D.5.1
Methodologies for cost-benefit and impact analyses in urban transport innovations
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About TIDE

TIDE (Transport Innovation Deployment in Europe) is funded under the Seventh Framework Programme by the EU Commission Directorate-General for Research. It runs from October 2012 until September 2015. The TIDE consortium consists of POLIS (coordinator), Rupprecht Consult (technical coordinator) EUROCITIES, WSP Sweden; University of Southampton (TRG), Fraunhofer Institute, University of Gdansk; Wuppertal Institute, Reading Borough Council; City of Rotterdam, Donostia San-Sebastian Municipality, Centre of Budapest Transport, Milan City Council.

The overarching aim of TIDE is to enhance the adoption of innovative urban transport measures throughout Europe and to make a visible contribution in establishing them as mainstream measures. TIDE focuses on 15 innovative measures in five thematic clusters: financing models and pricing measures, non-motorised transport, network and traffic management to support traveller information, electric vehicles, and public transport organisation. The measures will be implemented by TIDE cluster leading cities and TIDE champion cities (Table 1). Sustainable Urban Mobility Plans is a horizontal topic to integrate the cluster activities.
### Table 1: Overview of TIDE innovative measures and TIDE cities

<table>
<thead>
<tr>
<th>Measure</th>
<th>TIDE cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Road user charging in urban areas</td>
<td>Milan, Huesca</td>
</tr>
<tr>
<td>1.2 Parking charge policies</td>
<td>Milan, Ghent</td>
</tr>
<tr>
<td>1.3 Efficient and convenient pricing and charging for multimodal trips</td>
<td>-</td>
</tr>
<tr>
<td>Cluster 2</td>
<td></td>
</tr>
<tr>
<td>2.1 Innovative Bicycle Parking schemes</td>
<td>Donostia - San Sebastian, Craiova</td>
</tr>
<tr>
<td>2.2 Creating people friendly streets and public spaces</td>
<td>Donostia - San Sebastian</td>
</tr>
<tr>
<td>2.3 Fast Cycle Lanes</td>
<td>Aalborg</td>
</tr>
<tr>
<td>Cluster 3</td>
<td></td>
</tr>
<tr>
<td>3.1 Open-access server for applications-based traveller information</td>
<td>Reading, Rome</td>
</tr>
<tr>
<td>3.2 User friendly human machine interface (HMI) for traveller information</td>
<td>Reading, Lyon</td>
</tr>
<tr>
<td>3.3 Advanced priority systems for public transport</td>
<td>-</td>
</tr>
<tr>
<td>Cluster 4</td>
<td></td>
</tr>
<tr>
<td>4.1 Clean City Logistics</td>
<td>Rotterdam, Barcelona</td>
</tr>
<tr>
<td>4.2 Financing Schemes for Charging Station</td>
<td>Rotterdam, Tampere</td>
</tr>
<tr>
<td>4.3 Inductive Charging for Public Transport</td>
<td>-</td>
</tr>
<tr>
<td>Cluster 5</td>
<td></td>
</tr>
<tr>
<td>5.1 Creation of public transport management bodies for metropolitan areas</td>
<td>Budapest, Vilnius</td>
</tr>
<tr>
<td>5.2 Contracting of services focused on improvement of passenger satisfaction and efficiency</td>
<td>Budapest</td>
</tr>
<tr>
<td>5.3 Marketing research as optimisation tool in public transport</td>
<td>Bologna</td>
</tr>
</tbody>
</table>
Local authorities are often confronted with a number of urban mobility issues, for which a multitude of alternative solutions are available. Guiding local authorities and providing them with information on the potential costs, benefits and overall impacts of innovative urban transport measures is the key objective of this paper and the TIDE Practitioners’ handbook for which this paper provides the basis. This will help making informed transport policy and planning decisions that will foster sustainable mobility in cities. Especially for innovative measures, detailed knowledge of possible costs and benefits is often very limited. Decision support tools such as cost benefit analysis (CBA), multi-criteria analysis (MCA) or Environmental Impact Assessments can be used to measure (ex-ante or ex-post) the potential or observed impacts of different policy options and can thus assist decision makers in selecting an appropriate policy.

In times of constrained budgets, projects’ economic viability is a decisive factor, often assessed using cost-benefit analyses. Cost-benefit analyses attempt to express the viability of a project by defining (as many as possible) of a measure’s relevant direct and indirect impacts in monetary terms. CBAs assist policymakers in understanding the wider impacts of a project, including its external costs. A drawback of the method is its limited ability to reflect difficult to monetise impacts (e.g. improved comfort or improved quality of life). In addition to CBAs, multi-criteria analyses can, and are increasingly, used to assess qualitative effects.

Improved knowledge of innovative measures’ impact is likely to foster their adoption; TIDE’s stated mission. In gathering this knowledge, the TIDE project has evaluated methodologies suitable to identify and assess urban transport innovations’ costs and benefits, both on an ex-ante and ex-post basis (i.e. pre-or post-implementation).

Ex-ante evaluations (e.g. using traffic models to predict congestion) are used predict measures’ cost-effectiveness or ability to meet the city’s key objectives, which, in turn, can be used to justify a measure’s implementation. Such ex-ante assessments will be the focus of the TIDE impact analysis method.

In addition to ex-ante assessments, ex-post (post-implementation) assessments of measures implemented in ‘donor cities’ provide valuable empirical evidence of measures’ effects; key to fostering their deployment elsewhere. For this reason, TIDE will also analyse ex-post assessments of measures similar to the TIDE innovative measures.

A transferability analysis has been completed within TIDE, a key aspect of which is the identification and quantification of a measure’s impacts in the ‘donor city’. Before a measure’s adoption is considered by a city, it is necessary to clarify and demonstrate the measure’s potential impacts (see TIDE Transferability Handbook Shrestha et al. 2013).

The aim of the present analysis of existing tools for impact analysis is to identify methodologies that meet the needs of practitioners in different contexts. This working paper compiles an overview of methodologies, focusing on cost-benefit analysis and multi-criteria analysis.

The results of the present paper are based upon:
a) an extensive review of CBAs related to the TIDE measures and on current methods in transport project appraisal, including scientific literature as well as practitioners’ guidelines and handbooks;

b) a survey of the TIDE leading and champion cities regarding their current practices and experience with cost-benefit analysis for local transport policies and measures. The survey was completed in March 2013 (leading cities) and June 2013 (champion cities);

c) a workshop conducted in April 2013 in Budapest, during which focus groups, including external CBA experts, city representatives and cluster support partners, discussed suitable methodologies for the TIDE measures.

This document is structured as follows: firstly, the cost-benefit analysis and multi-criteria analysis methodologies are introduced, along with a listing of their strengths and weaknesses. The second part of the document is structured along the lines of the TIDE clusters. Previous CBAs of TIDE measures/clusters, or analyses thereof, are summarised and used to draw methodological conclusions. The examples provide some insight into the cost and benefits of similar measures. Current practices in the TIDE leading and champion cities in each cluster are outlined. Based on these findings, and on the results of cluster-specific focus-group discussions during the TIDE CBA workshop, the methodological findings are presented for each cluster. These include the applicability of CBAs to the proposed measures and specific information on the methodological issues related to CBAs in the respective cluster. Finally, an overview of the applicability of CBAs to the various TIDE measures is provided and resulting implications for the TIDE method for impact analysis are summarised. Based on this, the TIDE method has been developed, which is presented in the final section.
Introduction – Current practices and challenges in assessing transport innovations

In light of limited public budgets, it is vital that public funds are spent efficiently. Investments should deliver the maximum economic, social and environmental benefits possible. To ensure that policies’ benefits are maximised and to prevent investments in projects that fail to address critical problems, the concept of evidence-based decision-making is an important guidance for policy makers at all levels. Its intention is to ensure the selection of the most appropriate measure, based on robust evidence of potential effects. Tools such as CBA or MCA indicate which policy or measure will most efficiently achieve a stated objective by assessing potential costs and benefits in a structured manner. As such, these tools are used to provide appropriate evidence upon which to base decisions. In addition they can be used to inform the public of the advantages of a specific decision and to justify a decision against an opposition.

Cost benefit analyses are widely used to assess transport projects or measures, especially large-scale infrastructure projects. For instance, the UK’s and the Netherlands’ guidelines for the appraisal of transport projects require CBAs for major transport projects, or non-CBA project assessment for smaller measures (Geurs et al., 2009). Since 2000, the EU cohesion policy requires a CBA for projects in order to qualify for funding from various sources (e.g. Structural Funds, Cohesion Funds and Instruments for Pre-accession Assistance). The EC Directorate-General Regional Policy has developed a common guideline to cost-benefit analysis, including a specific section on transport projects. However, this is focusing primarily on larger transport projects are addressed: depending on the fund, a CBA is required only for projects with a volume of €10 million or more (EC DG Regional Policy, 2008). Some elements of cost-benefit analysis are also included in Impact Assessments, applied to EC initiatives and EU legislation. Similar to a CBA, it assesses direct and indirect economic, social and environmental impacts compared to a baseline scenario, both quantitatively and qualitatively (EC, 2009).

The application of CBAs on local level policies or measures is rare and mainly limited to infrastructure projects and to projects that generate revenue (e.g. road pricing). The EC funded CIVITAS projects provided an opportunity to gain experience on CBAs for urban transport projects. For several of the CIVITAS measures, an ex-post CBA was carried out based on measurable impacts, although the quality and coverage of the data was insufficient to complete the CBA in some cases, while in others insufficient data allowed for only a simplified CBA.

Multi-criterion analyses (MCAs), based on the scoring, ranging and weighting of quantitative and qualitative criteria, have become increasingly popular in recent years for transport project appraisal (Macharis and Ampe, 2007). A MCA may be completed in conjunction with a CBA, but the method is particularly useful when quantitative data is scarce and a CBA would be difficult to complete.

In the following, the cost benefit analysis method is introduced followed by a brief introduction to the multi-criteria analysis method.

Cost benefit analysis

For many municipalities, money has become scarcer; optimising spending has become more critical. CBAs are seen as an appropriate tool to this end. CBAs are often used to
justify a project’s or measure’s (non) implementation from an economic perspective, citing specific economic viability indicators (see green box, Table 1 below) (Jansson, 2010). However, many effects, such as noise, air pollution or travel time savings associated with a transport project or measure do not have a market price, but are nevertheless valued by individuals or society as a whole, and as such, should be included in a CBA. Doing so requires the (often elaborate) monetisation of effects; this can be done by, for example, assessing citizens’ ‘willingness-to-pay’ for the benefit. CBAs are an elaborate tool consisting of several steps (see blue box, below).

**Important terms**

**Discounting:** a technique to compare costs and benefits that occur at different times. Discounting allows the expression of the present value of future costs (and benefits). A fixed discounting rate is usually used.

**Net Present Value (NPV):** the difference between the discounted value of benefits and costs \[\text{NPV} = (\text{PV Benefits}) - (\text{PV Costs})\]. If the NPV is positive the project is considered economically viable. This indicator is often used to accept or reject a project.

**Benefit to Cost Ratio (BCR):** the ratio of the present value of total economic benefits from a measure to the present value of the total economic costs \[\text{BCR} = \frac{\text{PV (Benefits)}}{\text{PV (Costs)}}\]. It describes the value of the benefits produced relative to the money invested. A BCR of 2.5 means that for every Euro invested, benefits of €2.5 are obtained. As the values are normalised, the BCR allows comparisons across differently sized projects.

**Internal Rate of Return (IRR):** the discount rate for which the present value of the total benefits equals the present value of total costs. The IRR can be seen as theoretical average annual rate of return of a project in which costs and revenues vary over time. It is often used to compare various alternatives.

CBA methodologies vary, with conventional approaches characterised by several strengths and weaknesses or challenges. CBA results are not automatically transferrable, as they are highly dependent on the specific characteristics of a project and on the framework conditions in the city in which the project is planned. Furthermore, results are often not comparable, especially if different impacts have been appraised. Some effort has been made to improve the comparability of CBA results. As part of the HEATCO project, for instance (Bickel et al., 2006).

At national level, several attempts at a harmonised CBA methodology have been made, especially in the UK. The UK Department of Transport’s WebTAG provides guidelines for transport project appraisal, including CBA guidelines. Additionally, the software packages Cost Benefit Analysis Software (COBA), for highway improvements and transport user benefit appraisal (TUBA) have been developed.
Steps of a conventional Cost Benefit Analysis:

1. **Identify objectives and criteria.** The project’s objectives are defined, along with the appraisal criteria. It is also important to define the system boundaries (e.g., Is the assessment limited to local effects? To what extent are outside effects included?) and the period over which costs and benefits are analysed.

2. **Identify project alternatives.** The planned project is described in detail and its costs and benefits compared to those of a reference, ‘do nothing’ or ‘do minimum’, scenario. This is important as the reference situation might also require investments, e.g., for maintenance of existing infrastructure. Thus, the reference scenario is usually a ‘do-minimum’ scenario, rather than a ‘do-nothing’ scenario. More than one project may be compared to the reference scenario.

3. **Identify project impacts.** All costs and benefits resulting from the project’s implementation are identified. In doing so it is important to understand the causal relationship between the measure and its various impacts (positive and negative). Also, the CBA’s perspective must be defined. A CBA from the perspective of a private company usually considers only the company’s own costs and benefits. A social CBA, on the other hand, as completed for public investments, will include the impacts on society as a whole. Defining the CBA’s geographic scale is another sensitive issue. A too narrow CBA might fail to include adverse effects of a project outside the implementation area (e.g., congestion charge leading to increase traffic levels outside the charging zone). In contrast, a CBA extended across the administrative boundaries will become more complex and data-intensive. In general, the geographic scale needs to suit the measure and the municipality’s objectives. For example, CO₂ emissions have no direct impact on cities, but yet many set ambitious CO₂ mitigation targets, acknowledging their responsibility in combating climate change.

4. **Quantification of relevant impacts.** For each impact included in the CBA, a method to measure and quantify it is identified. For example, estimating the effect on local air pollution may use average vehicle emission factors with correction factors to account for specific local conditions, if necessary. Some impacts might have been identified that are not quantifiable and/or difficult to measure. In a conventional CBA these impacts are often simply excluded.

5. **Monetary valuation of impacts.** Monetary values are defined and applied to non-market effects. Different ways to monetise non-market effects (e.g., hedonic pricing or contingent valuation) are available. The monetisation of non-monetary effects is difficult and current approaches - such as monetisation of fatal accidents - are controversial. As monetisation is an elaborate process, often guideline values are used (e.g., a standard value for the costs of one tonne of local particulate matter emitted). A sensitivity analysis is recommended for those effects whose values are not so reliable.

6. **Discount rates.** Future costs and benefits are discounted to their present value, allowing comparison of costs or benefits that occur at different times. However, discount rates vary significantly between countries, significantly affecting the results’ comparability. High discount rates are likely to overrate current benefits (and costs) and undervalue future benefits; from a societal perspective low discount rates should be applied.
7. **Presentation of the results according to one or more indicators.** Depending on the purpose of the CBA, different indicators (NPV, BCR, IRR) can be used. Often the NPV (net present value) is used to justify adopting or rejecting a project. The BCR is often used to rank different projects in order of benefits per unit of invested capital as it allows comparisons across different project sizes.

8. **Sensitivity analysis.** As some impact-values (e.g. discount rate, project lifetime) are associated with uncertainties, a sensitivity analysis is often completed to determine the influence of single parameters on the overall results.

Based on (Jensen, 2012), (Damart and Roy, 2009) and (Bickel et al., 2006)

More information on transport project CBAs can be found on the online guide for transportation benefit-cost analysis provided by the Transportation Economics Committee:

[https://sites.google.com/site/benefitcostanalysis/](https://sites.google.com/site/benefitcostanalysis/)

The website also provides examples of CBAs. For example, a cost-benefit analysis for a public transport telematics system.

[https://sites.google.com/site/benefitcostanalysis/case-studies/public-transport](https://sites.google.com/site/benefitcostanalysis/case-studies/public-transport)

One of the main advantages of CBAs is transparency and the ease in communicating the results. CBAs enable rational decision-making based on economic efficiency. However, among the disadvantages, especially for smaller projects, are extensive data requirements and complexity. The monetisation of non-monetary effects is difficult and current approaches in assigning monetary values to specific effects are controversial (e.g. Beria, Maltese and Mariotti, 2012). Consequently, several non-monetary effects are frequently excluded from assessments; conventional CBAs often fail to appropriately incorporate wider social, environmental and economic costs and benefits. Less tangible effects, such as comfort, quality of life or aesthetics are not usually included at all. Moreover, as the cost and benefits are aggregated into one indicator, distributional effects are not visible; some projects are beneficial to society as a whole, but for certain groups adverse effects may outweigh the benefits. To mitigate this, the results can be disaggregated to highlight the effect on various groups (e.g. effects on local residents, effects on effected retailers), instead of communicating just a single value. In general, it is important to define which costs and benefits are included. CBAs for public decision-making are often designed as societal CBAs, implying that all costs and benefits to the society are included and that social discount rates are applied. However, very often the public budget is the priority and wider socio-economic effects remain a secondary consideration.

Overall, CBAs are very useful tools to support decision-making but may not be sufficient to reflect all of a project’s relevant impacts. This limitation could be addressed by combining CBAs’ strength in monetary values with MCAs’ more in depth analysis of (Beria, Maltese, and Mariotti 2012), which would allow the inclusion of non-monetary and less-tangible effects in the decision making process; very useful because of decision-makers’ occasional ignorance of CBAs’ strengths and weaknesses.

Following is a table (Table 2), summarizing some of the effects usually relevant in transport project assessment, along with potential sources of guideline monetisation-values for them. Ideally, these values should be specifically calculated for the city in question as the guideline-values provide a useful approximation but are mostly aggregated to country or continent level. As conditions in a specific city are rarely
identical to conditions in its encompassing country/continent, the values will vary accordingly. Using the values provided may necessitate a sensitivity analysis/analyses to be carried out to determine the effect of possible variations. Also, care should be taken when using these values as they may have different underlying calculations and/or assumptions.

It should be noted that some values or indicators can be associated with different underlying effects, hence it may be necessary to disaggregate further into several sub-indicators. Furthermore, effects can be direct and indirect. For instance, a congestion charging scheme generates direct revenue for the operating company, but at the same time might indirectly increase public transport revenue by increasing ridership. In addition, it is important avoid double counting of individual effects. The relevance of the indicators varies by TIDE cluster and specific measure within the cluster. It is important to identify all relevant indicators based on the specific outline of a project.

Many of the standard values can be derived from the EU HEATCO project, which aimed to create a harmonised guideline assessment of trans-national projects in Europe. It provides comprehensive guidance for calculating transport-project costs and benefits, in particular those related to time-savings and congestion, accident casualties, air pollution health effects, noise, and global warming. The report includes tables of values in case local values are unavailable.

Another EU project, IMPACT, with its central aim of providing methods for estimation and internalisation of external costs of transport infrastructure pricing and scheme design, is another valuable source of information. Many of the values used in IMPACT build upon those provided by HEATCO.

Table 2: Key items for a cost-benefit assessment of transport projects (based on literature reviews and the TIDE CBA workshop)

<table>
<thead>
<tr>
<th>Effect</th>
<th>Potential data sources</th>
<th>Cluster relevance</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment cost</td>
<td>Local data</td>
<td>All</td>
<td>Beside local information, information from previous implementations of the relevant measure in other jurisdictions may be used. These may also assist in estimating implementation and running costs.</td>
</tr>
<tr>
<td>Operation cost</td>
<td>Local data</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Maintenance costs</td>
<td>Local data</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>Revenue (and user costs)</td>
<td>Local data</td>
<td>1, 2, 4 and 5</td>
<td>This item depends on the perspective of the analysis. In a real societal CBA, “revenues” are only a transfer between different stakeholders within a system.</td>
</tr>
<tr>
<td>Effects on tax receipts</td>
<td>Local data</td>
<td>All (potentially)</td>
<td></td>
</tr>
<tr>
<td>Indicator</td>
<td>Description</td>
<td>Monetization Factor(s)</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Travel time reduction</td>
<td>HEATCO: VTTS(^1) monetization factor.</td>
<td>1, 2 and 3</td>
<td>VTTS is usually differentiated by passenger and freight transport and different modes and trip purposes (work, non-work).</td>
</tr>
<tr>
<td>Travel time reliability</td>
<td>HEATCO: reliability ratios (multiplied by VTTS) provide a basic value.</td>
<td>1, 2 and 3</td>
<td>Usually differentiated by travel-mode or journey purpose.</td>
</tr>
<tr>
<td>Local air quality</td>
<td>HEATCO: monetization factors for NO(_x), NMVOC, SO(_2), and PM.</td>
<td>1, 2, 4</td>
<td>Expressed as €/t of pollutant emitted; should be differentiated by location of emission.</td>
</tr>
<tr>
<td>Local noise pollution</td>
<td>HEATCO: monetization factors can be derived.</td>
<td>1, 2, 4</td>
<td>Costs depend on the number of persons exposed to a certain noise level: expressed as €/year/person exposed.</td>
</tr>
<tr>
<td>Safety/accidents</td>
<td>HEATCO: monetization factors provided.</td>
<td>1, 2, 4</td>
<td>Factors for fatalities and injuries avoided and the underreporting rate are provided, those for material damage not.</td>
</tr>
<tr>
<td>Health effects</td>
<td>Health effects of noise and pollutant emissions are included in HEATCO</td>
<td>2, 4</td>
<td>The WHO HEAT tool can be used to assess the health effects of walking and cycling measures.</td>
</tr>
<tr>
<td>GHG emissions</td>
<td>HEATCO: values for GHG emissions provided.</td>
<td>1 and 2</td>
<td>Values expressed in €/t CO(_2)e. Values increase with the year of emission.</td>
</tr>
<tr>
<td>Nature and landscape</td>
<td>IMPACT: differentiated and summarized values provided.</td>
<td>1 and 2</td>
<td>Costs expressed in €/km (infrastructure). As such only relevant to new infrastructure.</td>
</tr>
<tr>
<td>Soil and water pollution</td>
<td>IMPACT: values provided (for CH)</td>
<td>1-4</td>
<td>Values are provided for Switzerland (in €/vehicle-km).</td>
</tr>
</tbody>
</table>

Several indicators relevant to transport projects are rather difficult to quantify and monetise, for which reason these indicators might not be properly reflected in a CBA. Table 3 provides an overview of some of these indicators.

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\(^1\) VTTS: Value of travel time savings
Table 3: Indicators often not appropriately represented in a CBA

<table>
<thead>
<tr>
<th>Effect</th>
<th>Reason for difficulty</th>
<th>Cluster relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real estate value</td>
<td>Highly site-specific</td>
<td>1 and 2</td>
</tr>
<tr>
<td>Visual intrusion</td>
<td>Difficult to monetise and highly site specific</td>
<td>1, 2 and 4</td>
</tr>
<tr>
<td>Employment</td>
<td>Elaborate data requirements.</td>
<td>2, 4 and 5</td>
</tr>
<tr>
<td>Distributional effects</td>
<td>Lack of data</td>
<td>1</td>
</tr>
<tr>
<td>Vibration</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Quality of life</td>
<td>Difficult to monetise and lack of data.</td>
<td>1, 2 and 3</td>
</tr>
<tr>
<td>Sense of comfort</td>
<td></td>
<td>2 and 3</td>
</tr>
<tr>
<td>Commercial attractiveness</td>
<td>Potential lack of data</td>
<td>1 and 2</td>
</tr>
<tr>
<td>Energy security</td>
<td>Values only available for the USA (IMPACT)</td>
<td>4</td>
</tr>
<tr>
<td>Image/user perception</td>
<td>Difficult monetisation; can be assessed with marketing research</td>
<td>All</td>
</tr>
<tr>
<td>Modal distribution</td>
<td>Potentially a key objective of local authorities but is often integrated in other criteria, not assessed in isolation within a CBA</td>
<td>All</td>
</tr>
</tbody>
</table>

Multi-criteria analysis – Example of an alternative decision support tool

Multi-criteria analysis is a decision-aiding technique which takes into account quantitative and qualitative criteria, and can, as such include soft impacts otherwise difficult to quantify or monetise (Browne and Ryan, 2011). MCAs are increasingly used in environmental and transport decision-making for this reason. The EC DG Regional Policy recommends MCAs in combination with CBAs, or as a approximate alternative to CBAs if impact-monetisation is difficult or impossible (EC DG Regional Policy, 2009). Odgaard (2006) found that 9 of 26 European countries use MCAs in road project appraisal (all countries surveyed used CBA).

In a MCA, the performance of a policy or project is assessed based on scoring, ranking and weighting the impacts (see blue box, below) rather than by expressing the impacts in monetary terms. The impacts’ performance values can be based on projections, literature or experts’ opinions, while the criteria’ importance-weighting values should be assigned in consultation with stakeholders.

The final scores for each measure can be used to rank the measures, which, in turn, can be used to identify a limited number of options for detailed assessment, or to distinguish acceptable from unacceptable projects (DCLG, 2009).
**Steps in a multi-criteria analysis:**

1. *Define the project/policies to be assessed.* The different alternative project/policy options are identified and described including a reference case.

2. *Define the judgment criteria.* Criteria for assessing the options are defined. Often the criteria are clustered and disaggregated into sub-criteria.

3. *Weight the various criteria.* Importance values are assigned to each (sub-) criterion or to reflect their relative importance to decision makers.

4. *Analyse measures’ impact according to criteria.* For some criteria quantitative data might be available. The performance regarding qualitative criteria is often assessed along a performance scale with the help of expert opinions.

5. *Score the impacts.* The impacts are translated into a numerical score.

6. *Combine scores and weights.* The weighted scores are calculated for each criterion.

7. *Score or rank alternatives.* The performance according to different criteria are aggregated. Different aggregation approaches exist.

8. *Sensitivity analysis.* A sensitivity analysis can reveal the influence of different weightings and can be applied to less robust criteria.

Based on (Beria, Maltese and Mariotti, 2012 and DCLG, 2009)

More information on completing MCAs in cities can be found in ‘Multi-criteria analysis: a manual’ provided by the Department for Communities and Local Government London (2009):


An example of a sophisticated MCA of alternative fuel-for public transport can be found in (Tzeng et al. ‘Multi-criteria analysis of alternative-fuel buses for public transportation’):

http://eng.sut.ac.th/transportenergy/data/paper4web/Multi-criteria%20analysis%20of%20alternative-fuel%20buses%20for%20public%20transportation.pdf

MCAs are considered to be very subjective by some. As groups of stakeholders select the analysis-criteria and determine their weighting (importance), the outcomes can be biased. It is unlikely that the group’s preferences will reflect those of the society as a whole. Participating individuals or groups will most likely have their own interests and prejudgements regarding the measures, leading to selection bias. Special interest groups might disproportionately influence the overall results through the weighting process. To minimise the risk of selection bias, various methods can be used to determine the MCA criteria (e.g. Delphi method, least mean square method, correlation coefficient methods – for more information see Wang et al. 2009). Similarly, a variety of approaches are available to assign weights to criteria and complete the decision
analysis (see Wang et al. 2009), with the Analytic Hierarchy Process (AHP) the most frequently used of them (Beria, Maltese and Mariotti, 2012). AHP assigns weighting factors based on breaking the importance allocation down into the smallest possible size: a pair-wise comparison of individual criteria. As such, the number of decisions grows exponentially with the number of criteria. AHP and other criteria selection and weight assigning procedures are rather complex and can be costly and burdensome for a local administration.
Comparison of CBA and MCA

Cost-benefit analysis and multi-criteria analysis have each its individual strengths and weaknesses (Table 4). One of the main advantages of CBAs is the easy reporting of their results in one indicator (benefit to cost ratio). This indicator is consistent and can be compared across different types and sizes of measure. They also clearly define the measures’ economic efficiency, which is of significant importance to local governments, especially in times of constrained budgets. Furthermore, motorised transport’s external costs, often neglected in decision-making, are included in the analysis. Among the weaknesses of CBAs are the extensive data required: all effects must be quantified and monetised. Monetisation approaches are controversial, especially concerning intangible effects or ethical problems in assessing health or safety effects (Beria, Maltese and Mariotti 2012). The common dominance of travel time-savings in CBAs is also often criticised (e.g. Van Wee et al. 2006). The key weakness of the approach specific to the TIDE project is the difficulty in including qualitative impacts.

In contrast, one of the key advantages of a MCA is the possibility of including both qualitative and quantitative impacts. This allows criteria that are difficult to quantify or monetise to also be accounted for, especially important for local level projects or measures where many qualitative effects are (highly) relevant. Furthermore, as data at urban or suburban scale is limited, or quantification processes too costly, and MCAs do not required this to be done, they can be cheaper to perform. One of the key advantages of a MCA is that it can easily include stakeholder participation, while experts, decision-makers and public institutions can be involved in the performance scoring and weighting of criteria. This allows an MCA to be easily linked with Sustainable Urban Mobility Planning (SUMP). A SUMP adopts a holistic perspective of the transport system, addressing all modes of transport to create a more sustainable system. A key characteristic of SUMP is its participatory approach: involving stakeholders and citizens in the decision-making, implementation and evaluation of measures. On the one hand, the participatory approach of MCAs makes decision-making more transparent and can prevent conflicts or settle possible arguments (Browne and Ryan 2011/Beria, Maltese and Mariotti 2012). On the other hand, the subjective assessment is one of the main weaknesses of the method, as the comparability of results is limited. Furthermore, participatory processes can be very elaborate and time consuming.
Table 4: Strengths and weaknesses of CBA and MCA (based on Beria, Maltese and Mariotti, 2012 and Browne and Ryan 2011)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>CBA</th>
<th>MCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Indicator based → transparent and easy to communicate</td>
<td>• All of a measure's impacts (quantitative &amp; qualitative) can be evaluated</td>
<td></td>
</tr>
<tr>
<td>• Highlights economic efficiency</td>
<td>• Promotes public participation and compromises</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Applicable to soft measures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Applicable to local level projects</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weaknesses</th>
<th>CBA</th>
<th>MCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Extensive data requirements</td>
<td>• Subjective</td>
<td></td>
</tr>
<tr>
<td>• Monetization is difficult and controversial</td>
<td>• Little consistency</td>
<td></td>
</tr>
<tr>
<td>• Elaborate</td>
<td>• Participation process may be elaborate</td>
<td></td>
</tr>
<tr>
<td>• Non-monetary effects often limited to VTTS and safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Results often dominated by VTTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Can not assess soft/less tangible effects</td>
<td></td>
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</table>
Assessing TIDE transport innovations

Cluster 1: new pricing mechanisms

Examples

Congestion charging

For several congestion charging schemes implemented in European cities, a CBA has been conducted. Thus, several CBA examples are available for analysis:

- Ex-post CBAs of the Stockholm congestion charge trial

Transek (2006) and Eliasson (2009) review the *Stockholm congestion charge (trial)* ex-post, incorporating the charge's effect upon travel times, mode-of-travel changes, the direct income from the charge, GHG emissions, human health and environmental factors, traffic safety, revenues (including from the charge itself, public transport fares and fuel taxes), infrastructure degradation and passenger comfort. Based on these factors, it was calculated that the charge would generate an annual social benefit of €70m, at which rate the investment cost would be repaid within four years. Also, it was found that the system generates €0.9 societal benefits for each €1 of direct income.

- Ex-post CBA of the London congestion charge

The study uses the UK Department of Transport’s methodologies, as set out in the online transport analysis guidance document on CBAs (WebTAG 3.5.4), including revenues & costs, safety, CO₂, pollutants & travel time cost. The study excluded impacts on pedestrians, bicyclists and motorcyclists, coach passengers, underground and rail passengers and waiting time for taxi passengers. A net benefit to business users and bus passengers was calculated, whereas individual road users suffer a small loss. With the £5 charge the system resulted in a £71m/a net surplus and a BCR of 1.5, with the £8 charge this increased to £99m/a and a BCR of 1.7 (Transport for London, 2007).

- CBA review for the Stockholm and the London congestion charges

Raux et al. (2012), in a review of two CBAs carried out for the aforementioned cases from Stockholm and London, point out some methodological issues with the analyses, such as issues with the way in which travel time savings and their sensitivity are calculated and the way in which indirect effects of the charges were assessed.

- Simplified CBA for Milan

For Milan, Rotaris et al. (2010), describe the scheme implemented there along with its impacts and a simplified (due to lack of data) society-wide CBA. The total benefits and costs are also differentiated according to different groups, e.g. car drivers, city administration etc. The scheme differs from London and Stockholm in that its primary aim is the improvement of the city’s air quality, and accordingly has differentiated charges based on vehicle emissions class (Euro I-VI). It generated a net benefit of €6m.

- Micro & macro economic comparison of European charge systems, incl. traffic,
social & environmental effects

Taking a broader view, May et al., (2010), carry out a comparison of various congestion charges implemented in seven major European cities. The schemes are assessed according to not only their direct revenue and operating costs but also to their broader macro-economic effects. The schemes’ effect on traffic flows and volume are also analysed, along with social and environmental effects, such as social equity and the reduction of accidents and emissions of CO₂, NOx and PM_{10}. Detailed data was available for London, Milan, Rome and Stockholm. Even though cases are hardly comparable, as time and geographical boundaries varied, all cities showed similar effects: the level of congestion decreased by about 30% (reference London and Stockholm), CO₂ emissions within the charging zone decreased by between 10% and 20%, local air pollutants (NOx and PM_{10}) decreased by 8% to 18% and the number of accidents decreased by 14% (reference only Milan).

- Additional studies on CBAs for road pricing schemes

A purely economic comparison is presented by Jansson (2010), in which the charges levied, the total investment and running costs for schemes in Singapore, Stockholm and Oslo are compared. While not describing a cost benefit analysis per se, Creutzig and He’s (2009) analysis of feasible transport demand policies for Beijing considers the effects of congestion charging on revenue and external costs (air pollution, climate change, noise, congestion and traffic accidents) and a sensitivity analysis of the costs.

Table 5: Overview of the BCR ratio found for several congestion charging schemes in European cities

<table>
<thead>
<tr>
<th>Author</th>
<th>City</th>
<th>Benefit to cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eliasson</td>
<td>Stockholm</td>
<td>2.5 – 2.6</td>
</tr>
<tr>
<td>Transek</td>
<td>Stockholm</td>
<td>7.9</td>
</tr>
<tr>
<td>Tfl</td>
<td>London (£5)</td>
<td>1.5 – 2.1</td>
</tr>
<tr>
<td></td>
<td>London (£8)</td>
<td>1.7 – 2.5</td>
</tr>
<tr>
<td>Raux et al.</td>
<td>London (£5)</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>Stockholm</td>
<td>1.2</td>
</tr>
<tr>
<td>Prud’homme and Bocarejo</td>
<td>London (£5)</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Parking charging

Less information is available concerning parking charging and combined charging for multimodal trips. Although the following studies are not directly comparable, they provide information about the costs and benefits of (dynamic) parking charging schemes and of combining different modes in terms of information and pricing:

Rodier and Shaheen (2010) assessed a smart parking system in the San Francisco Bay area. The system allocates train station parking spaces to peak-period commuters, who are provided with parking space availability information and the possibility to reserve spaces. The scheme is not, however, run in conjunction with the transport system’s ticketing system. The author’s evaluation considers the system’s effect on travel behaviour (modal shift) and public perception along with its costs, but not from...
Pierce and Shoup (2013) evaluate the dynamic demand oriented parking pricing in San Francisco (SFpark). The authors found that price elasticity varies by time of day and location. It was shown that the demand-oriented pricing improved the occupancy rate of parking spaces. Overcrowding was reduced and in blocks with a very low initial occupancy rate, the occupancy was increased.

In COST (2005), evaluations of a variety of different parking pricing schemes in several European cities are presented. The schemes' effects on parking space occupancy rate, search time for available car parks or shift to other transport modes are documented, along with the economic viability of affected areas. Retailers sometimes object to parking pricing schemes on the grounds that the policy will deter their customers. Indeed, immediately following the introduction of such schemes, retail-turnover diminishes. Soon after, however, turnover was observed to recover to the previous, or even higher, level due to faster parking-space turnover and fewer long-term parkers (e.g. residents or local workers).

### Integrated charging for multimodal trips

Several examples of the application of integrated charging for multimodal trips are available, for instance the use of smart cards for public transport ticketing and other services in London, Hong Kong and Sydney. Even though no CBA has been carried out, studies such as Jain (2011), quantifying the impacts of the London Oyster card, and Graham and Mulley (2012) on Sydney’s MyZone provide information on possible effects that could feed into a project appraisal process.

### Current practices and experiences in the TIDE cities

In Italy, some guidelines for transport project assessment exist, e.g. a national guideline for the assessment of public investments. For major infrastructure projects, a CBA is recommended (>€10m) or mandatory (>€50m). At the local level, SEAs (Strategic Environmental Assessment) and EIAs (Environmental Impact Assessment) must be carried out for transport and mobility plans and primary infrastructure investments. The AMAT (Milan Agency for Mobility, Environment and Territory) voluntarily completes CBAs to support planning processes. The CBAs include a wide range of externalities, such as pollution, noise, climate change and accidents. However, qualitative effects such as beauty or visual intrusion are not considered. A simplified CBA is applied to other policies. A major challenge in completing CBAs in Milan (and Italy in general) is the lack of an appropriate standard CBA guideline, along with insufficient/unreliable input data. Milan has analysed its ‘road user charging’ scheme’s potential effects and the scheme was included in a SEA, however, to this date, no CBA has been carried out for it.

Huesca, Spain, developed a transport policy plan using the SUMP (Sustainable Urban Mobility Plan) framework, including non-economic analysis of the plan’s (and BAU’s) environmental impacts. CBAs are not mandatory, although they are seen to be very important in establishing the viability of the SUMP projects given their high cost (€10m). Some aspects of a CBA have already been analysed, using guidelines provided by the CiViTASPlus, HEATCO and IMPACT projects. Difficulties are expected

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2 BAU – Business As Usual, describes the baseline scenario, e.g. regular maintenance is continued.
in monetising qualitative and indirect impacts such as quality of life or citizens' welfare.

Ghent, Belgium does not have the benefit of national CBA guidelines, nor does it have a municipal standard appraisal method for transport projects, though it wishes to develop one. The municipality has little experience carrying out CBAs, although a basic one was performed as part of the Civitas Elan project, including financial costs and benefits along with environmental and societal costs and benefits. A key challenge perceived by the municipality is obtaining the necessary expertise to complete CBAs.

Methodological findings

As presented previously, many examples of CBAs on congestion charging, and reviews thereof, are available. The methods and the parameters included in the assessments vary. The following key issues in carrying out a CBA have been identified for congestion charging (but are partly also valid for the other measures):

- **Time savings**

  Congestion reduction, and thus time savings for individual transport users, is one of the key objectives of congestion charge schemes. Thus time savings play an important role in CBAs for such pricing schemes. Time savings are often the dominant benefit (Raux et al. 2012), although often through the accumulation of small time savings (<5 min) which may be irrelevant to individual users. There is a debate as to whether all time changes should be treated equally. Otherwise irrelevantly small savings, when multiplied by a large enough number of users, may result in a significant overall saving, overestimating the net benefit (Raux, Souche & Pons 2012, TfL 2007). In contrast, the models used tend to neglect network effects, which may lead to underestimation of time savings (Eliasson 2009). The models are based upon traffic models, whose reliability/accuracy is difficult to determine in advance, and which is very important, given the aforementioned sensitivity to small changes (Raux et al. 2012).

  The price-value assigned to time is also a point of discussion. Setting a value is difficult, and varies among cities and countries and for large cities compared to their average national values (Transek 2006). Values are assigned homogeneously, even though traffic users assign a range of values to their time. CBAs should instead represent this by assigning time values via a distribution (Raux et al. 2012).

  It is also noted that there is a growing trend toward valuing time reliability rather than time alone (Raux et al. 2012).

- **Funds accounting**

  The manner in which funding costs are accounted for is a significant factor in CBAs (Raux et al. 2012), particularly the way in which the future costs are discounted. If discounting is not used, the London congestion charge has a benefit to cost ratio of around 2.1:1 and 2.5:1 with £5 and £8 charges, compared to discounted BCRs of 1.5:1 and 1.7:1 respectively. (TfL 2007)

  - **Non monetary effects**

    CBAs often account for neither non-monetary effects, especially transport service provision (Transek 2006), nor amenity benefits such as noise due to the difficulty in doing so (TfL 2007). Accounting for climate change effects is noted to be difficult given
the significant insecurity in estimating its costs (Creutzig and He 2009)

- Co-benefits

Co-benefits, such as the increased possibility of improving pedestrian infrastructure as a result of decreased road traffic are difficult to account for (TfL 2007). Co-benefits such as indirect economic benefits - allowing the move to more productive jobs, improved competition etc. - have been evaluated but found to be insignificant (TfL 2007).

As the examples from literature show, CBAs for congestion charging are very complex as this measure often induces other changes. A traffic-volume reduction is usually observed in the charging zone: some trips are shifted to other modes, some are avoided and some trips are re-directed. Thus, it is important to also consider the effects outside the charging zone and effects on other transport modes in the assessment. Furthermore, not only effects on passenger transport, but also on goods transport should be considered.

The effects of parking charging depend highly on design of the pricing scheme and the previous charging situation. Parking charging schemes can reduce car use and thus effect the traffic situation; possibly reducing external effects like air pollution. These effects might be difficult to define on an ex-ante basis and difficult to monitor ex-post. Effects like cost and revenues are much easier to assess.

Conclusion

Much data is available from cities that have introduced congestion charging and the underlying methods are well established. CBAs seem to be an appropriate tool for congestion charging. It must be noted, however, that results are very sensitive to the effects included, and to the monetisation method and standard values used. For this reason, sensitivity analyses should be carried out. Milan is already experienced in CBAs for congestion charging and can provide assistance to Huesca, which is less experienced.
Cluster 2: non-motorised transport

Examples

Several CBAs for non-motorised transport (NMT) projects, similar to those covered within TIDE, have been conducted:

- **Expansion of the walking and cycling track network in Hokksund, Hamar and Trondheim (Norway)** (Sælensminde, 2004)

  The CBA conducted for investments in the walking and cycling networks in three sample cities resulted in the following BCRs: Hokksund = 4.09, Hamer = 14.34 and Trondheim = 2.94. A sensitivity analysis was also carried out, including a range of estimations of future pedestrian and cyclist numbers, and cost estimate uncertainties. The highest BCR value achieved was 32.78 for a large increase in pedestrians and cyclists in Hamar. For minimum cyclist and pedestrian estimates in Hamar, the BCR was 0.51, below the threshold value of 1. For Trondheim and Hokksund, the minimum estimate led to a slightly negative BCR (-0.05 and -0.13 respectively).

- **Review of 16 economic analyses of cycling and walking infrastructure improvements** (Cavill et al., 2008)

  Reviewing 16 studies on the economic effects of investments in walking and/or cycling infrastructure, the authors found a range of BCRs, based on very different assumptions and including different effects. However, some general conclusions can be drawn. Out of 16 CBAs of walking and cycling investments, only one had a negative BCR (-0.4) and most exceeded the threshold value of 1. The maximum BCR was 32.5 and nearly half were higher than 10.

- **Economic evaluation of changes to the built environment (construction of sidewalks)** (Guo and Gandavarapu, 2010)

  Based on data from Dane County, Wisconsin, the travel impacts of built environment changes were modelled. It was found that sidewalks in individuals’ neighbourhoods lead to changes in VMT (Vehicle Miles Travelled) and MWB (Miles Walked or Cycled). Based on the results, a CBA was conducted for a scenario in which sidewalks were made available to all residents. The investment cost for sidewalks were compared to health and air quality benefits, resulting in a BCR of 1.87.

- **CBA of cycling investments in Portland, Oregon** (Gotschi, 2011)

  CBAs for different investment options (associated with different degrees of cost and distance cycled) were conducted for Portland. Benefits of the increased cycling activity due to investments, such as reduced health care costs and fuel savings, were included in the analysis. Depending on the investment option under investigation, the BCR ranged between 3.8 and 1.2.

Current practices and experiences in the TIDE cities
The transport department of Donostia - San Sebastian does not have any standard appraisal method for transport projects; for major projects the financial viability is tested, rarely in form of a CBA, however. Neither municipal nor national CBA guidelines are available. In the cases where the city does carry out a CBA, data availability is a major challenge to a valid assessment. The city has some experience in carrying out CBAs, gained during the CIVITAS project, during which, an ex-post CBA was carried out on the extension of cycling lanes and personal travel plans. Within the TIDE project, the municipality plans to carry out a CBA for ‘bicycle parking schemes’ (Measure 2.1) and probably also for ‘people-friendly streets’.

CBAs are not used by Aarlborg to aid transport infrastructure decision making, especially not for small projects. The municipality is not obliged to carry out a CBA on the TIDE measures and it has not done so, nor does it plan to. For larger infrastructure projects, national CBA guidelines are, however, provided, the usage of which is mandatory.

The municipality of Craiova has limited experience in carrying out CBAs for urban transport projects, but has built up some capacity on this as part of the CIVITAS MODERN project (ex-post for energy-efficient trams). The municipality intends to have a consultant carry out a CBA for its planned bicycle parking facilities, based on the methodology proposed by the European Commission for funding applications (“Guidance on the Methodology for carrying out Cost-Benefit Analysis”, Work Document 4). This prescribes assessment of direct economic effects, but also impacts on the environment, safety, accessibility and integration (e.g. land-use policy). As part of the CBA, the municipality expects estimating the operational costs, revenues and overall economic benefits to be challenging, in addition to the monetisation of social benefits. Health benefits and reduced emissions are seen as the proposed measure’s key benefits. These will be assessed by surveying users to determine how many will be willing to replace their cars with bicycles.

Difficulties in applying CBAs to transport projects are seen to be presented by accurately and comprehensively quantifying and monetising a project’s real effects, particularly for cycling measures.

**Methodological findings**

A good understanding of the cost-benefit relationship of cycling and walking infrastructure investments is helpful to increase the competitiveness to other types of infrastructure regarding decision-making and prioritising investments. Examples of CBAs for walking and cycling investments show that in most cases the benefits of cycling investments exceed the associated costs.

Many studies focus or limit their investigations to the health effects (e.g. Gotschi, 2011), such as the WHO HEAT\(^3\) tool, which provides an easy to use approach to estimate the health benefits of cycling and walking. The HEAT tool is included in several countries’ transport project appraisal guidelines (e.g. UK, Sweden) (Kahlmeier et al., 2010). Underlying approaches to estimate health related benefits vary, however. For instance, health benefits can be estimated on the basis of the value of statistical life or based on the actual health care costs.

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3 [www.euro.who.int/HEAT](http://www.euro.who.int/HEAT)
Other studies (e.g. Sælensminde, 2004) extend their scope to wider benefits such as travel time, comfort and security, school bus transport and reduced external costs incurred by motorised road transport. The authors (ibid.) include the external costs of motorised traffic such as CO$_2$ emissions, local pollutants and noise in their CBA. On the contrary Börjesson and Eliasson (2012) argue that many of these costs are internalised through fuel taxation and other means. Consequently, one needs to take care that only the non-internalised share is included in the CBA. Both Angelov (2008) and Sælensminde (2004) argue that comfort and the perception of security is highly valuable for cyclists and that these factors strongly influence their choice of modes. Similarly, Börjesson and Eliasson (2012) find that cycling on a separate path instead of on-street cycling is valued €5.40 per hour. However, it is very difficult to find reliable data and to monetise these effects.

Most CBAs for walking or cycling measures use a network-wide approach assuming improvement not only in isolated points and include different kinds of improvements. For instance Sælensminde (2004) assumes in their scenario that investments are made not only in the walking paths or cycling lanes, but also that safer parking facilities for bicycles and safer crossing facilities are provided. However, these measures are not directly reflected in the investment cost included in the CBA. To assess effects of small scale isolated measures might be difficult because effects of such measures are limited and detailed data on pedestrian and bicycle traffic in different sections of the network is not available. In general, assumptions usually have to be made with regard to changes in demand associated with the policies and measures under investigation. However, the role played by different kinds of measures can be assumed based on prior empirical studies on the influences of several factors such as bicycle parking facilities or signalized intersections (see Börjesson and Eliasson, 2012, Hunt and Abraham, 2006).

From a municipal perspective, it is important to have an assessment method for non-motorised transport projects which is simple and requires relatively little data. Health benefits often dominate the benefits of walking and cycling investments, however, if the health budget is not linked to transport projects, transport decision-makers might be tempted to prioritise their own targets.

Innovative bicycle parking schemes’ operational costs and revenues are important elements of an assessment for municipalities. Other impacts that are within the remit of the local authority are, for instance, the effects on bicycle theft. To complete a reliable ex-ante assessment, a survey to estimate the number of potential users is paramount.

Regarding “creating people friendly streets and public spaces”, qualitative effects like quality of life for residents or the city’s image play an important role, but are difficult to include in a CBA. Furthermore, it can be assumed that the measure will affect land and real estate values. As no studies were found that included these effects for similar measures, it can be concluded that doing so is difficult.

**Conclusion**

Several CBAs for cycling measures are available, whereas less information is available for projects that address pedestrians. To limit a CBA to only the effect of one of the three TIDE measures in this cluster is likely to be challenging, subject to significant workload and several uncertainties. Including several non-motorised transport measures in one CBA could be a useful approach, especially if sensitivity analyses (e.g. to improved bicycle parking and/or improved bicycle lanes) are included. Lack of
detailed data on walking and cycling traffic might restrict the assessment. As has been shown in the European COST project 358, “Pedestrian Quality Needs”, little data on pedestrians is collected in European cities; where data is available, its usability is limited (Sauter and Tight, 2010). In case of data scarcity, empirically based assumptions can be made on the basis of prior assessments. Standardised values are available for several parameters, such as health effects. The qualitative impacts resulting from walking and cycling investments (e.g. enhanced quality of life, image improvements) are usually not included and are better reflected by a MCA.

Cluster 3: advanced network and traffic management to support traveller information

Examples

Advanced traveller information systems

Examples of CBAs for advanced traffic management systems (ATMS) or advanced traveller information systems (ATIS) are difficult to come by in the literature. Generic descriptions of such schemes are available (Gao and Huang 2012), as is technical literature describing models which could be used as the basis for the provision of such ATIS systems (Zhang et al. 2011), however.

Nelson and Mulley (2013) provide a broad overview of Intelligent Transport System (ITS) policies and policy goals in the EU and in Australia, along with listing examples of implemented ITS systems in Australia. In Sydney, a linked priority and public transport information system was developed. This included signal pre-emption, real-time passenger information and tools for operators to monitor and interact with their vehicles. First estimates have shown that the scheme resulted in one-minute travel time reduction for a 60 to 90 min trip.

Bus priority systems

The strategy of intermittent priority bus lanes is assessed by Eichler and Daganzo (2006), who evaluate the effect of such a system on bus and car speed compared to transit signal priority (TSP) systems.

Gardner et al. (2009) provide an extensive worldwide overview of bus priority system applications and reported effects. In most cities, a reduction in travel time of about 5 to 10% was observed. For instance in Cardiff, UK, travel time was reduced by 3 to 4% on average weekdays and by 11% at peak periods. Helsinki achieved a reduction in travel time of 11% and 58% improvements in punctuality. As a result, passenger volume increased by 11%. In Stuttgart, Germany, 34 traffic lights along a specific bus line were equipped with bus priority technology, at an investment cost of $4 million. The average travel speed of this line was increased and one bus per line could be reduced. Therewith, savings of $250,000 were realised and the upgraded bus line attracted 10% more passengers.

The (non-monetary) effects on customers of dynamic at-stop real-time information displays are examined by Dziekan and Kottenhof (2007). Possible effects include reduced perceived waiting time, higher customer satisfaction, increased willingness to pay, reduced uncertainty and increased ease of use. These effects can lead do adjusted travel behaviour. The authors further review results from studies on passenger surveys and effects reported in several studies. For instance, in Liverpool, traveller numbers increased by between 5 and 10%. In The Hague, the average
perceived waiting time of travellers was reduced by about 20% after real time passenger information was installed.

All of these examples provide an overview of the possibilities of ATMS and ATIS, though without discussing the costs and benefits of such systems, at least not specifically enough to consider them CBAs.

Current practices and experiences in the TIDE cities

In the UK, the method by which projects are appraised varies from project to project but CBAs are an important aspect of these appraisals. Especially at the outset, CBAs are used to provide the economic case for projects, though financiers typically also consider non-monetary aspects; not necessarily allocating funding to projects with the highest BCR. To this end, CBAs are accompanied by a “social and distributional impacts report”, outlining projects’ effects on different social groups. The British Department of Transport provides CBA guidelines in the form of online transport analysis guidance (WebTag). As guidelines, these are not mandatory for all projects, but are nevertheless considered important. Along with economic aspects, WebTag provides guidance on monetising various externalities including guideline values. Difficulties remain, however, in quantifying projects’ effects (e.g. a measure’s effect on the number of cyclists), especially for small-scale and soft measures and those involving new technology. This can be/is negated to some degree by completing a CBA for many measures combined. CBAs are not considered applicable to the planned cluster 3 measures in Reading as these are low cost and difficult to analyse.

The Roman Mobility Agency evaluates transport projects on a case-by-case basis using a complex set of models, taking into account the project’s expected effect on congestion, accidents, driving distances and pollutant emissions. In addition, other key performance indicators are analysed based on other projects such as CITEAIR II and CONDUITS. Official CBA methods or guidelines are not available to the agency. An online tool to assess the effects of sustainable transport measures on air pollution has, however, been launched, the usage of which will become compulsory for sustainable transport projects financed by the Italian Environmental Ministry. Specific to the TIDE measures, however, no CBA is required or planned.

Lyon is not obliged to undertake CBAs, but nevertheless uses standard methods to appraise transport projects’ effect on modal shift, air quality, traffic flow, service quality and ease of operation, amongst others. The municipality considers these appraisals to be vital as they concern the allocation of public funds; this also applies to the TIDE measures. The exact appraisal method used differs depending on the type of project, but the same broad principle is used: the measure’s benefits, such as functionality, services for users and operators and impact w.r.t. mobility objectives are compared to the measure’s investment and operating costs. This comparison is used to assist decision making. CBAs are seen to tend to over-estimate benefits and under-estimate costs. Qualitative effects (e.g. from improved travel information) are usually assessed by conducting surveys.

Methodological findings

Of the measures in this cluster, advanced priority systems for public transport are most likely to be suitable for a CBA. However, examples of prior CBAs for this kind of measure are not well documented in the literature. Nevertheless, several examples
providing costs and effects on travel time are available, and traffic models can provide good estimates of potential time savings if the necessary data is available, yet issues can arise regarding the monetization of these time savings (see 2.1). Compared to minor time savings, improved reliability might be the more important benefit; this should be taken into account in a CBA for bus priority systems.

Regarding measures on traveller information, project assessment might be much more difficult and CBAs seem to not be an appropriate tool. Concerning the provision of open traffic data, it might be more important for the local government to compare the costs, benefits and especially risks of different options. Depending on the degree of data processing and fusion required, the municipality’s costs might rise. However, better data also offers the possibility of offering better applications based on it and sets an incentive for third parties to develop applications. It would be much costlier for the municipality to develop the app or tool itself, but would allow more control over the data and the quality and contents of the application. The actual effect of an application on travel behaviour is very uncertain and also highly dependant on the number of users: the data does not, itself, have any effect.

Project appraisal effort and cost for such measures are likely to be low. Surveys on user response to improved traveller information can provide information on possible effects, but the responses are likely to depend on the design of the scheme. Furthermore, most of the effects are qualitative, such as increased traveller comfort.

Conclusion

The only measure in this cluster which is suitable for assessment with CBAs is the public transport priority system, however this measure will not be implemented by any TIDE leading or champion city. For “improved human machine interfaces” and “open data servers” CBAs are not applicable. These measures are low-cost measures, have mainly qualitative effects (e.g. more convenient trip planning) and have only indirect effects on travel behaviour. In addition, “open data servers” are only enablers of other measures. Even though some of the TIDE cities in this cluster possess guidelines for CBAs or have experience in conducting them, the cities agree that CBAs are not applicable to the two measures. A multi-criteria analysis is likely to be more suitable to evaluate these measures and to appropriately reflect their benefits and risks.
Cluster 4: electric mobility

Examples

Although electric mobility has a long history, it experienced a revival only in recent years; measures in the field of electric mobility are still relatively new and assessments and evaluations of projects or measures in this field are rare. Even though assessment of the total cost and benefits of electric mobility measures are available, CBAs of specific projects are scarce. The following studies are available:

- Urban consolidation centre and electric vehicles in the City of London (Browne et al., 2011; Leonardi et al., 2012)

  The city logistics trial, which took place between 2009 and 2010 in London, tested the combination of an urban consolidation centre and electric vehicles, used for an office supply company’s deliveries. Before the trial, 7 diesel vans transported the deliveries from a suburban depot to the different delivery points in the city centre. For the trial, a micro-consolidation centre was established in the delivery area. Trips between the consolidation centre and the delivery points were made by six electric tricycles and three electric vans, while the journeys between the depot and the consolidation centre were made with a larger diesel truck. The new logistics concept resulted in a reduction in the total distance driven per parcel by 20%. The CO$_2$e emissions were reduced by 54% per parcel. Financial data about the trial were not published.

- Studies on charging infrastructure costs (Kley 2011)

  Kley (2011) provides an overview of infrastructure costs assumed by several studies and presents estimates for investment and operational costs for different charging options. For conductive charging infrastructure in public or semi-public space, costs range between €1,000 and €50,000 depending on the load and the accounting system. Operational costs are also quantified, ranging between €100 and €5,000 per year. Detailed estimates are provided for the different components, such as parking space costs. For inductive charging infrastructure, manufacturers provide cost estimates ranging from €3,500 to €18,000 per facility, while operational costs are estimated to range from €200 to €2,500.

- Studies on the general costs and benefits of electric vehicles (e.g. Marjanović et al., 2009)

  Marjanović et al. (2009) assess the costs and benefits of electric vehicles for the Serbian transport sector. Incremental prices for battery electric (BEV) or hybrid electric vehicles compared to conventionally fuelled vehicles are estimated. For a small electric car, incremental prices range between €6,400 and €22,700 depending on the driving range, while an advanced hybrid diesel bus is estimated to cost about €30,000 more than a conventional diesel bus. Furthermore, noise and environmental costs are assessed for different types of vehicles, along with effects of electricity generation from renewable or fossil sources are also included. Gasoline passenger cars are concluded to have environmental costs of €1.45 to €3.20/100km. In contrast, environmental costs for BEVs range from €0 to €0.82/100km. For diesel buses, environmental costs range from €15.47 to €23.79, compared to €7.54 - €13.11 for advanced hybrid buses. The environmental benefits are compared to the consumer costs and the necessary infrastructure investments, with the resulting social net-benefit being negative for BEVs, except in a scenario with high valuation of CO$_2$ emissions, non-fossil electricity
production and no rapid charging technologies. Replacing diesel buses with hybrid
diesel buses, however, results in a positive net social benefit.

- Trial of inductively charged electric buses in Milton Keynes, UK (Sharpe 2012)

The city of Milton Keynes replaced diesel buses with 8 electric buses on one route. It is
expected to reduce running costs by £12,000 – £15,000 per year. In addition, tailpipe
CO\textsubscript{2} emissions were reduced by 500t/a, other noxious tailpipe emissions were reduced
by 45t/a.

Current practices and experiences in the TIDE cities

To date, cost-benefit assessments have not played a role in the decision-making
processes on the selected electric mobility projects in Rotterdam.

No national or municipal CBA guidelines apply to transport infrastructure projects in
Tampere, however, projects are analysed. Due to ever-lower budgets, projects’ costs
are carefully scrutinised; as a natural part of this process the costs are compared to the
benefits, though this comparison does not take place within the framework of a CBA.
This notwithstanding, the municipality does intend to perform CBAs or use other
appraisal methods for future projects, where the method’s result is expected to be
important (by some) from effectiveness, financial and learning points of view.

Methodological findings

Cost benefit analyses are rarely applied to local projects or measures in the field of
electric mobility. However, existing literature and previous applications provides
information on the investment costs and environmental benefits associated with electric
vehicles. On the cost side, it was highlighted during the workshop that charging
stations need additional fire protection, which can impose further costs on the
municipal budget. Local air pollutant and potential CO\textsubscript{2} emissions reduction and noise
abatement are electric vehicles’ most important benefits. If electric bicycles are used to
supplement conventional cars, additional benefits may apply. Image reasons are often
an additional motive of a city or a private company to implement policies and measures
related to electric mobility due to the widespread perception of electric mobility as
being environmental friendly and innovative. From a municipal perspective, such an
image can have positive effects on tourism or attractiveness for businesses.
Furthermore, often such measures intend to increase awareness of electric mobility,
which can induce private actors to invest in it. However, these effects are very difficult
to quantify or monetise.

If a CBA is applied to electric transport policies or measures, it is important that the
scope of the costs and benefits are defined properly. Incremental costs of the electric
vehicles and cost of the charging infrastructure should both be included.

Clean city logistics: Improving city logistics with electric vehicles often includes the
implementation of new distribution centres. Either associated costs have to be taken
into account or the benefits related to the consolidation of goods have to be separated
from the use of clean vehicles.

Financing schemes for charging stations: CBAs are probably not applicable to
financing schemes for charging stations. Here, wider benefits and long-term targets,
which are not reflected in a typical CBA, might be the main driver for implementation.
Inductive charging for public transport: Some previous projects on inductively charged electric buses are available. However, no CBA has been conducted and data is rarely available. If the measure is compared against diesel-fuelled buses, additional costs for bus procurement and operation have to be included.

Some of measures in this area highly dependent on the cooperation of private actors. For instance, the success of city logistics schemes depends on the willingness of the logistics companies to operate electric vehicles. Parking operators, electricity suppliers or private public transport companies may also be involved. Depending on the specific situation and project, the costs of the measure will primarily be borne by private actors. This has to be reflected in the CBA’s cost accounting. In light of the need to involve several public and private actors, a participation-oriented evaluation of electric mobility measures was suggested during the TIDE CBA workshop.

Conclusion

CBA seems not to be the preferable project assessment tool in the field of electric mobility. Long-term targets, awareness raising and image reasons are often the main reasons for implementing small-scale electric mobility projects or trials. A participation-oriented multi criteria analysis might better reflect a city’s many objectives in implementing these measures. Furthermore, participation of many actors in the implementation can facilitate improved assessment of potential effects.
Cluster 5: public transport organisation

Examples

- Public transport management bodies

There is very little literature on the organisation of public transport management bodies in general, much less so wider costs and benefits. The intricacies of the way in which public transport is organised are manifold. Van de Velde (1999) provides an initial step in understanding the different organisational forms, including the difference between “on-road” and “off-road” competition, arrangement of authority and planning responsibilities of the different organisation types. An important point is the separation of the organisation type from the way in which service provision is allocated (e.g. tendering). The author mentions various strengths and weaknesses of the various forms in terms of costs and efficiencies, but in a broad sense.

Holmgren (2013) studies the organization of Swedish counties' public transport by “Public Transport Authorities” (PTAs). The focus of the study is the efficiency of the PTAs from the point of view of subsidy costs; it is, as such, not a CBA of this organisational form. He does however, mention that the separation of fare/timetable setting from service operation is a possible source of inefficiencies.

Longva and Osland (2010) examine the impact of professional procurement bodies on local public transport policy (the “Swedish Model”) and its effectiveness. They point out that setting up separate bodies responsible for planning, marketing and procuring public transport services (which often go hand in hand with the introduction of competitive tendering) should have the benefit of “separate entities performing separate tasks”.

The authors point out various problems and difficulties with the Swedish Model. The possible overlapping of competencies may increase transaction costs and hinder coordination between different sectors. Policy coordination is another crucial area due to public transport’s serving of other objectives, such as overall transport system efficiency, and social and environmental aspects.

Current practices and experiences in the TIDE cities

For large-scale EU-funded urban transport development projects in Hungary, or other projects where a CBA is carried out, planners are obliged to apply national guidelines. Alongside a CBA, these guidelines also prescribe the completion of a multi-criteria scenario analysis, along with a sensitivity analysis and qualitative risk assessment. The CBA prescribed includes travel time savings, vehicle operating costs, environmental costs (air pollution, noise, climate change) and accident costs. In Budapest, however, CBAs are afforded limited importance; primarily used to justify investments. CBAs are thought to disregard travel time variability, real estate (property) value changes, equity issues, heterogeneous travel time, regional development impact, impact of the landscape and border (segregation) effects. In the case of Budapest, CBAs are not compulsory, nor considered to be applicable to the TIDE cluster 5 measures.

Vilnius faces difficulties in funding its public transport system, for which reason economic considerations are the most important factors in the evaluation of measures in this area. The municipality receives some guidance in performing these evaluations from the national level. While a CBA has not yet been carried out on the specific TIDE
measure in Vilnius, it is expected that one will be (voluntarily) completed in order to implement experts’ recommendations and achieve the project’s objectives.

In Bologna, CBAs are usually not carried out at the municipal level, although projects are typically assessed from an economic point of view, supplemented by generic qualitative evaluation of economic/social effects. On the national scale, however, recently introduced legislation has changed the situation regarding (primarily large) infrastructure projects, whereby only the most socially and economically effective of them (based upon a comprehensive CBA) will be allocated co-financing. Specifically to the TIDE measure in the city (establishing a Public Transport Users’ Advisory Committee), difficulties are expected in quantifying the relevant factors affected and effected by the measure; exacerbated by a lack of experience assessing such innovative instruments. Despite these misgivings, the Bologna municipality expects to be able to define some indicators with which to measure and evaluate the project’s impact, although the assessment methodology is yet to be developed.

Methodological findings

Public transport management bodies are set up for a number of reasons, one of which is often the overall effectiveness of the urban transport system. During the CBA workshop it was highlighted that it is important to differentiate between short and long term effects. In the short-term, overcapacity can result from the creation of an integrated public transport management body, leading to higher costs for the municipality. An integrated management body facilitates easier implementation of improved passenger information, integrated ticketing and more efficient operation, which can lead to increased patronage, and thus positive environmental effects. In the long-term, public transport management bodies can contribute to improved urban planning and to reduced public expenditure on public transport. However, most of the social and environmental effects of integrated public transport management bodies depend on the implementation of additional measures; body itself only paves the way for easier implementation of these measures.

Similarly, contracting of services for improved passenger satisfaction and efficiency has only indirect impacts which are difficult to include in a CBA. For instance, the measure can trigger measures to increase ridership and can lead to fleet renewal, which in turn can improve passenger comfort, and usage of less polluting vehicles.

Marketing research as optimisation tool in public transport also cannot be included in a conventional CBA. Instead, it is a tool supporting other measures’ effectiveness and ensuring public transport services are planned and executed according to passengers’ needs. The data resulting from marketing research can even feed into a CBA or a qualitative assessment to estimate a measure’s potential or the measure’s impact on users’ perception of the public transport system.

Conclusion

The measures in this cluster are not assessable by a conventional CBA as their effects on the transport system are indirect. A multi-criteria analysis might better reflect the cost and benefits, trade offs and synergies of these measures. Especially regarding an issue as complicated as establishing a public transport management body a MCA might be favourable by providing a structure for the multidimensional issues related to its implementation. Participatory process, as usually integrated in a MCA, might also be
valuable regarding the implementation of transport management bodies.
Conclusion and outlook

Literature on CBA analysis is available for some of the TIDE measures. These assessments provide insight into possible results, but it should be kept in mind that the specific design of measures and the specific framework conditions in which they have been implemented differ greatly. In these cases, the disadvantages of CBAs, such as a) the extensive data requirements, b) dominance of travel time c) difficulty of monetisation and d) the neglecting wider socio-economic effects also must be considered. As some effects are often not properly included in CBAs, it might be necessary to supplement a CBA with a qualitative assessment to ensure that all co-benefits, trade-offs or synergies are appraised.

Current project appraisal practices vary among the TIDE leading cities. Some cities can refer to national guidelines on project assessment and/or cost benefit analyses, though usually, these guidelines are not mandatory for smaller projects, such as the majority of the TIDE measures; several of these are classified as not suitable for a CBA by the respective TIDE city.

For several measures, or even whole TIDE clusters, no literature on CBAs is available. Due to the specific characteristics of these measures, a CBA cannot properly reflect the measures’ effects or the data and efforts required to conduct a CBA are excessive in comparison to the cost of the measure itself. Table 6 provides an overview of the applicability of CBAs to the different TIDE measures.

The multi-criteria analysis method was identified as a potential alternative to CBAs. This tool allows assessment of qualitative and quantitative effects, trade-offs, synergies and co-benefits. Conventional MCAs are, however, also very complex. Especially for low-cost TIDE measures, the assessment method used must be very simple to keep the effort required to a minimum. The TIDE impact analysis methodology (see below) is intended to be applicable to all TIDE innovative measures by allowing assessment based on qualitative or quantitative indicators, or ideally a combination of both. Thus, measures which are not, or only inadequately, assessable by a CBA can be assessed using the qualitative component of the tool.

The TIDE impact assessment method is an important step towards a universal method of appraising innovative local transport projects across Europe. Assessing innovative projects is important in supporting their wide-scale deployment for two reasons. Firstly, the results of reputable ex-post assessments of measures in donor cities yield valuable information for adopting cities, such as potential impacts (including synergies and trade-offs), unforeseen difficulties and overall benefits. Secondly, an ex-ante assessment is vital in the adopting city, as it can considerably improve the measure’s acceptance amongst decision-makers and the general public, if the assessment shows that the measure will efficiently and effectively fulfil the city’s objectives. This is especially important for difficult to quantify measures which are often overlooked in favour of more easily quantified ones.

By anchoring ex-ante and/or ex-post assessments in the conditions for local transport project funding schemes, European institutions are able to contribute to improved knowledge of innovative measures’ impacts and support evidence-based decision-making in local transport planning. If empirical assessment of measures’ impacts was to become more common, and the results more widely disseminated amongst European cities, more municipal officials may be receptive to innovative measures.
In addition, the questionnaire addressed to the TIDE cities regarding current practices of local transport project appraisal has revealed the wide range of practices and experience amongst European cities regarding project assessment. Some cities have little experience in using CBAs, MCAs or other urban transport appraisal tools, and often national guidelines are not provided. To prevent inefficient investments, or those which lead to unintended side-effects, and to support evidence based decision making in European cities, the European institutions could foster mutual learning on transport project appraisal.

Table 6: Overview of the applicability of the TIDE innovative measures to a CBA

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Measure</th>
<th>CBA applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 Road user charging in urban areas</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>1.2 Parking charge policies</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>1.3 Efficient and convenient pricing and charging for multimodal trips</td>
<td>Limited</td>
</tr>
<tr>
<td>3</td>
<td>2.1 Innovative Bicycle Parking schemes</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>2.2 Creating people friendly streets and public spaces</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>2.3 Fast Cycle Lanes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>3.1 Open-access server for applications-based traveller information</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>3.2 User friendly human machine interface (HMI) for traveller information</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>3.3 Advanced priority systems for public transport</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>4.1 Clean City Logistics</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>4.2 Financing Schemes for Charging Station</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td>4.3 Inductive Charging for Public Transport</td>
<td>Limited</td>
</tr>
<tr>
<td>5</td>
<td>5.1 Creation of public transport management bodies for metropolitan areas</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>5.2 Contracting of services focused on improvement of passenger satisfaction and efficiency</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>5.3 Marketing research as optimisation tool in public transport</td>
<td>No</td>
</tr>
</tbody>
</table>
Draft methodology for TIDE impact analysis

The method proposed for TIDE impact analysis is based on a combination of CBA and MCA. This allows to properly reflect the variety of effects across qualitative and quantitative criteria and to reveal trade-offs and synergies. The impact of the measure is expressed in monetary terms for all criteria for which a monetization is applicable. Standard monetisation factors are provided based on literature review. For those measures, where a CBA is suitable the benefit to cost ratio can be obtained from these data and can be communicated along with results from the qualitative assessment. For the integration of qualitative and quantitative criteria, the monetary values are normalised and translated into a performance scale. The performance scale is also applied to assess the impact along qualitative criteria. In addition, a weighting system allows the individual cities to reflect the specific objectives of the city by highlighting the importance of selected criteria. The weighting is to be conducted in a participatory process. As a final result, the weighted, normalised impacts are aggregated to a total performance score. This score can be compared for the reference scenario and the implementation scenario of the measure or can be compared to the results for an alternative measure.

The method is designed to be flexible to allow adaptation to the variety of TIDE measures. Therefore, suggestions for the selection of criteria for each measure will be provided (based on literature analysis and the results of the TIDE CBA workshop), but the final set of criteria need to be defined based on the specific design of a project that is to be assessed. It is noticed that such a flexible approach limits the comparability of results across different types of measures. However, an assessment that suits the characteristics of the individual TIDE measures and highlights its specific impacts on different areas is considered important to be a useful tool.

The TIDE impact analysis method will be presented in a handbook. The document will provide a guideline for the application of the method and will name and describe the various steps of the assessment. Besides explaining the methods itself, the handbook provides a guideline on how to conduct the assessment within the municipality. Roles of different actors involved in the assessment will be highlighted. A special emphasis will be on the communication of the results. The meaning and restraints of aggregated results such as a BCR have to be made explicit. To communicate the performance along the different criteria might be of higher importance than presenting the total performance scores. A key objective in the TIDE impact analysis development, was that the method can be easily applied by local practitioners. As the simplicity of the method is a key criterion for actual application in the city, the method is designed to be less comprehensive and demanding than a conventional CBA or MCA. Methodological limitation that result form the simplification will be highlighted in the TIDE impact analysis handbook to ensure a proper application of the proposed approach.

The handbook will be complemented by an Excel spread sheet tool that offer an template for cities to insert project specific data and to easily compare the qualitative and quantitative impacts of the measure to a reference scenario or an alternative measure (Figure 1). The tool will contain standard values and monetization factors from guiding documents and empirical examples presented in the present document. Based on their own data and own weighting factors, the spread sheet tool will calculate the performance along the different criteria. Furthermore, for communication purpose, the results will be linked to graphics that allow presenting the performance of the measure along different criteria.
Figure 1: Simplified outline of the TIDE impact analysis tool

<table>
<thead>
<tr>
<th>Criteria and Sub criteria</th>
<th>Weight of the Criterion</th>
<th>Cost factor</th>
<th>Impact in Reference Scenario</th>
<th>Impact in New Policy scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Absolute value</td>
<td>Normalized value</td>
</tr>
<tr>
<td>Investment cost</td>
<td>€</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation costs</td>
<td>€/a</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues</td>
<td>€/a</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local air quality</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nox</td>
<td>t/a 2.5</td>
<td>4.300 €/t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NMVOC</td>
<td>t/a 2.5</td>
<td>600 €/t</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM</td>
<td>t/a 5</td>
<td>450,000 €/t</td>
<td></td>
</tr>
<tr>
<td>Visual intrusion</td>
<td>qualitative</td>
<td>1.5</td>
<td>n.a.</td>
<td></td>
</tr>
<tr>
<td>Sense of comfort</td>
<td>qualitative</td>
<td>3</td>
<td>n.a.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Total 100

More details on the tool will be included TIDE Practitioners’ Handbook for innovative transport measure assessment.
References


