

Project Emissions Estimation Tool (PEET) user guide

19 October 2023

Version 2

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More information

Waka Kotahi NZ Transport Agency
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If you have further queries, call our contact centre on 0800 699 000 or write to us:

Waka Kotahi NZ Transport Agency
Private Bag 6995
Wellington 6141

This document is available on Waka Kotahi NZ Transport Agency's website at www.nzta.govt.nz

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Foreword

This user guide supports the Project Emissions Estimation Tool (PEET) that has been developed by AECOM, Waka Kotahi NZ Transport Agency (Waka Kotahi), Auckland Transport and KiwiRail to calculate high-level estimates of the greenhouse gas (GHG) emissions associated with the lifecycle of transport infrastructure.

PEET was first released in 2022. A list of changes made within each version are provided in the 'Changelog' tab of PEET. This user guide applies to current version of the tool: PEET V4.

PEET is a password-protected excel spreadsheet that is available on the Waka Kotahi website: [Project Emissions Estimation Tool \(PEET\)](#).

To request the password, please email environment@nzta.govt.nz with 'Project Emissions Estimation Tool' in the subject line. By registering as a user of PEET we can send updates and corrections. You can also email environment@nzta.govt.nz to ask for technical support and to give feedback.

PEET is one of a range of tools that can be used throughout project delivery to support decision-making and to report on emissions. For more guidance on greenhouse gas assessment and for more information on Waka Kotahi climate change mitigation policy, guidance, research and tools see the [Climate change mitigation](#) page on our website.

1. Introduction

1.1. What is PEET?

PEET is a greenhouse gas (GHG) emissions calculation tool designed to be used during the early business case stages of a project. It uses data collected from Waka Kotahi, Auckland Transport and KiwiRail to create standard design examples which, along with industry research, provide a high-level estimation of GHG emissions associated with the lifecycle of transport infrastructure. As shown in Figure 1, PEET can be used to estimate:

- construction emissions (for road and rail projects)
- operations and maintenance emissions (for road and rail)
- enabled emissions from vehicle use
- avoided emissions from the use of public transport or active modes
- end of life emissions (new to V4).

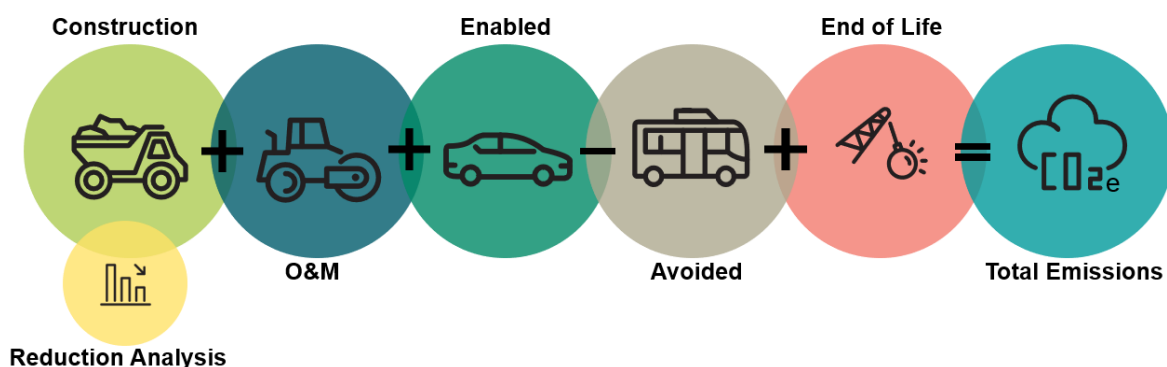


Figure 1: PEET emission sources

Information from PEET can be used to inform decisions on a project or programme business case and to estimate emissions for different design options. By being implemented in the planning phase of a project, PEET can have the most impact, by highlighting areas of the project with the most emissions and allowing users to understand potential emissions-reducing options at an early stage.

The infrastructure components within PEET include state highways, local roads and rail. Depending on the amount of data available, construction and M&O emissions estimates for these components can be derived using benchmark data for similar structures or from a bill of materials, as described in section 3.

At the detailed design phase, and during implementation, construction emissions estimates and reporting should move from PEET to a more detailed reporting tool.

1.2. Comparing the ‘do minimum’ with the ‘do intervention’

When comparing options in a business case, the benefits (and disbenefits) of possible options or interventions are typically compared against a ‘do minimum’ scenario.

In the PEET tool:

- ‘Do minimum’ sections are shown by a light blue background and blue text. These sections will estimate the emissions that would arise from the existing infrastructure if the planned project or intervention does not take place.
- ‘Do intervention’ sections are shown by a green background and blue text. These sections estimate the emissions that would arise if the planned infrastructure project were in place. A project may be an upgrade of an ‘existing route/infrastructure’ and/or the development of a ‘new route/infrastructure’. There is an option to fill out both or either section depending on the project.

The sections of the tool that consider the ‘do minimum’ and ‘do intervention’ are shown below in Figure 2.

	Construction	Reduction Analysis	O&M	Enabled	Avoided	End of Life
Do Minimum	✗	✗	✓	✓	Δ Change	✓
Do Intervention	✓	✓	✓	✓		✓

Figure 2: Summary of the ‘do minimum’ and ‘do intervention’ sections throughout PEET

‘Do minimum’ sections are not shown in the ‘Construction’ or ‘Reduction analysis’ worksheets because, by definition, a ‘do minimum’ scenario involves little to no asset construction.

There are two worksheets that can be used to estimate the change in vehicle emissions associated with use of the infrastructure:

- The ‘Enabled’ worksheet can estimate the change in enabled (vehicle) emissions by comparing modelled predicted future traffic flows (the ‘do intervention’) against traffic flows expected without the project in place (the ‘do minimum’), using estimates of vehicle kilometres travelled (VKT) and speed, combined with vehicle fleet emission factors.
- The ‘Avoided’ worksheet can be used to estimate the reduction in emissions attributable to changes in mode, for example from cars to public transport, cycling or walking. This worksheet measures the change in emissions against the ‘do minimum’, and the net result is attributed to the ‘do intervention’ (for more information see section 7).

Fleet emission factors from the Waka Kotahi [Vehicle Emissions Prediction Model \(VEPM\)](#) are integrated into the ‘Enabled’ and ‘Avoided’ calculation worksheets in PEET. VEPM can be applied to the output from traffic models and uses modelled future emissions of the transport fleet to estimate the emissions associated with vehicle use (enabled emissions).

1.3. Alignment of PEET with other tools and methods

PEET aligns with the principles of PAS 2080, BS EN 17472:2022 and other Life Cycle Analysis (LCA) methods that are focussed on carbon estimates of infrastructure projects. Each of the sections within PEET align with the stages and modules commonly reported in LCA carbon assessments, as shown below in Figure 3. However, PEET is not a replacement for detailed LCA tools or certified to international standards.









PEET	Construction			Operation and Maintenance		Enabled (vehicle)	Avoided (vehicle)	End of Life
								
PAS 2080	Before use stage			Use stage			End of Life Stage	
Modules (based on EN15804+A2)	A1-A3	A4	A5	B1-B5	B6	B9		C1-C4
	Raw material supply, transport and manufacture	Transport to works site	Construction and installation processes	Use, Maintenance, Repair, Replacement and refurbishment	Operational energy usage	Vehicle use of infrastructure <small>*Categorisation used in PAS2028:2016; also categorised as B8 in EN 17472:2022</small>		Deconstruction, transport, waste processing for recovery and disposal

Figure 3: Summary of the alignment between PEET sections and other LCA carbon methods

1.4. Limitations of PEET

PEET has not been developed to provide a detailed emissions analysis of specific project elements; the tool only considers the most significant emission sources in a project life cycle. PEET is not a replacement for detailed transport modelling or a detailed emissions assessment for infrastructure design. The limitations, key assumptions and sources of uncertainty associated with any estimate made using PEET should be clearly stated in any documentation or presentation of results. Results from PEET are not to be relied on for publication of emission reductions from a project and it does not replace the Infrastructure Sustainability (IS) Materials Calculator for those projects pursuing Infrastructure Sustainability Council (ISC) sustainability rating and certification.

When using PEET during the business case or concept phases, the results are only ‘estimated’ because projects have not completed construction. ‘Actual’ emission footprints refer to calculations that have been made after the completion of the project with the actual quantities of fuel, materials and energy used for the project. While emission estimates are not as accurate as actual emission footprints, they provide critical knowledge early in the design phase which allows for emission reduction options to be realised and implemented during construction.

The emission reduction options utilised in PEET seek to inform the scale of emission reductions possible in construction projects. The viability of the application of emission reduction options are specific to the design constraints of each project.

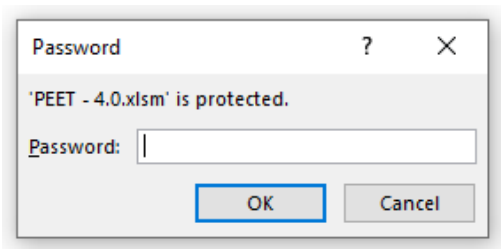
Caution is advised when using PEET as a comparative baseline tool. PEET has been designed to provide a conservative estimate of emissions with contingency to account for differences in material quantities built into the tool. It would be inaccurate to create a project emissions baseline using PEET in the concept phase and then use other tools to measure changes in emissions (compared against the PEET estimate) through detailed design or construction. When comparing changes against an emissions baseline it is critical that all emissions results have been created using a consistently applied tool to ensure there are no changes due to the assumptions inherent in the tool.

2. Using PEET

This and the following sections provide step by step instructions on using PEET. Technical support on the use of PEET is available by emailing environment@nzta.govt.nz.

2.1. Getting started

Download the PEET tool from the Waka Kotahi website: [Project Emissions Estimation Tool \(PEET\)](#)



The tool is an Excel spreadsheet. When you open it, it will request a password. To obtain the PEET password, send an email to environment@nzta.govt.nz with 'Project Emissions Estimation Tool' in the subject line.

Once you have entered the password, ensure that 'Enable Editing' has been selected and that macros have been enabled, for more information on enabling and troubleshooting macros see Appendix A: Enabling macros. The PEET workbook should open with the worksheet named 'READ ME' as shown below in Figure 4.

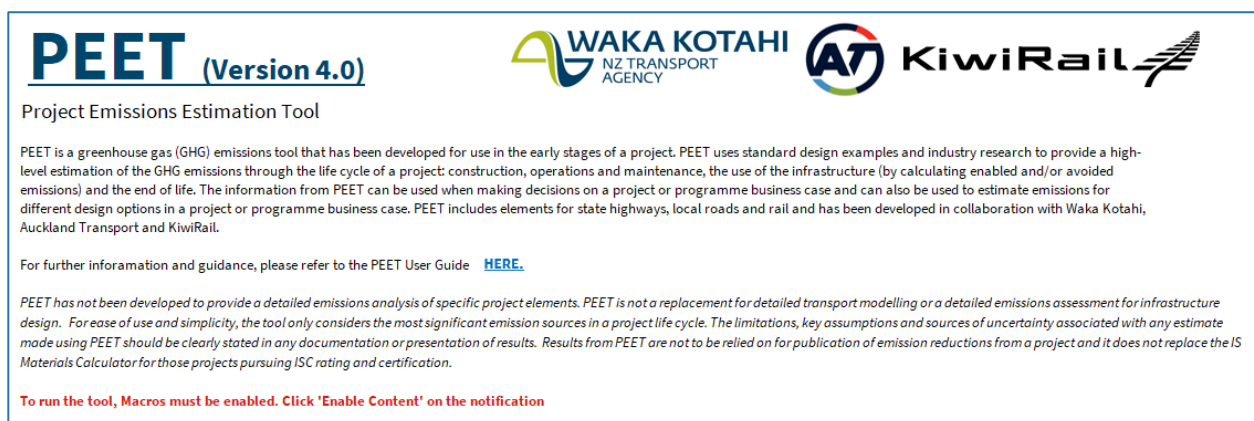



Figure 4: Screenshot of PEET 'READ ME' worksheet

The 'READ ME' worksheet contains important information on the tool structure, the data used in the tool, the emission factors used, a guide to using the emission reduction analysis, cell types, important units, definitions and references.

In PEET the general layout is consistent between worksheets, with:

- tool descriptors on the left of the screen
- user inputs and calculations in the middle, and
- assumptions and notes on the right of the screen.

Cells in the worksheets have been locked so the user can only select and modify cells that are required to use the tool. Some rows will only become visible when expanded using the plus buttons on the left of the screen  ← Expand to populate .

2.2. Tool structure

The tool is made up of several worksheets. Some are unlocked to enable the user to enter data, while others are locked.

Unlocked worksheets

Summary

Input worksheet for general project information and description (see section 2.3).

Construction

Use this worksheet to estimate the emissions from the construction of the project (including the embodied emissions of materials and the emissions from transport of materials during construction). The estimate can be derived using any of three methods, depending on the amount of data that the user has available. See section 3 for more information.

Reduction Analysis

Use this worksheet to review the effect of choosing alternative materials that have different emissions factors (to the default material). This function only applies to estimates prepared using the second order construction estimate. For detailed instructions on how to activate this option, see section 4.

O&M

Use this worksheet to estimate the emissions from the operations and maintenance activities associated with the project taking into consideration the project lifetime and activity frequency. The estimate can be derived using either of two methods, depending on the amount of data that the user has available. See section 5 for more information.

Enabled

Avoided

These two worksheets estimate the emissions associated with the use of the infrastructure over time and require estimates of traffic volumes, distances and speeds, which are available from temporal traffic modelling data:

- The Enabled worksheet can be used to estimate the change in enabled emissions arising from vehicles using the infrastructure, using estimates of vehicle kilometres travelled (VKT) combined with vehicle emission data sourced from the Vehicle Emissions Prediction Model (VEPM).
- The Avoided worksheet can be used to estimate the reduction in emissions attributable to changes in mode, for example from cars to public transport, cycling or walking.

PEET estimates the change in enabled emissions by comparing the modelled predicted future traffic flows (with the project in place, the 'do intervention' scenario) against the traffic flows expected without the project in place (the 'do-minimum' scenario).

End of Life

If appropriate, use this worksheet to generate a high-level estimate of the emissions from the end of life/decommissioning. Not all projects need to consider this stage (some assets are abandoned in their original location, many are never decommissioned) but where appropriate, this sheet can be used to provide an indication of the emissions and opportunities for potential material reuse and recycling.

Results

Use this worksheet to view the summary of results and the change of emissions, along with a breakdown of the results for different stages and orders of assessment (see section 8).

Whole of Life Results

Use this worksheet to visualise the emissions of the 'do Intervention' over the life cycle of the project. The results exclude vehicle (user) emissions.

Locked worksheets

The following worksheets are locked and do not require input from the user. They contain the supporting information for the calculations and provide useful background information.

Emission Factors

This worksheet contains the material emission factors used in PEET along with a reference source for each factor. PEET uses the hierarchy of emission factors shown in Figure 5, to ensure that as many New Zealand-specific factors as possible can be used. The emission factors used in PEET attempt to reflect average industry (default) values when possible, this means that higher or lower emission factors may be available for certain products. However it is not the purpose of PEET to compare all products and materials within the tool. Factors sourced from ISC have been used with the approval of ISC for purposes consistent with the intent of the PEET tool. Users wishing to use ISC factors outside PEET must seek permission from the ISC.

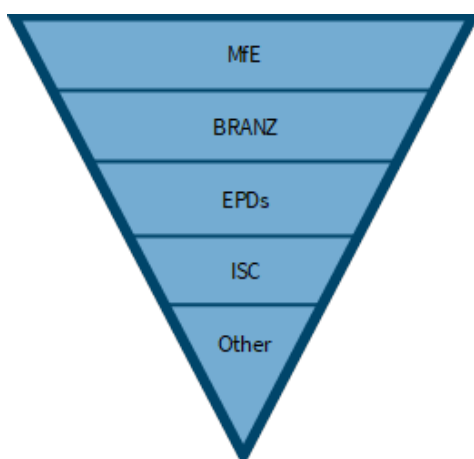


Figure 5: PEET emission factor hierarchy

The sources for these factors are:

- **Ministry for the Environment (MfE):** The current version of [Measuring emissions: a guide for organisations](#) published by MfE is the primary source of emission factors for New Zealand projects. The guide uses data consistent with New Zealand's GHG inventory, as well as from other sources.
- **BRANZ:** For many construction materials, MfE refers users to the [BRANZ CO₂NSTRUCT](#) dataset, which contains emission factors for New Zealand construction materials sourced from environmental product declarations (EPDs) and industry research.
- **EPD Australasia:** MfE also recommends users refer to the [EPD Australasia database](#), which provides published, independently verified emissions data for various building and construction products and services across Australasia.
- **Infrastructure Sustainability Council (ISC):** The ISC has approved the use of a limited number of emission factors from the ISC Materials Calculator to be included in Waka Kotahi tools. Once projects reach detailed design stage, and if they are pursuing an ISC rating, the ISC Materials Calculator must be used to measure GHG emissions.

Other databases, research and published emission factors for materials or services may be used when no other data is available. In this situation, care should be taken when comparing emissions

factors for similar materials and activities from different countries, particularly where transport and electricity is a major contributor to the emission source.

VEPM Table

This worksheet contains outputs from the Vehicle Emissions Prediction Model (VEPM) (version 6.3), which is used to calculate the change in vehicle enabled emissions from the use of the infrastructure over time. The Enabled and Avoided worksheets link to this worksheet; no input is required on the VEPM worksheet.

Materials

This worksheet displays the material quantities used to calculate the emission factors used in the construction second order estimate.

2.3. Adding and reviewing project details in the Summary worksheet

To add details about the project, users should navigate to the 'Summary' worksheet, as shown in Figure 6. Enter the project details in the light green boxes; the grey cells for the lane km will populate once data has been entered.

If a 'do minimum' scenario is being evaluated, add the project details in the section with the light blue background underneath. For more information about the 'do minimum' refer to section 1.2.

Do Intervention - Option 1

Project Details	Do Intervention
Project Name:	Example Project
Project Location:	Auckland
Option No:	1
Project Type:	Road/Busway/Path
Road Length:	24 km
Number of lanes:	4 Lanes
	96 Lane km
Construction Start Year:	2025
Construction Finish Year:	2029
Project lifetime:	100 years
Description:	A simple example project in Auckland for the purposes of the PEET User Guide.

Figure 6: Screenshot of Project Details

3. Construction worksheet

Construction emissions are those embodied in the materials and the emissions that occur during construction phase activities and processes. The 'Construction' worksheet aligns with the PAS2080 Before Use Stage and the LCA Modules A1-A5. Construction GHG emissions are calculated by identifying and quantifying materials and construction activities and then applying an appropriate emission factor (the GHG emissions per unit of the relevant measure). To estimate construction emissions, users have the option to complete a first, second or third order estimate depending on the level of detail of data available and the type of project. **When comparing projects or options, only estimates developed using the same order should be directly compared i.e., compare first order with first order; second order with second order.**

3.1. First order estimate

First order estimates are only available for roading projects and should be used when little information is known about the specific elements of the project.

The first order estimate is based on the results from a research project to develop carbon emissions baselines for infrastructure projects.¹ The results of this study draw on existing carbon footprints from New Zealand and international footprints from land-based transport infrastructure projects in Australia, the United States, Ireland and the United Kingdom. The data used in PEET uses information only from Australia and New Zealand projects and will be updated as additional information becomes available. The data is likely to over-estimate emissions and is only suitable for initial option screening.

To complete a first order estimate only the road length, number of lanes and project type is required for input. The project types and their descriptions are shown in Table 1. These are also displayed in the 'Assumptions and notes' section on the right of the worksheet once a project type has been selected.

Table 1: Construction first order project types and descriptions

Project type	Description
Road/busway/path	Projects that cover the construction of new roads, busways and road-widening projects and projects that include paths.
Shared path only	Projects that include walking and/or cycling paths where isolated from other road construction works.
Intersection improvements – at grade	Junction improvements at ground level. This includes changes to roundabouts and signalised intersections.
Intersection improvements – grade separated	Junction improvement where sections of the junction are above ground level (eg a flyover).
Tunnel	Projects where most of the emissions footprint involves the construction of a tunnel.
Safety and traffic flow improvements	Projects which include installation of smart motorways, safety barriers and lane layout/widening.

¹ [Carbon emissions baselines for infrastructure projects](#)

3.2. Second order estimate

The second order estimate should be used when more information is known about the project, for example structure types, pavement types, and dimensions. Emission estimates have been developed based on standard design for a range of project elements (relevant to state highways, local roads, and rail). Note that the emissions calculations for standard design elements include a contingency of 20% to provide an estimate appropriate for the initial stage of project assessment.

Elements relevant to the project can be selected to estimate the overall emissions associated to the project. The elements are listed by materiality (that is elements with the greatest impact are listed first) and not all elements need to be completed to run the tool. The supporting information on which the second order estimates are based is contained in the 'Materials' worksheet.

The 'Key elements' (structures, and pavements and surfacing) are listed first as they contribute the most emissions in a typical project, making them the most important elements to consider (along with fuel and energy usage).

Structures

The user can choose to input data for the 'Standard design' and/or 'Material quantities'. In the 'Results' worksheet, the total of these will be summed so care must be taken that double counting of materials does not occur if both inputs are used.

The 'Standard design' provides estimates for large (greater than 14m width), medium (7–14m width) or small (3–7m width) bridges. The bridges have been split into three components, the superstructure (input in m²), the abutments (input in m) and the piers (input in m). For example, a large four-lane Super T bridge that is 28m wide and 50m long with no piers would be estimated as shown in Figure 7. Note that the abutments are measured per m and the total length of abutments is required (for both ends of the bridge).

The 'Material quantities' section allows users to input specific structures material quantities when more detailed information is available.

The 'Key elements' are separated into state highways (dark green) and local roads (light blue) to capture the differences in typical projects designs.

The standard design estimates include a 20% contingency appropriate for the initial stage of estimation. This contingency is not applied to 'Material quantities' input by the user.

State Highway Structures			
Standard design elements (per m ²)			
Waka Kotahi Large Bridge	1,400 m ²	1.184 tCO ₂ -e/m ²	1,658 tCO ₂ -e
Bridge Abutment Width	56 m	13.111 tCO ₂ -e/m	734 tCO ₂ -e
Waka Kotahi Medium Bridge			
Bridge Abutment Width	m	1.522 tCO ₂ -e/m ²	0 tCO ₂ -e
Bridge Piers	m	30.651 tCO ₂ -e/m	0 tCO ₂ -e
Waka Kotahi Small Bridge			
Bridge Abutment Width	m	11.224 tCO ₂ -e/m	0 tCO ₂ -e
		1.705 tCO ₂ -e/m ²	0 tCO ₂ -e
		14.599 tCO ₂ -e/m	0 tCO ₂ -e

Figure 7: Screenshot of large bridge standard design element

Pavements and surfacing

As for the 'Structures' element, the user can choose to input data for the 'Standard design elements' and/or 'Material quantities'. In the 'Summary' reporting, the total of these will be summed so care must be taken that double counting of materials does not occur.

State highways

The 'Standard design' provides per m² options for either minor or major roads that are full-depth construction or resurfacing of the surface layer. Minor roads are considered highways or secondary roads while major roads are considered to be motorways or heavy traffic volume routes. Only chipseal surfacing is available for minor roads but major roads can be open graded porous asphalt (OGPA), epoxy modified open graded porous asphalt (EMOGPA), asphaltic concrete (AC) or stone mastic asphalt (SMA). The user can also select whether the basecourse is foamed bitumen, cement modified or structural asphalt. If lime will be added to the subgrade for stabilisation the user should select 'Yes'. For example, a project that has a 20m-wide minor road with 800m of chipseal, cement modified basecourse and subgrade stabilisation would be estimated as shown in Figure 8.

Note: road dimensions should include the total area of the carriageway – the total paved surface including the median and shoulders.

State Highway Pavements and Surfacing			
Standard design (per m ²)			
Minor Road Full Depth(Chipseal)	Total Carriageway Area		
Dimensions	16,000 m ²	<u>0.031</u> tCO ₂ -e/m ²	493 tCO ₂ -e
What is the Road Type?	Chipseal - Cement Modified/Bound		
Is the Subgrade Stabilised?	Yes		
Minor Road Resurfacing (Chipseal)	Total Area	<u>0.0013</u> tCO ₂ -e/m ²	0 tCO ₂ -e
Major Road Full Depth	Total Area	<u>0.031</u> tCO ₂ -e/m ²	0 tCO ₂ -e
Dimensions	AC		
What is the Asphalt Type?	Foamed Bitumen		
What is the Road Type?	No		
Is the Subgrade Stabilised?			
Major Road Resurfacing (OGPA)	Total Area	Please Select Treatment Type tCO ₂ -e/m ²	0 tCO ₂ -e
Dimensions	<Make a Selection>		
What is the treatment type ?			

Figure 8: Screenshot showing state highway pavement and surfacing of minor road full-depth chipseal

Local roads

The 'Standard design' provides per m² options for full-depth construction of either minor or major urban and rural roads, or for resurfacing of the surface layer of urban and rural roads. Minor roads are considered low-volume collectors or local roads while major roads are considered to be arterials or high-volume collectors. Local roads have a predetermined pavement profile mix of asphalt and cement treated basecourse for urban roads and chipseal or unsealed for the rural roads. For example, a project that has a 20m-wide major urban road 800m long would be estimated as shown in Figure 9.

Local Roads Pavements and Surfacing		Standard design (per m ²)		Total Carriageway Area			
Urban							
Major Urban	16,000	m ²	0.066	tCO ₂ -e/m ²	1,055	tCO ₂ -e	
Minor Urban		m ²	0.026	tCO ₂ -e/m ²	0	tCO ₂ -e	
Urban Resurfacing		m ²	0.008	tCO ₂ -e/m ²	0	tCO ₂ -e	
Rural							
Major Rural		m ²	0.018	tCO ₂ -e/m ²	0	tCO ₂ -e	
Minor Rural		m ²	0.021	tCO ₂ -e/m ²	0	tCO ₂ -e	
Minor Rural (unsealed)		m ²	0.002	tCO ₂ -e/m ²	0	tCO ₂ -e	
Rural Resurfacing		m ²	0.002	tCO ₂ -e/m ²	0	tCO ₂ -e	

Figure 9: Screenshot showing local road pavement and surfacing of a major urban road

The worksheet contains a number of 'Other elements' that are typical transport infrastructure elements, listed in order of materiality. Not all elements will be material for every project so the user should only populate those that are appropriate for the project. The 'Other elements' are based on standard designs so all results include the 20% contingency to account for differences in material quantities. The inputs are required in a format that is usually provided in a schedule of quantities; however, care must be taken to ensure that the appropriate units have been used in PEET. Unit conversions using material densities may be required.

Rail

The rail section (grey colour) provides railroad, overhead line, drainage and structures elements. The railroad element considers the rail, ballast, structural fill, sleepers and fasteners. If overhead lines are included in the project the posts, gantries and wires can be considered. The rail structures use a similar approach to roads, however, a standard 4.5m width has been assumed so only the bridge length requires input (not the area). For example, an 80m long, 4.5m bridge with piers would be estimated as shown in Figure 10.

Rail Structures (does not include rail or sleepers)*						
Large Precast Concrete Trough length (with piers)	80	m	8.127	tCO ₂ -e/m	650	tCO ₂ -e
Bridge Abutment Width	4.5	m	28.149	tCO ₂ -e/m	127	tCO ₂ -e
Bridge Piers	80	m	26.803	tCO ₂ -e/m	1,876	tCO ₂ -e

Figure 10: Screenshot of rail large precast-concrete trough bridge with piers

Transport of Materials to Site

These are emissions associated with the transport of materials from the factory gate to the construction site. Emissions from the fuel and energy used can be estimated as a proportion of the total (A1-A5) construction emissions and/or as an estimate of the quantity of fuel or energy required in litres or kilowatt hours. Research conducted by Waka Kotahi² found that the emissions associated with the transport of materials to site is on average 8% of a project's construction emissions. If the 'proportion of transport %' is populated, and quantities of 'fuel and energy' are added, the total emissions will be summed. To avoid, double counting, the 'proportion of transport %' may need to be adjusted appropriately.

² [Carbon emissions baselines for infrastructure projects](#), AECOM 2023

Fuel and Energy Use on Site

These are emissions associated with all the construction processes including earthworks/landscaping, site development, deconstruction of pre-existing assets and the installation of new assets (any waste management processes generated from the construction site should also be included in this section). Emissions arise from the fuel and energy used and can be estimated as a proportion of the total (A1-A5) construction emissions, and/or the area or volume of site earthworks and clearance, and/or as a direct estimate of the quantity of fuel or energy required in litres or kilowatt hours. Research conducted by Waka Kotahi³ found that the emissions from Fuel and Energy Use on site is on average 21% of a project's construction emissions. If the 'proportion of fuel and energy %' is populated, and quantities of 'Site Clearance and Earthworks' and/or quantities of 'fuel and energy' are added, the total emissions will be summed. To avoid double counting emissions, the 'proportion of fuel and energy %' may need to be adjusted appropriately.

3.3. Third order estimate

The third order estimate should be used when detailed project information about the material quantities and transport distance is known.

On-site construction fuel and energy use

The volume of fuel (litres) and the electricity (kilowatt hours) can be input by the user. These inputs should exclude fuel or energy used in the transportation of materials which is accounted for below.

Construction materials

The quantities of aggregate, asphalt and bitumen, concrete and cement, metals, plastic, wood and other products can be entered as either a volume or mass. Note that if both volume and mass are entered, the volume will be progressed in the calculations.

Transport of materials

The one-way road distance of each of the construction materials can be input. The calculation accounts for the transportation of construction materials to site and the completion of a return journey. Only transport within New Zealand should be considered. A table of typical one-way distances is shown below in Table 2.

Table 2: One-way distance categories and ranges

Distance category	Distance range (km – one way)
Urban	0–25
Regional	25–100

³ [Carbon emissions baselines for infrastructure projects](#), AECOM 2023

Same island	100–500
Other island	500–2,500
International	2,500–25,000

Note that only the highest order estimate will be reported in the 'Results'. So, if data is entered in both the second and third order estimates these will not be added together, only the results from the third order estimate will be reported.

4. Reduction analysis worksheet

If the second order construction estimate has been populated, the 'Reduction analysis' worksheet can be used to review the effect of choosing alternative materials that have lower emissions factors than the default material (industry average). Inclusion of a material emission factor in PEET does not constitute an endorsement or recommendation of a particular product or material by the developers. This information is intended to promote understanding of emissions sources so that options to reduce emissions can be considered throughout the lifecycle of transport infrastructure. The emissions reduction analysis can be completed in a series of steps:

Step 1: Choose the emission reduction option to activate. Some materials have several emissions reduction options, for example '20% Fly Ash' or '35% Fly Ash'. Other materials have only one emissions reduction option or do not have one.

Emissions Reduction Options Activation	
Materials	Step 1: Select Option
Precast concrete	20% Fly Ash
In-situ concrete	20% Fly Ash
Cement for aggregate stabilisation	Low emission cement
Steel reinforcing bar	Lower emissions steel
Steel coil	Low carbon steel
Steel reinforcing mesh	GFRP
Asphalt RAP	30%
Warm Mix	15% energy saving
Aggregate RCC Replacement	40%
Aluminium	Local supply of aluminium

Step 2: Activate the emission reduction option by selecting 'Yes'. If the emission reduction option reads 'No' then the default material will be used, and the emissions reduction option will have no influence on the results.

Step 2: Activate Option

Yes
No
Yes
No

Step 3: Activate the elements to which the activated emissions reduction options should be applied. For example, select 'Yes' to apply the emissions reduction options to the pavement elements. By selecting 'Yes', all of the materials within the element will have the activated emission reduction option applied. Due to the large variation in the railroad assets, drainage assets and pipe network, the sub-elements can be activated.

Elements	Step 3: Activate Element
State Highway Structures	Yes
Local Road Structures	Yes
State Highway Pavements and Surfacing	Yes
Local Roads Pavements and Surfacing	Yes
Drainage Assets	
Kerb and Channel	No

Once these three steps are complete the user can scroll down to see the results of the analysis which include the emissions reductions of each element, material type and the overall emissions. The results from a typical emissions reduction analysis are provided in Appendix B: Typical reduction analysis results.

Note that if the emission reduction options are activated, the results will be updated throughout the tool and reported in the 'Results' and 'Whole of Life Results' worksheets

5. Operations and maintenance worksheet

Operations and maintenance (O&M) emissions are those embodied in maintenance materials, those that occur during maintenance activities, and operational emissions (such as from electricity for lighting), all of which occur over the asset's service life. The 'O&M' worksheet aligns with the Use Stage of PAS 2080 and the LCA Modules B2-B6. As for construction, GHG emissions are calculated by identifying and quantifying materials and activities to which an appropriate emission factor (the GHG emissions per unit of the relevant measure) is applied.

To estimate O&M emissions, users have the option to complete a first or second order estimate depending on the level of detail of data available. As the PEET tool is intended for use early in project phases, a third order, detailed estimate would not be available for O&M activities. A detailed assessment would be undertaken as part of contract procurement and award.

The 'O&M' worksheet provides the ability to consider the 'do minimum' and 'do intervention' – described further in section 1.2.

When comparing projects or options, only estimates developed using the same order should be directly compared i.e., compare first order with first order; second order with second order.

5.1. First order estimate

First order estimates are only available for roading projects and should be used when little information is known about the specific elements of the project. To complete a first order estimate only the project lifetime, road length and number of lanes is required for input. The data is likely to over-estimate emissions and is only suitable for initial option screening.

The first order estimate is based on the results from a research project to develop carbon emissions baselines for infrastructure projects.⁴ The results of this study draw on existing carbon footprints from New Zealand and international footprints from land-based transport infrastructure projects in Australia, the United States, Ireland, and the United Kingdom. The data used in PEET uses information only from Australia and New Zealand. The first order estimate will be updated as additional information becomes available.

5.2. Second order estimate

The second order estimate should be used when more information is known about the project, for example, structure types, pavement types, and dimensions. Emission estimates have been developed based on the materials required for standard maintenance activities for a range of project elements (relevant to state highways, local roads and rail). Note that the emissions calculations for standard design elements include a contingency of 20% to provide an estimate appropriate for the initial stage of project assessment.

Elements relevant to the project can be selected to estimate the overall emissions associated to the project. The supporting information on which the second order estimates are based is contained in the 'Materials' worksheet. The 'O&M' worksheet in PEET accounts for the life cycle modules of maintenance, repair, replacement and refurbishment and operational energy use (B2-B6).

⁴ [Carbon emissions baselines for infrastructure projects](#), AECOM, 2023

Pavement resurfacing

PEET assumes that pavement resurfacing fully replaces the surface pavement layer with new material. For these estimates, the user must specify a resurfacing frequency. PEET assumes that the resurfacing emission factor will be constant over the project lifetime (that is, the model does not account for reductions in emissions due to efficiency improvements or material changes). This is considered appropriate given the same assumption is being used for the 'do minimum' and given that the tool estimates the change in emissions between two scenarios.

State highway

The user must input the pavement resurfacing frequency, which is typically approximately 10 years but can vary depending on the pavement type. The user must then populate the resurfacing area for minor roads (highways or secondary roads) and major roads (motorways or traffic routes) and select the treatment type as shown in Table 3. Typically, the resurfacing area will be the total paved road area of the project. The emissions will be reported both per activity and over the project lifetime. Note, the emissions per activity are assumed to be constant over the project lifetime and consistent throughout the frequency interval.

Table 3: State highway pavement resurfacing treatment types and descriptions

Road type	State highway pavement reconstruction treatment type	Description
Minor	Chipseal	20mm chipseal, bitumen @ 2.0l/m ²
Major	OGPA/EMOGPA	40mm OGPA seal, tack coat, bitumen @ 0.3l/m ²
	OGPA/EMOGPA with membrane seal	40mm OGPA seal with two chipseal coats

Local road

The user must input the pavement resurfacing frequency which is typically approximately 10 years, but can vary depending on the pavement type. The user must then populate the resurfacing area for urban and rural roads. Typically, the resurfacing area will be the total paved road area of the project. The emissions will be reported both per activity and over the project lifetime. Note, the emissions per activity are assumed to be constant over the project lifetime and consistent throughout the frequency interval. For example, an urban roading project with a 100-year lifetime, 40,000m² of pavement and a 10-year pavement resurfacing frequency would be estimated as shown in Figure 11.

The local road pavement resurfacing treatments are 55mm of AC14 (asphaltic concrete) for urban and a two-coat chipseal for rural resurfacing.

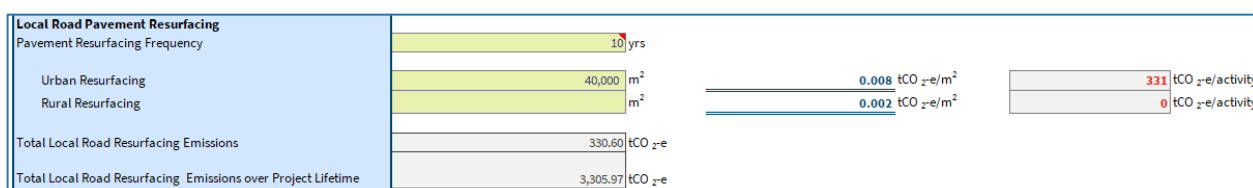


Figure 11 Screenshot of local road pavement resurfacing

Pavement reconstruction

PEET assumes that pavement reconstruction fully replaces the pavement layers above the subgrade with new material.

State highways

The user must input the pavement reconstruction frequency, which is typically approximately 25–50 years, but can vary depending on the pavement type.

The user must then populate the reconstruction area for minor roads (highways or secondary roads) and major roads (motorways or traffic routes), and select the treatment type from those shown in Table 4.

Table 4: State highway pavement reconstruction treatment types and descriptions

Road Type	State Highway pavement reconstruction treatment type	Description
Minor	Unbound aggregate overlay and bound sub-base	150mm new aggregate with 4% cement stabilisation to 200mm (does not include surfacing)
	Unbound aggregate overlay	150mm new aggregate (does not include surfacing)
	Recycle	50mm new aggregate with 2% cement stabilisation to 200mm (does not include surfacing)
Major	Structural Asphalt Overlay	60mm AC14 and 50mm SMA
	Structural Asphalt Inlay	250mm asphalt
	Foamed Bitumen Basecourse	75mm new aggregate with 1% cement, 3% bitumen stabilisation to 200mm (does not include surfacing)

Typically, the reconstruction area will be the total paved road area of the project. The emissions will be reported both per activity and over the project lifetime. Note, the emissions per activity are assumed to be constant over the project lifetime (the same treatment type) and consistent throughout the frequency interval. For example, a project that has 16,000 m² of minor road and a reconstruction frequency of 25 years with a recycle treatment would be estimated as shown in Figure 12.

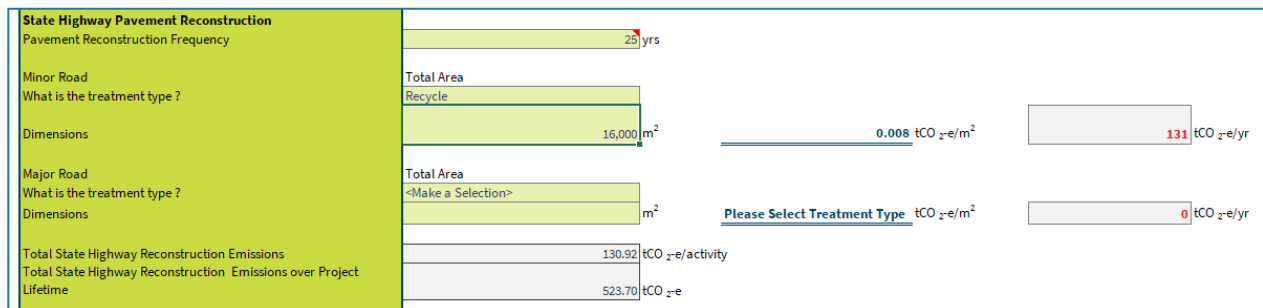


Figure 12: Screenshot of State Highway pavement reconstruction

Local road

The user must input the pavement reconstruction frequency, which is typically approximately 25–50 years but can vary depending on the pavement type. The user must then populate the reconstruction area for urban and rural roads. The descriptions of these treatment types are shown below in Table 5. Typically, the reconstruction area will be the total paved road area of the project. The emissions will be reported both per activity and over the project lifetime. Note, the emissions per activity are assumed to be constant over the project lifetime and consistent throughout the frequency interval.

Table 5: Local road pavement reconstruction treatment types and descriptions

Local road pavement reconstruction treatment type	Description
Urban	55mm AC14, 180mm AC20, 200mm CTB (5%) (AC = asphaltic concrete; CTB = cement treated base)
Rural	Two coat chipseal (3/5), 200mm cement modified aggregate (2%)

Other activity

Other maintenance activities can be considered by adding material quantities in the 'Other activity' section. Simply input the frequency of the activity (years) and the quantity of materials required and the emissions over the project lifetime will be calculated.

Operational energy usage

The energy required per year for lighting, ventilation or diesel can be input by the user. The total energy emissions over the project lifetime are estimated using the project lifetime (the expected lifetime of the assets within the project) input by the user. Note, this assumes that the energy emissions are constant over the project lifetime; this assumption is considered appropriate for the early project phase when PEET is used to inform optioneering.

6. Enabled worksheet

Emissions that arise from the vehicles (light vehicles, heavy vehicles, buses) using the transport network are often referred to as enabled emissions. These emissions are part of the Use Stage in PAS 2080. Vehicle emissions are directly proportionate to fuel use – so for any given vehicle the amount of fuel used, and the resulting emissions, are dependent on the vehicle kilometres travelled (VKT), efficiency of the engine, vehicle load, driving conditions (speed, acceleration/deceleration), and road features (including gradient, surface roughness).

Vehicle emissions are calculated using the Vehicle Emissions Prediction Model (VEPM), which provides the possible future emissions of the fleet per kilometre. VEPM is a standalone tool, but the outputs have been integrated into PEET. To learn more about VEPM see the Waka Kotahi website.⁵

The change in vehicle emissions as a result of a project must be quantified by comparing the emissions between the 'do minimum' and 'do intervention' as described in section 1.2. To calculate the enabled emissions, the user must therefore have access to future predictions of the vehicle kilometres travelled (VKT) per year and speed for both the 'do minimum' and 'do intervention'. It is recommended that this is derived from detailed transport modelling. However, it is possible to estimate the VKT from traffic counts, the annual average daily traffic (AADT) and route lengths (in kilometres). The user must also input the average speed of vehicles along the route (minimum speed 5 km/h, maximum speed 110 km/h).

For example, a project has traffic modelling for light vehicles for a 'do minimum' scenario in which the VKT was predicted to be 154,365,857 VKT in 2025, 175,650,410 VKT in 2030, 213,192,485 VKT in 2040, and 243,769,995 VKT in 2050, and the average speed is predicted to fall from 67 km/h in 2025 to 55 km/h in 2050, as shown in Figure 13. Note, the user can change the year inputs to match the future modelling years available, however, PEET and VEPM only calculate emissions up to 2050. Any years modelled post 2050 should assume 2050 emissions.

When calculating the enabled emissions for the 'do intervention', the user can estimate emissions for both the existing route and a new route. This will be helpful if there is traffic modelling for two routes of a project.

Modelled years for Do Minimum and Do Intervention				
	Year			
Year 1	2025			
Year 2	2030			
Year 3	2040			
Year 4	2050			

Do Minimum - Existing Route/Infrastructure					
VKT Inputs	2025	2030	2040	2050	
	General Fleet Vehicle Kilometres Travelled				
Light Vehicle Kilometres Travelled	154,365,857	175,650,410	213,192,485	243,769,995	VKT per year
Heavy Vehicle Kilometres Travelled					VKT per year
Rail Freight Gross Tonne Kilometres (GTK)					GTK per year

Inputs for VEPM	2025	2030	2040	2050	
	Speed General Fleet, or				
Speed Light Vehicle	67	64	60	55	km/h
Speed Heavy Vehicle					km/h

Figure 13: Screenshot of inputs for enabled section

⁵ [Vehicle Emissions Prediction Model](#)

To help users estimate the VKT, the VKT estimate calculator is provided, as shown in Figure 14. The user can input the AADT for a given year and the route length, and be provided with an estimate for the VKT, which should then be copied into the 'VKT Inputs' section, as shown in Figure 12.

VKT Estimate Calculator

Calculated Year:

Annual Average Daily Traffic (AADT): trips a day

Route Length: km

VKT = per year

Note: The number of annual trips divided by 365 provides an estimate of the Annual Average Daily Traffic (AADT)

Figure 14: Screenshot of VKT estimate calculator

7. Avoided worksheet

An increase in vehicle emissions can be avoided by designing land use and transport networks to avoid the need for light vehicle trips altogether, or shifting from fossil fuelled vehicles to walking, cycling or public transport. The 'Avoided' worksheet can be used to estimate the reduction in emissions attributable to changes in mode as a result of the project, for example from cars to public transport, or from cars to active modes. Avoided emissions are part of the Use Stage in PAS 2080.

Important note: Consideration of public transport and active modes within transport models vary from project to project. This worksheet should only be used when the transport model for the project does not account for reductions in vehicle trips due to public transport or active modes. If public transport and active modes usage is included in the transport modelling, then the reduction in VKT due to mode shift will be incorporated within the input (and output) of the 'Enabled' worksheet.

Avoided emissions are quantified by estimating the change in emissions between the 'do minimum' and 'do intervention' (as described in section 1.2). The resultant change in emissions is attributed to the 'do intervention', that is the 'do intervention' will either be increasing or decreasing emissions (negative emissions) in comparison to the 'do minimum'.

The calculation of avoided emissions is based on the number of new trips that occur as a result of the project. See the calculation in Figure 15 as an example. When calculating the emissions from public transport, the calculations consider the emissions from the vehicles (the buses and the trains) and the avoided emissions from reductions in private passenger vehicles as a result of the public transport. The 'Public Transport' section allows for the calculation of bus and rail emissions. The active modes calculation follows a similar process to public transport, however, there are only avoided emissions from the decrease in vehicle emissions (there are no vehicle emissions from walking or cycling).

Do Minimum

Year	2020	2030	2040	2050
Trips	1,000	2,000	3,000	4,000

Do Intervention

Year	2020	2030	2040	2050
Trips	1,500	2,750	4,000	5,250

New Trips	500	750	1,000	1,250
------------------	-----	-----	-------	-------

Figure 15: Example calculation of the number of new trips

7.1. Bus emissions

The bus passenger kilometres travelled (PKT) and vehicle diversion rates are used to calculate the avoided emissions. To help users estimate the PKT, a PKT estimate calculator is provided, as shown in Figure 15. The user can input the new daily trips because of the project, the occurrences a year and the route length; the estimate for the PKT should then be copied into the 'Public transport inputs' section as shown in Figure 16.

Bus Passenger Kilometres Travelled (PKT) Estimate Calculator					
Calculated Year:	2020	2030	2040	2050	
Number of new daily bus passenger trips along route:	500	750	1,000	1,250	one way trips
Occurrences a year:	365	365	365	365	
Route Length:	4	4	4	4	km
PKT =	730,000	1,095,000	1,460,000	1,825,000	per year

Figure 16: Screenshot of Bus PKT Estimate Calculator

To calculate the future emissions from buses, PEET uses VEPM data so the new bus vehicle kilometre trips (VKT) is also required. The new bus VKT can be estimated by dividing the bus passenger kilometres travelled by the bus passenger loading.

7.2. Rail emissions

To calculate the future emissions from rail travel, PEET uses an emission factor provided by the Ministry for the Environment, which only requires the PKT.⁶ However, this factor does not have a future forecast, so rail emissions are assumed to be constant over time. The rail fuel type must be selected as either electric, diesel or average. This emission factor will be updated as better information becomes available.

Change in emissions - Public Transport Use					
Public Transport Inputs					
	2020	2030	2040	2050	
Change in Bus Passenger Kilometres Travelled	730,000	1,095,000	1,460,000	1,825,000	PKT per year
Change in Rail Passenger Kilometres Travelled	1,765,804	2,330,861	4,032,390	4,604,989	PKT per year
Bus Passenger Loading (2017/18 Average Bus Passenger Loading for Auckland Region is: 9)	11	11	11	11	Passenger/Bus
<i>The average bus passenger loading per region is used to calculate the kilometres travelled by bus</i>					
Change in Bus Vehicle Kilometres Travelled	66,364	99,545	132,727	165,909	VKT per year
Average Bus Speed	45	45	45	45	km/h
Public Transport Emissions					
Select the Rail Fuel Type	Average			0.000019	tCO ₂ -e/PKT
	2020	2030	2040	2050	
Bus Emissions Factors	639	562	488	378	gCO ₂ -e/km
Rail Emissions Factors	0.000019	0.000019	0.000019	0.000019	tCO ₂ -e/PKT
Bus Emissions	42	56	65	63	tCO ₂ -e/yr
Rail Emissions	34	44	77	87	tCO ₂ -e/yr

Figure 17: Screenshot of public transport inputs for bus and rail

7.3. Calculation

To calculate the avoided emissions due to a reduction in passenger vehicle trips diversion rates are used. A diversion rate provides the percentage of light vehicles trips that are removed from the road because of the public transport initiative. Based on the Waka Kotahi *Monetised benefits cost manual* (MBCM), a diversion rate of 37.5% has been adopted in PEET.⁷ This assumes that for every three public transport trips, one light vehicle trip is removed. Diversion rates are a complex factor that can vary considerably depending on the project location, the existing transport options, and community travel patterns. Therefore, forecasting future diversion rates will require modelling on a project-by-project basis.

As well as the diversion rate, the average speed of the avoided vehicle trip must be input so the emissions from VEPM can be calculated. The avoided emissions are input as shown below in Figure 18.

⁶ [Measuring and reporting greenhouse gas emissions: guide for organisations](#)

⁷ Based on *Monetised benefits and costs manual* version 1.5, August 2020. Note, version 1.6 of the manual was released in April 2023 and includes updated diversion rates which will be incorporated into the next version of PEET.

Light Vehicle Avoided Emissions	2020	2030	2040	2050	
Light Vehicle Diversion Rate for Buses	38%	38%	38%	38%	VKT/PKT
Light Vehicle Diversion Rate for Rail	38%	38%	38%	38%	VKT/PKT
Average Speed of Light Vehicle	50	50	50	50	km/h
Light Vehicle Emissions Factor	201	181	124	51	gCO ₂ -e/km
Avoided Emissions from Bus use	-55	-74	-68	-35	tCO ₂ -e/yr
Avoided Emissions from Rail use	-133	-158	-188	-87	tCO ₂ -e/yr

Figure 18: Screenshot of inputs for the avoided emissions calculation

8. End of Life

The End of Life (EOL) project stage has been added to PEET V4 to provide a high-level understanding of emissions expected from decommissioning. Not all projects need to consider this stage (some assets are abandoned in their original location, many are never decommissioned) but where appropriate, this sheet can be used to provide an indication of the emissions and opportunities for potential material reuse and recycling. Considering end of life emissions aims to help drive decision making to improve resource efficiency and circular design, however given that end of life activities will generally take place some time in the future, a conservative estimate is recommended, and a high level of uncertainty is associated with these results.

End of life (EOL) emissions are those that occur once the project is decommissioned and the infrastructure not intended to have any further use. The end of life activities may include the clearing and removal of all assets and materials from the site or the project might be decommissioned and abandoned. The 'End of Life' worksheet is split into 4 modules:

1. Demolition or deconstruction activities (C1)
2. Transport of waste and materials (C2)
3. Waste/Recycling Processing (C3)
4. Landfill material waste (C4)

Both the 'do minimum' and the 'do intervention' scenarios should be completed in the 'End of Life' worksheet. It is important to consider that if an intervention or new project did not take place, then the existing assets would still reach the end of life. Therefore, a 'do minimum' scenario should be considered so that the change in emissions can be calculated. If there is no data available for the 'do minimum' then the change in EOL emissions as a result of the intervention will provide a conservative result.

Demolition or deconstruction activities

Input the area of structures that require demolition or deconstruction; the emission factor is based on the amount of fuel required for demolition. For example, a project that contains a 50m long, 20m wide bridge and 2,000m² of other structures (i.e. retaining walls, culverts, buildings) would be estimated as shown below in Figure 19.

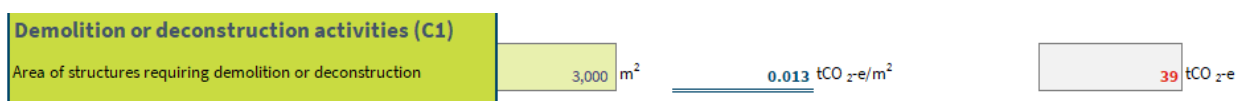


Figure 19: Screenshot of demolition or deconstruction example

Transport of waste and materials

This section covers the transportation of materials to disposal or until an end-of-waste state is reached (including transport from intermediate storage/processing locations). Weight data will automatically populate from the 'Construction' worksheet depending on whether a Second or Third Order estimate was used. The percentage of material (by mass) diverted from landfill has been pre-populated based on information from BRANZ but they can be updated by the user. The pre-populated values are based on current data due to the inability to forecast future practices. The distances to recycling facilities and landfill use a default value of 50km however these can be updated by the user, if needed. For example, a project that uses 48,086 tonnes of precast concrete considers that 20% of the concrete can be sent to

a local concrete recycler 50km away however the remaining concrete will need to be sent to the landfill 50km away.

Transport of waste and materials (C2) (Transport until the end-of-waste state is reached)				
Second Order Estimate (weight automatically populated from inputs in the Construction Second Order)				
Concrete and Cement				
	Weight (t)	Material % by mass diverted from landfill	One Way Road Distance (km) to recycling facility	One Way Road Distance (km) to landfill
Precast Concrete (Generic)	38,924	20%	50	50
Precast 30 MPa, (OPC)	9,162	20%	50	50
Precast 45 MPa, (OPC)	-	20%	50	50

Figure 20: Screenshot of transport of waste and materials example

Waste/Recycling Processing

According to the Polluter Pays Principle, the subsequent waste user shall carry the environmental impact from processing and refining the waste. Therefore, if the waste is being processed to become an input material for another product system, the waste generator carries the environmental impact until the waste is delivered to the next user e.g. delivered to a recycling operator or the site of reuse. Therefore, in PEET there are no waste processing emissions.

Landfill material waste

Most construction and demolition waste from transport infrastructure projects is inert and not biodegradable and is therefore sent to non-municipal landfills (including clean fills). For the purposes of PEET, landfill GHG emissions are considered negligible.

However, timber products that enter landfill are not inert and will release biogenic methane and carbon dioxide during decay. The sequestration of biogenic carbon during the growth of timber means that the net impact over the whole of life cycle is neutral. Therefore, in PEET, only the fossil carbon footprint of timber products is considered. This approach is aligned with EN 15804+A2 and other carbon footprint methods.

9. Results

Once data input is complete, users can navigate to the 'Results' worksheet to see analysis of the emissions from both the 'do minimum', the 'do intervention' and the emissions summary, which shows the change between the two, as shown in Figure 21. A breakdown of emissions for each section of the tool can be found below the summary of the results.

Summary of Results

Results by project stage	Do Minimum	Do Intervention
Construction (before use stage A1-A5)	0 tCO ₂ -e	111,972 tCO ₂ -e between 2025-2029
Operation and Maintenance (use stage B2-B6)	36,285 tCO ₂ -e over 100 yrs	100,421 tCO ₂ -e over 100 yrs
Enabled (use stage B9)	609,289 tCO ₂ -e between 2025-2050	937,575 tCO ₂ -e between 2025-2050
Avoided (use stage B9)		-2,896 tCO ₂ -e between 2020-2050
End-of-life (C1-C4)	2,659 tCO ₂ -e	12,938 tCO ₂ -e
Grand Total Emissions	648,233 tCO₂-e	1,160,010 tCO₂-e

Change in Emissions by project stage	
Change in Construction	111,972 tCO ₂ -e between 2025-2029
Change in Operation and Maintenance	64,136 tCO ₂ -e over 100 yrs
Change in Enabled	328,286 tCO ₂ -e between 2025-2050
Change in Avoided	-2,896 tCO ₂ -e between 2020-2050
Change in End-of-Life	10,279 tCO ₂ -e
Grand Total Change in Emissions	511,777 tCO₂-e

Construction Results

Construction First Order Emissions Breakdown
← Expand to view

Construction Second Order Emissions Breakdown
← Expand to view

Construction Third Order Emissions Breakdown
← Expand to view

Operation and Maintenance Results

O&M First Order Emissions Breakdown
← Expand to view

O&M Second Order Emissions Breakdown
← Expand to view

Enabled and Avoided Results

Enabled Emissions Breakdown
← Expand to view

Avoided Change in Emissions Breakdown
← Expand to view

End of Life Results

Enabled Emissions Breakdown
← Expand to view

Figure 21: Screenshot of Results worksheet

10. Whole of Life Results

The 'Whole of Life (WOL) Results' worksheet can be used to visualise the construction, O&M and end of life emissions of the 'do intervention' over the full life cycle of the project (excluding user (enabled and avoided) emissions). This can be a useful tool for projects that are not considering a 'do minimum' scenario.

The LCA module table provides a breakdown of the emissions aligned with the LCA modules that are considered in PEET.

LCA Module Table*	Emissions (tCO ₂ e)
Construction (before use stage A1-A5)	111,972
Material Element Emissions Subtotal (A1-A3)	77,092
Transport of Materials to Site (A4)	8,686
Fuel and Energy Use on Site (A5)	26,193
Operation and Maintenance (use stage B2-B6)	100,421
Maintenance, Repair, Replacement and Refurbishment Emissions (B2-B5)	67,309
Operational Energy Usage (B6)	33,112
End-of-life (C1-C4)	12,938
Demolition or deconstruction activities (C1)	39
Transport of waste and materials (C2)	12,899
Waste/Recycling Processing (C3)	-
Landfill material waste emissions (C4)	-
Whole of Life Emissions	225,331

*this table excludes user emissions (B9)

To use the 'Whole of Life Results' worksheet, the project lifetime and construction start and finish year must be input in the 'Summary' worksheet

Figure 22: Screenshot of LCA Module Table

The Whole of Life emissions over Design Life figure provides a visual aide to understand the contributions of different elements to the emissions over the project design life.

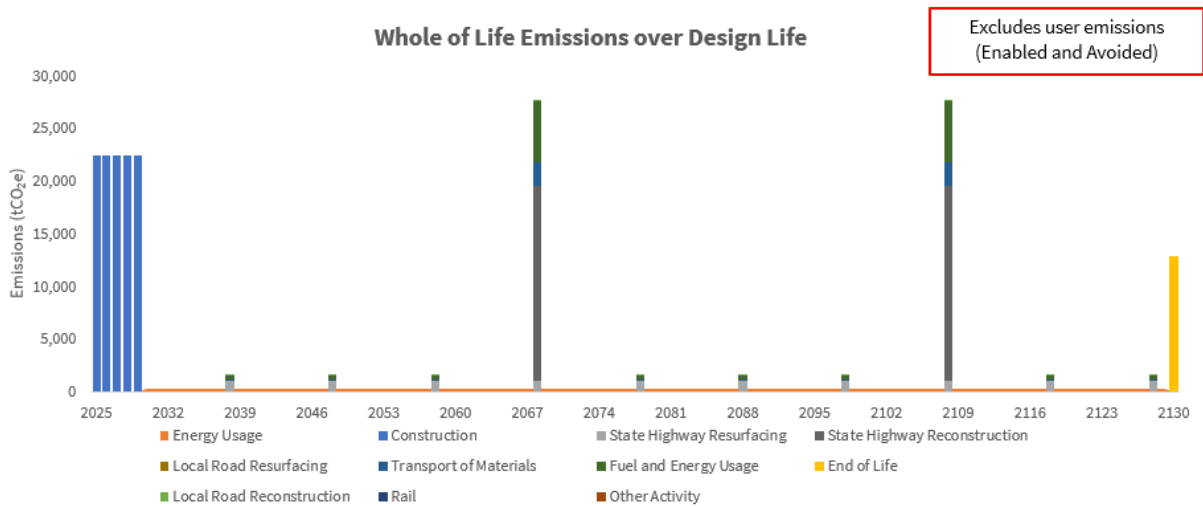


Figure 23: Whole of Life Emissions over Design Life

The cumulative emissions over the project design life figure shows how total emissions increase over time to reach the 'Whole of Life Emissions Total'.

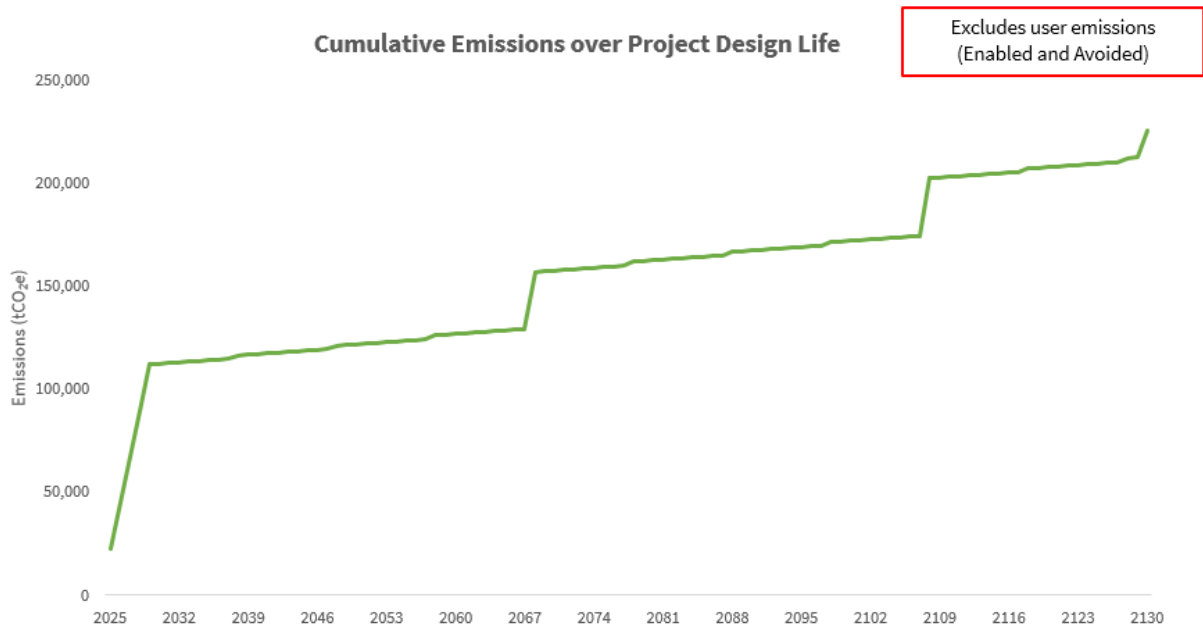


Figure 24: Cumulative Emissions over Project Design Life

The whole of life pie shows the contributions of the stages in the inner ring and the proportions of the modules in the outer ring.

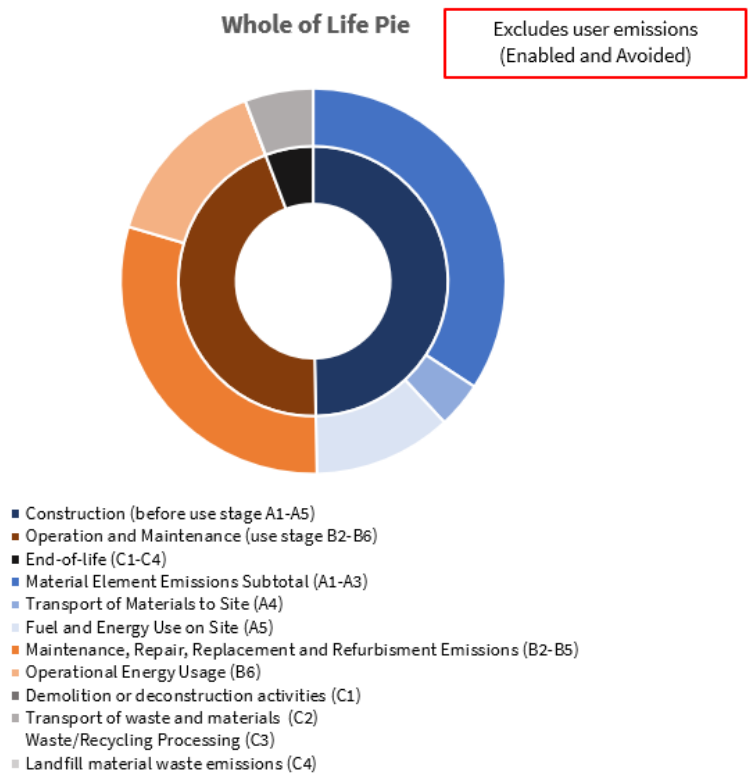
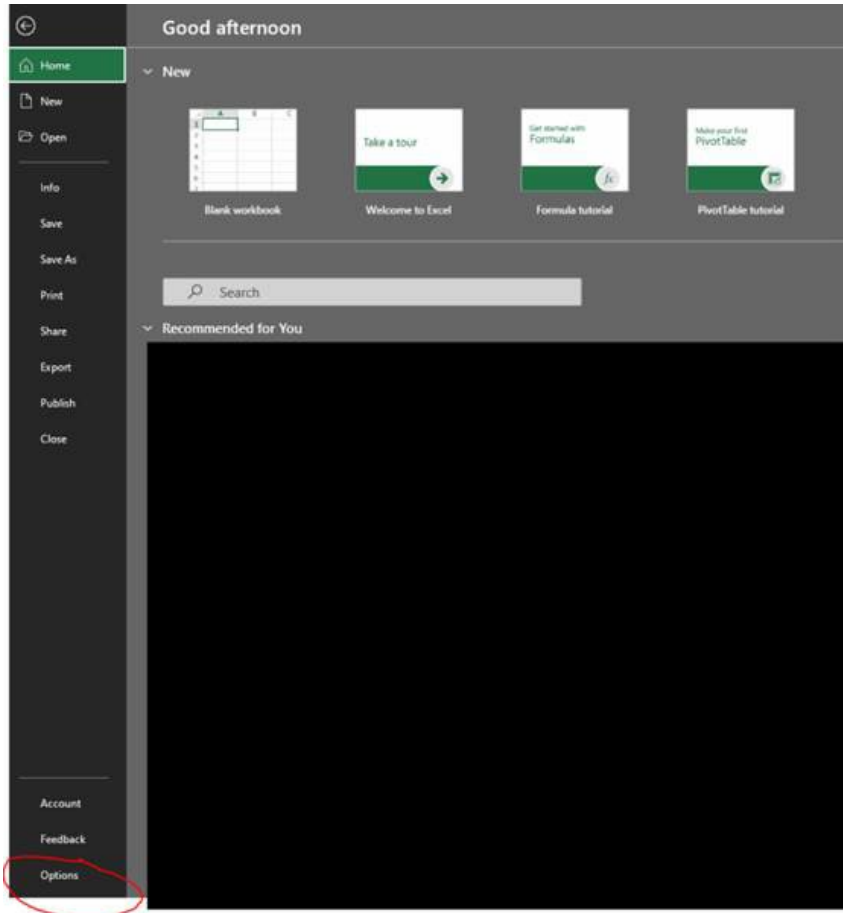


Figure 25: Cumulative Emissions over Project Design Life

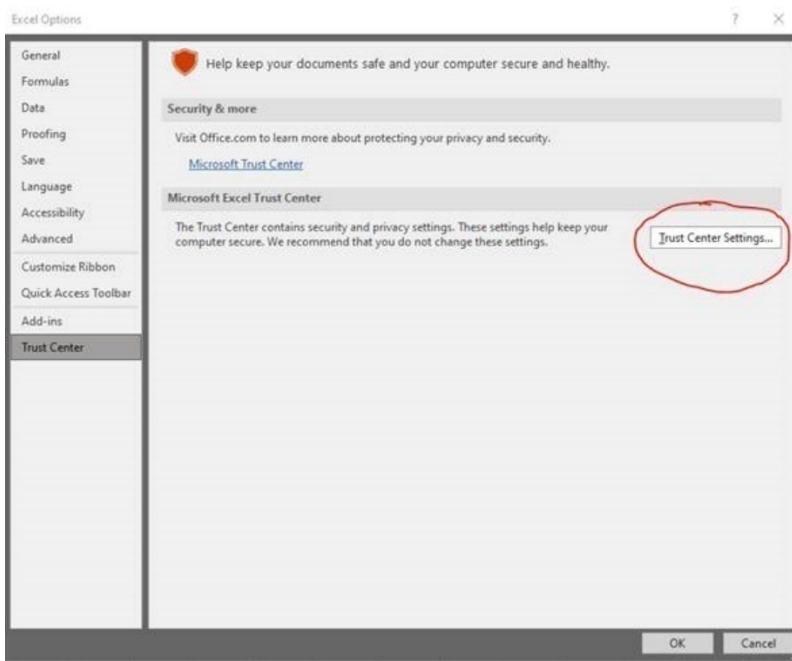
Appendix A: Enabling macros

Macros are required to allow the 'Reduction Analysis' worksheet to function appropriately. To ensure macros are enabled follow these steps:

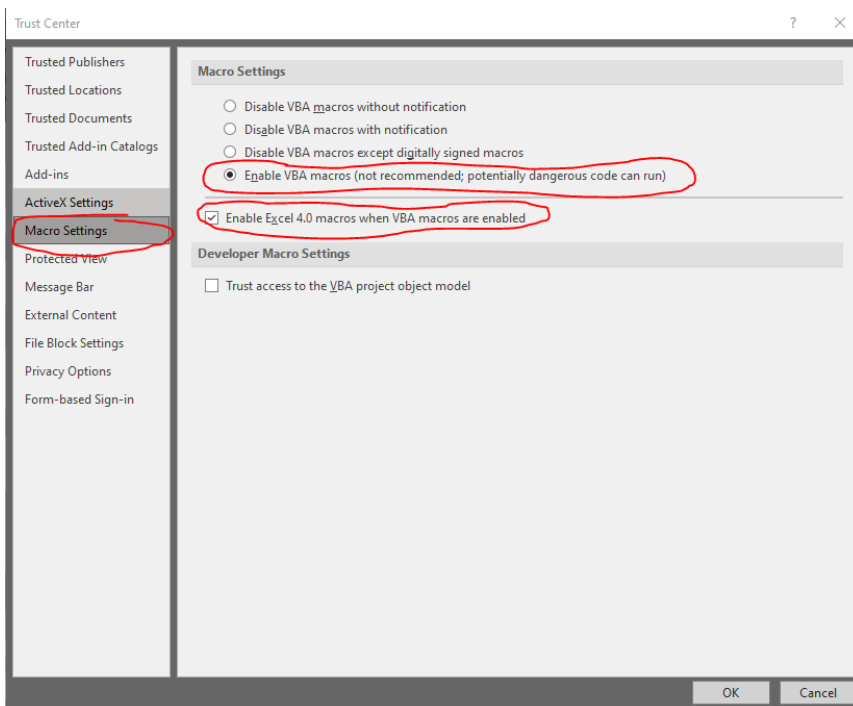
1. Click 'File' in the top left of Excel.
2. Click 'Options' down the bottom left.



3. Click 'Trust Center' and then 'Trust Center Settings...'



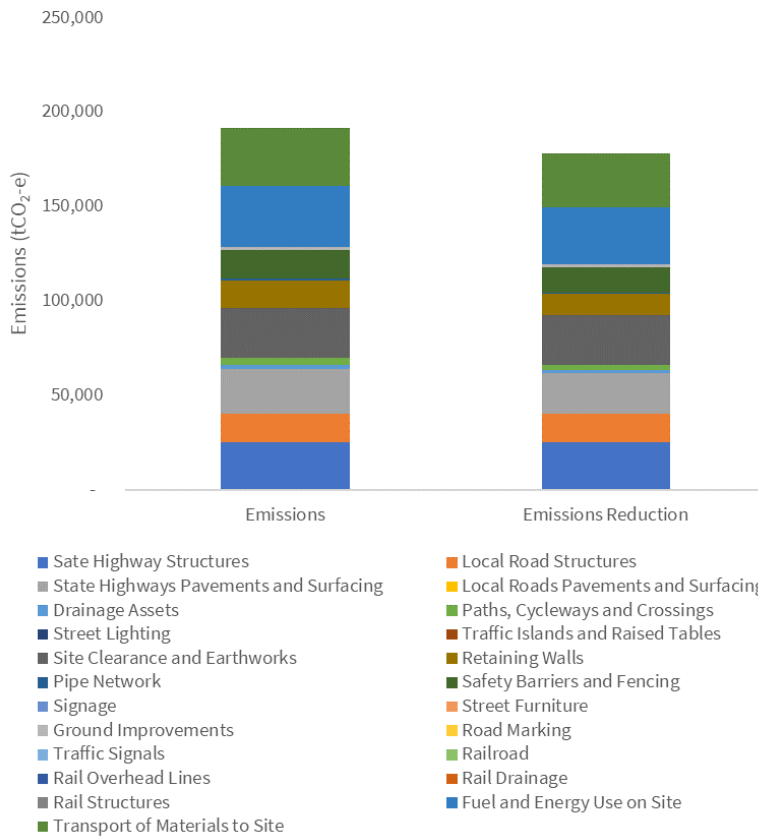
4. Click 'Macro Settings' and then 'Enable VBA macros' and 'Enable Excel 4.0 macros ...'



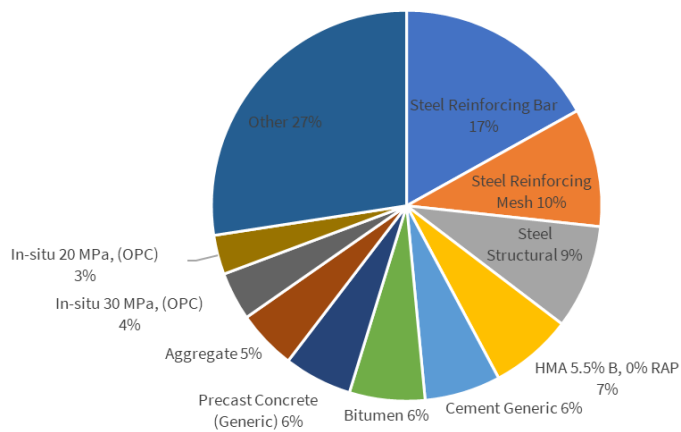
If the macros are still not enabled the file may need to be 'unblocked' using [guidance on the Microsoft website](#).

Appendix B: Typical reduction analysis results

Emissions Analysis



Top 10 Material Emissions



Emissions Reduction Analysis

Elements	Emissions Reduction (tCO ₂ -e)	Reduction (tCO ₂ -e)	Reduction (%)
State Highway Structures	25,306	-	0%
Local Road Structures	14,811	-	0%
State Highways Pavements and Surfacing	21,880	- 1,711	-7%
Local Roads Pavements and Surfacing	-	-	0%
Drainage Assets	1,359	- 1,040	-43%
Paths, Cycleways and Crossings	2,619	- 918	-26%
Street Lighting	164	- 8	-5%
Traffic Islands and Raised Tables	-	-	0%
Site Clearance and Earthworks	26,460	-	0%
Retaining Walls	11,259	- 3,514	-24%
Pipe Network	370	- 298	-45%
Safety Barriers and Fencing	13,564	- 1,597	-11%
Signage	243	- 6	-2%
Street Furniture	-	-	0%
Ground Improvements	1,370	-	0%
Road Marking	-	-	0%
Traffic Signals	-	-	0%
Railroad	-	-	0%
Rail Overhead Lines	-	-	0%
Rail Drainage	-	-	0%
Rail Structures	-	-	0%
Fuel and Energy Use on Site	30,297	- 2,307	-7%
Transport of Materials to Site	28,515	- 2,171	-7%
Total	178,217	- 13,570	-7%