject to separate assessment and approval. However, in line with the guiding principle of 'completeness' for greenhouse gas reporting and to provide an assessment of the 'whole of life' of the project, an estimate of emissions from major maintenance activities has been included in the greenhouse gas assessment boundary.

The project includes the closure of the Alexandria Landfill, including landform works to facilitate the construction of the St Peters interchange and upgrade of the existing leachate, and landfill gas management systems. At this stage, options for the ongoing management of landfill gas are still being considered and would be investigated as part of detailed design. A qualitative assessment of landfill gas emissions has been undertaken as part of this greenhouse gas assessment to identify the potential sources of emissions associated with the use of the Alexandria Landfill site and the ongoing management of landfill gas post closure.

## 22.2 Existing environment

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 greenhouse gas 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 greenhouse gas 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.

The Australian Government recently announced it is committed to a target of reducing greenhouse gas 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 Government has submitted this new target to the UNFCCC as its intended nationally determined contribution to the proposed new agreement to be negotiated at United Nations Climate Change Summit held in Paris in December 2015.

### 22.2.1 Policy Setting

The Emissions Reduction Fund, as part of the Direct Action Plan, aims to reduce Australia's greenhouse gas emissions by creating positive incentives to adopt better technologies and practices to reduce greenhouse gas emissions.

In August 2013, the NSW Office of Environment and Heritage (OEH) released the NSW Energy Efficiency Action Plan (OEH, 2013a), which provides a strategic management approach to improving energy efficiency, with a target for annual energy savings of 16,000 gigawatt-hours by 2020.

The NSW Government Resource Efficiency Policy (OEH, 2014a) '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, 2012a) (Transport Master Plan) includes an objective to 'Improve sustainability – by maintaining and optimizing 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 greenhouse gas emissions from the NSW transport sector.'

In addition the Environment and Sustainability Policy Framework (Transport for NSW, 2013f) includes an energy management objective ‘To use Transport’s energy sources more efficiently and reduce its greenhouse gas emissions’.

### 22.2.2 Greenhouse gas emissions reporting

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

The most recently published Australian National Greenhouse Accounts estimate annual Australian greenhouse gas emissions for the year to March 2015 to be 533.9 Mt $CO_2$-e as reported under the Kyoto Protocol (Department of the Environment, 2015b). For 2013, annual NSW greenhouse gas emissions totalled 146.7 Mt $CO_2$-e (Department of the Environment, 2015c).

The transport sector contributes about 17 per cent of Australia’s total greenhouse gas emissions (Department of the Environment, 2015b). Around 90 per cent of these emissions are 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 have a significant impact on reducing emissions from the transport sector, and for Australia’s overall emissions profile.

## 22.3 Assessment of potential impacts

The data used to estimate the greenhouse gas emissions associated with the project is provided in **Appendix U**. Assumptions have been made, where necessary, to provide a quantitative estimate of emissions.

### 22.3.1 Construction greenhouse gas emissions

It is estimated that the project would generate about 473,200 t $CO_2$-e during construction of the project. The breakdown of emissions by scope is shown in **Figure 22-1** and summarised (with numbers rounded to the nearest hundred tonnes) as:

- 83,700 t $CO_2$-e direct Scope 1 (direct) greenhouse gas emissions
- 109,200 t $CO_2$-e indirect Scope 2 (indirect) greenhouse gas emissions
- 280,300 t $CO_2$-e indirect Scope 3 (indirect upstream/downstream) greenhouse gas emissions.

Key emissions sources for construction are shown in **Table 22-2** and **Figure 22-1**. Detailed greenhouse gas emissions results are provided in **Table U-6** of **Appendix U**.

The results demonstrate that the majority of GHG emissions associated with the construction of the project are attributed to indirect Scope 3 emissions (59 per cent). Direct Scope 1 and indirect Scope 2 emissions account for 18 per cent and 23 per cent of total construction emissions 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 89 per cent (**Figure 22-1**). The use of concrete and, to a lesser extent, asphalt and steel would contribute significantly to the emissions associated with construction materials. 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 the operation of mobile construction plant and equipment contributes the largest proportion of Scope 1 emissions (59 per cent), followed by the consumption of fuel associated with heavy vehicle movements for the haulage of construction materials, spoil and waste (28 per cent).

Mitigation and management measures to reduce greenhouse gas emissions for construction of the project are provided in **Section 22.4**.

**Table 22-2 Construction greenhouse gas emission results**

| Emissions source | | Greenhouse gas emissions (t $CO_2$ e) Scope 1 | Scope 2 | Scope 3 | Total | % of total |
|---|---|---|---|---|---|---|
| Fuel use (diesel) – mobile plant and equipment | | 48,990 | - | 2,501 | **51,492** | 10.9% |
| Fuel use (diesel) – transport of materials and waste to / from site | | 23,134 | - | 1,181 | **24,315** | 5.1% |
| Fuel use (petrol) – project light vehicles | | 9,250 | - | 492 | **9,743** | 2.0% |
| Vegetation clearance | | 2,334 | - | - | **2,334** | 0.5% |
| Electricity consumption | | - | 109,200 | 15,600 | **124,800** | 26.4% |
| Construction materials | Concrete | - | - | 174,511 | **174,511** | 36.9% |
| | Cement | - | - | 3,280 | **3,280** | 0.7% |
| | Steel | - | - | 51,870 | **51,870** | 11.0% |
| | Aggregate | - | - | 2,450 | **2,450** | 0.5% |
| | Asphalt | - | - | 7,830 | **7,830** | 1.7% |
| | Copper | - | - | 1,030 | **1,030** | 0.2% |
| | Plastic | - | - | 6,003 | **6,003** | 1.3% |
| | Water | - | - | 2,100 | **2,100** | 0.4% |
| Waste | Construction and demolition waste | - | - | 11,400 | **11,400** | 2.4% |
| **Total** | | **83,709** | **109,200** | **280,249** | **473,158** | 100% |
| **% of total** | | **18%** | **23%** | **59%** | **100%** | |

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

The results demonstrate that the majority of greenhouse gas emissions associated with the construction of the Operational greenhouse gas emissions

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

- Road infrastructure operation: the annual use of electricity for powering tunnel lighting and ventilation, communications systems, control systems, computer and safety systems, the emergency response system, the motorway control centre, 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 New M5 during operation: use of the New M5 during operation by future traffic between the St Peters interchange and theM5 East Motorway / King Georges Road interchange, as well as the potential changes to traffic volumes on alternative parallel routes within the study area.

The greenhouse gas assessment results are presented in the following sections. The emission source data, and assumptions used to estimate the greenhouse gas emissions associated with operation and maintenance of the project, are provided in **Appendix U**.

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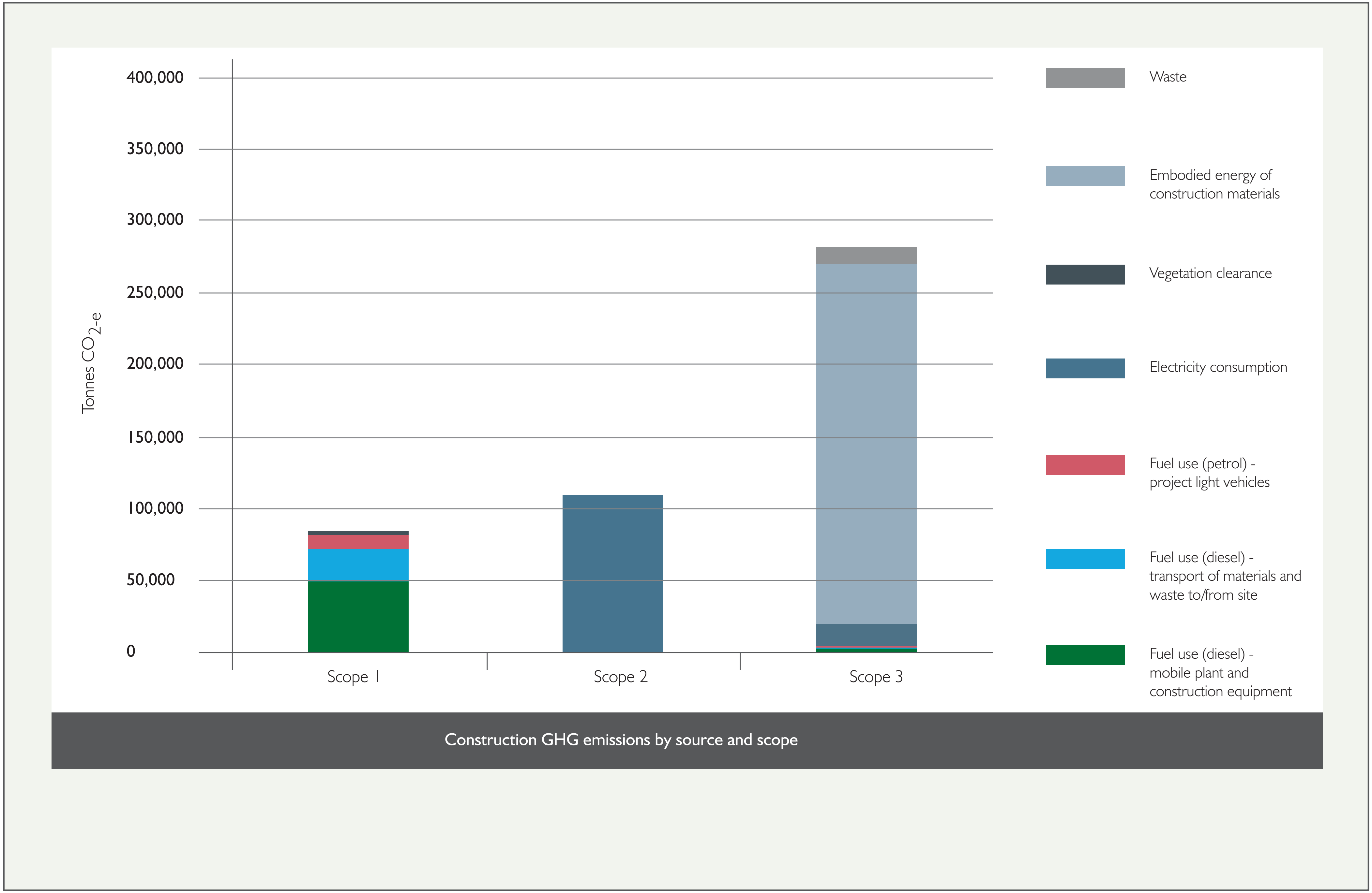


**Figure 22-1 Construction GHG Emissions by scope and emission source**

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### Emissions from road infrastructure operation and maintenance

The estimated greenhouse gas emissions that would be generated by road infrastructure operation and maintenance activities are presented in **Table 22-3**. Annual operational emissions and emissions from major maintenance have been calculated according to the greenhouse gas assessment methodology summarised in **Section 22.1** and the assumptions and inputs provided in **Appendix U**.

**Table 22-3 Road infrastructure operation and maintenance greenhouse gas emissions results**

| Emission source | | Greenhouse Gas Emissions Scope 1 | Scope 2 | Scope 3 | Total |
|---|---|---|---|---|---|
| **Annual operation emissions (t $CO_2$-e per year)** | | | | | |
| Annual electricity consumption of road infrastructure and associated management systems | Lights | - | 1914 | 273 | 2188 |
| | Jet Fans | - | 2995 | 428 | 3422 |
| | Vent Fans Kingsgrove | - | 3898 | 557 | 4454 |
| | Vent Fans Bexley | - | 759 | 108 | 867 |
| | Local control centre | - | 1104 | 158 | 1261 |
| | Water treatment plant | - | 552 | 79 | 631 |
| | Pumps | - | 2872 | 410 | 3282 |
| | Vent fans Golf Course | - | 920 | 131 | 1051 |
| | Vent fans St Peters | - | 6762 | 966 | 7728 |
| | Sub stations & control points | - | 1546 | 221 | 1766 |
| Total annual emissions from operational electricity consumption | | - | 23321 | 3332 | 26,652 |
| **Total maintenance emissions (50 year major maintenance) (t $CO_2$-e)** | | | | | |
| Fuel use (diesel) – mobile plant and equipment | | 5211 | - | 396 | 5606 |
| Maintenance materials | Cement | - | - | 944 | 944 |
| | Steel | - | - | 7991 | 7991 |
| | Aggregate | - | - | 106 | 106 |
| Total maintenance emissions | | 5211 | 0 | 9436 | 14,647 |

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

Annual electricity use of for powering tunnel lighting and ventilation, communications systems, control systems, computer and safety systems, the emergency response system, the motorway control centre, electronic signage and other associated electrical systems would generate around 23,300 t $CO_2$-e indirect Scope 2 emissions and around 3,300 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 the replacement of five per cent of the concrete pavement every 50 years, with only the top concrete layer requiring replacement (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 5,200t $CO_2$-e direct Scope 1 emissions and around 9,400 t $CO_2$-e indirect Scope 3 emissions. The total quantity of greenhouse gas emissions associated with the above road maintenance activities would be about 14,600 t $CO_2$-e. Averaged over the 50 year period from the commencement of operation, this would generate around 300 t $CO_2$-e of maintenance emissions per year.

### Emissions from vehicles during operation

Greenhouse gas emissions generated from the operation and maintenance of road infrastructure are relatively small compared to 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 greenhouse gas emissions savings as a result of the project, the following road use scenarios were considered:

- Base case (2021) without the project:
  - The primary ‘do minimum’ case assumes that the King Georges Road Interchange Upgrade and the M4 Widening projects are complete, but the remainder of the WestConnex program of works and the future Southern extension are not built. It is called ‘do minimum’ rather than ‘do nothing’ as it assumes that infrastructure schemes currently incomplete but scheduled for opening prior to the assessment year are operational
- Base case (2021) with the project:
  - As per the primary 'do minimum' scenario with the project, King Georges Road Interchange Upgrade and the M4 Widening complete and open to traffic, but without any other subsequent components of the WestConnex program of works or the future Southern extension (note: the NSW Government has committed to achieving completion of the project by 2019)
- Future case (2031) without the project:
  - A future network including the WestConnex King Georges Road Interchange Upgrade and the M4 Widening and some upgrades to the broader transport network over time to improve capacity and cater for traffic growth but does not include the remainder of the WestConnex program of works or the future Southern extension
- Future case (2031) with the project:
  - As per the ‘do minimum’ scenario for 2031 with the project, King Georges Road Interchange Upgrade and the M4 Widening complete and open to traffic, but without any other subsequent components of the WestConnex program of works or the future Southern extension (note: the NSW Government has committed to achieving completion of the project by 2019)
- Future (2031) cumulative case:
  - All WestConnex projects complete and the Sydney Gateway and the Southern extension projects also complete and operational (note: the NSW Government has committed to achieving completion of the M4 East project by 2019 and the future M4–M5 Link project by 2023).

Traffic volumes were modelled in line with the traffic and transport assessment provided in **Chapter 9** (Traffic and transport).

Results of the operational road use assessment are provided in **Table 22-4** and **Appendix U**. **Table 22-4** shows the difference between the total greenhouse gas emissions generated in the ‘do minimum’ (without project) and ‘do something’ (with project) scenarios for both 2021 and 2031. The final column in **Table 22-4** shows the difference between the total greenhouse gas emissions generated in the ‘do minimum’ (without project) and the ‘cumulative’ scenarios for 2031.

**Table 22-4 Scope 3 operational road use greenhouse gas emissions results**

| Route | Greenhouse gas emissions (t $CO_2$ e) | | | | | Difference between scenarios (t $CO_2$ e) | | |
|---|---|---|---|---|---|---|---|---|
| | 'Do minimum' (without project) | | 'Do something' (with project) | | 'Cumulative' | 'Do something' 'Do minimum' | | 'Cumulative' 'Do minimum' |
| | 2021 | 2031 | 2021 | 2031 | 2031 | 2021 | 2031 | 2031 |
| Existing road network (within the study area) | 5,924,115 | 7,885,465 | 5,938,768 | 7,532,411 | 5,812,520 | 14,653 | -353,054 | -2,072,945 |
| New M5 | NA | NA | 94,946 | 123,867 | 198,909 | 94,946 | 123,867 | 198,909 |
| **Totals** | **5,924,115** | **7,885,465** | **6,033,714** | **7,656,278** | **6,011,429** | **109,599** | **-229,187** | **-1,874,036** |

Note: negative values indicate a savings in greenhouse gas emissions for the 'do something' (with project) and 'cumulative' scenarios compared with the 'do minimum' (without project) scenario. NA = not applicable (the 'do minimum' scenario does not include the project).

The results for 2021 indicate that the project would generate an additional 109,600 t $CO_2$-e of Scope 3 emissions from fuel use of light and heavy vehicles using roads within the study area, compared with the '2021 without project' scenario.

Over time, it is anticipated that the road network performance would improve, as traffic patterns become accustomed to changes brought about by the project. The results for 2031 demonstrate the benefits of road tunnel usage in urban areas, where travel along a more direct route at higher average speeds results in fewer greenhouse gas greenhouse gas emissions being generated by road users, as reduced congestion and stop-start driving reduces the fuel used by vehicles.

The assessment results indicate that the project would reduce annual greenhouse gas emissions by around 229,200 t $CO_2$-e the future case (2031) with the project scenario and around 1,874,000 t $CO_2$-e in 2031 for the 'cumulative' scenario, within the study area assessed. The predicted reduction in greenhouse gas emissions as a result of the project would be due to an improvement in vehicle fuel efficiency for most links within the study area as well as the operational efficiency of the project tunnels.

The magnitude of greenhouse gas emissions savings for the future 'cumulative' scenario is likely to be attributed, not only to an increase in average speeds, but to a reduction in the number of vehicles utilising roads within the study area as alternate routes become available through the completion of subsequent WestConnex projects and projects and the future Southern extension. This conclusion is consistent with the future forecast traffic performance of the study area as identified in Technical Working Paper: Traffic and transport (**Appendix G**).

Forecast changes in daily road-based freight, heavy vehicle movements and general traffic movements, show large daily volumes forecast for the M4 East, the future M4-M5 Link and the future Sydney Gateway to Sydney Airport. Reductions are forecast for the existing M5 East Motorway, King Georges Road between the M4 East and the M5 East Motorway, Southern Cross Drive, Princes Highway, Parramatta Road and the City West Link, as well as other regional roads, compared to the 2031 'with project' scenario, i.e. just the New M5. The shift of vehicles to the surrounding road network is less under the 'full WestConnex and southern extension' scenario than in the 'with project' scenario, i.e. just the New M5, as drivers realise the benefits of the full WestConnex network.

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

- Increased average speeds on key parallel routes within the study area due to reduced congestion
- Increased average speeds as a result of the operational efficiency of the New M5 tunnels, which would minimise the number of intersections and the frequency of stopping
- Reduced length of travel between the St Peters interchange and the M5 East Motorway / King Georges Road interchange.

Mitigation and management measures, including efficiencies incorporated into the project design to reduce energy and resource requirements, and therefore greenhouse gas emissions, are provided in **Section 22.4**.

### Combined greenhouse gas emissions

The additional greenhouse gas emissions of around 109,600 t $CO_2$-e generated by the project in the 'base case (2021) with project' scenario for 2021 would represent around 0.02 per cent of the Australian national inventory for the year ending March 2015, and 0.07 per cent of the NSW inventory for 2013, as discussed in **Section 22.2**.

The greenhouse gas emissions saving of 229,200 t $CO_2$-e in the year 2031 under the future case (2031) with project scenario would represent around 0.04 per cent of the Australian National inventory for 2015, and 0.16 per cent of the NSW inventory for 2013.

**Figure 22-2** shows the combined emissions profile for the project, from the completion of construction in 2019 to the operational road use in 2031. **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 be offset against emissions savings as a result of improved road performance. Emissions were not able to be extrapolated beyond the operational traffic impact footprint for the project, which was assessed up to 2031. However, it is expected that the savings in emissions from improved road performance would reduce over time as traffic volumes increase.

As discussed, the magnitude of greenhouse gas 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 alternate routes become available through the completion of subsequent future WestConnex projects and such as the future Southern extension.

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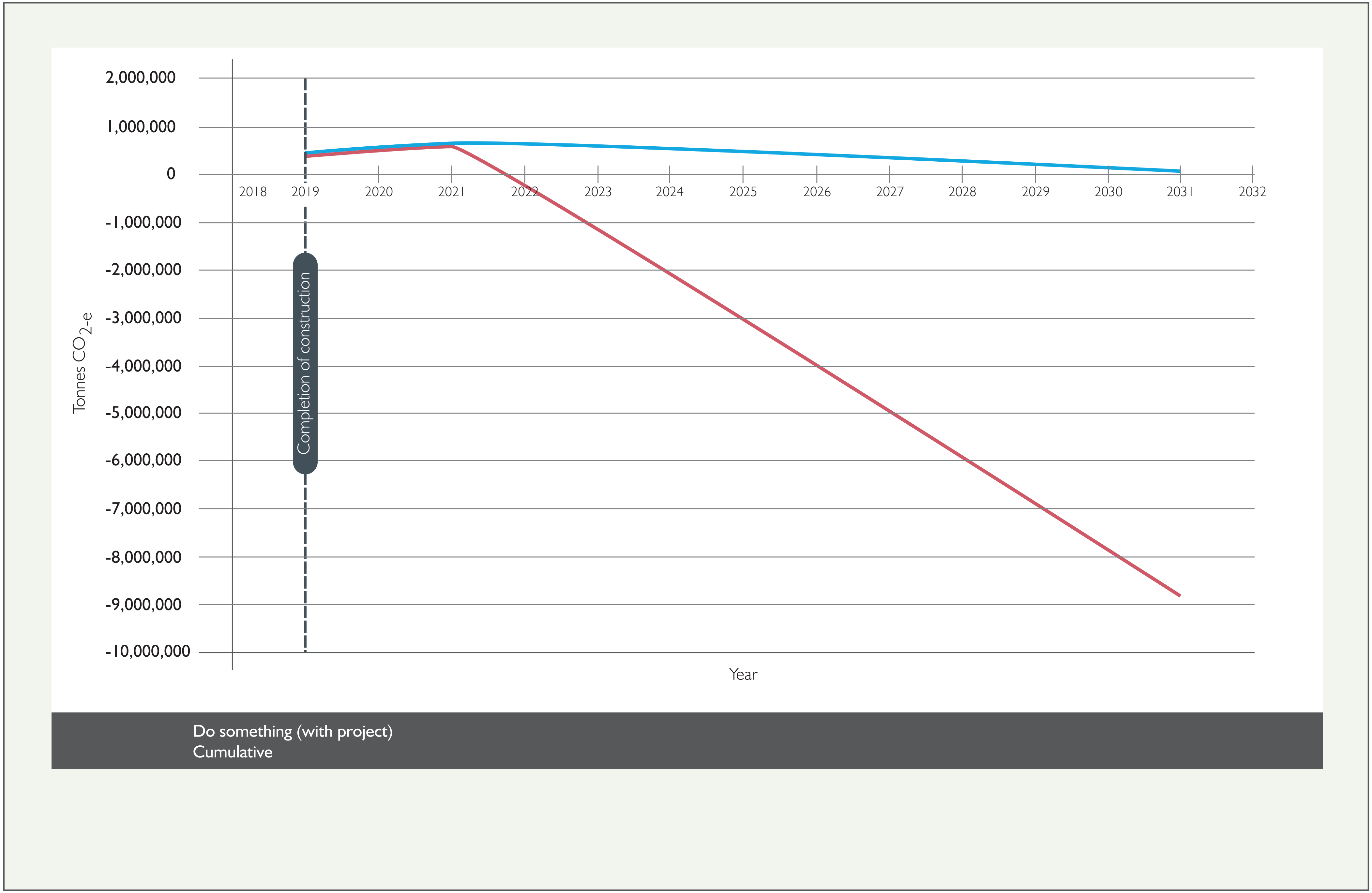


**Figure 22-2 Combined greenhouse gas emissions profile: construction, operation and maintenance emissions offset against emissions savings**

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## 22.3.2 Emissions associated with the Alexandria Landfill

Landfill gas is generated when organic waste within a landfill decomposes. The volumetric composition of the gas produced is approximately 50 per cent methane, 38 per cent carbon dioxide, and 12 per cent other gases (Warnken ISE, 2007).

Landfill gas emissions are considered anthropogenic as human activities create the anaerobic conditions which cause the decomposition of organic waste, when waste is buried and contained in an unnaturally low oxygen environment. Methane generation from waste in landfill is therefore required to be assessed as part of a greenhouse gas assessment under the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth). Carbon dioxide emitted as landfill gas is not considered in the assessment of greenhouse gas as it is considered to be part of the natural carbon cycle, and would be emitted from the decomposition of organic materials regardless of human intervention.

The anaerobic decomposition of waste varies depending on the composition of waste within the landfill and is influenced by local climate conditions. Landfill gas is not generated immediately at the time of disposal of the waste. Legacy landfill gas emissions can therefore continue to be generated post-closure of the landfill, requiring the ongoing management of landfill gas (Warnken ISE, 2007).

### Qualitative assessment of greenhouse gas emissions for the Alexandria landfill

A qualitative assessment of landfill gas emissions has been considered within the greenhouse gas assessment boundary as the closure and remediation of the Alexandria landfill forms part of the project.

The Alexandria Landfill site was acquired by the NSW Government in December 2014 and the operations of the previous landowner ceased at that time. Activities consistent with the existing planning approvals are continuing on site. The Alexandria landfill was historically operated as a non-putrescible landfill, waste recycling and storage facility, accepting the following waste streams:

- Non-putrescible household waste
- Demolition and construction waste
- Solid industrial and commercial waste
- Incinerated and unincinerated green waste
- Incinerator ash from the former Waverly Woollahra Process Plant
- Shredded tires
- Asbestos.

An overview of Alexandria landfill gases is provided in **Chapter 17** (Contamination), with further detail provided in Technical working paper: Contamination (**Appendix O**).

Works to facilitate the closure and remediation of the Alexandria landfill facility would include:

- Bulk earthworks to prepare the site for construction of the St Peters.
- Installation of a capping layer
- Installation of a cut off wall to minimise inflow from the Botany Sands aquifer
- Augmentation of the existing leachate management system
- Installation of a landfill gas collection and management system

As part of the landfill closure works, a gas collection and management system would be installed, comprising both active and passive components. It is anticipated that the collected gas will be treated through flaring, but other control measures, such as the use of biological treatment to convert methane to carbon dioxide, would be considered as part of detailed design. Not all landfill gas would be able to be captured by the gas collection system, and some fugitive emissions of landfill gas are anticipated to continue to be emitted. The management of landfill gases throughout construction and operation of the project is described in more detail in the Alexandria Landfill Closure Management Plan provided in **Appendix F**.

**Table 22-5** summarises the emission sources and activities considered likely to be generated during the closure, remediation and ongoing management of the Alexandria landfill, according to scope.

**Table 22-5 Greenhouse gas emission sources and activities associated with Alexandria landfill**

| Emission source category | Emission source | Emission scope | | |
|---|---|---|---|---|
| | | Scope 1 | Scope 2 | Scope3 |
| **Construction** | | | | |
| Landfill gas | Fugitive emissions of legacy landfill gas (methane) | ✓ | | |
| Fuel use | Mobile construction equipment | ✓ | | ✓ |
| | Site vehicles | ✓ | | ✓ |
| | Delivery of plant, equipment and materials | | | ✓ |
| Materials | Embodied energy of materials required for landform reshaping works, capping of landfill and installation of new leachate, groundwater and gas management systems | | | ✓ |
| **Operation and maintenance** | | | | |
| Landfill gas | Fugitive emissions of legacy landfill gas (methane) | ✓ | | |
| | Emissions from treatment of landfill gas through flaring, biological treatment or other gas management system(s) | ✓ | | |
| Electricity consumption | Electricity used to power the upgraded leachate treatment plant, gas collection and management system and other associated environmental control systems | | ✓ | ✓ |

Given that the Alexandria landfill was operated as a non-putrescible landfill, the quantity of methane produced under the anaerobic conditions of the landfill and the subsequent fugitive emissions of landfill gas are anticipated to be lower than that of a general solid waste (putrescible) facility (Warnken ISE, 2007). The proportion of inert materials such as glass, steel, concrete and plastic is likely to be higher, with no putrescible material such as organic food waste within the landfill. The composition of the waste and the lower amount of degradable organic carbon in the landfill is therefore anticipated to result in a lower quantity of methane produced. Further assessment of the potential methane generation from the Alexandria Landfill would be undertaken during detailed design.

Ongoing monitoring of the Alexandria Landfill would be undertaken in accordance with the relevant requirements outlined in the existing consents and trade waste agreement.

A Landfill Closure Management Plan has been developed in accordance with the requirements of the *Protection of the Environment Operations Act 1997* and is provided in **Appendix F**. The Landfill Closure Management Plan outlines the key landfill closure activities and document the proposed landform, capping detail, leachate and gas management and monitoring protocols to be adopted for the landfill closure process. The Landfill Closure Management Plan has been prepared in consultation with the NSW Environment Protection Authority and the Site Auditor, accredited under the *Contaminated Land Management Act 1997* and all landfill closure works would be carried out in accordance with the final approved Landfill Closure Management Plan.

Further detail regarding the closure of the Alexandria Landfill is provided in **Section 5.9** (Landfill closure infrastructure).

## 22.4 Environmental management measures

The design of the project has been optimised such that measures to reduce energy and resource requirements, and therefore greenhouse gas emissions, are inherent in the design. The project design has been optimised to:

- Reduce energy and resource consumption, and spoil generation during tunnel excavation, by selecting to excavate the main alignment tunnels using roadheader and drill and blast methods, instead of use of a tunnel boring machine which would consumes more electricity, potable water and concrete, and generate more spoil
- Reduce 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 (EastLink) motorway in Melbourne and the Airport Link, the number of fittings can be reduced by using LED lights as they can be oriented to spread the light evenly while meeting lighting standards. LED light banks also have a longer life expectancy and decrease the operational power demand.
- Reduce power consumption through the design of the ventilation system, which incorporates low pressure fans that consume around 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 20-30 per cent, reducing the amount of embodied energy.
- Reduce power consumption associated with tunnel ventilation by locating the ventilation facilities close to the main alignment tunnel portals thereby optimising the piston effect generated by vehicles moving through the main alignment tunnels.

**Table 22-6** provides a list of mitigation measures to further reduce the greenhouse gas emissions generated by the project.

**Table 22-6 Environmental management measures**

| Impact | No. | Environmental management measures | Timing |
|---|---|---|---|
| **Construction** | | | |
| Emission of greenhouse gases during construction | GHG1 | Prepare a Greenhouse Gas Emissions Strategy and Management Plan for the project. | Detailed design |
| | GHG2 | Undertake an updated greenhouse gas assessment based on detailed design. | Detailed design |
| | GHG3 | The emissions intensity of significant construction materials specified in the design of the project would be assessed and, where feasible and in compliance with technical specifications, low emission construction materials would be used. | Detailed design |
| | GHG4 | Where feasible, recycled content road construction materials such as recycled aggregates in road pavement and surfacing, or similar, would be used. | Detailed design |

| Impact | No. | Environmental management measures | Timing |
|---|---|---|---|
| | GHG5 | The fuel efficiency of construction plant and equipment would be assessed before selection and, where feasible and reasonable, equipment with the highest fuel efficiency or equipment that uses lower greenhouse gas intensive fuel such as biofuels (eg biodiesel, ethanol) would be used. | Pre-construction and construction |
| | GHG6 | Project planning would be undertaken to ensure that the site vehicle movements and construction activities are efficient, to avoid double handling of materials and unnecessary fuel use where possible. | Detailed design |
| | GHG7 | Locally produced goods and services would be procured where feasible and cost effective to reduce transport fuel emissions. | Detailed design and construction |
| | GHG8 | At least six per cent of construction energy required for the project would be sourced where possible from an accredited GreenPower energy supplier | Pre-construction and construction |
| | GHG9 | Where possible, and fit for purpose, spoil would be beneficially re-used within the project before off-site re-use or disposal options are investigated. A spoil management strategy would be developed for the project prior to the commencement of construction and would identify spoil disposal sites and the management of excess spoil. | Pre-construction and construction |
| | GHG10 | Waste would be diverted from landfill, including diversion of spoil, construction and demolition waste, and commercial and industrial waste, where reasonable and feasible. The management of waste would be considered as part of the preparation of the Construction Environmental Management Plan for the project, detailing the appropriate procedures for waste management. | Detailed design and construction |
| **Operation** | | | |
| Emission of greenhouse gases during operation | OpGHG 1 | The main alignment tunnels would be designed to minimise fuel consumed by vehicles using the road, for example through the provision of a vertical alignment that allows consistent vehicle speeds to be maintained. | Detailed design |
| | OpGHG 2 | A life cycle assessment would be undertaken as part of the detailed design in order to select mechanical and electrical systems with increased energy efficiencies, where reasonable and feasible, such as the tunnel ventilation system, tunnel lighting, water treatment systems and electronic toll and surveillance systems. | Detailed design |

| Impact | No. | Environmental management measures | Timing |
|---|---|---|---|
| | OpGHG 3 | Low carbon energy generation options would be investigated as part of the detailed design process in order to reduce the demand on mains electricity and generate renewable energy onsite, where feasible. At least six per cent of energy required for the project would be sourced from an accredited GreenPower energy supplier, where possible. | Detailed design |

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