Environment
Effects Statement

Technical Report R
Greenhouse gas

North East Link

North East Link Environment Effects Statement

Technical report R – Greenhouse gas impact assessment

Prepared for North East Link

April 2019

This publication is prepared to inform the public about the North East Link. This publication may be of assistance to you but the North East Link Project (a division of the Major Transport Infrastructure Authority) and its employees, contractors or consultants (including the issuer of this report) do not guarantee that the publication is without any defect, error or omission of any kind or is appropriate for your particular purposes and therefore disclaims all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

Table of contents

Table index

Figure index

Appendices

Executive summary

This technical report is an attachment to the North East Link Environment Effects Statement (EES). It has been used to inform the EES required for the project, and defines the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives.

Overview

North East Link ('the project') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister for Planning declared North East Link to be 'public works' under Section 3(1) of the Environment Effects Act 1978, which was published in the Victorian Government Gazette on 6 February 2018 (No. S 38 Tuesday 6 February 2018). This declaration triggered the requirement for the preparation of an EES to inform the Minister's assessment of the project and the subsequent determinations of other decision-makers.

The EES was developed in consultation with the community and stakeholders and in parallel with the reference project development. The reference project has been assessed in this EES. The EES allows stakeholders to understand the likely environmental impacts of North East Link and how they are proposed to be managed.

GHD was commissioned to undertake a greenhouse gas impact assessment for the purposes of the EES.

Greenhouse gas context

The scoping requirements for the EES issued by the Minister for Planning set out the specific environmental matters to be investigated and documented in the project's EES, which informs that scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The evaluation objective relevant to the greenhouse gas assessment is:

- To demonstrate that the project will contribute to the need for an effective, integrated and climate change-resilient transport system that provides a wide range of travel choices for all Victorians.

A summary of the key assets, values or uses potentially affected by North East Link, and the associated impacts assessment are summarised below.

Greenhouse gas impact assessment

The purpose of this report is to assess greenhouse gas impacts associated with North East Link to inform the preparation of the EES and EPBC Act assessments required for the project.

Greenhouse gas emissions are a global issue due to their contribution to climate change from a local to global level. Greenhouse gas emissions in Victoria make the same contribution to climate change as emissions in any other part of the world. Consequently, the results of the impact assessment are presented at a whole-of-project level rather than split into the project's key elements.

This report does not seek to assess climate change impacts or adaptation requirements nor to compare North East Link with alternative transport projects. Chapter 8 – Project development describes the strategic alternatives proposed for addressing the transport challenges of North East Link and the evaluation process that was applied during the business case development. During the business case development, the assessment of project options and development of the reference project considered matters relevant to intergenerational equity. This included consideration of energy and water use, greenhouse gas emissions and resilience to climate change in the design of North East Link and minimising ecological impacts from the project's construction and operation. Climate change adaptation measures are described in EES Attachment I – Sustainability approach.

Existing conditions

In alignment with the Kyoto Protocol and its pledge to the United Nations Framework Convention on Climate Change (UNFCCC), under the Cancun Agreement, Australia has a target of reducing emissions to 5 per cent below 2000 levels by 2020 (AGEIS, 2018). This was updated at the Paris Climate Conference to a commitment that Australia will reduce emissions by 26 to 28 per cent of 2005 levels by 2030.

The Victorian Government has set a target of net zero emissions by 2050, meaning greenhouse gas emissions will be reduced to the lowest possible amount, and the remaining emissions counteracted (DELWP, 2016).

The AGEIS (2018) reported national emissions for 2016 were 532,971 kt CO_2-e, representing an approximate 3 per cent reduction in emissions since the 2000 total of 551,786 kt CO_2-e.

The AGEIS (2018) total for Victoria in 2016 was 115,103 kt CO_2-e, an approximate 2 per cent reduction since the 2000 Victorian total of 117,757 kt CO_2-e.

Impact assessment boundary

The greenhouse gas impact assessment for North East Link was separated into construction impacts and operational impacts.

The assessment estimated greenhouse gas emissions associated with the following construction activities:

- Fuel consumption for:
  - The operation of construction plant and equipment
  - Site vehicles, the delivery of plant and equipment and materials to site and the transportation of tunnel spoil off-site
- Electricity consumption for plant and equipment including tunnel boring machines (TBM)
- The manufacture of construction materials
- Vegetation clearance.

The assessment estimated greenhouse gas emissions associated with the following operational activities:

- Electricity consumption for tunnel lighting and ventilation, other lighting and signalling
- Fuel consumption from site vehicles and maintenance plant and equipment
- The manufacture of maintenance materials.

Emissions from vehicle traffic using the Melbourne (statistical division) road network including the regional areas of Geelong, Ballarat, Bendigo and Traralgon (this was assessed as a comparison between the 'with project' and 'no project' scenarios).

Assessment methodology

The greenhouse gas impact assessment involved:

- Reviewing the reference project, legislation and policy context at a national, state and local level
- Establishing existing conditions and the study area
- Undertaking an initial risk assessment and identifying initial EPRs
- Undertaking the impact assessment and assessing the need for additional EPRs
- Reviewing the residual risk.

Estimations of greenhouse gas emissions from North East Link's construction and operation were calculated using the following three calculation methods:

- The Carbon Gauge Calculator, supported by the Transport Agencies Greenhouse Gas (TAGG) Workbook
- Manually though Microsoft excel (for tunnel calculations as the Carbon Gauge Calculator can't be used to estimate emissions associated with the construction and operation of tunnels)
- VLC's Zenith Economics Assessment Model (for Scope 3 emissions from road users).

Key findings

Total emissions across the seven-year construction of North East Link were estimated at 2,020 kt CO_2-e. These emissions were dominated by two emission sources; the manufacture of construction materials and electricity consumed by the TBMs. Combined, these two emission sources would contribute 88 per cent of total emissions from North East Link's construction.

On an annualised basis the total calculated greenhouse gas emission for the project's construction would be approximately 289 kt CO_2-e p.a. This represents 0.25 per cent of emissions from all Victorian sectors in 2016 and 0.05 per cent of the national 2016 emissions (AGEIS, 2018).

The largest emission source from the operational phase of the project is from electricity consumed in the operation of the tunnels, which was estimated at 96 per cent of the 84 kt CO_2-e per annum operational (including maintenance) greenhouse gas emissions.

This represents 0.07 per cent of emissions from all Victorian sectors in 2016, and 0.02 per cent of the national 2016 emissions (AGEIS, 2018).

Operational emissions from vehicle traffic were calculated based on comparing the 'with project' and 'no project' scenarios. The 'with project' scenario would reduce greenhouse gas emissions. Model outputs estimate a marginal reduction of 10 kt CO_2-e per annum (0.04 per cent) and 33 kt CO_2-e per annum (0.13 per cent) in emissions in 2026 and 2036 under the 'with project' scenario compared with the 'no project' scenario.

The scale of operational emissions from North East Link would be small in the context of Victoria's overall greenhouse emissions. While operational emissions are not large at the Victorian scale, it is still important they are reduced as far as practicable to help achieve the Victorian Government's 2050 net zero emissions target.

Model results show a more significant reduction in emissions per vehicle kilometre travelled (VKT) under the 'with project' scenario. Emissions per VKT can be seen as a measure of the efficiency of vehicle movement. Reductions of 0.82 per cent and 0.89 cent are estimated for 2026 and 2036 respectively across the road network under the 'with project' scenario. This indicates that North East Link would contribute to more efficient vehicle movement.

Environmental Performance Requirements (EPRs)

Greenhouse gas emissions are associated with planned activities, such as the consumption of electricity in the TBMs and the use of construction materials. The following EPRs were identified to address the largest sources of greenhouse emissions as listed above:

- **EPR SCC1** – North East Link Project must set sustainability targets and specify ratings to be achieved under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool. Contractors must develop and implement a Sustainability Management Plan that considers measures to meet, as a minimum, the sustainability targets and specified ratings.
- **EPR SCC2** – Integrate sustainable design practices into the design process to minimise, to the extent practicable, greenhouse gas emissions arising from construction, operation and maintenance of North East Link.
- **EPR SCC3** – Best practice measures for energy usage are to be applied for the tunnel ventilation and lighting systems in accordance with the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry).

Structure of the EES

Abbreviations

Abbreviation	Definition
AGEIS	Australian Greenhouse Emissions Information System
AQM	Air Quality Management
EAM	Zenith Transport Model Economic Assessment Model
EES	Environment Effects Statement
EP Act 2017	*Environment Protection Act 2017 (Vic)*
EP Act 1970	*Environment Protection Act 1970 (Vic)*
EPR	Environmental Performance Requirement
NELP	North East Link Project
NGA Factors	National Greenhouse Accounts Factors
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NGER Measurement Determination	*National Greenhouse and Energy Reporting (Measurement) Determination 2008*
NGER Regulations	*National Greenhouse and Energy Reporting Regulations 2008*
PEM	Protocol for Environmental Management
SEPP	State Environment Protection Policy
TAGG	Transport Authorities Greenhouse Group
TBM	Tunnel boring machine
UNFCCC	United Nations Framework Convention on Climate Change
VLC	Veitch Lister Consulting

1. Introduction

1.1 Purpose of this report

North East Link ('the project') is a proposed new freeway-standard road connection that would complete the missing link in Melbourne's ring road, giving the city a fully completed orbital connection for the first time. North East Link would connect the M80 Ring Road (otherwise known as the Metropolitan Ring Road) to the Eastern Freeway, and include works along the Eastern Freeway from near Hoddle Street to Springvale Road.

The Major Transport Infrastructure Authority (MTIA) is the proponent for North East Link. The MTIA is an administrative office within the Victorian Department of Transport with responsibility for overseeing major transport projects.

North East Link Project (NELP) is an organisation within MTIA that is responsible for developing and delivering North East Link. NELP is responsible for developing the reference project and coordinating development of the technical reports, engaging and informing stakeholders and the wider community, obtaining key planning and environmental approvals and coordinating procurement for construction and operation.

On 2 February 2018, the Minister declared the works proposed for North East Link as Public Works and issued a decision confirming that an Environment Effects Statement (EES) is required for the project due to the potential for significant environmental effects.

Similarly, the project was referred to the Australian Government's Department of the Environment and Energy on 17 January 2018. On 13 April 2018 the project was declared a 'controlled action', requiring assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999 (Vic)* ('EPBC Act'). Separate to this EES, a Public Environment Report (PER) is required to be prepared to satisfy the EPBC Act requirements, and assess the impacts of the project on Commonwealth land and matters of national environmental significance (MNES).

The purpose of this report is to assess the potential greenhouse gas impacts associated with North East Link to and to define the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives.

1.2 Why understanding greenhouse gas emissions is important

Changes to the climate have been observed globally, including increased atmospheric and sea-surface temperatures, increased sea levels, increased water vapour in the atmosphere, and decreased sea and glacier ice. In Australia, climate change affects temperature, rainfall, snow, tropical cyclones, and fire weather. The increase of atmospheric CO_2 concentrations since 1750 is the largest contributing factor to global climate change (CSIRO, 2016).

The construction and operation of North East Link would involve activities that generate CO_2 and other greenhouse gases. It is important to quantify greenhouse gas emissions from North East Link to understand the scale at which it contributes to broader emissions. Management of activities to reduce greenhouse gas emissions is important in the efforts to reduce our national and global emissions, and reduce the effects of climate change in the future.

2. EES scoping requirements

2.1 EES evaluation objectives

The scoping requirements for the EES, released by the Minister for Planning, set out the specific environmental matters to be investigated and documented in the project's EES, which informs the scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of constructing and operating the project.

The following evaluation objective is relevant to the greenhouse gas assessment:

- To demonstrate that the project will contribute to the need for an effective, integrated and climate change-resilient transport system that provides a wide range of travel choices for all Victorians.

While North East Link's construction would generate greenhouse gases, largely from construction of the tunnels, the project would also generate benefits for Victorians. For example, it would reduce traffic congestion and the tunnels would reduce the need to acquire properties to construct the project.

Environmental Performance Requirements (EPRs) have been developed for the project to reduce the amount of greenhouse gases emitted, so that North East Link could most effectively contribute to an effective integrated and climate change-resilient transport system for Victoria.

This evaluation objective for greenhouse gases is also addressed in Technical report A – Traffic and transport, which describes how North East Link would promote an integrated transport system with a more efficient road network that includes improvements to the Doncaster Busway and the walking and cycling network.

During the business case development, the assessment of project options and development of the reference project considered matters relevant to intergenerational equity. This included the consideration of energy and water use, greenhouse gas emissions and resilience to climate change, and minimising ecological impacts due to the project's construction and operation. Further consideration of climate resilience has continued throughout the design and planning of North East Link, which is presented in EES Attachment I – Sustainability approach.

2.2 EES scoping requirements

The aspects from the scoping requirements relevant to the greenhouse gas evaluation objective are shown in Table 2-1, as well as the location where these items have been addressed in this report.

Table 2-1 Scoping requirements relevant to greenhouse gas

Aspect	Scoping requirement	Section addressed
Key issues	The need to consider the commitment to achieve a climate resilient community and economy with net zero emissions by 2050 in designing and assessing the project.	Executive summary State legislation: Section 4.2.2 Sustainability approach: EES Attachment I *Also refer to North East Link Business Case*

Aspect	Scoping requirement	Section addressed
Design and mitigation measures	Describe the proposed approach to design, construction methods, materials and equipment to reduce energy use, including vehicle emissions, during construction and operation over the life of the project.	Impact assessment: Section 8 Environmental Performance Requirements: Section 9
Assessment of likely effects	Evaluate the greenhouse gas emissions associated with the design, construction and operation of the project in accordance with *Greenhouse Gas Assessment Workbook for Road Projects* (TAGG) and the *Australian National Greenhouse Accounts Factors*.	Impact assessment: Section 8
	Evaluate compliance with the policy principles and provision of SEPP Air Quality Management related to energy efficiency and greenhouse gas emissions.	Method: Section 5 Environmental Performance Requirements: Section 9 *Also refer to EES Attachment V – Works Approval Application*
	Identify the contribution to the State's transport greenhouse gas emissions with reference to projections in 2050.	Operational emissions from vehicle traffic: Section 8.3
Approach to manage performance	Describe the environmental performance requirements to set greenhouse gas generation outcomes that the project must achieve.	Environmental Performance Requirements: Section 9

2.3 Linkages to other reports

This report relies on or informs the technical assessments as indicated in Table 2-2.

Table 2-2 Linkages to other technical reports

Specialist report	Relevance to this impact assessment
Technical report A – Traffic and transport	Greenhouse gas emissions associated with vehicle traffic across the Melbourne road network, including the regional areas of Geelong, Ballarat, Bendigo and Traralgon, for the 'with project' and 'no project' scenarios were estimated from the VLC traffic modelling.
Technical report B – Air quality	Greenhouse gas emissions associated with the consumption of electricity to operate North East Link's tunnel ventilation system have been included in this report.
Technical report C – Surface noise and vibration	Greenhouse gas emissions associated with the embodied energy of noise walls installed to mitigate impacts from the operation of North East Link have been included in this report.
Technical report Q – Ecology	Greenhouse gas emissions associated with the removal of vegetation during construction of North East Link have been included in this report.

3. Project description

3.1 Overview

The North East Link alignment and its key elements assessed in the Environment Effects Statement (EES) include:

- **M80 Ring Road to the northern portal** – from the M80 Ring Road at Plenty Road, and the Greensborough Bypass at Plenty River Drive, North East Link would extend to the northern portal near Blamey Road utilising a mixture of above, below and at surface road sections. This would include new road interchanges at the M80 Ring Road and Grimshaw Street.
- **Northern portal to southern portal** – from the northern portal the road would transition into twin tunnels that would connect to Lower Plenty Road via a new interchange, before travelling under residential areas, Banyule Flats and the Yarra River to a new interchange at Manningham Road. The tunnels would then continue to the southern portal located south of the Veneto Club.
- **Eastern Freeway** – from around Hoddle Street in the west through to Springvale Road in the east, modifications to the Eastern Freeway would include widening to accommodate future traffic volumes and new dedicated bus lanes for the Doncaster Busway. There would also be a new interchange at Bulleen Road to connect North East Link to the Eastern Freeway.

These elements are illustrated in Figure 3-1.

The project would also improve existing bus services from Doncaster Road to Hoddle Street through the Doncaster Busway as well as pedestrian connections and the bicycle network with connected walking and cycling paths from the M80 Ring Road to the Eastern Freeway.

For a detailed description of the project, refer to EES Chapter 8 – Project description.

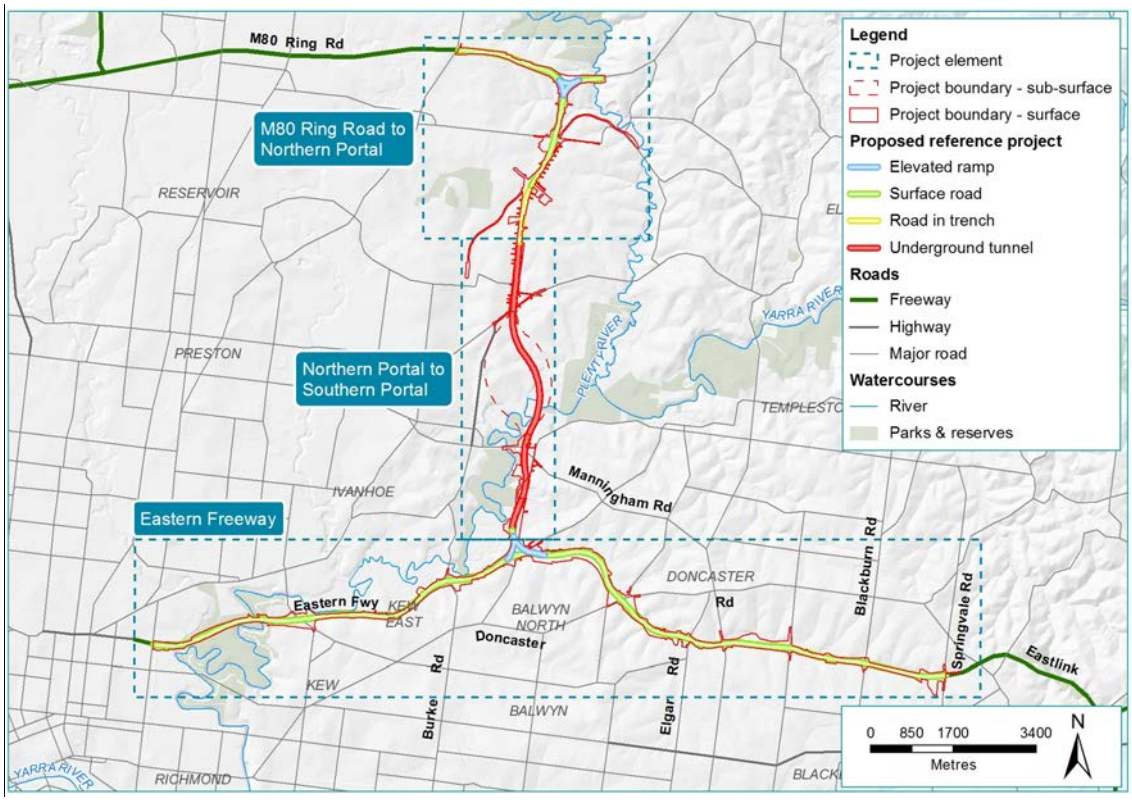


Figure 3-1 Overview of North East Link

3.2 Construction

Key construction activities for North East Link would include:

- General earthworks including topsoil removal, clearing and grubbing vegetation
- Relocation, adjustment or installation of new utility services
- Construction of retaining walls and diaphragm walls including piling
- Ground treatment to stabilise soils
- Tunnel portal and dive shaft construction
- Storage and removal of spoil
- Construction of cross passages, ventilation structures and access shafts
- Installation of drainage and water quality treatment facilities
- Installation of a Freeway Management System
- Tunnel construction using TBMs, mining and cut and cover techniques
- Installation of noise barriers
- Restoration of surface areas.

3.3 Operation

Following construction of North East Link, the key operation phase activities would include:

- Operation and maintenance of new road infrastructure
- Operation and maintenance of Freeway Management System
- Operation of North East Link motorway control centre
- Operation and maintenance of the tunnel ventilation system
- Operation and maintenance of water treatment facilities
- Operation and maintenance of the motorways power supply (substations)
- Maintenance of landscaping and water sensitive urban design features.

4. Legislation, policy, guidelines and criteria

4.1 Legislation, policy and guidelines

Numerous legislative, policy and guidance documents were found to be relevant to this greenhouse gas impact assessment and are discussed further in this report. The key legislation, policy and guidelines that apply to the greenhouse gas assessment for the project are summarised in Table 4-1. Further detail is provided in Section 4.2 to Section 4.4.

Table 4-1 Key legislation, policy and guidelines

Legislation/policy/guideline	Relevance to this impact assessment
National Greenhouse and Energy Reporting Act 2007 (Cwlth) ('NGER Act')	The NGER Act is a national framework for the reporting of energy usage and greenhouse gas emissions by corporations and facilities. This may apply to some of the contractors engaged to construct North East Link as well as its operator.
National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Measurement Determination)	Made under s. 10(3) of the NGER Act, the NGER Measurement Determination outlines the required methods for measuring greenhouse gas and energy use for reporting.
Climate Change Act 2017 (Vic) ('Climate Change Act')	The Climate Change Act sets the legislative foundation to manage climate change risks and drive Victoria's transition to net zero emissions by 2050.
Environment Protection Act 2017 (Vic) ('EP Act 2017')	The EP Act and the associated *Environmental Protection Act 1970 (Vic)* ('EP Act 1970') defines greenhouse gases as a waste and gives authority to the EPA Victoria to issue approvals and licences.
Environment Protection (Scheduled Premises) Regulations 2017	Category L03 of the regulations classify the tunnel ventilation system as scheduled premises as defined in the EP Act 1970.
State Environment Protection Policy (SEPP) Air Quality Management (AQM) 2001	The SEPP (AQM) establishes a framework for managing emissions and an action program for the protection of the air environment to achieve the regional air quality objectives of the SEPP
Protocol for Environmental Management (PEM): Greenhouses Gas Emissions and Energy Efficiency in Industry (2001)	The PEM provides guidance on the SEPP (AQM) for businesses and the requirements for managing greenhouse gas emissions and energy consumption associated with Scheduled Premises. The tunnel ventilation system is a Scheduled Premises and hence the PEM applies to this section of the Project.
Victoria's Climate Change Framework (2016)	The Framework sets out Victoria's long-term plan to achieve net zero emissions by 2050.

Legislation/policy/guideline	Relevance to this impact assessment
Victoria's Climate Change Adaptation Plan 2017–2020	The Adaptation Plan includes a section on building the resilience of our transport system.
Banyule City Council – Climate Change Action	North East Link is located within the boundary of the City of Banyule. Banyule City Council is committed to acting on climate change and has a plan to achieve carbon neutrality by 2019/20.
Our Low Carbon Future – City of Boroondara Strategy July 2009	North East Link is located within the boundary of the City of Boroondara. The Boroondara City Council has the vision 'By working together and changing practices in our natural and built environments, we can help create a sustainable city and future'.
Manningham Climate 2020 – a climate and energy plan	North East Link is located within the boundary of the City of Manningham. Manningham City Council has a strategy to achieve net zero greenhouse gas emissions by 2020.
Nillumbik Climate Change Action Plan 2016–2020	North East Link is located within the boundary of the Shire of Nillumbik. The Nillumbik Shire Council has an Action Plan that sets the goal of reducing greenhouse emissions from its operations by 17 per cent and from community operations by 6 per cent from 2012 levels by 2020.
Whitehorse City Council – Climate Change Adaptation Plan 2011	North East Link is located within the boundary of the City of Whitehorse. Whitehorse City Council's Climate Change Adaptation Plan sets out actions to build its resilience and measures that it and the local population can take to reduce greenhouse gas emissions.
Yarra Environment Strategy 2013–2017	North East Link is located within the boundary of the City of Yarra. Yarra City Council is committed to reducing its net carbon emissions and in 2012 became the first Victorian municipality to achieve carbon neutrality.

4.2 Legislation

4.2.1 Commonwealth legislation

National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act 2007* ('NGER Act') outlines the national reporting framework for corporations and facilities required to report their energy use and greenhouse gas emissions. Under the NGER Act, a corporation is considered to be the entity that has operational control. Controlling corporations that exceed the following thresholds are required to report under the NGER Act:

- For facilities, consumption of more than 100 terajoules (TJ) of energy annually or emits over 25,000 tonnes CO_2-e annually
- For corporations, consumption of more than 200 TJ of energy annually or emits 50,000 tonnes CO_2-e annually.

Contractors engaged to construct North East Link and its future operator may be required to report their Scope 1 and Scope 2 greenhouse gas emissions and energy use if they exceed these thresholds.

4.2.2 State legislation

Climate Change Act 2017

Victoria's *Climate Change Act 2017* ('Climate Change Act') sets the legislative foundation to manage climate change risks and drive Victoria's transition to net zero emissions by 2050. The Climate Change Act embeds the 2050 net zero emissions target and provides for the setting of five-yearly interim greenhouse gas emissions reduction targets, climate change strategies, and adaptation action plans to ensure the 2050 target is achieved and vulnerabilities to climate change impacts are reduced while potential opportunities are realised. Adaptation action plans will cover systems including the built environment and transport.

The Climate Change Act requires decision-makers to take climate change into account when making specified decisions under Victoria's *Catchment and Land Protection Act 1994, Coastal Management Act 1995, Environment Protection Act 1970, Flora and Fauna Guarantee Act 1998, Public Health and Wellbeing Act 2008* and the *Water Act 1989.*

More specifically, the Environment Protection Authority (EPA) Victoria must regulate the potential impacts greenhouse gas emissions relating to Victoria's long-term and interim emissions reduction targets as part of the works or other development approvals process.

The Climate Change Act requires the Minister to undertake additional periodic reporting and publishing of five-yearly climate science reports, 'end of interim target period' reports, as well as annual greenhouse gas emissions reports to provide transparency, accountability and to meet community engagement principles.

The Minister is also required to prepare a whole-of-government emissions reduction pledge and sector-specific emissions reduction pledges for every five years from 2020. The pledge must include a description of the actions to be undertaken to reduce greenhouse gas emissions from Victoria's transport sector, and a reasonable estimate of the total reduction in greenhouse gas emissions expected from implementing those actions. The Climate Change Act also requires the Victorian Government to ensure any decisions it makes and any policy, program or process it develops or implements appropriately takes account of climate change, with regard to the policy objectives and the guiding principles.

Environment Protection Act 2017 (Vic)

Victoria's *Environment Protection Act 2017* ('EP Act') is the first of two planned phases of legislative reform to overhaul the *EP Act 1970*. Its introduction and passage followed the Victorian Government's response to the Independent Inquiry into EPA Victoria.

The EP Act 2017 came into full effect on 1 July 2018. The Act must now be read as if it forms part of the EP Act 1970.

Under the EP Act 1970, greenhouse gases are defined as a waste. The Act authorises EPA Victoria to issue works or other development approvals and licenses to regulate the State Environment Protection Policies (SEPP).

The North East Link tunnels would be scheduled premises as defined by the EP Act 1970 under category L03 of the Environment Protection (Scheduled Premises and Exemptions) Regulations due to the proposed tunnel ventilation system.

Further details of requirements related to greenhouse gases are outlined in the SEPP Air Quality Management (AQM) 2001 and the Protocol for Environmental Management (PEM): Greenhouses Gas Emissions and Energy Efficiency in Industry.

4.3 Policy

4.3.1 Commonwealth policy

Direct Action Plan

The Direct Action Plan is a policy consisting of programs including the Emission Reduction Fund (ERF). The Australian Government established the ERF in December 2014. The ERF consisted of $2.55 billion of funds through which the government purchases Australian Carbon Credit Units (ACCUs – 1 ACCU is equivalent to 1 tonne of CO_2-e abatement). ACCUs are generated by a range of organisations and individuals who implement projects under the ERF using one of the approved methodologies. As of June 2018, the ERF has paid or committed $2.3 billion for 192 million tCO_2-e of actual or future abatement at an average price of $11.97 per ACCU. Funds are committed at reverse auctions where participants nominate the minimum price they will accept per ACCU.

4.3.2 State policy

State Environment Protection Policy (SEPP) Air Quality Management (AQM) 2001

The SEPP (AQM) 2001 is a framework for managing emissions to the air environment. Objectives of this SEPP are supported through protocols for environmental management (PEM) relating to greenhouse gas emissions and energy.

Protocol for Environmental Management (PEM): Greenhouses Gas Emissions and Energy Efficiency in Industry 2001

This PEM aims to ensure that entities subject to an EPA Victoria works approval or licence manage greenhouse gas emissions and energy associated with their activities. The PEM stipulates a range of thresholds based on the annual predicted or actual number of gigajoules of energy used, or tonnes of energy-related CO2-e. Where a works approval is required or a licence is in place under the EP Act 2017 and Environmental Protection (Scheduled Premises Regulations) and the thresholds are exceeded, the proponent would be required to implement greenhouse gas emissions and energy use reduction best practice and/or complete a Level 2 energy audit as outlined in the PEM. North East Link's tunnel ventilation system would be classified as a Scheduled Premises under the EP Act 2017 and so the PEM applies to the tunnels of the project.

***Victoria's Climate Change Framework* (2016)**

Victoria's Climate Change Framework is Victoria's long-term plan to 2050, with the overarching goal of limiting warming to 1.5°C above pre-industrial levels while safeguarding Victoria's economic competitiveness. The Climate Change Framework contains a 2020 emissions reduction target of 15 to 20 per cent below 2005 levels and achieving net zero emissions by 2050. The Climate Change Framework sets out actions in four areas to build Victoria's resilience to climate change: increase energy efficiency and productivity; a clean energy supply and 40 per cent renewable by 2025; electrify our economy and switch to clean fuels; and reduce non-energy emissions and increase carbon storage.

Investment in the public transport system is identified as a priority in the Climate Change Framework, including the following initiatives: purchasing renewable energy to power Melbourne's trams and supporting projects including the Metro Tunnel, High Capacity Metro Trains and Regional Network Development Plan. Other priorities for the transport sector include supporting walking and cycling, and encouraging the manufacturing and development of electric and autonomous vehicles.

4.3.3 Local policy

A number of local councils have policies to reduce carbon emissions. These are summarised below:

Banyule City Council – Climate Change Action

Banyule City Council is committed to acting on climate change and has a plan to achieve carbon neutrality by 2019/20. Climate change initiatives include:

- Investment in energy efficient streetlights
- Incorporating energy efficiency measures into the design and building of local businesses
- A solar photovoltaic (PV) program on council buildings to generate clean, green electricity and reduce greenhouse gas emissions
- Vehicle fleet improvement including hybrid vehicles, a fully electric vehicle and encouraging council staff to use public transport.

These initiatives stem from the Banyule City Council's Energy Plan and its Council Plan. The *Council Plan 2017–2021* outlines the following focus areas relating to climate change:

- Reduce our contribution to climate change
- Review Energy Plan to work towards zero Council emissions, with a focus on self-generated green energy
- Investigate the development of a community Energy Plan to assist the community to minimise energy use and lower greenhouse gas emissions.

Our Low Carbon Future – City of Boroondara Strategy July 2009

Boroondara City Council has the vision 'By working together and changing practices in our natural and built environments, we can help create a sustainable city and future'.

The five principles identified to support this vision are:

- Leadership by Council with the community
- Assuming a moral obligation to act
- Pursuit of multiple benefits and a 'no regrets' approach to action
- Action prioritised by impact

- Equity in both strategy and action.

Manningham Climate 2020 – a climate and energy plan

Manningham City Council has a strategy to achieve net zero operational greenhouse gas emissions by 2020 from its operations.

The strategy is based around three main objectives:

- *Efficiency* – Reduce energy demand of buildings, lighting, appliances, ventilation and air conditioning
- *Decarbonise* – Embrace sustainable local energy generation, GreenPower and green electric vehicles
- *Leadership* – Community and Council leads the way – 100 per cent carbon neutral by 2020.

Nillumbik Climate Change Action Plan 2016–2020

Nillumbik Shire Council recognises the serious challenge the world faces through climate change and has developed an Action Plan with the overarching mitigation goal of reducing greenhouse emissions from its operations by 17 per cent and from community operations by 6 per cent from 2012 levels by 2020.

The Action Plan for Nillumbik Shire Council is divided into seven goal areas:

- *Strategic* – To ensure Climate Change action is embedded into council operations
- *Corporate* – Improving the energy and water efficiency of council-owned assets and to enhance operational resilience to climate change impacts
- *Residential* – Providing assistance and education to households to improve the energy and water efficiency
- *Business* – Providing assistance and education to businesses to improve energy, water and resource efficiency of their operations and to enhance operational resilience to climate change impacts
- *Energy supply* – Decarbonising the energy supply through advocacy to Australian and Victorian governments and providing assistance for households, businesses and community groups to transition to clean renewable energy sources
- *Transport* – Improving transport links to facilitate active transport usage
- *Residual emissions* – Offsetting council's unavoidable operational emissions and encouraging the community to offset emissions in a cost-effective and environmentally beneficial way.

City of Whitehorse – Climate Change Adaptation Plan 2011

Whitehorse City Council has a Climate Change Adaptation Plan that sets out actions to build its resilience and ensure that identified climate change risks do not become extreme by 2030 or 2070.

The Adaptation Plan sets objectives to achieve this goal:

- Ensure that climate change impacts are highlighted and able to be acted upon in all applicable council operations
- Provide climate change adaptation actions that are prioritised and linked with the identified risks, major areas of responsibility and council's operational and capital works processes

- Contribute to ensuring that all council services can be delivered sustainability and reliably under all circumstances and continue to build community resilience
- Continue to raise awareness amongst the community and across council about appropriate local actions that can be taken to mitigate and adapt to climate change.

Yarra Environment Strategy 2013–2017

Yarra City Council is committed to reducing its net carbon emissions and in 2012 the municipality became the first in Victoria to achieve carbon neutrality. Some of the key issues addressed by its Yarra Environment Strategy are population growth, resilience in a changing climate and over-consumption of resources. The Environment Strategy for 2018 onwards has not been released yet.

4.4 Greenhouse gas criteria

Standards and guidelines used in preparing this North East Link greenhouse gas assessment report include:

Greenhouse Gas Assessment Workbook for Road Projects **published by the Transport Authorities Greenhouse Group (TAGG), February 2013 and its supporting calculator, *Carbon Gauge release 01.8*.**

The TAGG workbook provides a process for estimating greenhouse gas emissions for major activities of a road project. It was developed by a group of Australian state road authorities (including VicRoads) and the New Zealand Transport Agency to provide a common methodology and calculation factors for estimating greenhouse gas emissions using a whole-of-life approach.

National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Measurement Determination) made under the *National Greenhouse and Energy Reporting Act 2007*, July 2018

National Greenhouse Accounts Factors **(NGA Factors) published by the Department of Environment and Energy, July 2018**

The NGER Measurement Determination and the NGA Factors have been used as a guide for calculating emissions which are not calculated by the TAGG workbook and supporting Carbon Gauge Calculator. The NGER Measurement Determination and the NGA Factors are both updated in July each year.

Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Tool and its supporting resources

ISCA is the peak industry body for advancing sustainability in Australia's infrastructure. ISCA is a member-based, not-for-profit industry (public and private) council. ISCA's mission is 'Improving the productivity and liveability of industry and communities through sustainability in infrastructure'. ISCA developed and administers the Infrastructure Sustainability (IS) rating scheme. The IS scheme is Australia's only comprehensive rating system for evaluating sustainability across design, construction and operation of infrastructure. The IS scheme evaluates the sustainability (including environmental, social, economic and governance aspects) of infrastructure projects and assets (ISCA, 2018).

The IS rating tool covers a range of categories. Those particularly relevant to greenhouse gas emissions from the construction and operation of North East Link are: Energy and Carbon; and Resource Efficiency. Targets would be set for North East Link with reference to these IS categories and their corresponding credits and levels. Sustainability targets are discussed further in Section 9.

5. Method

5.1 Overview of method

This section describes the method that was used to assess the potential impacts of North East Link. A risk-based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects. Figure 5-1 shows an overview of the assessment method.

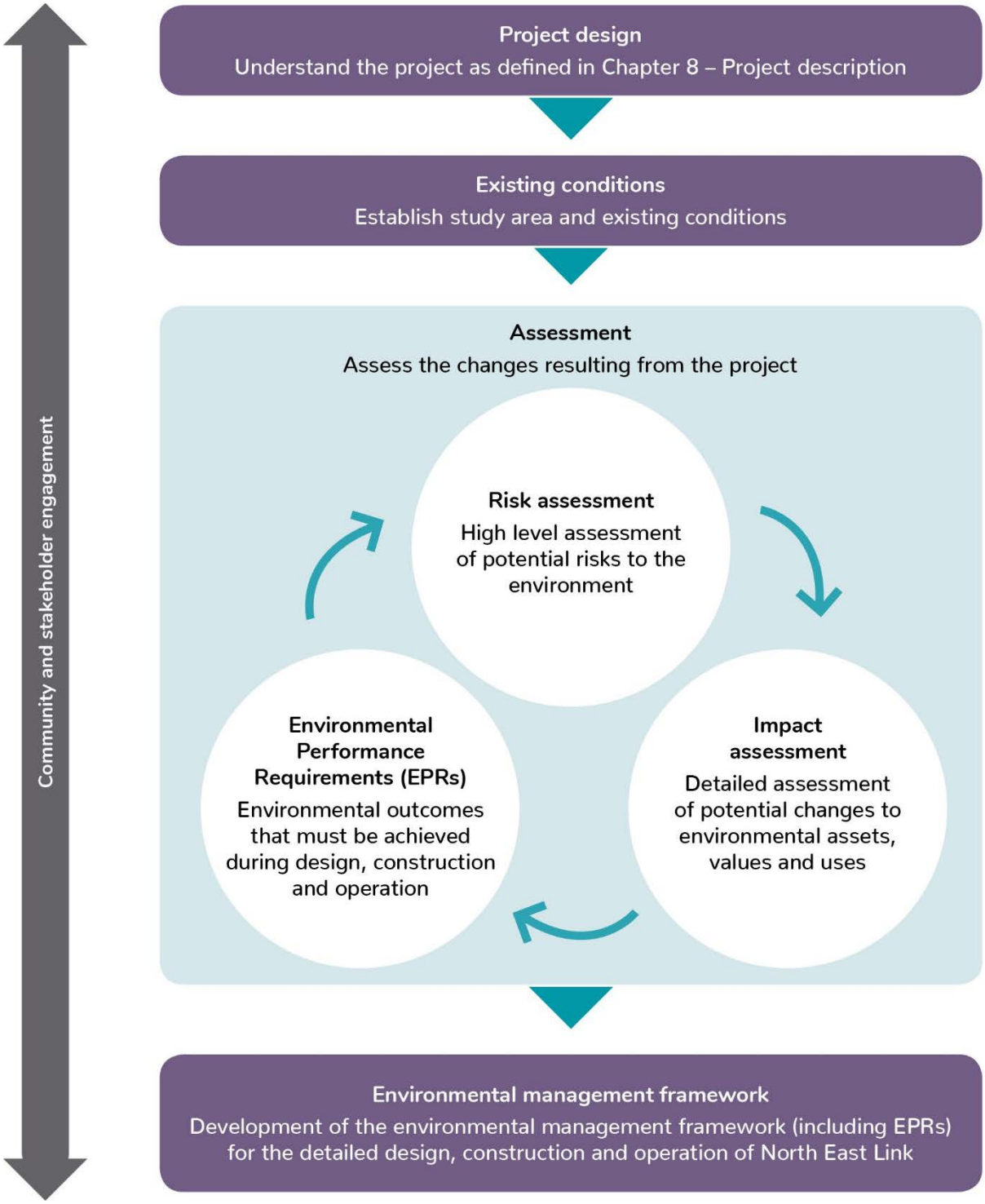


Figure 5-1 Overview of assessment method

The following sections outline the method adopted for the greenhouse gas impact assessment.

5.2 Study area

A study area for construction and operation of North East Link was established. This was defined as emissions of the entire alignment and the emissions due to changes in traffic assessed over the broader Melbourne road network. Emissions were calculated for a period spanning up to 50 years. Embodied emissions associated with materials used during construction have also been considered. For further information refer to Section 5.5.

Activities for North East Link's construction and operation are summarised in Section 3. In addition to predicting the greenhouse gas emissions from these activities, the study also assesses the change in greenhouse gas emissions related to traffic across the wider Melbourne road network, as well as the regional areas of Geelong, Ballarat, Bendigo and Traralgon, as a result of North East Link. Refer to Section 8.2.2 for the discussion on emissions from vehicle traffic.

Indirect greenhouse gas emissions associated with the project were considered for the greenhouse gas assessment, including material use and electricity use. The assessment therefore included consideration of greenhouse gases which, while emitted remotely from North East Link, would be directly due to the project, such as emissions from the generation of raw materials used to construct North East Link.

5.3 Existing conditions

Existing conditions for this report are different to many of the other EES reports. This is because rather than having local existing conditions, greenhouse gas emissions are a global issue. Consequently, existing conditions are discussed in a regional context in Section 6.1.

5.4 Risk assessment

An environmental risk assessment has been completed to identify environment risks associated with construction and operation of North East Link. The risk-based approach integral to the EES as required by section 3.1 of the Scoping Requirements and the *Ministerial guidelines for assessment of the environmental effects under the Environment Effects Act 1978*.

Specifically the EES risk assessment aimed to:

- Systematically identify the interactions between project elements and activities and assets, values and uses
- Focus the impact assessment and enable differentiation of significant and high risks and impacts from lower risks and impacts
- Inform development of the reference project to avoid, mitigate and manage environmental impacts
- Inform development of EPRs that set the minimum outcomes necessary to avoid, mitigate or manage environmental impacts and reduce environmental risks during delivery of the project.

This section presents an overview of the EES risk assessment process. EES Attachment III Environmental risk report describes each step in the risk assessment process in more detail and contains a consolidated risk register.

This technical report describes the risks associated with the project on Greenhouse gas. Wherever risks relating to this study are referred to, the terminology 'risk XX01' is used. Wherever EPRs relating to this study are referred to, the terminology 'EPR XX1' is used. The risk assessment completed for this study is provided as Appendix A.

5.4.1 Risk assessment process

The risk assessment process adopted for North East Link is consistent with AS/NZS ISO 31000:2009 Risk Management Process. The following tasks were undertaken to identify, analyse and evaluate project risks:

- Use existing conditions and identify applicable legislation and policy to establish the context for the risk assessment
- Develop likelihood and consequence criteria and a risk matrix
- Consider construction and operational activities in the context of existing conditions to determine risk pathways
- Identify standard controls and requirements (Environmental Performance Requirements (EPRs) to mitigate identified risks
- Assign likelihood and consequence ratings for each risk to determine risk ratings considering design, proposed activities and standard EPRs.

While there are clear steps in the risk process, it does not follow a linear progression and requires multiple iterations of risk ratings, pathways and EPRs as the technical assessments progress. Demonstrating this evolution, a set of initial and residual risk ratings and EPRs are produced for all technical reports. Figure 5-2 shows this process.

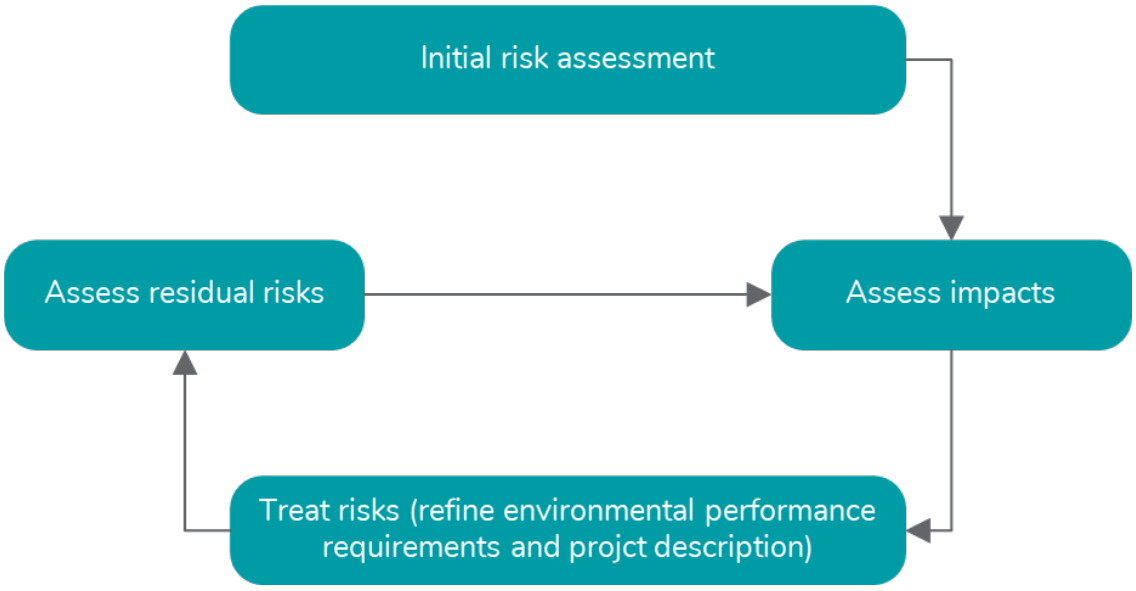


Figure 5-2 Risk analysis process

Rating risk

Risk ratings were assessed by considering the consequence and likelihood of an event occurring. In assessing the consequence, the extent, severity and duration of the risks were considered. These are discussed below:

Assigning the consequences of risks

'Consequence' refers to the maximum credible outcome of an event affecting the asset, value or use. Consequence criteria as presented in Chapter 4 – EES assessment framework, were developed for the North East Link EES to enable a consistent assessment of consequence across the range of potential environmental effects. Consequence criteria were assigned based on the maximum credible consequence of the risk pathway occurring. Where there was uncertainty or incomplete information, a conservative assessment was made on the basis of the maximum credible consequence.

Consequence criteria have been developed to consider the following characteristics:

- Extent of impact
- Severity of impact
- Duration of threat.

Severity has been assigned a greater weighting than extent and duration as this is considered the most important characteristic.

Each risk pathway was assigned a value for each of the three characteristics, which were added together to provide an overall consequence rating.

Further detail on the consequence criteria are provided Chapter 4 – EES assessment framework.

Assigning the likelihood of risk

'Likelihood' refers to the chance of an event happening and the maximum credible consequence occurring from that event. The likelihood criteria are presented in Table 5-1.

Table 5-1 Likelihood of an event occurring

Planned	The event is certain to occur
Almost certain	The event is almost certain to occur one or more times a year
Likely	The event is likely to occur several times within a five-year timeframe
Possible	The event may occur once within a five-year timeframe
Unlikely	The event may occur under unusual circumstances but is not expected (ie once within a 20-year timeframe)
Rare	The event is very unlikely to occur but may occur in exceptional circumstances (ie once within a 100-year timeframe)

Risk matrix and risk rating

Risk levels were assessed using the matrix presented in Table 5-2.

Table 5-2 Risk matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Severe
Rare	Very low	Very low	Low	Medium	Medium
Unlikely	Very low	Low	Low	Medium	High
Possible	Low	Low	Medium	High	High
Likely	Low	Medium	Medium	High	Very high
Almost certain	Low	Medium	High	Very high	Very high
Planned	Planned (negligible consequence)	Planned (minor consequence)	Planned (moderate consequence)	Planned (major consequence)	Planned (severe consequence)

Planned events

North East Link would result in some planned events, being events with outcomes that are certain to occur (ie planned impacts such as land acquisition), as distinct from risk events where the chance of the event occurring and its consequence is uncertain. Although planned events are not risks, these were still documented in the risk register as part of Attachment III – Risk report for completeness and assigned a consequence level in order to enable issues requiring further assessment or treatment to be prioritised.

These planned events were assessed further through the impact assessment process.

Risk evaluation and treatment

The risk assessment process was used as a screening tool to prioritise potential impacts and the subsequent level of assessment undertaken as part of the impact assessment. For example, an issue that was given a risk level of medium or above, or was identified as a planned event with a consequence of minor or above, would go through a more thorough impact assessment process than a low risk.

Where initial risk ratings were found to be 'medium' or higher, or were planned events with a consequence of 'minor' or higher, options for additional or modified EPRs or design changes were considered where practicable. It should be noted that the consequence ratings presented in the risk register are solely based on the consequence criteria presented in Attachment III – Risk report. Further analysis and evaluation of the impacts potentially arising from both risks and planned events and information on how these would be managed is provided in Section 5.6.

5.5 Scope and boundaries for greenhouse gas impact assessment

The following references were used to obtain greenhouse gas emission factors and calculation methodologies for the estimation of greenhouse gas emissions for the impact assessment:

- Greenhouse Gas Assessment Workbook for Road Projects developed by the Transport Authorities Greenhouse Group, February 2013 and its supporting calculator, Carbon Gauge release 01.8
- National Greenhouse Accounts published by the Commonwealth Department of Environment, July 2017.

The Materiality Checklist in the Carbon Gauge Calculator (TAGG 2013, Appendix C) was completed and the greenhouse gas impact assessment boundaries were determined to include Scope 1 and Scope 2 greenhouse gas emission sources and select Scope 3 greenhouse gas emission sources.

The definitions of emission scopes are described within the NGER Act and National Greenhouse and Energy Reporting Regulations 2018 (NGER Regulations) as follows:

- Scope 1: The release of greenhouse gas into the atmosphere as a direct result of North East Link activities. For instance, the combustion of fuel in construction equipment.
- Scope 2: The release of greenhouse gas into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by North East Link through purchases. For instance, the consumption of electricity by the tunnel boring machines (TBMs).
- Scope 3: Other indirect release of greenhouse emissions. For instance, emissions associated with the production of raw materials consumed during construction such as steel.

Emissions associated with the design of North East Link have been assumed to be immaterial as international travel, which would be the key contribution to greenhouse gas emissions, would largely not be required.

Table 5-3 summarises the estimates of greenhouse gas emissions from North East Link's construction and operation by source and scope.

Table 5-3 Greenhouse gas emission scopes for relevant construction and operational (including maintenance) activities by source and scope

Emission source category	Emission source	Emission scope		
		Scope 1	Scope 2	Scope 3
Construction				
Fuel use	Construction plant and equipment	✓	–	✓
	Site vehicles	✓	–	✓
	Delivery of plant, equipment and construction materials	–	–	✓
	Transportation of tunnel spoil	✓	–	✓
Electricity consumption	Operation of plant and equipment, including tunnel boring machine (TBM)	–	✓	✓
	Operation of site offices	–	✓	✓
Materials	Construction materials	–	–	✓
	Use of lime to treat acid sulfate soils	–	–	✓
Land use changes	Vegetation removal	✓		
Operation				
Electricity consumption	Tunnel pumps, lighting and ventilation	–	✓	✓
	Operation of substations	–	✓	✓
	Electrical systems (such as street lighting, signalling, toll gantries and intelligent transport systems)	–	✓	✓
Traffic	Operation of vehicles	–	–	✓
Maintenance				
Fuel use	Plant and equipment	✓	–	✓
	Site vehicles	✓	–	✓
	Delivery of maintenance materials	–	–	✓
Materials	Maintenance materials	–	–	✓

- Not applicable

The following Scope 3 construction greenhouse gas emission sources were deemed to be immaterial and excluded from the assessment, in accordance with the framework set out in the NGER Act:

- Fugitive emissions (intentional or unintentional leaks or evaporative sources)
- Employee travel to and from site
- International delivery of plant, equipment and materials
- Emissions from disposal of construction waste other than spoil[1]
- Emissions sinks associated with plant vegetation
- Construction of the motorway control centre.

5.6 Impact assessment

Greenhouse gas emissions from the construction and operation of North East Link were estimated using the following three calculation methods:

- The TAGG Carbon Gauge Calculator (version 01.8), supported by the Transport Agencies Greenhouse Gas (TAGG) Workbook
- Manual calculation using Microsoft Excel (for tunnel calculations, as the Carbon Gauge Calculator is unsuitable to estimate emissions associated with the construction and operation of tunnels)
- VLC's Zenith Economics Assessment Model (for Scope 3 emissions from road users).

Table 5-4 outlines which calculation approach was used for assessing each emission source.

Sourced data is provided be in Appendix B, Appendix D and Appendix E.

This assessment responds to the requirements of the SEPP Air Quality Management (AQM) to estimate greenhouse gas emissions associated with North East Link. The requirements of the PEM (Greenhouse Gas Emissions and Energy Efficiency in Industry 2001) to identify and implement best practice measures associated with reducing greenhouse gas emissions from the tunnel ventilation system was assessed in the Works Approval Application for the project and is summarised in Section 9 of this report.

Table 5-4 Calculation methodologies for greenhouse gas emissions

Emission source category	Emission source	Source of data	Calculation approach
Construction			
Fuel use	Construction plant and equipment	Calculated by Carbon Gauge based on general project information.	Carbon Gauge Release 01.8.
	Site vehicles		Carbon Gauge Release 01.8.
	Transportation of tunnel spoil	Initial estimates provided by reference project engineering team.	Manual calculation based on assumptions listed in Appendix D.

[1] While waste management is a scoping requirement for this project and underpins the basis for this greenhouse gas impact assessment, direct waste and landfill greenhouse gas emissions during construction and operation are excluded as a materiality assessment identified that these were immaterial to the total greenhouse gas footprint. The greenhouse gas emissions from the transportation of construction spoil are included in this assessment.

Emission source category	Emission source	Source of data	Calculation approach
Electricity consumption	Operation of plant and equipment, including tunnel boring machine (TBM)	West Gate Tunnel EES GHG Impact Assessment (AECOM, 2017).	Manual calculation based on relative length of tunnels.
	Operation of site office(s)	Assumption based on West Gate Tunnel EES GHG Impact Assessment (AECOM, 2017).	Manual calculation based on assumption from West Gate Tunnel Project.
Materials	Construction materials (excluding materials for tunnel construction)	Initial estimates provided by reference project engineering team.	Carbon Gauge Release 01.8.
	Construction materials for tunnel construction	Initial estimates provided by reference project engineering team.	Manual calculation based on tunnel material estimates provided by Advisian.
	Lime for treatment of Acid Sulfate Soils	Initial estimates provided by reference project engineering team.	Manual calculation based on Acid Sulfate Soil Volume estimates.
Land use changes	Vegetation removal	Technical Report Q *Ecology*	Carbon Gauge Release 01.8.
Operation			
Electricity consumption	Tunnel pumps, lighting and ventilation	Initial estimates provided by reference project engineering team.	Manual calculation based on tunnel power estimate.
	Electrical systems (such as signalling, toll gantries and intelligent transport systems)	Initial estimates provided by reference project engineering team.	Carbon Gauge Release 01.8.
Traffic	Operation of vehicles	VLC traffic model	
Maintenance			
Materials	Maintenance materials	Initial estimates provided by reference project engineering team.	Carbon Gauge Release 01.8.

5.6.1 Emission factors

Table 5-5 lists the emission factors and rates used to calculate greenhouse gas emissions from vehicle traffic in Melbourne for fuel type. Table 5-6 shows them for vehicle type.

Table 5-5 Emission factors (kg CO_2-e/GJ)

Fuel type	Energy content (GJ/kL)	CO_2 kg CO_2-e/GJ	CH_4 kg CO_2-e/GJ	N_2O kg CO_2-e/GJ
Petrol	34.2	67.4	0.5	1.8
Diesel	38.6	69.9	0.1	0.5

Source: DoEE (2018, Table 3)

Table 5-6 Emission rates (g CO_2-e/L fuel consumed)

Vehicle type	CO_2-e emitted, g/L
Car	2,421.01
LCV	2,591.35
HCV	2,698.50

Source: VLC (2018)

Table 5-7 lists the emission factors for indirect (Scope 2 and Scope 3) emissions resulting from purchased electricity consumption during North East Link's construction and operation.

Table 5-7 Indirect (Scope 2 and Scope 3) emission factors for purchased electricity consumption

Scope	Emission factor kg CO_2-e/kWh
Scope 2	1.07
Scope 3	0.10

Source: DoEE (2018)

Table 5-8 lists the emission factors adopted for the greenhouse gas assessment of the tunnels construction.

Table 5-8 Emission factors used for the calculations

Emission type	Emission factor	Units	Source
Indirect (Scope 2) emission factor for consumption of purchased electricity from the grid in Victoria	1.07	t CO2-e/MWh	DoEE, 2018
Indirect (Scope 3) emission factor for transmission and distribution losses of purchased electricity from the grid in Victoria	0.1	t CO_2-e/MWh	DoEE, 2018
Construction material emission factor for concrete	0.195	t CO_2-e/t	ISCA, 2018
Construction material emission factor for steel	3.2	t CO_2-e/t	ISCA, 2018
Agricultural liming – emissions factor	0.12	t CO_2-e/t $CaCO_3$	AJM JV, 2016
Diesel fuel – energy content factor – Scope 1	38.6	GJ/kL	DoEE, 2018
Diesel fuel – emission factor CO_2 – Scope 1	69.9	kg CO_2-e/GJ	DoEE, 2018
Diesel fuel – emission factor CH_4 – Scope 1	0.1	kg CO_2-e/GJ	DoEE, 2018
Diesel fuel – emission factor N_2O – Scope 1	0.5	kg CO_2-e/GJ	DoEE, 2018
Diesel fuel – emission factor – Scope 3	3.6	kg CO_2-e/GJ	DoEE, 2018

5.6.2 Greenhouse indicators

The indicators used to measure greenhouse gas emissions performance for this assessment are:

- Annual greenhouse gas emissions
- Greenhouse gas emissions per vehicle kilometre travelled (VKT).

The annual greenhouse emissions allow a comparison of total emissions between the 'with project' and 'no project' scenarios; that is, the difference in annual emissions of greenhouse gases if North East Link did not proceed.

The emissions intensity of travel by road for the 'with project' scenario compared with the 'no project' scenario can be assessed in terms of the greenhouse gas emissions per vehicle kilometre travelled (VKT).

5.6.3 Methodology for calculating construction emissions

Greenhouse gas emissions from North East Link's construction were primarily estimated using the Carbon Gauge Calculator. The calculator is a tool developed based on actual construction data from road projects which calculates tonnes of CO_2-e of a project based on specified project inputs.

The calculator comprises four steps to estimate greenhouse gas emissions from projects:

- Select major activities
- Complete materiality checklist
- Add project specific data
- Review results.

The Carbon Gauge calculator cannot currently calculate greenhouse emissions associated with the construction and operation of tunnels, nor the manufacture of construction materials for tunnels. Tunnel emissions were calculated using a separate, bespoke Microsoft Excel spreadsheet drawing on approaches used for previous major projects that involved tunnels.

5.6.4 Methodology for calculating operational emissions

Greenhouse gas emissions generated from North East Link's operation were primarily calculated using the same methods used to assess emissions from its construction, using the TAGG Carbon Gauge Calculator (version 01.8) for the majority of calculations, and manual calculations for tunnel operation.

Emissions from the operation of North East Link due to a change in the Melbourne (statistical division) road network, including the regional areas of Geelong, Ballarat, Bendigo and Traralgon, were calculated separately.

This calculation used the *Zenith Transport Model Economic Assessment Model* (EAM) based on the reference project for North East Link. The calculation estimated the emissions from vehicle travel on the Melbourne road network for the 'with project' and 'no project' scenarios. Refer to Appendix E for more information on the assessment. Further discussion of the transport model is provided in EES Technical report A – Traffic and transport.

5.7 Limitations, uncertainties and assumptions

5.7.1 Assessment based on information available during reference design

This assessment has been undertaken based on the reference project for North East Link. Where data was not available, conservative assumptions were made as documented throughout this report. Assumptions were made in the following areas:

- Site vehicle fuel type
- Drainage length and type
- Wire rope barrier length
- Noise barrier length
- Amount of strip and respread topsoil
- Area of Vegetation loss
- TBM electricity consumption
- Material transport distance.

Further details on assumptions are provided in Appendix B and Appendix D. It is likely that more accurate information would become available during the detailed design and tendering of North East Link.

5.7.2 Carbon Gauge

The TAGG Carbon Gauge Calculator (version 01.8) was used to estimate greenhouse gas emissions for the majority of the emissions sources for this impact assessment. The TAGG Carbon Gauge Calculator is used widely across Australia to calculate greenhouse gas emissions, and is considered by greenhouse gas specialists as the best option available for road projects. Details on the assumptions and limitations of the Carbon Gauge Calculator are provided in *Greenhouse Gas Assessment Workbook for Road Projects* (TAGG, 2013). Table 5-4 details which sources of emissions were assessed using the Carbon Gauge Calculator. Assumptions made and data used for inputting into the Carbon Gauge Calculator are listed in Appendix B, with Carbon Gauge outputs in Appendix C.

As discussed in Section 5.6.3, the Carbon Gauge Calculator cannot estimate greenhouse gas emissions from tunnel construction and operation. These calculations have been performed manually using Microsoft Excel. Assumptions, calculations and outputs for North East Link's tunnels are provided in Appendix D.

Only the construction and operation phases of North East Link are considered in this greenhouse gas emissions assessment. Emissions associated with the design phase are considered immaterial. In cases where a project involves significant numbers of international staff travelling internationally for the design phase, the *Greenhouse Gas Assessment Workbook for Road Projects* notes that emissions associated with design may be material. However, international travel would not be required for the design of North East Link. Excluding emissions from the project's design phase is consistent with the approach taken when assessing similar road projects.

5.7.3 Induced demand

A key challenge of forecasting future GHG emissions from road networks is induced demand. Induced demand is the concept that constructing or improving a road would attract additional traffic. The VLC Zenith model was used to estimate traffic-related greenhouse gas emissions across the entire Melbourne (statistical division) network, including the regional areas of Geelong, Ballarat, Bendigo and Traralgon, for the 'with project' and 'no project' scenarios. The VLC report is provided in Appendix E. The VLC model recognise seven ways that people could respond to a road improvement. VLC has indicated the following six factors of induced traffic demand responses to a road improvement have been incorporated into its modelling (VLC, 2018):

- **No change in behaviour** – Drivers do not change their journeys
- **Changing route** – Drivers make the same journeys but use the improved route
- **Changing destination** – Drivers decide to travel to more distant destinations because the improvement makes the journey time acceptable
- **Changing mode** – Active transport or public transport passengers switch to car because the improvement makes road travel more attractive
- **Time of travel change** – Drivers decide to travel in the commuting peak period because the improvement reduces journey times to an acceptable level
- **Generated or new travel** (such as from different land use patterns) – People and businesses relocate to take advantage of the improvement and so make journeys that are new in the area.

Table 5-9 summarises the other factor which has not been modelled – making additional journeys – and VLC's statement on how this was addressed for the North East Link assessment.

A more complete discussion of how induced demanded has been considered in the traffic model is provided in Technical report A – Traffic and transport.

Table 5-9 Justification for factor not addressed by VLC's Zenith model

Induced traffic response to a road improvement	VLC's statement on how induced demand is addressed by the North East Link model
Making additional journeys – People are more willing to make additional car journeys because of the improvement	These trips would not exist in the scenario without the project. According to research by VicRoads and DEDJTR induced demand from making additional journeys can be assumed to be negligible for a new road connection.

5.7.4 Accuracy and assumptions

Emission estimates are presented to the thousand tonnes (kilotonne) of carbon dioxide equivalent. The assessment is based upon data and best estimates available at the time of the assessment. Results may change in the future as the design of North East Link was the project is further refined. The most recently available emission factors at the time of calculation were used.

It was assumed for calculation purposes the following would not occur:

- Inefficient use of materials, fossil fuels and electricity during the project's construction and operation
- Construction delays causing additional consumption of materials and fossil fuels during construction

- Accidental release of uncombusted natural gas during the realignment of the transmission gas pipeline
- Unacceptable quality of materials from the manufacture of precast (or other materials) leading to additional resource consumption
- Change in the planned operation of the TBMs (such as a change in their operation speed to reduce vibration or as a result of unplanned geological conditions)
- Increases in the construction footprint leading to increase vegetation clearing.

If any of these assumptions prove incorrect, it may be that emissions increase beyond those estimated in this assessment.

Traffic modelling was undertaken by VLC and Smedtech to predict traffic volumes and fleet mixes [passenger cars (PC), light commercial vehicles (LCV) and HCVs] for the years 2026 and 2036 for the purposes of the EES. These years are understood to be generally representative of the 'no project' and 'with project' scenarios. This traffic data formed the basis for the greenhouse gas assessment. The upper limit of the predicted traffic volume range provided was conservatively selected.

5.8 Stakeholder engagement

Stakeholders and the community were consulted to support the preparation of the North East Link EES and to inform the development of the project and understanding of its potential impacts. Feedback received during community consultation sessions is summarised in Section 5.9.

5.9 Community feedback

In addition to consultation undertaken with specific stakeholders, consultation has been ongoing with the community throughout the design development and the EES process. Feedback relevant to the greenhouse gas impact assessment is summarised in Table 5-10, along with where and how these topics are addressed in this report.

Table 5-10 Community consultation feedback addressed by greenhouse gas impact assessment

Issues raised during community consultation	How it's been addressed
Increases in greenhouse gas emissions from vehicles using North East Link and the upgraded Eastern Freeway.	Section 8.2.2 sets out the forecast for greenhouse gas emissions for the 'with project' and 'no project' scenarios for 2026 and 2036. The results are based on the outputs of the traffic model which includes vehicles using North East Link and the upgraded Eastern Freeway as well as induced demand. The results show a marginal decrease in greenhouse gas emissions across the Melbourne road network for the 'with project' scenario compared with the 'no project' scenario.

Issues raised during community consultation	How it's been addressed
Increases in greenhouse gas emissions from vehicles using North East Link that under the 'no project' scenario would otherwise have used an alternative mode of transport (such as cycling or public transport).	Section 8.2.2 sets out the forecast greenhouse gas emissions for the 'with project' and 'no project' scenarios for 2026 and 2036. The results are based on the outputs of the traffic model which does include impacts on active and public transport use from North East Link. The results show a marginal decrease in greenhouse gas emissions across the Melbourne road network for the 'with project' scenario compared with the 'no project' scenario.
Loss of mature trees (or replacing mature trees with young trees) resulting in an increase in greenhouse gas emissions, and requests for this to be considered in impact assessments and mitigation measures.	Section 8.1 sets out the forecast of greenhouse gas emissions from removing vegetation to construct North East Link. An estimated 4 $ktCO_2$-e of greenhouse gas emissions are forecast to result from removing vegetation across the seven years of the project's construction. This equates to 0.2 per cent of the total forecast construction emissions.
Replacement of mature trees lost with mature trees to minimise greenhouse gas emissions.	Section 8.1 sets out the forecast of greenhouse gas emissions from removing vegetation to construct North East Link. An estimated 4 $ktCO_2$-e of greenhouse gas emissions are forecast to result from removing vegetation across the seven years of the project's construction. This equates to 0.2 per cent of the total predicted construction emissions. The reduction of greenhouse gas emissions associated with the project is addressed by EPR SCC2, which relates to the integration of sustainable design practices to minimise, to the extent practicable, the greenhouse gas emissions arising from construction and operation (refer Section 9).
Greenhouse gas emissions associated with construction, including the production of materials such as concrete, to be considered in impact assessments and mitigation measures.	Section 8.1 sets out the forecast greenhouse gas emissions associated with the construction of North East Link including the production of concrete and other construction materials.

Issues raised during community consultation	How it's been addressed
Project to use LED or solar lighting for overhead lights, solar or other renewable power sources as well as innovative technologies and low carbon or carbon neutral materials (such as recycled road surfaces) during construction and operation.	Section 9 sets out the EPRs relating to greenhouse gas emissions for the project, including a requirement for contractors to integrate sustainable design practices during construction. Best practice measures are included, such as the use of LEDs, as well as measures such as using renewable energy and low carbon materials to help meet the project's sustainability targets. Sustainability targets for North East Link are currently being developed and would be included in the project's construction and operation contracts.
Design elements such as 'green' walls to be used to help minimise greenhouse gas emissions during operation.	Section 9 sets out the EPRs relating to greenhouse gas emissions for the project, including a requirement for contractors to integrate sustainable design practices. Best practice measures are included, such as the use of LEDs, as well as measures including using renewable energy and low carbon materials that could help meet the project's sustainability targets. Sustainability targets for North East Link are currently being developed and would be included in the project's construction and operation contracts.

6. Regional context

The existing conditions of the assets, values and uses being considered throughout this assessment are described in the following section.

6.1 Existing conditions

In alignment with the Kyoto Protocol and its pledge to the United Nations Framework Convention on Climate Change (UNFCCC) under the Cancun Agreement, Australia has a target of reducing emissions to 5 per cent below 2000 levels by 2020 (AGEIS, 2018). This was updated at the Paris Climate Conference to a commitment that Australia will reduce emissions by 26 to 28 per cent of 2005 levels by 2030.

The Victoria Government has set a target of net zero emissions by 2050, meaning greenhouse gas emissions will be reduced to the lowest possible amount, and the remaining emissions offset (DELWP, 2016).

The Australian Greenhouse Emissions Information System (AGEIS, 2018) reported national emissions for 2016 were 532,971 kt CO_2-e, representing an approximate 3 per cent reduction in emissions since the 2000 total of 551,786 kt CO_2-e.

The AGEIS (2018) total for Victoria in 2016 was 115,103 kt CO_2-e, representing an approximate 2 per cent reduction since the 2000 Victorian total of 117,757 kt CO_2-e.

The most current available data for greenhouse gas emissions emitted annually through Australian and Victorian transportation are summarised in Table 6-1.

Table 6-1 2016 road transportation emissions (total kt of CO_2-e) (AGEIS, 2018)

Fuel type	Australia (kt CO_2-e)	Victoria (kt CO_2-e)
Cars	44,276	11,168
Light commercial vehicles	15,411	3,738
Heavy-duty trucks and buses	22,651	5,001
Motorcycles	294	72
Total	82,633	19,979

7. Risk assessment

A risk assessment of project activities was performed in accordance with the methodology described in Section 5.4. The risk assessment has been used as a screening tool to prioritise the focus of the impact assessments and development of EPRs. The risk pathways link project activities (causes) to their potential effects on the environmental assets, values or uses that are considered in more detail in the impact assessment. Risks were assessed for the construction and operation of the project.

The identified risks and associated residual risk ratings are listed in Table 7-1. The likelihood and consequence ratings determined during the risk assessment process and the adopted EPRs are presented in Appendix A.

The risk assessment shows that greenhouse gas emissions occur due to planned activities. The assumptions associated with those planned activities are documented in Section 5.7 of this report. It is acknowledged that should any of those assumptions prove incorrect that greenhouse gas emissions may exceed those estimated in this report.

Table 7-1 Greenhouse gas risks

Risk ID	Potential threat and effect on the environment	Risk rating
Construction		
Risk GH01	Land clearing and consumption of materials and electricity generated from fossil fuels, operation of plant and equipment, and transportation of materials and equipment during construction result in the release of greenhouse gas emissions which could contribute to global climate change.	Planned (major consequence)
Operation		
Risk GH02	Operational and maintenance activities including consumption of fossil fuels for electricity generation, operation of plant and equipment and transportation of materials and equipment result in greenhouse gas emissions, which could contribute to global climate change.	Planned (moderate consequence)
Risk GH03	Operation of North East Link will cause a change in vehicle flow through Metropolitan Melbourne which may result in an increase or decrease in the overall vehicle emissions.	Planned (moderate consequence)

8. Impact assessment

This chapter summarises the results of the North East Link greenhouse gas assessment. This includes predicted greenhouse gas emissions which would result from the construction and operation of North East Link, and traffic forecasts with and without the project.

8.1 Construction impacts

The greenhouse gas assessment considered the potential greenhouse gas emissions from North East Link's construction, which would contribute to global climate change (risk GH01).

The current schedule for North East Link expects the project to be completed over seven years. The total calculated greenhouse gas emissions per annum for the project's construction is approximately 289 kt CO_2-e p.a. This represents 0.25 per cent of emissions from all Victorian sectors in 2016 and 0.05 per cent of the national 2016 emissions (AGEIS, 2018).

The predicted greenhouse gas emissions from North East Link's construction by source and scope (refer to Section 5.5) are summarised in Table 8-1. The majority of greenhouse gas emissions from the project's construction would result from the indirect release of greenhouse gas emissions through the use of construction materials, which would account for approximately 81 per cent of construction emissions, followed by the operation of plant and equipment (electricity consumption) which would account for 7 per cent. Figure 8-1 provides a pie chart that shows the percentage of greenhouse gas emissions by source from the construction of North East Link.

Table 8-1 Predicted greenhouse gas emissions from North East Link construction by emissions source and scope

Emission source category	Emission source	Scope 1 (kt CO_2-e)	Scope 2 (kt CO_2-e)	Scope 3 (kt CO_2-e)	Total (kt CO_2-e)
Construction					
Fuel use	Electricity generation	1	–	<1	1
	Site vehicles	1	–	<1	1
	Transportation of spoil	38	–	2	40
	Plant and equipment	62	–	12	74
	Demolition and earthworks	62	–	5	67
	Vegetation removal	<1	–	<1	<1
Electricity consumption	Operation of plant and equipment, including tunnel boring machines (TBMs)	–	134	12	146
Materials	Construction materials	–	–	1627	1627
	Liming treatment of Acid Sulfate Soils	–	–	59	59

Emission source category	Emission source	Scope 1 (kt CO_2-e)	Scope 2 (kt CO_2-e)	Scope 3 (kt CO_2-e)	Total (kt CO_2-e)
Land use changes	Vegetation removal	5	–	–	5
TOTAL (kt CO_2-e)		**169**	**134**	**1717**	**2020**

*Due to rounding, figures may appear to not add correctly

- Not applicable

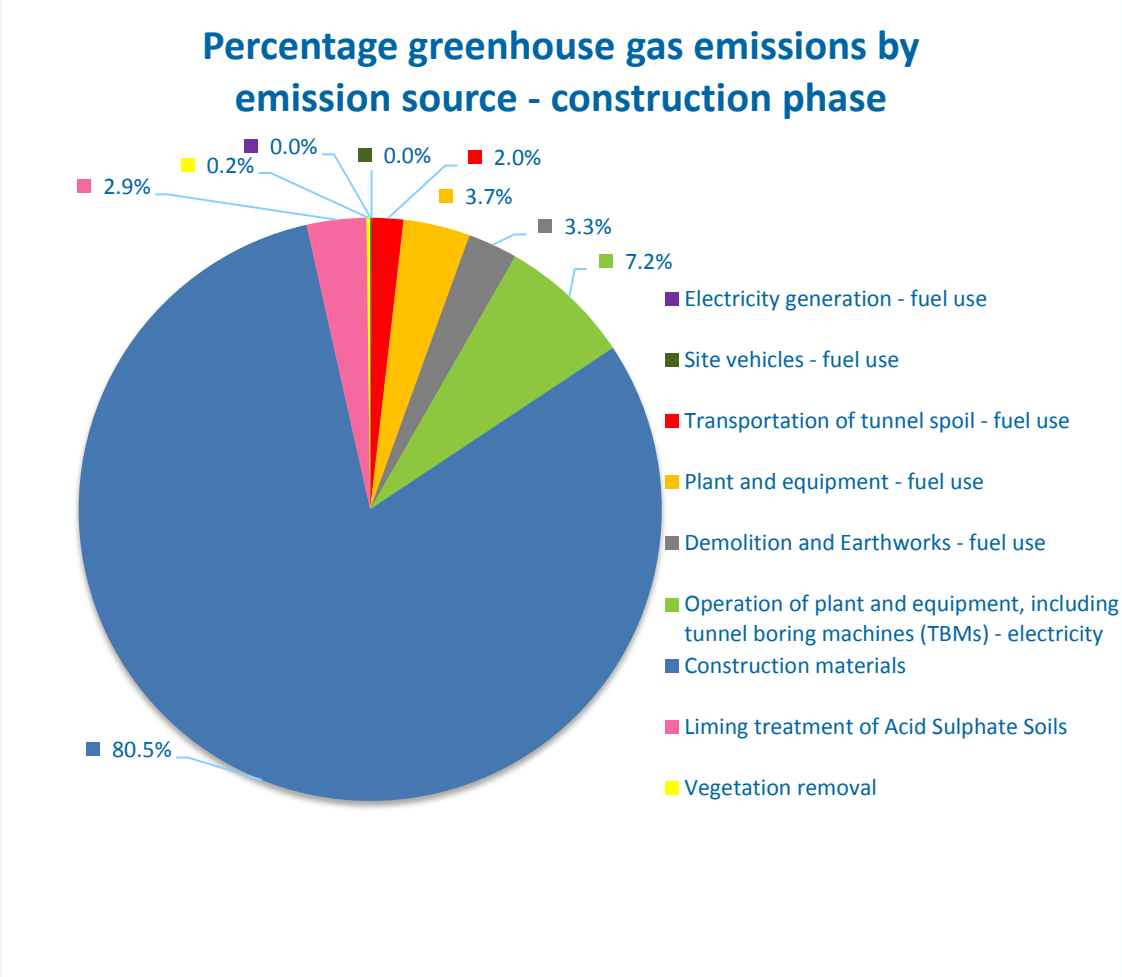


Figure 8-1 Percentage of greenhouse gas emissions by source from North East Link construction

A Sustainability Management Plan for North East Link would be developed and implemented to meet, as a minimum, the sustainability targets set for the project and specified ratings under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool (EPR SCC1).

In addition, sustainable design practices would be integrated into the design process to minimise, to the extent practicable, greenhouse gas emissions from the construction and operation of North East Link (EPR SCC2).

8.2 Operational impacts

8.2.1 Operational electricity consumption

The greenhouse gas assessment considered the potential emissions from the operation and maintenance of North East Link, which could contribute to global climate change (risk GH02).

The total calculated greenhouse gas emissions per annum during the project's operation (including maintenance) is approximately 84 kt CO_2-e p.a. This represents 0.07 per cent of emissions from all Victorian sectors in 2016, and 0.02 per cent of the national 2016 emissions (AGEIS, 2018). The majority of greenhouse gas emissions from the operation of North East Link would be from operating the tunnels, which would account for approximately 96 per cent of greenhouse gas emissions.

Table 8-2 summarises the predicted annual greenhouse gas emissions from the operation (including maintenance) of North East Link for a 50-year period, by source and scope (refer to Section 5.5).

Figure 8-2 provides a pie chart that shows the percentage of greenhouse gas emissions by source from the operation of North East Link.

Table 8-2 Greenhouse gas emissions from North East Link operation (including maintenance) by emissions source and scope per annum

Emission source category	Emission source	Scope 1 (kt CO_2-e)	Scope 2 (kt CO_2-e)	Scope 3 (kt CO_2-e)	Total (kt CO_2-e)
Operation					
Electricity consumption	Operation of tunnels (eg pumps, lighting and ventilation)	–	74	7	81
	Operation of other technical systems (such as signalling, toll gantries and operations centre)	–	2	<1	2
Maintenance					
Materials	Maintenance materials	1	–	<1	1
TOTAL (kt CO_2-e)		**1**	**76**	**7**	**84**

*Due to rounding, figures may appear to not add correctly

- Not applicable

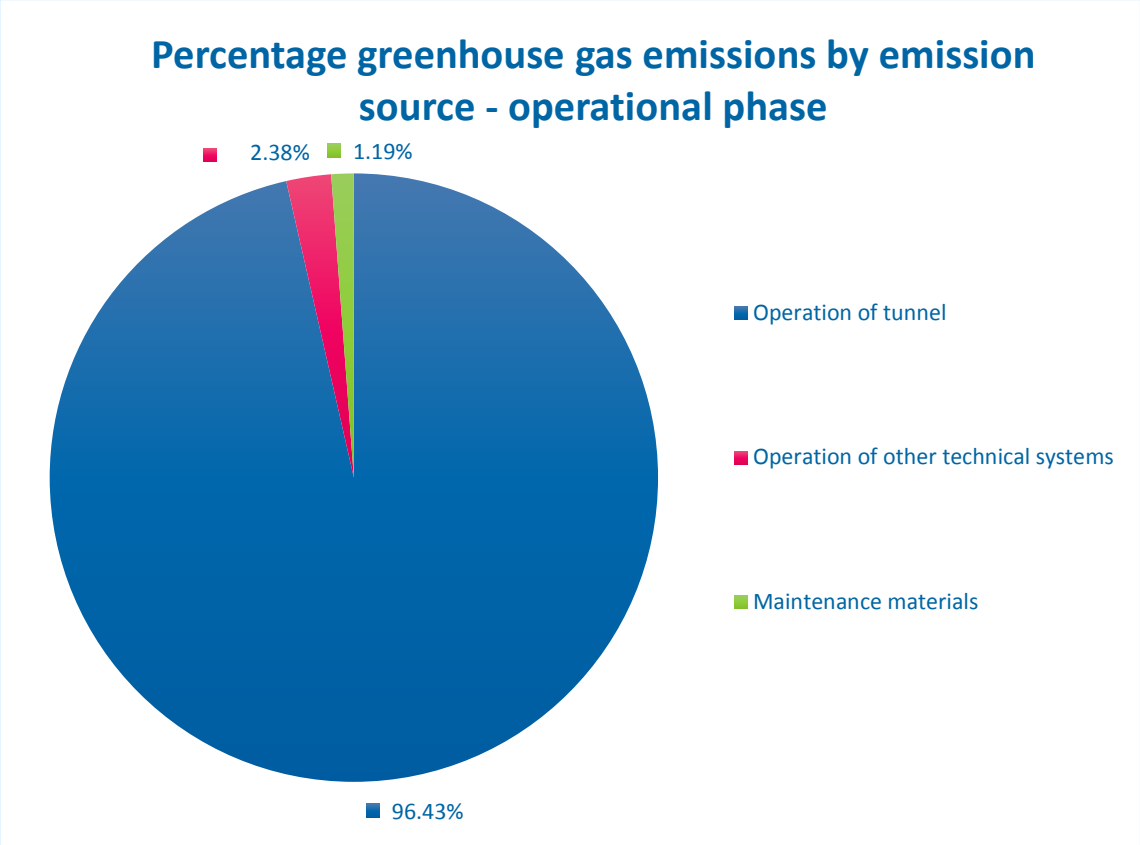


Figure 8-2 Percentage greenhouse gas emissions by source from North East Link operation (including maintenance)

A Sustainability Management Plan for North East Link would be developed and implemented to meet, as a minimum, the sustainability targets set for the project and specified ratings under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool (EPR SCC1).

In addition, sustainable design practices would be integrated into the design process to minimise, to the extent practicable, greenhouse gas emissions from the construction and operation of North East Link (EPR SCC2).

Furthermore, best practice measures for energy usage would be applied for the tunnel ventilation and lighting systems in accordance with the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry) (EPR SCC3).

8.2.2 Operational emissions from vehicle traffic

The greenhouse gas assessment considered the potential for the operation of North East Link to change vehicle flow through Melbourne, which may increase or decrease overall vehicle emissions (risk GH03).

This report uses the outputs from the VLC model to estimate greenhouse gas emissions from vehicle traffic across the Melbourne (statistical division) road network including the regional areas of Geelong, Ballarat, Bendigo and Traralgon, as described in Section 5.7.3.

Table 8-3 and Table 8-4 show VLC estimates for the Melbourne road network for the 'with project' and 'no project' scenarios in 2026 and 2036. Model outputs estimate a marginal decrease of 0.04 per cent and 0.13 per cent in 2026 and 2036 respectively in greenhouse gas under the 'with project' scenario compared with the 'no project' scenario.

Values have been converted from a weekday value to a yearly value by multiplying by a factor of 330, which is currently considered to be the best known way of converting weekday traffic day to yearly, and has been used across multiple Melbourne road project calculations.

Table 8-3 Estimated 2026 greenhouse gas emissions from road traffic on the Melbourne road network (kt CO_2-e per average weekday) (VLC, 2018)

Mode	2026 'no project' forecast (kt CO_2-e/year)	2026 'with project' forecast (kt CO_2-e/year)	Change in emissions (kt CO_2-e/year)	Change in emissions (%)
Car	16,851	16,906	+56	0.33%
LCV	1,178	1,175	-3	-0.29%
HCV	3,805	3,744	-62	-1.62%
Total	**21,835**	**21,825**	**-10**	**-0.04%**

Table 8-4 Estimated 2036 greenhouse gas emissions from road traffic on the metropolitan Melbourne road network (kt CO_2-e per average weekday) (VLC, 2018)

Mode	2036 'no project' forecast (kt CO_2-e/year)	2036 'with project' forecast (kt CO_2-e/year)	Change in emissions (kt CO_2-e/year)	Change in emissions (%)
Car	20,005	20,058	+53	0.27%
LCV	1,420	1,414	-7	-0.48%
HCV	4,701	4,622	-79	-1.69%
Total	**26,126**	**26,093**	**-33**	**-0.13%**

The results show that while North East Link would increase emissions from cars, this is more than offset by a larger reduction in emissions from heavy vehicles. This would likely be due to heavy vehicles moving off local roads and on to North East Link, as discussed in Technical report A – Traffic and transport.

The results were sensitivity tested by VLC by varying a number of parameters within its model. In all scenarios, emissions from the traffic network were lower for the 'with project' scenario than the 'no project' scenario.

Table 8-5 and Table 8-6 show VLC estimates of the vehicle kilometres travelled (VKT) for the 'with project' and 'no project' scenarios in 2026 and 2036. While North East Link would generate a higher daily number of kilometres travelled under both scenarios, the 'with project' scenarios for 2026 and 2036 would generate fewer emissions per VKT than the 'no project' scenarios.

Estimates of greenhouse gas emissions do not include changes to fuel efficiency of vehicles over time nor the uptake of electric vehicles.

Table 8-5 Estimated 2026 emissions per vehicle kilometre travelled (VLC, 2018)

	2026 'no project' forecast	2026 'with project' forecast	Difference (%)
Vehicle kilometres travelled (VKT) per day	149,471,719	150,641,662	0.78%
Total vehicle emissions/day (kg CO_2-e)	66,165,342	66,136,120	-0.04%
Emissions per VKT (kg CO_2-e/VKT)	0.442	0.439	-0.82%

Table 8-6 Estimated 2036 emissions per vehicle kilometre travelled (VLC, 2018)

	2036 'no project' forecast	2036 'with project' forecast	Difference (%)
Vehicle kilometres travelled (VKT) per day	173,024,654	174,361,744	0.77%
Total Vehicle Emissions/day (kg CO_2-e)	79,170,953	79,070,552	-0.13%
Emissions per VKT (kg CO_2-e/VKT)	0.458	0.453	-0.89%

8.2.3 Contribution to Victorian target

The Victorian Government has set a target of net zero emissions by 2050 (refer to Section 4.2.2). This impact assessment shows that while North East Link's operation would reduce Victoria's annual greenhouse gas emissions from the road network, these would be offset by the greenhouse gas emissions associated with operating the tunnels.

The scale of operational emissions from North East Link would be small in the context of Victoria's overall greenhouse emissions. While operational emissions are not large at the Victorian scale, it is still important they are reduced as far as practicable to help achieve the Victorian Government's 2050 net zero emissions target.

As discussed in Section 4.2.2, the Victorian government will be making sector specific emission reduction pledges every five years from 2020. The role that major projects, including North East Link, can play in transport sector and Victorian wide greenhouse gas mitigation would inform a future transport sector pledge. These opportunities include:

- Strategically utilising procurement to create markets for and drive production in lower emission construction materials
- Encouraging improvements in industry practice, including research and development, leading to emission reductions for future projects
- Encouraging mode shift to active transport through investment in shared use paths
- Designing for adaptability to future technological change, and in particular, greater electrification of the vehicle fleet.

These opportunities that arise from major projects are also recognised by the Victorian Government's Social Procurement Framework. The Victorian Government's sustainability procurement objectives contained within the framework seek to capitalise on these opportunities, and achieve emission reductions through strategic procurement activities.

These sustainability opportunities form part of NELP's Sustainability Approach, and in particular, would contribute to North East Link's policy objective to 'play a part in Victoria achieving its emission reduction targets while preparing for the challenges presented by climate change'. More information on North East Link's Sustainability Approach is provided in Attachment I to the EES.

8.3 Alternative design options

Although the reference design for North East Link has largely been finalised, there are currently two design options being considered for the arrangement of the Manningham interchange, and two locations for the launch of the tunnel boring machine (TBM) being considered. For information on the design options, refer to EES Chapter 8 – Project Description.

This section explains how the potential impacts associated with the alternative design options would differ from the impacts associated with the project design assessed in Section 8.1 and Section 8.2 above.

8.3.1 Manningham Road interchange alternative design option

The potential greenhouse gas impacts of the alternative design option for the Manningham Road interchange have been reviewed. As most of North East Link's greenhouse emissions would result from construction materials and the operation of the tunnels, the Manningham Road interchange alternative design is not expected to make a material difference to the project's greenhouse gas emissions due to the small size of the difference between the reference project for the interchange, and the size of the interchange relative to the size of the overall North East Link.

8.3.2 Northern tunnel boring machine (TBM) launch

The potential greenhouse gas impacts of the alternative TBM launch from the north of Lower Plenty Road have been assessed. Based on the estimated materials required and waste acid sulfate soils produced, the greenhouse gas emissions from construction of the alternative TBM launch site, including the TBM retrieval site north of Bridge Street, are estimated to be 47 kt CO_2-e. However it is noted that if this option goes forward there would be a reduction in emissions associated with the original TBM launch location which would no longer require construction, at least partially cancelling out the greenhouse gas impacts of the alternative option.

8.4 Cumulative impacts

Cumulative greenhouse gas emissions from multiple sources are a key contributor to climate change impacts such as greater frequency and intensity of extreme weather. It is acknowledged that a number of major infrastructure projects would be under construction in Melbourne at the same time as North East Link, including the West Gate Tunnel Project and the Metro Tunnel. These additional transport infrastructure projects would release greenhouse gas emissions over a similar construction timeframe as North East Link. However, the development of the Metro Tunnel may assist in reducing transportation emissions by increasing public transport use for some trips.

9. Environmental performance requirements

Table 9-1 lists the recommended Environmental Performance Requirements (EPRs) relevant to greenhouse gas assessment.

EPRs relevant to other technical disciplines such as vegetation removal (ecology) and acid sulfate soils (contaminated land) treatment which can impact on greenhouse gas emissions are provided in the relevant EES Technical reports.

Table 9-1 Environmental Performance Requirements

EPR ID	Environmental Performance Requirement
EPR SCC1	**Implement a Sustainability Management Plan** North East Link Project must set sustainability targets and specify ratings to be achieved under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool. Contractors must develop and implement a Sustainability Management Plan that considers measures to meet, as a minimum, the sustainability targets and specified ratings.
EPR SCC2	**Minimise greenhouse gas emissions** Integrate sustainable design practices into the design process to minimise, to the extent practicable, greenhouse gas emissions arising from construction, operation and maintenance of North East Link.
EPR SCC3	**Apply best practice measures for energy usage for tunnel ventilation and lighting systems** Best practice measures for energy usage are to be applied for the tunnel ventilation and lighting systems in accordance with the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry).

9.1 Sustainability management

Sustainability targets, including targets relating to climate change and carbon emissions, are being developed by NELP. The role of these targets and how they are embedded in contract requirements is described in Attachment I – Sustainability approach to the EES.

The IS Rating tool would be used to drive sustainability on North East Link as discussed in Section 4.4 and the credits within the rating tool would assist in setting targets.

Contractors would be required to develop and implement a Sustainability Management Plan to demonstrate how targets would be met or exceeded.

Greenhouse gas emissions would be quantified and modelled through the detailed design process as well as being measured and quantified during the construction and operation of North East Link. This modelling and quantification would be consistent with the IS rating scheme.

9.2 Minimising greenhouse gas emissions

9.2.1 Best practice energy efficiency in the Tunnel Ventilation System

Under the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry), best practice would be required for the energy efficiency of North East Link's tunnel ventilation system. This would be assessed by EPA in its determination of the Works Approval Application for the tunnel ventilation system.

The SEPP(AQM) defines best practice as:

'the best combination of eco-efficient techniques, methods, processes or technology used in an industry sector or activity that demonstrably minimises the environmental impact of a generator of emissions in that industry sector or activity'

where eco-efficient is defined as:

'producing more goods with less energy and fewer natural resources, resulting in less waste and pollution'.

Energy efficiency best practise measures which have been incorporated into the reference project to be implemented for North East Link's tunnel ventilation and lighting systems include:

- Use of variable speed drive (VSD) fans for main ventilation fan control and selected jet fans to ensure acceptable in-tunnel air quality is maintained
- Tailoring ventilation levels to traffic flows
- Use of light emitting diode (LED) lighting throughout the vehicle and access tunnels
- Maintaining a minimum level for safety purposes always with enhanced lighting activated on proximity
- Implementing an intelligent tunnel lighting control system that enables the control of tunnel luminaires during the daytime.

EPA Victoria has in the past required that tunnels be designed and operated to have zero portal emissions. However, through undertaking air quality monitoring and air impact modelling it has been possible for some tunnel operators to demonstrate that achieving zero portal emissions is not required at all times of the day. Consequently, EPA Victoria has amended some tunnel operator's licence conditions to allow portal emissions over night and on weekends (ie non-peak periods).

The North East Link tunnel ventilation system has been designed to be adaptable so that if, following further monitoring and modelling, the EPA were to grant approval for some portal emissions, energy savings could be achieved.

The assessment of best practice energy efficiency would need to be further considered at the detailed design phase. In previous similar projects, EPA Victoria has applied Works Approval conditions to account for possible changes made by the construction contractor to the design. For example, the Works Approval conditions for the West Gate Tunnel Project relating to greenhouse gas and energy use have required that:

> *'Before commencing construction of the following components of the works, you must provide to EPA a report or reports with the plans and specifications of those components, including details of: …*
> *(d) the tunnel ventilation and lighting systems, showing compliance with best practice requirements of the Protocol for Environmental Management 'Greenhouse Gas Emissions and Energy Efficiency in Industry'…'*

It is anticipated the conditions of the Works Approval for the ventilation system of the North East Link tunnels would include a similar provision.

9.2.2 Further opportunities for greenhouse gas mitigation

The impact assessment discussed in Section 8 identifies materials and electricity consumption as the largest sources of greenhouse gas emissions from North East Link. Opportunities that could be investigated for their feasibility and potential to reduce these emissions and other smaller emission sources are summarised in Table 9-2.

Table 9-2 Potential mitigation opportunities

Emission source category	Emission source	Potential mitigation approaches for consideration
Design and construction		
Fuel use	Electricity generation	Use of biofuels or lower or no emission vehicles and fuels (such as hydrogen or electric vehicles). Sourcing materials locally to minimise transport-related emissions. Design optimisation to reduce the amount of spoil and materials requiring movement from the site.
	Site vehicles	
	Transportation of spoil	
	Plant and equipment	
	Demolition and earthworks	
	Vegetation removal	
Electricity consumption	Operation of plant and equipment, including tunnel boring machines (TBMs)	Energy efficiency measures such as including energy efficiency as a procurement consideration. On-site generation or purchase of renewable energy Optimise designs (especially tunnel ventilation) to minimise energy usage Introduce solar energy collection and battery storage Make use of technology and sensors to facilitate optimisation of energy consumption as part of the control system's design and operation
Materials	Construction materials	Avoid the use of materials through detailed design. Source alternative materials with lower embodied energy such as replacing Portland cement with flyash where practicable and using recycled steel.
Land use changes	Vegetation removal	Minimise vegetation removal, replace removed vegetation

Emission source category	Emission source	Potential mitigation approaches for consideration
Operation		
Electricity consumption	Operation of tunnels (such as pumps, lighting and ventilation)	As per best practice measures identified above. On-site generation or purchase of renewable energy Solar energy, batteries and optimisation of power consumption through use of sensors and smart technology Consider co-generation to supply power to the tunnels
	Operation of other technical systems (such as signalling, lighting, toll gantries and operations centre)	Use of LEDs and intelligent integrated systems
	Operation and maintenance vehicle emissions	Use energy efficient vehicles and non-carbon-based fuels for incident response and maintenance vehicles

Consideration can be given to the purchase of carbon offsets for residual emissions.

10. Conclusion

The purpose of this report is to provide greenhouse gas impact assessments to inform the preparation of the EES required for the project.

The results of the greenhouse gas assessment and the associated impacts are summarised below.

The scoping requirements set out the specific environmental matters to be investigated and documented in the North East Link EES. The evaluation objective relevant to the greenhouse gas assessment is:

- To demonstrate that the project will contribute to the need for an effective, integrated and climate change-resilient transport system that provides a wide range of travel choices for all Victorians.

A summary of the key assets, values or uses that North East would potentially impact on and the associated impacts assessment are summarised below.

Existing conditions

In 2016 the total road transportation emissions in Victoria were 19,979 kt CO_2-e, with total emissions from all Victorian sectors in 2016 at 115,103 kt CO_2-e (AGEIS, 2018).

To reduce the effects of climate change and achieve the Victoria Government's target of net zero emissions by 2050 and Australia's pledge under the Paris Agreement, it is important to account for and reduce the greenhouse gas emissions from North East Link's operation and construction.

Impact assessment

Total emissions across the seven-year construction of the project were estimated at 2,020 kt CO_2-e. These emissions were dominated by two emission sources; the manufacture of construction materials and electricity consumed by the TBMs. Combined, these two emission sources would contribute 88 per cent of greenhouse gas emissions from North East Link's construction.

The total calculated annual greenhouse gas emissions from the construction of North East Link would be approximately 289 kt CO_2-e. This represents 0.25 per cent of emissions from all Victorian sectors in 2016 and 0.05 per cent of the national 2016 emissions (AGEIS, 2018).

The largest emission source during North East Link's operation would be from the electricity consumption in the operation of the tunnels, which was estimated at 96 per cent of the 84 kt CO_2-e per annum operational (including maintenance) greenhouse gas emissions.

This represents 0.07 per cent of emissions from all Victorian sectors in 2016, and 0.02 per cent of the national 2016 emissions (AGEIS, 2018).

Operational emissions from vehicle traffic were calculated separately, based on comparing the 'with project' and 'no project' scenarios. The 'with project' scenario would generate fewer greenhouse gas emissions in all cases. Model outputs estimate a marginal decrease of 10 kt CO_2-e per annum (0.04 per cent) and 33 kt CO_2-e per annum (0.13 per cent) in greenhouse gas emissions in 2026 and 2036 under the 'with project' scenario compared with the 'no project' scenario.

The scale of operational emissions from North East Link would be small in the context of Victoria's overall greenhouse emissions. While operational emissions are not large at the Victorian scale, it is still important they are reduced as far as practicable to help achieve the Victorian Government's 2050 net zero emissions target.

Model results show a more significant reduction in emissions per vehicle kilometre travelled (VKT) under the 'with project' scenario. Emissions per VKT can be seen as a measure of the efficiency of vehicle movement. Reductions of 0.82 per cent and 0.89 per cent are estimated for 2026 and 2036 respectively across the road network under the 'with project' scenario.

The following EPRs have been developed to address the estimated greenhouse gas emissions from North East Link:

- **EPR SCC1** – North East Link Project must set sustainability targets and specify ratings to be achieved under the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Tool. Contractors must develop and implement a Sustainability Management Plan that considers measures to meet, as a minimum, the sustainability targets and specified ratings.
- **EPR SCC2** – Integrate sustainable design practices into the design process to minimise, to the extent practicable, greenhouse gas emissions arising from construction, operation and maintenance of North East Link.
- **EPR SCC3** – Best practice measures for energy usage are to be applied for the tunnel ventilation and lighting systems in accordance with the Protocol for Environmental Management (Greenhouse Gas Emissions and Energy Efficiency in Industry).

11. References

AECOM, West Gate Tunnel Project – Technical report Q – Greenhouse gas, May 2017.

Aurecon Jacobs Mott MacDonald in association with Grimshaw Joint Venture (AJM JV), Melbourne Metro Rail Project – Greenhouse Gas Impact Assessment, April 2016.

Australian Greenhouse Emissions Information System (AGEIS) *National Greenhouse Gas Inventory – Kyoto Protocol classifications* <http://ageis.climatechange.gov.au/NGGI.aspx> (15 April 2018).

CSIRO, *Climate Change in in Australia – Projections for Australia's NRM Regions* <https://www.climatechangeinaustralia.gov.au/en/climate-campus/global-climate-change> (1 June 2018), 2016.

Department of Environment, Land, Water and Planning (DELWP), *Victoria's Net Zero by 2050 Emissions Reduction Target* <https://www.climatechange.vic.gov.au/media-releases/victorias-net-zero-by-2050-emissions-reduction-target> (1 June 2018), 2016.

Department of the Environment and Energy (DoEE) *National Greenhouse Accounts Factors 2018*, Commonwealth of Australia, 2018.

Infrastructure Sustainability Council of Australia (ISCA) 2016, Infrastructure Sustainability Materials Calculator – Version 1.2, March 2016.

Infrastructure Sustainability Council of Australia (ISCA) 2018, Infrastructure Sustainability Materials Calculator – Version 2.0, July 2018.

Transport Authorities Greenhouse Group (TAGG) 2013, *Greenhouse Gas Assessment Workbook for Road Projects*, February 2013.

Veitch Lister Consulting (VLC) *Greenhouse Gas Assessment – Zenith Economics Assessment Model*, October 2018.

Appendices

Appendix A – Risk assessment

Risk ID	Potential threat and effect on the environment	INITIAL RISK							RESIDUAL RISK							
		Initial EPR	Characterisation of consequence			Overall consequence	Likelihood of impact	Risk level	Final EPR	Magnitude of effect			Overall consequence	Likelihood of impact	Risk level
			Extent	Severity	Duration					Extent	Severity	Duration			
Construction															
Risk GH01	Land clearing and consumption of materials and electricity generated from fossil fuels, operation of plant and equipment, and transportation of materials and equipment during construction result in the release of greenhouse gas emissions which could contribute to global climate change.	EPR SCC1 Implement a Sustainability Management Plan EPR SCC2 Minimise greenhouse gas emissions	Wider region	Medium	2-7 years	Major	Planned	Planned	EPR SCC1 Implement a Sustainability Management Plan EPR SCC2 Minimise greenhouse gas emissions	Wider region	Medium	2-7 years	Major	Planned	Planned
Operation															
Risk GH02	Operational and maintenance activities including consumption of fossil fuels for electricity generation, operation of plant and equipment and transportation of materials and equipment result in greenhouse gas emissions, which could contribute to global climate change.	EPR SCC1 Implement a Sustainability Management Plan EPR SCC2 Minimise greenhouse gas emissions	Wider region	Medium	7+ years	Major	Planned	Planned	EPR SCC1 Implement a Sustainability Management Plan EPR SCC2 Minimise greenhouse gas emissions EPR SCC3 Apply best practice measures for energy usage for tunnel ventilation and lighting systems	Wider region	Low	7+ years	Moderate	Planned	Planned
Risk GH03	Operation of North East Link will cause a change in vehicle flow through Metropolitan Melbourne which may result in an increase or decrease in the overall vehicle emissions.		Wider region	Low	7+ years	Moderate	Planned	Planned		Wider region	Low	7+ years	Moderate	Planned	Planned

Appendix B – Carbon Gauge inputs and assumptions

Carbon Gauge category		Carbon Gauge input	Data provided and GHD assumption/s for project design
Fuel type			
Construction activity	Site offices	Diesel	Assumption made of 100 per cent diesel vehicles on site.
	Construction	Diesel	
	Demolition and earthworks	Diesel	
	Vegetation removal	Diesel	
	Percentage of site vehicles using petrol	0%	
Pavements			
Pavement types	Pavement 2	• 1,500,000 m²	Assume pavement type is ‘deep strength’ in Carbon Gauge as per recommendations from the reference project engineering team.
	Pavement 5	• 380,000 m²	Assume pavement type is ‘reinforced concrete’ in Carbon Gauge as per recommendations from the reference project engineering team.
	Pavement 2	• 150,000 m²	Assume pavement type is ‘deep strength’ in Carbon Gauge as per recommendations from the reference project engineering team.

Carbon Gauge category		Carbon Gauge input	Data provided and GHD assumption/s for project design
Structures			
Structures type	Bridges (including interchanges and overpasses)	Concrete: • Length = 6.534 km • Width = 16.00 m Steel: • Length = 9.932 km • Width = 10.39 m	Calculations from reference project engineering team. Assumed all bridges to be concrete based unless specified to be steel or truss. Average width was calculated from total lengths and areas.
	Reinforced soil walls	• 8,330 m in length • 8 m in height	Calculations from reference project engineering team. Advised heights may vary up to 8 m, a conservative value of 8 m was used for calculations.
	Retaining walls	• 3,000 m in length • 8 m in height	
Drainage			
Drainage type	Kerbing	• 50,744 m upright kerb and gutter (channel)	Advice from reference project engineering team.
	Culverts – pipes or box culverts for water drainage	• 124,968 m Medium (450–750 RCP) Culverts	No advice provided – assumption of medium drainage type on either side of the road for a length of 62,484 m

Carbon Gauge category		Carbon Gauge input	Data provided and GHD assumption/s for project design
Road furniture			
Road furniture type	Road safety barriers	• 320.403 km F-type barrier	Advice from reference project engineering team.
	Noise walls	43.5 km	Advice from reference project engineering team.
Earthworks			
Earthwork type	Strip and respread topsoil	0	No information provided, assume zero.
	Cut to spoil	4,917,806 m³	Advice from reference project engineering team.
	Cut to fill	1,182,194 m³	Advice from reference project engineering team.
	Import and place filling	650,000 m³	Advice from reference project engineering team.
Vegetation removal			
Vegetation removal type	Biotype class	• 20.844 ha Class C Open Forest • 6.253 ha Class D Open Woodland • 25.012 ha Class G Open Shrubland	Advice from reference project engineering team. Estimated total loss of 52.109 ha loss. 40%-12%-48% split between Class C, D and G vegetation types respectively.
	Vegetation removed		

Carbon Gauge category		Carbon Gauge input	Data provided and GHD assumption/s for project design
Street lighting			
Street lighting type	Freeway through carriageways	• 54,870 m	Advice from reference project engineering team of 62,484 m, with 35,049 m of this on carriageway on Eastern Freeway which may be retained. Assumed lighting on both sides of the road.
	Freeway lamps and arterial roads	• 20,000 m	Advice from reference project engineering team. Assumed lighting on both sides of the road.
	Underpasses	• 4,838 m	Advice from reference project engineering team Assumed lighting on both sides of the road. Tunnel lighting included separately in tunnel calculations
Traffic Signals			
Traffic signal type	LED traffic signals	• 5 Freeway with divided road (full diamond interchange)	Assumption based on advice from reference project engineering team: 5 new or significantly changed intersections + 27 ramp meters. Assumption made that ramp meters would be negligible in comparison to large intersections.

Appendix C – Carbon Gauge inputs and outputs

Carbon Gauge

Materiality Checklist

Activity/Emission Source	Tick if included	Emission source to be included in GHG Assessment
Construction		
Will a diesel generator be used to provide power to the project site office for more than 12 months?	☑ YES	If yes, fuel combusted in powering site offices will be included.
Will more than 120 buildings be required to be demolished per 1km of road?	☐ YES	If yes, fuel combusted in demolishing buildings will be included.
Will more than 0.5 ha (5,000m^2) of vegetation be removed?	☑ YES	If yes, vegetation removal and/or revegetation will be included.
Will the project involve tunnelling?	☐ YES	If yes, electricity consumption and explosives used will be included. **Tunnelling is not yet included.**
Is the project located more than 50 km from the nearest material suppliers/quarry/city?	☐ YES	If yes, the emissions associated with the transport of materials to site will be included.
Will the project utilise on-site batching plants or other continuously operating stationary plant and equipment for more than 6 months?	☐ YES	If yes, fuel combusted in stationary engines will be included. **Batching plants are not yet included.**
Will the project include road safety barriers along more than 50% of the road length if barriers are used on both sides of a dual carriageway (i.e. 4 sets) or 100% of the road length if used on both side of a single carriageway (i.e. two sets)?	☑ YES	If yes, the emissions from the construction and installation of road safety barriers will be included.
Will the project include noise walls along more than 50% of the road length on both sides or 100% of the road length on one side?	☑ YES	If yes, the emissions from the construction and installation of noise walls will be included.
Operation		
Will the project include street lighting continuously along more than: 15% of the road length (VIC) 20% of the road length (ACT, NSW, QLD) 25% of the road length (SA, WA, NT) 70% of the road length (TAS)? 100% of the road length (NZ)?	☑ YES	If yes, the emissions from the operation of street lighting will be included.
Will the project include traffic signals and/or interchanges using incandescent lights that are less than: 14.9 km apart (VIC) 11.5 km apart (ACT, NSW, QLD, NT) 8.0 km apart (SA, WA) 3.1 km apart (TAS)? 1.7 km apart (NZ)?	☑ YES	If yes, the emissions from the operation of traffic signals using incandescent lights wil be included.
Will the project include traffic signals and/or interchanges using quartz halogen lights that are less than: 5.6 km apart (VIC) 4.5 km apart (ACT, NSW, QLD, NT) 3.5 km apart (SA, WA) 1.3 km apart (TAS)? 0.6 km apart (NZ)?	☐ YES	If yes, the emissions from the operation of traffic signals using quartz halogen lights wil be included.
Will the project include traffic signals and/or interchanges using LED lights that are less than: 2.7 km apart (VIC) 2.0 km apart (ACT, NSW, QLD) 1.8 km apart (SA, WA, NT) 0.6 km apart (TAS)? 0.3 km apart (NZ)?	☑ YES	If yes, the emissions from the operation of traffic signals using LED lights wil be included.
Will the project include emissions from vehicles using the road during its 50 year life?	☐ YES	If yes, enter the emissions from vehicles using the road over the 50 year life of the road project. Note that these emissions must be calculated separately and then entered into the calculator.

Carbon Gauge

Inputs

Key: 50 User Input | 0 Calculated Cell | Cell not available for input

Project Details

Project title	North East Link		
Project location	Western Ring Road (M80) to the Eastern Freeway	Country: (●) Australia ( ) NZ	Region: ( ) Rural (●) Urban
State	VIC		
Brief description of the works e.g. (eg. new road, road duplication, road upgrade, intersection upgrade, etc)	New Freeway Standard road connection		

Construction

Estimated Value ($m)	15000	Large Project
Project Duration (Months)	84	

Fuel Type

	Construction Activity	Fuel Type	Percentage of site vehicles using Petrol
Plant Equipment Fuel	Site Offices	Diesel	0%
	Construction	Diesel	
	Demolition and Earthworks	Diesel	
	Vegetation Removal	Diesel	

Pavements

Pavement Options are only available for road pavement types 1 to 5

	Pavement types	Pavement area (m^2)	Use Pavement Option	Press Button to configure
Pavement 1	02. Deep Strength Asphalt	1,550,000	☐ YES	
Pavement 2	05. Reinforced Concrete (RC)	380,000	☐ YES	
Pavement 3	02. Deep Strength Asphalt	150,000	☐ YES	
Pavement 4	01. Full Depth Asphalt	0	☐ YES	
Pavement 5	01. Full Depth Asphalt	0	☐ YES	
Pavement 6	01. Full Depth Asphalt	0	☐ YES	

Structures

	Type	Total Length (km)	Width (m)	Height (m)
Bridges (including interchanges and overpasses)	Bridge constructed using precast reinforced concrete beams	6.534	16	
	Bridge constructed using steel beams	9.932	10.39	
Reinforced Soil Walls	Reinforced Soil Walls	8.33		8
Retaining Walls	Concrete retaining walls	3		8
	Timber retaining walls	0		0
	Rock retaining walls	0		0

Drainage

		Total Length (km)
Kerbing	Mountable Kerb	0
	Semi-mountable Kerb	0
	Upright kerb and Gutter (Channel)	50.744
	Invert drain	0
Culverts – pipes or box culverts for water drainage	Small <450 RCP	0
	Medium 450 – 750 RCP	124.968
	Large 750 – 1200 RCP	0
	375x 600 RCBC	0
	600 x 1200 RCBC	0
Open, Unlined Drains	Form open, unlined drains	0

Road Furniture

		Total Length (km)
Road Safety Barriers	Wire rope barrier	0
	W-beam barrier	0
	F-type (New Jersey) barrier	320.403
Noise Walls	Reinforced concrete wall	43.5
	Hebel noise wall	0
	Timber wall	0
	Steel plate wall	0

Material Transport

	Pavements	Structures	Drainage	Road Furniture	Truck Size per Load of Material (GVM)	Distance from source to site (km)
Aggregate						

Only include materials being transported more than 50km

Asphalt & Bitumen						
Cement and Concrete						
Steel						
Timber						

Earthworks

		Total Volume (m^3)
Earthwork Types	Strip and respread topsoil	0
	Cut to spoil	4,917,806
	Cut to fill	1,182,194
	Import and place filling	650,000

Demolition

		Quantity demolished (Number of buildings)
Buildings	Houses	
	Small commercial	
	Medium commercial	
	Large commercial	

Vegetation Removal

		Select biomass class
Biomass Class	Potential maximum biomass class	Class 1: 0 - 50 (t dry matter/ha)

		Area cleared (ha)
Vegetation Removed	Class A (Rainforest and vine thicket)	Not Possible
	Class B (Eucalypt tall open forest)	Not Possible
	Class C (Open forest)	21
	Class D (Open woodlands)	6
	Class E (Callitris forest & woodland)	0
	Class F (Mallee & Acacia woodland)	0
	Class G (Open shrubland)	25
	Class H (Heathlands)	0
	Class I (Grasslands)	0

Operations

Street Lighting

		Street Length (m)
Lighting Street lighting is only for one side of the road, if lighting is on both sides double the length entered	Freeway through carriageways	54,870
	Freeway ramps and arterial roads	20,000
	Underpasses	7,200

Traffic Signals

		Number of Intersections
Incadescent Traffic Signals	Major urban intersection - Divided Road	0
	Major intersection - Undivided Road	0
	Freeway with divided road (full diamond interchange)	0
Quartz Halogen Traffic Signals	Major urban intersection - Divided Road	
	Major intersection - Undivided Road	
	Freeway with divided road (full diamond interchange)	
LED Traffic Signals	Major urban intersection - Divided Road	0
	Major intersection - Undivided Road	0
	Freeway with divided road (full diamond interchange)	5

Vehicle Use

		Emissions GHGe (t CO2-e)
Vehicles	Emissions from vehicles using road	

Maintenance

Maintenance Activities

		Pavement area (m^2)	Construction area (m^2)
Pavements - Flexible	01. Full Depth Asphalt	0	0
	02. Deep Strength Asphalt	1,620,133	1,700,000
	03. Granular with Spray Seal	0	0
Pavements - Rigid	04. Plain Concrete (PC)	0	0
	05. Reinforced Concrete (RC)	350,202	380,000

Carbon Gauge

Summary Report

Note: This Workbook is designed to enable a consistent methodology for the assessment of significant emission sources and estimation of greenhouse gas emissions. As such it deliberately does not cover activities and emission sources assessed as insignificant, and it is not designed for compliance reporting.

Project Description

Project title	North East Link
Project location	Western Ring Road (M80) to theEastern Freev
State	VIC
Description	New Freeway Standard road connection

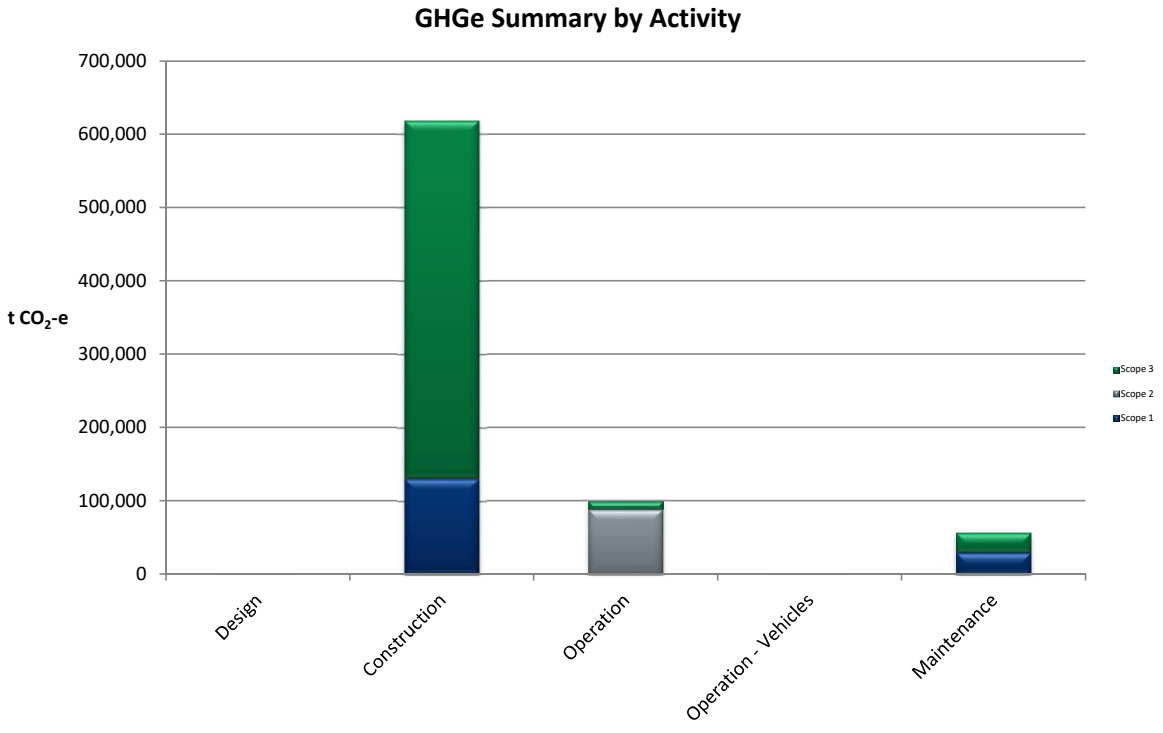
Project Value ($m)	15000
Project Duration (Months)	84

Greenhouse Gas Emissions

Scope 1 emissions	Emissions released into the atmosphere as a direct result of an activity, or series of activities (including ancillary activities) that constitutes the facility.
Scope 2 emissions	Emissions released as a result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.
Scope 3 emissions	Emissions that occur outside the site boundary of a facility as a result of activities at a facility that are not Scope 2 emissions.

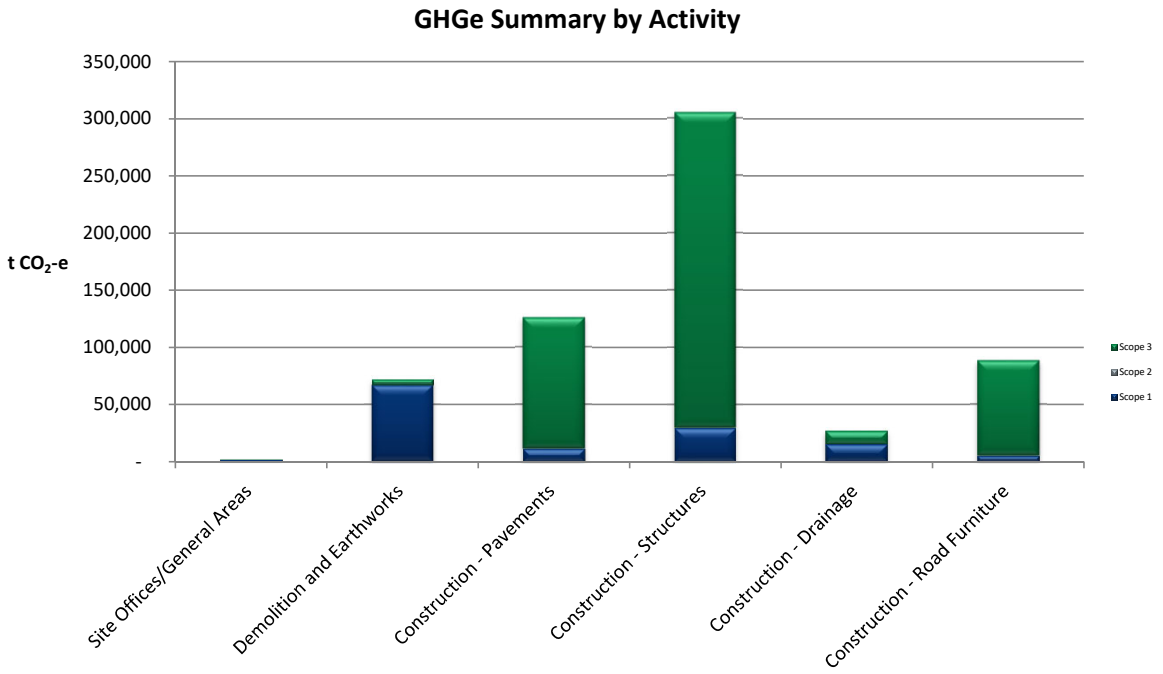
Project Summary

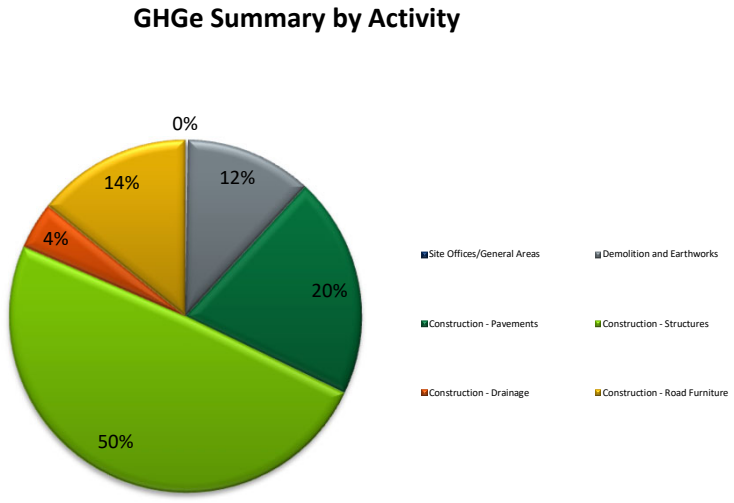
Major Activity	Scope 1	Scope 2	Scope 3	Total
Design	0	0	0	**0**
Construction	130,362	0	488,136	**618,498**
Operation	0	87,639	11,047	**98,686**
Operation - Vehicles	0	0	0	**0**
Maintenance	29,176	0	26,224	**55,400**
Total	**159,539**	**87,639**	**525,406**	**772,583**



Construction Summary

GHGe Summary by activity	Scope 1	Scope 2	Scope 3	Total
Site Offices/General Areas	1,465	0	112	**1,576**
Demolition and Earthworks	67,015	0	4,736	**71,751**
Construction - Pavements	11,462	0	114,009	**125,471**
Construction - Structures	29,778	0	275,338	**305,116**
Construction - Drainage	15,141	0	11,370	**26,511**
Construction - Road Furniture	5,502	0	82,571	**88,073**
Total	**130,362**	**0**	**488,136**	**618,498**



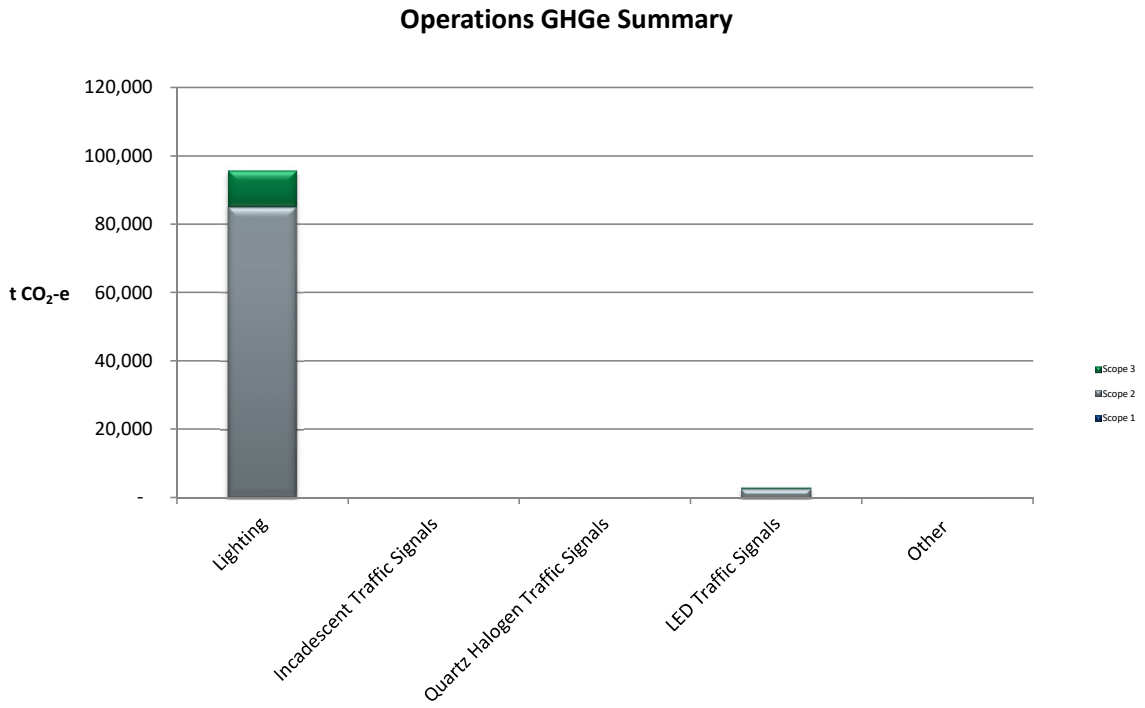


Carbon Gauge

Operations Summary (Emissions are calculated for a 50 year period)

Summary	Scope 1	Scope 2	Scope 3	Total
Lighting	-	85,015	10,716	**95,731**
Incadescent Traffic Signals	-	-	-	**-**
Quartz Halogen Traffic Signals	-	-	-	**-**
LED Traffic Signals	-	2,624	331	**2,954**
Other	-	-	-	**-**
Total	**-**	**87,639**	**11,047**	**98,686**

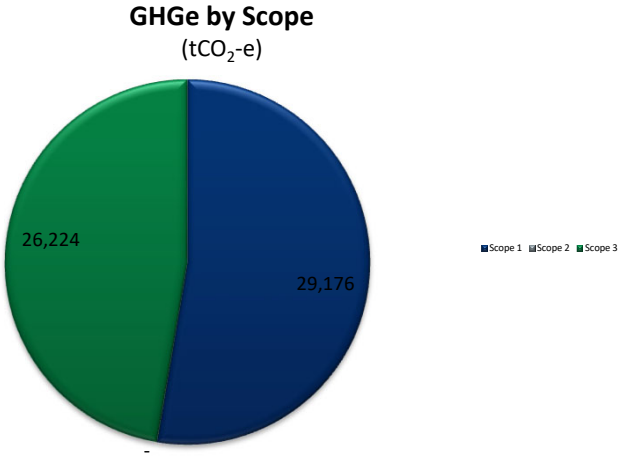
Summary - Vehicles	Scope 1	Scope 2	Scope 3	Total
Vehicle Use	-	-	-	**-**
Total	**-**	**-**	**-**	**-**



Carbon Gauge

Maintenance Summary (Emissions are calculated for a 50 year period)

Summary by Pavement	Scope 1	Scope 2	Scope 3	Total
01. Full Depth Asphalt	-	-	-	**0**
02. Deep Strength Asphalt	19,123.86	-	24,559.84	**43,684**
03. Granular with Spray Seal	-	-	-	**0**
04. Stablised Pavement	-	-	-	**0**
04. Plain Concrete (PC)	-	-	-	**0**
05. Reinforced Concrete (RC)	10,052.51	-	1,663.71	**11,716**
Other	-	-	-	**0**
Total	**29,176**	**0**	**26,224**	**55,400**



Appendix D – Tunnel construction and operation inputs and outputs

Data inputs – Construction	Amount	Units	Comments
TBM electricity consumption during construction	124,510	MWh	Assumption made using West Gate Tunnel values converted based on tunnel lengths
Site electricity consumption, including site office, during construction stage	753	MWh	Assuming total construction period of seven years, and office consumption of 107.541 MWh p.a., which was calculated for the West Gate tunnel assessment.
Indirect (Scope 2) emission factor for consumption of purchased electricity from the grid in Victoria	1.07	t CO_2-e/MWh	National Greenhouse Accounts Factors July 2018
Indirect (Scope 3) emission factor for transmission and distribution losses of purchased electricity from the grid in Victoria	0.1	t CO_2-e/MWh	National Greenhouse Accounts Factors July 2018
Tunnel calculations – Materials			
Volume of concrete	2,425,287	Tonnes	Converted from m^3 value provided by the reference project engineering team. Assuming 0.435 m^3 = 1 tonne (Based on conversion factors in Appendix C of the Greenhouse Gas Assessment Workbook for Road Projects).
Volume of steel	215,000	Tonnes	Reference project engineering team
Tunnel calculations – Materials – DELIVERY			
Total number of truckloads	102,853	truckloads	25 t truckload capacity has been assumed.
Total km for tunnel materials delivery (assuming 22.5 km one way trip)	4,628,379	km	-
Total tunnel materials transportation (diesel)	2,592	kL	-

Data inputs – Construction	Amount	Units	Comments
Tunnel calculations – Materials – EMISSION FACTORS			
Construction material emission factor for concrete	0.195	t CO_2-e/t	Adopted from the IS Materials Calculator v. 2.0 2018-10-26. Material type assumed to be 'Concrete 40 MPa' and 0% Supplementary Cementitious Material (SCM).
Construction material emission factor for cement	0.82	t CO_2-e/t	Adopted from the TAGG Greenhouse Gas Assessment Workbook for Road Projects 2013. Material type assumed to be 'Portland cement'.
Construction material emission factor for steel	3.200	t CO_2-e/t	Adopted from the IS Materials Calculator v. 2.0 2018-10-26. Material type assumed to be 'Steel Fibres for concrete reinforcement'.
Construction material emission factor for aggregate	0.005	t CO_2-e/t	Adopted from the TAGG Greenhouse Gas Assessment Workbook for Road Projects 2013. Material type assumed to be 'crushed rock'.
Construction material emission factor for fly ash	0.161	t CO_2-e/t	Adopted from the TAGG Greenhouse Gas Assessment Workbook for Road Projects 2013.
Construction material emission factor for sand	0.003	t CO_2-e/t	Adopted from the TAGG Greenhouse Gas Assessment Workbook for Road Projects 2013.
Tunnel calculations – Spoil transportation			
Spoil – cut to spoil (BCM)	4,917,806	BCM	Reference project engineering team
1.2 BCM conversion to m^3	5,901,367	m^3	-
1.5 spoil conversion m^3 to tonnes	8,852,051	t	-
Total number of truckloads	354,082	truckloads	25 t truckload capacity has been assumed.
Total km for disposal of spoil (assuming 35 km trip one way)	24,785,742	km	
Diesel fuel use for heavy vehicle truck	0.00056	kL/km of diesel	Assuming the same fuel usage as trucks for the West Gate Tunnel EES.
Total spoil transportation (diesel)	13,880	kL	-

Data inputs – Construction	Amount	Units	Comments
Tunnel calculations – Spoil transportation – EMISSION FACTORS			
Diesel fuel – energy content factor – Scope 1	38.6	GJ/kL	National Greenhouse Accounts Factors July 2018
Diesel fuel – emission factor CO_2 – Scope 1	69.9	kg CO_2-e/GJ	National Greenhouse Accounts Factors July 2018
Diesel fuel – emission factor CH_4 – Scope 1	0.1	kg CO_2-e/GJ	National Greenhouse Accounts Factors July 2018
Diesel fuel – emission factor N_2O – Scope 1	0.5	kg CO_2-e/GJ	National Greenhouse Accounts Factors July 2018
Diesel fuel – emissions factor – Scope 3	3.6	kg CO_2-e/GJ	National Greenhouse Accounts Factors July 2018
Tunnel calculations – Spoil transportation – EMISSION FACTORS			
Total Waste Acid Sulfate Soil (WASS) and Rock	2,630,000	m^3	Reference project engineering team
Liming rate	186	kg $CaCO_3/m^3$	A conservative estimate taken from the liming rate calculations from the Melbourne Metro Tunnel EES, in the absence of a full assessment of the acidity of the soils for the North East Link corridor.
Emissions Factor – Agricultural liming	0.12	t CO_2/t $CaCO_3$	The same emission rate as Metro Tunnel has been used for consistency. This is considered to be a conservative estimate.

Data inputs – Operation	Amount	Units	Comments
Total tunnel operation (MWh)	69,475	MWh	Reference project engineering team
Tunnel calculations – Operation – EMISSION FACTORS			
Indirect (Scope 2) emission factor for consumption of purchased electricity from the grid in Victoria	1.07	t CO_2-e/MWh	National Greenhouse Accounts Factors July 2018
Indirect (Scope 3) emission factor for transmission and distribution losses of purchased electricity from the grid in Victoria	0.1	t CO_2-e/MWh	National Greenhouse Accounts Factors July 2018

Data inputs – Operation	Amount	Units	Comments
Operation centre/FCC			
Floor space	360	m^3	Assumes 12 m x 15 m over two floors
Total electricity consumption	107,514	kWh p.a.	For the greenhouse gas assessment for the West Gate Tunnel, this was calculated using NABERS Energy for offices reverse calculator v. 11.0 – base building. Based on 3-star (average) electricity allowance for an office building in the city, operating 24/7. Excludes gas, coal, and diesel energy sources. In the absence of any other information we are making the same assumption.

Data outputs – Construction	Amount	Units
Tunnel construction – electricity – TBM		
Scope 2 Greenhouse gas emissions construction – TBM	133,226	t CO_2-e
Scope 3 Greenhouse gas emissions construction – TBM	12,451	t CO_2-e
Tunnel construction – electricity – P&E and site offices		
Scope 2 Greenhouse gas emissions construction – P&E	805	t CO_2-e
Scope 3 Greenhouse gas emissions construction – P&E	75	t CO_2-e
Scope 3 Greenhouse gas emissions from tunnel construction materials delivery to site (full fuel cycle)	7,413	t CO_2-e
Tunnel construction – materials		
Concrete 40 MPa	460,060	t CO_2-e
Steel	688,000	t CO_2-e
Scope 3 Greenhouse gas emissions from total tunnels material required	1,148,060	t CO_2-e
Spoil transportation		
Scope 1 Greenhouse gas emissions from spoil transportation	37,772	t CO_2-e
Scope 3 Greenhouse gas emissions from spoil transportation	1,929	t CO_2-e
Liming treatment		
Scope 3 emissions from production of lime used to treat acid sulfate soils	58,702	t CO_2-e

Data outputs – Operation	Amount	Units
Tunnel operation		
Total tunnel power demand	69,476	MWh/yr
Scope 2 Greenhouse gas emissions from tunnel operation	74,339	t CO_2-e/yr
Scope 3 Greenhouse gas emissions from tunnel operation	6,948	t CO_2-e/yr
Operation centre		
Total Scope 2 greenhouse gas emissions from operations centre	115	t CO_2-e
Total Scope 3 greenhouse gas emissions from operations centre	11	t CO_2-e

Appendix E – VLC Zenith economics assessment model

Veitch Lister Consulting Pty Ltd

Prepared for

North East Link Project

Transport Modelling for North East Link

Greenhouse Gas Assessment – Zenith Economics Assessment Model

October 2018

Transport Modelling for North East Link

Greenhouse Gas Assessment – Zenith Economics Assessment Model

Project 16-081

Date	Revision	Prepared By	Checked By	Approved By	Description
26/02/2018	A	AA	LS	AA	DRAFT for Comment
20/04/2018	B	LL	AA	AA	Updated Parameters in Section 3.2
24/10/2018	C	AA	AA	AA	updated due to TRG comments

Contents

List of Figures

List of Tables

1 Introduction

This technical note describes the greenhouse gas calculation methodology, which is a subset of the Zenith transport model economic assessment model (EAM). The EAM is used to calculate the economic benefits associated with transportation projects.

1.1 Background

The Zenith EAM is a procedure implemented by Veitch Lister Consulting (VLC) within the OmniTRANS software package, which calculates the input data used in the economic assessment of transportation projects. The Zenith EAM is designed to interface with outputs produced by the Zenith Model.

The output of the Zenith EAM is stored within a specially designed Microsoft Excel spreadsheet, which can house the results of multiple modelled transport scenarios. This spreadsheet will be referred to as the "*Zenith EAM Spreadsheet*".

The scope of the Zenith EAM includes the calculation of:

- user benefits (consumer surplus);
- resource costs (i.e. vehicle operating costs);
- externalities (i.e. vehicle emissions including greenhouse gases and road accidents);
- agglomeration benefits.

The Zenith EAM can be applied to estimate the economic benefits of a wide variety of transportation projects, including:

- new road infrastructure and road upgrades;
- toll roads;
- new public transport infrastructure / services and service upgrades;
- changes in public transport fares, parking prices, etc.

The Zenith EAM can be applied to both "*variable demand*" scenarios, where the modelled trip matrices are predicted to change in response to the particular infrastructure / service improvement (so as to reflect "*induced travel*") and to "*fixed demand*" scenarios (where "*trip matrices*" are assumed to remain constant). In the case of the North East Link (NEL) project, the Zenith EAM was applied to "*variable demand*" scenarios that reflect "*induced travel*". This is discussed in more detail in Section 3.3.

The scope of the Zenith EAM does not extend to estimating the cost of constructing, operating and maintaining new infrastructure / services.

1.2 Report structure

The balance of this document is structured as follows:

- Section 2 describes the overall economic assessment framework
- Section 3 describes the calculation of environmental benefits

2 Summary of economic assessment framework

2.1 Scenarios

The economic benefits of a transportation project are generally calculated by comparing the outputs generated by two modelled scenarios:

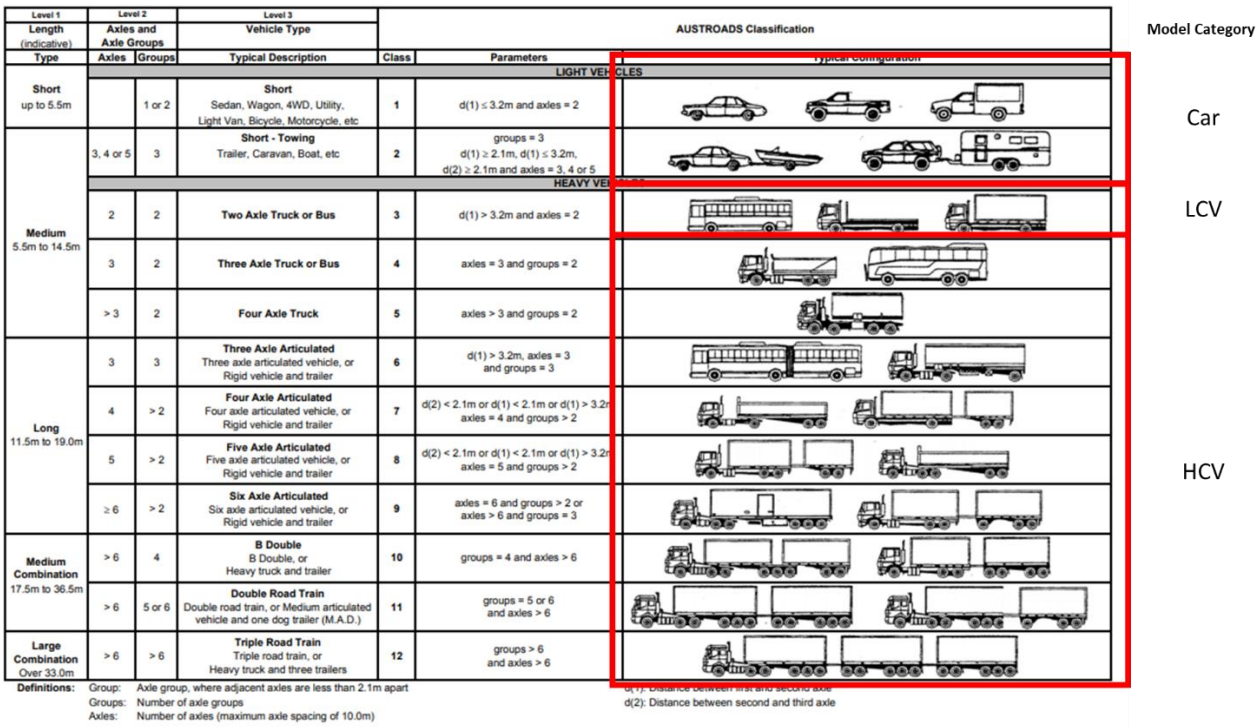
- the “Base case scenario” (sometimes referred to as the “Reference Case Scenario”). This scenario does not include the particular project which is of interest; and
- the “Project Scenario”. This scenario does include the project of interest.

Generally, a series of base case and project scenarios are generated for a range of forecast years (2026, 2036 etc.), allowing the benefits of the project scenario to be forecast and appropriately discounted.

2.2 Vehicle classification

The Zenith model separately forecasts car, light commercial vehicle (LCV) and medium/heavy commercial vehicle (HCV) flows. A car is defined as Austroads vehicle classification 1 and 2, while LCV’s are defined as classification 3, and HCV’s are defined as classifications 4 to 12.

Figure 2.1 - Austroads vehicle classification system and model category



Source: Austroads

3 Environmental assessment

The emission of greenhouse (and other) gases cause impacts that are detrimental to both health and the environment. Emissions related to vehicular traffic (cars, light commercial vehicles and heavy commercial vehicles) are captured within the Zenith EAM, in terms of tonnages. These outputs are stored within the “report_Emissions” and “report_TonnesEmissions” tabs of the Zenith EAM Spreadsheet.

The calculation of emissions takes a two step process:

1. Calculate fuel consumption on each road link
2. Convert fuel consumption to emissions in tonnes

Each step is now described.

3.1 Calculating fuel consumption

Austroads (2005) provides the following model of fuel consumption as a function of average link speed:

$$F = A + \frac{B}{V} + C \times V + D \times V^2$$

Where: F is the rate of fuel consumption (L / 100km)

A, B, C, D are model parameters

V is the average link speed (in km / hr)

Different parameter sets (A, B, C, D) are defined for each combination of road type (freeway / non-freeway), and vehicle type (car, light commercial vehicle, heavy commercial vehicle). The parameters, drawn from Austroads (2005) are reproduced in Table 3.1and Table 3.2.

Table 3.1 - Fuel consumption parameter values on freeways

Vehicle Type	A	B	C	D
Cars	7.149	268.1	0.0	0.0003
LCV	11.365	423.0	0.0	0.0005
HCV	26.932	1276.4	0.0	0.0008

Source: Austroads (2005), Table 4.3

Table 3.2 - Fuel consumption parameter values on non-freeways

Vehicle Type	A	B	C	D
Cars	0.361	528.0	0.0	0.000785
LCV	-3.129	1017.0	0.0	0.001481
HCV	-10.495	2915.7	0.0	0.00315

Source: Austroads (2005), Table 4.4

3.2 Calculating emissions in tonnes

3.2.1 Calculating CO_2-e emission rates

Emission rates for equivalent carbon dioxide (CO_2-e) were calculated using emission factors sourced from the Australian National Greenhouse Accounts (Department of the Environment, 2017) as set out in Table 3.3 for petrol and diesel vehicles. The ABS Motor Vehicle Census data from July 2017 was used to estimate the proportion of diesel fuel vehicles of each vehicle type, to calculate a weighted average CO_2-e emission rate accordingly.

Table 3.3 – Emission factors (kg CO2- e/GJ)

Engine Type	Energy Content (GJ/kL)	CO_2 kg CO_2-e/GJ	CH_4 kg CO_2-e/GJ	N_2O kg CO_2-e/GJ
Petrol	34.2	67.4	0.5	1.8
Diesel	38.6	69.9	0.1	0.5

Source: Dept. of the Environment, National Greenhouse Accounts Factors (July 2017), Table 4

Table 3.4 shows the ABS Motor Vehicle Census data, by type of fuel and vehicle from January 2012.

Table 3.4 – Registered vehicles by fuel type across Australia

ABS category	Vehicle Type	Leaded	Unleaded	Diesel	LBG/Dual fuel/Other	Total
Passenger vehicles	Car	234,428	11,951,282	1,613,618	279,278	14,078,606
Camper vans	Car	5,130	15,242	41,456	1,822	63,650
Light commercial vehicles	LCV	69,901	1,056,737	1,845,178	107,774	3,079,590
Light rigid trucks	LCV	2,796	4,492	141,349	1,734	150,371
Heavy rigid trucks	HCV	8,852	3,511	327,487	1,328	341,178
Articulated trucks	HCV	222	818	96,879	189	98,108
Non-freight carrying trucks	Other	1,061	1,641	20,381	392	23,475
Buses	HCV	366	17,039	75,630	3,895	96,930
Motorcycles	Car	42,768	806,204	17	307	849,296
Total		365,524	13,856,966	4,161,995	396,719	18,781,204

Source: ABS Motor Vehicles Census (July 2017), Table 4: Motor Vehicles On Register (a), Type of Fuel , by Type of Vehicle—Census years

The proportion of diesel vehicles by vehicle type, as defined in Table 3.4, can be seen in Table 3.5.

Table 3.5 -Proportion of diesel vehicles by model vehicle category, based on ABS Motor Vehicles On Register data

Vehicle Type	Diesel	TOTAL*	Proportion of Diesel Vehicles
Car	1,655,091	14,991,552	11.04%
LCV	1,986,527	3,229,961	61.50%
HCV	499,996	536,216	93.25%

*Excluding non-freight carrying trucks

As a result, for the calculation of CO_2-e emission rates, it was assumed that 11.04% of cars, 61.50% of light commercial vehicles and 93.25% of heavy commercial vehicles use diesel fuel.

The energy content per engine type was then multiplied by the emission factors for each CO_2-e gas and weighted by the proportion of diesel vehicles by modelled vehicle type. This resulted in the final CO_2-e emission rates as set out in Table 3.6, which lists the rates assumed in grams per litre of fuel used, disaggregated by vehicle type.

Table 3.6 - Emission Rates (grams of emissions / litre of fuel consumed)

Vehicle Type	CO_2-e emitted, g/L
Car	2,421.01
LCV	2,591.35
HCV	2,698.50

Note that this methodology does not make allowance for changes in fuel efficiency or the petrol/diesel fleet mix.

3.3 Induced demand

In response to issues raised in several Victorian Auditor-General's Office (VAGO) reports[1], the State prepared transport modelling and economic appraisal guidelines[2] to oversee the appraisal of major projects, such as the North East Link. Table 3.7 has been modified to highlight the minimum requirements specified by the guidelines (as seen in the blue box) and the components of behavioural response incorporated in the North East Link traffic and transport impact assessment (as seen in the green boxes).

Table 3.7 - Traffic Classification by Behavioural Response

Behavioural Response	Definition	Classification from the perspective of		Description
		Demand associated with the project	Demand within the entire multi-modal transport system	
1. No change in behaviour	Fixed matrix, no change in journeys	Base Load or Traffic	Normal Load or Traffic	Guidelines minimum requirements
2. Route change	Travellers have same origin and destination and make the same journeys but use the improved route	Re-assigned or Diverted Traffic		
3. Mode change	Passengers switch mode because the improvement makes the new route more attractive			NEL Project
4. Destination change	Travellers decide to travel to more distant destinations because of the improvement makes the journey time acceptable (redistribution)			
5. Time of travel change	Travellers decide to travel in the commuting peak period because the improvement reduces journey times to an acceptable level	Induced Traffic		NEL Project*
6. Trip frequency increase	Travellers are willing to make additional journeys because of the improvement			
7. Generated or new (e.g. from different land use patterns)	People and businesses relocate to take advantage of the improvement and so make journeys that are new to the area.		Generated Traffic	NEL Project**

* estimated by an adjustment outside the strategic model

** generated by a project-specific land use scenario

The North East Link traffic and transport impact assessment includes six of seven components of behavioural responses, including the minimum requirements specified by the guidelines. Based on VicRoads research[3] on induced demand, the DEDJTR[4] response to VAGO's issues on induced demand and the appraisal guidelines, it has been concluded that the scale of any trip frequency increase that might possibly occur would not lead to an invalid or misleading evaluation of the North East Link.

More details relating to the induced demand in transport modelling can be found in Section 4.5.1 of the North East Link traffic and transport impact assessment.

---

[1] *Management of Major Road Projects, June 2011, Managing Traffic Congestion, April 2013, East West Link Project, December 2015*
[2] Guidelines for Transport Modelling and Economic Appraisal in Victoria, V3.03 December 2016
[3] VicRoads, *"Transport Modelling Guidelines - Volume 2: Strategic Modelling"*, April 2012
[4] Department of Transport Victoria, *"Induced Travel Demand - Draft Position Paper"*, November 2011

4 References

Austroads, (2005) "*Update of RUC Unit Values to June 2005*", AP-T70/06, Austroads, Sydney, Australia

Department of the Environment and Energy, (2017). *"Australian National Greenhouse Accounts – National Greenhouse Accounts Factors",* Canberra, Australia.

Australian Bureau of Statistics, (2017). *"Motor Vehicle Census – Australia*", Canberra, Australia.

Department of Infrastructure, (2002). "*Draft Economic Evaluation Framework*", Melbourne, Australia.

Austroads, (2012). "*Guide to Project Evaluation Part 4: Project Evaluation Data*", AGPE04/12, Austroads, Sydney, Australia.

Victorian Auditor-General's Office, (2011). *"Management of Major Road Projects"*, Melbourne, Australia.

GHD

180 Lonsdale Street
Melbourne Victoria 3000
T: 61 3 8687 8000 F: 61 3 8687 8111 E: melmail@ghd.com

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Tom Young	Vic Buljubasic		Monique Roser		April 2019

www.ghd.com