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TEMPLATE for PUBLICATION: Evaluating Whole-Of -Life Infrastructure Carbon Emissions

Cover Page
Paper title **Evaluating whole-of -life infrastructure carbon emissions**

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ABSTRACT

Under the Government Policy Statement for Land Transport 2021, Climate Change is a strategic priority and Waka Kotahi has a key role to play through prioritising its investment decisions funded by the National Land Transport Fund to support the transition to a low carbon land transport system. This role has been amplified in 2021 when the Climate Change Commission published its draft carbon reduction targets, including for the transport sector. Upcoming changes to the Resource Management Act also require infrastructure projects to assess and address climate change impacts.

To gear up for this work, Waka Kotahi has developed a process that sets out our expectations and the methodology to measure construction, operational, enabled and end-of-life carbon emissions from the land transport system. This paper discusses the approach, methodology and wider implications of addressing carbon emissions generated from the construction, maintenance and use of our land transport system, including emissions from vehicles.

The methodology is based on international best practice (e.g. PAS2080) and is part of a broader piece of emissions profiling work within Toitū Te Taiao, our Waka Kotahi Sustainability Action Plan. Once fully implemented this methodology will be critical in helping us baseline our current land transport emissions, support our understanding of the transport contribution required to reach net zero greenhouse gas emissions by 2050 and assist infrastructure funding decision making to achieve required emissions reduction outcomes.

INTRODUCTION

In 2019 the Climate Change Amendment Act New Zealand set a national target to reduce greenhouse gas (GHG) emissions to net zero by 2050. The Climate Change Commission advice issued in February 2021 highlighted the transport sector as an area crucial to meeting climate change targets. In 2018, transport emissions made up 36.3% (16.6 Mt CO_2e) of total long-lived greenhouse gases (GHG) emitted by New Zealand (MfE 2021). Most transport emissions are from fossil fuels used to power vehicles. For example, petrol and diesel used by light vehicles and trucks emit 91% of CO_2e within the transport sector. The Climate Change Commission recommends GHG emissions from transport are reduced by 8.8 Mt CO_2e by 2035 to meet New Zealand's net zero target (He Pou a Rangi, Climate Change Commission, 2021).

The COVID-19 Recovery (Fast-track Consenting) Act 2020 (Parliamentary Council Office 2021) introduced new requirements for infrastructure projects to assess and address climate change impacts. Under the COVID-19 Recovery (Fast-track Consenting) Act 2020, infrastructure projects must have regard to whether the project will contribute to New Zealand's efforts to mitigate climate change and transition more quickly to a low-emissions economy (in terms of reducing New Zealand's net emissions of greenhouse gases (section 19(vii)). Further upcoming changes to the Resource Management Act also require infrastructure projects to assess and address climate change impacts with the aim of preventing future emissions being 'locked-in' by infrastructure choices made at the present time.

These reductions in greenhouse emissions represent a major challenge for the transport sector requiring a transformation in urban travel choices and vehicles used. Emissions from road transport liquid fuels have increased 6,981.5 kt CO_2e (93.4 per cent) between 1990 and 2017 (Ministry for the Environment, 2020). To date, efforts to reduce emissions have focussed on transitioning to a low/no carbon light vehicle fleet and supporting the uptake of electric vehicles (EVs). Meeting the 2050 target by this mechanism is a challenge of immense proportions, requiring on average over 140,000 fossil fuel vehicles to be replaced by low/no carbon vehicles every year from 2020 to 2050. While the pace of uptake has seen a big increase since 2017 – the pace required to meet the net zero is far, far greater. Additional actions beyond the widespread uptake of electric vehicles are required.

In response the Waka Kotahi Board has committed to delivering the vision of a 'low carbon, safe and healthy land transport system' as set out in Toitū Te Taiao Our Sustainability Action Plan. The action plan commits Waka Kotahi to reducing land transport greenhouse gas emissions to mitigate climate change. Assessing the GHG emissions from land transport projects will soon become a requirement for all infrastructure projects. Developing a consistent approach to assessing emissions will ensure that Waka Kotahi can respond appropriately to the challenge posed by climate change.

This paper summarises a draft Waka Kotahi methodology used to complete the greenhouse gas emissions assessment for infrastructure and its ability to contribute to meeting greenhouse gas reductions in the transport sector. The method uses the lessons learnt from the assessment of greenhouse gas emissions from previous Waka Kotahi infrastructure projects.

WAKA KOTAHI EXPECTATIONS

During 2020 Waka Kotahi has developed an interim climate change policy. As part of the interim policy Waka Kotahi has committed to prepare, periodically update and formally approve; regional, metro and programme-level strategic baseline assessments of GHG emissions arising from vehicles using the land transport system.

The assessments are required to the opening year for infrastructure and any relevant future baselines (e.g. 2030 and 2050). They will provide the basis for understanding the impact of enabled GHG emissions associated with projects covered by the scope of the interim policy.

The work to outline the method below will inform the assessment of projects that can contribute to the baseline assessments overtime.

ASSESSMENT METHODOLOGY

The scope of the assessment is particularly important for the measurement of GHG emissions. The scope applied for the draft method will be adapted from the framework set out in PAS 2080 Carbon Management in Infrastructure (BSI, 2016) and the technical guidance provided by the ISCA Technical (v1.2) in respect to climate change.

A criticism of previous emission assessments made for infrastructure in New Zealand is that these assessments rarely consider emissions beyond construction activities. To be effective any Waka Kotahi method will cover whole of life emissions, including emissions generated from operating, maintaining and the use of the transport network. That said, reducing emissions from construction remains an important focus of resource efficiency initiatives for Waka Kotahi.

Whole of life emissions measurements aimed at reducing emissions over time will need to be considered in the definition of the project, design of infrastructure and during construction and commissioning. The aim being to ensure emissions sources are identified and appropriate action taken to reduce emissions in a targeted and efficient manner.

Scope of Emissions to be Measured

From examining previous emission assessment studies completed both in New Zealand and internationally it is possible to determine an effective scope. The aim of the scope is to provide a whole of life estimate of GHG emissions. Waka Kotahi will assess the impact of GHG emissions associated with land transport infrastructure projects and activities that are planned, designed or delivered by Waka Kotahi, this includes:

a) Construction GHG Emissions, e.g. from construction materials and construction activities
b) Operational GHG Emissions, e.g. from infrastructure maintenance activities and energy use.
c) Enabled GHG Emissions e.g. from vehicle fuel consumption using new or improved infrastructure.
d) End-of-life GHG Emissions, e.g. from demolition activities and waste.

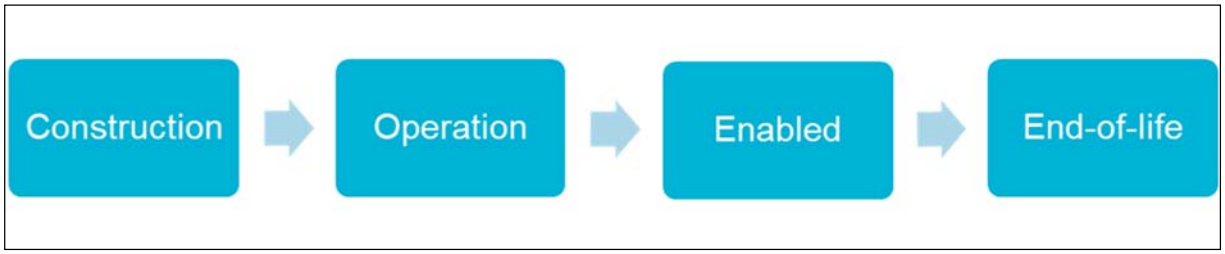

Figure 1 Emissions measured for whole of life impact

Construction Emissions

Assessing and understanding construction emissions is the area that has received most attention in New Zealand in the past. A standardised method has not been developed for reporting construction emissions. However, past emissions studies include some of the different elements listed below as part of the method proposed by Waka Kotahi.

In the proposed method construction emissions must include the following sources:

- Emissions associated with the production of construction materials;
- Emissions from transport of materials to site;
- Emissions from fuel use during construction, e.g. for earthworks, equipment use and includes electricity;
- Emissions from disposal of waste materials removed from the site during construction.

Construction emissions must account for embodied emissions for materials. For clarity, embodied emissions construction materials include the GHG emission associated with extraction, manufacturing, transporting construction materials before inclusion in infrastructure. Embodied emissions also include energy and fuel used to produce materials. The inclusion of embodied emissions for construction is not only important to lower emissions but also to ensure greater efforts for resource efficiency are pursued to lower emissions, use resources efficiently and preserve important materials e.g. aggregates.

Previous work completed by Waka Kotahi identified the most important construction materials that must be included in an emissions assessment. An investigation of emissions from eight New Zealand infrastructure projects shows the typical top emission sources in construction are concrete (and cement), steel, aggregates and the use of fuel (predominantly diesel) used in construction activities. The method developed by Waka Kotahi will require project teams to measure emissions from these top sources as a minimum. Construction emissions can be estimated from a bill of materials or based on the business case or design options produced for a project.

Operational Emissions

After completion of the infrastructure delivery operational emissions will occur. Operation of an asset also includes a wide range of maintenance to ensure the infrastructure is available during its service life.

The following GHG emissions will be included as part of operational emissions.

- Ongoing emissions from electricity demands e.g. for lighting over the service life of the infrastructure.
- Emissions relating to maintenance of the infrastructure during its' service life including repair work and resurfacing.

The type of operational emissions and their contributions to the overall total emissions depends on the type and size of infrastructure, e.g. road, cycleway or rail line. Operational emissions also relate to activities including the use of materials such as asphalt, concrete, steel and aggregates for maintenance activities. This includes fuel use by vehicles, electricity for lighting and waste disposal.

Operational emissions need to be described for the whole of the infrastructure once it is opened. For projects that modify or add to existing infrastructure all operational emissions for both the existing and new infrastructure must be estimated and reported for the service life of the infrastructure.

Enabled Emissions

Enabled emissions are used to describe the impact an infrastructure project will have on GHG emissions over time. Sources of enabled emissions include emissions from vehicles using the road and avoided emissions from mode shifts (e.g. through swapping fossil fuelled light vehicle trips for low emissions modes such as cycling or public transport).

Enabled emissions change over time as changes to fuel efficiency of the vehicle fleet occur, urban growth happens and as congestion changes both upstream and downstream of infrastructure in an interconnected transport system.

The following types of enabled emissions are used to describe different scenarios for enabled emissions:

- Enabled emissions (baseline) - describes the enabled emissions of the transport system at

the current time or for the year with most recent data before the infrastructure is constructed.
- Enabled emissions (do minimum) - describes the enabled emissions of the transport system at a future time without change to the infrastructure.
- Enabled emissions (option scenario) – describes the enabled emissions of the transport system at a future time with a change to the infrastructure (e.g. for a new motorway, public transport system or a cycling lane).
- Enabled emissions (change) – describes the difference in enabled emissions of the transport system as a result of the project (e.g. the option scenario minus the do minimum scenario).

The different scenarios for enabled emissions are used to improve understanding and communicate the results in this area. For example, the difference between a do minimum and an option scenario can be factored into investment for approving infrastructure that will reduce rather than increase emissions. The enabled emissions (change) scenario can also be used to understand the carbon intensity of different design choices for a piece of infrastructure e.g. highlighting designs that will lower emissions over time.

Estimates of enabled emissions are based on sophisticated traffic modelling. The assessment requires developing an understanding of changes to interconnected infrastructure e.g. the knock-on effects of congestion after the completion of new infrastructure. The results for enabled emissions modelling are sensitive to the assumptions made during the traffic modelling. For example, traffic models may include planned modifications to other parts of the transport system. The inclusion of different pieces of infrastructure or not will influence modelling of congestion, traffic speeds, as well as the use of cycleways or busways. If some of the infrastructure and projects included in the traffic modelling are not built, then the enabled emissions predicted are likely to be different to those that occur when a project is added to the transport system.

Another example of a factor that may influence modelling results of enabled emissions is the uptake rate of electric vehicles. The Vehicle Emissions Prediction Model (VEPM) uses travel demand and network performance results from regional or local transport tools to estimate the impact of changes to both the road capacity and other mode elements. The rate of uptake of electric vehicles is a subject of debate and the VEPM Model is regularly updated to reflect the latest forecasts.

End-of-life Emissions

Waka Kotahi will develop simplified methods for estimating emissions for end-of-life infrastructure. The reasons for considering end-of-life activities for infrastructure are two-fold. Increasingly, resource efficiency is a major factor for infrastructure development. Work by Waka Kotahi shows the supply of key materials including New Zealand premium aggregate will be limited in some parts of the country in the future and their use will need to be optimised. Apart from the use of resource constrained materials reuse and recycling of materials can lower the lifetime emissions of infrastructure.

Figure 2 summarises typical emission sources within each category.

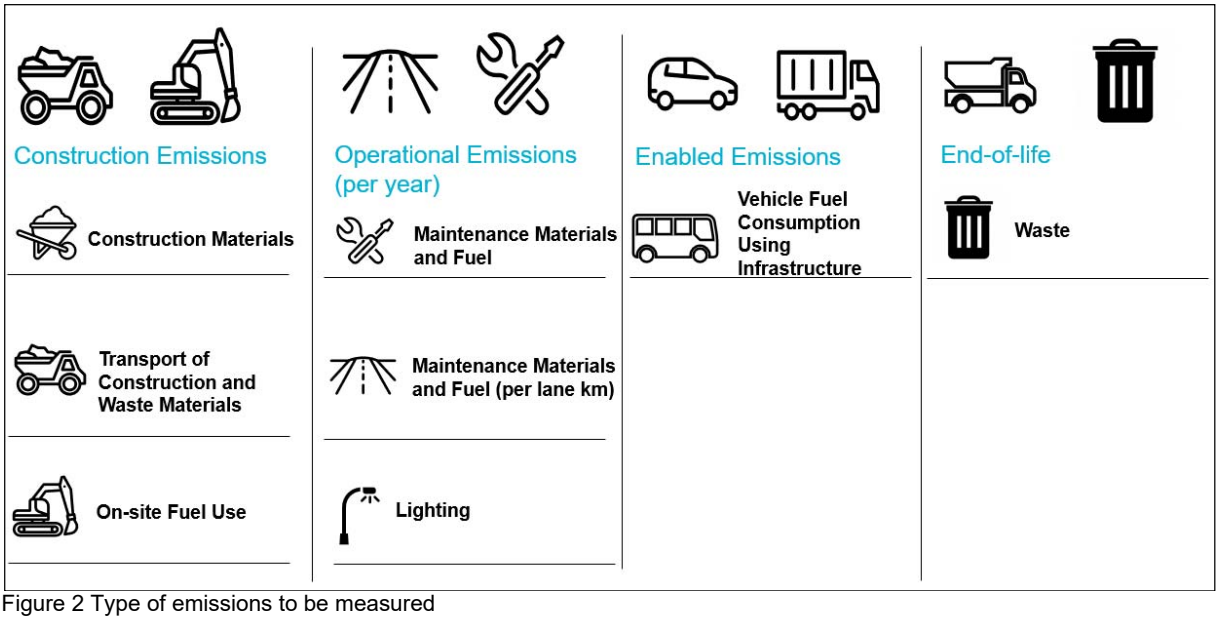

Figure 2 Type of emissions to be measured

Geographical Boundary

The geographical scope for an assessment of emissions must be defined and will need to be agreed with Waka Kotahi. For example, a new piece of infrastructure e.g. a cycleway may have a very localised impact on traffic volumes and congestion levels and in-turn emissions. The introduction of new infrastructure e.g. bus lanes or rail lines may have impacts on city wide transport flows that need to be considered in the assessment of enabled emissions. Establishing and agreeing the geographical boundary where emissions will contribute to the inventory is essential to ensure enabled emissions are estimated correctly.

Time Boundary

To estimate emissions of infrastructure effectively the time period over which emissions will be assessed must be set. In most cases emissions will continue to be produced for many years after construction. Waka Kotahi intends to implement a method that illustrates the carbon impact of infrastructure across the whole of the life. This means the time boundary chosen must be suitable to ensure GHG emissions for the service life are covered.

To meet the legislated net zero emission targets any project or set of projects will need reduce net GHG emissions over time. As the legislation sets a hard target of net zero carbon emissions in 2050, Waka Kotahi will use this as an important date to work towards in policy development and for GHG emission benchmarks.

Technology Boundary

The impacts on GHG emissions from emerging vehicle technology such as autonomous vehicles or infrastructure construction and design innovations is difficult to predict. For the most part the method used by Waka Kotahi will exclude unproven technical innovations that may reduce emissions as this may lead to over optimistic emission estimates. One innovation that is relatively easier to predict is the introduction of electric vehicles. The uptake of electric vehicles has been included in the method for establishing enabled emissions. Technical innovations that become widespread and deliver lower emissions will be included in Waka Kotahi as the method is updated.

Context/ Significance

Responding to and understanding the findings from an emissions assessment requires a position on how to determine whether emissions are significant or not. The IEMA EIA guide to Assessing

Greenhouse Gas Emissions and Evaluating their Significance (2017) suggests that emissions have a combined environmental effect that is approaching a scientifically defined environmental limit. As such any greenhouse emissions (or reductions) are considered significant and a project should mitigate them.

Similarly, the California Air Pollution Control Officers Association (2021) suggests that GHG impacts are considered exclusively cumulative impacts because no single project makes a significant contribution to global climate change. Waka Kotahi intends to develop guidance for project and programme level significance thresholds to provide greater context for decision making on GHG emissions.

Good Practice Reporting

Experience from the implementation of Greenroads and other sustainability rating schemes shows it is better for emissions to be reported on an ongoing basis rather than as a one off at the end of a project. There are several points in the design and delivery process when emission estimates for infrastructure will need to be reported to Waka Kotahi. Initially, emissions estimates using this method will need to be reported to Waka Kotahi for consenting of projects. Waka Kotahi projects required to obtain ISCA climate change credits will also be required to report the emissions in the design stage and in the as built stage on a quarterly and annual basis to Waka Kotahi. Waka Kotahi in turn will collate and report the GHG emissions from infrastructure projects on an annual basis as part of the agency's efforts to meet New Zealand's net zero target.

CONCLUSIONS AND RECOMMENDATIONS

Waka Kotahi is updating its guidance and specifications related to climate change assessments to give effect to the interim climate change policy. This will ensure a consistent approach to develop GHG assessments and enable climate change impacts to be considered in the development and delivery of infrastructure projects.

The method discussed in this paper will form the basis for further work and understanding of GHG emissions from infrastructure for Waka Kotahi. The method has been developed based on the developing standards and approaches for GHG measurement both in New Zealand and internationally. A whole of life approach to analysing and communicating the details of GHG measurements for infrastructure are essential to reducing emissions in all areas possible. Both construction and operation of infrastructure can be directly influenced by Waka Kotahi policies and investment choices. Enabled emission will be the largest source of emissions but assessments needs careful interpretation and be used carefully to ensure design choices contribute to long-term emission reduction.

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AUTHOR CONTRIBUTION STATEMENT

This paper was prepared collaboratively by Dr. Anthony Hume, Maurice Marquardt and Sarah Lindberg.