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Transport decarbonisation: A ‘base case’ carbon framework in project business case and economic evaluation

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Abstract

This research paper proposes a ‘base case’ carbon framework for the development of business cases and cost-benefit analyses of transport projects. The framework comprises three modules: life cycle carbon measurement, carbon valuation, and policy implications. The life cycle carbon measurement module attempts to estimate the embodied carbon from materials, plants, and equipment used for transport construction, as well as greenhouse gas emissions from passenger cars, freight trucks, buses, and rail transport from transport operations. The carbon valuation module explores the most appropriate approach to assigning carbon values for project cost-benefit analyses. Finally, the policy implications module outlines the various policy scenarios in which the ‘base case’ carbon framework can be applied, including the assessment of transport decarbonisation in project scenarios, the assessment of construction tenders when a low-carbon approach is proposed by a project proponent, and other decarbonisation initiatives such as electric vehicles, hydrogen trucks or circular economy.

1. Why do we need a ‘base case’ carbon framework and what problems this paper tries to solve?

Greenhouse gases (GHGs) are compounds in the atmosphere that trap heat and cause the greenhouse effect, a process that warms the atmosphere and surface on Earth (Australian Government Department of Agriculture, 2022). To counteract climate change and the negative impacts caused by GHGs, world leaders signed the Paris Agreement in 2016[1]. The goal of the Paris Agreement is to limit global temperature increase to below 2 degree Celsius, with efforts to further limit the increase to 1.5 degrees Celsius compared to pre-industrial levels.

As a signatory to the Paris Agreement, the Australian Government enacted the Climate Change Act 2022 on 14 September 2022, and the Commonwealth and State Governments have since reset their transport decarbonisation targets. Table 1 summarises the carbon reduction targets by Commonwealth and NSW Governments.

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[1] The United Nations Climate Change, see https://unfccc.int/process-and-meetings/the-paris-agreement, current as at 11 April 2023.

Table 1: Carbon reduction targets

Jurisdiction	2030	2050
Australian Government	Reducing emissions in Australia by 43% of 2005 levels	Achieving net zero emissions for Australia
NSW Government	Reducing emissions in NSW by 50% of 2005 levels	Achieving net zero emissions for NSW

Transport construction and operations generates 20-30% of total GHGs. Transport decarbonisation contributes to national and NSW carbon reduction targets. This paper aims to develop a 'base case' carbon framework by presenting ideas on the following issues:

1. Estimating embodied carbon from transport construction
2. Estimating greenhouse gas emissions from transport operations
3. Valuing carbon in cost-benefit analyses and business cases
4. Transport decarbonisation from project business case and economic appraisal perspectives.

2. Embodied carbon from transport constructions

2.1 Context

In NSW, the NSW Environment Protection Authority (EPA)'s draft Protection of the Environment Policy (NSW EPA 2023) for sustainable construction requires business cases of NSW infrastructure projects to include estimates of embodied carbon from 2024. In Victoria, Infrastructure Victoria is reporting to the government on opportunities to decarbonise future infrastructure investments, which also include embodied carbon from construction (Infrastructure Victoria 2023).

While the Commonwealth Climate Change Act and NSW EPA's Policy provides legislative impetus for decarbonisation of both constructions and operations, current transport project business case guidelines do not require inclusion of embodied carbon from construction. To develop a life cycle carbon measurement, the first step is to understand the magnitude of embodied carbon in constructions. Table 2 shows that the embodied carbon from construction accounts for 5-10% of total emissions from the NSW economy, while greenhouse gas emsissions from transport represent 20% of the total emissions. It indicates that the embodied carbon from construction is significant, and cannot be overlooked from a life cycle carbon measurement perspective.

Table 2: Greenhouse Gas Emission by economic sector

Sector	Percentage of total emissions	Note
Carbon emissions from transport operations	20%	**Breakdown** Cars and LCVs: 63% Trucks: 21% Aviation and ships: 12% Buses and trains: 4%
Embodied carbon from constructions	5-10%	INSW (2022, p. 2)
Other sectors in the NSW economy	70-75%	
Total NSW economy	**100%**	

Source: Analysis by the authors, INSW 2022

2.2 Estimating embodied carbon from transport constructions

Embodied carbon is the emission resulted from the production of materials and inputs used in construction, the transportation of materials to the construction site, the construction process, infrastructure maintenance and where applicable, demolition. As GHG emission is a global issue, embodied carbon from materials imported from interstate and overseas should also be included. The state of practice of the construction industry, manufacturing and transportation should be established to determine an industry average or benchmark to formulate the ‘base case’ carbon. The ‘base case’ should neither be the industry best practice to allow for industry improvement and performance uplift, nor from the low performing industry players.

Existing business case and economic appraisal frameworks and guidelines allow for a way to account for embodied carbon, which the ‘base case’ is often defined as the ‘business-as-usual’ or ‘no investment’ option. However, such approach will almost always lead to additional disbenefit or externalities in the investment options, as any form of transport construction will lead to additional embodied carbon emissions. It also does not support the demonstration of reduced emissions when the low emission building materials or construction practices are adopted in the business case and economic appraisal. Furthermore, not having an industry benchmark does not support the establishment of requirements for reducing embodied emissions in tenders, and procurement strategies in business cases which focuses on reducing embodied emissions.

The most common inputs in transport infrastructure construction are concrete, steel, asphalt, fuel, and electricity. However, estimating emissions from various materials, and differentiating between low, average, and high emission products are some of the key challenges. An integration of Building Information Modelling (BIM) systems and cost estimates can provide accurate estimates of the volumes of materials required for the project. The system should be agile in order to respond to scope changes.

Table 3 listed some indicative embodied carbons obtained from various research and projects. For each cubic metre of concrete, 0.3 to 0.4 tonnes of carbon dioxide equivalent (CO2-e) emission are expected. Emission rates from other products can be interpreted in a similar way.

Table 3: Indicative embodied carbon of construction inputs

Input	Unit	Emission (tonne CO2-e)
Concrete	Cubic metre of concrete	0.3 – 0.4
Steel	Tonne of steel	1.9 – 2.9
Electricity	Meta Watt Hour (MWH)	0.2 – 0.7

Source: Unpublished research from various transport projects and analyses by the authors. Values are indicative only and should be used with caution.

For surface projects in outer metropolitan and regional areas, infrastructure may be built on vegetated land. Vegetation removal and the resultant loss of carbon sinks can contribute to a significant amount of embodied carbon. Table 4 demonstrates an indicative breakdown of embodied carbon of a sample road and tunnel project.

Table 4: Indicative percentage of embodied carbon

Material and input	Indicative percentage of embodied carbon	
	A typical road project	A typical tunnel project
Concrete and cement	31%	26%
Steel	20%	22%
Diesel for plant and equipment	16%	5%
Diesel for transport of materials, waste and spoil		15%
Electricity for tunnelling		26%
Vegetation removal (loss of carbon sink)	27%	
Other construction materials	3%	2%
Others not included in above	3%	4%
Total	**100%**	**100%**

Source: Authors' analysis based on sampled projects

The 'base case' carbon for transportation of materials and to and from the construction site could be estimated using existing methods and parameters values. These are discussed in section 3.

2.3 Considerations of a construction phase 'base case' carbon scenario at business case development stage

There is a significant knowledge gap regarding the specification of a 'base case' carbon scenario at the business case development stage. While it is possible to estimate the construction inputs of concrete, steel, diesel, and electricity with reasonable accuracy from BIM, it is challenging to define what the 'base case' carbon is. What is the best way to establish an industry average, benchmark, or agreed Australian values for material inputs? How can we determine the embodied carbon from imported materials compared to local contents, given the manufacturing and transportation process for imported materials are less visible? While some research activity is underway, such as the Integrated Carbon Metrics Embodied Carbon Life Cycle Inventory Database (ICM Database) by UNSW, the measurement of embodied carbon is a research area that this paper identifies.

Apart from extended databases which allow a 'base case' to be determined, another policy implication is how the carbon reduction claims made by suppliers and construction firms for their products, construction processes and services can be evaluated or verified. To achieve transport decarbonisation, the government may opt to pay higher prices for greener constructions. However, the verification of actual carbon reduction from the 'base case' or benchmark may be technically challenging.

The current practice of business case development does not consider embodied carbon. Its inclusion could introduce carbon emission disbenefits during the construction phase, leading to a lower Benefit-Cost Ratio (BCR). Based on observations of some transport projects, disbenefits of embodied carbon range from 1% to 5% of project capital cost using current carbon values recommended by NSW Treasury (2023).

The inclusion of the 'base case' carbon may lead to increased construction costs, either from the increased "offsetting" requirement or higher cost of low carbon methodology. With a combination of carbon emission disbenefit and increased construction cost, capital investment prioritisation may shift towards solutions with less embodied carbon. These solutions include active transport and bus infrastructure, and demand side measures encouraging mode shift to public transport. These solutions involve less earthwork, civil structure, concrete, and steel to build compared to road and rail infrastructure for the same transport capacity. With the commitment of achieving carbon reduction by 2030 and net-zero by 2050, the government is increasingly willing to pay higher prices for greener and more environmentally friendly construction options, and the general public being increasingly receptive of these commitments.

3. Carbon from transport operation

The methodologies for estimating carbon emissions from transport operations have been well-established for years, making them less challenging in comparison to measuring embodied carbon in transport constructions. Most carbon emissions come from the fuel consumed by private cars, freight vehicles, and the energy used for powering public transport. Figure 1 illustrates the three steps involved in measuring carbon emissions from transport operations.

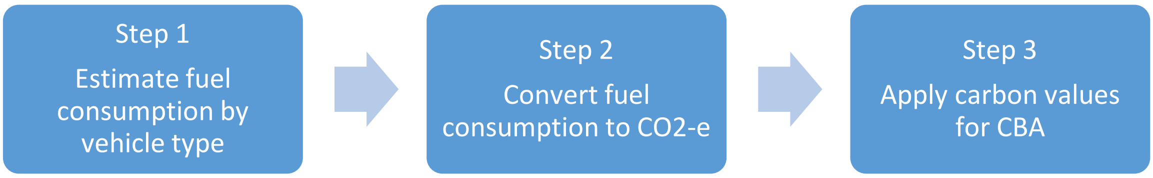

Figure 1: Steps of measuring carbons from transport operations

3.1 Fuel consumption of uninterrupted traffic flow on regional highways

Australian Transport Assessment and Planning Guidelines (ATAP 2022) provides a fuel consumption model for uninterrupted traffic flow on regional highways as shown in the equation below.

$$\text{Fuel consumption (litres/km)} = BaseFuel * (k1 + k2/V + k3*V2 + k4*IRI + k5*GVM)$$

Where,

$BaseFuel$ = lowest fuel consumption point in curve from raw HDM-4 output
V = Vehicle speed in km/h
IRI = International Roughness Index in m/km
GVM = gross vehicle mass in tonnes
$k1$ *to* $k5$ = model coefficients.

The model coefficients k1 to k5 can be found in ATAP (2022) which are not reproduced in this paper. The core model parameters are shown in Table 5.

The several factors in the fuel consumption model are explained below:

- Base fuel consumption: This refers to the fuel consumption of vehicles operating at maximum fuel efficiency or lowest fuel consumption level. Table 5 shows that the base fuel consumption for cars ranges from 6.4 to 9.8 litres per 100 vehicle kilometres travelled (VKT), with variation primarily caused by car size (i.e., small, medium or

large cars). For B-Doubles and A-Doubles, the base fuel consumption can range from 38.1 to 47.8 litres per 100 VKT.
- Speed adjustment: The most fuel-efficient speed varies by vehicle type and body design. For most vehicles, the lowest fuel consuming speed is around 70 km/h. Lower speeds (due to congestion) or higher speeds (for time savings) result in increased fuel consumption.
- Surface roughness adjustment: High quality road pavements reduce fuel consumption and are adjusted in the fuel consumption model.
- Vehicle weight adjustment: Heavier vehicles, including both tare weight and load weight, require more fuel to power.
- Horizontal curvature and vertical rise and fall adjustment: Sharp curves and high road gradients increase fuel consumption.

Table 5: Fuel consumptions by vehicle type – uninterrupted flow in rural areas

	Base fuel consumption (Litres / 100 km)	Fuel consumption adjustments
Cars	6.4 – 9.8	Fuel consumption adjustments for speed, surface roughness, and gross vehicle mass Adjustment for road horizontal curvature Adjustment for road gradient, rise and fall
LCVs	7.6 – 10.2	
Rigid trucks	8.1 – 23.2	
Heavy bus	23.3	
Articulated trucks	27.2 – 33.8	
B-Doubles and A-Doubles	38.1 – 47.8	

Source: Authors' analysis based on ATAP (2016) and TfNSW (2023)

3.2 Fuel consumption of interrupted traffic flow on urban roads

The fuel consumption of vehicles driven on urban roads is estimated using fuel models that considers interrupted traffic flow and a stop-start operation pattern. The base fuel consumption on urban roads is higher compared to regional roads, which are generally less congested. Since the operational conditions on urban motorways are different from other urban roads, a specific model for urban motorway is available. The impacts of curvature, gradient, and road roughness are less significant and thus not adjusted in the urban fuel models. However, the urban fuel models consider the effects of speed and road congestion and takes into account the vehicle tare weight based on vehicle types, as shown in Table 6.

Table 6: Fuel consumptions by vehicle type – interrupted flow in urban areas

	Base fuel consumption (Litres / 100 km)	Fuel consumption adjustments
Cars	7.9 – 10.5	Fuel consumption adjustments for vehicle speed and urban congestions. Separate model for urban motorways exists. In Sydney, urban motorways are generally toll roads.
LCVs	8.1 – 11.5	
Rigid trucks	16.1 – 45.5	
Heavy bus	38.3	
Articulated trucks	64.0 – 75.4	
B-Doubles and A-Doubles	90.1 – 117.1	

Source: Authors' analysis based on ATAP (2016) and TfNSW (2023)

3.3 Fuel and carbon conversion

To estimate carbon dioxide emissions from operating motor vehicles, one method is to measure the fuel consumption and corresponding carbon emissions from the tailpipe. However, the amount of carbon dioxide produced per litre of fuel used can vary depending on the type of vehicle and fuel quality. On average, 1 litre of petrol produces about 2.3 kg of carbon dioxide, while 1 litre of diesel produces about 2.7 kg of carbon dioxide. (National Transport Commission, 2021).

3.4 Consideration of an operation phase 'base case' carbon scenario at the business case development stage

The ATAP Parameter Values[2] and TfNSW (2023) have established methodologies to estimate carbon emissions from various forms of transport, including cars, road trucks, light rail, electrified trains, diesel trains, and buses. The 'base case' carbon emissions can be calculated for current transport operations or for 2005 when the carbon reduction base value was set at the 2016 Paris Agreement.

Although there is some debate about whether embodied carbon should be included in the government carbon reduction target, operational carbon emissions are targeted to be reduced by 50% from the 2005 levels by 2030. The NSW Government has committed to initiatives and policy changes to reduce transport operational carbon emissions. For example, the Net Zero Emission Buses (ZEB)[3] project replaces 8,000 diesel and natural gas buses with net zero electric buses, the Electric Vehicle Strategy[4] sets out frameworks for electric vehicles and hydrogen freight fleets, while High Productivity Vehicles (HPV) will adopt Euro5 fuel standards to reduce carbon emissions. The Future Transport Strategy also supports multimodal mobility including elevating active transport travels. These policy changes and initiatives will likely result in lower transport operation carbon emissions in both the base case and project case.

Since its establishment in 2011, Transport for NSW has taken a clear position to include operational carbon emissions in the cost-benefit analyses and business cases. However, existing methods, while well-developed, require some fine-tuning to improve accuracy due to the renewed interest in the inclusion of operational carbon emissions. Similar to the construction phase 'base case' carbon scenario, the key challenge is to estimate upstream (also known as Well-to-Tank) and downstream carbons, especially those from new technologies. As an example, the embodied carbon emissions from manufacturing a transport fleet are not captured in either the construction or operation phases. There are opportunities to investigate carbon reduction from the shared economy and circular economy, which could reduce the demand for new cars and, in turn, reduce carbon emissions. This is a global supply chain issue that appears more difficult to model.

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[2] ATAP PV1 Public Transport, PV2 Road Transport, PV3 Freight Rail, PV4 Active Travel and PV5 Environment

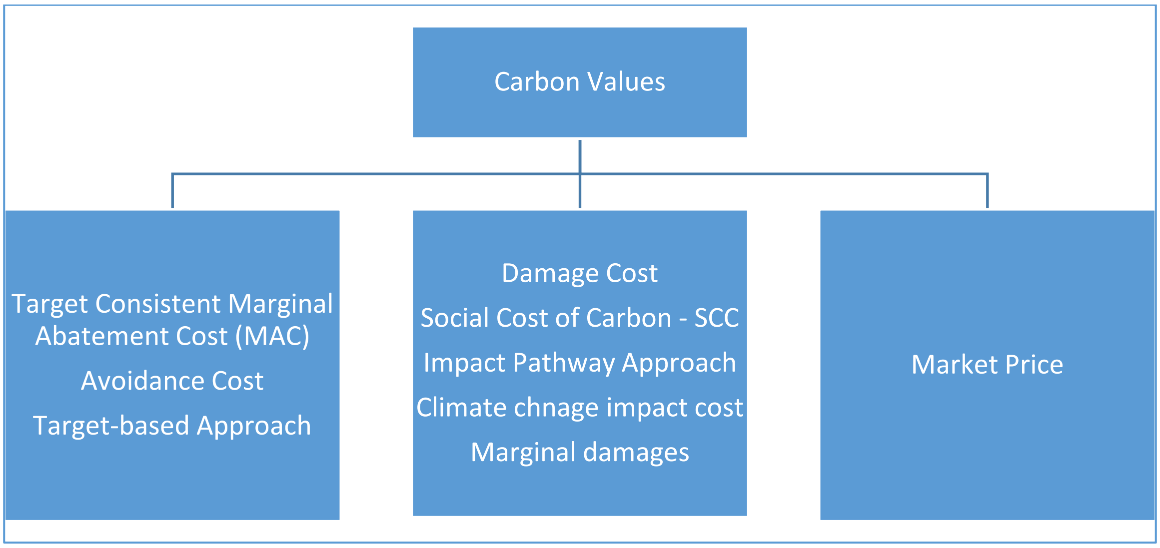
[3] See https://www.transport.nsw.gov.au/projects/current-projects/zero-emission-buses, accessed on 7 April 2023.

[4] See https://www.energy.nsw.gov.au/nsw-plans-and-progress/government-strategies-and-frameworks/electric-vehicle-strategy, accessed on 7 April 2023

4. Carbon valuations

The carbon values used in NSW transport business cases were initially based on ATAP recommendations, which suggested a value of around \$65 per tonne of CO2-e. However, in 2023, NSW Treasury established a higher value of \$123 per tonne of CO2-e for cost-benefit analyses, based on the average European Union Emissions Trading System (EU ETS) market spot price (NSW Treasury 2023). This value is subject to a real increase of 2.25% annually, to account for the expected real increase in the cost of carbon. While there is a debate about whether the market price is the most appropriate carbon value for cost-benefit analyses, this section outlines three approaches commonly used to establish carbon values. After evaluating these approaches, a marginal abatement cost (MAC) approach is concluded to be the most suitable methodology for setting carbon values.

Figure 2: Carbon valuation methodologies



4.1 Target Consistent Marginal Abatement Cost (TCMAC)

The TCMAC approach involves using a relevant policy target, such as ‘net-zero by 2050’, and determines the scale and cost of GHG abatement required to achieve that target over a given timeframe (UK Government 2021, UK Government BEIS 2021).

The method is based on a cost-effectiveness analysis, which determines the least expensive option to achieve a required level of GHG emission reduction (CE Delft 2019). The resulting option is depicted on a Marginal Abatement Cost (MAC) curve, which shows the cost of a series of discrete abatement measures, such as ‘reforestation’ or ‘implement fuel economy standards’. The carbon value is set at the level that is consistent with the level of marginal abatement costs required to reach the targets adopted (UK Government BEIS, 2021). The curve shows an incremental increase in abatement costs as the abatement target is increased.

Although the TCMAC approach is widely used internationally by groups such as the Intergovernmental Panel on Climate Change (IPCC) and in countries such as the UK, there are no reliable or recent peer-reviewed studies on marginal abatement costs that are specific to New South Wales or Australia. Further research is needed to develop marginal abatement cost curves that are specific to the Australian and NSW economies, as well as the transport sector. These curves may be useful in refining GHG valuations for use in transport business cases.

4.2 Social Cost of Carbon (SCC)

The SCC is calculated by estimating the net present value of the impacts of climate change over the next hundred years for each additional tonne of carbon released into the atmosphere today (Stern et. al 2022). From an Economics perspective, damage costs are the best representation of SCC as they directly measure and value the impacts of climate change, providing the most accurate estimates of the monetary value of welfare impacts.

Damage costs are calculated using an impact pathway approach which relies on the use of climate-economic Integrated Assessment Models (IAMs) to assess the physical impacts of climate change. The physical impacts include melting ice caps, rising sea levels, and the increased intensity and frequency of extreme weather events. These impacts are then combined with estimates of their economic, social, or environmental impacts to determine the damage cost estimates (CE Delft 2019). The damage costs are also estimated yearly, and discounted to the base year to represent a present value.

Damages in the SCC model include:

- Sea level rises with either the cost of land lost, property damage and cost to relocate populations or the cost of coastal protection.
- Agricultural impacts from temperature and precipitation changes with costs and benefits of changing crop yields to producers and consumers.
- Increasing frequency and intensity of climate disasters (e.g., cyclones, bushfires, flooding) with costs to property, infrastructure, and loss of human life.
- Rising ozone concentrations with the cost of air pollution-related deaths and diseases.
- Ecosystem decline with society’s willingness to pay to avoid environmental losses.
- Temperature with changes in cost of energy consumption for heating and cooling, health costs from hospital admissions and mortality because of heat stress or larger dispersion of disease carried by parasites or insects, such as malaria.

However, forecasting into the next hundred years involves a high degree of uncertainty in the modelling and the physical impacts. As CE Delft pointed out, the absence and reliable short and longer-term damage cost estimates undermines the use of damage costs in valuing carbon in cost-benefit analyses (CE Delft 2019).

One key assumption of the damage cost estimation is the link between the locality of emissions and the physical impact. Table 7 demonstrates the carbon values estimated by three successive US administrations. During the Obama administration, the carbon value was estimated at US$50 per tonne. The value plunged to US$8 per tonne during Trump administration when international impacts caused by US emissions are excluded. A subsequent revision by the Biden administration estimated the carbon value at US$62 per tonne. This example demonstrates that the carbon value based on damage cost is highly sensitive to modelling assumptions.

Table 7: The estimated social cost of carbon from different assumptions

	2030	2050	Note
US Interagency Working Group (IAWG, 2007, Obama Administration	US$50	US$69	Average discount rate of 3%. The SCC for cost benefit analysis
US Interagency Working Group (IAWG, 2018, Trump Administration	US$8		Excluding international impacts caused by US emissions

US Interagency Working Group (IAWG, 2021, Biden Administration	US$62	US$85	Average discount rate of 3%. Values far lower than those needed to limit warming to well below 2°C or to reach net zero by 2050

4.3 Market price

The NSW Government Guide to Cost-Benefit Analysis (NSW Treasury 2017) outlines the following requirements for valuing the costs of carbon emissions:

- Market prices should be used as a basis for valuing the costs of carbon emissions, where reliable evidence can demonstrate that those market prices are not significantly biased as a direct consequence of scheme design.
- Where market prices are not deemed to reflect the true cost of carbon emissions, estimates of damage or damage mitigation costs (i.e., target consistent approach) may be used.

Despite the wide adoption of market price as a basis for valuing carbon in NSW cost-benefit analyses, the limitations of its use have been well documented. Hutley (2021) notes that the EU ETS only regulates a subset of emissions in Europe (40-50%), and thus may not reflect the carbon abatement costs in other sectors or those in Australia. It is reflective of short-term caps (i.e., emission targets for selected industries) and may not capture long-term target or price changes (CE Delft 2019).

4.4 The recommended approach for carbon evaluation

A review of the three common carbon valuation methodologies points to a preference for the Target Consistent Marginal Abatement Cost (TCMAC) approach. The TCMAC is not as sensitive to assumptions compared to SCC, as demonstrated in Table 7, where the revision of an assumption could lead to a substantial change in the carbon value. It is also more comprehensive compared to using a market price, which inefficiencies in the market influences the valuation.

4.5 What does carbon values mean for transport decarbonisation?

Table 8 shows a high level of variations of carbon values estimated by different jurisdictions, reflecting the uncertainty of carbon value methodologies.

Table 8: Range of carbon values used in different jurisdictions

Jurisdiction	2023	2030	2050
Australia, ATAP	$65	$65	$65
Australia NSW Treasury	$123	$144	$225
NZ	$85	$102	$164
EU	$168	$168	$452
UK	$464	$524	$719

Source: TfNSW (2022), TfNSW & WSP (2022), NSW Treasury (2023)

Carbon values discussed in this paper are for use in cost-benefit analyses to support transport decarbonisation and achieving ‘net-zero’. The question remains as to whether a higher or lower carbon value better contribute to transport decarbonisation. Some transport initiatives have an objective of carbon reduction or net zero (e.g., Net Zero Emision Buses, Electric Vehicle). A higher carbon value in cost-benefit analyses increases the monitised economic benefits, in turn, increases the Benefit Cost Ratio (BCR). If the BCR is considered in investment prioritisation, such carbon reduction projects have a higher chance of being prioritised.

The optimal treatment for embodied carbons in constructions in cost-benefit analyses remains debatable. A higher carbon value will result in a greater economic disbenefit for the 'base case' embodied carbon. Typically, vegetation loss must be offset in construction projects. If all embodied carbon must be offset, project costs will increase. However, if only the difference from the benchmarked 'base case' carbon is considered in cost-benefit analyses, environmentally friendly construction methods or low-carbon approaches may yield economic benefits. Noting the reduction of embodied carbon in investment decisions can contribute to transport decarbonisation.

5. Concluding observations

Establishing a system for determining the 'base case' carbon in transport projects and business cases can contribute to transport decarbonisation through opportunities in design, procurement, delivery, and operation. However, the concept and understanding of embodied carbon in transport construction is still at an early stage and requires further research to properly specify the 'base case' carbon scenario. Similar to operational carbon emissions, relevant components of the 'base case' should first be established, and subsequently the appropriate measurement methods, models and benchmark values. Business case developers need to understand GHG emissions from exploration, transportation, and manufacturing processes of materials and inputs to construction, including key production processes for steel, cement, concrete, diesel, and electricity. An industry-agreed benchmark carbon including values for different materials, construction approaches and transportation may form the 'base case' carbon, which can be used as a standard to evaluate low-carbon solutions, innovative procurement, alternative materials, and circular economy approaches.

Contrary to the embodied carbon 'base case', operation phase carbon is better established with defined methodologies and refined parameter values . The 'base case' can be the transport fleets (cars, trucks, trains, light rails, and ferries) with emission rates as of 2005 (or as of 2023). Most vehicles are powered by petrol or diesel. Using this more readily acceptable 'base case', emission reduction from transport initiatives, including EVs, hybrid vehicles, hydrogen trucks, demand management, active transport, and an increased public transport share, can be evaluated.

The target consistent marginal abatement cost (TCMAC) offers the most useful carbon valuation framework due to its link to carbon reduction targets and associated costs of various abatement technologies. This approach is less sensitive to assumptions of potential damages from climate changes over the next 100 years. While there are no established MAC carbon values, authors have noted a couple of working groups in Australia attempting to estimate Australian or NSW carbon values using TCMAC.

Carbon measurement and valuation in cost-benefit analysis can contribute to transport decarbonisation. However, current transport business cases do not consider embodied carbon emissions during the construction stage. Acknowledging embodied carbon will open up opportunities for increased vegetation offsetting beyond construction-related vegetation loss. TCMAC carbon values may demonstrate economic benefits of low-carbon construction and carbon reduction projects. It could significantly reduce carbon emissions if investment prioritisation included low-carbon approaches and high-carbon values.

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