SCORELCA

STUDY No. 2015-04

MONETARY VALUATION OF ENVIRONMENTAL IMPACTS IN LCAS: A PRACTICAL CASE

Summary

September 1st, 2017

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The SCORE LCA association is a study and research structure dedicated to Life Cycle Assessments (LCA) and environmental quantification. Its aim is to promote and organise cooperation between industrial, institutional or scientific actors in order to favour a shared and recognised evolution, at European and international level, of the Life Cycle Assessment methodology and its implementation.

- ✓ This work has been supported by the ADEME (French Agency for the Environment and Energy Management)

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- ✓ The views and recommendations expressed in this document are the sole responsibility of the authors and do not necessarily reflect the opinion of all SCORE LCA members unless otherwise stated.

- ✓ The information and conclusions presented in this document have been drawn up on the basis of scientific and technical data and existing regulatory and normative framework at the time of the publication of the document.

Scientific summary

Introduction

Monetary valuation is a method which aims at expressing in monetary terms, costs (or benefits) for the society of environmental or social impacts associated to product, service or, more broadly, to a system.

It is therefore a potentially powerful assessment and decision-making tool, which can be used to:

- Compare the costs of environmental damages (negative externalities[1]) with private costs (associated with financial transactions).
- Compare multiple products, scenarios or technological alternatives on the basis of a single criterion (expressed as a monetary value). Using monetary valuation therefore allows, via a single score, the removal of constraints for the interpretation and use of multicriteria results, such as in an LCA.

In other words, monetary valuation provides an overall view of the performance of a system (or of several systems to be compared) on all sustainable development components (economic, environmental and social performances) while taking into account the effects on market and non-market goods and services of the systems. It can also provide monetary values for internalising environmental and social externalities into the economic calculation.

Monetary valuation of environmental impacts has always faced many criticisms. Some of these criticisms are based on its very principle (is trying to express all values as a monetary value relevant, even ethical?), others on its practical feasibility (is giving a monetary value to everything achievable from a practical point of view?). Some of the criticisms are based on the intrinsic limitations of monetary valuation. It is important to keep these in mind to be able to clarify the validity, applicability and limitations of the results of monetary valuation studies.

From the end of the 90s, sets of monetary valuation factors have been developed, which can be directly used to translate environmental impacts or damages assessed by LCA into monetary values (and possibly aggregate the results into a single score).

However, there are still many **obstacles to implementing monetary valuation methods in LCA studies:** the complexity of the associated economic concepts, especially for LCA users who do not necessarily have in-depth training in economics, the heterogeneity and potential inconsistency of methods from one impact indicator to another, the lack of completeness for covering all environmental issues, the low availability of the tools providing a consistent framework, etc.

Objectives of the study

In this context, SCORE**LCA** launched a first study on monetary valuation in 2012. This first study established a state of the art of monetary valuation methods applicable to an LCA, a review (via a survey) of the use of these methods, as well as a decision tree and recommendations providing guidance to the LCA user with regards to the different monetary valuation methods depending on the case studied (Weidema et al. 2013). To complement this study, SCORE**LCA** members wanted to have **operational recommendations** to monetise environmental impacts related to their products and projects, by using the monetary valuation approach most suited to the case in hand: for example, how to implement a contingent valuation, a conjoint analysis, or a hedonic pricing method? What is the procedure for developing ad hoc monetary valuation factors using one of these methods? What are the strengths and weaknesses of each of these monetary valuation approaches, conceptually and in terms of implementation?

[1] An externality characterises the fact that an economic agent creates, through its activity, an effect on other agents without any monetary counterpart (such as a free benefit, damage without it being reflected in the price, or damage without compensation).

The purpose of this study was to update the 2012 study and provide operational recommendations to assist LCA users in their monetary valuation studies. These recommendations are presented as a decision tree (DT).

The work was carried out in five phases:

- **Phase 1: Update of the state of the art summary** from the 2012 study (preparation of a detailed glossary and update to the literature review);
- **Phases 2 to 4: Practical case – Monetary valuation applied to LCA:**
  - Phase 2: Applying generic monetary valuation factors to LCA results for the cogeneration of electricity and heat from different types of biomass (miscanthus and wood pellets);
  - Phase 3: Calculation of case-specific monetary valuation factors from a pilot survey to understand the methodological principles of stated preference methods (contingent valuation and conjoint analysis). The monetary values of biodiversity and human health were estimated and were compared to those used in Phase 2;
  - Phase 4: Training workshop to transfer theoretical components and know-how used in the Phase 3 pilot survey to SCORE**LCA** members;
- **Phase 5:** Development of **operational recommendations** for the implementation of the main monetary valuation approaches in LCA (these recommendations are presented in the study as **Decision Trees** and **practical information sheets**).

In this summary, we will focus on the decision trees since the other phases of the project have a mainly didactic purpose and have contributed to the final recommendations phase.

Decision tree 0: General procedure for monetary valuation of an LCA

To monetise LCA results, we suggest a monetary valuation approach structured around two iterations (as illustrated in **Decision tree 0** (DT 0) in Figure 1):

- A first iteration based on generic monetary valuation factors (DT 2);
- A second iteration, based on specific monetary valuation factors to delve further into the specific challenges of the analysed system (DT 4).

Before each iteration, there are questions on the objectives (DT 1) and the approach (DT 3) to ensure the relevance and usefulness of the approach.

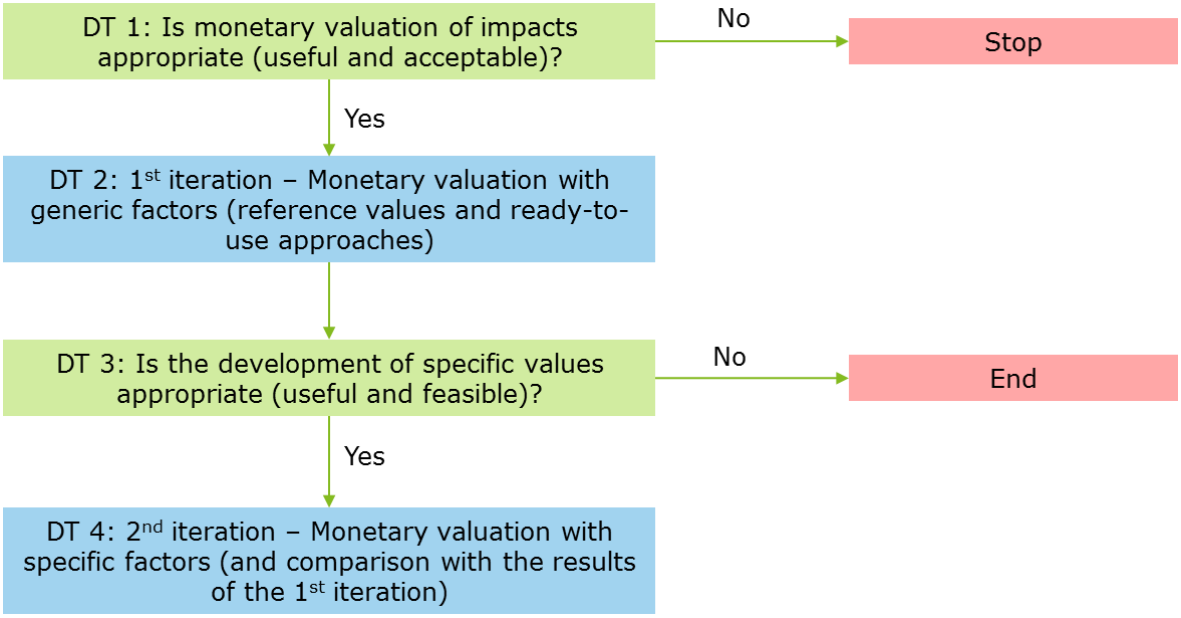

Figure 1 - Decision tree 0: Overall diagram of the decision trees detailed in the following sections

DT 1 to 4 are explained in the following sections of this summary.

Decision tree 1: Is impact monetary valuation suitable?

Decision tree 1 (Figure 2) presents the preliminary thoughts on a monetary valuation study. Before starting the actual monetary valuation exercise, it is important to be aware of the theoretical assumptions on which it is based and ensure that this approach does not conflict with the values of the stakeholders (customer, company, etc.).

As part of an LCA, one of the monetary valuation objectives is to determine a single unit for the different impact or damage indicators. This is particularly useful during a comparative analysis of two (or more) systems where the system performing best is different depending on the environmental impact indicator considered.

Monetary valuation is a potentially powerful method but has important limitations. It should therefore not be used more than necessary, in the sense that it is important to check that a monetary valuation study would provide significantly more information compared to other assessment methods (i.e. that one of the above objectives is achieved) and make reporting of results easier.

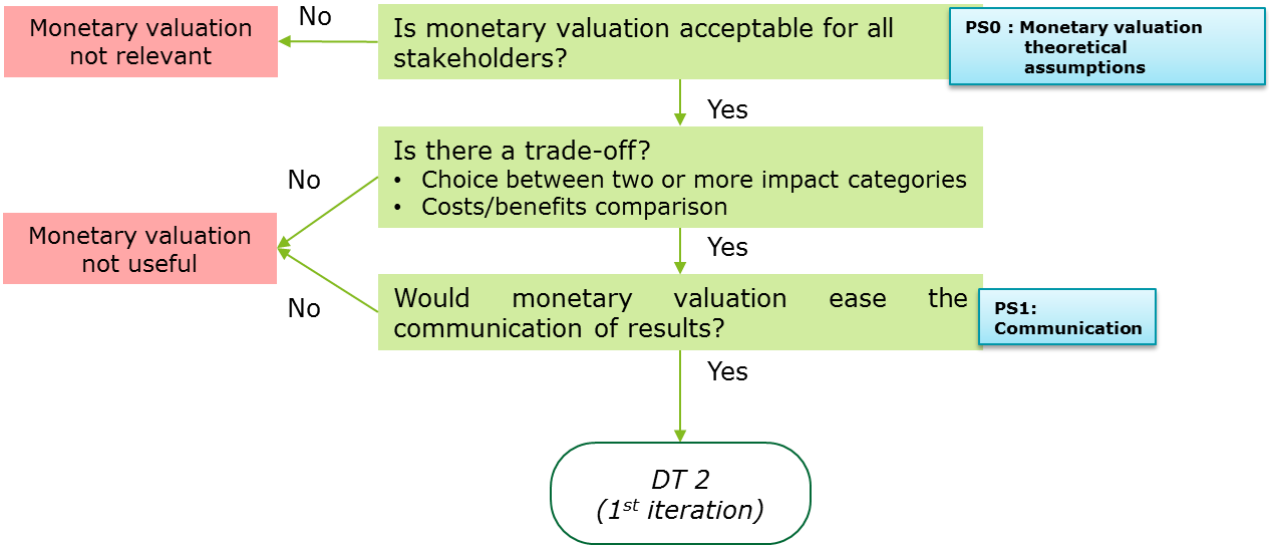

Figure 2 - Decision tree 1: Is impact monetary valuation suitable?

Two practical information sheets on DT 2 are presented in the study report:

- **Practical Sheet 0:** Reminder of monetary valuation theoretical assumptions;
- **Practical Sheet 1:** Recommendations on how to communicate monetised LCA results.

Decision tree 2: 1st iteration –Monetary valuation of impacts using generic monetary valuation factors (use of sets of monetary valuation factors for LCA)

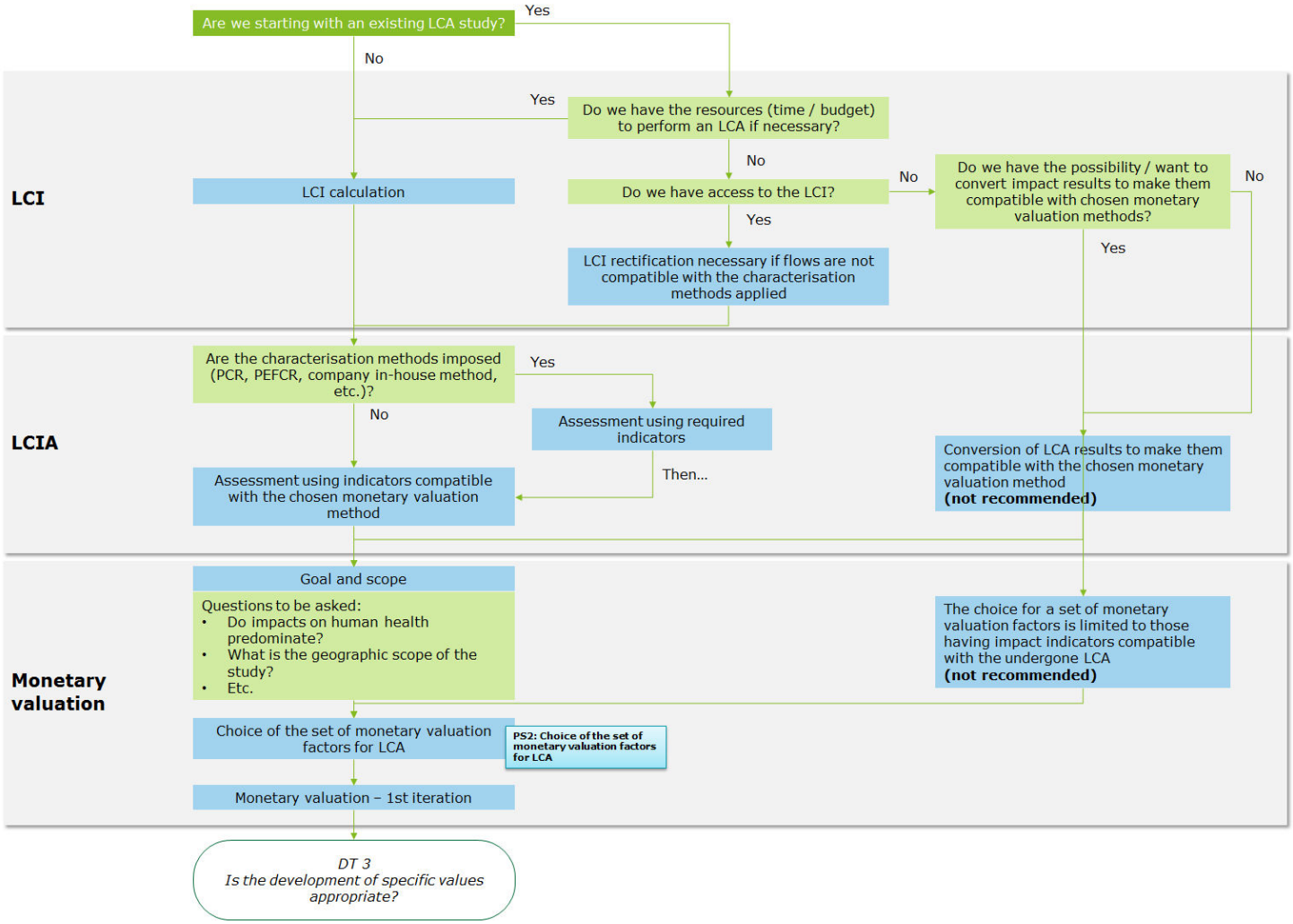

Figure 3 - Decision tree 2 - Selecting a set of monetary valuation factors for the LCA

Once the usefulness of the monetary valuation approach has been validated (DT 0), the first iteration of the monetary valuation exercise consists in applying already available monetary valuation factors.

It is best if the LCA and the monetary valuation step are carried out by the same team, or to have access to the documentation of all stages of the LCA (including the LCI – Life cycle Inventory) in order to monetise the results. The different sets of monetary valuation factors for LCA[2] are only compatible with certain impact characterisation methods. Identifying the needs of the monetary valuation step at the start of the exercise will therefore save time and allow the selection of the correct impact characterisation methods (i.e. compatible with the set of monetary valuation factors for LCA) from the start (referred to as "required indicators" in Decision tree 2).

The table below lists the different methods available to directly convert LCA results (*midpoints* or *endpoints*) into monetary values and specifies the LCA impact characterisation methods with which they are compatible.

Table 1 - Compatibility of sets of monetary valuation factors for the LCA including the impact characterisation methods

Set of monetary valuation factors for LCA (*alphabetical order*)	Impact characterisation method
ECOTAX	CML midpoint except on resources where the exergy approach is adopted
ECOVALUE	ReCiPe midpoint
EPS	EPS endpoint
EVR	Midpoints recommended by the ILCD (7 categories)
LIME	LIME endpoint
STEPWISE	STEPWISE endpoint (calculated from EDIP2003 and IMPACT 2002+)

If the characterisation methods are imposed, for example by a company in-house methodological guide, by *Product Category Rules* (PCR) or *Product Environmental Footprint Category Rules* (PEFCR), we recommend to calculate the indicators required by the reference guide / framework and then the indicators compatible with the chosen monetary valuation, as indicated in decision tree 2 above. In practice, the *Product Environmental Footprint* (PEF) requires the calculation of ILCD indicators (with some exceptions to be justified by the PEFCR), and most type III environmental reporting programs recommend the use of CML indicators (such as the *International Environmental Product Declaration System*, the EN 15804 standard for construction products, the *PEP Ecopassport* program). However, to us, the sets of monetary valuation factors compatible with these two sets of indicators do not seem to be the most robust:

- EVR is the method compatible with ILCD indicators. It is based on abatement cost methods and does not include all impact categories. The abatement cost method is irrelevant because it does not assess the damage costs (see Decision tree 4 for a detailed explanation).
- The method compatible with CML indicators (for most impact categories) is ECOTAX, which is only valid in a Swedish context.

It therefore seems preferable to first calculate the indicators required by the reference guide / framework and then, for the monetary valuation step, repeat the LCA with an impact method suited to the chosen monetary valuation method.

We can hope for the development of sets of monetary valuation factors which are robust and compatible with indicators recommended by the most renowned or used methodological reference guidelines / frameworks.

If the results of the LCA are not compatible with the set of monetary valuation factors, but if the LCI is available, the results can be recalculated. However, it is important to ensure that the LCI is in the correct format (because

[2] Set of factors used for converting LCA results (*midpoint* or *endpoint)* into monetary values.

of a format issue, a flow may not be taken into account in the impact characterisation as implemented in the LCA software used).

Practical Sheet 2, provided in the study report, analyses and compares existing sets of monetary valuation factors, their scope, their strengths and limitations in order to guide the choice of the LCA user. **EPS, LIME and STEPWISE emerge as the most relevant sets of monetary valuation factors for LCA** (unless the specific context of a study requires the use of reference values for one or more impacts). As these three methods stand out as having their strengths and limitations, **it is recommended to carry out sensitivity analyses (i.e. carrying out the same LCA with several sets of monetary valuation factors, which involves reassessing the impacts with other methods)**. This allows to better understand how sensitive the results are to the set of monetary valuation factors chosen for the LCA and to identify the cases where the different methods give similar results (even when absolute values may be significantly different, the conclusions on comparing the impacts between the systems or scenarios analysed can remain unchanged).

Decision tree 3: Is the development of specific monetary valuation factors relevant?

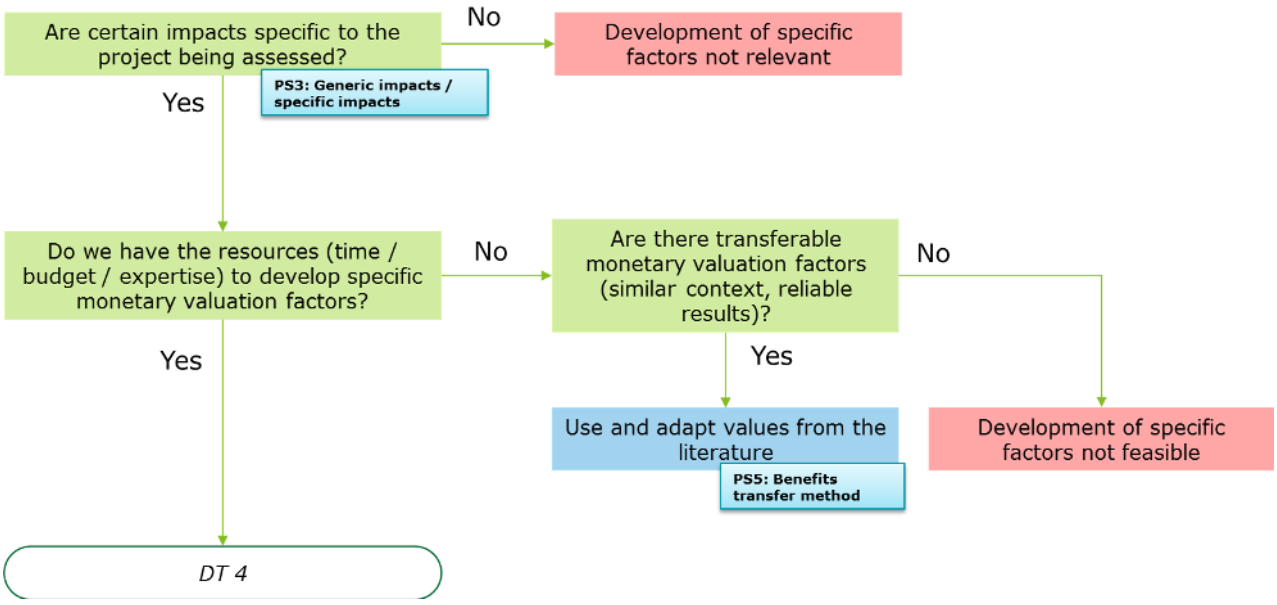

Figure 4 - Decision tree 3 - Relevance of the development of specific monetary valuation factors

Decision tree 3 details the necessary thought process at the end of the first iteration on the relevance of carrying out a second iteration. By using generic monetary valuation factors (such as reference values or one or several sets of monetary valuation factors for LCA), a first calculation is carried out and the steps and flows which contribute the most to the assessed scenario can be identified (via a contribution analysis).

After interpreting the results, it will be determined whether certain impacts are specific and significant to the project being assessed. **Practical Sheet 3**, presented in the study report, details the definitions of specific and generic impacts. An impact is specific when linked to a specific location and/or to the stages of the life cycle in the foreground system and/or when the stakeholders who may be interviewed have a reasoned opinion on this impact.

If specific impacts are confirmed, it is recommended to **monetise these impacts by using specific monetary valuation factors (developed for the current monetary valuation exercise).** The development of these factors can be costly and the user will check whether the required resources and expertise for this work are available. The way of selecting the monetary valuation method to be applied for each identified specific impact is detailed in Decision tree 4.

If resources are not available for estimating a specific monetary valuation factor, values from literature may be used (benefit transfer method described in Practical Sheet 5).

Decision tree 4: Impact monetary valuation with specific monetary valuation factors

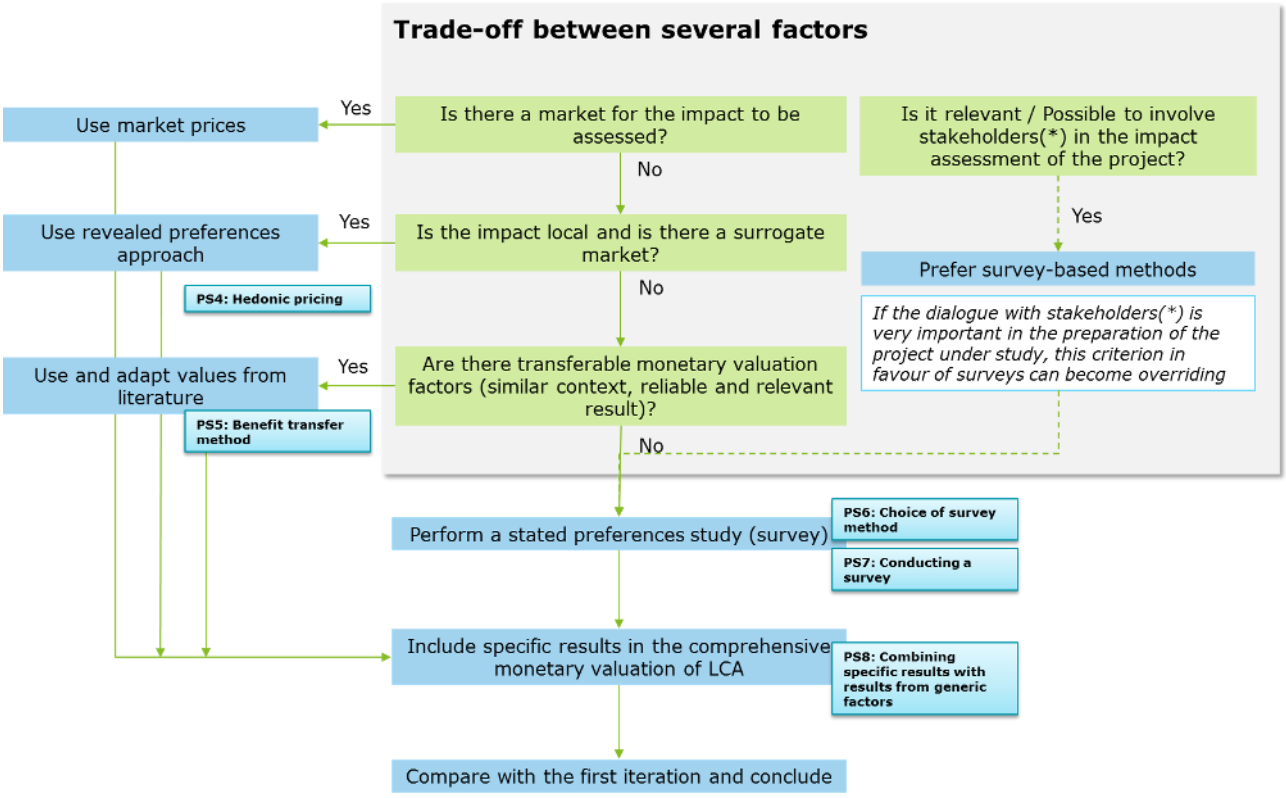

Figure 5 - Decision tree 4 – Selecting the monetary valuation method

(*) In this context, the following are considered as stakeholders: (i) Companies and individuals potentially impacted in a specific manner by the project under study; (ii) Companies and individuals potentially having a specific impact on the project under study.

The process for the selection of the monetary valuation method is presented in a simplified manner in the Decision tree 4 above. Several impact monetary valuation methods are available and can be used to calculate specific monetary valuation factors:

- **Market price method:** Estimating the private value of goods by observing the market price[3];
- **Human capital method:** Using existing labour market prices to estimate the statistical value of human life;
- **Revealed preferences approach:** It consists in extrapolating the willingness to pay (WTP) or willingness to accept (WTA) for non-market goods from actual values recorded for (another) market good in a market affected by changes in availability of the non-market good (for example, using the hedonic pricing method and travel cost method);
- **Stated preferences approach:** This approach works on the basis of surveys that try to estimate how much an individual is willing to pay (or accept) to avoid (or suffer) a specific damage. Among the stated preferences approaches, the most commonly used are the contingent valuation and the conjoint analysis;
- **Abatement cost method:** Use of potential costs to reduce or eliminate a damage, for example by using marginal replacement technology or marginal measures to avoid that damage;

[3] It should be noted that the market price method provides the lower bound values

- **Benefit transfer method:** Extrapolation of the results of an existing study to another more or less similar situation;
- **Meta-analysis method:** Compilations of values taken from previous studies using statistical methods (outliers identification, mean calculation, linear regression, etc.).

Selecting one or several methods is a matter of trade-off between different criteria which are often analysed in parallel (and therefore difficult to represent in a decision tree):

- Cost of implementing the method:
  - Generally, the costs of the different methods can be classified as follows, in order of increasing cost: "Sets of monetary valuation factors for LCA" < Transfer of specific factors < Surveys < Hedonic pricing. Costs vary greatly depending on the complexity of the project and the availability of data to be analysed. Here are a few orders of magnitude:
    - For a simple contingent valuation, the indicative budget is approximately EUR 60,000: 10% for the survey preparation (description of scenarios, definition of forms of payment, etc.), 30% for the pilot survey and focus groups, 35% for implementing the survey, and 25% for results analysis and study documentation.
    - For choice experiment, the indicative budget is slightly lower, around EUR 55,000, mainly because of the smaller sample size (typically 600 respondents for a survey, although this will depend on the number of attributes assessed).
    - The indicative budget for a hedonic pricing study is approximately EUR 75,000: 30% for the research and compilation of real estate sales data and environmental data, 35% for the *geographic information system* (GIS), and 25% for the results analysis and study documentation.
- Covering all the components of the Total Economic Value (TEV):
  - Ideally, it is better to use methods capable of covering all the TEV components for the environmental goods assessed. Some methods are not able to quantify non-use values: market price and revealed preferences methods are only relevant for estimating the use value of environmental goods. They are therefore only suitable when the non-use value can be considered negligible compared to the use value. The stated preferences approaches are mostly recommended for estimating the TEV, when the non-use value is significant and must be assessed.
- Ability to differentiate the willingness to pay for the different attributes of a good:
  - In order to have a finer ins and outs analysis, it may be interesting to be able to isolate the contribution of the different attributes to the monetary value of a good. Using the choice experiment method (i.e. stated preferences), unlike most other methods, a finer analysis is possible (the willingness to pay for protecting each of the attributes of a good can then be estimated).
- Willingness to involve stakeholders:
  - The stated preference methods are the most recommended where stakeholder involvement is considered a key factor for the success of the project (these methods involve the stakeholders through surveys).
  - The supply chains for the products subjected to an LCA can be complex and cover a wide geographical area. It is not, of course, practical nor realistic to convene and train all stakeholders involved throughout the life cycle of the product studied for consultation. As mentioned above (note below decision tree 4), in this context, the following stakeholders are taken into account: companies and individuals potentially impacted in a specific manner by the project under study and/or companies and individuals potentially having a specific impact on the project under study. The analysis of the contributions of the first monetary valuation iteration is useful from this point of view as it allows a preliminary identification of the stakeholders potentially impacted by the project, focusing on the foreground processes.

Facing the trade-off between these factors, the hierarchy for applying the monetary valuation methods will vary according to the situations. The different factors must be analysed on a case-by-case basis to make the appropriate choice.

As a general rule, the objectives, feasibility and constraints may influence the method selection. All the potential situations cannot be included in the decision tree, which is intended as a summary. On the other hand, **this decision tree should be discussed with a relatively large panel of people at the start of the study**, during the phase defining the objectives and the scope of the study. This panel should at least include the sponsors of the study (those funding it), those who will carry out the study, those who are likely to communicate the results, those who are likely to make decisions based on those results, or even those likely to be affected by the decisions taken on the basis of its results.

From a technical point of view, it should be noted that the abatement cost methods[4] do not appear among the possible choices in the decision tree presented above as **we do not recommend the use of abatement cost methods** for two main reasons:

- The abatement cost methods do not assess the damage costs but the required technology costs to avoid impacts, and there is no evidence that these two costs are correlated. In an LCA, we assess impacts and potential damages. These methods are therefore not in line with the LCA principles.
- This type of method is based on potential costs, i.e. hypothetical future scenarios: there is no proof that the costs used for monetary valuation will really be accepted by individuals or public actors, therefore this type of method is not relevant from the economic point of view. This point sets them apart from, for example, preventive cost methods (revealed preferences methods), which are based on expenditures that have either been approved by the public authorities (for example, through taxes) or actually incurred by individuals (avoidance behaviour methods).

The practical sheets, listed below and presented in the study report, can be used as part of developing monetary valuation factors for the specific impacts of a project:

- **Practical Sheet 4:** General remarks on the hedonic pricing method (revealed preferences method) including an example on the disamenity cost of wind turbines.
- **Practical Sheet 5:** Recommendations for carrying out a transfer of values (benefit transfer method).
- **Practical Sheet 6:** Strengths and weaknesses of the various stated preference methods (contingent valuation or conjoint analysis) to guide the reader when choosing the type of survey.
- **Practical Sheet 7:** Practical recommendations on conducting a pilot survey.
- **Practical Sheet 8:** Recommendations for combining “specific” results (results on specific issues) with the results of the monetised LCA for all impact categories (or with the best possible coverage in terms of impact categories) carried out with sets of generic monetary valuation factors.

Conclusions

For several years, monetary valuation has been applied to LCAs. This is an interesting tool, especially as it allows all the results of an LCA to be translated with one single indicator expressed in the unit generally used by the decision makers. There are, however, many significant conceptual and practical limitations. It is therefore recommended to only use this tool when necessary. Results should be communicated with great caution.

This study provides LCA users with operational recommendations to help them effectively carry out monetised LCAs by taking advantage of the latest theoretical advances in an effective and suitable manner.

[4] (*Abatement cost method)* This method consists in using potential costs to reduce or eliminate a damage, for example by using marginal replacement technology or marginal measures to avoid that damage. Note that we separate "abatement costs” from “preventative costs”, with the latter used in “revealed preferences approaches”, see detailed monetary valuation method definitions in Chapter 1.