RR 720: Determining the carbon footprint of land transport infrastructure in New Zealand.

NZTA research summary

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Land transport infrastructure is a vital part of modern society, allowing for the movement of goods, services and people.

However, land transport infrastructure has been identified as a major contributor to climate change through the carbon emissions generated from the infrastructure itself and the use of it. The way we construct, maintain, manage and use infrastructure has a major impact on how we meet our commitment to the Paris Agreement and keep global warming within 1.5 °C.

This research sought to understand the carbon footprint of all land transport infrastructure in Aotearoa New Zealand, which will contribute to wider pieces of work that are taking place within the industry and assist the NZ Transport Agency Waka Kotahi (NZTA) and other transport authorities in targeting emissions reductions.

Definitions

Embodied carbon: Greenhouse gas emissions associated with creation, refurbishment, maintenance and end-of-life treatment of an asset.

Enabled emissions: Greenhouse gas emissions associated with utilisation of an asset, network or transport system.

Upfront carbon emissions: Greenhouse gas emissions associated with creation of an asset, network or transport system.

NZ TRANSPORT AGENCY WAKA KOTAHI

Te Kāwanatanga o Aotearoa
New Zealand Government

The research

The research focused on embodied carbon of land transport infrastructure (road and rail) and analysed the whole-of-life emissions of New Zealand's land transport network, including material and construction, maintenance, operation and end of life. It excluded vehicle emissions that arise from the use of the infrastructure.

The objectives of the research were to:

- analyse literature and available data around the quantification of the carbon footprint
- identify and determine an appropriate methodology for quantification of the carbon footprint from New Zealand's land transport infrastructure
- determine a baseline carbon footprint for land transport infrastructure in Aotearoa New Zealand
- identify the greatest contributors to carbon emissions to inform decisions on where to target reductions
- provide a framework and data, including recommendations for addressing any data gaps, to help the sector develop tools that can assess the greenhouse gas emissions impacts of land transport investments.

Literature review

A literature review was undertaken of research in New Zealand and international contexts to understand if carbon quantification of infrastructure at a similar scale has taken place before. The aims of the review were to:

- establish the context for researching the carbon baseline of land transport infrastructure, including the policy context
- summarise existing standards, frameworks and methodologies that direct the approach to carbon emissions quantification and carbon management
- review existing literature to understand how large-scale emissions estimation has occurred in either New Zealand or international contexts, with a particular focus on the methodology undertaken and boundary setting
- analyse asset data and design information to understand how assets can be organised and standardised.

The review found that embodied carbon in construction and infrastructure is considered a hidden impact, with much more attention in policy and literature being given to vehicle emissions from the use of the infrastructure. The literature review found methodologies for quantifying the carbon emissions for individual infrastructure projects but limited methodologies on undertaking large-scale carbon quantification across a whole infrastructure network.

Methodology

The literature available on approaching this task for individual asset types, particularly the quantification of the impacts of roads and rail such as the global standard PAS 2080:2023 Carbon management in buildings and infrastructure, formed the foundations for establishing a methodology at a national network scale. Profiles representing a 'typical' infrastructure asset were developed using the NZTA Project Emissions Estimation Tool (PEET) combined with research and technical knowledge from subject matter experts. Each profile was assigned an emissions factor and asset data was obtained from New Zealand's Road Assessment and Maintenance Management (RAMM) digital asset and KiwiRail and placed within the emissions framework.

Key findings

This research estimates that the upfront carbon footprint of the road network, which includes state highways, local roads and all associated assets such as footpaths, traffic signals and signage, is 37,250 $ktCO_2e$ (±10%). Maintenance emissions for the road network have been estimated at 855 $ktCO_2e$ (+10%, -14%) per year with operational emissions estimated at 35 $ktCO_2e$ (+10%, -22%) per year.

The total national upfront carbon footprint for the rail network, including tracks, structures, retaining walls and culverts, is 15,380 $ktCO_2e$ (±15%). Maintenance emissions for the rail network have been estimated at 220 $ktCO_2e$ per year.

Note: for an illustration of scale, New Zealand's national net emissions for the 2022 year were estimated at 59,100 $ktCO_2e$, of which the total land transport (fuel) emissions comprise an estimated 13,600 $ktCO_2e$.

These are the key findings:

- Over decades, investment into infrastructure has produced significant carbon emissions through its construction, maintenance and operation. Much of this is essentially a sunk cost that cannot be recovered or changed, but there are significant opportunities to reduce carbon by changing how we invest in, design, construct and maintain our current and future assets. However, these opportunities can only be realised if we consider whole-of-life carbon (including embodied and enabled emissions) in decision making about investment into infrastructure.
- Maintaining and optimising our current network is better from a carbon perspective than building new, and all new assets will increase carbon through upfront emissions as well as through the maintenance cycles and end-of-life impacts that are created. Optimising our current network can occur in many ways, and in the context of this research, we consider it to be when whole-of-life and whole-of-network considerations are brought to the forefront of investment decision making, with build nothing and build less being the desired outcome.
- Although gains have been made in recent years, there is a lack of information about maintenance activities on the road network and end-of-life impacts and the subsequent carbon emissions from these activities. This presents a risk to New Zealand's future infrastructure investment, particularly considering increased maintenance requirements due to more heavy vehicles on the roads and impacts from extreme weather events.
- This research looked at embodied carbon across the life cycle of infrastructure assets, but embodied carbon is only one piece of a very complex puzzle that should not be analysed alone. Enabled vehicle emissions and embodied emissions are two interrelated elements and must also be considered in conjunction with other impacts, including a just transition, community wellbeing, environmental impacts and climate resilience.
- There is significant opportunity to reduce upfront carbon emissions through innovation of new materials, technologies and processes when new infrastructure assets are required or through maintenance. Although quantifying emissions reduction opportunities was out of scope of this research, the significance of upfront and maintenance emissions suggests that developing, trialling, implementing and eventually mandating low-carbon materials will reduce carbon in future investments.

Recommendations

Through this research report, several recommendations have been identified that will improve understanding of the carbon footprint of land transport infrastructure and identify ways to investigate reducing the impact:

- Future land transport investment decisions should consider whole-of-life carbon (embodied and enabled) in the context of New Zealand's net-zero by 2050 reduction target. Particular focus should continue on improving information available on maintenance, operations and end of life activities.
- Future land transport investment decisions should consider the whole transport network and other related horizontal infrastructure. Consideration of optimising existing infrastructure before new construction is important.
- Technological and process innovations that reduce embodied carbon should continue to be researched, trialled and implemented to reduce emissions when new assets are needed or maintenance is occurring.
- Asset databases should be standardised and improved (particularly in how maintenance is recorded).

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NZ Transport Agency Waka Kotahi research report.
Available at **www.nzta.govt.nz/resources/research/reports/720**