Australian Government

Infrastructure Australia

July 2021

Guide to economic appraisal

Technical guide of the **Assessment Framework**

The Assessment Framework comprises an overview, stages 1 to 4 and technical guides:

- Overview
- 1 Defining problems and opportunities
- 2 Identifying and analysing options
- 3 Developing a business case
- 4 Post completion review
- **Technical guides**

Infrastructure Australia is an independent statutory body that is the key source of research and advice for governments, industry and the community on nationally significant infrastructure needs.

It leads reform on key issues including means of financing, delivering and operating infrastructure and how to better plan and utilise infrastructure networks.

Infrastructure Australia has responsibility to strategically audit Australia's nationally significant infrastructure, and develop 15-year rolling infrastructure plans that specify national and state level priorities.

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Introduction

At a glance

- Economic appraisal is the process of determining the impacts and merit of a proposal. This includes presenting relevant information for consideration by decision-makers. This guide describes various economic appraisal techniques and the circumstances in which you should apply them.
- Cost–benefit analysis (CBA, sometimes called social CBA) is the standard technique for economic appraisal. It analyses the social, economic and environmental value of proposals (that is, the change in overall societal welfare) over the life of those proposals using a common measure, the net social benefit. The analysis is 'social' in the sense that it takes into account all impacts on the welfare and wellbeing of the population.
- CBA follows a structured process to identify, measure, monetise and present all costs and benefits, as described in detail in this document. Some costs and benefits may be challenging or costly to monetise in a CBA – these impacts are still relevant for decision-makers and should be considered alongside the CBA results.
- CBA can be undertaken at different levels of rigour. For example, rapid CBA applies standard CBA principles and techniques, but focuses on quantifying the most material economic costs and benefits only. It is less intensive and most suitable as an early indicator of a proposal's impact.
- Cost-effectiveness analysis (CEA) is a partial CBA approach that compares the costs of alternative ways of producing the same or similar outputs. The aim is to achieve the outcome(s) at least cost. This approach is only appropriate in very limited circumstances
- Other supplementary analysis techniques include computable general equilibrium (CGE) models and input–output (I–O) analysis, which are usually used to estimate changes in key economic indicators at the national and specified regional levels.

1.1 How to navigate this document

This document is designed for proponents (you) developing infrastructure proposals for submission to Infrastructure Australia (us) in accordance with the Infrastructure Australia Assessment Framework (the Assessment Framework). If you are unfamiliar with the Assessment Framework, we recommend that you review our **Overview** and relevant **Stage volumes** before reviewing this document.

- **Section 1** provides an overview of economic appraisal methods and their application within the Assessment Framework.
- **Section 2** provides a summary of the approach and theoretical basis of cost–benefit analysis (CBA). It then provides detailed guidance on the key steps and considerations for applying CBA to infrastructure proposals.
- **Section 3** describes the simplifications that might be applied to the CBA approach to conduct a rapid CBA for filtering options.
- **Section 4** describes cost-effectiveness analysis (CEA), how to apply it for infrastructure proposals and the circumstances where it is appropriate to use.
- **Section 5** summarises other supplementary analysis techniques, including computable general equilibrium (CGE) models and input–output (I–O) analysis.

This document also provides a number of appendices to provide additional technical detail:

- **Appendix A** provides references to relevant jurisdictional and sector-specific CBA guidance.
- **Appendix B** describes our departures from the Australian Transport Assessment and Planning (ATAP) guidelines.
- **Appendix C** provides a detailed summary of identifying and measuring land use impacts.
- **Appendix D** provides a detailed summary of identifying and measuring wider economic benefits (WEBs).
- **Appendix E** provides guidance on residual value and the treatment of land value.
- **Appendix F** identifies specific considerations for applying CBA in the water sector.
- **Appendix G** discusses the specific challenges of CBA for proposals in remote areas. It provides guidance for identifying costs and benefits relevant to proposals in remote areas for the transport, energy, water, telecommunications, social housing and health sectors.

Box 1: **Key terms**

Business case: a document that brings together the results of all the assessments of an infrastructure proposal. It is the formal means of presenting information about a proposal to aid decision-making. It includes all information needed to support a decision to proceed, or not, with the proposal and to secure necessary approvals from the relevant government agency. Unless otherwise defined, we are referring to a final or detailed business case, rather than an early (for example, strategic or preliminary) business case, which is developed in accordance with state or territory requirements. A business case is prepared as part of Stage 3 of the Assessment Framework.

Option: a possible solution to address identified problems and opportunities. A wide range of options should be considered and analysed to determine the preferred option, which will be recommended in the business case.

Program: a proposal involving a package of projects that are clearly interlinked by a common nationally significant problem or opportunity. The package presents a robust and holistic approach to prioritise and address the projects, and there is a material opportunity to collaborate and share lessons across states, territories or agencies. The projects can be delivered in a coordinated manner to obtain benefits that may not be achieved by delivering the interventions individually.

Project: an infrastructure intervention. A project will move through the stages of project initiation, planning, delivery and completion. A suite of related projects to address a common problem or opportunity will create a program.

Proponent: an organisation or individual who prepares and submits infrastructure proposals to us for assessment. To be a proponent of a business case (a Stage 3 submission), the organisation must be capable of delivering that proposal.

Proposal: the general term we use for successful submissions to the *Infrastructure Priority List*, across the key stages of project development, specifically – early-stage (Stage 1), potential investment options (Stage 2) and investment-ready proposals (Stage 3). Proposals that have been delivered would be assessed in Stage 4.

1.2 Purpose of this technical guide

A fundamental part of the infrastructure decision-making process is economic appraisal. There are a number of different methods of analysing proposals which differ in their robustness and information requirements.

We require the use of CBA as it includes cost and benefit measures to estimate the impacts for the Australian community. This responds to our legislative requirement to consider infrastructure that materially improves national productivity.

CBA is preferred as it is the most robust technique for appraisal, allowing the social, economic and environmental merits of a proposal to be identified, measured, valued and compared. The use of CBA for the analysis of infrastructure investments is supported by international agencies. Other appraisal techniques may be relevant at different stages of the assessment process or be used to provide supplementary information, but are rarely effective substitutes for CBA.

The economic appraisal techniques described in this document are:

- **Cost–benefit analysis (CBA) – CBA (sometimes called social CBA) is the standard technique for economic appraisal.** It analyses the social, economic and environmental value of proposals (that is, the change in overall societal welfare) over the life of those proposals using a common measure, the net social benefit. **The analysis is social in the sense that is takes into account all impacts on the welfare and wellbeing of society.** It is a key input to decision-making, as it compares the economic welfare implications of different proposals to society as a whole in a common monetary measure. Detailed guidance is provided in **Section 2**.
  - **Rapid CBA** – Rapid CBA applies standard CBA principles and techniques, but focuses on quantifying the most material economic costs and benefits only, and has a lower level of precision about design, costs and benefits. Rapid CBA is less intensive and most suitable as an early indicator of the impact of a proposal. In the context of the Assessment Framework, we recommend it is used in Stage 2 to provide a preliminary analysis of options. Rapid CBA provides greater objectivity and rigour compared to tools such as multi-criteria analysis. Guidance is provided in **Section 3**.
- **Cost-effectiveness analysis (CEA)** – CEA is a partial CBA approach that compares the costs of alternative ways of producing the same or similar outputs. The aim is to achieve these outcome(s) at least cost. CEA is used to compare the costs of different options where outcomes are taken as given or considered very similar across options, in the limited cases that CBA is not appropriate. Guidance is provided in **Section 4**.

Other supplementary analysis techniques are described in **Section 5**, including the use of:

- **Computable general equilibrium (CGE) models** – CGE models are an economic analysis tool with an economy-wide focus that estimates changes in key economic indicators at the regional, state and national level, for individual industries, as a result of external changes or policy changes. Key indicators that CGE can estimate include impacts on gross domestic product (GDP), household income and consumption, investment, exports, employment and industry outputs.
- **Input–output (I–O) analysis** – I–O analysis is a macroeconomic analysis tool to measure the impact on economic activity of a policy or economic change, including the flow on effects throughout the economy.

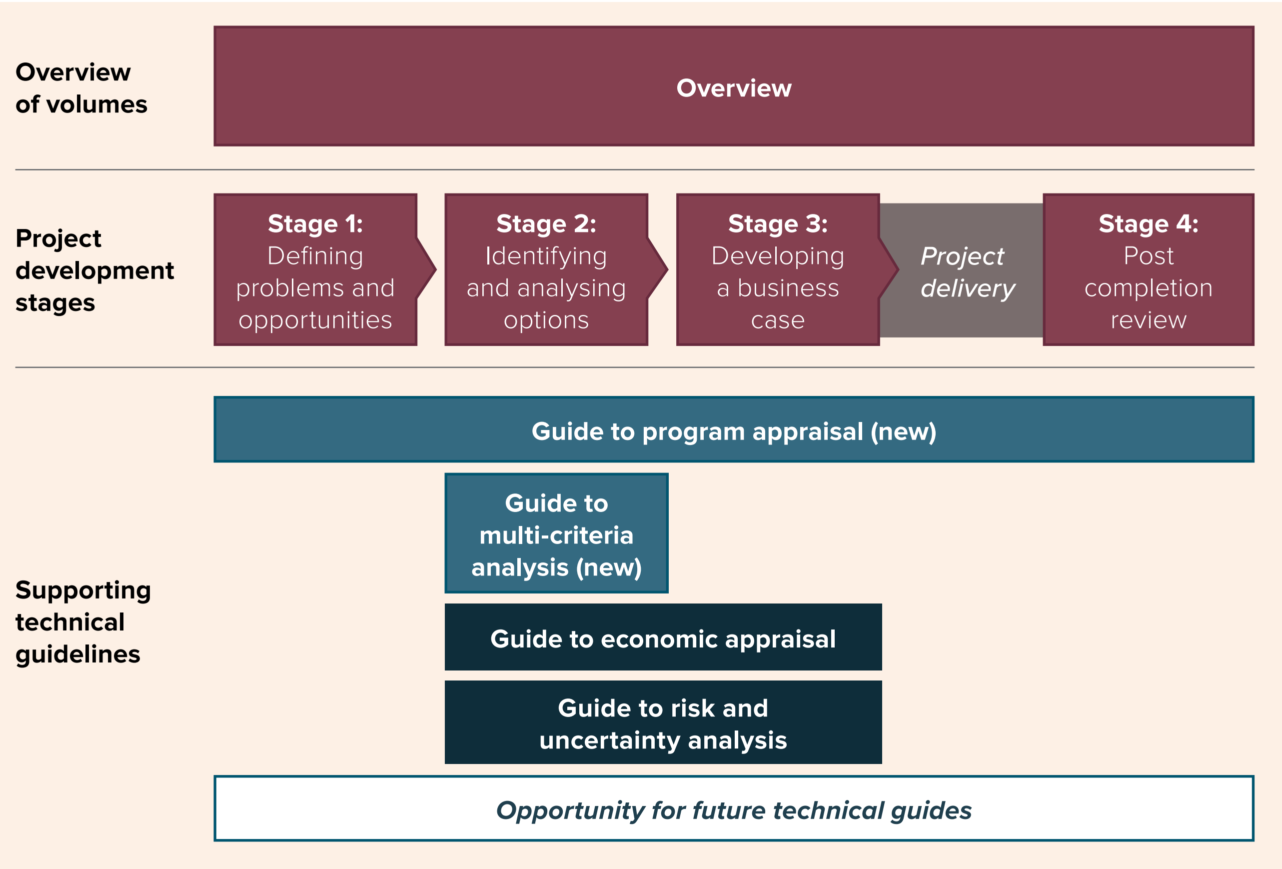
1.3 Structure of the Assessment Framework

The Assessment Framework consists of a series of volumes and technical guides. Together, they describe the activities in a typical project development and review process, and how we assess proposals that are submitted to us.

For practicality and ease of use, each submission stage is described in a separate document and supported by the technical guides. This allows you to focus on the guidance most relevant to you and the stage you are up to in project development.

The structure of the Assessment Framework is shown in **Figure 1**. The suite of Assessment Framework documents is available at **www.infrastructureaustralia.gov.au/publications/assessment-framework**.

Figure 1: Structure of the Assessment Framework



2

Cost–benefit analysis methodology


FOUR POINTS
BY SHERATON

2.1 Overview of cost–benefit analysis

CBA is a quantitative technique to assist decision-making for public policy development and investment proposals, and the most robust tool for economic appraisal. It measures the implications of interventions for the welfare and wellbeing of communities by analysing the social, economic and environmental impacts over their operational life.

CBA seeks to systematically measure the effects of a proposal over time from the perspective of the relevant community. Effects, often referred to as impacts, can be positive (a benefit) or negative (a cost). The output is expressed in terms of net benefit. For Infrastructure Australia's purposes, this is the Australian community. Costs and benefits are typically expressed in dollars for comparison.

The CBA process requires:[1]

- Systematically cataloguing project impacts as costs and benefits.
- Valuing these costs and benefits in dollar terms, which is used to determine their relative importance. It considers a benefit as any gain in societal wellbeing, and a cost as any loss in wellbeing. CBA assumes that individual human preferences form the basis for rational economic decisions, using willingness to pay and willingness to accept as measures of human preference that are used to value changes in societal wellbeing.
- Considering all costs and benefits that accrue to society as a whole. That is, it considers social costs and social benefits to the community, rather than costs and benefits that accrue to an individual entity or firm undertaking a project. For this reason, CBA is also called social CBA.
- Determining if there are net benefits (that is, benefits greater than costs) for the proposal compared to the base case (see **Section 2.3**). If benefits are greater than costs, then the project is potentially worthwhile. There may be other better proposals, so proposals may need to be ranked, particularly if there is an overall budget constraint or implementing one proposal will rule out another.

Some costs and benefits may be challenging or costly to monetise in a CBA – these impacts are still relevant for decision-makers and should be considered alongside the CBA results. Our holistic approach to assessment is described in detail in the Overview and Stage 3 volumes of the Assessment Framework.

Figure 2 shows the key steps of a CBA process to identify the net social benefit of investment proposals. The following sections discuss each of the steps in detail.

CBA can be undertaken at different levels of rigour. For example, 'rapid CBA' is often used to support a Stage 2 submission (sometimes referred to as a preliminary or strategic business case in state and territory frameworks), while a 'detailed CBA' is applied for a business case for a Stage 3 submission. CBA is described in detail in this section and common simplifications applied in a rapid CBA are described in **Section 3**. Additionally, CBA is flexible in its application to different types of interventions, including policy and regulation changes, infrastructure projects and programs.

The CBA methodology involves a number of key assumptions and parameters, including the real social discount rate and the appraisal period (see **Section 2.4**). In reviewing submissions made to us, we carefully assess methodologies and assumptions to ensure that costs and benefits have been appropriately considered and measured.

Guidance on other areas such as cost-estimation methods, land use impacts and wider economic benefits is provided in appendices to this guide.

1. Boardman, et al 2018, *Cost–Benefit Analysis: Concepts and Practice*, 5th edn. Cambridge University Press, NJ, p. 1–2.

Figure 2: Key steps in a CBA and where these are relevant to the Assessment Framework

CBA steps	Assessment Framework stages
Step 1: Articulate the problems and opportunities being addressed	**Stage 1**
Step 2: Identify the base case and project case options	**Stage 2**
Step 3: Identify costs and benefits and how they are measured	**Stage 2 –** Preliminary analysis (rapid CBA) **Stage 3 –** Detailed analysis (detailed CBA)
Step 4: Forecast demand and impacts over the life of the investment	
Step 5: Monetise the costs and benefits	
Step 6: Identify non-monetised impacts	
Step 7: Discount costs and benefits to determine the net benefit	
Step 8: Analyse risks and test sensitivities	
Step 9: Report on CBA results	

Theoretical basis of cost–benefit analysis

An economic appraisal seeks to determine the net benefits from a project for the Australian community as a whole, relative to the base case. CBA does this by calculating the net benefit of a project, which is the total incremental project benefits less the total incremental project costs.

Australian governments at various levels provide guidelines on CBA (for example, NSW Treasury 2017,[2] Victorian Department of Treasury and Finance 2013,[3] Queensland Government 2020[4]). **Appendix A** provides a list of relevant state, territory and sector-specific guidance.

The Australian Transport Assessment and Planning (ATAP) guidelines[5] outline best practice for transport planning and assessment in Australia. They also provide detailed guidance on the theoretical underpinnings of CBA, including technical guidance, graphs and equations.

Economic appraisals seek to measure the opportunity cost of addressing an economic problem or realising an opportunity. Therefore, economic appraisals use resource costs, which is the opportunity cost of resources used, measured from the point of society as a whole. They do not include taxes and subsidies, which are financial transfers[6] between individuals in an economy, and do not lead to an increase in net economic benefits.

CBA is different from a financial analysis, which measures financial costs and benefits from a producer's perspective. CBA also considers non-financial costs and benefits and undertakes the appraisal from an overall community perspective. See the **Stage 3** volume for more guidance on financial analysis.

In economics, net benefits to society are described as the change in social surplus. This is made up of changes resulting from the project:

- the **change in consumer surplus** – the net cost or benefit to consumers (or the users)
- the **change in producer surplus** – the net cost or benefit to producers, being service providers or operators (including government entities where they provide a good or service)
- the **change in externalities** – the net impact on third parties that are impacted by the investment without being direct participants. This could include governments, communities or businesses.

Mathematically, net benefits is expressed as follows:

ΔSocial surplus (net benefits to society) = *ΔConsumer Surplus* + *ΔProducer Surplus* + *ΔExternalities*

Understanding the component parts of net benefits to society is important because it identifies the beneficiaries and stakeholders of the project and thus enables quantification of the costs and benefits in an economic appraisal.

2. NSW Treasury 2017, *Policy and Guidelines Paper: NSW Government Guide to Cost–Benefit Analysis*, NSW Government, Sydney, available at: arp.nsw.gov.au/tpp17-03-nsw-government-guide-cost-benefit-analysis
3. Department of Treasury and Finance 2013, *Economic Evaluation for Business Cases Technical guidelines*, Victorian Government, Melbourne, available at: www.dtf.vic.gov.au/sites/default/files/2018-03/Economic%20Evaluation%20-%20Technical%20Guide.doc
4. Queensland Government 2020, *Business Case Development Framework – Cost Benefit Analysis Guide*, Queensland Government, Brisbane, viewed 17 December 2020, www.statedevelopment.qld.gov.au/industry/infrastructure
5. Transport and Infrastructure Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, p. 19, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.
6. Financial transfer payments between various individuals/firms are not included in the economic CBA because they do not result in a net change in welfare. It is purely a financial gain or loss, without a change in economic efficiency. They result in a change in the distribution of benefits or costs without changing the overall net benefits. Most taxes, fares and tolls are transfer payments from consumers to government or infrastructure owners/operators, while subsidies are often transfer payments from government to consumers.

2.2 Step 1: Articulate the problems and opportunities being addressed

Our process for identifying and understanding problems and opportunities is detailed in the **Stage 1** volume of the Assessment Framework.

To develop your proposal, it is important that you gain a comprehensive and evidence-based understanding of identified problems and opportunities and their root causes. If you have a partial or incomplete understanding, it is more likely that you will recommend a proposal that does not adequately address the issues that you are trying to solve.

At this stage, you should think about the nature and scale of the problems and opportunities and how they can be monetised. This will inform the anticipated impacts of the proposal, and the baseline and forecast information you will require to quantify and monetise them in later steps of the CBA process.

Identifying the problems and opportunities is an important first step for the CBA. It provides a sound basis for identifying and analysing options that could respond to these needs and focuses the CBA on the costs and benefits most relevant to addressing them. For this reason, the CBA should be considered from the start of project development, rather than being viewed as an isolated calculation that happens towards the end. For example, decisions about how investment impacts will be modelled are likely to critically enable or constrain the scope and quality of the CBA, while the effectiveness of options at addressing the problems and opportunities, as determined by CBA, is a key determinant of the option merit.

When determining the scope of your CBA, it is also important to decide whose costs and benefits count. For Infrastructure Australia's purposes, this is the Australian community, rather than measuring any international impacts or specific local, state or territory impacts that do not take the aggregate national impact into account.

2.3 Step 2: Identify the base case and project case options

Project appraisals compare the costs with the benefits (and disbenefits) of doing something, the project case, with not doing it, the base case or 'counterfactual':

- The **base case** is a real world scenario of what is expected to occur in the absence of the project case. It is required to measure what will happen without an intervention.
- The **project case** describes the 'do something' options that reflect proposed interventions, such as discrete capital investments, aimed at addressing the identified problems and opportunities.

These are explained in further detail in the following sections.

Our recommended process for identifying options is detailed in the **Stage 2** volume of the Assessment Framework.

Defining the base case

A well-established base case provides a fundamental foundation for analysing the relative merits of prospective project options. An incorrectly specified base case can bias the analysis of different options by overstating the benefits and understating the costs. Alternatively, it could underestimate the future impact of the existing problem and understate potential project benefits. As an example, underestimating population growth will typically underestimate the benefits of a project that increases capacity.

The base case should represent a 'do-minimum' situation,[7] reflecting the continued operation of the network or service under good management practices (the 'business as usual' or 'keep safe and operational' situation). Importantly, the 'do-minimum' case is not the same as a 'do-nothing' case, as it should include relevant minor improvements to the infrastructure network or services that can reasonably be expected to occur in the absence of the project case. This will require careful consideration in rapidly developing areas or where significant investment is planned.

7. Every Commonwealth, state and territory guidance document recommends a 'do-minimum' base case.

A 'do-minimum' base case assumes that general operating, routine and periodic maintenance costs will continue to occur, plus a minimum level of capital expenditure to maintain services at or near their current level without significant deterioration (for example, maintaining access or service quality). This may include asset renewals and replacement of life-ending components on a like-for-like basis, as well as committed and funded projects and smaller scale changes required to sustain viable operations under the base case.

Base case in practice

In practice, the base case represents expenditure, generally of a non-capital nature, to ensure that existing assets or networks can continue operating to satisfy current requirements into the future. This should not include asset augmentation or enhancement (such as an additional traffic lane) to meet incremental demand beyond the capacity of the existing infrastructure, although in some cases the inclusion of asset replacement may result in minor capital expenditure.

In some circumstances, where a high level of future growth is expected, minor network improvements may need to be assumed to obtain realistic future demand estimates within the technical limitations of forecasting models and to meet the requirement to keep the current situation safe and operational. On the occasions where this is the case, the incremental capacity assumptions should be discussed with us to understand their likely impact on the project. These incremental capacity assumptions should exclude enhancements that may form alternatives to or be dependent on the project case options over their lifespan. Any such incremental capacity assumptions should be treated as separate project case options.

We acknowledge that a do-minimum base case can be defined in two different ways:

- The **committed and funded expenditure** approach – which only includes those projects that are committed to by governments and fully funded.
- The **planning reference case** approach – which includes all projects that are outlined in strategic planning documents, such as transport and land-use strategies, even if they have not been committed to and fully funded.

Table 1 shows the typical components included in a 'do-nothing' and a 'do-minimum' base case.

We prefer and recommend the committed and funded expenditure approach but recognises that some jurisdictions use the planning reference case approach. While we will consider the planning reference case approach, the base case should not include investment which is either complementary to or a major substitute for the project being analysed. Including these projects can artificially overstate or understate project benefits respectively.

Where the planning reference case is being used, you should engage with us to:

- Demonstrate the inclusion of non-committed projects in relevant strategic plans or the forward budget forecast.
- Explain how the non-committed projects are neither a substitute nor a complement to the project being considered.
- Consider if additional sensitivity tests are required in which the projects that have not been committed or have not been funded are removed.

Where the planning reference case has been adopted, we will review and consider whether substitute/complementary projects have been appropriately treated. If necessary, we will discuss the implications for the economic appraisal with you to agree how our assessment is finalised.

Box 2 draws together our key guidance for specifying the base case.

Table 1: Scope of the base case under different definitions

Scope	Do-Nothing	Do-Minimum	
		Committed and funded	Planning reference case
Existing network	✔	✔	✔
Routine maintenance	✔	✔	✔
Periodic maintenance	✔	✔	✔
Asset renewal	✖	✔	✔
Essential safety works to keep safe and operational	✖	✔	✔
Minor network improvements to maintain services at their current level	✖	✔	✔
Committed & funded projects[8]	✔	✔	✔
Committed but not funded projects	✖	✖	✔
Projects outlined in long-term planning documents	✖	✖	✔

8. Funded projects should be supported by listing in jurisdictional budget forward estimates.

Box 2: **Specifying the base case**

A proposal submitted to us should specify for the base case:

- **The service(s) being delivered** in the target region/area/jurisdiction, including identifying the users, demand, providers, service levels and pricing – currently and in the future over the appraisal period.
- **Current and future expected maintenance and capital works**, capturing all assets/services in the network that may impact the target region/area/jurisdiction.
  - The likelihood of future capital works should be considered: you should provide specific details on the characteristics of future projects and the rationale explaining their inclusion or exclusion from the base case. This is particularly important if the proposed project forms part of a larger network, where the benefits of a project may be contingent on other projects being implemented.
  - Anticipated costs, such as renewal cost at the end of an asset's life, replacement of components of the main asset and periodic maintenance costs that occur over time.
- **Current and future expected demand**, capturing the number of users and utilisation of the assets or services over the appraisal period.
- **Other future developments that will affect the service demand and quality**, such as one-off events (for example, Olympic Games) and exogenous land use changes (for example, relocation of demand generators).
  - Similar to future capital works, you should consider the likelihood of these developments occurring and provide evidence to support the determined likelihood. This should include details on the development's characteristics, in particular, the expected impact of developments on the existing infrastructure network and rationale explaining the inclusion or exclusion from the base case.
- **The main constraint or issue presented by the base case** (for example, lack of capacity, reliability issues). The base case should describe and measure the costs of the problems that arise with the 'do-minimum' option, such as costs of congestion or poor reliability of services.
- **Whether assumptions have been independently verified or independently generated** (for example, in the communications sector – from submissions to the Australian Competition and Consumer Commission, the Australian Communications and Media Authority, other government agencies, industry bodies or national/international benchmarks).
- **The key planning documents that inform the base case**, these are likely to include state infrastructure strategies, strategic land use plans and relevant sector plans.

Defining the project case options

You should describe each option shortlisted for detailed appraisal including:

- option description and scope
- infrastructure and non-infrastructure changes or enablers
- **information specifying the incremental effects of each option, as per the requirements for the base case in Box 2.**

Following the CBA and other relevant analysis of the proposal, you should define:

- estimated lifecycle costs, including:
  - investment cost – costs to construct the scope of each option
  - annual operating and maintenance costs
  - periodic and life-expiring component renewal costs
- expected impacts, including:
  - monetised benefits (and disbenefits)
  - non-monetised quantitative and qualitative impacts
  - residual value
- consideration of risks and uncertainties
- other information supporting the Assessment Criteria (see **Glossary**), such as sustainability assessments, environmental impact assessments, feasibility studies
- anticipated funding model/s
- other assessments, such as distributional effects, sensitivity, scenario and real options analyses, if available
- interdependencies with other problems and opportunities and/or programs and projects
- indicative deliverability considerations (risks, schedule, model etc.).

In addition, you should provide any supporting information about each project case that is relevant to the appraisal, such as engineering designs, demand forecasts, land use forecasts and relevant assumptions.

The options are compared against the base case to determine the incremental results for the options. In other words, this measures the economic merit of each option over and above the base case.

In the context of the Assessment Framework, **we recommend that at least two options are considered for detailed appraisal as part of a business case**, in addition to the base case. For further detail, please see **Box 10** in the **Stage 2** volume.

2.4 Step 3: Identify costs and benefits and how they are measured

After specifying the base case and project case options, the next step of a CBA is to identify the costs and benefits of the project options compared to the base case and document the CBA method.

In this section, we describe how to set up the CBA and the costs and benefits that should be included in the analysis.

CBA should consider all costs and benefits in real prices, rather than nominal prices. A nominal price is a value or price at a given time. Nominal prices rise with inflation. In contrast, real prices are prices after the effect of inflation has been removed – that is, they must exclude the general escalation of prices, but include real escalation of prices (for example, real escalation of wages). Real prices must be stated for a specific base year, for example '2021 prices'.

Setting up the cost–benefit analysis

It is important to plan and define your approach to the CBA at the outset of the investigation to confirm your approach and to enable us to understand your methodology. You should define and document your approach to the CBA so that an assurance reviewer is able to understand and provide feedback on the proposed approach.

A 'CBA approach document' is a useful way to defining and documenting the CBA methodology. This document can also form the early chapters of the CBA report (which is a recommended supplement to the business case), by adding the CBA results once it is completed. This document should apply relevant technical guidance, any relevant state, territory or sector-specific guidance, and include:

- the scope and characteristics of the base case and project case options (see **Section 2.3**)
- the overall appraisal assumptions, including the discount rate, appraisal period and base year used for the analysis (typically all costs and benefits are represented in current year prices)
- the method for quantifying and monetising the costs and benefits:
  - the inputs describing project costs and impacts (for example, transport model outputs on changes in journey times)
  - the quantification and monetary valuation parameters used to monetise the benefits and the methods used to estimate capital and operating costs across the appraisal period
  - how monetised cost and benefit estimates are used to populate cost and benefit streams that cover the appraisal period. This involves expanding benefit estimates that are made for a part of a year to annual values, then interpolating and/or extrapolating these values across the entire appraisal period. It also involves determining cash flows for the investment and operating costs compared to the base case
  - how the key CBA results (for example, measures using discounted costs and benefits) will be calculated and presented.

Appraisal methodologies and parameters

When developing a proposal, you should make use of available best practice methodologies and standard parameter values, including relevant Commonwealth, state and sector-specific guidelines. Relevant jurisdictional and sector-specific guidance is referenced in **Appendix A**.

For transport appraisals, we recommend the ATAP guidelines[9] as the default guidance for almost all aspects of the appraisal process. However, in some cases, our approach differs from the ATAP Guidelines, as detailed in **Appendix B**.

Appraisal methodology techniques are subject to constant development, both in Australia and worldwide, reflecting a welcome emphasis on improving the understanding of all costs and benefits of a proposal. However, it is important to achieve an appropriate balance between the desire to be as comprehensive as possible and maintaining the methodological rigour of the appraisal process.

We will consider additional benefits and costs arising from emerging methodological developments (for example, wider economic benefits) separate to the traditional and widely accepted CBA, and treat each case on its merits. The results should be presented separately in the submissions made to us.

9. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au.

Discount Rate

Discounting translates future costs and benefits to a common time unit, to compare costs and benefits that accrue at different times. It is usual to undertake the CBA in real terms (that is, excluding inflation). Therefore, you should use a real discount rate to discount real cash flows in the CBA.

Discounting also allows the appropriate comparison of costs and benefits over different timescales between different options and projects. For assessment purposes and comparability, we recommend that you present appraisal summary results for the following real discount rates:

- 4% per annum
- 7% per annum (for the central case)
- 10% per annum.

This aligns with the majority of current national, state and territory guidelines on CBA in Australia. In cases where a different real discount rate is used in an appraisal, the basis for doing so should be specified. You should contact us for specific advice in these cases.

Any change to the central discount rate (and sensitivities) would need to be determined and agreed with national and state/territory treasury departments. We welcome engagement with treasury departments and will consider a change to the discount rates used in the Assessment Framework upon a consistent change across the jurisdictions.

To increase transparency, our project evaluations present the economic appraisal results using all three discount rates to show the range of analysis.

Appraisal period

The length of the appraisal period determines the period of time over which to discount the lifetime costs and benefits of a proposed project. Therefore, it is important for you to use an appraisal period that matches the costs and benefits generated by the proposal to achieve the most robust CBA result.

The appraisal period should be based on the expected economic or design life of the asset created by the project, with the construction period added. It is assumed that the expected life of the asset is generally equivalent to the operating phase of the asset, which is measured from the first year in which the benefits of the project accrue. This recommendation is consistent with the recommendations made in 2020 ATAP guide *T2 Cost–Benefit Analysis*.[10]

You must provide justification and evidence for the proposed appraisal period, and resulting cost and benefit streams. This includes, but is not limited to:

- undertaking longer-term modelling of the infrastructure network implications of the project, rather than simply extrapolating benefits over long intervals of the overall appraisal period
- understanding the sensitivity of project benefits to demand changes, as forecasting over long time horizons will become increasingly uncertain
- considering the costs of the project over the entire appraisal period, such as capital replacement and periodic maintenance costs within the period.

ATAP provides some guidance on the typical economic lives of some infrastructure assets:

- 30 years for road infrastructure projects
- 50 years for rail infrastructure projects.[10]

Further, the Commissioner of Taxation has made a determination on the effective life of certain depreciating assets applicable for section 40–100 of the *Income Tax Assessment Act 1997*.[11]

Because of the uncertainty of demand modelling over longer time horizons, many jurisdictions suggest 30-year appraisal periods and include a residual value (see **Appendix E**) for longer lived assets.

Table 2 summarises relevant state and territory guidance on appraisal periods.

In estimating the net benefits over a long time horizon, you should examine the suitability of your existing demand models and pursue improvements to their modelling capabilities.

10. Transport and Infrastructure Senior Officials' Committee 2020, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, p 19, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.
11. Australian Taxation Office 2016, *TR 2020/3 - Income tax: effective life of depreciating assets (applicable from 1 July 2020)*, Australian Taxation Office, Canberra, available at: www.ato.gov.au/law/view/document?docid=TXR/TR20203/NAT/ATO/00001

Table 2: Guidance on appraisal period by jurisdictions

Jurisdiction	Guidance	Notes
National (ATAP)	• Expected life of the asset created by the initiative in its intended use, plus the construction period. For example: – 30-year life for road initiatives (except bridges) – 50-year life for rail initiatives – 10 years for Intelligent transport system (ITS) initiatives.	• When comparing options with different asset lives for a particular initiative, make adjustments to ensure a valid comparison. There are two ways to do this: 1. Find a common multiple of the lives (for example, if the appraisal period is 30-years for a road initiative but some of the assets like bridges will have a longer life, you may then take the residual value of the remaining economic life of the longer life assets at 30 years). 2. Convert the net present value to an annuity over the initiative's life.
Queensland	• Life of the project, but the measurement of project impacts which are longer than 30 years is generally not recommended due to uncertainty in the forecast.	• Calculate residual value for extremely long-lived assets.
New South Wales	• For major new capital expenditure, NSW recommends a practical asset life of 20–30 years.	• Calculate residual value for longer-lived assets. • Proposals to adopt longer analysis periods beyond the recommended 20–30 years should be discussed with Treasury, having regard to the plausibility of data and assumptions over long time periods.
Victoria	• Projects should generally be analysed over their full lifecycle. However, it is acknowledged that appraisal may be difficult for infrastructure projects (or alternative options) with a long lifecycle. • Accordingly, agencies may wish to limit the appraisal to a shorter period, such as to 30 years, by including any estimated residual value at the end of the appraisal period (which reflects any further unmodelled values).	• When the economic life of an asset (or alternative option) exceeds the appraisal period of the project, the residual value can be counted as an inflow of benefits (or costs) in the last year.

Sources: Transport and Infrastructure Senior Officials' Committee 2020, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, p 19, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index. Transport and Main Roads 2011, *Cost-benefit analysis manual, Queensland Government*, 1st edn., p. 2.16, available at: **www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Cost-Benefit-Analysis-Manual.aspx**. NSW Treasury 2017, *NSW Government guide to cost–benefit analysis, NSW Government*, p. 55, available at: arp.nsw.gov.au/tpp17-03-nsw-government-guide-cost-benefit-analysis, Department of Treasury and Finance 2013, *Economic evaluation for business cases technical guidelines, Victorian Government*, pp. 26–27, available at: www.dtf.vic.gov.au/sites/default/files/2018-03/Economic%20Evaluation%20-%20Technical%20Guide.doc.

Peer review of the CBA and key inputs

The CBA and relevant inputs involve specialist analysis and inherent uncertainty. **We strongly recommend you conduct independent peer reviews on the CBA, as well as key inputs including both the demand forecasts and the cost estimates**. This provides confidence that the conclusions of the analysis are robust.

Types of costs and benefits

As far as practicable, all costs and benefits arising from a project should be identified, quantified and monetised in the CBA for the business case. You should adopt a 'whole-of-life' approach in estimating costs and benefits.

Infrastructure interventions create value by providing a service, that is, through the use of the asset. Therefore, expected benefits from a project should focus on the direct impacts of the use of the asset (including private benefits and external benefits), rather than on wider benefits that may be less strongly linked to the project.

Monetised costs and benefits form the basis of CBA used for infrastructure appraisal. Practices for monetising costs and benefits should adhere to relevant jurisdictional and sector-specific guidelines. However, based on their merit we will also consider:

- Monetised costs and benefits arising from methodological developments, including land use impacts (see **Appendix C**) and wider economic benefits (see **Appendix D**). **These should be presented separately from the conventional CBA results (that is, 'below the line')**.
- Non-monetised costs and benefits where impacts cannot be robustly expressed in monetary units, or it is difficult to do so. These may include quality-of-life, environmental, sustainability and resilience outcomes, including equity and distributional impacts. **These should be presented alongside the CBA outputs and supported by quantitative or qualitative evidence.** These impacts are considered in detail in **Step 6** (see **Section 2.7**).

Table 3 describes our suggested categorisation of costs and benefits for a typical infrastructure project over its economic lifetime. You do not have to follow this categorisation, although this should help capture all of the costs and benefits in the business case, and hence avoid a potential understatement of the net benefits.

In addition to the costs and benefits outlined in **Table 3**, we will consider any other benefits set out in business cases. Submissions to us should contain compelling evidence supporting these benefits, as well as clearly setting out the assumptions and methods used to calculate and monetise them.

Table 3: Suggested categories of costs and benefits

Category	Cost/benefit[(a)]	Description
Private costs (offset to producer surplus)	Initial project capital costs	Upfront capital costs.[(b)] Avoided capital costs (see item below) should be reported separately and not netted off in the total capital costs. Capital costs should include all costs that are involved with delivering the project, including disruption costs, where appropriate, which are costs incurred by other agencies and by users during infrastructure construction (see **Box 3**).
	Project operating and maintenance costs	Operating expenditure and maintenance costs.
	Capital replacement costs	Costs for capital replacement/asset renewals, such as for smart motorway systems and technology components.
	Decommissioning and rehabilitation costs	Decommissioning existing assets and services; rehabilitation of contaminated environment.
	Costs incurred indirectly by the project, such as by other government agencies	Investment required by other agencies due to wider infrastructure/service impacts of the project. These should be included where they are necessary to achieve the project benefits. For example, the redevelopment of a major hospital requires significant changes to existing traffic routes, public transport services, new access routes, pedestrian access and local parking. If these are essential for realising the project benefits then they should be attributed to the project.

Table 3: *Continued*

Category	Cost/benefit[(a)]	Description
Private benefits (producer surplus)	Increased operating revenue	The economic value from changes in revenue to the owner or operator (e.g. passenger farebox revenue). Put simply, operating revenue less capital and operating costs equates to producer surplus.
	Increased ancillary revenue	The increase in revenue from other activities, e.g. airport or station retail concessions, advertising revenue, car parking revenue.
	Avoided capital costs[(3)]	Avoided capital investment costs (e.g. avoided rolling stock acquisition costs). This is an incremental approach, the avoided capital costs or savings may arise from differences between capital costs required in the base case, without the project proceeding, and the project case.
	Avoided operating costs[(c)]	Reduced expenditure, for example, savings in operating, maintenance, compliance and investment costs. This is also an incremental approach to the base case.
	Residual value of assets	The measurement of residual values or terminal asset values is a proxy for future user benefits generated by the asset beyond the appraisal period. In practice, it is measured as the residual value of assets at the end of the appraisal period, when the asset's economic life is greater than the appraisal period. For additional guidance on the residual value of assets, including on determining the residual value of land, see **Appendix E**.

Table 3: *Continued*

Category	Cost/benefit[a]	Description
Private benefits (consumer surplus)	Improved accessibility	Reduced accessibility costs in accessing facilities such as hospitals and educational institutions, or services such as improved water supply. It could also include improved accessibility to transport for passengers with disabilities.
	Improved quality of service	The economic value of a change in service quality (e.g. the economic value of reduced scheduled journey time and/or reduced vehicle operating costs.)
	Changes in the cost of services	Changes in the price of services for consumers, such as changes in tolls.
	Changes in service reliability	The economic value of improvements in service reliability (e.g. fewer drop-outs for telecommunications, or fewer disruptions for electricity networks).
	Improvement in journey experience	The economic value of greater amenity, comfort or improved information from higher specification of services (e.g. the impacts of improved rolling stock and stations, and lower levels of crowding).
	Changes in safety and security	The economic value arising from a reduction in the number of accidents, deaths and security incidents. This may also include improved actual or perceived personal security from installation of security systems like CCTV and lighting.
	Changes in health outcomes	Projects may also improve health outcomes by encouraging additional physical activity (e.g. active transport) or by mitigating the health impacts associated with high temperatures.
	Changes in resilience	Benefits derived from improved resilience to adverse events (e.g. the value of reducing the frequency, severity or recovery of flooding events).

Table 3: *Continued*

Category	Cost/benefit[a]	Description
External benefits (and disbenefits)	Environmental externalities	Description of any significant positive or negative environmental externalities of the project. This may include air quality, carbon emissions, water pollution, noise and vibration, biodiversity and climate adaptation issues.
	Network externalities of the project (e.g. network resilience)	Changes in user behaviour may have implications for the broader infrastructure network and infrastructure users not directly affected by the project (e.g. congestion and health and safety network externalities arising from a project). It may also have implications for third parties (e.g. improved health outcomes would reduce government expenditure on healthcare).
	Land use impacts	Costs and benefits derived from land use changes due to the project (see **Appendix C**). This may include higher or lower value of land use and public infrastructure cost changes, impacts on wider economic benefits, as well as second round impacts on transport costs and benefits and public health costs.
	Health and safety externalities	Third parties may enjoy health and safety benefits or suffer from disbenefits from infrastructure projects. For example, residents may suffer from health problems from local air pollution.
	Social impacts	Description of any significant positive or negative social impacts of the project. This may include considerations of the wider groups/individuals impacted as a result of the initiative (local community, infrastructure users only, new or existing customers) and any other relevant social impacts.
	Other external impacts	Include and justify other external costs and benefits, such as construction disruption costs during project delivery (see **Box 3**). Relevant assumptions and supporting data should be provided.

Notes:

(a) Resource cost corrections sometimes have to be made because perceived costs and resource costs are not the same. For example, the resource cost of fuel is different to the perceived costs of fuel. The resource costs of fuel do not include all the taxes. To make a resource cost correction, costs are often subtracted from consumer surplus based on the perceived cost of consuming a good or service. However, in some circumstances the resource cost correction can be a positive adjustment. For more information on resource cost corrections, please see chapters 6 and 7 of ATAP *T2 Cost–benefit analysis*[12].

(b) Note that, in the case of land, the capital costs should include the opportunity cost of the land used, even where this is currently owned by government.

(c) While avoided costs could be counted as a cost offset (i.e. it is used to net off gross costs), it is acceptable and conventional to count avoided costs as a benefit to the producer or the community. It may also be necessary to offset the avoided benefits, where applicable.

12. Infrastructure and Transport Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.

Box 3: **Disruption costs**

Disruption costs are costs imposed on producers, users or the community during infrastructure construction. Examples of disruption costs include higher travel times associated with a reduction in road capacity, replacement public transport services, property and business impacts, noise and environmental impacts.

The ATAP CBA guidelines identify the need to include construction externalities in assessment, which are costs imposed on others during construction, such as disruption to traffic, severance, noise and dust.[13]

These may be important impacts of the proposal, so should be included in the CBA. We recommend that you consider the scale and significance of the disruption and include in the CBA for projects where these costs are expected to be large. The costs are likely to be significant when building a major transport upgrade (light rail, rail or a major road expansion) through a highly urbanised and developed area. Projects building infrastructure on greenfield sites or corridors are likely to be less disruptive. The construction costs and benefits included in the CBA should cover impacts during construction and operation.

13. Infrastructure and Transport Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, p. 19, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.

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Avoid double counting costs and benefits

You should avoid 'double counting' when considering costs and benefits – that is, counting the same costs and benefits across two or more categories. **Box 4** provides examples of double counting that often occur in business cases. Where you believe that this may be an issue, you should highlight this in your submission to us.

Box 4: **Examples of double counting**

The following examples of double counting often occur in business cases:

- Including a change in the value of property directly from a transport improvement and measuring travel time savings will double count benefits. This is because the change in the value of property is the capitalisation of the change in travel time savings, and they are therefore measuring the same benefit in different ways (see **Appendix C** on land use impacts).
- Including a change in electricity bills and a change in the capital and operating costs of the electricity system (covering generation, distribution, transmission and retail) from an energy efficiency project. The price of electricity reflects the costs of operating the system in the absence of specific distortions. Therefore, the change in electricity bills is a proxy for the costs of the electricity system, and these should not be added together.
- Including a benefit for people who change from car to public transport mode as a result of a public transport project using the rule-of-a-half, and also including the avoided car costs for these people. The rule-of-a-half approach measures the net benefit for people who switch mode. It is double counting to also include avoided costs for these users.
- Including a reduction in delays caused by reduced congestion in the calculation of travel time savings and measuring the value of reduced congestion for all road network users.
- Measuring crash values with the human capital approach, and separately measuring hospital costs. The human capital approach to calculating crash values incorporates a range of ex-post costs relating to a road accident, including human costs, vehicle costs, and general costs. If costs to the public health system, such as hospital in-patient costs, are included in the CBA as well as crash value, this is double counting.[14] Note that we recommend using willingness to pay (WTP) values to calculate personal costs from a crash.

14. Transport for NSW 2018, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, NSW Government, Sydney, available at: www.transport.nsw.gov.au/projects/project-delivery-requirements/evaluation-and-assurance/resources.

Treatment of broader economic benefits

We are aware that there may be broader economic benefits, sometimes referred to as secondary economic benefits, to infrastructure projects that are not adequately captured within published guidelines. These secondary benefits may include the benefit of increased accessibility to health services, employment and education and may be of particular relevance to proposals in non-urban settings where accessibility is a major barrier to reaching these services.

This section summarises the role of these broader benefits for remote area proposals, while **Appendix G** provides further discussion on some of the common broader benefits.

Please note the broader economic benefits of infrastructure projects referenced here should not be confused with *wider* economic benefits (WEBs) that may be applicable for major urban transport projects. WEBs arise from agglomeration economics, market imperfections and labour market impacts. See **Appendix D** for more detail, or ATAP *T3 Wider Economic Benefits*[15] for detailed guidance.

Where justified, secondary benefits should be included in submissions, with clear detail on the rationale for the parameters chosen and the prediction of the scale of the benefits, so that we can treat each case on its merits.

These broader sources of benefits are particularly relevant to projects in remote areas. Using transport infrastructure as an example, the transport needs in remote areas can be different in comparison with those in urban areas because:

- remote communities may be served by a single road, which places increased dependency on the availability of that road for access
- roads in remote communities can be subject to seasonal constraints due to flooding or other extreme weather conditions, meaning that the community would rely on more expensive, less convenient routes or modes of transportation, or not travel at all[16,17]
- lack of accessibility is a major barrier to education, training, employment centres and health care[18]
- road is the main mode of transport available to remote areas and these are generally of a lower quality than urban roads[19]
- remote area roads are less safe than urban roads.[20]

Table 4 provides an example of benefits that relate to a remote area example, where no transport options exist currently or the only alternatives are cost prohibitive (for example, access by air only), and how they may be quantified.

It is also important that considering broader benefits does not cause double counting. For example, if a transport improvement project reduced the cost of travel (including time and out of pocket costs) from $60 to $30 using national valuation parameters, then the calculated benefit of an additional trip would be half the change in cost ($30÷2 = $15). If these impacts are fully captured in the monetised health outcomes, then measuring these separately would be double counting. However, if you can establish that these consequent benefits (and related costs) are not adequately captured in the transport appraisal for remote areas, then they should be separately included and justified.

See **Box 4** for further guidance on double counting.

We recognise that infrastructure investment is just 'one piece of the puzzle' and often does not deliver these broader economic benefits by itself. For example, upgrading a road may provide access to health services, but this will only improve health outcomes if it changes the behaviour of the local community and if there are health facilities for communities to visit. To this end, we encourage you to provide robust evidence that demonstrate the validity and potential size of these benefits to the extent possible.

15. Infrastructure and Transport Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T3 Wider Economic Benefits*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/wider-economic-benefits.
16. Infrastructure and Transport Senior Officials' Committee 2019, *Australian Transport Assessment and Planning (ATAP) Guidelines O2 Flood Resilience Initiatives*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/other-guidance/flood-resilience-initiatives/index.
17. See, for example, Transport and Infrastructure Council 2016, *National remote and regional transport strategy*, p 21.
18. Austroads 2016, *Reforming remote and regional road funding in Australia*, Ausroads, p 57.
19. Austroads 2016, *Reforming remote and regional road funding in Australia*, Ausroads, p v. Further, roads are more likely to be unsealed in remote areas, see Transport and Infrastructure Council, *National remote and regional transport strategy*, 2016, p 6.
20. Bureau of Infrastructure, Transport and Regional Economics 2018, *International road safety comparisons 2016*, Australian Government, p 6.

Table 4: Treatment of broader benefits

Broader benefit	What the outcomes may include	Example of how the benefit could be quantified
Accessibility to health care	Greater likelihood of visiting doctors for routine check-ups is likely to reduce the long-term cost of healthcare.[21] Improved transport infrastructure also allows medical professionals to visit remote communities more easily.	Improved health outcomes are realised through lives saved, increased life expectancy, and increased quality of life. Health outcomes can be quantified through the value of life or the value of living longer (measured through value of statistical life and value of statistical life year, respectively) and the improved quality of life from being healthier (commonly measured using disability adjusted life years (DALY)).[22] The NSW Health Guidelines set out a framework for quantifying the benefits to the health system of non-admitted patient services (NAPS).[23] This involves quantifying the avoided operating and capital costs. Where expected benefits are based on state-wide parameters and methods, you should consider whether these adequately capture the benefits for remote areas. For example, does increased accessibility have a greater impact on health outcomes in remote areas?
Lower the cost of production for businesses	Businesses may be able to access inputs at a lower cost. New businesses may also become viable that were otherwise not.	A transport project could lower the cost of inputs to production or increase the quantity able to be supplied.[24] You should consider whether existing CBA frameworks fully capture these benefits for remote areas.

21. Studies have suggested that for many diseases, preventative healthcare including routine check-ups reduces the total medical cost compared to treatment once diagnosed. See: National Center for Transit Research 2014, *Cost–benefit analysis of rural and small urban transit*, Tampa FL, p 6.
22. A similar concept is quality adjusted life year (QALY). QALY measures both quantity and quality of life and is calculated by weighting life years by the quality of life experience in those years.
23. NSW Health 2018, *NSW Guide to Cost–Benefit Analysis of Health Capital Projects*, NSW Government, pp 28–29, available at: www1.health.nsw.gov.au/pds/ActivePDSDocuments/GL2018_021.pdf
24. Note that this would relate to WB1 under ATAP guidelines. See Infrastructure and Transport Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T3 Wider Economic Benefits*, Transport and Infrastructure Council, Canberra, www.atap.gov.au/tools-techniques/wider-economic-benefits.

Table 4: *Continued*

Broader benefit	What the outcomes may include	Example of how the benefit could be quantified
Accessibility to employment	Vacant jobs could be filled (such as jobs that are seasonally vacant). Businesses could hire more productive workers if they become available. Higher levels of employment and lower levels of unemployment and underemployment.	For example, suppose a transport project provides access for individuals to employment centres by reducing travel times or reducing disruption during flooding. The key benefit of access to employment is additional income for workers and higher productivity for businesses. The benefit of the transport project for those that are able to access additional employment can be quantified as the increase in lifetime income that access to employment would provide. Reduced externalities related to unemployment should also be considered, such as welfare costs, crime, and increased taxation revenue. You should consider whether current CBA approaches in transport adequately capture the full range of potential benefits in a remote context. For example, the full benefits of better connecting people in remote communities with employment opportunities.
Accessibility to education	Improved transport infrastructure can provide easier access to education opportunities.	For example, suppose a transport project provides access for individuals to attend university. The key benefit of attending university is that lifetime income is higher for those that attend university than those who do not.[25] The benefit of the transport project for those that attend university, who otherwise would not, can be quantified as the increase in lifetime income that a university education would provide.
Social inclusion and cohesiveness	Improved transport infrastructure can better connect people with family, friends and local community / cultural and sport centres to deal with personal matters and crisis.	For example, a transport project or access to a digital network like the National Broadband Network removes barriers and improves the ability to participate adequately in society, including social and recreational activities and improving quality of life and liveability.[26] Research by Stanley and Hensher et al[27] examined the impacts of social exclusion and the value of increasing transport choices for these people. The modelling and quantitative analysis estimated that the value of an additional trip for socially excluded people was significantly higher than the 'equity' value of time used in national and state CBA frameworks.

25. Australian Bureau of Statistics, *Characteristics of employment, Australia*, August 2015, www.abs.gov.au/ausstats/abs@.nsf/Previousproducts/6333.0Main Features3August 2015?opendocument&tabname=Summary, accessed 9 April 2019.
26. Infrastructure and Transport Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines O3 Urban Amenity and Liveability*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/other-guidance/urban-amenity-liveability/index.
27. Stanley, J., Hensher, D.A., et al 2011. 'Social Exclusion and the Value of Mobility'. *Journal of Transport Economics and Policy*, Vol. 45, (2), pp 197–222, available at: www.worldtransitresearch.info/research/4020/

2.5 Step 4: Forecast the demand and impacts over the life of the investment

Costs and benefits of infrastructure projects are usually strongly related to forecast service and utilisation levels, as future demand in the base case and the project case underpins the CBA. Generally, it is not possible to monetise costs and benefits without forecasting demand and estimating the consequent change in service impacts first.

A key determinant of the benefits of a proposed project is the demand for the infrastructure and the resultant service. Similarly, the scale of options developed will be directly linked to forecast service and utilisation levels.

Estimates of investment costs for infrastructure projects require forecasts of the quantities of resources involved such as land, labour, material and capital. Similarly, forecasts of operating and maintenance costs will be a function of the scale of operations. Our expectations of the level of project development, design and cost confidence is detailed in each stage of the Assessment Framework. In this document, the estimation of costs is covered in detail in **Section 2.6**.

This step involves estimating:

- the scale and pattern of demand for the infrastructure across the appraisal period for the base case and the project options
- the change in impacts for the base case and project options. This means estimating changes in the quantity, quality and efficiency of the services delivered through improved infrastructure
  - whatever the investment, you need to determine the impacts of each project option compared to the base
  - for transport, these are likely to encompass changes in travel times, reliability, distance travelled and speeds
  - for schools, the impacts targeted will include crowding, ease of travel and educational attainment from more accessible educational facilities.

Demand forecasts and the estimation of impacts may be provided as inputs to the CBA by other professionals (for example, demographic forecasters, transport planners and health/education demand and impact specialists). It is important to include sufficient information within the CBA documentation to demonstrate the nature and reliability of these inputs and their impact on the CBA results.

We recommend that you commission independent peer reviews of both the demand forecasts and the cost estimates, given the specialist nature and inherent uncertainty of this work.

The role of demand and service forecasts in determining proposal impacts

Demand and service forecasts for the base case and project case options are critical inputs to the calculation of costs and benefits. Along with the demand forecasts, modellers and analysts also calculate the changes in performance likely to result from improved infrastructure. Examples of these impacts include:

- for transport, changes in journey times and the reliability of these journeys, changes in the number and severity of crashes, changes in the cost of vehicle operation and changes in air pollution and greenhouse gas emissions
- for health, changes in treatment types for patients and the quality and duration of the lives affected by the investment
- for education, changes in crowding, the quality of learning spaces and the impacts of these on educational attainment (and lifetime earnings) and changes in the costs involved with travelling to the place of education.

Similar impacts occur across every investment sector and you should document the source of and methods used to estimate these service impacts, including providing sufficient information to explain the changes and providing assurance about their reliability.

Box 5: **Optimism bias**

It is important to be aware of optimism bias when estimating demand, costs and benefits. Optimism bias refers to the underestimation of the likelihood of an adverse event, and affects cost estimation, demand forecasting, and benefits identification and estimation. Research in recent decades indicates that optimism bias is a significant problem in infrastructure.

Underestimating costs or overestimating benefits leads to biased assessments of proposals and erodes the community's confidence in infrastructure processes. Optimism bias also leads to higher realised delivery costs than expected costs, causing budgetary stress. Reviewers that consider optimism bias to be apparent may also revise downward the results of economic appraisals.

ATAP recommends the following strategies for mitigating optimism bias:[28]

- Raise awareness of the potential for optimism bias.
- Adopt best practice techniques and use of best practice data.
- Use probabilistic methods and rigorous deterministic methods for cost estimation, as defined by the Australian Government Department of Infrastructure and Regional Development.[29]
- For demand estimation, use the expected value or the most likely scenario. High scenario projections (for example, population) should only be for sensitivity.
- Avoid double counting (see **Avoiding double counting of costs and benefits** in **Section 2.4** for further guidance).
- Undertake risk workshops with key stakeholders to review cost and demand estimates.
- Ensure that underlying assumptions are transparent.
- Compare estimates with past comparable projects, if available.
- Conduct independent peer reviews.
- Test results with sensitivity analysis, particularly an uplift in costs and downward adjustment of benefits (see detailed guidance in the **Guide to risk and uncertainty analysis**).

28. Transport and Infrastructure Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines O2 – Optimism Bias*, Transport and Infrastructure Council, Canberra, https://www.atap.gov.au/other-guidance/optimism-bias/index.
29. Department of Infrastructure, Transport, Regional Development and Communications 2018, *Cost Estimation Guidance*, Australian Government, available at: investment.infrastructure.gov.au/about/funding_and_finance/cost_estimation_guidance.aspx.

Demand forecasting for infrastructure projects

Introduction

Demand forecasts are critical in estimating changes in performance and describing the number of people that these changes should be applied to. Base case demand will be a function of variables such as population growth, population composition and economic growth assuming that the services provided are broadly the same. The demand for project options might use the same demand but often an improvement in infrastructure will induce additional demand.

For some applications, such as in transport, models will be applied at intervals (say, every 10 years) to estimate demand and the annual demand derived from interpolating between these points. Other applications might estimate demand in each year where it is tightly correlated to a single input such as population growth. These demands and the associated models will be often used to estimate the impacts on the quality and effectiveness of the services delivered.

As demand forecasts play a critical role in the appraisal of proposals, we need to understand the basis upon which demand estimates have been produced. Even when a proposed project relates, for example, more to an improvement in service quality rather than to an increase in infrastructure capacity, demand information will assist us to understand the scale/location/nature of users benefitting and being otherwise impacted by a particular investment.

Overall guidance on demand forecasting

For each proposal, the following information should be provided:

- A comprehensive list of the detailed assumptions which drive demand, including:
  - Growth rates – such as population growth, employment growth, technological change, climate change (see the **Guide to risk and uncertainty analysis**) and how these may change over the appraisal period.
  - Values – such as number of households, number of businesses, the price of services, elasticities, take-up of services, consumer preferences.
- The magnitude and basis of probabilities assigned to uncertain events (for example, technological change and level of consumer demand – low, medium or high), and the basis for selecting the central scenario.
- Detail of land use assumptions in the base case and with the proposed project options such as residential or employment densification assumed in the demand modelling, including any commitments to rezoning or other planning law changes which would be necessary to facilitate land use changes.
- The methodology used to estimate demand – the nature of the demand model used and how 'knock-on' and wider network effects are calculated, plus an explanation of the independence of forecasts and the degree of external or independent scrutiny of the forecasts. This should include full details on how the model forecasts 'induced' demand. See **Induced demand** later in this section for further detail.
- The underlying justification for assumptions and growth rates and sensitivity testing of central economic and project specific assumptions.
- A detailed disaggregation – by year, date and user type – of the results of the demand modelling.

Demand forecasting in the transport sector

For transport projects, in addition to the information required for general infrastructure projects, the following information should be provided:

- A comprehensive list of the detailed assumptions which drive demand, including:
  - Values, such as private vehicle demand and public transport demand.
  - How these change over the appraisal period, such as growth rates or changes for population, employment, land use (see fourth bullet point).
- A description of how the assumptions change due to significant exogenous project drivers such as technological disruption and climate change.
- The underlying justification for these assumptions and growth rates, particularly the expansion and extrapolation factors used and sensitivity testing of central case assumptions.
- Details of any changes in land use expected with the proposal, such as residential densification or Transport Orientated Developments. Note that land use change may or may not be appropriate for direct incorporation into the appraisal. In these circumstances you should discuss this with us before undertaking modelling.
- The approach used to forecast network demand and behavioural change – the nature of the analysis/modelling, an explanation of the degree of external or independent scrutiny of the forecasts, and full details on how the model forecasts 'generated' or 'induced' demand (see the following sections).
- A detailed disaggregation – by year, forecast period, scenario and user type – of the results of the demand modelling, following the information requirements set out in our **submission templates and checklists**.

Typically, this information will be contained in a detailed transport modelling report and/or patronage forecast report, which will have been prepared by you and peer reviewed. Wherever possible, you should submit this report to support your business case.

Demand forecasting in the water sector

Demand forecasts for water sector projects offer unique challenges for analysts. In particular, these arise because projects often involve benefits related to induced agricultural activity and benefits are likely to be subject to climatic variability.

For water projects, in addition to the information required for general infrastructure projects, the following information should be provided:

- A justification of the key types of demand relevant for the project, such as agricultural demand, urban demand (commercial, household and government), mining demand and environmental water requirements, and the extent to which these activities are relying on water provided by the project.
- An understanding of how demand for water varies depending on different rainfall outcomes.
- A comprehensive list of the detailed assumptions which drive demand, including population growth, changes in agricultural and mining activities, changes in water efficiency and on-site water storage and recycling, water pricing assumptions and future rainfall assumptions.
- A description of how the assumptions change due to significant exogenous project drivers such as climate change, climate change policies, water use behaviour or changes to key using sectors such as mining and agriculture.
- A detailed disaggregation for each option – by year, demand scenario and user – of the results of the demand modelling.

Wherever possible, you should align to relevant jurisdictional and sector-specific guidelines, and submit supporting forecasts to support your analysis, such as the *National Water Infrastructure Investment Policy Framework*.[30]

Additional detail on challenges and considerations for demand forecasting in the water sector is provided in **Appendix F**.

30. National Water Grid Authority 2020, *National Water Infrastructure Investment Policy Framework*, Australian Government, available at: www.nationalwatergrid.gov.au/framework.

Demand forecasting in the energy sector

For energy projects, in addition to the information required for general infrastructure projects, the following information should be provided:

- A justification of the key types of demand relevant for the project, such as energy volumes by type of user, peak demand for relevant spatial area
- A comprehensive list of the detailed assumptions which drive demand, including changes in the population and new large users (for example, mines and industrial facilities), energy prices, economic activity, embedded generation; and how these change over the appraisal period.
- Capital expenditure plans built into the base case for other relevant energy infrastructure.
- The energy outcomes expected under the base case, such as the price, energy mix and reliability outcomes.
- A description of how the assumptions change due to significant exogenous project drivers such as energy market and climate change policies and flexible working arrangements.
- If the project is expected to allow for new users to become commercially viable, such as new mines or major users (that is, induced demand), the amount of demand expected from these users, and why they are reliant on the energy infrastructure.

Wherever possible, you should submit supporting energy demand modelling report(s) prepared to document future demand to support your business case.

A number of organisations provide national, state/territory and zone substation level electricity forecasting and planning reports, such as the Australian Energy Market Operator (AEMO)[31] and electricity distributors, as part of their submissions to the Australian Energy Regulator (AER).[32] You are encouraged to consider and reference these forecasts as the basis for developing project-specific methodologies for demand and to align with current public information.

Demand forecasting in the telecommunications sector

For telecommunications projects, in addition to the information required for general infrastructure projects, the following information should be provided:

- A justification of the key types of demand relevant for the project, such as the volume of data, peak bandwidth, number and type of devices/users.
- A comprehensive list of the detailed assumptions which drive demand, including the rate of user growth, volume and peak demand per user, device usage, future uses of the telecommunications infrastructure and their associated demand requirements and price assumptions; and how these change over the appraisal period.
- A description of how the assumptions change due to significant exogenous project drivers such as technological disruption, ability to adapt existing technology to accommodate higher demand and flexible working arrangements.
- A detailed disaggregation for each option – by year, demand scenario and user type – of the results of the demand modelling.

31. Australian Energy Market Operator, 'NEM electricity demand forecasts', viewed May 2021, aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/nem-electricity-demand-forecasts.
32. Australian Energy Regulator 2020, *Guidelines to make the integrated system plan actionable*, AER, Melbourne, available at: www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/guidelines-to-make-the-integrated-system-plan-actionable.

Induced demand

Induced demand is defined as additional or new demand that occurs as a result of a project. It relates to demand that would not otherwise occur, for example:

- widening a motorway may improve travel times, leading to additional demand for the use of the motorway, and of car travel in general
- an electricity transmission line may reduce the cost of electricity and thereby increase demand
- a new water supply asset may increase available water, allowing for additional land to be used for irrigated agriculture
- hospital infrastructure improvements can induce greater visitation.

In most cases, allowing for induced demand will increase the benefits of a project. The main counter example to this is for transport and especially road projects, where inducing additional demand can reduce benefits because the congestion caused by additional users affects all road users. For this reason, this section focuses on induced demand in the transport sector, but it may also be relevant to other sectors (and we include some examples of this).

The overall framework for conceptualising induced demand is shown in **Figure 3**. A project shifts the supply curve (the cost) for a service down. This leads to an expansion of demand from Q0 to Q1. This increase in demand is the induced demand.

Measuring induced demand

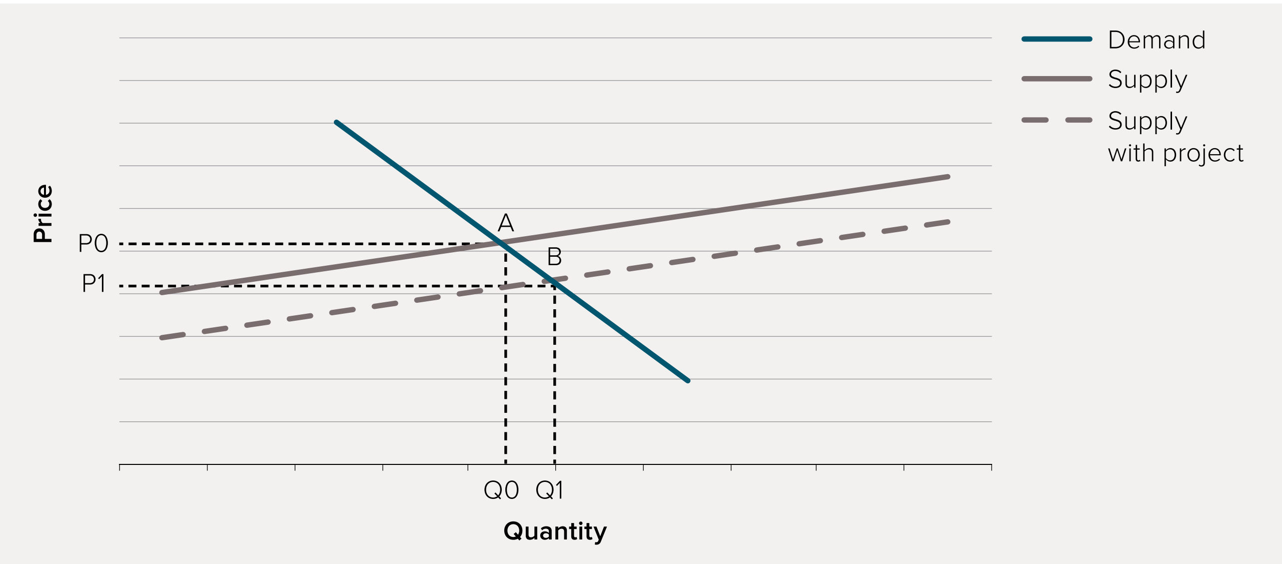
The principle for measuring induced demand is that a person or business would not want to undertake an activity in the base case but would want to undertake this activity if the project proceeds. For example, if a water corporation increases water supply to a region, the increased water supply might persuade a local grower to plant a more lucrative crop that requires more water because the supply is now available. This decision due to the investment will increase demand.

There is no standard approach to measuring how large the induced demand effect would be for a particular project. Possible options to measure the induced demand include:

- using elasticities (see **Glossary**) of demand for the specific sector and geographical area
- analysing the commercial feasibility of individual activities with and without the project.

If a large part of the benefits of an infrastructure project result from induced demand, even more scrutiny is required to ensure that the induced demand has been appropriately calculated. The benefit realisation strategies, risk management and project staging would also be expected to focus on how to manage the risk of whether or not the expected induced demand materialises – a 'build it and they will come' approach would lead to a high risk of benefits not being realised if induced demand is a major part of benefits.

Figure 3: Conceptualising induced demand



1 Introduction
2 CBA methodology
3 Rapid cost–benefit analysis
4 Cost-effectiveness analysis
5 Other appraisal techniques
Glossary
Appendices

In transport, sophisticated modelling approaches exist for measuring induced demand, which should be applied in the assessment of major projects (see **Box 6**). In other sectors, in the absence of similar sophisticated modelling approaches, treatment of induced demand should be explicitly documented.

Valuing induced demand

By definition, induced demand relates to activities that are currently not chosen by customers or infrastructure users, but who change their behaviour because of the project. When calculating benefits, the benefit per existing user will be greater than for new users because they will gain the full benefits of this change. This is because for existing users the only thing that has changed is improved performance of facilities or routes they are already using.

The method for valuing induced demand for users is shown in **Figure 4**. Where there are no externalities, the benefit is Area A.

The behaviour of new users has changed due to the intervention, but we do not know all the factors that drove this behaviour. For example, we do not know the tipping point that persuaded new users to change (some new users might have changed with a small improvement while others might need the full improvement to make this change).

In the transport sector, this is often approximated using the rule-of-a-half – any induced demand is given a benefit equal to half the benefit of existing demand.[33] In this case, the benefit from induced demand is equal to the change in demand multiplied by the change in cost[34] divided by two. In other sectors, benefits to new users are often calculated directly, rather than being calculated with reference to existing users.

In many cases, induced demand comes with additional costs and benefits that do not accrue to the person making decisions. Such externalities could include:

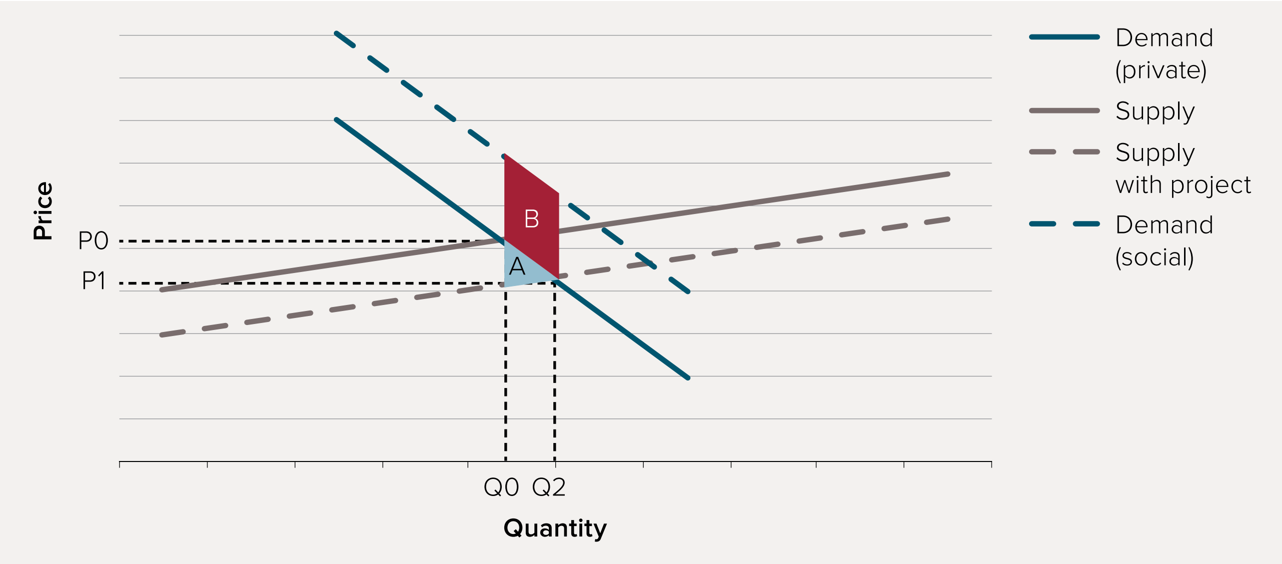
- road congestion – an additional person may decide to use the road network because of a project, but this then imposes costs on other users (a negative externality)
- royalties or tax revenues – an additional activity may lead to revenue being generated for government that is not accounted for as part of the user's decision
- environmental impacts – induced demand may have environmental impacts that are not priced by the user.

For the example of valuing an externality of induced demand shown in **Figure 4**, if there was a positive demand externality for a service, such as additional production that can be enabled by the service, then there could be an additional area B included as a benefit.

In some cases, the value of induced demand is measured using measures such as average value added or gross operating surplus associated with new activity. These measures are not measures of the net benefit of additional activity and should be avoided. They will tend to overstate benefits because they do not account for all the costs related to an activity occurring. They are also averages rather than measures of the marginal activity induced by a project.

33. This is an approximation of Area A assuming that the demand curve is linear.
34. Or increase in willingness to pay.

Figure 4: Valuing induced demand



The notable exception to applying the rule-of-a-half approach for transport projects is where individuals do not have a choice available in the base case, where the market does not exist or, the only alternatives are cost-prohibitive.

An example in transport is when an area does not have a viable public transport service. It is not appropriate to apply an approach that relies on measuring the demand and costs from improving a service, because there is no historical information to allow a marginal approach. Instead, it would be appropriate to measure the attributes and areas under a demand curve.

There are also challenges applying the rule-of-a-half where the cost changes are very large because it is not appropriate to assume the relationship between cost and demand is linear. In this situation, the rule-of-a-half may understate the benefit. Where the rule-of-a-half is not applied to specific trips, this should be clearly identified and justified. Chapter 6 of ATAP's *T2 Cost–Benefit Analysis*[35] provides further guidance on the treatment of induced demand and application of the rule-of-a-half.

Reporting costs and benefits with induced demand

For transparency, your submissions should clearly set out the types of demand responses that demand models include and exclude. In addition, the CBA should separate out the costs and benefits related to base case demand and the costs and benefits that arise from induced demand, where possible. For example, the costs and benefits for a public transport project could report:

- benefits to existing public transport users
- benefits to new public transport users (which is induced demand)
- benefits to road users.

35. Transport and Infrastructure Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.

Box 6: **Induced demand in transport proposals**

For major transport proposals, demand forecasts should account for an appropriate range of user behaviour changes that can be expected with the project.

For example, in the case of major road projects, it is not sufficient to assume that the same number of peak period private vehicle trips will be present in the base case and the project options, as a proportion of users are likely switch routes to take advantage of improved speeds on the project route. This simple assumption is known as a 'fixed trip matrix' approach to transport modelling and is only appropriate for minor improvement projects or where there is very little prospect of the project inducing demand.

Proponents of major urban transport projects should follow a 'variable trip matrix' approach in their network modelling. This means adopting a variable origin-destination matrix that accounts for the additional (induced) demand where measurable and appropriate. Sources of induced demand include:

- changing mode – for example, public transport passengers switch to car because a highway improvement makes road travel more attractive than bus or rail
- making additional journeys – for example, people are willing to make additional car journeys because of the improvement in accessibility
- changing destination – for example, drivers decide to travel to more distant destinations because the improvement makes the journey time acceptable
- changing time of travel – for example, drivers decide to travel in the peak period because the improvement reduces journey times to an acceptable level
- land use changes – for example, over time, the new or improved part of the transport system may encourage higher population and business activity near the improved facility and/or encourage households and firms to locate further away from their usual destinations.

Large projects may generate different components of induced demand, while small projects are likely to have smaller impacts. It is possible for some large road projects to have small induced demand effects. For example, where an improvement happens on a long inter-urban route with very limited public transport options. Induced demand may reduce private benefits as the additional users 'use up' the additional network capacity before the end of the appraisal period, resulting in disbenefits to users and the community due to congestion and externalities like pollution, noise and crashes.

For major road projects, our assessment of a number of past projects indicates that accounting for induced demand using a variable trip matrix can reduce benefits by around 25%, relative to the benefits estimated using fixed trip matrix models. This is because the fixed trip matrix overstates benefits, as it does not account for the response of demand to change in travel times. Variable matrices should more accurately measure traffic behaviour.[36]

This demonstrates that appropriate consideration of induced demand is a key part of good practice project appraisal, and we expect that it be considered appropriately for the scale of project options under consideration.

36. An expanded discussion can be found in ATAP's *T2 Cost–Benefit Analysis*, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index

Box 6: **Induced demand in transport proposals** *continued*

The modelling of induced demand is of greater importance for those transport networks with:

- high levels of congestion
- high elasticity of demand (that is, a small change in generalised costs results in a large change in demand)
- relatively large changes in transport costs.

Where induced demand reduces the benefits of a project, this suggests that approaches to minimise induced demand, such as tolling, can substantially increase project benefits, and could be usefully explored as part of project options.

Further guidance on modelling induced travel demand is provided in the ATAP guideline *T1 Travel Demand Modelling*[37].

Wider impacts that may be included in the CBA

Land use impacts

Land use impacts are explained at a high-level here and in further detail in **Appendix C**.

Infrastructure projects can have significant land use impacts that are not easily captured in conventional CBA. This is because the estimation of land use impacts (benefits or costs) is a complex and challenging activity, and approaches and parameter values for quantifying land use impacts are still in development. For example, major transport projects, such as metro style train services, are often considered to be 'city shaping' because they influence where people choose to live and where businesses choose to locate on a large scale over time. Similarly, airports, ports, major roads, education and health infrastructure can influence land use via land take, ancillary services and the impact on location decisions for households, firms and population.

Understanding such land use impacts can be important for several reasons. For some projects, changing land use may be a primary objective of the project and being able to predict the degree to which they achieve this aim will then be important. Land use impacts may also give rise to a range of costs and benefits in addition to the travel time savings and other impacts typically captured in an appraisal, such as potential savings in the costs of providing public infrastructure and utilities like water, electricity, gas, health and education services to less dense urban areas as compared to more dense areas.

Not all infrastructure projects are expected to incorporate land use costs and benefits into a CBA. Submissions should only include such impacts where there is compelling supportive evidence and clear justification for why the project is expected to generate significant land use impacts.

37. Transport and Infrastructure Senior Officials' Committee 2016, Australian Transport Assessment and Planning (ATAP) Guidelines T1 Travel Demand Modelling, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/travel-demand-modelling/index.

You must establish that the change in land use is directly attributable to the project. The forecast land use change must be both principally dependent on the transport project in question and the necessary conditions (for example, zoning changes, other supporting infrastructure and excess demand or associated public and private investment) must be present in order for the identified land use impacts to materialise. **If these conditions are not met, then it is unlikely that any land use impacts should be included in the proposal.** See **Appendix C** for further detail on the necessary conditions for land use benefits to be considered.

The infrastructure projects that do cause changes in land use across a given area may create benefits, which can be estimated and included in the CBA. ATAP[38] provides detailed guidance on measuring land use impacts for transport projects. Costs and benefits described in this guidance include:

- **Higher value land use** – Subject to the qualifications on 'attribution', 'dependency' and 'conditionality' (see **Appendix C**), an infrastructure improvement may leads to unlocking additional land use (which would not have occurred in the absence of the investment). The change in land use will generate a net economic benefit if the value of the new use is higher than the value of the current use, less the cost of achieving the change and the existing capital. This value is appropriate to capture in a CBA.
- **Second-round transport impacts** – Once you allow for a change in land use in response to an infrastructure investment, there may be additional costs and benefits to those that should be captured in CBA. For instance, new residents that are attracted to a location in order to access improved amenities, better transport, etc. do so because they are better off. These benefits should be captured using the rule-of-a-half.
- **Second round transport externalities** – Similarly, households clustered more tightly around trip destinations typically make shorter trips and make more use of walking, cycling and public transport, while more spread-out land uses are usually associated with longer trips and a higher share of car use. Therefore, by changing land use, a project can change transport patterns and external costs (crowding, congestion, pollution, crash costs, etc.) of the total transport task.
- **Public infrastructure cost impacts** – Connecting and providing infrastructure services such as utilities (water, electricity and gas), transport and larger scale social infrastructure (for example, schools and hospitals) in less dense urban environments tends to be more expensive per dwelling than providing or upgrading the same infrastructure in denser environments. If these infrastructure costs are not fully recovered from the developers that create them, a project that leads to a change in the balance of distribution of future growth across denser and less dense parts of a city can lead to a net change in the cost of facilitating this growth. Importantly, the private cost of public infrastructure is often lower than the marginal social cost, as the government tends to meet some of the costs of development. Changes in the costs of providing public infrastructure and services should be included only where you can show evidence of a net benefit.
- **Sustainability impacts** – Changes in built form may result in sustainability benefits or costs where they have upstream or downstream environmental impacts. Higher density development tends to be more energy efficient than lower density development. For example, lower ongoing energy use (for example, electricity, gas and water consumption) or lower environmental impacts of construction for high/medium density developments compared to low density housing. The infrastructure/transport projects which lead to changes in urban form may result in sustainability impacts.

38. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines O8 Land Use Benefits*, available at: www.atap.gov.au/other-guidance/index

- **Public health cost changes** – Infrastructure projects that result in a denser pattern of urban development have grounds to claim public health cost savings associated with net increased incidence of trips using active transport. The NSW Government's 'Economic Framework for Urban Renewal' identifies the possibility of health benefits from increased active transport use as a result of urban infill.[39]

For detailed guidance for measuring, quantifying and reporting land use impacts, see the ATAP Guidelines O8 *Land Use Benefits of Transport Initiatives*.[40]

Wider Economic Benefits

Wider economic benefits (WEBs) are explained at a high-level here and in further detail in **Appendix D**.

WEBs are benefits that are outside of the benefits to users and are not captured in traditional CBA. They arise when changes in behaviour as a result of a project flow through into other markets that are subject to distortions. WEBs are improvements in societal welfare associated with changes in accessibility or land use that are not captured in traditional CBA. They arise from market imperfections, that is, prices of goods and services differing from costs to society as a whole. Reasons include economies of scale and scope, positive externalities, taxation and imperfect competition. For example, a change in transport costs could lead to positive flow-on impacts if it increases business interactions and there are productivity spillovers from this. They should not be confused with broader (but direct) social benefits, such as those described in this document and the Assessment Framework more broadly.

WEBs are only likely to be significant, and therefore worth estimating, for major transport projects located in or improving access to large urban areas. Therefore, proposals that are including WEBs should give rise to significant demand changes, that is, induced demand. Similarly, WEBs can also be negative for proposals that reduce the concentration of economic activity.

In general, these are the benefits derived from face-to-face contact, information exchange and networking only available where industries are working close to each other. Estimation of WEBs should be accompanied by a narrative describing how each type of estimated WEB arises. The narrative serves as a common sense test for the reasonableness of the claim that a proposal will generate WEBs of the size estimated.

It is worth noting that the behavioural changes that have accompanied COVID-19, such as reduced commuting and increased working from home, may reverse WEBs assumptions. While the longer-term implications for travel behaviour remain uncertain, the risks to realising WEBs that are included in CBA results should be considered in decision-making.

Where appropriate, for particular types of proposals, we will consider WEBs such as those defined in the ATAP guidelines.[41]

- **Agglomeration economies (WEB1)** – Productivity gains from clustering by firms whereby they benefit from access to a greater number of other firms, their workers and customers. These benefits arise from: sharing of inputs and outputs; better matching of workers to employers, suppliers or customers to firms; and workers learning from one another.

39. This is supported by data from the Australian Bureau of Statistics census which suggests there are significant differences in the rate of active travel as part of travel to work in infill and greenfield areas. Although workers living in greenfield areas that walk or cycle to work travel further than infill residents, the vast majority are heavily dependent on motor vehicles. See also Australian Transport Assessment and Planning Guidelines *M4 Active Travel guidance*, available at: www.atap.gov.au/mode-specific-guidance/active-travel/index.
40. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines O8 Land Use Benefits of Transport Initiatives*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/other-guidance/index.
41. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T3 Wider Economic Benefits*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/wider-economic-benefits.

- **Improved labour market and tax impacts (WEB2)** – These impacts arise from individuals changing their level of participation in the labour force or changing job, in response to impacts of transport proposals on commuting costs and land use.
- **Output changes in imperfectly competitive market (WEB3)** – Profit increases for firms through output changes. In imperfectly competitive markets, increasing output results in a marginal benefit greater than the marginal cost – a net gain, or welfare benefit, that accrues to the firm as additional profit. Transport interventions produce such a benefit because, by reducing the cost of production for firms, they lead to an increase in output in imperfectly competitive markets.
- **Change in competition (WEB4)** – Gains to consumers and more efficient production. A new transport link, or greatly improved existing link to the rest of the economy, can introduce competition from outside causing the monopolist to reduce prices, cut costs and improve service quality. ATAP has not provided a methodology for WEB4 because it is not considered relevant for economies that already have a good base level of transport connectivity such as Australian cities. Therefore, we do not support the inclusion of WEB4 in the CBAs and business cases submitted to us for assessment.

For detailed guidance for measuring, quantifying and reporting WEBs, see ATAP Guidelines *T3 Wider Economics Benefits*.[42]

Reporting land use impacts and WEBs in CBA results

If you are seeking to incorporate land use impacts and WEBs in a CBA associated with a proposed project, you should consult with us to discuss the justification for including these benefits in the context of the project's strategic objectives.

If measuring land use impacts or WEBs is justified, when presenting CBA results you should:

- present conventional CBA results (that is, excluding land use impacts and WEBs)
- report results with land use impacts as a 'below the line' item (but excluding WEBs)
- report results with land use impacts and WEBs as a 'below the line' item.

Note that this is a revised approach to previous guidance in the Assessment Framework. The robustness of the methods for estimating land use impacts and WEBs is developing, therefore we require benefit categories to be presented separately for full transparency of the results.

See **Section 2.9** for further detail on presenting CBA results with land use impacts and WEBs.

42. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T3 Wider Economic Benefits*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/wider-economic-benefits.

2.6 Step 5: Monetise the costs and benefits

This section provides guidance about monetising the costs and benefits of options, relative to the base case. This involves taking the quantified impacts and the total changes predicted from demand and service forecasts, then applying valuation parameters to represent these in monetary terms. The sub-sections below:

- summarise the expected impacts by sector
- describe the approach to monetising these impacts or benefits
- describe the approach to estimating the investment capital, operating and maintenance costs.

In a CBA, costs and benefits are classified as either 'private' or 'external'. External costs and benefits are conventionally termed 'externalities'. Such classifications are used to help identify the beneficiaries of the project and those stakeholders who may be disadvantaged by the project.

Private costs and benefits accrue to either consumers/users (for example, consumer surplus derived from consuming a good or service) or producers (for example, producer surplus or value of avoided capital, replacement, maintenance, operating and compliance costs, or extra fare revenue received).

External costs and benefits are accrued by third parties not directly involved in the market for a good or service (for example, costs of damage to the environment, reduction in visual and other amenity).

Both private and external costs and benefits should be monetised where possible.

Where costs and benefits are monetised in the CBA, they should be expressed in real terms (that is, adjusted to remove the effect of inflation). The base year for the monetised values should be consistent for all costs and benefits included in the CBA and should be clearly stated in CBA reporting. When you report CBA results in a submission to us, you should also report annual real costs and benefits for each year of the appraisal period, for each benefit and cost component.

Approaches to monetising costs and benefits for different infrastructure sectors

Section 2.5 provided guidance on forecasting demand and the impacts that underpin the monetary estimation of project benefits. This section focuses on approaches to monetising benefits (and disbenefits), while additional guidance on estimating investment costs is provided in the following sections.

The following tables list the potential costs and benefits that are generally monetised in a CBA of passenger transport, freight transport, telecommunications, energy, water and social infrastructure projects respectively.

In undertaking a detailed CBA, proponents should refer to relevant guidelines. A number of general and sector specific guidelines are provided in **Appendix A**.

Table 5: Typical monetised benefit and cost items

Passenger transport

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs and benefits: • Investment and ongoing project expenditure (e.g. operating expenditure, maintenance costs, decommissioning costs) **User value (commercial and private consumers of transport infrastructure) – increased surplus from:** • Timeliness/speed – Changes in travel times such as in-vehicle time and out-of-vehicle time (e.g. wait, access and transfer/boarding) • Frequency – how many services per hour • Reliability – Changes in unscheduled delays • Other quality measures – Changes in crowding (rolling stock and platform) and amenity (e.g. station, rolling stock) • Access and egress times • Safety and security (upgrade lighting, CCTV cameras) • Changes in vehicle operating costs (perceived and unperceived) • Changes in health and physical fitness • Residual values **Producer value (producers of transport services and/or infrastructure) – increased surplus from:** • Expenditure avoided, (e.g. savings in operating, maintenance, compliance and investment costs) • Incremental fare box/toll revenue • Incremental costs of realising land use changes	**Environmental:** • Changes in values associated with environmental externalities, including noise and vibration, local air pollution, greenhouse gases (e.g. CO2, CH4, NOx) • Climate change influencing existing economic, land-use and cultural activities (e.g. due to inundation, or excessive heat) **Social/cultural:** • Changes in values associated with aesthetics and visual amenity • Changes in heritage values, including Aboriginal and Torres Strait Islander sites of importance, or to historic buildings, sites and landscapes **Safety and network:** • Changes in crash costs • Road network decongestion **Other:** • Competition benefits taking into account the behaviour of competitors who may have a degree of market power • Consequential costs during construction (e.g. noise, delay, congestion, displaced economic activity etc.) • Wider Economic Benefits or costs from agglomeration, imperfect competition and labour supply effects • Land use benefits or costs, (e.g. from higher or lower value land use, public infrastructure cost changes, etc.) • Market and policy responses to climate and technological disruptions (e.g. renewable energy and carbon pricing)

Table 6: Typical monetised benefit and cost items

Freight transport

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs and benefits: • Investment and ongoing project expenditure, (e.g. operating expenditure, maintenance costs, decommissioning costs) **User value (commercial and private consumers of freight transport infrastructure) – increased surplus from:** • Timeliness/speed – Changes in freight travel times (e.g. faster loading, improved network speeds) • Increased capacity – Change in tonnes of freight transported along the network • Reliability – Changes in unscheduled delays • Other quality measures – Changes in flexibility of supply chains (e.g. ability to provide freight services when and where required) • Safety and security • Changes in vehicle operating costs (perceived and unperceived) • Residual values **Producer value (producers of freight transport services and/or infrastructure) – increased surplus from:** • Expenditure avoided (e.g. savings in operating, maintenance, compliance and investment) • Increased freight operating margin • Increased government revenue (e.g. access charges)	**Environmental:** • Changes in values associated with environmental externalities, including noise and vibration, local air pollution, greenhouse gases (e.g. CO2, CH4, NOx) • Climate change influencing existing economic and land use activities (e.g. due to increased extreme events) **Social/cultural:** • Changes in values associated with aesthetics and visual amenity (e.g. from fewer heavy vehicle movements) • Changes in heritage values, including Aboriginal and Torres Strait Islander sites of importance, or to historic buildings, sites and landscapes affected by freight supply chains **Safety and network:** • Changes in crash costs (e.g. from fewer heavy vehicle movements) • Road network decongestion **Other:** • Competition benefits taking into account the behaviour of competitors who may have a degree of market power • Consequential costs during construction (e.g. noise, delay, congestion during, displaced economic activity etc.) • Market and policy responses to climate and technological disruptions (e.g. renewable energy and carbon pricing)

Table 7: Typical monetised benefit and cost items

Telecommunications

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs: • Investment and ongoing project expenditure, e.g. operating expenditure, maintenance costs, decommissioning costs **User value (commercial and private consumers of telecommunications) – increased surplus from:** • Reliability • Timeliness/speed • Consistency • Other quality measures – such examples include: – Health benefits (e.g. providing for remote consultations) – Education benefits (e.g. remote learning ability) – Entertainment value for individuals • Residual values **Producer value (producers of communications services) – increased surplus from:** • Improvements in business productivity due to higher speeds, greater access and improved reliability of connections • Increases in hours worked due to enabled teleworking • Expenditure avoided (e.g. savings in operating, maintenance, compliance and investment costs) • Increased communications service revenues	**Environmental:** • Changes in values associated with environmental externalities, including greenhouse gases (e.g. CO_2, CH_4, NO_x) • Climate change influencing emergency needs or reliability (e.g. due to increased extreme events) **Social/cultural:** • Changes in values associated with aesthetics and visual amenity • Reduced public health costs from improved access to information • Changes in heritage values, including Aboriginal and Torres Strait Islander sites of importance, or to historic buildings, sites and landscapes **Other:** • Competition benefits taking into account the behaviour of competitors who may have a degree of market power • Consequential costs during construction (e.g. noise, delay, disrupted services, congestion etc.) • Public safety benefits, (e.g. increased telecommunications services in remote areas can improve communication with emergency services or reducing the need to travel to work from home)

Table 8: Typical monetised benefit and cost items

Energy

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs: • Capital and ongoing project expenditure (e.g. operating expenditure, maintenance costs, decommissioning costs) **User value (commercial and private consumers of energy) – increased surplus from:** • Reliability (e.g. as outages occur less frequently and may facilitate business development) • Other quality measures • Residual values **Producer value (producers of energy) – increased surplus from:** • Expenditure avoided (e.g. savings in operating, maintenance, compliance and investment costs) • Increased energy revenues	**Environmental:** • Changes in values associated with environmental externalities including greenhouse gases (e.g. CO2, CH4, NOx) • Climate change influencing existing economic, land-use and cultural activities (e.g. due to inundation, extended periods of excessive heat and dryness, increased extreme events) **Safety:** • Change in value associated with safety improvements **Social/cultural:** • Changes in values associated with aesthetics and visual amenity • Changes in heritage values, including Aboriginal and Torres Strait Islander sites of importance, or to historic buildings, sites and landscapes **Other:** • Competition benefits taking into account the behaviour of generators who may have a degree of market power • Consequential costs during construction (e.g. noise, delay, congestion etc.) • Market and policy responses to climate and technological disruptions (e.g. renewable energy and carbon pricing)

Table 9: Typical monetised benefit and cost items

Water

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs: • Capital and ongoing project expenditure (e.g. operating expenditure, maintenance costs, decommissioning costs) **User value (commercial and private water users) – increased surplus from:** • Reliability (reliable supply for producers, avoided water restriction costs for urban users) • Quality (avoided costs of household mitigation responses) • Recreation • Residual values **Producer value (producers using water) – increased surplus from:** • Expenditure avoided (e.g. savings in operating costs etc.) • Increased agricultural production • Mining and industry production	**Environmental:** • Water quality, marine habitats, fish stocks, other ecosystem functions • Water salinity **Social/cultural:** • Changes in values associated with aesthetics and visual amenity, and other non-use impacts • Changes in public health (from water quality improvements), mental health (from prolonged drought) • Damage to public spaces, parks, etc. due to water restrictions/scarcity • Changes in heritage values, including Aboriginal and Torres Strait Islander sites of importance, or to historic buildings, sites and landscapes **Other:** • Consequential costs during construction (e.g. noise, delay, congestion etc.)

Table 10: Typical monetised benefit and cost items

Social infrastructure

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
Project costs: • Capital and ongoing project expenditure (e.g. operating expenditure, maintenance costs, decommissioning costs) **User value (social infrastructure users) – increased surplus from:** • Change in quality of social infrastructure facilities associated with changes in user amenity (e.g. WTP for an individual or attending a gallery, WTP to visit open space) • User benefits of social housing – value of additional housing, improved labour market outcomes, health, education outcomes and safety • Change in transport costs associated with access to social infrastructure • Other quality and access measures: – Health benefits – change in QALYs or DALYs; – Education benefits – change in lifetime earnings net of education costs – Entertainment value for individuals (e.g. the WTP for an individual or attending a gallery) • Change in the risk of loss of life, injury or other adverse impacts due to better emergency and justice services – change in QALYs or DALYs, and property damage • Residual values **Producer value (producers of social services and/or infrastructure) – increased surplus from:** • Expenditure avoided (e.g. savings in operating costs from better functioning of the justice system etc.) • Increased labour productivity due to better education and/or health outcomes – change in production • Incremental user fees (e.g. court fees, gallery entry fees)	**Social/cultural:** • Changes in values associated with aesthetics and visual amenity, and other non-use impacts (e.g. WTP for heritage protection, WTP to share beliefs and customs, WTP for canopy cover, change in property values due to increase in nearby open space) • Changes in public health (e.g. public health care cost savings) from: – improved health care and emergency services – increased active recreation (e.g. from additional active transport or open space) – urban cooling impacts of green infrastructure – better access to secure, appropriate, and affordable housing • Changes in labour market outcomes (e.g. tax receipt increases and welfare payment reductions) from: – improved health and education – better access to secure, appropriate, and affordable housing **Environmental:** • Changes in values associated with environmental externalities, including noise and vibration, local air pollution, greenhouse gases (e.g. CO_2, CH_4, NOx) associated with access to social infrastructure and/or reduced electricity consumption due to urban cooling impacts of green infrastructure • Change in values associated with desirable environmental outcomes (e.g. WTP for biodiversity, waterways health etc.) • Climate change influencing existing economic, land-use and cultural activities (e.g. due to inundation, or excessive heat)

Table 10: *Continued*

Private costs and benefits (for users and producers)	External costs and benefits (for the broader community)
	Safety and network: • improved safety of the community (e.g. justice system cost savings) from better access to secure, appropriate, and affordable housing • Changes in crash costs from improved access • Road network decongestion from improved access **Other:** • Consequential costs during construction (e.g. noise, delay, congestion etc.)

Valuation approaches for monetising costs and benefits

To quantify the benefits specific to each proposal, there are a range of possible approaches.

Default parameter values should be applied where these have been defined or agreed in state, territory or national guidance, for example, accepted parameters for value of time (VOT), value of a statistical life (VSL) and educational attainment impact on lifetime earnings.

Where this is not the case, you will need to develop project-specific values. The following section summarises common valuation approaches.

These different methods value benefits with varying degrees of accuracy. In general, valuations based on market prices, or other observed consumer and producer behaviour, will provide more reliable estimates of benefit values compared to non-market valuation techniques. Where justified, we generally support use of these rapid non-market valuation techniques. Where market values are not available, you should provide the rationale for the technique/ parameters chosen and the prediction of the scale of the benefits relative to each specific proposal, so that we can consider each case on its own merits.

3. **Using market prices to measure economic benefits where available.**

Market prices, where they exist, provide a great deal of information concerning the magnitude of costs and benefits. Market prices may be relevant as a signal of how much the community/businesses value the quantity or quality of the infrastructure. In such situations, demand and price forecasts for the base case and project case could be made based on the available market information.

If relevant markets are efficient, these estimates can then be used to estimate consumer and producer benefits from a project. However, **whenever there is a market failure, market prices may not reflect true marginal social costs or benefits** (for example, when there are capacity constraints or externalities). In these cases, the true marginal social cost or benefit should be measured by calculating the shadow price, which does not exist in the market, but is the true social costs and benefits reflected imperfectly in the market price.[43]

A shadow price is an estimate of a market price when a market price of a product or service is not available, such as externalities like environmental impacts, or when the market price is known to be distorted, such as where taxes or subsidies exist. For example, when making travel choices involving a congested road, the perceived cost of travel to drivers does not equal the average marginal social costs. A person might choose to drive on a congested day based on perceptions about the likely journey time and fuel costs. However, drivers are unlikely to take account of the congestion they impose on other users or the environmental impacts for the wider community. In this case, the shadow price would include the congestion costs on other users and the environmental impacts, in addition to the journey time and fuel costs.

4. **Using non-market valuation to measure economic benefits.**

Often valuations for goods or services are not reflected in market prices (for example, the value of future technologies enabled by improved quality of communications infrastructure, the value of time or the value of biodiversity). In such cases, a range of techniques are available to estimate the non-market value for the costs and benefits, which are often measured as the aggregate willingness to pay for a particular good, service or outcome.

There are two main types of non-market valuation methods: revealed preference and stated preference:

a. **Revealed preference approaches – use market/ historical data such as prices or the number of users of a service**. This method uses observations of purchasing decisions and other behaviour (for example, the number of users) to estimate non-market monetary valuations. By isolating a specific characteristic and the change in price or users, it may be possible to estimate the value placed on a particular characteristic. For example, higher prices paid for internet access with faster download and upload speeds could reveal information about the value of higher quality communications infrastructure, or the amount paid by people on tolls to avoid travel time can be used to infer the value of travel time. Similarly, people's preferences for housing – as reflected by the prices paid for property – can be used to infer the values they hold for environmental and social factors such as clean waterways or parklands.

43. Stiglitz 2000, *Economics of the public sector*, 3rd edn, Norton & Company New York.

Revealed preference methods include the travel-cost method (for example, generalised travel costs can be used to estimate an implied demand curve for visiting an unpriced attraction such as an urban green space, from which consumer surplus can be measured) and hedonic pricing methods (which isolates the influence of non-market attributes on the price of goods, see **Box 7** for further detail).

b. **Stated preference approaches – aim to simulate a hypothetical market or choice experiment for analysing preferences for the provision of non-market goods and services.** They are a survey-based method, which impute values for non-market characteristics by asking people to make choices between hypothetical policy options. The willingness to pay for a specific outcome is inferred from these survey responses. The accuracy of stated preference approaches is highly dependent on survey design and the types of outcomes being valued (value estimates for unfamiliar outcomes may be less accurate).[44]

Revealed preference methods tend to be more reliable than stated preference methods. You should transparently present the application of either application in your submission.

3. **Other rapid non-market valuation techniques.**

It is recognised that undertaking original research using revealed and stated preference methods can be costly and time consuming. However, there are approaches that can be used to provide an indication of economic value, and enable comparative analysis of options. The following discussion outlines some of these methods which lend themselves to the task of rapidly placing monetary values on benefits:

a. **Replacement-cost method** – also known as avoided costs, the cost of replacing an unpriced asset or service can be a useful measure of benefit. For example, an area of parkland may be endangered by investment in infrastructure, but perhaps it could be replaced, or an equivalent area provided. The cost of this replacement is a measure of the benefit of the parkland. The key assumption is that the replacement costs can be calculated and that they are not greater than the value of the asset which would otherwise be destroyed.

b. **Interpretation of previous decisions** – occasionally, a decision to spend or save money in a similar situation elsewhere can be interpreted to value a non-market benefit. The level of past expenditure to achieve similar benefit characteristics, in similar situations, and in similar economic circumstances, can be used as an estimate of the value of a resource. When the similarities are strong, the method is useful in providing an indication of value. It is advisable to exercise caution when using this method as the past may not be a reliable indicator of the future, particularly given the speed of technological development taking place in the infrastructure sector.

Box 7: **Hedonic modelling**

Hedonic modelling is a technique to extract the value of individual attributes from market prices. For example, suppose that a project was intending to increase accessibility to parks. One method to understand the value of better access to parks is through examining property prices, and whether properties that are close to more parkland have higher values, once other factors that influence property prices have been accounted for. That is, while there is not a direct market for access to parks, as this is a public good, the market for housing can be used to extract an implicit value for access to parks.

Sources: Rosen S 1974, *Hedonic prices and implicit markets: product differentiation in pure competition*. J Pol Econ 82:34–55.

44. Baker, R. and Ruting, B. 2014, *Environmental Policy Analysis: A Guide to Non-Market Valuation*, Productivity Commission Staff Working Paper, Canberra, available at: www.pc.gov.au/research/supporting/non-market-valuation/non-market-valuation.pdf.

c. **Benefit transfer** – benefit transfer is the process of taking willingness-to-pay estimates from one context (the 'study site') and transferring it to another context (the 'option site'). It may be appropriate to transfer an average willingness-to-pay estimate from one primary study, transfer willingness-to-pay estimates from many studies, or transfer a willingness-to-pay function. The first option is the most practised. In selecting the appropriate value for transfer a good understanding of the quality of the original study and the new context is required. The following criteria should be similar enough to ensure a valid result:
   - Physical characteristics of the two sites
   - Changes being valued in study
   - Policy context
   - Cultural and socio-economic characteristics of the populations.

d. **Other economic techniques, usually used to determine cost of carbon emission:**[45]
   - **Damage cost approach** – This approach measures the damage or opportunity costs for the society that is suffering from environmental impacts or that is repairing these impacts.
   - **Avoidance (abatement) cost approach** – This approach reflects the cost of prevention or mitigation. It involves finding the minimum cost that has to be incurred to achieve given specified levels of environmental damage reduction.
   - **Social cost of carbon (SCC)** – This approach reflects the total present value of future costs related to the emission of one additional unit of CO_2.[46] A summary value of the cost of damages, and discounting it over time in relation to CO_2 emissions, is used in order to determine the SCC.

Approach for probabilistic estimation of investment cost

The investment and operational costs of projects play a fundamental role in determining their social, economic and environmental value. It is therefore important that the capital expenditure and operating expenditure estimates used in the economic appraisal are robust and consistent.

You should detail full year-by-year costs for the lifetime of your proposal and present these as 'the expected cost'. We prefer that you **calculate expected costs using detailed probabilistic cost estimates**, which are based on the risk analysis undertaken for the project.[47] This approach provides a more accurate cost estimate and can avoid the inclusion of large generic contingencies. For more information on expected values, please see also ATAP *O1 Cost Estimation*.[48]

Both the risk analysis and the design of project options need to be considered when determining the cost estimates over the project's lifetime. For instance, there could be larger upfront costs with smaller ongoing operating and maintenance costs, or smaller upfront costs with larger ongoing staged expenses. We prefer that you include the basis of cost estimates in your submission, including specialist engineering and operations reports as supporting documentation.

Probabilistic cost estimates are generated through a probability distribution, which describes the likelihood that a value will not be exceeded.

Cost estimates are primarily presented as at P50, P90 and/or expected value. P50 and P90 costs are estimates of project costs based on 50% and 90% probability that the cost estimate will not be exceeded. The P50 cost is the median of the cost distribution, while the expected value reflects the mean value of the cost distribution.

45. See Austroads 2014, *Updating Environmental Externalities Unit Values*, Austroads, available at: austroads.com.au/publications/environment/ap-t285-14; and Austroads, 2003, *Valuing Environmental and Other Externalities*, Austroads, available at: austroads.com.au/publications/economics-and-financing/ap-r229-03.
46. See Transport and Infrastructure Senior Officials' Committee 2020, *Australian Transport Assessment and Planning (ATAP) Guidelines PV5 Environmental parameter values (Draft for Public Consultation)*, Transport and Infrastructure Senior Officials' Committee, Australian Government, Canberra, available at: www.atap.gov.au/sites/default/files/documents/pv5-environmental-parameter-values-public-consultation-draft.pdf. See also, Bruyn et al., 2018, *Environmental Prices Handbook EU28 version*, CE Delft, available at: cedelft.eu/publications/environmental-prices-handbook-eu28-version/.
47. Probabilistic project cost estimates identify cost components, determine the probability distribution for each cost component and then undertake a simulation, often a Monte Carlo simulation, to generate a probability distribution of project costs.
48. Transport and Infrastructure Senior Officials' Committee 2020, *ATAP Guidelines O1 Cost Estimation*, Transport and Infrastructure Senior Officials' Committee, available at www.atap.gov.au/other-guidance/cost-estimation/index.

If the cost distribution is symmetrical, the expected value will be equal to the P50 value (see **Figure 5**). However, if the cost distribution is positively skewed, the mean will be above the P50 value and may lie closer to the P90 value (see **Figure 6**).

Due to it being the closest estimate to final cost, **we prefer that the CBA present the central case scenario results using expected value costs**. Where the cost distribution cannot be integrated within the economic model, we favour a **P50 cost estimate, with sensitivity testing using the P90 cost estimate**.

However, we still prefer to receive **a proposal's full cost distribution at each cost point**, as it enables us to review the full shape of the curve and all the probabilities. When providing the cost distribution, you should still provide expected value, P50 and P90 cost estimates for reporting.

Box 8 provides a summary of the appropriate level of project development, design and cost estimate at each of the Assessment Framework stages.

Figure 5: Symmetrical cost distribution

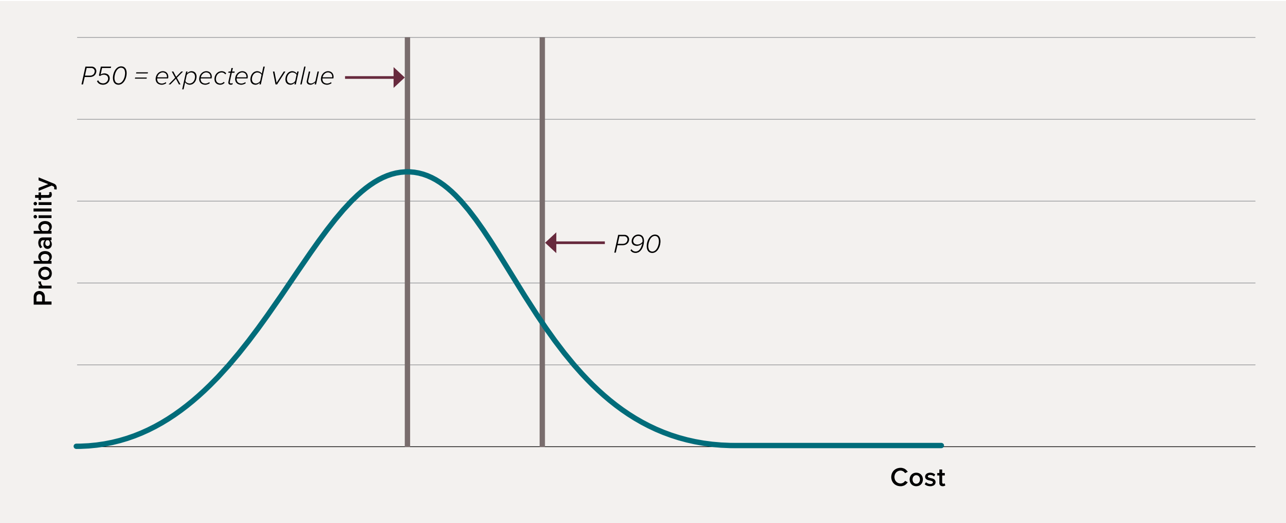
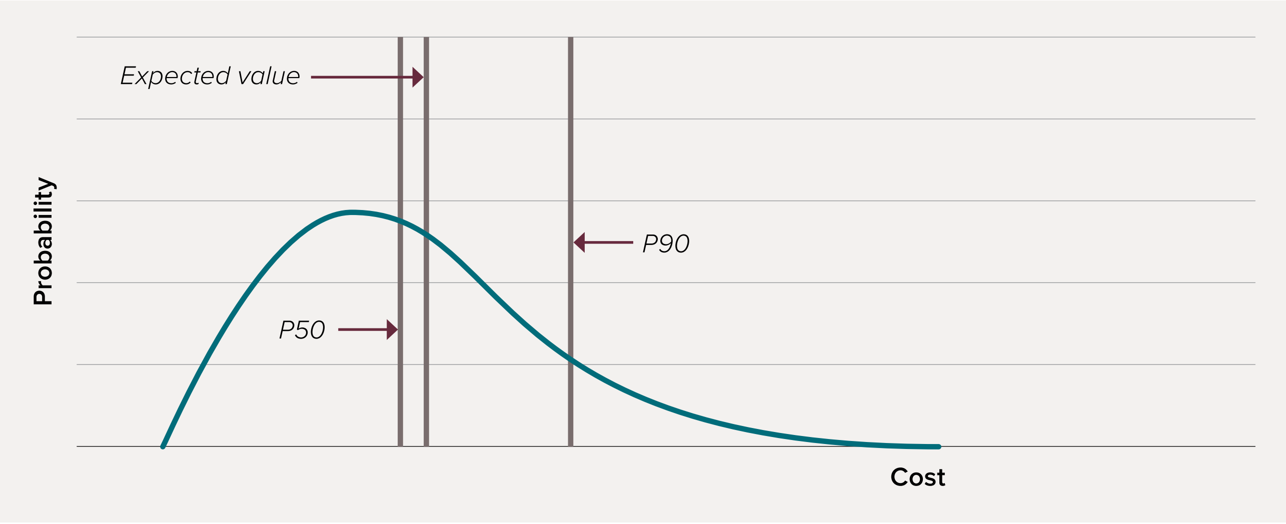


Figure 6: Positively skewed cost distribution



Box 8: **Level of project development, design and cost estimate during project development**

Having reviewed numerous proposals at varying stages of the infrastructure lifecycle, we have identified high level guidance to assist you in appropriately developing a cost estimate to inform your CBA. There are different requirements across states, territories and sectors. Therefore, we recommend you consider your relevant state, territory or sector guidance with regard to cost estimation. That guidance will also provide further explanation of the terms referred to in the table below.

The table below provides a snapshot of the appropriate level of project development, design and cost estimate during project development.

	Stage 2		Stage 3	Delivery	Stage 4
Recommended inputs to design and cost estimate	**Options identification (longlist)**	**Quantitative options analysis (filtered list)**	**Business case**	***Contract award***	**Post completion review**
Level of project design	0–5%, or usually concepts/ sketches/ descriptions	5–20%, or usually strategic/ thick pen	20–40%, or usually a Preliminary/ Schematic design	*40–90%, or usually detailed*	100%, or as built
Investigations to inform project definition	Demand modelling (current and future years) Network/ system analysis See **Stage 2** volume for more detail.	Network optimisation analysis Rapid economic appraisal Preliminary technical investigation	See **Stage 3** volume	*As required by contract and delivery model*	n/a
Cost estimate bases	Order of magnitude/ recent comparable projects	Comparative/ benchmark rates	Primarily first principles	*Tender price*	Actual
Cost estimate class/category	Proponent to nominate applicable jurisdictional or sector specific cost estimate class/category at each stage				
Quantified Risk & Contingency	40%–70%	40%–70%	20%–40%	*10%–30%*	0%–10%

Box 8: **Level of project development, design and cost estimate during project development** *continued*

	Stage 2		Stage 3	Delivery	Stage 4
Recommended inputs to design and cost estimate	**Options identification (longlist)**	**Quantitative options analysis (filtered list)**	**Business case**	***Contract award***	**Post completion review**
Cost Ranging	Low side: -20%/-50% High side: +30%/+100%	Low side: -15%/-30% High side: +20%/+50%	Low side: -10%/-20% High side: +10%/+20%	*Low side: -5%/-10%* *High side: +5%/+20%*	Low side: -0%/-5% High side: +0/+10%
Probabilistic Risk	n/a	P50/ Expected Value for financial and economic	P50/P90/ Expected Value for economic and financial	*P50 & P90 for financial*	n/a
Estimate confidence level	Low	Low	Moderate	*High*	Certain
Usage	Project initiation and planning budget	For shortlisting	For investment and budget allocation	*For construction*	For post completion review

We understand the implications of either insufficient funding or time for appropriate technical investigations on the level of confidence in the cost estimate. Where these are identified as constraints or limitations, we will identify these as risks in our evaluation. Key considerations to be highlighted by you, and key deliverability risk areas that will be reflected in our evaluations, include:

1. **Planning / business case budget:** The level of project definition and design to inform cost estimates is directly linked to the planning budget available to complete a business case. For example:

- Where **limited funding** is available, risk adjusted P50/P90 and Expected Value cost estimates will need to appropriately consider and make assumptions regarding:
  - site issues, constraints, ground conditions
  - materials, quantities
  - other major risks associated with the project.
- Where there is **sufficient funding**, appropriate levels of investigation and design are able to be carried out to inform the Stage 3 business case cost estimate, with investigations potentially including:
  - geotechnical, site investigations
  - environmental approvals
  - demand modelling
  - preliminary/schematic design.

Box 8: **Level of project development, design and cost estimate during project development** *continued*

2. **Timeframe:** The level of project definition and design to inform cost estimates is directly linked to the timeframe available to complete a business case, for example:
   - where **limited time** is available, time should be dedicated to informing material elements and key risk areas for the project
   - where **sufficient time** is available, appropriate site investigations can be scheduled and completed to inform the Stage 3 business case.

3. **Delivery Model:** The level of project definition and design is also linked to the delivery model for the project, for example:
   - a design *then* construct model will require further design by the principal, noting this may occur as part of, or after Stage 3
   - a design and construct model (plus maintenance variants) requires a preliminary design to allow the D&C team to further develop and potentially innovate the design
   - a PPP model requires only a preliminary design to allow the PPP consortium to further develop and potentially innovate the design.

We also support the adoption of the following practices when estimating and presenting costs:

- Base case and project options include all relevant capital, land acquisition, maintenance, replacement and operating costs. Also include all reasonable external costs, such as wider network impacts.
- Capital expenditure (or 'Capex') estimates be presented separately from operating expenditure (or 'Opex') estimates. Capex should be supported by significant in-depth analysis.
- Be in real costs. That is, they must exclude the general escalation of prices (but include real escalation of prices) and the cash flow must be in real terms. For example, a CBA being conducted in 2021 would monetise all future costs and benefits in a 2021 price base. These costs and benefits would not be escalated for general inflation that affects all prices. However, if it is established that some of these elements are likely to clearly and significantly grow over and above background inflation, then you may use real escalation of the costs or prices used to value benefits.
- Land and property costs should reflect their market value. In some cases, total sum of land acquisition completed for a proposal will be excess to final requirements. The land cost reflected in the CBA should reflect only the net cost after resale of expected surplus land. See **Appendix E** for additional guidance on capturing the residual value of land.
- Only include cost elements to be realised after the decision to proceed with an initiative. Any costs incurred prior to that are 'sunk costs' and should be excluded from the CBA.
- You should also prepare an appropriate work breakdown structure to present the project costs and include it with your submission.
- All cost estimates should be rigorously tested in addition to being independently reviewed and verified.

For transport infrastructure proposals where Australian Government funding may be sought, it is recommended that you follow the capital cost breakdown and escalation approach outlined by the Department of Infrastructure, Transport, Regional Development and Communications.[49]

Box 9: **Identified common causes of ex-ante forecast cost errors**

There are a number of common causes of ex-ante cost forecast errors identified in published studies:

- premature cost announcement prior to detailed analysis and lack of cost re-evaluation
- project scope changes
- cost overruns are more likely and larger for large projects (defined as those that cost over $500 million), for reasons such as:
  - cost forecasts not accounting for project complexity and interrelated components
  - there are more interdependent elements, any one of which could suffer a setback that flows through to other elements
  - project delays are longer if projects are approved and undertaken in periods of significant public investment (a 'hot market')
- cost forecasts not accounting for industry/mode specific differences in the size and timing of project costs.

Sources: Terrill, et al, 2020, *The rise of megaprojects: counting the costs*, Grattan Institute, Carlton, available at: https://grattan.edu.au/report/the-rise-of-megaprojects-counting-the-costs/; and Flyvbjerg, et al 2004, 'What Causes Cost Overrun in Transport Infrastructure Projects?', *Transport Reviews*, vol. 24, no. 1, January, pp. 3-18.

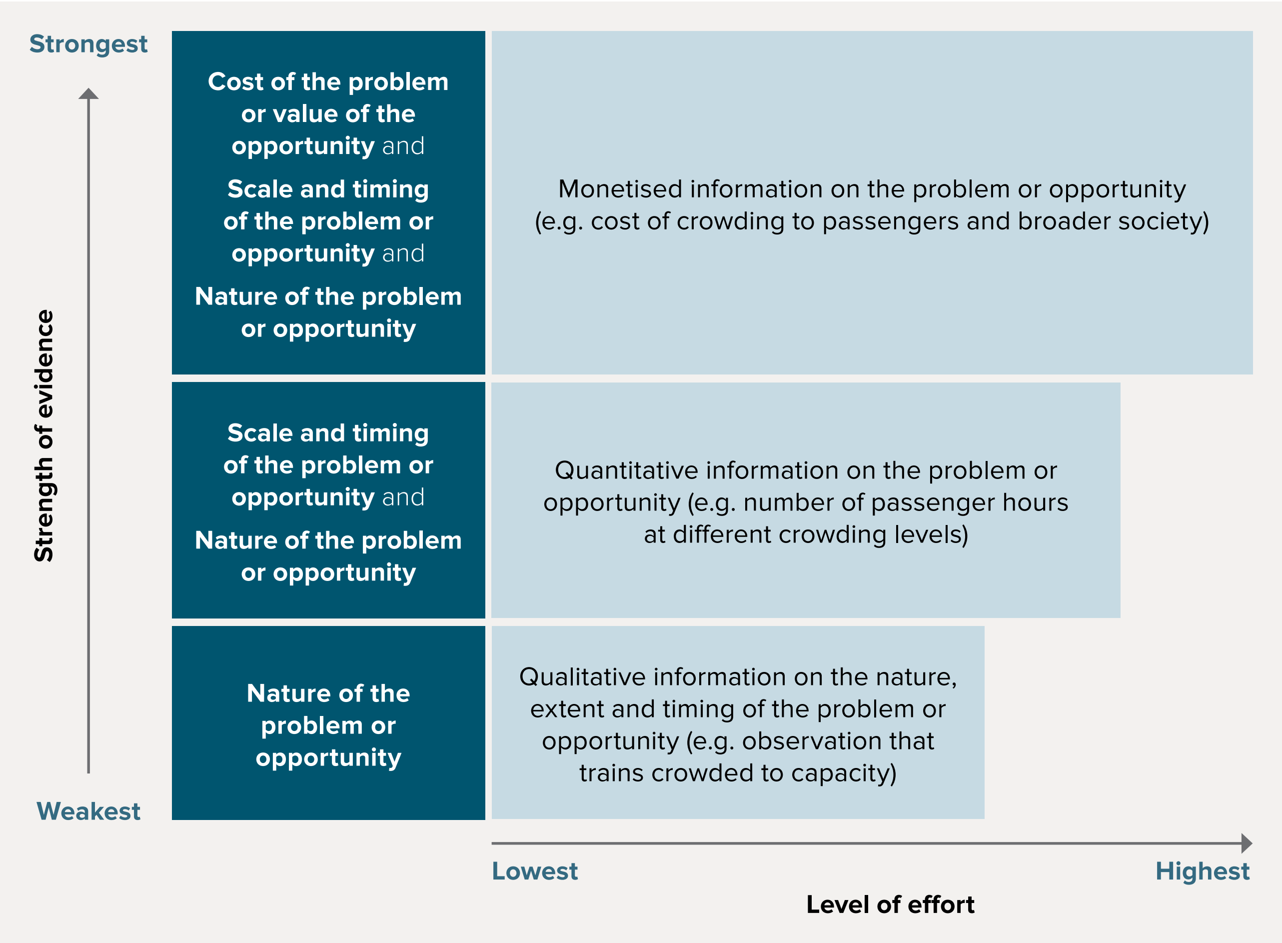
49. Department of Infrastructure, Transport, Regional Development and Communications, *Cost Estimation Guidance*, Australian Government, available at: investment.infrastructure.gov.au/about/funding_and_finance/cost_estimation_guidance.aspx.

2.7 Step 6: Identify non-monetised impacts

Where possible, costs and benefits should be monetised, but this may not always be possible. In such cases, qualitative analysis of the costs and benefits should be prepared and presented alongside the CBA results in accordance with the guidance in the Assessment Framework. Ultimately, reports should enable the costs and benefits of a proposal to be comprehensively understood.

We consider monetised information to be the strongest form of evidence, as shown in **Figure 7**. Monetised information should be supported by estimated quantitative and qualitative descriptions to explain the effects. This information may come from detailed simulation models or be based on recent and relevant studies such as surveys and consultation.

Figure 7: The three tiers of evidence for costs and benefits



Non-monetised costs and benefits

A CBA should identify all direct costs and benefits (that is, those directly attributable to the project), then quantify and monetise these where possible.

However, there may be some instances where impacts cannot be monetised due to uncertainty around the magnitude of the impact being measured. Also, in some instances, it may be very costly to monetise an impact using a willingness-to-pay survey or other approaches. If the impact is expected to be minor and unlikely to affect decision-making, the additional cost of monetising the impact may not be prudent.

Examples of impacts that may be difficult or costly to monetise include:

- cultural or heritage impacts
- indigenous values
- visual amenity/landscape
- biodiversity
- indirect mental and physical health impacts.

It is important to document non-monetised quantitative and qualitative impacts as part of the analysis as they may provide important information for decision-makers to fully understand the impacts of the option being considered. Non-monetised impacts should be presented alongside the monetised impacts to account for the full range of effects of the options.

If impacts cannot be monetised, you should quantify the impacts. Where benefits cannot be quantified, you should qualitatively describe them:

- **Quantify, but not monetise impacts**. This approach may be used where there are difficulties in monetising specific costs and benefits, in particular where the necessary evidence base has not been developed. Quantification provides an indication of the challenges or opportunities faced, but may not capture the overall magnitude of the problem. When the problem is quantified, but not monetised, it is useful to provide benchmarks for comparison and the number of stakeholders impacted, to demonstrate the magnitude. Quantified information should be accompanied by qualitative information linking the problem or opportunity to societal welfare. Quantitative impacts should include reference values for a comparison group or service standard to give context of the nature and scale of the impacts.
- **Qualitative description of the impact only**. In general, you should quantify and/or monetise the problem. However, this may not be possible for benefits where appropriate tools or data do not exist. Where this is the case, qualitative descriptions of the impacts should be provided and supported by evidence.

Non-monetised costs and benefits identified for the appraisal should align with a CBA framework and demonstrate a clear link to the project. They should also be analysed on an incremental change basis (as per monetised costs and benefits). That is, the non-monetised costs and benefits of each option should be compared with the base case.

Note that quantitative and qualitative measures are not easily comparable like monetised costs and benefits, as applying monetary values weights the relative importance of impacts. These characteristics require the judgement of decision-makers, which may vary from person to person, depending on the circumstances.

Equity and distributional effects

The benefits of proposals are often not uniformly distributed across the population. CBA does not explicitly take this into account, as it is generally conducted from the perspective of society as a whole. For some projects, understanding the distribution of costs and benefits may be critical to their economic analysis. Among other reasons, understanding how the project effects different groups is useful to measure performance against stated strategic objectives for equity, such as improving economic and social development, or levelling-up of disadvantaged areas or communities.

You should describe and analyse as best as possible the distributional effects of the change resulting from your proposal. An indication of the scale of those effects is also desirable at both a spatial and temporal level. We recommend the use of maps, diagrams and charts to help illustrate the scale of those effects.

Distributional analysis is the favoured method to analyse the distributional effects of a project. The key steps in undertaking a distributional analysis are:

1. Identify the key groups of interest for the analysis.
2. Allocate costs and benefits from the CBA to the identified groups.
3. Consider whether any of these costs or benefits may be shifted to another group.
4. Include any transfer payments that have not been included in the CBA, and consider which groups are impacted.
5. Consider whether the impacts not monetised in the CBA are likely to affect groups in different ways.

For items that cannot be monetised and included in a CBA or a distributional analysis, completing a descriptive analysis can demonstrate a project's differential effects. Stages 1 and 2 of the Assessment Framework provide advice on how to best complete this analysis. The key steps to complete a descriptive analysis are:

1. Describe the benefit or cost related to the overarching problem or opportunity identified in **Stage 1** of the Assessment Framework.
2. Establish the link from the service and infrastructure to the identified benefit or cost.
3. Determine the anticipated magnitude of the benefit or cost, using quantitative indicators where possible. Where impacts are not able to be quantified, you should describe relevant benchmarks (such as relevant regional or national comparisons) and government objectives for comparison.
4. Provide evidence of the anticipated impact, which could involve reporting on survey outcomes or insight from relevant academic literature.

2.8 Step 7: Discount costs and benefits to determine the net benefit

Costs and benefits generally arise throughout the life of projects. These need to be discounted back to the base year to calculate their present worth or present value. Discounting reflects the view that a dollar received in the future is worth less than a dollar today. Present values allow for decisions to be made in the present about proposals that have costs and benefits in the future.

The discount rate used is a critical factor in the project appraisal. High discount rates place relatively low values on costs and benefits that occur in the far future. Low discount rates attribute relatively comparable values to costs and benefits occurring in the far future, compared to those occurring in the near future. A high discount rate will favour projects where benefits occur sooner rather than later and disadvantage projects where it takes a long time for benefits to ramp up. Please see **Section 2.4** for further guidance on the discount rate.

The recommended central discount rate is 7% (in real terms). Sensitivity testing should be undertaken at 4% and 10% (in real terms).

Economic measures

The outcomes of an economic appraisal or a CBA are conventionally presented as measures of net benefit for each option, incremental to the base case. These include but are not limited to:

- net present value (NPV)
- benefit–cost ratio (BCR)
- other useful measures, such as:
  - net present value per dollar of capital investment (NPVI)
  - first-year rate of return (FYRR).

You should report the NPV and the BCR for all options analysed. A NPV greater than zero and a BCR greater than one both indicate that the benefits exceed the costs of a proposal. Options where costs are greater than benefits in present value terms reduce overall social welfare – that is, while they could have positive impacts on a local community, they will result in an overall cost to broader society and the economy.

The NPV and BCR provide similar information about whether benefits exceed costs or costs are greater than benefits. When multiple proposals are being prioritised, budget constraints can heavily influence decision-making. Differences in rankings may emerge between the NPV and BCR approaches under budget constraints. In this case, the preferred approach is to rank proposals on the basis of the BCR.

Net present value

The NPV is the difference between the present value (PV) of benefits and the present value of costs. It should be calculated using the following formula:

***NPV** = PV of benefits – PV of costs*

The NPV should be presented in real values (constant prices) in the current year, generally expressed in $ millions. A positive NPV indicates that the project has economic merit.

Benefit–cost ratio

The BCR could be calculated in a number of ways.

Consistent with the majority of state and territory guidelines, we recommend the use of the following formula:

***BCR** = benefits* / (investment costs + net increase in operating costs **)*

* generally represented by the PV of total benefits
** generally represented by the PV of total costs

These benefit and cost measures are incremental to the base case and discounted over the appraisal period (that is, present values).

A BCR equal to or greater than 1 for the central case indicates that the project has economic merit (that is, the present value of benefits exceeds the present value of costs) and is used to rank projects in a budget-constrained environment.

We recognise that some guidance may require calculation of BCR using an alternative formula, where only the change in capital investment cost is presented in the denominator. In this case all other effects are put in the numerator, including any change in operating costs. The formula for this calculation (sometimes referred to as BCR type 2 or BCR2) is:

***BCR2** = (PV of total benefits – PV of net increase in operating costs) / PV of total investment costs*

To calculate the BCR, you should use the expected value of costs. In the absence of the expected value, a P50 or P90 estimate can be used for central case analysis, although we suggest using P90 as a sensitivity.

Other useful economic measures

Net present value per dollar of capital investment

NPVI is a measure of the overall economic return of a project in relation to its requirement for initial capital expenditure and is used where there is a constraint on the availability of capital funds. It is defined by dividing the NPV by the present value of the investment costs:

***NPVI** = NPV / PV of investment costs**

*generally represented by the PV of capital expenditure

NPVI is exactly equal to BCR2 minus one. Therefore, if BCR2 is provided, there is no value in providing NPVI.

NPVI is the capital efficiency ratio and also used to rank projects in a budget constrained environment as it measures the total benefit received for each dollar of capital expenditure incurred. The project with the highest NPVI is chosen when there is a constraint on capital.

First-year rate of return and project deferral

Considering the optimal timing of a project is critical for projects where long appraisal periods are used, because modelling results for long horizons, such as 20 years or more, are less reliable than those in the near term. If a project's benefits are small in the near future and rely heavily on future modelled benefits growing substantially, then the project may not be a priority now. It could instead be re-evaluated at a future date to confirm that the forecasts have materialised. This could be tested through a deferral test, as described in the **Guide to risk and uncertainty analysis**.

FYRR is a measure of the value delivered by a project in its first year of operation. It can provide insight into whether a project's intended date of operation is early, late or appropriate. A FYRR below the discount rate suggests the project could be delayed in order to deliver optimal value. Conversely, an FYRR significantly greater than the discount rate suggests that it may be worth delivering earlier, if possible.

FYRR is calculated as:

FYRR = first year net benefits discounted to year 0 / discounted total cost

The first year net benefits are measured as benefits less operating costs, discounted to the start of the valuation period. The discounted total cost is generally the present value of capital expenditure.

2.9 Step 8: Analyse risks and test sensitivities

We are aware that economic growth, individuals' behaviour, commodity prices, pandemic risks, natural disaster risks, carbon prices, climate risks and so on may vary over time with some level of uncertainty. To ensure that the CBA process is robust to potential changes, we request a series of sensitivity tests of the demand and cost modelling and the CBA results, including testing for robustness across a range of future scenarios, where appropriate. You may also directly incorporate risk into your analysis using real options analysis.

Broadly, our recommended approach is to:

1. **Identify risks and uncertainties** that relate to the project.
2. **Test sensitivities to changes in assumptions and parameters** – test how the costs and benefits of each option change if there is a change in a particular assumption or set of assumptions. This may include cost variations, demand uncertainty and project deferral, as well as any other key assumptions and parameters. See **Box 10** for our recommended sensitivity tests. It is worth noting that a worst case sensitivity test may be a useful adjustment for the effects of optimum bias.
3. Apply additional approaches where there is significant risk or uncertainty in project cost and benefit estimation, such as:
    a. **Scenario analysis** considers a range of alternative future states, called 'scenarios', which could occur and analyses how options perform under these scenarios. Scenario analysis is the first step in real options analysis, and can be useful even if a full real options analysis is not undertaken. In addition, while it is often conventional to assume a fixed scenario in the base case for many proposals (particularly transport proposals), it is good practice to model at least one future alternative scenario in the base case for large, long-lived investments.
    b. **Real options analysis** considers different future scenarios which could occur and how alternative strategies or projects perform under these scenarios. Based on this analysis, the project can incorporate flexibility into the investment in response to uncertain future outcomes and value how this flexibility impacts the costs and benefits.

Detailed guidance on considering risks and uncertainty is provided in the **Guide to risk and uncertainty analysis.**

Box 10: **Our recommended sensitivity tests**

Table 11 identifies the minimum standard sensitivity tests and ranges that should be carried out for project proposals (in the absence of proposal-specific sensitivities). We encourage you to refer to sector-specific guidance and our **Guide to risk and uncertainty analysis** for further guidance in undertaking sensitivity analysis.

Table 11: Our recommended sensitivity tests applied at the business case stage

Test	Ranges used
Discount rate	4% and 10% (around a central case value of 7%)
Under/over estimation of capital costs	±20% of value used (expected value, P50 or P90). If P50 used, then test P90 as a sensitivity
Under/over estimation of maintenance and operating costs	±20% around central estimate
Best case sensitivity tests	Simple: Assume -20% total costs and +20% benefits. Complex: Assume upside adjustments for 4–5 key variables
Worst case sensitivity tests	Simple: Assume +20% total costs and -20% benefits. Complex: Assume downside adjustments for 4–5 key variables
Deferral test	*If the proposal presents marginal value for money and first-year rate of return (FYRR) is less than the discount rate:* defer cost and benefit cash flows by five years to test whether the CBA results (net benefits) improve because of the deferral of the project.

Test project deferral where the proposal does not present value-for-money

This test can be applied to any project, but **we recommended a deferral test if the proposal is marginal** (as a guide, this may be where the BCR is less than 1.2) **and the first-year rate of return (FYRR) is less than the discount rate**. This tests whether deferring the project by five years improves the net benefits of the proposal. However, we encourage you to contact us for assistance in determining the appropriate deferral period to use.

As an alternative to a deferral test, the FYRR also helps to identify the most economically efficient time to construct the project. If a project has a FYRR below the discount rate (that is, 7%) then you should defer the project until the FYRR either equals or exceeds the discount rate.

The purpose of the deferral test is to provide insight about the appropriateness of the investment's timing. For example, if a major capacity expansion is completed well in advance of the levels of demand that require this added capacity, deferring the project will generally increase the returns because:

- the present value of costs is likely to fall as capital expenditure is delayed and discounted
- the present value of benefits will not fall by as much because the early years of the investment will provide few benefits as the existing capacity is sufficient, but the major benefits will still occur over the same time period as the non-deferred option
- the likely outcome is that the net benefits will increase.

See the **Guide to risk and uncertainty analysis** for further detail on deferral tests.

Probabilistic cost–benefit analysis

Probabilistic modelling approaches can be useful for high-risk and large-scale infrastructure projects, where significant variances in cost and benefit estimates are expected. This involves applying probabilistic distributions to the key variables likely to determine project costs and benefits, within the CBA model itself.

These are then used to generate the probabilistic distribution outputs – for NPV, BCR and other decision criteria. **This raises the complexity of the analysis and is not something we expect to be routinely applied**, but may be relevant for proposals where there is significant risk or uncertainty. If you are not sure whether you should adopt this approach, please consult with us to discuss whether it is appropriate.

ATAP *T7 Risk and uncertainty assessment*[50] provides more detail on applying probabilistic CBA.

2.10 Step 9: Report on CBA results

CBA reporting and quality control

We require documentation of the CBA to support business cases submitted to us for assessment. This should document the methodology and assumptions for measuring costs and benefits of the project, then present the results and recommendations.

The report should include all information required to understand the analysis and recommendations. **Stage 3** of the Assessment Framework includes a checklist of required inclusions in the CBA report, or CBA component of an appraisal report. While the checklist is at a high level, in order to be of relevance to a wide range of applications, it aims to promote consistency across states and territories in the way CBA is reported.

The CBA report should also include the outcomes of independent peer reviews of the CBA, as well as key inputs including both the demand forecasts and the cost estimates (see **Section 2.4**).

Aims of the CBA report

The CBA report should be sufficient to provide:

- confidence in the methods applied to estimate costs and benefits
- transparency of the results, which will constitute a major contribution to deciding whether the project should proceed or not
- confidence in the robustness of results to appropriate risk analysis
- an understanding of how the analysis has informed the recommended option
- sufficient information to facilitate replicability of results
- information to support future post completion review or ex-post assessment.

We require the CBA report to:

- introduce the project, existing problems, issues or opportunities and the CBA
- explain the base case and the options analysed
- describe the CBA method including the general appraisal parameters, demand and other inputs, the estimation and monetisation of costs and benefits including the equations/formulae, parameter values and data used in estimating each benefit item:
  - these can be demonstrated through the economic appraisal spreadsheets, showing individual benefit and cost flows over the appraisal period, clearly differentiating between the outcomes for the base case and the respective options and the derived incremental results between them
  - provide a detailed description of assumptions, valuation approaches, parameter values and user data that was used to estimate each benefit over the appraisal period
- provide the CBA results for all analysed options including a breakdown of costs and benefits. The results section should also include sensitivity test results, comparing them to the central case
- describe the CBA conclusions on the preferred option.

50. Transport and Infrastructure Senior Officials' Committee 2020, *ATAP Guidelines T7 Risk and uncertainty assessment*, Transport and Infrastructure Council, Canberra, available at www.atap.gov.au/tools-techniques/risk-uncertainty-assessment/index.

If a 'Cost–benefit analysis approach document', as described in **Section 2.4**, has been completed, the CBA report can simply build on it to provide the results, sensitivity tests and conclusions.

We recommend you refer to ATAP *T2 Cost Benefit Analysis*[51], which provides detailed guidance on CBA documentation and reporting.

Reporting benefits

To aid the interpretation of results, benefits should be reported in sufficient detail that all the benefits of the project can be clearly understood. Principles for clearly reporting benefits include:

- Place the key benefits first, that is, the benefits that relate to the problems and opportunities being addressed (identified in **Stage 1**) and the benefits with the largest value. These are the main reason for undertaking the project and whether or not a project has economic merit will typically depend on these benefits. This also helps to demonstrate whether the key benefits align to the original problems and opportunities that the project is seeking to address, supporting the strategic case for the project.
- Separate out benefits for base case users and for induced or new users, to provide transparency about the beneficiaries.
- Separate out benefits for users of the project to benefits arising to third parties – for example, third party benefits for a public transport project could include road users who benefit from reduced congestion, or community impacts from reduced air pollution, greenhouse gas emissions and noise.
- Report unconventional or less certain benefits last, such as WEBs and land use impacts, as the economic merit of a project should not rely on these benefits. As described in our land use (**Appendix C**) and WEBs (**Appendix D**) guidance, these should be presented 'below the line' when reporting CBA results.
- Report qualitative benefits that cannot be monetised in the same table as monetised benefits to provide a holistic view of the benefits of the project and what has been able to be measured. An Appraisal Summary Table (AST) can be used to succinctly capture both the qualitative and quantitative elements of the proposal alongside the monetised CBA outputs. See **Section 2.6** of the **Stage 3** volume for an example AST.

Reporting results

We recommend the economic appraisal or CBA results should present with and without conventional economic benefits where land use impacts and/or WEBs have been estimated, for example:

- Present conventional CBA results – showing NPV, BCR etc. without land use impacts and WEBs
- Then present the land use impacts by category, if justified, and show results combined with conventional economic benefits – NPV, BCR etc.
- Then present the WEBs by category, if justified, then show CBA results – NPV, BCR etc, combined with land use impacts and WEBs.

An example for presenting the economic appraisal or CBA results based on the certainty in estimation approaches of benefits is presented in **Table 12**.

We require the CBA model to be provided as part of your submission, including detailed calculations – that is, the model is not 'hard-coded'.

To present the results of your risk analysis, we suggest presenting the key economic measures for each test (for example, for each sensitivity) in a single table alongside the central case CBA results. This will include our recommended sensitivity tests, as well as the results of any additional sensitivity, scenario or real options analyses. You should support these results with relevant explanations to allow decision-makers to understand the results and their implications for the proposal.

51. Transport and Infrastructure Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, p. 19.

Table 12: Example of presenting CBA results

Costs and benefits	Present value ($ millions 202X)
Benefit 1	
Benefit 2	
Benefit 3	
[Insert rows as required, e.g. to separate existing and new user benefits]	
Total benefits	
Capital costs	
Operating costs	
Maintenance costs	
Total costs	
NPV	
BCR	
FYRR	
Higher value land use impacts	
Second round transport benefits	
[Insert rows as required for sustainability, public health and other land use benefits]	
Total land use impacts	
NPV with land use impacts	
BCR with land use impacts	
FYRR with land use impacts	
Agglomeration WEBs	
Labour market tax WEBs	
Imperfect competition WEBs	
Total WEBs	
NPV with land use impacts and WEBs	
BCR with land use impacts and WEBs	
FYRR with land use impacts and WEBs	

3

Rapid cost–benefit analysis


EV PARKING
ELECTRIC CAR BAY

3.1 Overview of rapid CBA

Undertaking detailed CBA on a longlist of options (during **Stage 2** of the Assessment Framework) can be expensive and time consuming. A rapid CBA is useful for introducing more rigour to the options analysis process to filter out inefficient options from the longlist, by applying a quantitative economic analysis methodology without the time and cost of a detailed CBA. **We do not recommend using rapid CBA to select the preferred option**. Our recommendation for using rapid CBA aligns with all states and territories where guidance exists.

A rapid CBA applies standard CBA principles and techniques to compare multiple options using the present value of benefits and costs. Rapid CBA focuses on quantifying the most material economic costs and benefits only, and has a lower level of precision about design, costs and benefits. The benefits of rapid CBA include:

- reduced cost and time compared to a detailed CBA
- increased objectivity and rigour compared to other tools such as strategic review and MCA (see **Stage 2** volume)
- analysing options using a common measure, allowing comparison between options based on a high-level value-for-money analysis.

In practice, there is a spectrum of detail for analysis of options, and 'rapid' simply means less rigorous than a detailed CBA. The level of detail should be sufficient to justify removing options from further analysis. If rapid CBA provides a high level of certainty that an option will be more costly and achieve lower benefits than another option, then this is generally sufficient to remove the option from further analysis.

To ensure robustness and objectivity of the rapid CBA, the same approach to simplifying assumptions must be applied across the options considered. For example, you should not use specific parameters or a P90 cost on one option, while using general parameters or a P50 cost on another option.

3.2 Comparison between rapid and detailed cost–benefit analysis

To assist you in scoping the approach and requirements for rapid CBA and detailed CBA, **Table 13** summarises the key differences between each tool. **Box 11** provides a worked example of applying a range of simplifying assumptions to conduct a rapid CBA for a mass transit investigation, compared to the approach that would be taken for detailed CBA.

In the context of the Assessment Framework, rapid CBA should not be used for detailed analysis of the shortlist of options as part of determining the preferred solution (that is, Stage 3 assessment). Detailed CBA is required to provide the appropriate level of rigour.

Table 13: Comparison between rapid CBA and detailed CBA

Element	Rapid CBA	Detailed CBA
Purpose	Quantitative comparison of options to identify a shortlist for further development and detailed analysis. Should not be used to inform the selection of the preferred option, or as a robust value-for-money analysis of that option.	Quantitative comparison of a shortlist of options to assist in identifying the best option for society. Required to inform selection of the preferred option and provide a robust value-for-money analysis of that option.
Approach	Similar to a detailed CBA, but focuses on the most material costs and benefits, applying simplifying assumptions. Less sensitivity analysis compared with detailed CBA, but sufficient to test the robustness of parameters and assumptions. The output will be used to inform selection of a shortlist of options for detailed analysis by demonstrating the potential to deliver net economic benefits.	Detailed, robust analysis of all relevant costs and benefits using parameters and inputs specific to the project location and to a higher degree of accuracy compared to rapid CBA. This process would include thorough sensitivity analysis to test the robustness of the inputs. The output will provide confidence in selecting the preferred solution.
Base case specification	Fully define the do-minimum base case that was considered at a high level during Stage 1.	The same specification as used for the rapid CBA.
Defining demand	Demand will depend on the information and tools available and the level of detail of the rapid CBA. It may be specific to the options (e.g. using high-level simulation models) or be based on the most recent and relevant demand studies where specific models are not available (e.g. basing demand on past studies for this proposal or using demand studies for similar projects in the broader region).	Defining demand would likely involve the use of detailed simulation models (e.g. transport, hydrology and energy), relevant demand studies and primary research such as surveys and consultation. Demand models and outputs would be peer reviewed.

Table 13: *Continued*

Element	Rapid CBA	Detailed CBA
Costs	Cost estimates (may be a deterministic approach) should include all major costs to realise the benefits, including capital and operating costs. As the level of option definition and design will depend on the project, costs should be based on the best available information. This may be based on concept or strategic level of design, or, where not available, benchmarks for similar projects (see **Stage 2** volume). Care should be taken when interpreting results as cost accuracy will be low. For example, for an energy transmission project, rapid CBA could apply per km benchmark costs and typical connection and maintenance costs.	All costs to realise benefits integrated into the CBA probabilistically and subject to peer review. The scope/design of the project should usually be at a preliminary/ schematic level of design (See **Stage 3** volume).
Benefits	Prioritise estimating benefits that are likely to make up the majority of the total. For example, for a rail project it is probably essential to include travel time savings. Benefits that are less important, such as station amenity, might be omitted unless they are easily estimated and likely to influence the relative option performance.	Include all economic, social and environmental benefits and disbenefits, linked to the detailed simulation models.
Risk and uncertainty	Uncertainty addressed through sensitivity analysis using changes to deterministic parameters. For example, testing 'worst-case' (e.g. 20% reduction in benefits and 20% increase in costs) and 'best-case' (e.g. 20% increase in benefits and 20% reduction in costs) scenarios.	Standard and project-specific sensitivity testing of the key drivers of risk and uncertainty for cost and benefit streams. Scenario testing of the results for future plausible scenarios, such as climate and population change. Cost uncertainty modelled through probabilistic cost streams using stochastic techniques (e.g. Monte Carlo analysis). Results presented using expected NPVs and BCRs as well as percentile ranges.

Box 11: **Worked example of rapid CBA of a mass transit opportunity**

A transport corridor in a major city has experienced population growth of over 50% in the past 10 years. In comparison, the population of the city overall has increased by 20% over the same period. The corridor lacks any form of rapid public transit, presenting an opportunity to increase mobility and influence travel behaviour.

The transport corridor connects growing residential areas, major employment centres and the city's central business district. Outside of the transport corridor is an existing heavy rail network.

Stage 1: Identifying the problems and opportunities

Identified problems include a lack of connectivity, road congestion and poor urban amenity in activity centres, urban sprawl and a lack of equitable access to employment centres.

Identified opportunities include influencing long-term travel behaviour in the growth area, improving access to employment centres and supporting higher-value land use through integrated transport and land use planning.

Stage 2: Identifying and analysing options

A wide range of interventions are identified to connect the growth areas to the existing heavy rail network, as well as non-build solutions such as demand management and regulatory reform. This identified a longlist of modal/route options described below.

Filtering options through strategic assessment followed by multi-criteria analysis (MCA)

Following our suggested options filtering approach, the proponent conducted a strategic review and then an MCA to analyse how options performed against the city's strategic objectives and the problems and opportunities identified in Stage 1. As a result, the initial long list was narrowed down to 10 feasible options.

The proponent used an enhanced MCA for further options analysis, which included quantitative analysis of costs and technical feasibility impacts, to develop a filtered list of four options, in addition to the base case:

- **Option A** – a new heavy rail line connecting directly to the CBD using a partially tunnelled route.
- **Option B** – a new light rail line with the same alignment as Option A, but shorter distance.
- **Option C** – a new heavy rail line connecting to the existing heavy rail network outside the CBD.
- **Option D** – a BRT solution following a similar alignment to Option C and interchanging with a station on the existing heavy rail network.

Rapid CBA

Rapid CBA was conducted to provide a preliminary value-for-money assessment to determine which of the four options should be assessed using detailed CBA in Stage 3.

The approach for rapid and detailed CBA is fundamentally the same. The differences relate to the levels of confidence and accuracy of inputs used to estimate project costs and benefits, as well as using simplifying assumptions and parameter values to provide an indicative assessment. For example, capital costs are estimated at a lower design maturity level and include only major items, while only major benefits are estimated.

Table 14 compares the methodology, input assumptions and output components for rapid CBA and detailed CBA.

Box 11: **Worked example of rapid CBA of a mass transit opportunity** *continued*

Table 14: Comparison of rapid CBA and detailed CBA

Inputs	Rapid CBA	Detailed CBA
Appraisal period	50 years from project commencement	50 years from project commencement
Annualisation factor	Based on standardised values provided in ATAP guidelines.	Based on analysis of customer travel data specific to the project area.
Transport modelling	Travel behaviour is estimated using initial strategic travel model outputs and supplemented by existing model outputs from previous and related investigations. While the model was specific to the options assessed, inputs to the model may be lacking. For example, a simplified number of trips and less definition of operational inputs (timing, stopping patterns etc.). Assumptions are based on the latest land use data and projections, conservative analysis of historical data for public transport travel behaviour and considering the observed impacts of the opening of other recently opened rail lines.	Travel behaviour is estimated using updated strategic travel model outputs based on the latest available data. This includes detailed forecasting to apply validated inputs as relevant. Updated inputs include: • Project case definitions based on refined options. • Latest peak and off-peak data on public transport and private vehicle trips. • Latest census and land use inputs.
CBA model	The key focus for this investigation is the benefits for new and existing public transport users. Primarily, this will be through reduced travel time (in-vehicle and waiting time). Benefits from reduced crowding and improved amenity may be estimated using demand and simplified parameter values (e.g. from ATAP). The rapid CBA model uses road decongestion as an estimate for travel time savings and vehicle operating cost (VOC) savings. This is calculated using a constant cents-per-kilometre rate. It applies a resource cost correction to estimate the saving in unperceived VOCs for users who switch from the road network to using public transport. Additional simplifications include: • Reduced road crashes based on a vehicle kilometres travelled and standard parameter values – rather than say a crash estimator based on transport models. • Externalities measured using parameter values.	The benefits for new and existing public transport users are estimated from specific service plans and demand studies. Benefits from reduced crowding and improved amenity are estimated using crowding studies and willingness-to-pay surveys. The detailed CBA model uses a sophisticated treatment of road user benefits, estimating travel time savings separately based on road user value of time (VOT) and estimating VOC savings using a speed-based approach for different vehicle types. This estimates road user travel time savings using an approach that is consistent with public transport users. Additionally, crash benefits and externalities were estimated using a crash estimator based on transport demand model outputs, while pedestrian modelling was used to estimate crowding.

Box 11: **Worked example of rapid CBA of a mass transit opportunity** *continued*

Inputs	Rapid CBA	Detailed CBA
Type of benefits	• Public transport travel time savings. • Road decongestion. • Road crashes reduction. • Externalities.	The detailed CBA should thoroughly re-evaluate components of the rapid CBA based on the more detailed information available and make adjustments as appropriate. In addition to those measured in rapid CBA, the following benefits were also measured: • Separate estimates for public transport user travel and waiting time savings. • Separate estimates for road users VOT and VOC to replace road decongestion. • Reduced crowding on public transport. • Station amenity benefits. • Travel behaviour change benefits (generated demand). • Static agglomeration benefits.

Results of Rapid CBA

Assessment of the options using rapid CBA found that options C and D significantly outperformed the other options in economic terms. Option D slightly outperformed Option C. This result was supported by broader considerations in terms of Strategic Fit, Societal Impact and Deliverability (see **Glossary**) and so the two options were taken forward for detailed assessment.

Comparing outputs from rapid CBA and detailed CBA

The investigation proceeded to Stage 3, where the scope of the shortlisted options was revised for the business case based on lessons learnt from Stage 2. This included an additional station for Options C and D, plus a further BRT station for Option D only. Estimates of scheme construction costs, rolling stock costs, station and network operating costs were updated to reflect the changes in scope.

The detailed CBA of Option C and Option D was undertaken using specific inputs and updated cost estimates. It also included the full range of benefits that had not been previously captured. The result of the detailed CBA was that Option C had a higher BCR than Option D. This was despite Option C having a substantially higher capital cost compared to the Stage 2 assessment.

Summary

This worked example shows:

1. how rapid CBA is a robust but less intensive tool compared to detailed CBA
2. how rapid CBA is an effective method to inform the selection of shortlisted options
3. why detailed CBA is necessary to fully understand the total costs and benefits of project options to inform decisions on the preferred solution.

4

Cost-effectiveness analysis

4.1 Overview of cost-effectiveness analysis

Cost-effectiveness analysis (CEA) is a partial cost–benefit approach that compares the relative costs of different options in reference to specific outcomes that have been agreed upon (for example, reducing the road toll by a specified number of lives). CEA expresses the result in terms of the average cost per unit of effectiveness (for example, the average cost per life saved). CEA is generally used when the benefits of project options are identical. Its aim is to identify the least cost, and therefore the most cost-effective, option.

While CEA can be used when the main benefits cannot be easily valued, it does not indicate if the preferred option is of net benefit to society.

If the purpose of the assessment is to rank options that deliver similar outcomes when it is difficult to monetise these outcomes, then CEA provides a viable approach that remains within a CBA framework.

CEA is appropriate if it is not possible (practically, given data constraints, or within the investigation budget) to fully value particular outcomes and benefits. In this case, CEA is concerned with maximising agreed outcomes within a given cost constraint. It is concerned with calculating the 'cost per unit outcome'. In this way, it makes effective use of partial cost–benefit information that may be available.

However, CEA cannot be used to find or compare alternative projects that could achieve greater net social benefits by targeting *different* outcomes. Therefore, CEA is generally used where the decision to target specific outcomes has already been agreed upon by decision-makers.

As a result, it is important when using CEA that the outcomes you have defined for the cost comparison are clearly related to the overall objectives of the proposal.

Costs are 'discounted' over time to arrive at a present value (today's dollars).

For the vast majority of the business cases for infrastructure projects, where both costs and benefits differ between options, CBA is the appropriate appraisal tool to use. In some cases, such as proposals to satisfy government policy objectives in improving remote area communities, CEA may be an appropriate analysis tool. See **Appendix G** for guidance on remote area proposals.

4.2 Applying cost-effectiveness analysis

Table 15 illustrates a simple case where the full economic costs are compared with a single specific outcome (number of families with increased service access). In this case, it is clear that Option A would be preferable to Option B because it shows a lower cost per family provided with increased access.

Table 15: CEA with costs and one intangible benefit

	Option A	Option B
Cost (full economic cost, present value terms)	$5 million	$8 million
Number of families with increased access to services as a consequence of project	50	50
Cost effectiveness ($ cost per family with increased access)	$100 000	$160 000

5

Other appraisal techniques

5.1 Overview of other appraisal techniques

CBA is the principal tool for economic appraisal, as it measures changes in societal welfare as a result of interventions that have their primary impact in a single, localised market. It captures virtually the entire welfare impact of a project or policy change including allowing for relevant distortions such as unpriced externalities (for example, congestion) and taxes, along with quality-of-life effects such as private travel time reduction and better safety. CBA is a partial equilibrium analysis that treats the sector of the economy or market or infrastructure of immediate interest as operating in isolation from the rest of the economy, omitting the macroeconomic effects.

In some policy areas, such as where governments want to report on employment and output impacts, other types of analysis can provide useful additional information, such as computable general equilibrium (CGE) modelling or input–output (I–O) analysis. However, there is generally limited value in this kind of modelling for infrastructure appraisal because the directly measured impacts in the infrastructure sector (for example, time savings in transport) will capture the majority of the welfare impacts on the Australian community. Furthermore, these types of analysis are unlikely to clearly differentiate marginal options due to the aggregate level of analysis.

5.2 Role of computable general equilibrium models in an appraisal

CGE models are an economic analysis tool with an economy-wide focus that estimates changes in key economic indicators at the regional, state and national level, for individual industries and often regions, as a result of external changes or policy changes. Key indicators that CGE can estimate include impacts on GDP, household income and consumption, investment, exports, employment and industry outputs.

A CGE model represents the economy as a system of simultaneous equations that model supply of and demand for commodities and for factors of production (labour and capital). Typically, CGE models assume pure competition, markets operating at full capacity and without friction, constant returns to scale, full market clearing of all goods and services, perfect mobility of resources and perfect divisibility. A CGE model contains a database consisting of an I–O table, elasticities and other parameters governing behavioural responses of economic agents.

CGE models can be developed to different levels of sophistication in terms of spatial and industry disaggregation, dynamics and assumptions in relation to returns to scale and market competition. Available CGE models vary in setup, so project evaluators should choose a model that is suited to addressing the policy questions at hand.

In some policy areas, CGE modelling can provide useful additional information as it traces the flow-on impacts of a policy change in a systematic way, such as indirect impacts on sectors of the economy.

Traditionally, CGE models are used as a supplement to conventional CBA to provide information about macro-economic and distributional impacts of large projects or programs of multiple projects. Usually, the models do not measure welfare in a way that is consistent with CBA, instead using indicators such as GDP and aggregate consumption.

Newer spatial CGE models, including urban models, have high levels of spatial disaggregation particularly for urban areas, are comparative-static, model land-use markets and have welfare measures consistent with net benefits in a CBA. They can support a CBA by forecasting land-use change as a result of a transport intervention and thereby assist with estimating 'second-round' transport benefits, that is, benefits due to shifts in origin–destination demand curves due to land-use change.

Advocates of spatial CGE models make strong claims for their advantages over CBA for appraising major urban proposals. However, as yet, there is no substantial body of evidence showing the same projects appraised using both approaches with the differences between results explained and justified (see ATAP guidelines *T4 Computable general equilibrium models in transport appraisal*[52] for more information).

52. Infrastructure and Transport Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T4 Computable general equilibrium models in transport appraisal*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/index.

Points to note when using CGE outputs alongside CBA include:

- GDP changes estimated by CGE models do not measure changes in economic welfare. Welfare takes into account non-priced costs and benefits that do not enter into GDP, such as private travel time savings, amenity and environmental externalities. GDP measures other factors that are not related to economic welfare – household consumption is the closest equivalent to a measure of welfare in a CGE model.
- Impact estimates from CGE models are not interchangeable with nor additive to CBA results, but can provide additional information on project impacts to supplement the analysis. Urban spatial models have been developed that attempt to measure welfare outcomes but, due to the early developing nature of these models, we do not recommend adding CGE outcomes to CBA results.

Further information on CGE modelling is provided in ATAP's *T4 Computable general equilibrium models in transport appraisal*, available at **www.atap.gov.au/tools-techniques/index.**

When we would consider CGE outputs

We make no recommendation about circumstances where CGE modelling should be undertaken. We primarily use CBA data for assessing the costs and benefits of a proposal and are unlikely to consider CGE benefits as additive or complementary to CBA benefits. However, CGE models can be used *as a supplement* to CBA to analyse the economy-wide and regional effects of large projects in terms of impacts on GDP, household consumption, investment, exports, employment and industry output. The aggregate nature of CGE measures means they cannot provide sufficient granularity to differentiate between options like CBA does, although some updated models claim to have capability to provide project specific welfare benefits.

You should weigh up whether the additional information obtained from CGE modelling is worth the cost of the modelling. CGE should only be used on large projects because the level of shock required to change economic outcomes needs to be significant. Additionally, due to the cost and effort involved in CGE modelling, its use will only be justified for large projects.

5.3 Role of input–output analysis in an appraisal

I–O analysis aims to estimate the impact on economic activity of a policy or economic change, including the flow-on effects throughout the economy. It considers only the impact of investment costs, ignoring the benefits of proposals as measured by a CBA, and so does not provide an indication of the overall merit of a project. Due to the reduced complexity, it may be a less expensive alternative to CGE models to supplement CBA.

I–O analysis comes with major limitations and the results are likely to be biased upward. Therefore, **we do not recommend the use of I–O models for proposals** submitted to us. I–O analysis may be appropriate as a supplement to CBA for small projects that are considered in isolation in areas of high unemployment, where economic stimulus is a policy objective. For example, there may be value in providing I–O outputs to support smaller projects in regional areas where there is an objective to achieve broader impacts, such as employment in areas of high unemployment or tourism benefits. However, any conclusions should note the limitations of I–O models for adequately assessing impacts and differentiating options.

I–O analysis produces indicators that capture changes in measures of economic activity (such as output, household incomes, and employment) for the whole economy and by industry. Using regional I–O tables, these indicators can be produced at the regional level. Often the results of I–O analysis are presented as 'multipliers'.

I–O analysis only allows projects to be compared and ranked in the case where the government's objective is to maximise economic stimulus per dollar spent either for the whole economy or for one or more particular regions. But even if indicators of economic stimulus based on I–O analysis are what is required to assist decision-making, the restrictive assumptions of I–O mean the results should be treated with utmost caution.

Further information on I–O analysis is provided in ATAP *T4 Computable general equilibrium models in transport appraisal*, available at **www.atap.gov.au/tools-techniques/index**. I–O tables at a national level are published as part of the Australian National Accounts and are available at **www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-input-output-tables/latest-release**

Glossary

Term	Definition
Agglomeration	The benefits of clustering or high concentration of businesses and economic activity in a relatively small geographic area.
Appraisal	The process of determining the impacts and overall merit of a proposal, including gathering and presenting relevant information for consideration by the decision-maker.
Appraisal period	The number of years over which the benefits and costs of an infrastructure proposal are assessed in a **cost–benefit analysis**. A default value of 30 operational years plus construction time is generally used for infrastructure proposals. Refer to the **Guide to economic appraisal** for more information.
Appraisal summary table (AST)	This table succinctly captures both the qualitative and quantitative elements of a proposal. It will assist decision-makers to quickly understand the broader strategic, societal and deliverability aspects of the proposal.
Assessment	For the purposes of the **Assessment Framework**, this refers to Infrastructure Australia's evaluation of proposals submitted to us for inclusion on the ***Infrastructure Priority List*** or for a funded proposal review.
Assessment Criteria	The three criteria Infrastructure Australia assesses proposals against: Strategic Fit, **Societal Impact** and **Deliverability**.
Assessment Framework	A publicly available document that details how Infrastructure Australia assesses infrastructure proposals. It provides structure to the identification, analysis, appraisal, and selection of proposals and advises proponents how to progress through the following four stages: • Stage 1: Defining problems and opportunities • Stage 2: Identifying and analysing options • Stage 3: Developing a business case • Stage 4: Post completion review
Australian Infrastructure Audit	Published in August 2019, the Audit was developed by Infrastructure Australia to provide a strategic assessment of Australia's infrastructure needs over the next 15 years. It examined the drivers of future infrastructure demand, particularly population and economic growth. Data from the Audit is used as an evidence base for assessments of proposals for inclusion on the ***Infrastructure Priority List***.
Australian Infrastructure Plan	The 2021 Plan was developed by Infrastructure Australia as a positive reform roadmap for Australia. Building off the evidence base of the Audit (see ***Australian Infrastructure Audit***), the Plan sets out solutions to the infrastructure challenges and opportunities Australia faces over the next 15 years, to drive productivity growth, maintain and enhance our standard of living, and ensure our cities remain world class. The 2021 Plan supersedes the February 2016 Plan.
Base case	A project **appraisal** compares the costs and benefits of doing something (a 'project case') with not doing it (the 'base case'). The base case should identify the expected outcomes of a '**do-minimum**' situation, assuming the continued operation of the network or service under good management practices. We recommend the committed and funded expenditure approach to defining the base case, but recognise that some states and territories use the planning reference case approach.
Base year	The year to which all values are discounted when determining a present value. (See **discounting** and **discount rate**).
Benefit–cost ratio (BCR)	This is the ratio of the present value of economic benefits to the present value of economic costs. It is an indicator of the economic merit of a proposal presented at the completion of a cost–benefit analysis. (See **cost–benefit analysis**).

Term	Definition
Business case	A document that brings together the results of all the assessments of an infrastructure proposal. It is the formal means of presenting information about a proposal to aid decision-making. It includes all information needed to support a decision to proceed, or not, with the proposal and to secure necessary approvals from the relevant government agency. Unless otherwise defined, we are referring to a final or detailed business case, rather than an early (for example, strategic or preliminary) business case, which is developed in accordance with state or territory requirements. A business case is prepared as part of Stage 3 of the Assessment Framework.
Capital cost	The initial fixed costs required to create or upgrade an economic asset and bring it into operation. This includes expenses such as the procurement of land, buildings, construction, labour and equipment.
Computable general equilibrium (CGE) modelling	CGE modelling traces the flow-on impacts of a policy change in a systematic way, such as indirect impacts on sectors of the economy. The outputs of CGE models do not usually play a role in CBA. CGE models focus on 'economic activity impacts', which are not a measure of efficiency effects. (See **economic impact analysis**).
Consumer surplus	Consumer surplus is the difference between the price at which a consumer is willing to pay for a particular good or service and the price the consumer actually pays.
Cost–benefit analysis (CBA)	An economic analysis technique for assessing the economic merit of an infrastructure proposal. It involves assessing the benefits, costs, and net benefits to society the proposal would deliver. It aims to attach a monetary value to the benefits and costs wherever possible and provide a summary indication of the net benefit. (See **benefit–cost ratio**).
Cost-effectiveness analysis (CEA)	Cost-effectiveness analysis is used when the benefits of project options are identical. Its aim is to identify the option that will cost the least. The technique for valuing costs is the same as for **cost–benefit analysis**.
Cost distribution	**Probabilistic project cost estimates** identify cost components, determine the probability distribution for each cost component and then undertake a simulation (often a 'Monte Carlo' simulation) to generate a probabilistic distribution of project costs.
Cost escalation	Cost escalation is used to adjust cost estimates so they account for changes in technical, economic and market conditions over time. Costs are escalated using price indices, such as construction industry price indices, to a new base year.
Deliverability	One of three overarching **Assessment Criteria** we use to assess the merit of every proposal, at every stage. This criterion asks: can the proposal be delivered successfully? We assess whether the proposal is capable of being delivered successfully, whether risks have been identified and sufficiently mitigated, and whether there is a plan in place to realise the benefits. This criterion is divided into five themes: ease of implementation, capability and capacity, project governance, risk and lessons learnt.
Demand forecasting	The activity of estimating future demand (such as public transport patronage, vehicle volumes or water usage) in a particular year or over a particular period.
Depreciation	The amount that an asset reduces in value due to wear and tear, or environmental factors. Specifically, it could be defined as: • Economic depreciation: A decline in the value of an asset over time due to general wear and tear or obsolescence. • Financial depreciation: The allocation of the cost of an asset over a period of time for accounting and tax purposes. In an economic appraisal (using **cost–benefit analysis**), residual values are sometimes estimated based on the effects of economic depreciation. (See **residual value**).
Discount rate	The interest rate at which future dollar values are adjusted to represent their present value (that is, in today's dollars). This adjustment is made to account for the fact that money today is more valuable than money in the future. **Cost–benefit analysis** should use real social discount rates.

Term	Definition
Discounted cash flow (DCF)	An analytical technique for converting a monetary impact at one point in time to a monetary impact at another. Project performance measures (such as **internal rate of return** and **net present value)** are based on this technique.
Discounting	The process of converting money values that occur in different years to a common (base) year. This is done to convert the dollars in each year to present value dollars. (See **discount rate**).
Distributional effect	A change (positive or negative) in the economic welfare of a group of individuals or firms caused by a proposal.
Do-minimum	A base case reflecting the continued operation of the network or service under good management practices. It should assume that general operating, routine and periodic maintenance costs will continue to occur, plus a minimum level of capital expenditure to maintain services at their current level (e.g. maintaining access or reliability) without significant deterioration. This may include asset renewals and replacement of life-ending components on a like-for-like basis, as well as committed and funded projects and smaller scale changes required to sustain viable operations under the base case. (See **base case**).
Economic efficiency	A measure of the extent to which economic gains (also referred to as increases in societal welfare) have been or could be achieved. Economic efficiency is improved whenever those who gain from a change could compensate the losers out of their gains and still have some gain left over. Maximum economic efficiency is said to be obtained when no further changes of this type are possible (i.e there are no unexploited opportunities to improve everybody's welfare).
Economic impact analysis	A form of economic analysis aimed at establishing the effect that a proposal will have on the structure of the economy, or on the economic welfare of groups of people or firms. Economic impacts are usually expressed in terms of employment and income effects, broken down by economic sector and/or region. **Computable general equilibrium** and input–output analyses are types of economic impact analysis.
Elasticity	A mathematical measure used in economics to describe the strength of a causal relationship between two variables. It measures the responsiveness of the dependent variable to the changes in the independent variable (e.g. the price elasticity of demand). An elasticity value can be interpreted as the percentage change in the dependent variable in response to a 1% change in the independent variable.
Escalation index	A number by which a base-year **real price** must be multiplied in order to obtain the real price in the year of the index.
Ex-ante and ex-post	The term 'ex-ante' means 'before the event' and is applied to forecast or intended outcomes. This contrasts with 'ex-post' which means 'after the event' and reflects actual outcomes or performance. An ex-post evaluation (or post completion review) involves comparisons between actual outcomes and forecasts or benchmarks and provides insights into what degree a project has succeeded in meeting its objectives.
External cost	A cost imposed on third parties, including time lost from delays, accident risks and environmental impacts (valued at **resource costs** where applicable).
Expected Value	The mean value of the **cost distribution**. If the cost distribution is symmetrical, the Expected Value will be equal to the P50 value. Where the cost distribution is positively skewed, the mean will be above the P50 value and may lie closer to the P90 value. (See **P50 cost** and **P90 cost**)
Externality	An effect that one party has on another that is not transmitted through market transactions. An example is noise pollution from vehicles: those operating the vehicles disturb other parties such as nearby residents, but a market transaction between these parties is absent.
Financial analysis	The evaluation of the benefits and costs, measured in financial cash-flow terms, to a single entity (that is, not the community or the economy).
First-year rate of return (FYRR)	Benefits minus operating costs in the first full year of operation of a proposal discounted to the start of the evaluation period, divided by the present value of the investment costs, expressed as a percentage. The first-year rate of return is used to determine the optimum timing of proposals.

Term	Definition
Generalised cost	The sum of monetary and non-monetary costs that users incur for a service. For example, in the case of a transport project, users incur monetary costs for vehicles, fuel and parking spaces, as well as non-monetary costs like travel time. When a proposal reduces the generalised cost, this amounts to a benefit to the user.
Gross domestic product (GDP)	A monetary measure of the market value of all the final goods and services produced in a period of time, often annually or quarterly.
Impact	A generic term to describe any specific effect of a proposal. Impacts can be positive (a benefit) or negative (a cost).
Impact timeframe	For early-stage proposals (Stage 1), this indicates when the problem or opportunity is likely to have a nationally significant impact.
Indicative delivery timeframe	For investment-ready proposals (Stage 3), this provides the proponent's indication of when the proposal is likely to be delivered and operational.
Infrastructure	Physical assets and facilities that enable organisations to provide goods and services to the community and improve quality of life, efficiency, accessibility and liveability of our cities and regions. This includes, but is not necessarily limited to, transport, energy, telecommunications, water and social (such as health, education, social housing and community facilities) infrastructure.
Infrastructure Priority List	The Priority List is a credible pipeline of nationally significant infrastructure proposals that are seeking investment. Every proposal on the Priority List is expected to contribute to national productivity or to be otherwise socially beneficial. It is a statement of where governments, the community and the private sector can best focus their infrastructure efforts.
Internal rate of return (IRR)	The discount rate that makes the net present value equal to zero. The IRR must be greater than or equal to the discount rate for a proposal to be economically justified. The discount rate is therefore also known as the hurdle rate. (**See discount rate**).
Investment costs	The costs of providing the infrastructure before operations commence (e.g. costs for planning and design, site surveying, site preparation, investigation, data collection and analysis, legal costs, administrative costs, land acquisition, construction costs, consequential works, construction externalities). In some cases, investment costs can recur throughout the **appraisal period** (e.g. asset replacement or renewal costs). For **cost–benefit analysis**, these should all be expressed in economic cost terms (also known as **resource costs**).
Land use impacts	A change in the types of activities that occur in a section of land, or the intensity of those activities. Changes in activity may be caused by a change in use of the existing built form or a change in the built form itself. For example, an increase in the amount of high-density housing in the area around a train station.
Longlist of options	A comprehensive list of potential options to address the problems and realise the opportunities identified in Stage 1. The longlist includes all options that are identified for a proposal and should represent a range of reasonable alternatives, including capital and non-capital options, as well as demand-side and supply-side options.
Maintenance	Incremental work to repair or restore infrastructure to an earlier condition or to slow the rate of deterioration. This is distinct from construction and upgrading, which seeks to extend infrastructure beyond its original condition.
Market failure	When markets allocate resources inefficiently, they are said to exhibit market failure. There are four main causes: abuse of market power, typically markets where there is a monopoly or oligopoly; unpriced externalities, where the market does not take into account impacts on third parties; public goods, which are non-rivalrous and non-excludable; and asymmetry of information or uncertainty, where one side of the market systemically knows more than the other.

Term	Definition
Market prices	The price at which assets or services are sold. Market prices provide a great deal of information concerning the magnitude of costs and benefits, as well as where they exist, and if there is not a market failure. Market prices should be used as they provide more reliable estimates of benefit values compared to non-market valuation techniques.
Monetised	Where a quantified impact has a corresponding dollar value attached to it. (See **impact**).
Mutually exclusive	In the context of the **Assessment Framework**, the term is used to refer to options where choice to adopt one option precludes adoption of all the other options.
Net present value (NPV)	The monetary value of benefits minus the monetary value of costs over the appraisal period, with discount rates applied (See **discount rate** and **appraisal period**).
Network	Infrastructure networks are the physical assets that enable the provision of services such as transport connectivity, power, water and internet.
Nominal prices	A value or price at a given time. Nominal prices rise with inflation. In contrast, real prices are prices after the effect of inflation has been removed. (See **real prices**).
Non-infrastructure options/ solutions	Proposals that avoid the need for significant expenditure on new or upgraded infrastructure. For example, changes to pricing or reforms to regulations.
Non-market valuation (NMV)	Often, valuations for goods or services are not reflected in market prices. Where this is the case, approaches for non-market valuation should be applied, including revealed preference, stated preference, or a number of other rapid valuation techniques. (See **market prices**).
Operating costs	The costs of providing the infrastructure after it has commenced operation (e.g. maintenance and administration costs of a facility).
Opportunity	An evidence-based reason for action that results from a gap between an actual and a desired outcome. In the context of the Assessment Framework, an opportunity is informed by the ***Australian Infrastructure Audit*** and by our collaboration with proponents to identify jurisdictional and national opportunities.
Opportunity cost	The value lost to society from using a resource in its next best alternative use, represented in dollars. This is also called the '**resource cost**' or 'social cost'. This cost reflects market prices where there is an absence of market failure. Where market failure exists, appropriate adjustments are required to estimate the true opportunity cost.
Option	A possible solution to a problem, including base case options such as 'do nothing' or 'do minimum'. (See **base case**).
Option value	The value that consumers place on being able to keep an option available, even though they may never in fact choose it. For instance, habitual air travellers may be willing to subsidise a competing train service in order to be in a position to use it if the need arises. Another example might be the preservation of a national park that people may never visit, but derive a benefit from knowing that the option exists. (See **option**).
Options analysis	The analysis of alternative options for solving an identified problem or realising an identified opportunity. (See **option**).
Place	A geographical area within a clearly defined boundary. A 'place' can be scaled at different levels, for example, a precinct, strategic centre or sub-region.
Place-based	A 'place-based' approach to infrastructure applies a wide lens to consider the total impact and needs of a particular community or place over the longer term. It adopts an integrated approach to land use and infrastructure planning. It takes a cross-sectoral view of the interrelated infrastructure and amenity needs of a place, and identifies how and when these should be delivered. (See **place**).
Price elasticity	An economic measure to describe the sensitivity of a relationship between price variables. (See **elasticity**).

Term	Definition
Price year	The year in which the prevailing prices are used in the analysis for the valuation of impacts.
Private cost	Cost incurred by an individual user or service provider. Private costs are valued at market prices, where applicable, and may include user costs but exclude external costs imposed on others.
Probabilistic project cost estimates	These estimates identify cost components, determine the probability distribution for each cost component and then undertake a simulation (often a 'Monte Carlo' simulation) to generate a probabilistic distribution of project costs. (See **cost distribution**, **expected value**, **P50 cost** and **P90 cost**).
Problem	An evidence-based reason for action that results from a gap between an actual and a desired outcome. In the context of the Assessment Framework, problems are informed by the ***Australian Infrastructure Audit*** and by our collaboration with proponents to identify jurisdictional problems and national problems.
Producer surplus	The difference between the price at which a producer is willing to supply a particular good or service and the price the producer actually receives.
Productivity	The efficiency with which the economy as a whole convert inputs (labour, capital and raw materials) into outputs. Productivity grows when outputs grow faster than inputs, which makes the existing inputs more productively efficient.
Project	An infrastructure intervention. A project will move through the stages of project initiation, planning, delivery and completion. A suite of related projects to address a common problem or opportunity will create a **program**.
Program	A proposal involving a package of projects that are clearly interlinked by a common **problem** or **opportunity.** The package presents a robust and holistic approach to prioritise and address the projects, and there is a material opportunity to collaborate and share lessons across states, territories or agencies. The projects can be delivered in a coordinated manner to obtain benefits that may not be achieved by delivering the interventions individually. (See **project**).
Proponent	An organisation or individual who prepares and submits infrastructure proposals to us for assessment. To be a proponent of a business case (a Stage 3 submission), the organisation must be capable of delivering that proposal. (See **business case**).
Proposal	The general term we use for successful submissions to the ***Infrastructure Priority List***, across the key stages of project development, specifically – early-stage (Stage 1), potential investment options (Stage 2) and investment-ready proposals (Stage 3). Proposals that have been delivered would be assessed in Stage 4.
P50 cost	An estimate of project costs based on a 50% probability that the cost estimate will not be exceeded.
P90 cost	An estimate of project costs based on a 90% probability that the cost estimate will not be exceeded.
Qualitative	A description of an impact that does not rely on quantitative or monetised information.
Quantitative/quantified	A description of an impact that utilises, presents or references values, numbers or statistics.
Rapid cost–benefit analysis (rapic CBA)	A rapid CBA incorporates standard CBA principles and techniques but at a lower level of accuracy. (See **appraisal** and **cost–benefit analysis**).
Real prices	Prices that have been adjusted to remove the effects of inflation. They must be stated for a specific base year, for example '2016 prices'. (See **base year**).

Term	Definition
Real options analysis	An investment evaluation and decision-making framework used to embed flexibility into an investment strategy to better structure and manage projects impacted by **uncertainty**. Real options analysis can be used as a way of thinking or as a quantitative technique to place values on options and different investment strategies. In both cases, it represents a process of understanding the value of investments under different future states of the world and developing more nuanced investment strategies to reflect this.
Residual value	The value of an asset at the end of the appraisal period. Residual values are used in cost–benefit analysis calculations involving long-lived assets whose life extends beyond the end of the appraisal period. (See **appraisal period** and **cost–benefit analysis**).
Resilience	The ability of the community to anticipate, resist, absorb, recover, transform and thrive in response to shocks and stresses to realise positive social, economic and environmental outcomes.
Resource cost	The value foregone by society from using a resource in its next best alternative use. Also known as 'opportunity cost' and 'social cost'. (See **opportunity cost**). Economic appraisals use resource costs, which do not include taxes and subsidies. Taxes and subsidies are financial transfers between individuals in an economy, and do not lead to an increase in net economic benefits. Resource cost = market price – indirect taxes + subsidies.
Resource cost correction	Resource cost corrections are made when perceived costs and resource costs are not the same. Perceived costs include taxes and subsidies. (See **resource cost**). For example, the resource cost of fuel is different to the perceived costs of fuel. The resource costs of fuel do not include all the taxes. To make a resource cost correction, costs are often subtracted from consumer surplus based on the perceived cost of consuming a good or service.
Risk	Events that have probabilities of occurrence that are predictable and outcomes that can be estimated with some confidence.
Rule-of-a-half	In the transport sector, any induced demand is given a benefit value equal to half the benefit of existing demand (existing users). In other sectors, benefits to new users are often calculated directly, rather than being calculated with reference to existing users.
Scenario analysis	Scenario analysis provides a framework for exploring the uncertainty about future consequences of a decision, by establishing a small set of internally consistent future scenarios and assessing options against each of them. This form of analysis is especially useful for decision-makers faced with forms of uncertainty that are uncontrollable or irreducible (e.g. future technology change or increased climate variability).
Sensitivity analysis	Changing a variable, or a number of variables, in a model or analysis to test how the changes affect the output or results.
Shortlist of options	The set of options determined as most likely to benefit the Australian community using a structured, quantitative and unbiased analysis (in Stage 2). The shortlist of options is taken to Stage 3 for detailed analysis. We recommend the shortlist includes at least two viable options.
Social cost	See **opportunity cost**.
Social discount rate	Discount rates translate future costs and benefits to a common time unit, comparing costs and benefits that accrue at different times by expressing them as an equivalent amount in today's dollars. In the economic appraisal, a real discount rate should be used that considers societal resources. (See a**ppraisal** and **real discount rate**).
Social, economic and environmental impact	The positive and negative effects of a proposal, with regards to: • social: quality-of-life effects, such as social exclusion and access to services, employment and safety • economic: productivity effects, such as productive capacity, economic capability, global competitiveness • environmental: effects such as greenhouse gas emissions, waste treatment, noise pollution, visual intrusion, heritage impacts.

Term	Definition
Socially beneficial	Something is socially beneficial if you can demonstrate an evidence-based improvement that will change the quality of life of Australians. For example, through improved health outcomes, access to services/employment, and improved environmental outcomes.
Societal wellbeing	The welfare of Australian society as a whole. Effects on societal wellbeing, often referred to as impacts, can be positive (a benefit) or negative (a cost), and form the basis for **cost–benefit analysis.**
Societal Impact	One of three overarching **Assessment Criteria** we use to assess the merit of every proposal, at every stage. This criterion asks: what is the value of the proposal to society and the economy? We assess whether the social, economic and environmental value of the proposal, and its contribution to community sustainability and resilience is clearly demonstrated by evidence-based analysis. This criterion is divided into five themes: quality of life, **productivity**, environment, **sustainability** and **resilience**.
Sunk cost	A cost that cannot be retrieved by resale in the market. More specifically, a sunk asset is one which, once constructed, has no value in any alternative use. Bridges and railway tunnels are typically sunk assets. Sunk costs incurred in the past should be excluded from a **cost–benefit analysis**.
Themes	Themes are outcome areas within our Assessment Criteria. Each criterion is divided into five themes. (See **Assessment Criteria,** Strategic Fit, **Societal Impact** and **Deliverability**).
Sustainability	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Travel time savings	The benefit of less time spent travelling as a result of a project. The number of hours saved is typically modelled for both personal and business travel across a network, then converted to a monetary value for use in **cost–benefit analysis**.
Uncertainty	Events where probabilities of occurrence are difficult to predict and outcomes are challenging to quantify.
User costs	Costs incurred by a transport user in addition to the money price. For example, waiting time, time in transit, unreliability, damage to freight, passenger discomfort, additional costs to complete the door-to-door journey. In **cost–benefit analysis,** quality attributes such as time and reliability need to be expressed in dollar terms based on user valuations.
Value of statistical life (VSL)	A standardised paramater for valuing health outcomes through quantifying the value of life or the value of living longer, as outlined in relevant state, territory or national guidance.
Value of time	A standardised parameter for valuing time as outlined in relevant state, territory or national guidance.
Vehicle operating costs	The costs associated with owning, driving and maintaining a vehicle. This includes the costs of fuel consumption, oil and lubrication, tire wear, repair and maintenance, depreciation, and license and insurance.
Wider economic benefits (WEBs)	Improvements in economic welfare from agglomeration, imperfect competition and labour supply effects that are acknowledged, but have not been typically captured in traditional cost–benefit analysis. (See **cost–benefit analysis**).
Willingness-to-accept	A measure of human preference used to value changes in societal wellbeing, used in conjunction with **willingness-to-pay**.
Willingness-to-pay (WTP)	The maximum amount a consumer is willing to pay for a given quantity of a particular good or service (rather than go without it). It is measured as the total area under the demand curve up to the given quantity.

Appendix A

Published CBA guidance

A-1 Relevant jurisdictional and sector-specific guidance

In undertaking a detailed CBA, proponents may wish to refer to the guidance noted in **Table 16**.

Table 16: Published CBA guidance

Author	Document	Sector
NSW Treasury	NSW Treasury 2017, *NSW Government Guide to Cost–Benefit Analysis*, NSW Government, Sydney, available at: **arp.nsw.gov.au/tpp17-03-nsw-government-guide-cost-benefit-analysis**	General
Queensland Government	Queensland Government 2020, *Business Case Development Framework – Cost Benefit Analysis Guide*, Queensland Government, Brisbane, available at **www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0013/55030/further-guidance-04-cost-benefit-analysis-guide.pdf**	General
Victorian Department of Treasury and Finance	Department of Treasury and Finance 2013, *Economic Evaluation for Business Cases Technical guidelines*, Victorian Government, Melbourne, available at: **www.dtf.vic.gov.au/sites/default/files/2018-03/Economic%20Evaluation%20-%20Technical%20Guide.doc**	General
UK Green Book	HM Treasury 2020, *The Green Book: appraisal and evaluation in central government*, UK Government, available at: **www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent**	General
European Commission	European Commission 2014, Guide to Cost–Benefit Analysis of Investment Projects: Economic appraisal tool for Cohesion Policy 2014–2020, European Commission, Brussels, available at: **ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf**	General
Office of Best Practice Regulation	Office of Best Practice Regulation 2020, *Cost–benefit analysis guidance note*, Department of Prime Minister and Cabinet, Canberra, available at: **www.pmc.gov.au/resource-centre/regulation/cost-benefit-analysis-guidance-note**.	Regulatory
ATAP	Infrastructure and Transport Senior Officials' Committee 2021, Australian Transport Assessment and Planning (ATAP) Guidelines, Transport and Infrastructure Council, Canberra, available at: **www.atap.gov.au**.	Transport

Table 16: *Continued*

Author	Document	Sector
Transport for NSW	Transport for NSW 2020, *Transport for NSW Cost–Benefit Analysis Guide*, NSW Government, Sydney, available at: **www.transport.nsw.gov.au/projects/project-delivery-requirements/evaluation-and-assurance/transport-for-nsw-cost-benefit**. Transport for NSW 2020, *TfNSW Economic Parameter Values*, NSW Government, Sydney, available at: **www.transport.nsw.gov.au/projects/project-delivery-requirements/evaluation-and-assurance/technical-guidance**.	Transport
Queensland Transport and Main Roads	Queensland Government Transport and Main Roads 2011, *Cost–benefit Analysis manual, First Edition*, February 2011 p. 2.16 **http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Cost-Benefit-Analysis-Manual.aspx**	Transport
NZ Transport Agency	New Zealand Transport Agency 2020, M*onetised benefits and costs manual*, NZ Government, available at: **www.nzta.govt.nz/resources/monetised-benefits-and-costs-manual**	Transport
UK Department for Transport	Department for Transport 2021, *Transport analysis guidance (TAG)*, UK Government, available at: **www.gov.uk/guidance/transport-analysis-guidance-tag**.	Transport
National Water Grid Authority (NWGA)	National Water Grid Authority 2020, National *Water Infrastructure Investment Policy Framework*, Department of Infrastructure, Transport, Regional Development and Communications, Canberra, available at **www.nationalwatergrid.gov.au/sites/default/files/documents/national-water-infrastructure-investment-policy-framework.pdf**.	Water
NSW Health	NSW Health 2018, *NSW Guide to Cost–Benefit Analysis of Health Capital Projects*, NSW Government, available at: **www1.health.nsw.gov.au/pds/ActivePDSDocuments/GL2018_021.pdf**	Health
NBN Panel of Experts	Department of Communications 2014, *Independent cost–benefit analysis of broadband and review of regulation*, Department of Communications, Canberra, available at: **www.communications.gov.au/departmental-news/independent-cost-benefit-analysis-nbn**.	Telecommunications
AER	Australian Energy Regulator 2020, *Guidelines to make the integrated system plan actionable*, AER, Melbourne, available at: **www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/guidelines-to-make-the-integrated-system-plan-actionable**.	Energy

Table 16: *Continued*

Author	Document	Sector
THINK	THINK 2013, *Cost–Benefit Analysis in the Context of the Energy Infrastructure Package*, European University Institute, Firenze, available at: **op.europa.eu/en/publication-detail/-/publication/b5d3ecd3-4da4-42d6-b79d-f177c631d9d6**.	Energy
European Network of Transmission System Operators for Electricity (ENTSO-E)	ENTSO-E 2018, *2nd ENTSO-E Guideline for Cost–Benefit Analysis of Grid Development Projects*, ENTSO-E, Brussels, available at: **tyndp.entsoe.eu/Documents/TYNDP%20documents/Cost%20Benefit%20Analysis/2018-10-11-tyndp-cba-20.pdf**	Energy
CSIRO/ NCCARF	Wise, R.M. and Capon, T. 2016. *Assessing the costs and benefits of coastal climate adaptation. CoastAdapt Information Manual 4*, National Climate Change Adaptation Research Facility, Gold Coast. **https://coastadapt.com.au/sites/default/files/information-manual/IM04_Costs_and_benefits.pdf**	Climate change

Appendix B

Departures from ATAP guidelines

B-1 Infrastructure Australia departures from ATAP guidelines

For transport appraisals, we recommend the ATAP guidelines as the default guidance for almost all aspects of the appraisal process.

In some cases, the approach defined in the Assessment Framework differs from the ATAP guidelines. These include the methods to quantify and monetise vehicle operating costs (VOCs), and the assumptions for vehicle occupancy rates. We consider the current ATAP approach may overestimate these benefits.

We are working with the ATAP Steering Committee[53] to determine if our recommended policy positions could be accommodated within the ATAP guidelines.

The following sections explain our recommended approach for estimating VOCs, parameters for vehicle occupancy rates, and treating broader economic benefits for transport projects.

B-2 Vehicle operating cost method

We consider the VOC method outlined in the 2016 ATAP guidelines[54] may lead to overstated VOC savings for project cases.

ATAP's recommended methodology assumes that a stop-start traffic model, whereby an increase in the speed of the vehicle will increase the distance the vehicle is able to travel, will lead to a reduction in capital costs and associated interest payments. This is relevant for only couriers or freight delivery vehicles which operate throughout the day. It is not likely to be relevant for the vast majority of car users such as commuters.

Applying this methodology to all vehicles means the higher the increase in the speed, the higher the VOC savings.

The reasoning is that if average travel speed can increase from 30 kilometres per hour to 60 kilometres per hour, a vehicle can travel twice the distance, thereby spreading capital costs of the vehicle over twice the kilometres. Hence, the cost per kilometre falls rapidly with higher speeds. However, for most car users, the car is likely to be used for the same number of trips regardless of the speed it goes. It is not likely that a driver will decide to make more trips unnecessarily simply because they can travel at a higher speed. Therefore, the decline in VOCs as speeds increase would be overstated.

53. The ongoing maintenance of the ATAP Guidelines is overseen by the ATAP Steering Committee reporting to the Infrastructure and Transport Senior Officials' Committee. The Steering Committee ensures the Guidelines remain relevant and updated in future and consists of representatives from Australasian transport bodies, namely the Australian, state and territory governments, Infrastructure Australia, the New Zealand Government, Austroads (as a project management advisor) and additional members as the agreed by the committee.
54. Transport and Infrastructure Senior Officials' Committee 2016, *Australian Transport Assessment and Planning (ATAP) Guidelines PV2 Road Parameter Values*, Transport and Infrastructure Senior Officials' Committee, Australian Government, Canberra, available at: www.atap.gov.au/parameter-values/road-transport/index.

The ATAP 2016 approach also has a discontinuity in the VOC function at 60 kilometres per hour. This is a methodological issue, not a real reduction in VOCs at that point.

We have observed a number of CBA results using ATAP's approach compared to other methods, including the Austroads 2012[55] guidelines. The resultant estimated benefit can differ by a factor of 10, making a substantial difference to CBA results.

Until further notice, we suggest that you adopt the VOC method recommended in the Austroads 2012 guidelines where possible. The Austroads 2012 guidelines do not have the same issue as the ATAP guidance, but has several limitations, including only providing three vehicle classes. Care should also be taken to ensure that driver value of time is not included both within the VOC model and separately for commercial vehicles. TfNSW has also released guidance on VOCs,[56] which seeks to address some of the issues related to current ATAP parameters by removing depreciation.

We are working with ATAP to develop a revised VOC approach and parameters for use in CBA.

B-3 Vehicle occupancy rates

We are concerned that the urban vehicle occupancy rates recommended in the 2016 ATAP guidelines are higher than those recommended by state and territory guidelines and actual rates observed.

For example, **Table 17** shows the vehicle occupancy rates recommended by the NSW Government TfNSW, compared to the ATAP or Austroads guidelines.

Table 17: Vehicle occupancy rates in Australian guidance material

Vehicle type	Urban	Non-urban
NSW – recommended vehicle occupancy rates		
Cars private	1.46	1.7
Cars business	1.07	1.3
Heavy trucks	1.17	1–1.3
Bus passengers	20	21
ATAP – recommended vehicle occupancy rates		
Cars private	1.6	1.7
Cars business	1.4	1.3
Heavy trucks	1	1
Bus passengers	20	20

Sources: Transport for NSW 2017, *Principles and Guidelines for economic appraisal of transport investment and initiatives,* NSW Government, pp. 248–249 available at: **www.transport.nsw.gov.au/sites/default/files/b2b/publications/principles-and-guidelines-for-economic-appraisal-of-transport-investment.pdf**; ATAP Guidelines PV2 Road Parameter Values Table 12 p. 19 **www.atap.gov.au/parameter-values/road-transport/index**.

55. Austroads 2012, *Guide to Project Evaluation Part 4: Project Evaluation Data*, Austroads, available at: austroads.com.au/publications/economics-and-financing/agpe04-12.
56. Transport for NSW 2020, *Technical note on calculating road vehicle operating costs*, New South Wales Government, available at www.transport.nsw.gov.au/news-and-events/reports-and-publications/transport-for-nsw-technical-note-on-calculating-road

As can be seen from **Table 17**, the urban occupancy rates for cars in ATAP are higher than those recommended by the NSW Government.

Furthermore, there is evidence that the actual vehicle occupancy rates observed are lower than the assumptions recommended by ATAP. **Table 18** shows the vehicle occupancy rates observed in Sydney and Melbourne by time periods.

The data from VicRoads 2015[57] and the Bureau of Transport Statistics 2014[58] for Melbourne and Sydney respectively indicate occupancy rates for private vehicles range between 1.16 and 1.67, depending on time of day and the journey purpose. This implies that the recommended figures used in the ATAP guidelines for some categories are higher than the actual vehicle occupancy rates observed.

High occupancy rate parameters overstate benefits when vehicle kilometres are converted to passenger kilometres to which a value of time is applied. However, without new surveys, it is not possible to determine which of the observed vehicle occupancy rates are most appropriate for assuming in other states and territories.

To mitigate the impacts of this uncertainty, we suggest that you undertake the following:

- first, use the observed occupancy rates collected for a specific project (location-specific data). However, this may be cost prohibitive to do for all projects.
- where project-specific occupancy rates cannot be collected, a second-best solution is to use the latest and most relevant state or territory estimates.
- finally, where no updated information exists, use the current published rates recommended by ATAP for consistency. In this case, we recommend testing the values above as a sensitivity to determine the significance of the differences for the CBA results.

Table 18: Observed private vehicle occupancy rates for Sydney and Melbourne

	Average weekday (all day)	AM peak	PM peak	Off peak / non-work trips
Sydney	1.46	1.45	–	1.67
Melbourne	1.20	1.16	1.20	1.21

Sources: NSW Bureau of Transport Statistics 2014, *2012/13 Household Travel Survey Summary Report, table 4.8.3: Average vehicle occupancy per trip*, NSW Government, p 37; Vic Roads, *Traffic Monitor 2013–14, Weekday car occupancy rate for the monitored network across all time periods,* Victorian Government, Available at: www.vicroads.vic.gov.au/~/media/files/documents/traffic-and-road-use/trafficmonitorreport2012130315a.ashx?la=en.

57. VicRoads 2015, *Traffic Monitor 2012–13*, Victorian Government, Melbourne, viewed 31 May 2021 https://www.vicroads.vic.gov.au/~/media/files/documents/traffic-and-road-use/trafficmonitorreport2012130315a.ashx
58. Transport for NSW Bureau of Transport Statistics 2014, *2012/13 Household Travel Survey Summary Report*, New South Wales Government, Sydney, viewed 31 May 2017, https://www.transport.nsw.gov.au/sites/default/files/media/documents/2017/HTS%20Report%20Sydney%202012-13.pdf

Appendix C

Land use impacts

C-1 Background and context

The measurement of welfare gain in CBA has its origins in applied microeconomics in the 19th century and it has been a key feature in the appraisal of infrastructure investments and practical decision-making for over the last 50 years. The body of economics knowledge and guidance on investment appraisal has grown in recent years as economists and CBA practitioners seek to measure the welfare gains which have been unaccounted for due to imperfect markets. It is important to recognise that the growing practice of quantifying and monetising land use impacts emerged from the same imperfect market theories which led to the development of guidance on WEBs, and hence the estimation of land use impacts is grounded in economic principles.

Infrastructure projects can have significant land use impacts that are not easily captured in conventional CBA. For example, major transport projects, such as metro style train services, are often considered to be 'city shaping' because they influence where people choose to live and where businesses choose to locate on a large scale over time. Similarly, airports, ports, major roads and intermodal terminals can influence land use via land take, ancillary services and the impact on location decisions for households, firms and population.

Understanding such land use impacts can be important for several reasons. For some projects, changing land use may be a primary objective of the project and being able to predict the degree to which they achieve this aim will then be important. Land use impacts may also give rise to a range of costs and benefits in addition to the time savings and other impacts typically captured in an appraisal, for example the cost of providing public utilities such as water, electricity and gas to less dense urban areas as compared to more dense areas.

Not all infrastructure projects are expected to incorporate land use costs and benefits into a CBA. Submissions to us should only include such impacts where there is compelling supportive evidence and clear justification for why the project is expected to generate significant land use impacts. Evidence collected as part of updating these guidelines suggests that land use changes are most likely to occur where there is expected to be areas undergoing a change in density (for example, population or employment density), or a clear relieving of a land, property or infrastructure supply-side constraint (see the following section for further discussion of this).

C-2 Measuring land use impacts

In order to determine costs and benefits associated with land use impacts, the magnitude and distribution of change must first be determined. In a practical sense, land use can be taken to refer to the spatial distribution and intensity of population, households and economic activity. There are a number of different models and approaches to measuring land use impacts, which can be delineated along multiple lines of separation. For instance, demand-side approaches follow the impacts infrastructure can have on land use by making a location more attractive, while supply-side approaches consider how infrastructure can unlock additional development through reducing the cost of private development or by allowing a relaxation of planning controls. Another line of separation is static structures, which focus on a single year, compared to dynamic structures, which represent an evolution over time. Lastly, linked models involve separate land use and transport models, while integrated models have an interaction of land use patterns and transport needs within the same model. Different models face different trade-offs between their respective advantages and disadvantages.

We recommend use of the approach recently developed by ATAP Guidelines *O8 Land Use Benefits of Transport Initiatives*[59] for estimating land use impacts in CBA. However, in the case of using other approaches, you should clearly indicate the type of approach or model used, including the name of the model, the types of behaviours it models, key inputs and assumptions, and interaction with other demand- and supply-side models (for example, traffic models). You should also provide details on how the following methodological issues have been treated:

- *Interaction between supply and demand* – consideration of both demand- and supply-side influencers must be made when modelling land use change. Submissions should set out how quantified land use impacts reflect demand- and supply-side opportunities and constraints. For approaches that separate out the demand- and supply-side components, there should be an iterative approach whereby a change in demand is considered with any regulatory constraints (that is can the forecast land use change be achieved given the current regulatory controls?). Forecast supply-side land use change should also be considered with demand estimates (that is can the envisaged land use be achieved given the demand?).
- *Dual causality* – any approach used to measure and model land use change should seek to correct for the dual causality between infrastructure and density. This dual causality arises through both infrastructure improving accessibility to change density and density itself driving infrastructure change. It is critical that, when estimating land use change, this reverse causality is corrected for, so as to isolate the impact of accessibility and attractiveness of an area on density, as opposed to density impacting an area's accessibility and attractiveness.
- *Attribution* – often changes in both the regulatory environment and the infrastructure project are needed for the land use impacts to occur. In many cases, it may therefore be inappropriate to attribute all land use impacts to the project in question. You should clearly document the proportion of land use change attributed to the project, supported by a clear rationale. Any costs and benefits from land use change that would be likely to occur in the absence of the infrastructure project (for example, through supply-side regulatory intervention only, such as a zoning change) should not be incorporated into the CBA. It may also be necessary to undertake additional infrastructure projects to ensure land use changes take place.
- *Compatibility* – when selecting a modelling approach, you should be mindful of the need for outputs to be at the appropriate level of spatial disaggregation so that they can inform benefits estimation. In transport projects, for example, traffic models generally require a high level of spatial disaggregation of inputs, at a base travel zone unit.
- *Time Dimension* – approaches used for measuring land use should be able to consider over what time horizon the change is likely to happen. Often there may be a lag between an infrastructure project and its associated land use change. For example, there may be a delay between an accessibility change brought about by a transport project, and a response from residents and firms to relocate closer to the affected corridors. Likewise, land use change could lead an infrastructure project where planning change and investment happen in anticipation of the completion of the project. Where possible, land use modelling techniques should incorporate such potential lead and lag effects to land use change being realised.
- *Additionality* – this refers to the proportion of the estimated benefits that are truly net additional to the national economy. It is difficult to measure this at a national level in Australia given the geographic scale, distance between major urban centres and the inhabited land mass in the country. At the very least, you should attempt to measure net additionality at a city, region, or in some instances, at a state level.
- *Displacement* – this refers to a specific land use impact which simply displaces activity elsewhere in the geography. This is a situation that is likely to occur in a situation of full employment, such that employment created at one site simply displaces employment elsewhere. The net impact then depends on whether there is a societal value from the employment being located at the new site. While in practice, this might be difficult to support analytically, you should articulate a narrative of where there is value to society from the displaced activity.

59. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines O8 Land Use Benefits of Transport Initiatives*, Transport and Infrastructure Council, available at: www.atap.gov.au/other-guidance/index.

- *Net Effects – Additionality and Displacement* – it is important to recognise that, while the 'additionality' of land use is highly visible at a local and city level (for example, the development of commercial office buildings), the net benefits related to land use do not always flow to the national level because of displacements which occur within the national economy. For example, the increase in population density in a new area might be made up by the decrease in density in another area. Therefore, the estimation of land use impacts needs to take into account any displacements which might offset the original increase in density. This is particularly important for submissions to us given the need to demonstrate the national significance of the problem or opportunity being addressed. The current lack of definitive evidence and the difficulty in estimating 'additionality' at the national level means that land use impacts should be considered as a sensitivity test with the total impacts estimated being effectively an upper bound.

C-3 Dependency and conditionality

Not all infrastructure projects will be eligible to incorporate costs and benefits associated with land use change. Projects should demonstrate that any land use impacts – and therefore any additional costs and benefits to those typically captured in the CBA – are dependent on the infrastructure project in question. Projects should also demonstrate that the necessary conditions (such as zoning changes, other infrastructure, 'excess demand' or associated public and private investment) are present in order for the identified land use impacts to materialise. This is expanded on in the following points:

- *Dependency* means that infrastructure proposals should establish that the change in land use (that is, any land use impacts) directly depends upon implementing the proposed infrastructure investment. Any land use change that would be permissible without the project in question – that is, changes to land use that could have gone ahead anyway – should not be used to inform any CBA land use benefit quantification[60]. Supporting material for dependency could include evidence of current or predicted capacity constraints on nearby infrastructure, infrastructure needs assessments from infrastructure providers and/or government agencies or findings from consultation with local, regional and state planning agencies.

  A useful approach in helping to establish dependency could be to undertake an analysis of the impacts of the expected change in land use in the absence of the infrastructure project. If this were to show an unacceptable increase in congestion or crowding on the local transport network, the change might be unlikely to take place without an improvement to that infrastructure, and that some or all of the land use change might be dependent development. (For additional guidance, see the UK Department for Transport's *Transport Analysis Guidance (TAG) unit A2-1 wider economic impacts*, available at: **www.gov.uk/government/publications/tag-unit-a2-1-wider-economic-impacts**).

- *Conditionality* refers to the supporting conditions and activities necessary for the expected land-use impacts to materialise and ensuring that costs and delivery of these are part of the economic appraisal and business case. For example, whether the necessary supply-side factors such as zoning changes to allow densification, and public and/or private investment (for example, water upgrades or remediation, schools and hospitals) are in place. It should also include factors that can hinder the realisation of benefits (for example, local opposition to increased density). To claim land use impacts, you should provide assurance in the project submission that all the necessary supporting conditions are in place and the associated costs are included in the economic appraisal.

60. It is important here to distinguish between what could happen in theory and what would happen in reality. For example, theoretically the densification of inner city areas could be achieved through supply side regulatory intervention alone given demand (i.e. zoning change). In practice, however, planning regulations (and public sentiment) would be likely to prohibit this as it would impose negative impacts on existing residents or the existing transport system. If a project ameliorates these negative impacts and thus enables the planning regulations to be changed, then there are grounds to claim that the land use change is dependent on the project.

C-4 Quantifying costs and benefits

Based on the quantified and fully attributed set of land use impacts, supported by evidence of dependency and conditionality, costs and benefits could be captured within a CBA framework. There are a number of possible land use costs and benefits that may be considered in addition to typical transport user benefits[61]. Note that the benefit is only a net benefit where there is evidence of additionality and/or where the displacement is deemed to be of higher societal value. The infrastructure projects that do cause changes in land use across a given area may create benefits such as *higher value land use, second-round transport impacts/externalities, sustainability benefits*, and *public health benefits*, which can be estimated and included in CBA of infrastructure projects:

- **Higher value land use**[62] – A change in land use will generate a net economic benefit if the value of the new use is higher than the value of the current use, less the cost of achieving the change. Importantly, this benefit must not capture any land value uplift caused by the infrastructure itself (which would be captured through the direct benefits such as travel time savings, and externalities such as noise and air pollution). Rather, it should capture any unrealised value uplift less the additional costs incurred in deriving that input that has been suppressed through other constraints (such as planning controls). Subject to the qualifications on attribution, dependency and conditionality, if an infrastructure investment unlocks this development and leads to an increase in land value which is more than what would have occurred in the absence of the investment, this value is a net economic benefit which is appropriate to capture in a CBA. In some circumstances, an infrastructure investment may trigger a change in land use that reduces the value of some sites. Excluding costs that are captured separately through externalities, this estimation should take into account all changes in land use from the infrastructure project, and should be presented as a net figure in the CBA.
- **Second round transport impacts** – Once we allow for a change in land use in response to an infrastructure investment, there may be additional costs and benefits to those that relocate that should be captured in CBA. For instance, new residents that are attracted to a location in order to access improved amenities, better transport, etc. do so because they are better off. These benefits should be captured using the rule-of-a-half.
- **Second round transport externalities** – Households clustered more tightly around trip destinations typically make shorter trips and make more use of walking, cycling and public transport, while more spread-out land uses are usually associated with longer trips and a higher share of car use[63]. Therefore, by changing land use, a project can change transport patterns and external costs (crowding, congestion, pollution, crash costs, etc.) of the total transport task. These second-round effects can be isolated and attributed as benefits (or disbenefits) of a transport project. This would require robust analysis of the land use changes expected, as well as separate demand model forecasts that incorporate both the project and the forecast land use changes[64]. Total benefits can then be estimated comparing the 'with project, with land use change' scenario against the base case transport and land use scenario. To help understand the magnitude of the total benefits related to the transport improvement versus the land use change, you should show benefits both for a fixed land use scenario (that is first-round transport benefits) as well as for the full land use change scenario (for example, by showing the total impacts as an increment to the first-round benefits).

61. Typical transport user benefits should be based on fixed land use scenarios only (using the base case land use in the project case).
62. Measurement of changes in land use value (or value uplift) in CBAs should not be confused with value capture concepts. According to the Commonwealth Bureau of Infrastructure, Transport and Regional Economics (BITRE, 2015), value uplift is "the process where the value flows on the transport network are capitalised into land values", while value capture taps into this by capturing some of the uplift around infrastructure investments for funding the project. Value capture is the act of collecting a portion of the benefits from public infrastructure investments that flow to the value of land.
63. See, for example, Brandes, U. et al 2010, *Land use and driving: The role compact development can play in reducing greenhouse gas emissions- Evidence from three studies*, Urban Land Institute; and Ewing R. and Cervero, R 2010, *Travel and the built environment: A meta-analysis*, Journal of the American Planning Association, 76(3), pp. 265–294.
64. In estimating land use change attributable to the transport project, there needs to be a good understanding of existing exogenous land use forecasts (e.g. from state planning departments). These forecasts would typically represent base case land use against which the land use model would estimate land use changes. Of particular importance is whether the exogenous land use forecast already considers the transport project in question. This would result in the land use modelling and the exogenous land use forecasts both measuring the impact of the transport investment. In such circumstances, it may be appropriate to consider the problem in 'reverse' – i.e. how would future land use growth change if the transport project was not delivered.

- **Public infrastructure cost changes** – Connecting and providing infrastructure services such as utilities (water, electricity and gas), transport and larger scale social infrastructure (for example, schools and hospitals) in less dense urban environments tends to be more expensive per dwelling than providing or upgrading the same infrastructure in denser environments. If these infrastructure costs are not fully recovered from the developers that create them, a project that leads to a change in the balance of distribution of future growth across denser and less dense parts of a city can lead to a net change in the cost of facilitating this growth. Importantly, the private cost of public infrastructure is often lower than the marginal social cost, as the government tends to meet some of the costs of development.

  Therefore, the cost of public infrastructure can differ significantly between greenfield and infill locations. For example, a study by Infrastructure Victoria found that the capital cost of providing public infrastructure (excluding open space) typically varies from being two to four times more expensive in greenfield areas than established areas.[65]

  Changes in the costs of providing public infrastructure and services should be included only where evidence can be provided. Where possible, this should be specific to the location being studied, take into account variability in the type of housing, and have been tested with infrastructure and service providers. In particular, it should assess the comparative costs of providing new schools and hospitals in greenfield or established areas, noting the differences in land costs and availability of infrastructure capacity. Further guidance for estimating benefits associated with avoiding infrastructure costs from unlocking new housing developments is provided in the UK Department for Transport's *Transport Analysis Guidance (TAG) unit A2-1 wider economic impacts*, available at: **www.gov.uk/government/publications/tag-unit-a2-1-wider-economic-impacts**.

  It should be noted that the public infrastructure cost changes depend on the pricing framework applicable. In many cases, a reduction in the costs of supply in one area will simply shift fixed costs to other users. For example, with water recycling plants in infill developments, the per-connection costs of supply to those users may be lower for the utility, but the third-party pricing arrangements in some states could effectively shift these users off the utility's revenue base and increase the cost burden (maintenance and renewal of trunk infrastructure, etc.) per connection across the rest of the catchment.

  The public infrastructure cost changes should be the cost incurred by the public infrastructure provider or utility net of revenue from developers and user prices, relative to the base case.

- **Sustainability impacts** – Changes in built form may result in sustainability benefits or costs where they have upstream or downstream environmental impacts. For example, lower ongoing energy use (for example, electricity, gas and water consumption) or lower environmental impacts of construction for high/medium density developments compared to low density housing. To the extent that prices (and hence marginal willingness to pay) differ from marginal social costs due to environmental externalities, such as greenhouse gas emissions, transport initiatives which lead to changes in urban form may result in sustainability impacts.[66]

  Higher density development tends to be more energy efficient than lower density development. On average, households living in low density dwellings (such as freestanding houses) tend to consume more electricity and gas than those living in medium (such as semi-detached houses) or low-density (such as flats or apartments) dwellings. For example, low density dwellings in Sydney consume on average 93% more electricity than high density dwellings.[67]

65. Infrastructure Victoria 2019, *Infrastructure Provision in Different Development Settings*, Infrastructure Victoria, available at: www.infrastructurevictoria.com.au/project/research-infrastructure-provision-in-different-development-settings.
66. Note that land use change also has the potential to generate sustainability disbenefits, in particular, through impacts on the natural environment such as carbon sequestration, visual amenity and biodiversity.
67. Independent Pricing and Regulatory Tribunal (IPART) 2010, *Residential energy and water use in Sydney, the Blue Mountains and Illawarra*, IPART, available at: www.ipart.nsw.gov.au/Home/Industries/Special-Reviews/Reviews/Household-Survey/IPART-2010-Household-Survey-of-Electricity-Water-and-Gas-Usage-Sydney-Blue-Mountains-and-the-Illawarra

To the extent that energy prices are below marginal social costs, there are additional net benefits associated with a reduction in energy consumption as a result of land use change. Energy production has environmental externalities, which result in the price of energy not reflecting the full resource cost of production. In particular, energy production results in $C0^{2}$-e emissions, the costs of which are not fully internalised by households and business. The social cost of this misalignment is extensive with the International Monetary Fund estimating that if energy prices equalled marginal social costs, global carbon emissions would be reduced by 25% and premature deaths from fossil-fuel air pollution by 60%.

- **Public health cost changes** – Infrastructure projects that result in a denser pattern of urban development have grounds to claim public health cost savings associated with net increased incidence of trips using active transport. The NSW Government's 'Economic Framework for Urban Renewal' identifies the possibility of health benefits from increased active transport use as a result of urban infill.[68]

  Public health benefits can be calculated by applying the active kilometres travelled per person for each area to the change in estimated population for each area and multiplying by the health benefit per active kilometre travelled.

When calculating these land use costs and benefits, you will need to be mindful of the following methodological issues:

- **Double counting** – In incorporating costs and benefits associated with land use changes, you should guard against double counting. For land use impacts, this principally concerns the extent to which any land use costs and benefits may be implicitly included in other components of benefits, such as travel time savings. For example, in transport projects, if the traffic model includes induced demand and this (implicitly or explicitly) reflects induced demand from a change in land use, then the benefits to households and businesses changing location will already be captured in the first-round transport benefits. Where this is the case, a CBA should not also include the costs and benefits of this land use change on the transport network.
- **Redistribution** – Land use impacts captured in the CBA should only reflect a redistribution of population and employment in the geographic area that is modelled. The modelled area must be defined so that all positive and negative impacts are captured. This ensures that the benefits reflect all displacement of activity elsewhere and are net incremental benefits. Given the lack of appropriate evidence on the treatment of inward migration (population or firms) in existing literature, it is recommended that no new activity as a result of this is considered in a CBA analysis unless compelling evidence can be presented to support such impacts, and the resulting costs and benefits are included.
- **Net negative impacts** – Land use changes can have positive and negative impacts (that is, costs and benefits). Where projects incorporate costs and benefits associated with land use impacts, you should ensure that both positive and negative land use impacts are translated into the CBA. In some projects, this may result in a net negative land use outcome.

C-5 Reporting results

If you are seeking to incorporate costs and benefits associated with land use changes, you should consult with us to discuss the justification for including these benefits in the context of the proposal's strategic objectives.

When presenting CBA results you should:

- present CBA results with conventional benefits (that is, excluding land use impacts and WEBs)
- report results with land use impacts as a 'below the line' item.

See **Section 2.10** for further detail on presenting CBA results.

68. This is supported by data from the ABS census which suggests there are significant differences in the rate of active travel as part of travel to work in infill and greenfield areas. Although workers living in greenfield areas that walk or cycle to work travel further than infill residents, the vast majority are heavily dependent on motor vehicles.

Appendix D

Wider economic benefits

D-1 Background and context

WEBs are outside of the benefits to direct users of improved infrastructure. They arise when changes in behaviour as a result of a project flow through into other markets that are subject to distortions. A distortion is where a market does not operate efficiently. For example, a change in transport costs could lead to positive flow-on impacts if it increases business interactions and improved productivity results from this. They should not be confused with broader (but direct) social benefits described in this document and the Assessment Framework more broadly. WEBs are also not the same as the economic impact analysis determined by CGE or I–O models.

WEBs are improvements in economic welfare that are acknowledged but which have not been typically captured in CBA. In general, these are the benefits derived from face-to-face contact, information exchange and networking only available where industries are working close to each other. WEBs can be disaggregated into a number of specific benefit sources. The most significant is agglomeration, the notion that similar firms are drawn towards the same location since 'proximity generates positive externality'.[69]

Where appropriate, for particular types of proposals, we will consider WEBs such as those defined in the ATAP guidelines, based on the strength of evidence presented to us.[70]

D-2 Measuring WEBs

While it is recognised that the quantification of WEBs is still in development, both in Australia and internationally, the correct interpretation and accurate calculation of WEBs (using the most suitable data available) can add depth to the decision-making process for certain proposals.

ATAP updated its guidance on WEBs in 2021. You should follow ATAP *T3 Wider Economic Benefits*[70] for the estimation and inclusion of WEBs in CBA.

Some states and territories have developed guidance on the treatment of WEBs, for example, the Transport for NSW guidelines (2016).[71] While national guidelines on WEBs have been developed, you should consult relevant state and territory guidelines. In quantifying WEBs, you should discuss with us which guidelines you propose to use.

In particular, it is crucial to acknowledge that:

- only certain proposals, addressing a specific set of economic fundamentals, will generate WEBs
- significant WEBs will only be found in proposals with strong traditional benefits, since WEBs require high levels of behavioural change, such as strong demand for the new assets/services
- some proposals may have negative WEBs that need to be deducted from the positive WEBs
- the availability of Australian specific data to calculate WEBs is currently very limited.

69. Head, Ries, and Swenson 1995, *Agglomeration benefits and location choice: Evidence from Japanese manufacturing investment in the United States*, Journal of International Economics, 38, pp. 223–247.
70. Transport and Infrastructure Senior Officials' Committee 2021, *Australian Transport Assessment and Planning (ATAP) Guidelines T3 Wider Economic Benefits*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/tools-techniques/wider-economic-benefits.
71. Transport for New South Wales 2016, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, NSW Government, Sydney, available at: www.transport.nsw.gov.au/sites/default/files/b2b/publications/principles-and-guidelines-for-economic-appraisal-of-transport-investment.pdf.

If you are seeking to calculate WEBs you should consult with us to discuss the justification for including WEBs in the context of your proposal's strategic objectives, and its impacts on transport and labour markets.

The quantitative analysis should follow the latest guidance and use well-informed assumptions about the most appropriate proposal-specific data. Applying a broad percentage uplift to the results of the conventional appraisal does not provide any additional or meaningful information for us to consider in the assessment process.

See ATAP *T3 Wider Economic Benefits* for detailed guidance on the estimation and inclusion of WEBs in CBA. It may also be relevant to refer to further guidance published by the UK Government in *Transport Analysis Guidance (TAG) unit A2-1 wider economic impacts*, available at: **www.gov.uk/government/publications/tag-unit-a2-1-wider-economic-impacts**.

D-3 Reporting results

If measuring WEBs is justified, when presenting CBA results you should:

- present CBA results with conventional benefits (that is, excluding land use impacts and WEBs)
- report results with WEBs as a 'below the line' item.

See **Section 2.10** for further detail on presenting CBA results.

Appendix E

Residual value and treatment of land value

E-1 Residual value of the remaining economic life of assets beyond the appraisal period

Economic appraisals should analyse infrastructure projects over the full economic or design life of the assets to be created. In the case of a proposal involving multiple assets, the appraisal period should be set at the expected life of the primary asset.

When the economic life of an asset(s) exceeds the appraisal period, a residual value can be used as a proxy for future user benefits generated by the asset beyond the appraisal period. The residual value is included in the analysis as a benefit in the last year of the appraisal period.

There is a variety of ways to calculate a residual value where asset lives extend significantly beyond the end of the appraisal period:

- Straight-line depreciation of capital costs (the most common approach)
- Benefit-based methods, which estimate net benefits for the remaining life of the asset outside of the appraisal period. This may be estimated using the NPV of future net benefit streams beyond the appraisal period.

For multiple-asset projects, straight-line depreciation can be readily applied to component assets that will last beyond the appraisal period, where allocating parts of project benefits to individual component assets cannot be justified. Benefit-based methods can become complex, therefore straight-line depreciation is likely to be appropriate in this situation.

E-2 Treatment of land value in CBA

E-2-1 Considering land value beyond the appraisal period

Unlike built-assets, the value of land does not depreciate over time. If land costs are part of the investment costs, it is appropriate to include the value of the land as a residual value at the end of the appraisal period. This residual value of land is the value for the use of the land at the end of the appraisal period, rather than its current possible use.

The difference between the present value of the land costs at the start and end of the appraisal period represents the present value of the rental cost of occupying the land for the duration of the appraisal period, if its potential use is the same before and after the investment has occurred. If land values are expected to rise over the appraisal period in real terms, the land value at the end of the appraisal period can be adjusted accordingly.[72] See Section 3.4 of ATAP *T2 Cost–benefit analysis*[73] for detailed guidance.

If the real value of the land is expected to rise considerably during the appraisal period, it might be worth considering an option where the project is constructed with less durable/costly assets and the appraisal period commensurately shortened. The project could finish occupying the land sooner, making the land available for a higher value use compared with the net benefits forgone by shortening the project's life.

72. Note that the forecast growth rate in land value should never exceed the discount rate because it would result in a negative present value for the land rental cost over the time the land is occupied by the project.
73. Transport and Infrastructure Senior Officials' Committee 2018, *Australian Transport Assessment and Planning (ATAP) Guidelines T2 Cost–Benefit Analysis*, Transport and Infrastructure Council, Canberra, p 19, available at: www.atap.gov.au/tools-techniques/cost-benefit-analysis/index.

Any costs for land clean-up or infrastructure demolition at the end of the asset's life should be deducted from the residual value (after discounting these costs to the start of the appraisal period, if relevant).

E-2-2 Land reclamation

Projects can create land through land reclamation using waste materials from earthworks as infill. A recent example of land reclamation is in Sydney, where one million cubic metres of spoil from the NorthConnex tunnelling site were used to partially fill Hornsby Quarry. The local council has now rehabilitated the site into a public recreation area.[74] Other examples of land reclamation occur in coastal areas where land is reclaimed for ports, airports or mixed-use commercial and residential use. A benefit can be claimed for the project equal to the market value of the reclaimed land if it is sold, or the net benefits of the land in a public use such as a recreation area. In the latter case, benefits must be 'net' because costs of other investments necessary to realise the benefits must be deducted. Any negative environmental and social impacts from reclamation of coastal areas should be treated as disbenefits.

E-2-3 Air rights or air space

As our cities become increasingly densified, there are limited opportunities to build or expand on existing land. This has led to capitalising on the air space above existing or new structures. In Sydney, the City of Sydney Council and Sydney Living Museum have purchased the "air rights" to the 200-year-old heritage listed Hyde Park Barracks.[75] A new structure could be built to a lower height and stronger foundations to allow for future uses of the space above. The current market value of air space above, or alternatively, the present value of benefits minus costs for a future structure occupying the space above, can be used as the benefit measure.

E-2-4 Real options analysis

Real options analysis may be a suitable analytical approach in cases where there is uncertainty about further alternative uses of the land (for example, changing tram corridors to road vehicle use or vice versa) or utilising the air space above. It enables the additional costs of more flexible designs to be compared with probabilistic future benefits and costs dependent on uncertain future circumstances such as demographic, macroeconomic, social or technological changes.

See the **Guide to risk and uncertainty analysis** for guidance on real options analysis.

74. NorthConnex, 'Hornsby Quarry', Transport for NSW, viewed 25 July 2019, www.northconnex.com.au/project-construction/hornsby-quarry [accessed 25 July 2019]
75. ABC News, 'Private developers pay millions for Sydney's "air rights" above heritage sites', ABC, 2 May 2019, www.abc.net.au/news/2019-05-02/private-developers-purchasing-air-rights-sydney-heritage-sites/11063642

Appendix F

Water sector considerations in CBA

This appendix identifies considerations to avoid common pitfalls for conducting CBA in the water sector, related to demand forecasting, defining the base case and avoiding double counting.

F-1 Demand forecasts

A critical input to a CBA is forecast demand. However, demand forecasts for water sector projects offer unique challenges for practitioners.

F-1-1 Testing demand assumptions thoroughly

Water sector projects often involve agricultural benefits related to 'induced' agricultural activity. This may involve changes in land use from lower value crops to higher value crops or greenfield development. Demand forecasting needs to consider demand assumptions related to both the direct water demand (to grow crops) and demand for the final product itself.

Soil profiling and traditional water demand surveys provide an indication of what could be grown if a project proceeds. However, it is important to 'sense check' the demand profile to ensure that the forecast demand profile is commercially viable. For example, if the demand profile assumes 10,000 greenfield hectares of avocadoes can be developed, the developer needs to be able to purchase the land and water, invest in the on-farm infrastructure, pay for up-front and ongoing water infrastructure storage and delivery costs, cover other farm operating expenses and earn a risk-adjusted profit on the investment. Farm financial models that utilise contemporary, regionally specific input cost, yield and commodity price data provide a useful basis on which returns to agriculture can be estimated to sense check the demand profile. If a commercial, risk-adjusted return cannot be realised, the forecast demand and benefits in the CBA are unlikely to eventuate.

F-1-2 Climatic impacts

The agricultural benefits accruing to water sector projects are based on the provision of a key factor of production: water. The ability to provide water for most, but not all, water infrastructure projects is dependent on rainfall and therefore subject to climatic variability.

Water sector CBA often involves the interaction of economic models with biophysical (for example, climatic) models. For example, water yields available from a dam project are inherently linked to climatic forecasts. The economic benefits depend on water yield which is uncertain and should be assessed probabilistically. Failure to integrate probabilistic water yield outputs from the biophysical model into the CBA model can lead to over or under estimation of the economic benefits of the project. We recommend economic modellers collaborate early with hydrologists, and they collaborate on how best to combine the hydrological modelling outputs correctly into the CBA model to account for climatic variability, ideally probabilistically, over several potential climatic futures (see the **Guide to risk and uncertainty analysis**).

F-2 Key considerations and pitfalls for water sector projects

F-2-1 Exclude the costs of avoided options

Project appraisals compare the costs with the benefits (and disbenefits) of options with a well-defined base case (see **Section 2.3**). You should compare all options against a single base case, rather than comparing options against each other. You should not subtract the avoided costs of an alternative infrastructure option from the cost of the option under consideration. We have provided **two examples where this might occur, and why this is not appropriate**:

- Using the cost of alternative options to quantify a problem.
  - For example, consider a water infrastructure proposal that will deliver water security for an urban area to avoid future water restrictions and other problems that have economic costs for the town. In this situation, a proponent has used the investment cost of alternative infrastructure options to monetise the cost of the problem. This would be incorrect because the financial cost of solving a problem is unrelated to the economic costs of the problem itself.
  - Instead, these problems should be quantified using economic theory that aims to assess the changes in consumer and producer surplus. In the example above, the quantification approach should be as closely related to the economic problem (water restrictions) as possible. This may include the use of stated preference approaches, such as willingness-to-pay surveys that identify what a resident would pay to avoid water restrictions.
- Including the cost of alternative options as a cost that is 'avoided'.
  - In this situation, a proponent has included the cost of alternative infrastructure options as costs in the CBA that are 'avoided' if the preferred project is approved. This would increase the economic impact of the preferred option as these costly alternatives do not have to be paid for. This is an incorrect approach to CBA, as it has an incorrectly specified base case.
  - In CBA, the only costs that should be subtracted from the project case are those that occur under the base case. If alternative infrastructure options have not been committed and funded, they should not be included in the base case and therefore not be subtracted from the project case (that is, included as an avoided cost).
  - The error of this approach is demonstrated by considering what would happen to the results of a CBA if you continually subtract the costs of all feasible alternative infrastructure options. In this scenario, the NPV would increase with every additional infrastructure option avoided, and could be manipulated by adding additional avoided infrastructure investments until the desired result is reached.

F-2-2 Avoid double counting

The double-counting of benefits is a common pitfall in CBA. For water sector projects, double-counting can occur in a variety of ways. For example, consider an urban water proposal to improve water quality. It would be incorrect to consider both residents' willingness to pay for improved water quality under the project case, as well as the cost to households of water filtration devices to improve water quality under the base case, as these both measure the value of improving water quality.

F-2-3 Frequent use of non-market valuation

Non-market valuation (NMV) techniques are used more frequently in water sector projects than other sectors such as transport. You should therefore be cautious about the techniques used if NMV is the basis for a large proportion of the total benefits of a project.

See **Section 2.6** for detailed guidance on monetising costs and benefits, as well as approaches to non-market valuation.

We generally support the principle of proportionality in this respect. For example, if the largest benefit of a project is estimated via benefit transfer, a rigorous approach should be used – such as transferring the functional equation into the context of the project, rather than transferring values without considering how the context may have changed.

Appendix G

Proposals in regional and remote areas

G-1 Introduction

The 2019 *Australian Infrastructure Audit* confirmed the significant infrastructure service quality gaps faced by regional and remote communities in Australia. The infrastructure opportunities and challenges are very different from those affecting other parts of Australia and these include:

- vast distances with low population densities
- limited local workforces and significant challenges attracting workers
- exposure to extreme climate and weather events and more vulnerable to natural hazards
- reliance on single assets and networks with limited choice and redundancy.

These challenges and the lack of physical and digital connectivity result in lower quality-of-life outcomes for many living in these more remote settings in terms of their health, educational achievement, sense of inclusiveness, mental wellbeing and access to resources. While we are referring to regional and remote proposals in a general context here, these challenges will be most relevant for remote proposals.

The Australian Government wants to enhance the economic and social potential of regional and remote areas across five key areas of health, education, infrastructure, communications, and jobs and economic development.[76] Improved infrastructure access can assist these communities to more successfully meet economic challenges, build resilience and improve quality of life, especially in Aboriginal and Torres Strait Islander communities.

In addition to these factors, remote areas have the challenge that small numbers of dispersed communities require a minimum level of service, usually from infrastructure that cannot be scaled. Therefore, infrastructure investments in remote settings can return poor (monetised) economic results compared to projects serving less remote, more populated areas.

We are aware that quantifying and monetising potential benefits from infrastructure projects are challenging and therefore, in some circumstances, some benefits resulting from infrastructure investment in regional and remote areas may not be adequately captured within CBA. **Table 19** describes the ways that specific benefits of proposals in remote areas may not be captured in CBA. Benefits for specific sectors are then described in the subsequent sections.

For each of the benefits described, you should assess which of these categories the benefit fits into, then articulate and evidence them appropriately in your analysis.

76. Department of Infrastructure, Transport, Regional Development and Communications 2017, *Regions 2030—Unlocking Opportunity*, Australian Government, available at: www.regional.gov.au/regional/publications/regions_2030.

Table 19: Treatment of benefits for regional and remote proposals in CBA

Types of benefits of remote areas proposals	Treatment in CBA
Benefits that relate directly to improved access, quality or cost of services and where existing frameworks can be applied in regional or remote settings to adequately estimate these benefits. For example, safety improvements to roads with higher rates of accidents, or reduced business costs from improved roads measured through savings in freight journey time and VOCs. This may also apply to health interventions if the analysis can take account of current health outcomes and is able to adequately forecast the impact of an intervention on the life expectancy, quality of life and changes in ease of access and value these changes.	These benefits can be fully captured in CBA.
Benefits that have increased importance due to the specific challenges of remote areas or benefits that are not typically captured in CBA valuations that are important in the remote area context. These benefits are measured but do not adequately reflect the full impacts to regional and remote residents and businesses, as the same valuation parameters are applied as in an urban context. You should consider whether the scale of the benefits per individual resulting from transport, health or educational proposals are likely to be greater than would be measured with the application of standard appraisal frameworks. For example, investment in new or upgraded schools might estimate the benefits in terms of the impact of the improved facilities on educational attainment, reduced crowding and lifetime earnings. However, does a standard value for the change in lifetime earnings and its application adequately reflect the likely benefits for a remote situation? In some circumstances, the impact per individual in regional and remote areas could be far greater.	There are limitations capturing these benefits in CBA because the estimation of impacts and the parameter values used to monetise them may not fully capture the increased importance in regional and remote areas. Any alternative treatment of benefits must be supported by evidence justifying why there are additional benefits.
Some benefits that are very important to the community and are relevant to government policies, but are difficult to quantify or monetise. For example, improved social inclusion and mental wellbeing.	There are limitations capturing these benefits in CBA because of the difficulty in quantifying them. These benefits are generally better to be presented quantitatively and qualitatively where relevant, with supporting evidence provided.

G-1-1 Presenting economic appraisal results for regional and remote proposals

You need to consider carefully how you represent the full benefits of infrastructure investments in regional and remote contexts. You should provide evidence for benefits you think are undervalued or omitted and consider how to represent these in the assessment results. To present these benefits, **you should quantify and, where possible, monetise the impacts, supporting these with compelling evidence justifying the inclusion and scale of the benefits and why they may differ from a less remote context.**

This section sets out the investment context for each sector, some of the benefits resulting from investment in remote areas in each key infrastructure area, and how these benefits can be quantified, including examples.

G-2 Transport

G-2-1 Context

Transport infrastructure needs in remote areas can be different from those in more urban areas. Remote areas by definition involve vast distances from some services, and in some circumstances, are separated by demanding geography and climate conditions.

Road is the main mode of transport available to remote areas.[77] However, the road network is often of lower quality than urban roads – roads can be unsealed, even for major roads. For example, the Northern Territory has only five major sealed roads outside of Darwin.[78]

One of the consequences of the road network conditions is roads in remote areas are less safe than urban roads, for example, the rate of road deaths per capita is six and 13 times higher in remote Australia and very remote Australia respectively compared to major cities.[79]

In addition, roads in remote communities can often be subject to seasonal constraints, where roads are unavailable for a period of time, potentially for up to six months during the wet season.[80] When a road is unavailable, the community would need to either:

- rely on more expensive, less convenient alternative modes, such as aviation services or barges
- not travel.

The costs associated with alternative modes mean that it is more likely that the community does not travel when roads are unavailable.[81]

There is evidence to suggest that lack of accessibility is a major barrier to health care.[82] Not being able to travel for prolonged periods during the year can also make obtaining education or employment difficult. Further, not travelling can result in significant costs to individuals as remote communities often have limited or no service locally (for example, health services or government services).

Remote areas also typically have smaller populations and therefore are less likely to be able to exploit economies of scale. This also means that while ‘per trip’ benefits for rural and remote transport infrastructure may be higher than for urban infrastructure, the low number of users and high infrastructure cost mean the investment is not economically viable.

G-2-2 Types of benefits

Investments in transport in remote areas are likely to result in ‘step changes’ in terms of availability of the road network when compared to transport investment in urban areas, where the investment rationale is often to improve travel speeds.

Transport is a derived demand – in other words, the purpose of travel is to do other activities and so the benefits from transport investment can be wide reaching. The step change in accessibility and availability is therefore likely to facilitate people’s travel to other important locations, such as schools, workplaces, and hospitals. It follows that improved accessibility and availability will improve an individual’s ability to interact with the broader society.

77. Austroads 2016, *Reforming remote and regional road funding in Australia*, Austroads, p v.
78. Transport and Infrastructure Council 2016, *National remote and regional transport strategy*, p 6
79. Bureau of Infrastructure, Transport and Regional Economics 2018, *International road safety comparisons 2016*, Australian Government, p 6.
80. See, for example, Transport and Infrastructure Council 2016, *National remote and regional transport strategy*, p 21.
81. Refer Transport and Infrastructure Senior Officials' Committee 2019, *Australian Transport Assessment and Planning (ATAP) Guidelines O4 Flood Resilience Initiatives*, Transport and Infrastructure Council, Canberra, available at: www.atap.gov.au/other-guidance/flood-resilience-initiatives/index.
82. Austroads 2016, *Reforming remote and regional road funding in Australia*, Austroads, p 57.

Some of the key benefits of investing in road infrastructure for remote areas include:

- improving social inclusion and cohesiveness
- lowering the costs of production for businesses
- employment and education benefits
- health and safety benefits.

These benefits are also consistent with the objectives of the National Remote and Regional Transport Strategy, which includes long term goals to:[83]

  - Enhance the economic and social potential of remote and regional areas through the development of appropriate transport infrastructure, services and regulation;
  - Improve access to employment, education and health services across remote and regional Australia by improving transport infrastructure and services.

These benefits are set out in more detail in the following sections.

Lower costs of production for businesses

Infrastructure is a crucial input for a business, and so availability of improved infrastructure can help the economic development of a region.

Additional or better quality transport infrastructure for remote areas means that businesses have access to key inputs at a lower cost, or are able to access resources that would otherwise be too expensive to be feasible. The impact of this is that existing businesses will be able to make additional profits, which can then in turn be invested in the community. New businesses may also become viable in the region that were otherwise not.

The increase in economic activity made possible by improved infrastructure also has flow-on effects in two key areas:

- increase in government surplus, for example, in reduced welfare payments and additional tax revenue
- change in employment for individuals in the remote area.

Employment and education benefits

By improving transport infrastructure, individuals are more likely to be able to access jobs at all times of the year. For example, an individual may be able to fill a job that would have otherwise remained vacant and available (or seasonally vacant). Alternatively, an individual may be able to access a better job (for example, better pay or better career progression prospects).

Better transport also results in easier access to existing jobs, reducing the costs of travel (including reduced travel time).

These benefits work in two directions:

- local residents of remote areas have greater access to outside areas of employment, as described above
- individuals from outside the local communities may find employment or business opportunities inside the community, increasing the output of the local community.

In a similar manner, improved transport infrastructure allows (easier) access to education opportunities, leading to benefits as well as long-term employment and productivity benefits to individuals and to the local community. These can be 'step changes' or incremental improvements, depending on the added level of access.

Health and safety benefits

Increased access and improved quality and reliability of road infrastructure means that individuals are able to make trips they may have otherwise forgone, reducing the long-term cost of healthcare and improving quality of life. For example, individuals with reliable road access to hospitals or doctors' surgeries are more likely to visit healthcare than if road access was unavailable or unreliable.

This greater likelihood of visiting doctors for routine check-ups is likely to reduce the long-term cost of healthcare. Studies have suggested that for many diseases, preventative healthcare including routine check-ups reduces the total medical cost compared to treatment once diagnosed.[84]

83. Transport and Infrastructure Council 2016, *National remote and regional transport strategy*, p 2.
84. National Center for Transit Research 2014, *Cost–benefit analysis of rural and small urban transit*, Tampa FL, p 6.

Improved transport infrastructure also allows medical professionals to visit remote communities more easily, allowing for improved service for those who are unable to leave their communities.

We noted above that roads in remote areas are less safe than in urban areas, with significantly higher fatality rates per capita. Improved road quality will reduce the number of deaths on remote roads.

G-3 Energy

G-3-1 Context

According to the World Bank, 100% of the population in Australia has access to electricity.[85] However, the level of access differs across Australia.

In most urban areas, the electricity is supplied by a grid. For example, the National Electricity Market (NEM) services customers along Australia's eastern and south-eastern coasts.[86] In contrast, remote communities are often 'off the grid'.

The key performance indicator for electricity supply is reliability, that is, how often and for how long blackouts occur. Connection to the grid is more reliable than being off the grid. Supply of electricity on the grid is from multiple generators, meaning that if one or several generators go off-line, the supply of electricity is generally not disrupted. Similarly, there is often redundancy built into the electricity network so that one or multiple lines being down does not necessarily lead to wide spread blackouts.

In contrast, electricity in remote areas can often be supplied by a single diesel generator and a local electricity network. The lack of redundancy means that off-grid is less reliable as outages can result in electricity disruptions, particularly as the infrastructure ages over time.

Using diesel for electricity generation also means that electricity supply could be disrupted from road outages, since diesel is usually brought into remote areas via the road.

Solar panels and batteries are becoming cheaper over time and there is an increasing shift towards providing renewable energy as off-grid solutions.

G-3-2 Types of benefits

Investment in electricity infrastructure in remote areas generally involves replacing old existing infrastructure with new infrastructure.

The benefits from investment in electricity infrastructure in remote areas include:[87]

- improved service reliability from replacing old diesel generators
- reduced carbon emissions and other air pollution from shifting to on-grid sources or renewable off-grid solutions
- cost savings for businesses and households, as the cost of renewable energy falls over time and communities become less dependent on the price of diesel, particularly in areas with high transports costs (for example, see the *Infrastructure Priority List* early-stage proposal *Northern Territory remote community power generation program*).

G-4 Water

G-4-1 Context

The responsibility of providing water services varies by community. It could be the responsibility of a water authority, local council, state or territory government agency, or a local community could be required to 'self-supply'.[88]

Water infrastructure in remote areas has three main purposes, to:

- provide safe drinking water to local communities
- support industry and agricultural production
- treat waste water to protect the local environment.

In urban areas, drinking water is typically from sourced mains or townwater (that is, water is provided via a pipeline with centralised water treatment). In contrast, in rural areas, drinking water is often obtained from local sources, such as rainwater or underground water, and often has a higher risk of contamination, for example from fuel storage, landfill or wastewater.

85. World Bank, *World development indicators – access to electricit*y, 2017.
86. Australian Energy Market Operator 2018, *The National Electricity Market*, Fact Sheet, p 1.
87. See, for example: Australian Renewable Energy Agency, *Off-grid areas*, available at: https://arena.gov.au/where-we-invest/off-grid-areas, accessed 26 March 2019.
88. See, for example: Department of Health, *Drinking water in Western Australia*, Western Australian Government, available at https://www.healthywa.wa.gov.au/Articles/A_E/Drinking-water-in-Western-Australia, accessed 13 March 2019; Department of Water 2009, *Remote drinking water sources – self-supplied Indigenous communities*, Western Australian Government, available at: https://www.water.wa.gov.au/__data/assets/pdf_file/0009/4113/88087.pdf

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Securing sufficient water to support agriculture can be challenging in remote areas. However, water for these purposes does not necessarily need to be at the same standard as potable water, but at a fit-for-purpose level.

G-4-2 Types of benefits

Water investment in remote areas is generally undertaken to improve the quality of potable water or waste water. This results in a reduction in health risk, or provision of water that is more suitable for agricultural purposes.

Typical benefits from water infrastructure investment in remote areas therefore include:

- improved health outcomes from improved water quality and better treatment of wastewater
- increased producer surplus as agricultural yield improves.

G-5 Telecommunications

G-5-1 Context

Telecommunications plays a key role in modern society. Access to telecommunication services helps facilitate social inclusion, by allowing people to connect with their friends, family, the broader community, and call for help in emergency situations. Individuals in regional and remote Australia have historically had lower levels of access than those in urban regions.[89]

Given the importance of telecommunications, Australia has developed policy to ensure that these services are available, accessible and affordable on a universal basis, that is, the universal service obligation (USO).

The objective of the USO was to ensure that:[90]

> *all people in Australia, wherever they reside or carry on business, should have reasonable access, on an equitable basis, to:*
>
> a. *standard telephone services; and*
>
> b. *payphones.*

Despite this, access to telecommunication services is generally lower in remote areas. For example:

- in 2017, Telstra's network covered 99.3% of the Australian population, but only a little more than 30% of Australia's land mass (that is, it was concentrated on urban areas)[91]
- in 2013, around 6% of Australian houses did not have access to fixed broadband.[92]

The move towards the digital age has seen consumers move away from fixed lined technology (such as land lines) towards more cellular based technology (such as mobile devices)

The rollout of the National Broadband Network (NBN) is expected to improve the quality of telecommunication services (which is also voice-capable) across Australia, including in remote areas. As of December 2018, 98% of premises outside major urban areas can now order an NBN service or have construction underway.[93]

The Australian government has prepared broadband policy objectives so that NBN delivers economic and social benefits for all Australians. These objectives set explicit policy expectations on NBN Co, which is responsible for building and operating the NBN, and require the NBN to:[94]

- provide peak wholesale download data rates of at least 25 megabits per second (Mb/s) to all premises
- provide peak wholesale download data rates of at least 50 Mb/s per second to 90% of fixed line premises as soon as possible
- provide upload rates that are 'appropriate'
- provide wholesale services that enable retailers to supply services that meet the needs of end users.

A multi technology mix network was selected to achieve the above objectives 'as soon as possible, at affordable prices, and at least cost to taxpayers'.[95] Unlike densely populated areas where fixed lines, such as fibre to the premises, fibre to the node and fibre to the curb, are usually utilised, remote areas often require a mix of fixed lines and wireless/satellite

89. Shareholder Ministers of NBN Co Ltd, *NBN Co Ltd statement of expectations*, August 2018, p 2.
90. *Telecommunications (Consumer Protection and Service Standards) Act 1999* (Cth), s 4.
91. Australian Competition and Consumer Commission 2017, D*omestic mobile roaming declaration inquiry*, Final Report, October 2017, p 5.t
92. Department of Communications 2013, *Broadband availability and quality report*, Australian Government, p 4.
93. Senator the Hon. Mitch Fifield, *Media release – telecommunications Universal Service Guarantee*, Australian Government, 5 December 2018.
94. Shareholder Ministers of NBN Co Ltd, *NBN Co Ltd statement of expectations*, 24 August 2016, p 1.
95. Shareholder Ministers of NBN Co Ltd, *NBN Co Ltd statement of expectations*, 24 August 2016, p 1.

services. These additional services include:

- the NBN fixed wireless service, which requires an antenna to be installed on the premises and transmits data from a transmission tower
- the Sky Muster service, which requires a satellite dish to be installed on the premises and receives signal from a satellite.

The wireless and the Sky Muster services in particular are utilised in remote areas where there are highly dispersed populations.[96]

The difference in population density and services provided means that the cost of providing the NBN in remote areas and urban areas differs significantly. For example, the NBN estimates that the cost per premises[97] of using fibre to the node is $2,259 while the cost per premises of using fixed wireless is $3,800.[98] However, the fixed wireless service has a maximum service range of 14km from transmission tower[99] and so is not available for many remote communities. Instead, these premises must be connected via satellite at a much higher cost. Comments from the NBN Co suggests that services to remote areas are running at a loss and need to be offset by positive margins obtained in inner city areas.[100]

With the rollout of the NBN and the reduced need for fixed line phone services, the Productivity Commission (PC) has recommended replacing the USO with a set of more targeted responses once the NBN rollout is completed.[101] The PC recommended that the universal service policy objective should be defined in terms of a realistic baseline or minimum quality,[102] and that the existing USO should be replaced by 'a competitive tendering arrangement to address any gaps in voice services within the NBN satellite footprint'.[103]

G-5-2 Types of benefits

Telecommunication facilitates a broad range of activities, and so consequently has the potential to deliver a wide range of different types of benefits.

Types of benefits include:[104]

- Improved service for users – telecommunications services, and in particular the internet, allow individuals and businesses to access a wide range of online content and services. For example, individuals with improved internet access may be able to watch streaming video services for entertainment, and businesses may be able to access cloud-based services such as accounting or information storage services.
- Education benefits – the internet provides individuals with the ability to obtain education remotely (either formally through a registered provider or informally). Therefore, improved access to telecommunications services has the potential to increase education levels in remote areas.
- Health benefits – in some cases individuals are unable to travel for appointments with doctors or specialists, and it may be very costly for doctors to travel to patients. Improved access to telecommunications services may allow for remote consultations over the internet in some cases, greatly reducing travel costs and improving health outcomes. Health outcomes may also be improved due to increased interactions with the wider Australian community.
- Other benefits, such as:
  - public safety benefits – increased telecommunications services in remote areas will also improve communication with emergency services
  - travel benefits – reduces the need to travel and the associated costs, since telecommunication services facilitates worker's abilities to work from home.

96. NBN Co Ltd, *Corporate plan 2019–20*, August 2018, p 11.
97. This assesses the comparative incremental costs of initial construction of each access technology.
98. NBN Co Ltd, *Half year report for the six months ended 31 December 2018*, February 2019, p 23.
99. NBN Co Ltd, *nbn fixed wireless explained*, available at https://www.nbnco.com.au/residential/learn/network-technology/fixed-wireless-explained, accessed 26 March 2019.
100. J Gothe-Snape, 'NBN fixed wireless blowing out bush broadband bill as Government pins hopes on fixed-line levy', ABC, 1 June 2018.
101. Productivity Commission, T*elecommunications universal service obligation*, Inquiry Report Overview, 28 April 2017, p 2.
102. Productivity Commission, T*elecommunications universal service obligation*, Inquiry Report Overview, 28 April 2017, p 9.
103. Productivity Commission, T*elecommunications universal service obligation*, Inquiry Report Overview, 28 April 2017, p 12.
104. See, for example: NBN Panel of Experts, *Independent cost–benefit analysis of broadband and review of regulation, Volume II – the costs and benefits of high-speed broadband*, August 2014, p 121.

G-6 Social housing

G-6-1 Context

Social housing is subsidised rental housing to assist people who are unable to access suitable accommodation in the private rental market.

Priority access is typically provided to those with the greatest need, for example, those that are homeless at the time of allocation.

There is evidence to suggest that social housing is a particular issue for remote areas, for example:[105]

- there is more overcrowding in social housing and a greater proportion of the population in social housing for the indigenous population in remote areas as compared to urban areas
- remote communities have a higher rate of applying for social housing on a per capita basis
- applicants are more likely to be couples with children when compared to major cities.

There is also likely to be harsher conditions/less services to help homeless people and others in need of social housing in remote areas, such as food banks and public toilets.

G-6-2 Types of benefits

Investment in social housing provides a range of potential benefits. These benefits are derived from reduced overcrowding and homelessness. The key benefits relate to improved health, employment, education and social outcomes.[106]

Housing plays a fundamental role in determining physical and mental health of an individual.[107]
The health benefits from reducing crowding and homelessness include:

- improved hygiene through increased access to clean and hot water, and shelter
- improved ability to manage illness, store medicine and maintain medical equipment
- personal safety
- improved workforce participation and education attainment.

The notion that social housing helps improved health outcomes is supported by residents that live in social housing – 83.4% of people in remote or very remote areas indicated that they 'enjoy better health' because of living in social housing.[108]

Social housing can also lead to improved employment and education outcomes.[109] For example, reduced homelessness and overcrowding can help people rest and sleep properly, thereby promoting an individual's ability to work and study effectively. It can mean that items required for study or work are less likely to be misplaced or taken.

The notion that social housing facilitates employment and study is supported by the sentiments of those that live in social housing – 72.4 and 68.9% of people in remote or very remote areas indicated that they were 'more able to improve job situation' or 'start or continue education/training' after moving into social housing, respectively.[110]

105. See: Australian Institute of Health and Welfare, *Housing assistance in Australia 2018, Data tables: matching of dwelling to household size*, available at: www.aihw.gov.au/reports/housing-assistance/housing-assistance-in-australia-2018/data; and Australian Institute of Health and Welfare, *Specialist homelessness services annual report 2017–18*, available at www.aihw.gov.au/reports/homelessness-services/specialist-homelessness-services-2017-18/contents/shs-geography/service-geography; also see: www.aihw.gov.au/getmedia/d97f4848-6242-4cdc-8f7f-08e7f24591ab/11874-2-02.pdf.aspx.
106. Department of the Prime Minister and Cabinet 2017, *Remote Housing Review: A review of the National Partnership Agreement on Remote Indigenous Housing and the Remote Housing Strategy (2008–2018)*, Australian Government, pp 15–21.
107. Foster, G., Gronda, H., Mallet, S. and Bentley, R., Precarious housing and health: Research Synthesis, Australian Housing and Urban Research Institute, 2011.
108. Australian Institute of Health and Welfare, *Housing assistance in Australia 2018, Data tables: social housing tenants*, June 2018, see: www.aihw.gov.au/reports/housing-assistance/housing-assistance-in-australia-2018/data.
109. Department of the Prime Minister and Cabinet 2017, *Remote Housing Review: A review of the National Partnership Agreement on Remote Indigenous Housing and the Remote Housing Strategy (2008–2018)*, Australian Government, pp 19–20.
110. Australian Institute of Health and Welfare, *Housing assistance in Australia 2018, Data tables: social housing tenants*, June 2018, see: www.aihw.gov.au/reports/housing-assistance/housing-assistance-in-australia-2018/data.

G-7 Hospitals and health services

Health services in rural and remote areas are very different from their urban counterparts.

Facilities are generally smaller but tend to consist of more integrated health services, for example, mental health services, oral health, community and aged care, and social services.[111]

Rural and remote health services are more dependent on primary health care services, particularly those provided by General Practitioners (GPs). This is reflected in the fact that remote and very remote areas actually had more GPs per 100,000 population in 2016 than major cities.[112]

Remote areas typically have less infrastructure and locally available specialist services, and provide services to a more dispersed population, for example:

- the Australian Institute of Health and Welfare (AIHW) reported that in 2016, remote and very remote areas had, per 100,000 population:[113]
  - 37.6 specialist medical practitioners, compared to 174.8 in major cities
  - 29.3 psychologists, compared to 103.7 in major cities
  - 62.6 pharmacists, compared to 100.0 in major cities
- 21% of people living in outer regional, remote and very remote areas felt they waited longer than was acceptable for an appointment with a GP, compared with 18% for those living in major cities[114]
- people living in regional and remote areas reported spending an average of travelling one hour to see a GP, with some respondents travelling for five or more hours.[115]

The outcome of these differences is that health outcomes are typically poorer in remote areas, for example, average life expectancy is:[116]

- 6.2 years lower in remote or very remote areas compared with major cities for Aboriginal and Torres Strait Islander males
- 6.9 years lower in remote or very remote areas compared with major cities for Aboriginal and Torres Strait Islander females
- 1.0 years lower in remote or very remote areas compared with major cities for non-indigenous males
- 1.1 years lower in remote or very remote areas compared with major cities for non-indigenous females.

G-7-1 Types of benefits

The benefits of investing in health infrastructure and services in remote areas include:[117]

- health benefits, such as improved quality of life, increased life duration and decreased adverse events
- health system cost savings, such as reduced clinical costs due to reduced admissions and lower proportion of acute treatments
- reduced transport costs, including travel time savings and reduced emissions
- improved health education in local remote areas, further improving health outcomes
- other benefits, such as improved accessibility for visitors of patients.

111. Rural Health Standing Committee 2011, *National Strategic Framework for Rural and Remote Health,* Australian Government.
112. Australian Institute of Health and Welfare, *Australia's health 2018*, June 2018, p 266.
113. Australian Institute of Health and Welfare, *Australia's health 2018*, June 2018, p 266.
114. Australian Institute of Health and Welfare, *Australia's health 2018*, June 2018, p 267.
115. Australian Institute of Health and Welfare, *Australia's health 2018*, June 2018, p 268.
116. Australian Bureau of Statistics, *Life Tables for Aboriginal and Torres Strait Islander Australians*, 3302.0.55.003, November 2018.
117. See, for example: NSW Health, *Guide to cost–benefit analysis of health capital projects*, August 2018, pp 35–37.

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