NRA
An tÚdarás um Bóithre Náisiúnta
National Roads Authority

Project Appraisal Guidelines

Unit 6.1 Guidance on Conducting CBA

July 2011

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Version	Date	Comments
1.0	July 2011	New Guidance

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1 Introduction

1.1. Cost Benefit Analysis (CBA) forms one element of the appraisal process for road infrastructure projects. CBA serves a number of functions at both the individual scheme level and when comparing different projects:

- At the individual scheme level, the results of the CBA indicate whether a road scheme is economically viable; i.e. whether economic benefits resulting from the provision of a scheme outweigh the costs to construct and maintain it. Secondly, they can provide a comparison of alternative options; and
- At the national level, the Government has finite resources to commit to road infrastructure improvements. The outputs from economic assessments allow different schemes to be compared and enable the schemes that provide best value to be identified. If the results of the CBA are to be used to prioritise schemes, then the assessments need to be carried out in a consistent manner.

1.2. The requirement to undertake an economic appraisal of major road schemes should not be confused with the requirements set out in the Department of Finance guidelines to undertake a financial appraisal, which is needed only for schemes with a commercial aspect (e.g. PPP schemes). The NRA's PPP unit should be consulted for guidance on conducting financial appraisals.

1.3. Output from the CBA should be used to satisfy the requirement within the appraisal process to undertake an exchequer cash flow analysis.

1.4. Guidance on selecting the most appropriate method for undertaking the appraisal is provided within this chapter.

2 Cost Benefit Analysis Principles and Economic Theory

Why use Cost Benefit Analysis?

2.1. Resources, particularly public sector investment resources, are scarce. All Governments are therefore concerned with securing value for money from investment expenditure and with finding tools that measure value for money objectively in areas of public sector expenditure.

2.2. Governments need to be able to understand the value for money of different expenditure programmes (e.g. comparing road schemes with investment in other transport projects), to identify priorities within a single programme (e.g. comparing different road schemes) and to understand if individual projects provide value for money.

Consumer Surplus

2.3. CBA was developed for sectors that do not have a marketable output. For this reason, the change in 'consumer surplus' is used as an indicator of well being to measure the benefits of a particular road scheme.

2.4. Consumer surplus is the difference between the price consumers are willing to pay for a good or service and the actual market price. If a consumer is willing to pay more than the actual price then the consumer surplus is defined as the difference in the two prices. On a standard demand and supply curve, as illustrated in Figure 6.1.1, consumer surplus is shown by the shaded area.

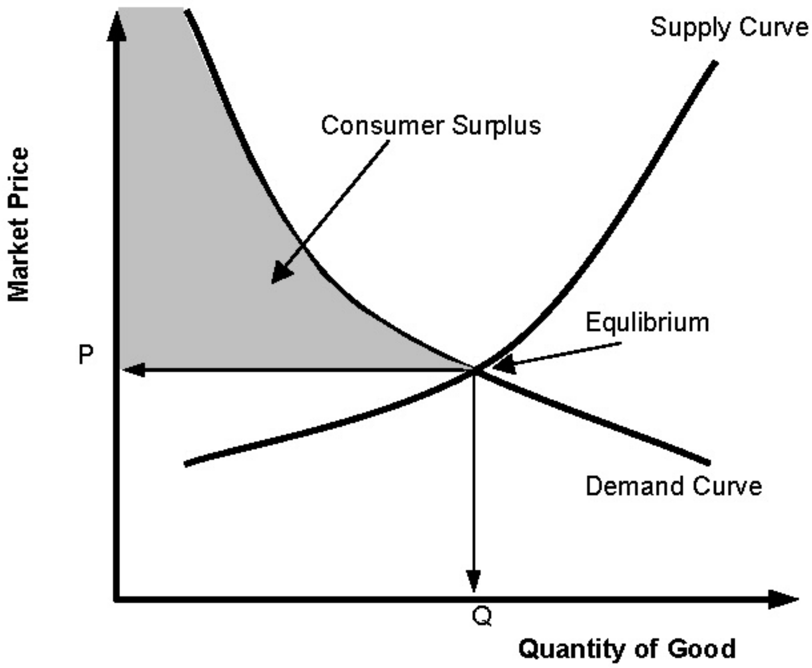

Figure 6.1.1 Definition of Consumer Surplus

2.5. The cost that a user is prepared to pay comprises of several elements, including any physical payments made (such as fares, tolls and vehicle running costs) and the value that the consumer places on his/her time. These elements are combined into an overall "generalised cost" of travel. Changes in generalised travel costs resulting from a transport scheme give rise to changes in consumer surplus, with positive movements representing a benefit to the consumer.

2.6. For example, if an individual is willing to travel for up to 15 minutes to enjoy a particular activity and a transport scheme reduces this time to 10 minutes then the traveller enjoys a consumer surplus equivalent to the generalised cost of five minutes of travel time.

2.7. Across all travellers making the same journey, the change in consumer surplus is the difference between the change in the total benefit enjoyed and the change in the costs.

2.8. If travel demand remains unchanged (i.e. demand is perfectly inelastic, meaning totally unresponsive to changes in price), but travel costs change, the change in consumer surplus is represented by the shaded area in Figure 6.1.2, and defined by the following formula:

$$\text{Change in consumer surplus} = (P^0-P^1)*T$$

Where P^0 and P^1 are the Do-Minimum and Do-Something travel costs respectively and T represents the number of travellers.

2.9. This situation is analogous to the fixed trip matrix assumption, where there is no increase in trips as a result of building a scheme.

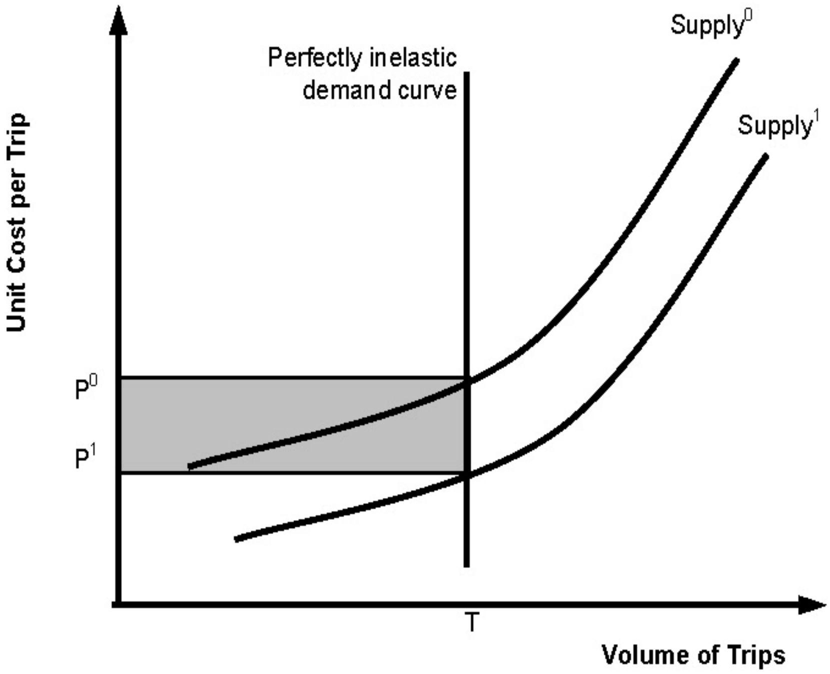

Figure 6.1.2 Change in consumer surplus – fixed demand

2.10. In the case where demand changes as result of changes in travel costs (i.e. demand is not perfectly inelastic), then the change in consumer surplus is as shown in Figure 6.1.3 and defined by:

$$\text{Change in consumer surplus} = (P^0-P^1)T^0 + \tfrac{1}{2}(P^0-P^1)(T^1-T^0)$$
$$= \tfrac{1}{2}(T^0+T^1)(P^0-P^1)$$

2.11. This situation is analogous to the variable trip matrix assumption, where there is a change in the number of trips as a result of building a scheme.

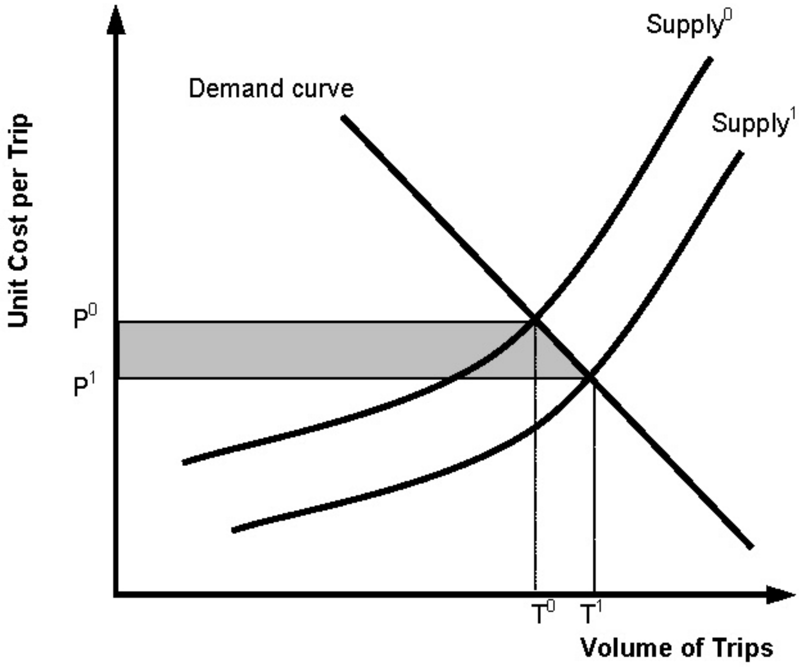

Figure 6.1.3 Change in Consumer Surplus – Variable Demand

2.12. The convention in this case is to attribute half of the change in costs (e.g. travel time, vehicle operating costs, tolls and environmental costs) to the change in trips and is known as the 'rule of half'.

Price Base Year

2.13. Implementing a transport scheme usually results in a stream of costs followed by a stream of benefits, some of which have monetary values applied to them. These monetised costs and benefits occur over a number of years, and cannot simply be added together as if they all occurred simultaneously.

2.14. In order to be able to add costs and benefits that occur over a period of time, two distinct issues must be dealt with:

- General changes in price levels over time (inflation); and
- Preferences for consumption now rather than later (time preferences).

2.15. The effects of inflation are resolved by means of converting all costs and benefits to a common price base year (using a "price index").

Present Value Year

2.16. Costs and benefits that arise in different years will have different values. For example, consumers will express a preference for €1 that is received today over €1 received next week or next year. This preference is independent of inflation effects. Costs and benefits arising in different years are therefore expressed in terms of their value from the standpoint of a given year. To take into account these time preferences, a discount rate is applied, discounting future costs/benefits back to a given year – the present value year. The present value year is usually the same as the price base year to simplify the appraisal process.

2.17. Whilst any year can be taken as the present value year, the current Project Appraisal Guidelines specify that 2009 should be adopted as the Present Value Year in all scheme appraisals. Summing the Present Values of Costs and subtracting these from the Present Value of Benefits gives the 'Net Present Value' (NPV) of the scheme at the present value year.

2.18. It is noted that whilst the Project Appraisal Guidelines specify a Price Base Year of 2009 for the appraisal of Road Schemes, the DoT Common Appraisal Framework specifies 2002 prices for the appraisal of other transport projects. If necessary to facilitate comparisons between different modal programmes, a Net Present Value based on 2009 prices can be converted to a 2002 price base year using the formula

$$NPV_{2002} = NPV_{2009} \times (CPI_{2002}/CPI_{2009})$$

The Discount Rate

2.19. Costs and benefits arising in different years are transformed to their present values by the process of discounting. This can be understood by considering the principle of compound interest. If €1 is invested at a real interest rate of r, at the end of one year it would be worth €(1 + r) and after two years €$(1 + r)^2$ and so on. By the same logic, €1 received in n years' time is worth €$1/(1 + r)^n$ now. Note that this illustration ignores the effect of inflation and therefore assumes that €1 has the same real spending value in each year. Inflation describes the change in spending power of money across different years and is distinctly separate from discounting. The illustration presented here is based on an inflation rate of zero.

2.20. Because discounting involves the notion of charging interest against a project, rather than paying interest to an investor, r is known as the discount rate. Any sum may be reduced to its Present Value (PV) by means of the following formula:

$$PV = \frac{S}{(1+r)^{y-p}}$$

Where:
PV is the present value;
S is the sum to be discounted;
r is the discount rate, expressed as a decimal;
y is the year in which the sum is received or incurred, and
p is the present value year.

Net Present Value

2.21. The Present Value of Benefits (PVB) represents the value in the present value year of all the benefits that will accrue over the appraisal period. It is calculated according to the following formula:

$$PVB = \sum_{y=year\,0}^{y=year\,n} \frac{B_y}{(1+r)^{y-p}}$$

Where B_y is the benefit occurring in each year, from the first year in which benefits are accrued *(Year 0)* discounted as appropriate, up to the limit of the appraisal period *(year n).*

2.22. The Present Value of the stream of Costs (PVC) represents the value in the present value year of all the costs that will accrue over the appraisal period, comprising mainly construction and maintenance costs. It is calculated in a similar way to the approach for calculation of PVB. For some schemes, it is possible that construction costs may have been incurred prior to the present value year. In such cases, this would require an inflation of the scheme costs to the present value year using the discount rate.

2.23. The approach to calculating PVC is therefore:

$$PVC = \sum_{y=year\,0}^{y=year\,n} \frac{C_y}{(1+r)^{y-p}}$$

where C_y is the cost incurred in year y, discounted as appropriate, up to the limit of the appraisal period *year n. Year 0* is the first year that costs are incurred, which may be prior to the present value year.

2.24. The NPV is the discounted sum of all future benefits less the discounted sum of all future costs over the appraisal period.

2.25. The NPV of the scheme can be calculated according to the following formula:

NPV = PVB – PVC

Benefit to Cost Ratio

2.26. The BCR is given by the ratio of the discounted sum of all future benefits to the discounted sum of all costs. It is one of a number of indicators that describe the efficiency of an investment and provides a means to compare alternative investments. Thus:

BCR = PVB / PVC

Internal Rate of Return

2.27. The IRR is the rate of discount that makes the present value of the benefits exactly equal to the present value of the costs. Put another way, the IRR is the rate of discount that makes the NPV of the entire stream of benefits and costs exactly equal to zero, and describes the rate of economic return that a defined investment is expected to generate.

2.28. The IRR 'λ'is that for which the sum:

$$\sum_{y=0}^{y=n} \frac{B_y}{(1+\lambda)^{y-p}} = 0$$

Where B_y is the net benefit (undiscounted) in year *y*.

2.29. It should be noted that there may also be other significant costs and benefits, some of which cannot be presented in monetised form. NPV and BCR are fairly powerful indicators of worth but it should be pointed out that do not provide information on benefits and costs that are not monetisable – refer to *PAG Unit 7.0 : Project Appraisal Balance Sheet*, which provides guidance on multi criteria analysis. In other words, although an important input, the economic analysis should not be used as the sole basis for decisions.

Valuation Principles

2.30. In presenting the results of CBA two distinct issues arise:

- Are the results to be presented exclusive of VAT and indirect taxation (i.e. expressed as factor / resource costs) or inclusive of VAT and indirect taxation (i.e. at market prices)?; and
- Do we present aggregated cost and benefits to society as a whole (social cost calculus) or do we disaggregate costs / benefits according to who bears them (the Willingness-To-Pay calculus)?

2.31. It is important to note that the choice of unit of account (i.e. factor versus market prices) or calculus (social cost versus Willingness-To-Pay) is immaterial to the results. It is important, however, to present all results on a consistent basis and to state which unit of account and calculus is used. Current guidance is to present all results in Willingness-To-Pay (WTP) as market prices. The standard appraisal software (COBA or TUBA) already outputs the required summary tables in WTP in market prices.

3 Application of CBA to Road Schemes

3.1. During the overall project timescale, CBA will normally be required during the following four phases:

- Route Selection;
- Design;
- Advance Works & Construction Document Preparation, Tender and Award; and
- Handover, Review & Closeout.

Route Selection

3.2. At this phase option comparison cost estimates, to be agreed with the NRA Cost Estimation Unit, will be used. The CBA must reflect the relative benefits of competing options. Default parameters for traffic composition and accident rates are therefore generally applicable. *PAG Unit 4.0: Definition of Alternatives* provides guidance on the selection of scenarios for the route selection phase. For all alternatives, the CBA process must be undertaken for the high, medium and low growth scenarios.

Design

3.3. The CBA at this phase is more detailed, using local parameter values for traffic composition and, perhaps, local accident rates. More robust scheme cost estimates will be available.

3.4. At this stage the CBA must be run (at least) six times, one for each combination of traffic growth scenario (‘high’, ‘medium’ and ‘low’) and cost estimate (Total Scheme Budget and Target Cost 1). For schemes involving tolling, separate tolled and un-tolled scenarios should also be presented.

Advance Works & Construction Document Preparation, Tender and Award

3.5. A revised CBA is to be carried out at advance works & construction documents preparation, tender and award phase if the tender price is notably different from that envisaged or if the project scope has changed on foot of changes in planning agreements.

3.6. At this stage the CBA must also be run (at least) six times, one for each combination of traffic growth (‘high’, ‘medium’ and ‘low’) and cost estimate (Total Scheme Budget and Target Cost 2). Toll schemes should focus on the tolled scenario, including all relevant costs such as the operation costs of the toll collection system.

Handover, Review & Closeout

3.7. The purpose of the handover, review & closeout phase CBA is to determine how the outturn costs and actual post-opening traffic flows compare with forecasts, and how these affect the overall economics of the scheme.

3.8. Analysis of a final account CBA can help identify issues relating to the assessment and provide useful information to feed into future assessments. The final account / closeout CBA should use actual scheme costs and traffic values. The CBA at this phase should use, insofar as possible, the same parameters used in the design and Advance Works & Construction Document Preparation, Tender and Award CBAs. Analysis of ‘high’, ‘medium’ and ‘low’ traffic growth scenarios should be prepared, in addition to any further sensitivity testing deemed necessary.

4 CBA Report

4.1. Having carried out a CBA, the AT is responsible for producing a formal CBA report for submission to the Design Office Project Manager (DOPM). The purpose of the report is to detail and justify the methodology, provide detailed information on the data inputs and to present the results of the economic appraisal.

4.2. The CBA report is the primary output from the CBA process, and will contain all the information required by both the NRA and the DOPM. This includes: the Validation Checklist; node-link diagrams (for COBA); maps; input and output files for each scenario tested, and any other information requested by the NRA or DOPM. Guidance on the contents of a CBA Report is contained in *PAG Unit 6.12: CBA Report* and *PAG Unit 6.13: CBA Audit Checklist*.

5 Project Management

5.1. CBA is undertaken by members of the approved Appraisal Team (AT). This may be a team within the Design Office, the Local Authority Road Design Team or an external consultant. The responsibilities of those involved in the CBA and the project management of CBA in the context of the overall appraisal process is described in *PAG Unit 2.0: Project Management*.

5.2. During the overall project process there are two levels of audit at each project phase: internal and external. Internal audits are undertaken by the Design Office Project Manager (DOPM) and supported by the Appraisal Team. The external audit is to be undertaken by either the NRA or an NRA appointed consultant. Guidance on the audit process is provided in *PAG Unit 6.12: CBA Report* and a sample checklist is contained in *PAG Unit 6.13: CBA Audit Checklist.*

6 Costs and Benefits

6.1. The analysis of monetised costs and benefits is currently limited to the assessment of the following core impacts:

- Changes in travel time;
- Changes in vehicle operating costs;
- Changes in tolls;
- Changes in scheme costs and maintenance expenditure;
- Delays and emissions during construction and maintenance;
- Changes in accident costs; and
- Changes in emissions of greenhouse and non-greenhouse gases.

6.2. Table 6.1.1 sets out those impacts of a road scheme that are not monetised; instead these are to be assessed qualitatively according to the guidance provided in *PAG Unit 7.0: Project Appraisal Balance Sheet (PABS)*.

Table 6.1.1: Non-Monetised Impacts in the Appraisal of Road Scheme

Criterion	Element
Environment	Air Quality Noise and vibration Landscape and visual quality Biodiversity Cultural heritage Land use Water resources
Safety	Security
Economy	Other economic impacts
Accessibility and Social Inclusion	Impact on vulnerable groups Impact on deprived geographic areas
Integration	Transport integration Land use integration Geographical integration Integration with other Government policies

6.3. Figure 6.1.4 illustrates how the costs and benefits of a scheme are brought together in the overall appraisal of monetised benefits.

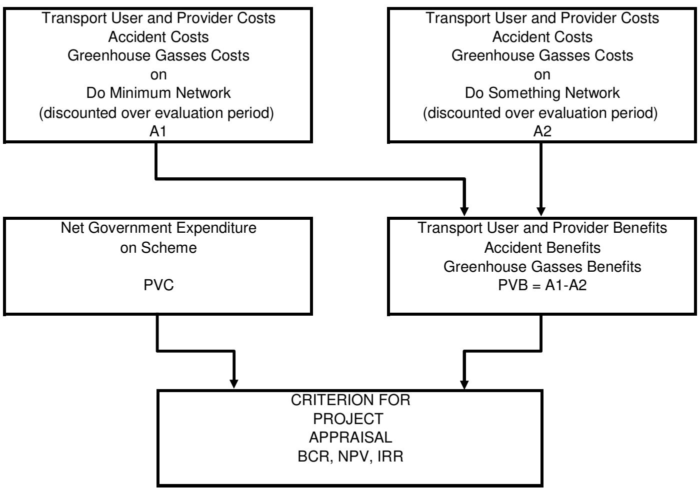

Figure 6.1.4: Overview of the CBA Appraisal Process

7 Values of Time

7.1. Travel time savings are the major items of the calculated benefit resulting from a typical road scheme.

7.2. For most schemes the aggregate time saving is positive, with the change in travel time directly or indirectly associated with the proposal, for example:

- Direct changes in travel time are incurred by transport users using the new facility, such as a bypass, rather than the next best alternative; and
- Indirect changes result from changes in travel times along other routes that may be affected by the scheme.

7.3. Three distinct purposes of travel are distinguished: travel in the course of work, commuting (travel to and from normal place of work) and other (travel for other non-work purposes). A different value of time can be applicable depending on the journey purpose, vehicle mode and whether the occupant is the driver or passenger.

7.4. The latest values of time recommended by the NRA for use in CBA of road infrastructure projects are provided in *PAG Unit 6.11: National Parameter Values Sheet*.

8 Vehicle Operating Costs

8.1. The use of the road system by private cars and lorries gives rise to operating costs for the user. These costs are split into two groups: fuel costs and non-fuel costs, the latter comprising items such as fuel, oil and tyres, and an element of vehicle maintenance.

8.2. Road schemes can give rise to changes in operating costs. The change in total VOC over all links depends on changes in the distance travelled by vehicles and on average link speeds. Whilst for most schemes the aggregate time saving is positive the change in overall VOC can be either negative or positive depending on the balance of changes in distance travelled and speeds.

8.3. The current VOC parameter values recommended by the NRA for use in CBA of road infrastructure projects are provided in *PAG Unit 6.11: National Parameter Values Sheet*.

9 Tolls

9.1. Any additional charges resulting from tolls should be treated as a cost (disbenefit) to travellers and a reduction in charges should be treated as a benefit.

9.2. Toll revenues are a benefit to the toll provider and possibly the Government / NRA if they receive a share of the toll revenue. Further advice on CBA of schemes involving tolling is provided in Section 13 of this PAG Unit.

10 Scheme Costs

10.1. The total costs of the scheme are considered in terms of:

- Investment costs (including construction, land, labour, preparation and supervision costs); and
- Operating costs, relating to changes in the cost of maintaining the network.

10.2. Detailed advice on how to undertake the computation of scheme costs for input into CBA is provided in *PAG Unit 6.7: Preparation of Scheme Costs*.

10.3. In the majority of cases, scheme costs will be borne entirely by national Government. However, in some instances contributions may be sought from private developers.

Exchequer Cash Flow Analysis

10.4. The overall net costs incurred by Government will take into account:

- Contributions from developers;
- Revenue raised by indirect taxation (as a result of changes in vehicle operating costs), contributions from developers; and
- Income received from tolled roads. Specific advice should be sought from the NRA's PPP Unit in such cases.

10.5. The exchequer cash flow analysis takes these factors into account and information required to complete this analysis, for reporting within the Project Appraisal Balance Sheet, is taken from standard output files produced by the COBA and TUBA programs.

Shadow Prices

10.6. Application of a shadow cost of public funds and shadow cost of labour can only be applied to monetisable criteria – other criteria are not so factored and so extra weight may be given to the economy criterion in comparison with other criteria such as integration. Current guidance from the Department of Transport Common Appraisal Framework requires that a shadow price factor of 1.0 should be adopted.

10.7. Further information relating to the shadow cost of public funds and shadow cost of labour is outlined in *PAG Unit 20.2: A Note on the Shadow Cost of Public Funds*.

Costs during Construction and Maintenance

10.8. Delays to road users that occur during construction and changes in delays due to routine maintenance are generally only considered for more complex schemes, or when they are likely to represent a significant element of the costs or benefits. In such instances the NRA SPU should be contacted to agree a method for assessing such implications.

10.9. The construction of a road scheme also generates emissions resulting from the manufacturing and construction process. See *PAG Unit 6.9 : Emissions During Construction* for further guidance.

11 Accidents

11.1. For road accidents, standard methodologies exist for calculating the projected number of accidents, the types of accidents and associated casualties in the Do-Minimum and Do-Something scenarios. The methods relate the traffic on a road (measured by vehicle-kilometres) to the number of accidents via the application of an accident rate.

11.2. Accident rates (and casualty rates) for different road types are set out in *PAG Unit 6.11: National Parameter Values Sheet* and these should be adopted. The COBA program adjusts these rates to account for the phenomenon of under-reporting.

11.3. Accident rates and accident severity rates are predicted to change over time irrespective of whether or not a specific intervention is being considered. Reduction factors for both accidents and casualty rates are provided in *PAG Unit 6.11: National Parameter Values Sheet*.

11.4. Standard cost values are attributed to fatal, serious and slight casualties allowing the monetisation of accidents in the before and after scenarios, and hence the calculation of the benefits or otherwise of a proposal. The standard costs per accident, are given in *PAG Unit 6.11: National Parameter Values Sheet*, which also provides costs per accident for insurance administration, damage to property and Gardaí costs for different types of accidents on different types of roads.

11.5. Local accident data can be used in place of national values for selected links where such data are considered to be reliable. The Irish version of COBA applies an automatic adjustment to take into account the phenomenon of accident under-reporting.

12 Emissions

12.1. Emissions should be considered in terms of the change in the equivalent tonnes of gas released as a result of implementing a road scheme. Emissions are estimated from fuel consumption in the Do-Minimum and the Do-Something options. Changes in emissions for the opening year and over the whole appraisal period, should be recorded in the PABS, quantified both in terms of kg of each emission type, and as a monetary value. The results of the calculation of emissions during construction should also be set out. The Irish version of COBA automatically calculates the change in emissions for a number of greenhouse gases and non-greenhouse gases for the appraisal period.

12.2. The construction of a road scheme also generates emissions resulting from the manufacturing and construction process. See *PAG Unit 6.9 : Emissions During Construction* for further guidance.

13 Toll Schemes

13.1. In the case of a scheme that proposes a toll, a benchmark CBA should be undertaken for the 'non-tolled' scenario. In such cases, the construction costs should be based on the anticipated tender cost, excluding VAT. Where required by the NRA, a separate assessment should be undertaken for the tolled scenario. The methodology and the public sector costs required for this evaluation should be agreed with the NRA.

14 Fixed Versus Variable Trip Matrices

14.1. When a road improvement takes place, several changes in trip patterns are possible in principle:

- Traffic travelling from A to B may transfer to the new route between A and B (reassignment effects);
- Trips may be made at a different time of day;
- Traffic may change its destination (redistribution effects); e.g. traffic may go to C instead of B;
- Trips to the same destination may be made by a different mode of transport; and
- The total number of trips may increase or decrease (generation effects).

14.2. In traffic modelling, the number of trips in the demand matrix is fixed between the Do-Minimum and Do-Something in situations when only the first reaction, reassignment, takes place. The change in consumer surplus in this instance is as illustrated in Figure 6.1.1.

14.3. When it can be demonstrated that a scheme, or combination of schemes, is likely to cause a *significant* response other than reassignment, the fixed trip matrix assumption may be inappropriate, and the Do-Something and Do-Minimum traffic demand will differ.

14.4. The method of CBA appraisal will depend upon whether the fixed trip or variable trip matrix assumption is applicable. For fixed trip matrixes, the CBA can be undertaken using either COBA or TUBA. COBA will calculate all benefits associated with a scheme, including accident benefits and residual value. Nevertheless, COBA calculates journey times using independent techniques from the traffic model and is therefore subject to inconsistencies, especially for larger or more complex schemes.

14.5. TUBA is particularly recommended where the majority of benefits are likely to come from travel time savings. TUBA calculates journey times from the traffic model and therefore is regarded as less liable to user error. With TUBA, residual value can be calculated by a separate assessment of benefits from year 30 onwards (see section 17 below for guidance on the residual value period). Furthermore, accident benefits can either be calculated using a simplistic COBA model, or through manual spreadsheet analysis using default accident rates and costs from *PAG Unit 6.11 : National Parameter Values Sheet*.

14.6. The TUBA program is also designed to address CBA in the case of variable trip matrices and is the recommended software for such appraisals. The use of alternative software titles will be subject to the agreement and approval of the NRA. TUBA requires time and distance skim matrices to be extracted from the traffic model.

14.7. Further guidance on undertaking a preliminary assessment as to whether the fixed trip matrix assumption is valid can be found in *PAG Unit 5.2: Construction of Transport Models*.

15 The CBA Method

15.1. Traffic flows with and without the road scheme under appraisal are obtained from a traffic forecasting process that is carried out separate from CBA. The traffic forecasting process assigns trips to the road network with and without the proposed road scheme, and forms the basis of the traffic input to CBA. The technique appropriate for this assignment will vary according to the particular scheme and specific guidance on traffic modelling is provided in *PAG Unit 5.0: Transport Modelling*.

15.2. Depending on whether a COBA or a TUBA style assessment is selected, different outputs from the modelling are required. In the former case assigned flows on links and junctions are required, whereas the latter uses matrices of total trips, travel times and distance travelled.

COBA

15.3. The essence of COBA is that the travel cost for each component (link and junction) of the network is calculated separately according to the flows and turning movements assigned to it. These individual link and junction costs (that is, time, vehicle operating and accident costs) are summed to yield the total user costs over the network.

15.4. The matrix of trips is assumed to be fixed in all cases when using the COBA programme. As such, a comparison can be made between total network costs before and after the road improvement in question. The reduction in costs is taken as a measure of the scheme benefits as they arise in each year of the appraisal period, and rests on the assumption that the improvement in question does not affect the number of trips made nor their origins and destinations.

15.5. User benefits are calculated for all traffic on the whole road network affected, and include impacts on traffic both using and not using the new road.

15.6. User costs consist of changes in travel time, vehicle operating costs (fuel and non-fuel) and the occurrence of accidents. COBA applies monetary values to each such that they can be set alongside capital and maintenance costs to provide total scheme costs as a single monetary value.

15.7. The COBA program requires all costs to be input as resource costs (i.e. net of indirect taxation), although the final output tables are provided in market prices.

15.8. Guidance on using the COBA programme is provided in *PAG Unit 6.2: Guidance on Using COBA*.

TUBA

15.9. The TUBA programme requires skim matrices relating to travel time and distances between each origin and destination. User benefits in terms of changes in travel time and VOC are calculated for each journey as a whole based on outputs from the traffic model, rather than on a link-by-link basis. The skim matrices may be disaggregated to represent different user groups and travel modes, depending on the complexity of the traffic model.

15.10. TUBA is the preferred approach for appraisal of schemes where the traffic models are derivatives of the National Traffic Model as set out in *PAG Unit 5.2: Construction of Traffic Models*.

15.11. Guidance on using the TUBA programme is provided in *PAG Unit 6.5: Guidance on Using TUBA*.

16 Appraisal Period

16.1. CBA considers the benefits arising over the ‘life’ of a project allowing a sounder basis for evaluation than is afforded by single year measures. Such measures can be particularly deceptive since two scheme options may yield similar returns for a given year but perform differently as traffic flows change over time.

16.2. The appraisal period is the period over which costs and benefits are calculated. The appraisal period for National Road schemes is currently set at 30 years unless otherwise agreed with the NRA Strategic Planning Unit.

16.3. It is recognised that some projects, particularly traffic management or Intelligent Transport Systems, may be designed with an initial design life for equipment of less than 30 years and in such circumstances the actual design life should be used as the appraisal period. However, traffic management or ITS projects may be intended to have serviceable lives considerably in excess of the design life of the equipment involved. Where periodic replacement of equipment and consumable infrastructure is required to ensure the serviceability of the project , the proper consideration of maintenance and operation costs throughout the appraisal period which will include such periodic re-investment may allow a 30-year appraisal period to be used.

17 Residual Value

17.1. In the appraisal of capital projects, the Department of Transport Guidelines state that this 30 year appraisal period should only be used where the life of an asset is at least 30 years. This is sensible, as it accepts that the benefits that flow from a scheme should only be appraised during the period when the infrastructure is available.

17.2. Nevertheless, where the lifespan of infrastructure is significantly in excess of 30 years, it is necessary to acknowledge this in scheme appraisal. Rather than increase the appraisal period, it is possible to quantify the likely benefits beyond the 30-year period through the definition of a 'Residual Value'.

17.3. For major transport schemes, the residual value is a measure of the net present value of the infrastructure over a specified period beyond the 30-year appraisal period. This is directly relative to the residual life of a scheme, which can range from no residual life at all, to quite a long residual life (greater than 100 years). Nevertheless, the definition of residual life also needs to account for the effect of the discount rate in reducing the present value of benefits that can arise.

17.4. Consider the example below for a scheme of indefinite life, where a benefit of €1 accrues each year over a 100 year period at a discount rate of 4%. From year 0 to year 30, approximately 65% of the overall benefits are accrued, rising to 90% by year 60. Beyond the 60-year period, the final 10% of the total benefit is accrued. This suggests that for projects with a long life span, the benefits accruable beyond the 30 year appraisal period can be significant. It also suggests, that although benefits can continue to be accrued for projects with indefinite life, there is little to be gained by accounting for any benefits beyond 60 years from opening.

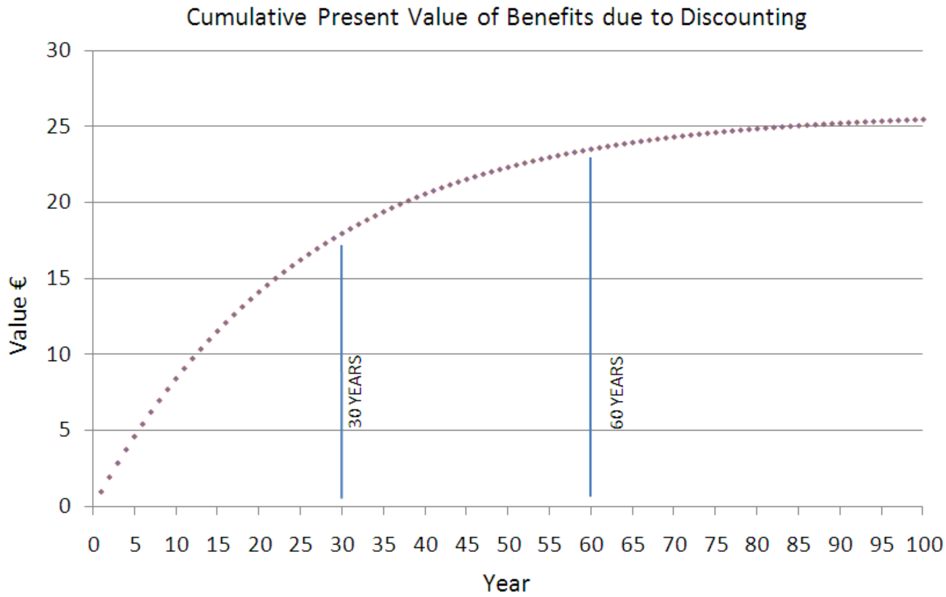

Figure 6.1.5: Accrual of Benefits

17.5. Obviously, there will be projects where the residual value will be curtailed due to the increasing cost of maintenance beyond a defined period, or the need for full reconstruction. For those projects, the periods within which the residual value should be calculated should ideally represent that period within which normal operation of the infrastructure (with a reasonable expenditure on maintenance) might be expected.

17.6. On this basis, the recommended period for the residual value calculation for infrastructure is set out in the table below.

Table 6.1.2: Period for Calculation of Residual Value

Category	Examples	Residual Value Period*
Long Life	Bridges, structures, tunnels, earthworks and other major investment in offline improvements	30
Moderate Life	Pavements or other online network rehabilitation on existing roads, where the design is such that no further major rehabilitation is required within a 40-year period	10
Short Life	Intelligent Transport Systems or other Traffic Management Solutions	0

** This relates to residual value calculated beyond the 30 year appraisal period*

17.7. The present value of the residual life should be included within the calculation of the overall Net Present Value and the Benefit to Cost Ratio of the scheme.

17.8. Although residual value can be incorporated into the reporting of benefits during scheme appraisal, the net present residual value should also be reported as a separate item in the appraisal summary.

18 Treatment of Parameter Values

18.1. COBA and TUBA contain a series of default parameters relating to items such as economic values (for example time, accidents and vehicle operating costs), accidents (rates and severity), annual traffic flow patterns and vehicle composition. Default values for the parameters can be found in *PAG Unit 6.11: National Parameter Values Sheet*.

18.2. An Irish version of the COBA programme has been developed which contains default parameter values. This software will be made available by Transport Research Laboratory. *PAG Unit 6.3: TRL COBA Report* provides further details on the work undertaken by TRL, highlighting the differences between the UK and Irish versions of the program.

18.3. When undertaking TUBA assessments, the standard economics file must be amended to overwrite values specific to the UK with those suitable for CBA assessments in Ireland. A default economics file is provided in *PAG Unit 6.6: TUBA Standard Input Files*.

18.4. Economic input parameters do not change by project phase; however the treatment of other parameters is dependent on the phase of scheme development and guidance on the source for each parameter and whether local or national default values should be used. Where local (i.e. non default) values are required, the user must update the relevant fields in the COBA input file.

18.5. In the future, the real value of a number of parameters will change. *PAG Unit 6.11: National Parameter Values Sheet* provides information on the growth factors that are to be applied to the value of time and the value of accidents. These factors are derived from forecast growth in real gross national product per person employed.

19 CBA Outputs

19.1. COBA and TUBA provide summary output tables that form the basis of the CBA results required for the CBA Report and Project Appraisal Balance Sheet (PABS).

- Transport Economic Efficiency Table (TEE) Table - contains the costs and benefits incurred by both users and operators of the transport system. Costs incurred by Government are not included in this table; instead these are reported in the Impact of the Public Accounts;
- Impact on the Public Accounts – the present value of the scheme costs are summarised in this table, which documents the net cost to Government after taking into account the contributions towards the scheme cost from other sources, revenues received from tolls and income received from changes in indirect taxation. This table provides the information required to undertake the Exchequer Cash Flow Analysis; and
- Analysis of Monetised Costs and Benefits – within this summary output table, all the benefits from the road scheme that can be expressed in monetary form are arranged to derive the NPV and BCR.