Valuation procedures for Product Environmental Footprint (PEF)

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This paper has been prepared for the Nordic PEF project as an input to the discussion on recommendations for the development of the European PEF scheme. The paper includes the responses from a group discussion in Copenhagen 2016-04-26.

Valuation covers the terms normalisation and weighting, as used in the LCA community.

1 Background

1.1 The purpose of valuation

Valuation serves the purpose of facilitating comparisons across different environmental midpoint impact categories, by applying weights (values) that reflect their relative importance (ISO 14040). Without valuation it becomes impossible to recommend the best decision when the options score best on different impact categories.

It is important to note that the values discussed here are the marginal values applied in trade-offs between alternative resource allocations, not moral values like the value of democracy or the value of human life as such, that cannot be subject to quantified measurement and trade-offs. Much critique of marginal valuation comes from a confusion of these two types of values.

1.2 Representativeness of valuation methods

When choosing a valuation method, there are a number of concerns that need to be considered with respect to the representativeness of the valuation, i.e., are those whose values are being sought and applied representing the population that is affected by the valuation or its later application?

1.2.1 Valuation is anthropocentric

Valuation is in its essence anthropocentric, since its purpose is to support human decision-making. Any concern for other species (or for that matter for any other group than the one that has the power to take the decision) must necessarily come as a concession from those who perform the valuation. However, the fact that it appears very difficult – or rather impossible – to design a truly non-anthropocentric valuation scheme, does not make it unimportant to raise the issue and seriously contemplate its relevance when deciding on the design of a valuation method. It should also be noted that an anthropocentric valuation does not necessarily imply a low valuation of nature; nature does have high value for humans, both use value (today often referred to as ecosystem services) and non-use values (existence value and bequest value).

1.2.2 Concern for equality

Especially in the context of sustainability, which has an inherent concern for equality between and within generations (World Commission on Environment and Development 1987), it is important to ensure that the valuation methodology gives equal weight to the values of each individual. For this purpose, utility-weighting can be applied, which weights values in relation

to the utility that each individual obtains from an additional unit of the good. A generalised utility-weighting across all impact categories can be performed by weighting the environmental impacts by the marginal utility of income for each affected population group:

$$Utility = \left(\frac{averageIncome}{subgroupIncome} \right) \wedge \delta$$

where δ is the elasticity of marginal utility of income. The value of δ can be empirically determined, typically between 1.1 and 1.4 (see e.g. Layard et al. 2008), which implies a larger weight to poor population groups than to richer, or normatively set to 1, in which case the same impact will be weighted equally across all levels of income.

1.2.3 Concern for special groups

Even when taking into account differences in utility, there may still be an additional concern for specially disadvantaged groups, e.g. indigenous people. As already mentioned in the section 1.2.1, such concerns must necessarily come as a concession from those who perform the valuation. If specific groups are affected more than other groups, it is important that they are represented in the population that performs the valuation, and additionally it may be required that such specifically affected groups give their informed consent to the valuation procedure or its specific results. This issue is largely parallel to the issue of minority protection in democracy.

1.2.4 Concern for group values

The individualistic nature of values and valuation has been criticised for not adequately taking into account that some values only occur as "group values" and that individual values may be affected by the discussions and opinions given in a group context. For many complex environmental goods, respondents may not have well-defined preferences prior to the process of value solicitation, but their latent preferences are developed during the solicitation process itself. This criticism has often been voiced in connection to the general critique of the assumptions made in neo-classical economics. While classical valuation techniques can take into account the (group) context of the solicited individual values, the values of the group as a whole are seen as the sum of the individual values.

This limitation in classical valuation procedures has led to the development of additional procedures in valuation under the name of "deliberative valuation" (Kenter 2015). In deliberative valuation, the solicitation of values take place in a process of reasoned social discourse and learning, which increases the participants' awareness of the issue and of the perceptions of other participants. Participants can discuss considerations such as equity, fairness, rights and responsibilities, alongside discussions of costs, benefits and trade-offs, uncertainties and risks, in order to come to a more meaningful constitution of their contextual values (Kenter 2015), thus taking more explicitly into account that preferences are socially constructed.

Deliberative valuation can be used both before a survey, to test the survey design (e.g. wording and comprehension of questions, validate the information content, help identify design biases) and after a survey, to validate the survey result. When combined with recording of the evolution of participants' values, attitudes, beliefs and norms during the course of the deliberation, the procedure offers the potential for increasing both the interpretative and the explanatory depth of the results (understanding the meaning of the responses and the reasons behind the responses, and how the complexities, uncertainties and risks influence the values solicited).

Deliberative valuation may also be used as a technique to overcome the incommensurability problem, i.e. that some individuals reject a valuation completely because they do not accept that the items to be valued are comparable. A claim for incommensurability is valid when the items to be valued belong to different logical levels (e.g. "What is largest: Mont Blanc or the roar of a lion?"), but is not a viable position when comparing items for which trade-offs between alternative resource allocations are in reality being made, in which case the problem of choice is unavoidable (Beckerman & Pasek 1997). By providing the context of the valuation, and an environment in which the concerns about incommensurability is taken serious, deliberative valuation can be expected to reduce outright rejections of the valuation questions and thus lead to more representative and less uncertain valuation results.

However, deliberative valuation is limited by the resources and time required to resolve complex issues, especially where competing value systems or beliefs are present. The representativeness of the results may be challenged by the typically small numbers of people who can be involved and the difficulty of adequately eliminating influence from power-relationships.

1.2.5 Concern for rationality

It is a widespread critique of valuation methods that they assume that participants exhibit rational, utility-maximising behaviour when making valuations, while empirical evidence show that people do not exhibit this rational behaviour, neither in normal market transactions nor in experimental settings, but are influenced by the framing of the decision situation.

A large body of literature on behavioural economics suggests improvements to the survey techniques to control and adjust for the systematic biases caused by the contextual and informational setting of the valuation.

One important example is that of the endowment effect, which causes a larger weight to changes that are framed as losses than to changes framed as gains, which must therefore be taken into account when interpretation values solicited under these two frames. Another example is the issue of scaling, which may cause large singular instances of impacts (catastrophes) to be systematically over-weighted relative to the same impact over a larger space or time, while empirical studies systematically controlling for this bias show that neither experts nor lay people are particularly catastrophe averse. By making such biases explicit, it is possible to adjust for them.

1.3 Damage or distance to target: Two approaches to valuation

There are two fundamentally different approaches to valuation: Damage valuation and distance-to-target (DTT) valuation. Both valuations are concerned with marginal damage, i.e. the value of an additional unit of damage (from e.g. an additional emission of nitrogen oxides to air), to be applied in trade-offs between alternative resource allocations, as opposed to the absolute value of the total impacts (e.g., the absolute or average "price of clean air").

The damage valuation directly values marginal change by looking at how much response (damage) results from an increase in an elementary exchange (dose); see Figure 1. The shape of dose-response curves is typically sigmoid, i.e. the damage from an additional dose is low when the background concentration is low (A), but increases as the environment becomes more stressed (B), and then becomes less as the environment becomes so damaged that only little more damage is possible (C). The marginal damage is given by the first derivative of the dose-response curve; see Figure 2.

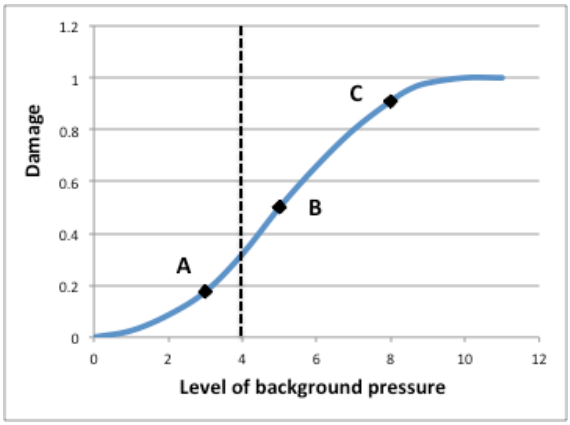

Figure 1. Dose-response curve

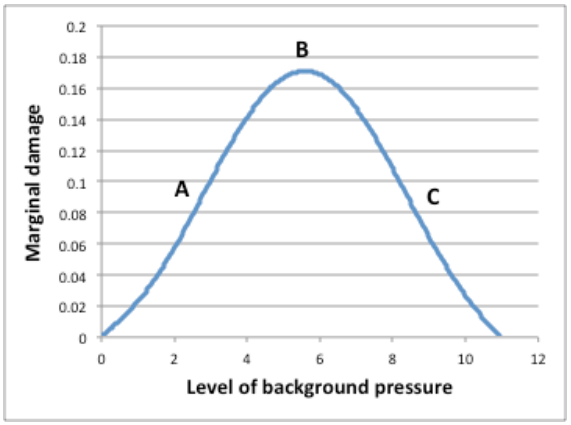

Figure 2. Marginal damage curve

As the name indicates, DTT valuation relies on a target, which can be politically determined or revealed from political decisions. Increasingly, there is an interest in determining "science-based" targets, based on the concept of dose-response curve thresholds, beyond which an additional impact will have much more severe impacts than below the threshold (e.g., popularised as "planetary boundaries").

Figure 3 shows the marginal DTT valuation corresponding to the marginal damage function of Figure 2, for the same three levels of background pressure. The difference between the two approaches to valuation is large, which is stressed in Figure 4, where the two value functions from Figures 2 and 3 are normalised per unit of additional damage. Figure 4 shows that the damage valuation is independent of level of total damage, so that e.g. a human life-year is valued the same at any level of total damage, while the DTT valuation gives lower weight to a damage when it occurs below the top of the marginal damage curve (point B in Figure 2 and 3) and increasingly higher weight to same damages when they occur above this point.

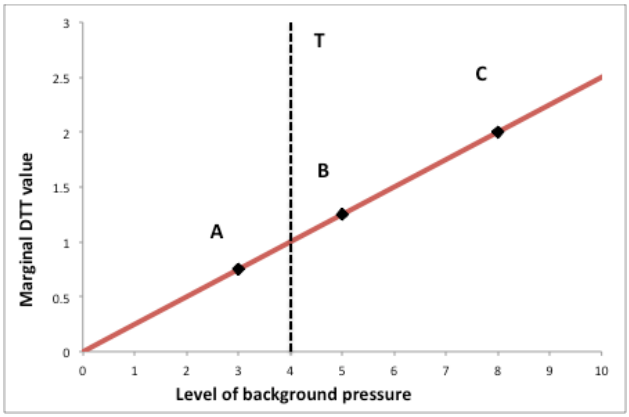

Figure 3. Marginal value of Distance-To-Target.

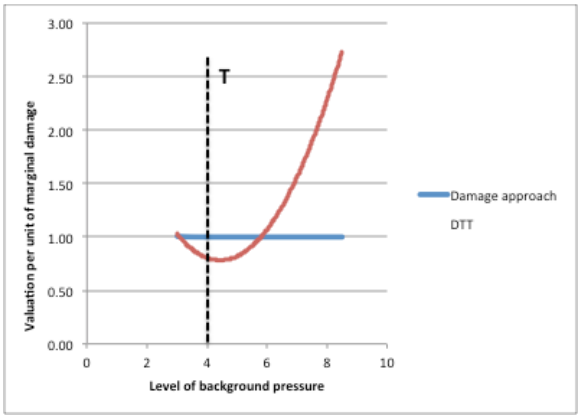

Figure 4. Damage and DTT values normalised per unit of damage.

1.3.1 Efficiency as criterion

Efficiency is generally regarded as relevant decision criteria, i.e. an option is preferred if it gives the highest desirable output (e.g., wellbeing) for the same input.

The discussion on the damage and DTT valuations reveals that these are based on different concepts of what is a desirable output. From the perspective of DTT valuation, the damage

valuation is not efficient because it does not reduce the distance to the targets the most. From the perspective of the damage valuation, the DTT valuation is not efficient, because it does not choose the options that reduce the damage the most.

However, given that a target is a means to an end (set with the purpose of reducing damage), it does not appear logically consistent to focus on the target rather than to focus on the end (the reduction of damage). So from the perspective of the end (the reduction of damage), the damage valuation appears the logical choice.

Furthermore, Figure 4 illustrates that the DTT valuation does not value the same damage equally across time and across affected population groups, which is in conflict with the requirements of the sustainability concept.

So why has targets been the focus of attention? This is discussed in the next section:

1.3.2 The role of targets in policy and valuation

In policy-making and in management, targets play important roles, both for expressing and communicating intent and for monitoring progress. Targets are quantified objectives specified to be achieved at a particular point in time. In this way, they are used to transform a general objective into specific actions that needs to be taken to achieve the objective.

One general objective, like reducing damage, can be transformed into several policy or management targets, each expressing a necessary precondition for achieving the general objective. The existence of multiple targets for one objective can give rise to conflicts between targets, which can only be solved rationally by referring to the overall objective.

So while targets play an important and often necessary role in policy making and management, targets should not be misunderstood as ends in themselves. Targets are not valuable in themselves, but obtain value from their role in achieving the overall objective. Therefore, targets should also not be used to express values, but should be valued in terms of the overall objective, e.g. to reduce damage.

1.4 Damage assessment at different points in the impact pathway

The impact pathway from an environmental exchange to its final damage endpoint may be truncated at several points. For example, the damage from an emission of CO_2 may be assessed at the level of final damage, i.e. lost species, lost human life-years, and lost capital assets, or at a step before, e.g. area and severity of affected nature, incidences of different diseases, or even at very early purely physical stages of the impact pathway such as increase in temperature or in radiative forcing.

The earlier in the impact pathway an assessment is made, the more of the impact pathway is left to the participants to fill in, and the more abstract the assessment will be from its endpoint impacts.

An argument that has been put forward for performing the assessment at an early stage of the impact pathway is that the uncertainty of the impact is lower at these early stages (Hauschild & Potting 2005). However, this also implies that it is left to the participants to include the remaining uncertainty in their assessment (Weidema 2009).

An argument for performing valuation at the final damage endpoints is that this reduces the number of valuations that needs to be made, and thereby reduces the risk of inconsistencies

between the larger number of different valuations that would otherwise be required to be performed at different (earlier) stages in the impact pathways. For example, an assessment of respiratory impacts of particulate emissions and another assessment of ozone formation may use different values for the same diseases – an inconsistency that would be avoided if performing the valuation at the level of diseases or human life-years.

1.5 Normalisation in assessment and communication

For DTT valuation, as shown in section 1.3, the value of a damage changes depending on its distance to the target, and thus depends on the size of the current absolute level of impact. Therefore, before DTT valuation is performed, the impact to be valued is typically placed in relation to a specific reference impact level, often the current absolute level of impact per person-year. This procedure is known as "normalisation".

In contrast, as shown in section 1.3, marginal damage valuation depends only on the size of the marginal damage at the specific level of impact (the slope of the dose-response curve) and is independent of the absolute level of impact. Therefore, the valuation can be performed independent of knowledge on the absolute size of the current or future impact. Prior normalisation is not required and may even give rise to confusion and bias.

While normalisation does not play any constructive role in marginal damage valuation, is relevant in communication contexts where the size of absolute damage is of interest. As mentioned in the following section, it can also play a role in allowing the communication of weighted LCA results.

1.6 ISO 14044 on normalisation and weighting

ISO 14044 states that weighting "shall not be used in LCA studies intended to be used in comparative assertions intended to be disclosed to the public" with the argument that weighting involves value choices and therefore cannot be science-based. This somewhat narrow view on behavioural economics as "not a science" is not very helpful for practical applications where the options score best on different impact categories.

It is possible to circumvent the ban on weighting in ISO 14044 by instead using normalisation (which is not excluded by ISO 14044) to a potential target reference situation in which the normalisation factors are identical to the desired weighting factors.

1.7 Uncertainty in normalisation and weighting

Uncertainty in valuation, i.e. beyond the uncertainty of the physical impact pathway modelling, is introduced partly by the fundamental variation between individual values and partly by the biases of the informational and contextual setting of the valuation. The former can be minimized by sampling and adjustment techniques that ensure representativeness, while the latter can be minimised by controlling for bias in the valuation setting, as described in the previous sections.

Uncertainty is a well-known condition of decision-making. Information on the uncertainty of valuations should not be supressed but rather be required to be included in the valuation results and in any derived communications.

2 Valuation in the PEF pilots

2.1 Proposed ensemble valuation

In a project for the EC-JRC, Huppes et al. (2012) analysed three quite disparate groups of preference-based valuation methods, and found that they gave quite converging results at the national level. This supports their suggestion of applying an ensemble "meta-model", aligned to the ILCD Handbook requirements for impact assessment, and where each individual method contributes to establish the uncertainty of the overall result.

2.2 1:1 weighting as default

This recommendation has not been followed in the PEF guidelines, which instead have suggested that the pilot screenings should use a 1:1 weighting of the normalised results from the 14 midpoint indicators. An official data set for PEF normalisation has been supplied by Benini et al. (2014). This procedure gives equal weight to all impact categories, and effectively means that no single impact category – also not global warming - can contribute with more than 1/14.

Such a 1:1 weighting gives arbitrary importance to the way the indicators are chosen. For example, the division of toxicity into human and eco-toxicity, and a further division of human toxicity into cancer and non-cancer, means that toxicity together make up 3/14, where one could as well have divided global warming into impacts on nature and impacts on humans (a.s.o.), which would have given more weight to global warming.

In the PEF pilot screenings, the 1:1 weighting leads to the identification of very strange impact categories and process hotspots. For example, in one pilot study where a marginal damage assessment would be dominated by global warming and particulate matter, the pilot screening finds global warming to contribute only 1.3-1.7% to the weighted results, and particulate matter only 2.8-4.1%, identifying instead resource depletion, human toxicity and fresh water ecotoxicity as the "most significant impact categories".

2.3 The selection of impact categories for communication

Each PEF pilot has been asked to select impact categories for communication, partly based on the 1:1 weighting results, but also by including other concerns.

Considering that practically all preference-based valuation methods analysed by Huppes et al. (2012) show a high weight for global warming relative to other impact categories, it is not surprising that the pilot screenings often result in a recommendation of including climate change as one of the impact categories to communicate on, in spite of the low importance that the 1:1 weighting assigns to it.

2.4 The late testing of different valuation methods

At the PEF Weighting Workshop on November 16th 2015, it was decided to ask the pilot studies to test a number of different valuation methods that were provided in a spreadsheet by JRC, sent to the pilots on the 15th of December 2015. The valuation methods included were 7 single-score methods and 2 methods where the aggregation was done only to the level of each separate endpoint (e.g., human health, ecosystems). Of the 7 single-score methods, 5 were

DTT valuation methods and only 2 were damage valuation methods. Damage valuation methods that express the damage in monetary units were excluded from the testing.

The results from this testing has not yet been received.

2.5 The exclusion of monetarisation

The exclusion from the PEF pilot testing of methods using monetary units for damage was not justified.

Most arguments that are generally being used as criticism of monetary valuation techniques apply equally to non-monetary valuation techniques. In principle, a valuation can be expressed in any unit, e.g. ecopoints, happiness points, QALYs, or a currency unit, and it should be possible to translate between these by applying the relevant conversion factor, e.g., 1 Euro/ecopoint. However, it has been shown that when a monetary instrument is included in the survey, respondents become more self-serving and less altruistic than when the monetary instrument is not present. This also applies to valuations that in the end is not expressed in monetary units, and is a bias that can be corrected for.

The only argument against the use of monetary valuation that is not equally applicable to non-monetary valuation techniques is the argument that expressing items in monetary units implies a commodification, which is morally questionable, a position that is supported by the above finding that commodification make respondents more self-serving and less altruistic. However, as pointed out above, there is no need for using monetary units during the value solicitation and there is no need to express the final single-score in monetary units. Monetary units are simply used for convenience by many decision-makers.

3 Recommendations

The following are some preliminary recommendations based on the above introduction and review.

3.1 Use damage assessment with minimum uncertainty

Damage assessment is the most logical choice for valuation for PEF, due to its focus on the direct trade-off objective (reduction of damage).

When performing new valuation studies, uncertainty within these can be minimised by appropriate sampling and adjustment techniques that ensure representativeness and by controlling for bias in the valuation setting, possibly supplemented by deliberative valuation for trade-offs that are particularly sensitive or contentious.

When choosing between different methods for damage valuation, the guiding rule should be to minimise the uncertainty. This is best done by using observed market data whenever possible, and results from choice modelling (which does not need to include a monetary instrument) when there is a need to include stated preferences (Pizzol et al. 2015).

By the use of ensemble modelling it is possible to take advantage of the aggregated results from all valuation studies that fulfil the quality criteria outlined above.

3.2 Use utility-weighting

Utility-weights should be applied to ensure that equal weight is given to the values of each individual.

3.3 Use normalisation and uncertainty in communication

Normalisation of damages should be avoided prior to valuation, but should be used in communication contexts where the size of absolute damage is of interest and when there is a need to communicate that PEF results are in accordance with the requirements of ISO 14044.

3.4 Use targets for policy making

The use of targets in valuation should be avoided due to the inconsistency that they introduce in the valuation of similar damages across impact categories. However, in policy-making and in management, targets should continue to play their important roles in reducing damages, by expressing and communicating intent and for monitoring progress.

3.5 Use monetary units when it is desired

When communicating values, including PEF results, the most appropriate unit should chosen, depending on the audience. The use of monetary units for communicating values should be limited to those situations where it is desired by the audience. PEF single-score results may be expressed in e.g. eco-points or QALYs. The choice of unit(s) and communication strategy may need to be determined through a dedicated market survey.

4 Responses from the group work to questions raised in plenum

Three questions were raised in the plenum discussion and discussed in a break-out group. The following is the group's responses.

What to do if you do not have a target for each impact category?
If you want to use target weighting, then targets have to be derived for each impact category. However, there is no agreement in the group that targets are useful for weighting. While targets play an important and often necessary role in policy making and management, targets should not be misunderstood as ends in themselves. The two main problems perceived with the use of targets for valuation across impact categories are that they do not value the same damage equally across time and across affected population groups, and that they are not efficient because they do not focus on the options that reduce the damage the most.

What to do if you want to have a value at mid-point level?
Even when doing valuation at endpoints, a value can still be calculated for the midpoints, simply by looking at the contribution of a unit of mid-point impact to the impact at endpoint. By doing valuation at endpoints, the uncertainty on the *valuation* is reduced, but the *overall* uncertainty (which is due to lack of knowledge) may be large. This uncertainty of endpoint damage from each midpoint should not be ignored by doing valuation at midpoint level.

Does the use of values influence how they should be derived?
No. There is no reason that the application of a value should influence the way it is derived.

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