Instruction
Design for **Optimised Resource Use**

Basic Principles

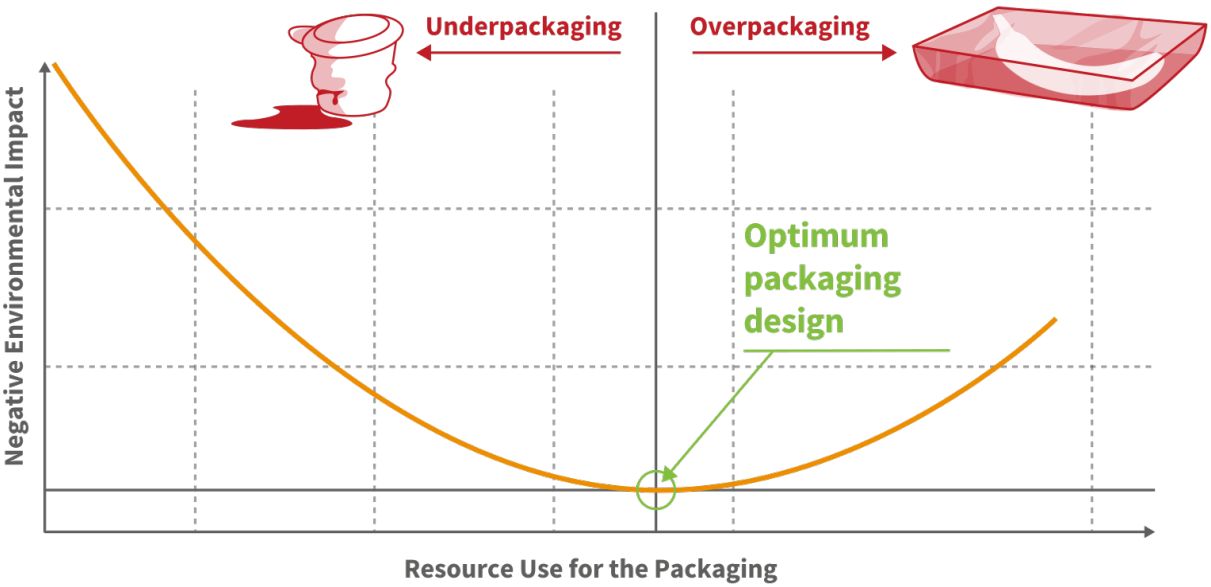
The Task of Optimisation

Natural resources are used in all processes of extracting raw materials and manufacturing packaging materials as well as in the packaging itself. Additional environmental impacts such as emissions into the air or discharges to water also occur.

From an environmental perspective, with respect to the use of materials for packaging, a good initial approach is simply: 'less is better!' By their very nature, the environmental burdens arising from resource extraction, manufacturing, transport and processing of materials occur proportionally to the amount required. If the same packaging benefit can be attained with a smaller amount of materials, this is beneficial from an environmental perspective.

However, two crucial aspects are to be taken into account here:

1. **Underpackaging is counterproductive!**
   The protective function of packaging plays a key role in reducing the environmental impacts on the life cycle of the packaged goods. Aggregated across the life cycle, the environmental burdens or 'ecological footprints' of these packaged goods are usually considerably greater than those of the packaging. For food, for example, packaging accounts for just 5 to 10 per cent of cumulative energy demand, and over 90 per cent relates to manufacturing, transport, storage and preparation of the food itself. Against this background, it should be stated that saving packaging materials must not result in the protective function no longer fulfilling minimum requirements arising from the planned/existing distribution concept.
   From an environmental perspective, underpackaging ('insufficient protective function because the amount of materials used is too small') would have at least the same negative consequences as overpackaging ('the amount of materials used is greater than what is needed for the protective function'). This is shown in the following figure.



2. **All (packaging) materials are not created equal!**
   From an environmental perspective, what matters is not only the mass of the packaging material but also the specific type of material in question. Manufacturing and processing various materials involve environmental impacts which may vary very significantly. This applies to various technical polymer materials as well as to the use of additional protective layers, e.g. metallic lamination. For this reason, a comparative environmental assessment of the materials used is always important. Reviewing the entire life cycle of packaging holistically is important as well. While some types of plastic materials available can be recycled efficiently and with high yields with the existing recycling structures, this is not true of other types or of poorly designed composite materials.

Optimisation Approaches

Approaches that contribute to ‘design for optimised resource use’ in an Eco Design project and thus to a reduction of the amount of natural resources used for packaging materials include:

- **Re-use solutions**
  in which the packaging itself and, consequently, its materials, too, are used for the task of packaging multiple times. Since the benefit of packaging is generated multiple times, the resource efficiency (the ratio of resource use to benefit generated) of the natural resources used for producing the packaging increases significantly.
- **Material reductions**
  by reducing the amount of packaging material used (e.g. through thinner layers of packaging). In a broader view, replacing materials with other materials requiring a smaller amount of resource consumption can be subsumed here. To ensure holistic assessment of material substitutions, including at the end of the life cycle of the packaging, the Eco Design strategy element ‘high-quality recycling’ should be applied in such cases. The following two optimisation approaches are special cases of material substitution.

- **Use of recycled material**
  by replacing packaging material produced from new natural raw materials (primary material) with material resulting from plastic recycling processes (secondary material). Since the recycled material already generated one or more benefits in its previous 'life', resource efficiency improves here, too, in a holistic perspective. In addition, using recycled material increases the demand for it and thus the further expansion of recycling infrastructures, which are desirable in terms of environmental policy.
- **Use of bio-based materials**
  by selecting bio-based plastics to replace primary material. This brings about a shift between the types of natural resources used, from non-renewable fossil resources to resources such as land areas of various ecological quality, water resources etc. Any conflicts potentially arising with other uses (e.g. competition with food production or for drinking water) as well as damage caused to the natural environment (e.g. a loss of biodiversity) must therefore be reviewed carefully and avoided. These aspects are the subject of the Eco Design strategy element 'sustainable sourcing' which is to be applied when bio-based materials are used.

Procedure

As provided for in the checklist for this strategy element, it is appropriate in an Eco Design project to review and, if necessary, optimise a packaging design option according to the various optimisation approaches.

It makes sense to begin with the optimisation approaches that may bring about particularly extensive changes to the entire packaging design option (in the case of reuse) or the basic packaging design (in the case of reducing materials) in order to minimise the need to repeat the steps of individual review approaches. Then, potential substitution of materials (with recycled or bio-based material) is to be reviewed.

Approach 1: Review of Possible Re-use Solutions

The question of whether a re-use system can be established for a specific packaging option depends on a number of basic factors primarily concerning aspects such as the structure of the distribution area, the channels of distribution and the resulting requirements for distribution, all of which are more in the area of strategic-conceptual specifications of a packaging project. Nonetheless, those working on the Eco Design project should pose the question to the relevant experts and decision-makers in the overall process whether it would in principle be possible to establish a functioning re-use system in light of the existing marketing requirements or to use an existing one.

The reason for this question about a potentially fundamental change to the (existing) specifications arises from the possibly highly significant and comprehensive reductions of negative environmental impacts if an efficient re-use system is used.

The key factor for potential resource efficiency of a re-use system is the number of re-use cycles that packaging achieves in practice. A crucial factor for the number of re-use cycles achievable under realistic assumptions is the opportunity and willingness of end consumers to actually introduce the packaging into such a reuse system; as a rule, this is much more important than the system's technical factors.

Numerous aspects play important roles here, for instance, the number and accessibility of places to return packaging, knowledge about the environmental advantages and potentially existing (financial) incentives for returning packaging.

The specific effectiveness of such factors is to be assessed by the relevant experts in each packaging project to arrive at realistic assumptions about the expected average number of packaging re-use cycles.

Whether the overall resource savings on the basis of this number of packaging re-use cycles are greater than the additional resources needed for the return system (especially for transport and cleaning, but potentially also for the packaging itself, which must be more robust) is to be evaluated using life cycle analyses (LCA).

On the one hand, since the time and effort for comprehensive LCA evaluation may well be considerable, particularly for multiple alternatives for implementing the re-use system, it makes sense to work with simplifications. On the other hand, as the results of the evaluation are to provide the basis for a very important basic policy decision (whether or not to develop a re-use solution), the procedure selected must be true to fact. One such approach is described below:

The first simplification: when comparing single-use and re-use solutions, examine only those processes that actually differ between the two alternatives.

Furthermore, this kind of initial evaluation can be sufficiently informative even though it is limited to a few LCA parameters, e.g. Cumulative Energy Demand (CED) and CO_2 equivalents. In order to capture specific aspects of the alternatives (e.g. a cleaning step) to be compared properly, it may be necessary to include further selected parameters, e.g. water consumption or wastewater load.

The expected numbers of packaging re-use cycles are a rather reliable indicator for determining which cases permit such simplifications and which ones require a more comprehensive assessment. According to experiences documented in a large number of such studies, certain numbers of re-use cycles generally result in distinct advantages for one system or the other (single-use/re-use):

- If the number of re-use cycles is ≥ 10, the re-use solution may be assumed to be more advantageous. A simple review will suffice.
- If the number of re-use cycles is ≥ 3 and < 10, it cannot be predicted which system will be more advantageous, so that a more detailed LCA would have to be performed on the basis of specific designs of the packaging and the re-use system.
- If the number of re-use cycles is < 3, the single-use solution may be assumed to be more advantageous. A simple review will suffice.

Depending on the results of the assessment, a single-use or re-use solution is to be developed as the final step of reviewing this approach. If the results of the evaluation are inconclusive, it may also make sense to fully develop both solutions as a basis for a more specific review of their ecological advantageousness.

The key review questions from the checklist for this optimisation approach 1 are summarised as follows:

Question	Instructions	Result
Is it possible in principle to establish a functioning re-use system in light of the existing	If **YES**: continue If **NO**: document the reasons and continue with approach 2.	[Please fill in]

Question	Instructions	Result
marketing requirements or to use an existing one?		
How many re-use cycles can be achieved under realistic assumptions?	If ≥ **10**, the re-use solution may be assumed to be more advantageous. A simple review will suffice. If **< 10 ≥ 3**, a more detailed LCA is to be performed on the basis of specific designs of the packaging and the re-use system. If **< 3**, the single-use solution may be assumed to be more advantageous. A simple review will suffice.	[Please fill in]
Can a re-use solution be expected to be ecologically advantageous?	If **YES**: continue developing the Eco Design for re-use packaging. If **potentially**: if the results of the evaluations are similar, both packaging alternatives (single-use/re-use) should be developed and then further evaluated in approaches 2-4. If **NO**: continue developing the Eco Design for re-use packaging.	[Please fill in]

Thus, the result of reviewing this optimisation approach includes one or potentially multiple packaging solutions which have been reviewed and potentially modified with respect to a re-use option, as input for evaluating this strategy element in the further optimisation approaches.

Approach 2: Review of Possible Material Reductions

When it comes to reducing the amount of material required by the packaging, it should first be reviewed whether changes are possible to the basic specifications for the packaging project. The specific question must be asked whether modifications to the logistics system can reduce the functional requirements of the packaging itself.

It is imaginable in principle that logistics solutions placing lower demands on packaging (in terms of transport and transfer processes as well as storage conditions) could reduce the functional requirements of packaging (e.g. in terms of stackability, stiffness etc.). This may result in packaging solutions requiring smaller amounts of materials.

When these options have been reviewed and exhausted, the next question is about optimising the combined effects of primary, secondary and potentially tertiary packaging. The core functionalities of a packaging system are generally provided for by combining various types of packaging in a targeted fashion. From an environmental perspective, the effectiveness of this combination is to be examined with a view to potentially reducing the total amount of materials. Refill solutions, for example, are one possible result of such a holistic optimisation effort.

As discussed above in the introduction, such optimisation should include review of whether the packaging precisely fulfils the necessary requirements of the protective function as previously defined. From an environmental perspective, both overfulfilment and underfulfilment of these requirements are problematic and should be avoided.

For reasons of marketing and/or distribution logistics, packaging is sometimes designed with an unfavourable ratio of volume to surface area. Relatively large headspace can also result from such considerations or from filling process requirements. Since each of these

requirements results in an increased need for materials, they are to be scrutinised critically with a view to finding optimised solutions to the extent possible.

Finally, it has to be assessed whether changing the selected materials, i.e. for example, using a different type or grade of polymer or changing a multi-layered structure (for instance, because of reduced thickness of walls or foils), can reduce the total amount of materials required.

It is important to review both the total weight (mass) of the materials in question as well as relevant LCA values such as CED and/or CO_2 equivalents. In addition, when reviewing such changes of materials, it is important to include the strategy element 'high-quality recycling' in the strategy for the Eco Design project in order to detect possible negative impacts in the end-of-life phase of the life cycle of the packaging.

The key review questions from the checklist for this optimisation approach 2 are summarised as follows:

Question	Instructions	Result
Can modifications of the logistics system reduce the functional requirements of the packaging?	If **YES**: document the result and continue. If **NO**: conduct potentially possible optimisations and document them.	[Please fill in]
Has the entire system consisting of primary, secondary and (as appropriate) tertiary packaging been reviewed and optimised in terms of total materials use?	If **YES**: document the result and continue. If **NO**: conduct any necessary optimisations and document them.	[Please fill in]
Can the thickness of the packaging material be reduced?	If **YES**: document the result and continue. If **NO**: make any necessary adjustments and document them.	[Please fill in]
Can the geometry of the packaging be changed to save materials?	If **YES**: document the result and continue. If **NO**: make any necessary adjustments and document them.	[Please fill in]
Can total material usage be reduced by using different (polymer) materials?	If **YES**: document the result and continue. If **NO**: conduct any possible optimisations and document them.	[Please fill in]

The result of reviewing this optimisation approach includes one or potentially multiple packaging solutions which have been reviewed and potentially modified (also) with respect to the materials used (amounts and ecological value), as input for the further optimisation approaches.

Approach 3: Review of Options to Use Recycled Materials

From a resource perspective, recycled materials carry a significantly lower burden compared to primary materials. In addition, their use contributes to promoting the closing of materials cycles, which is desirable on the basis of fundamental environmental policy considerations.

However, each packaging project should be reviewed to determine whether the specific functional requirements of packaging can be fulfilled precisely with the recycled materials in the qualities available on the market today or whether adjustments in packaging design, for example, are needed.

It should also be reviewed whether legal requirements are in force that must be observed when using recycled materials or that even prohibit their use for the packaging purpose in question. Such limitations exist, for example, in the area of food contact. Yet some of these

usage limitations can be bypassed by design adjustments (e.g. using recycled materials behind a functional barrier).

A further challenge today in the use of recycled materials lies in the fact that not all suppliers of such materials are capable of guaranteeing supply in sufficient amounts and consistent technical quality. For this reason, sourcing options are to be researched and evaluated.

Another aspect concerning sourcing of recycled materials is the fact that the positive impacts of their use with respect to attempts to close materials cycles occur in particular when post-consumer material is used again (in this context, 'consumer' also includes commercial/industrial end consumers). Thus, precursor materials of this type are to be given priority in sourcing, and it makes sense to ask for evidence that the material actually comes from such sources. When the strategy element 'sustainable sourcing' is applied, additional aspects are also reviewed, and it makes sense to translate them into requirements relating to sourcing of recycled materials, too.

The key review questions from the checklist for this optimisation approach 3 are summarised as follows:

Question	Instructions	Result
Can the functional requirements of the packaging also be fulfilled with recycled materials?	If **YES**: document the result and continue. If **NO**: potentially discontinue reviewing this approach.	[Please fill in]
Are modifications of packaging design necessary?	If **YES**: make any necessary adjustments and document them. If **NO**: document the result and continue.	[Please fill in]
Are there any legal requirements that have to be observed when using recycled materials?	If **YES**: document the result and continue. If **NO**: make any necessary adjustments and document them.	[Please fill in]
Can sufficient supply of recycled materials in the defined quality be guaranteed?	If **YES**: document the result and continue. If **NO**: as appropriate, agree on proof of relevant quality and origin, and document the results.	[Please fill in]

The result of reviewing this optimisation approach includes one or potentially multiple packaging solutions which have been reviewed and potentially modified (also) with respect to using recycled materials, as input for the further optimisation approaches.

Approach 4: Review of Opportunities to Use Bio-based Materials

Bio-based plastics contribute only to a very small extent, if at all, to the utilisation of non-renewable fossil resources. For this reason, it makes sense to review their use in the context of this strategy element. However, it must be taken into account that the bio-based materials are supposed to replace primary materials only and not recycled materials, which after all also reduce the burden on the non-renewable fossil resources.

It should also be noted that it is often assumed that bio-based plastics have a significantly lower CO_2 footprint than plastics on the basis of fossil raw materials (or even that they are CO_2 neutral). This is true only to a very limited extent. In fact, bio-based materials also carry CO_2 burdens because of the necessary agricultural processes. The CO_2 burden becomes considerably more relevant if impacts of land-use change are to be taken into account. If the plant-based raw materials are produced on land that was previously very biologically active and that accordingly fixed large amounts of CO_2, as is the case in particular for tropical rainforests, the bio-based materials produced on these lands may even carry a higher CO_2 burden than the fossil-based materials, depending on the method for accounting for the fixing

of CO_2 which is no longer taking place. These impacts, which are relevant from the perspective of climate change mitigation, must therefore be reviewed carefully. Unfortunately, many of the simple LCA tools do not provide for sufficient transparency about the specific way in which CO_2 values are calculated.

From a technical point of view, a distinction should be made between 'classic' polymers whose synthesis relies on bio-based precursor materials and biopolymers. The former, also called bio-based polymers, generally have the same technical characteristics as material produced entirely from fossil precursor materials. Biopolymers, in contrast, usually have characteristics of their own which differ from those of classic polymers. In addition, these (technical) characteristics may display greater variability, depending on the quality of the biologically produced precursor materials. In each case of packaging design, both of these aspects are to be reviewed and taken into account in comparison with the relevant requirements.

Particularly in the upstream agricultural chain, producing bio-based plastics generally involves completely different impacts on resources and the environment (e.g. land use, water consumption, pesticide pollution or loss of biodiversity) as well as possible conflicts around land use (e.g. competition with food production) than does the production of fossil-based materials. These potential negative aspects are to be taken into account, and it makes sense to minimise them through a responsible sourcing policy. The strategy element 'sustainable sourcing' includes further review questions and possible solutions concerning this matter.

The key review questions from the checklist for this optimisation approach 4 are summarised as follows:

Question	Instructions	Result
Can bio-based plastics be used in place of fossil-based plastics?	If **YES**: document the result and continue. If **NO**: continue.	[Please fill in]
Are modifications of packaging design necessary?	If **YES**: conduct potentially necessary adjustments and document them. If **NO**: document the result and continue.	[Please fill in]
Are there suppliers who can deliver sufficient amounts of the required precursor material (in the required quality)?	If **YES**: document and continue. If **NO**: document the reason (result of the review) and discontinue reviewing this approach.	[Please fill in]
Was the upstream chain of the production of bio-based polymers taken into account in terms of environmental aspects?	If **YES**: document the result and continue. If **NO**: apply the checklist on the *strategy element 'sustainable sourcing'*.	[Please fill in]

The result of reviewing this optimisation approach includes one or potentially multiple packaging solutions which have been reviewed and potentially modified (also) with respect to using bio-based materials.