Purchasing products containing recycled materials: what is the relevance in terms of environmental impact?

Increasing flows of recycled materials and regulatory incentives are driving manufacturers to incorporate recycled materials into their products. At first glance, recycling would seem to offer only environmental benefits: by transforming waste into resources, it reduces the pollution caused by the latter, and saves materials by reducing the pressure on those that are non-renewable or only marginally renewable.

However, this project was prompted by the realization that recycled content alone is not sufficient to assess the environmental performance of a product incorporating recycled content. As a matter of fact, the environmental added value of integrating recycled materials depends on numerous technical and economic parameters, linked to both the recycled material and the product integrating this material. These parameters relate to the following characteristics: recycling techniques used, more or less complex and profitable, quality of materials used for recycling and of those obtained from the process, logistics associated with collection and transformation.

The aim of this study, focusing on **plastics, concrete, steel and hollow glass**, is to provide tools to guide manufacturers and purchasers of products incorporating recycled materials, in **identifying the criteria likely to lead to a greater environmental impact than a product made from 100% virgin materials**.

These tools have been developed along two lines:

1. An initial methodological approach involving analysis of how recycling is taken into account in current standards and regulatory frameworks,
2. A sector-based approach to characterize the various target markets.

A / Methodological approach

As part of the methodological approach, 3 LCA modelling approaches were analysed and evaluated:

- **The Cut-off approach:**
    - Encourages the use of recycled materials provided that recycling has less environmental impact than the production of virgin materials (EV > ERec);
    - Provides an incentive to recycle a product after it has been used when processing has a positive impact and is therefore a burden on the environment (ET > 0),
    - A weak incentive to recycle when ET is low or when the overall environmental gain from recycling (EV + ET < ERec) is low,
    - No incentive to recycle after use, when waste treatment leads to an environmental benefit.

  This approach is also easy for users to implement. The data to be used is directly available in databases such as ecoinvent. However, it does not take into account certain environmental characteristics of the system, such as the availability or quality of the recycled material. Finally, there are limits to its relevance to decision-makers.

- **The Cut-off with Credits approach:**
    - Provides a moderate incentive to use recycled materials, not penalising those that incorporate a lot of recycled material without making any available at the end of life,
    - Provides a strong incentive to recycle a product, by attributing benefits to products that make materials available for recycling at the end of their life.

  However, this approach is more complicated to implement than the cut-off approach. In particular, there are more parameters to define and data to mobilise, and there is a risk of double counting. Unlike the cut-off approach, this approach takes account of the impact on quality of the degradation of recycled material. As with the cut-off approach, there are limits to its relevance to decision-makers.

- **The CFF method:**
  - Encourages the use of recycled material if the A factor is high (0.8) and the provision of material for recycling if the A factor is low (0.2).
  - Encourages the preservation of the quality of the material used and recycled and the optimisation of the use of the material according to its level of quality.

  However, of the three methodological approaches studied, the CFF is the most complex to implement. It requires more parameters to be determined and a larger amount of data to be mobilised. Nevertheless, this method takes into account more environmental characteristics, such as material quality and availability. It is also the most accurate in terms of relevance to decision-makers, thanks to the fact that it takes account of economic and political realities in the distribution of impacts.

A comparative analysis of **7 labels and certifications** of interest was then carried out, in relation to the materials of interest in the study. These could indicate to the buyer that the product contains recycled materials, in what proportions, with a possible life cycle approach. In particular, the aim was to assess the level of consistency of these labels with LCA methodologies and to provide food for thought on the need to quantify impacts and the risks of potential impact transfers.

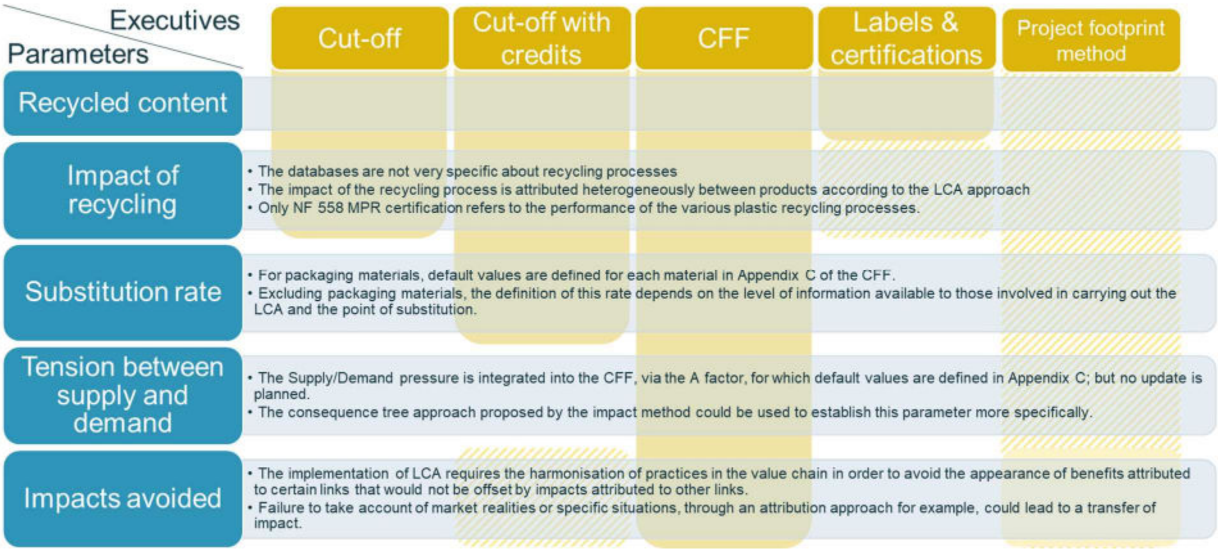
- Some labels, such as **Nordic Swan and Blue Angel**, are oriented towards finished products and consumers and cover the materials of interest in the study. They refer to the ISO 14024 standard for the development of environmental labelling programmes. They require the incorporation of a minimum percentage of recycled materials,
- In the construction and public works sector, two private labels - **CSC and 2EC** - involve either means-based obligations, with a forecast diagnosis of waste and traceability obligations, and the promotion of re-use, or results-based obligations, with the incorporation of a minimum % of recycled material,
- For plastics, the **RecyClass and NF 558 MPR certifications** refer to standards NF EN 15343 (traceability of plastics recycling and assessment of compliance and recycled product content) and NF EN 15347 (characterisation of plastics waste) and involve obligations of means, with the need for waste to be compatible with the recycling process, traceability and validation of this process, and obligations to achieve results, with verification of the % of RPM content, and even precise criteria for certifying the quality of products made from RPM. **NF558 RPM certification is the only certification found that refers to the performance of the various recycling processes**,

No such relevant label or certification could be found for steel and glass. The study proposes 3 grids for assessing the robustness of labels and certifications, from the point of view of their operation and their consideration of the most relevant environmental criteria according to the material they promote. Nevertheless, the exploration of labels and certifications showed that beyond the rate of incorporation, little information was traced back to the finished product to provide users with guarantees about the environmental performance of a product incorporating recycled materials.

The approach advocated by the **project footprint method**, for the construction of a consequence tree, makes it possible to address the consequential and complex issues of the subject in a more specific way than is currently possible with LCA approaches, which are very costly in terms of data. However, the parameters used by the CFF approach seem to be recommended up to level 3.

Conclusions of the methodological approach:

Our analysis of LCA methodologies, labels and the project footprint methodology has enabled us to identify the main criteria influencing the environmental performance of products containing recycled materials. They are presented in the figure below in order of importance:



- The databases are not very specific about recycling processes
- The impact of the recycling process is attributed heterogeneously between products according to the LCA approach
- Only NF 558 MPR certification refers to the performance of the various plastic recycling processes.

- For packaging materials, default values are defined for each material in Appendix C of the CFF.
- Excluding packaging materials, the definition of this rate depends on the level of information available to those involved in carrying out the LCA and the point of substitution.

- The Supply/Demand pressure is integrated into the CFF, via the A factor, for which default values are defined in Appendix C; but no update is planned.
- The consequence tree approach proposed by the impact method could be used to establish this parameter more specifically.

- The implementation of LCA requires the harmonisation of practices in the value chain in order to avoid the appearance of benefits attributed to certain links that would not be offset by impacts attributed to other links.
- Failure to take account of market realities or specific situations, through an attribution approach for example, could lead to a transfer of impact.

The rate of recycled material is a parameter commonly used in LCA approaches and labels, but it does not guarantee a product's better environmental performance. **The impact of recycling** includes the pre-treatment, transport and recycling stages until a secondary material is obtained, and can vary depending on the materials, collection channels and recycling processes. Assessing the impact of recycling can influence the interest in incorporating recycled materials. **The substitution rate** is a parameter that takes into account the material replaced in the Cut-off with credits and CFF approaches. In the Cut-off with credit method, the QR parameter reflects the functional equivalence of performance, while in the CFF method, three parameters (Q_p, Q_sin and Q_sout) are used to establish the impact of incorporating a recycled material and the impact of a recycled material. However, the definition of these parameters may be limited by the level of information available and the difficulty of defining quality objectively. **The tension between supply and demand** is explicitly integrated into the CFF via the A factor, but the market for recycled materials is highly volatile and the relevance of this parameter is weakened by the absence of an updating procedure. **Avoided impacts** include the impacts avoided by the production of virgin materials and the impacts avoided by not treating recycled materials at the end of their life, but their implementation in LCA methods requires practices in the value chain to be harmonised and market realities to be taken into account in order to avoid impact transfers.

The study shows that the choice of recycling modelling methodology can influence the final LCA results, as illustrated by the example of a drinks manufacturer wishing to include recycled PET in its packaging presented in Appendix 6.

B/ Sectoral Approach

Before looking at the use of recycled materials and recycling itself, it is important to have a good understanding of the flow of materials in the waste state, as well as their potential destination.

				
Waste deposits	Mainly selective collections	Principalement collectes sélectives (80%)	Mainly industrial	Mainly construction and public works industry (90 to 95% reuse on site or as landfill)
Collection	1 428 kt	13 558 kt	2 310 kt	153 Mt
Imports	161 kt	1 819 kt	144 kt	
Recyclability	44% effectively recycled	46% effectively recycled	94 % effectively recycled	22% potentially recyclable
Supply/ Demand	Varies according to sector	Demand > Supply	Demand >> Supply	Demand >> Supply

As part of the **sectoral approach**, an in-depth analysis of the recycling channels in the target markets was carried out, including interviews with professionals in the sector, in order to characterise the issues involved.

Plastics are numerous and immiscible, making them complex to collect and recycle. They physically degrade over time and lose around 10% of their mechanical properties during processing, limiting their incorporation into recycled products. According to ADEME's national recycling report for 2019, 1,428 tonnes of plastics were collected, but only 622 tonnes were recycled, giving a sector efficiency rate of 43% for collected materials and 61% for sorted materials. The efficiency rates are relatively low because of the lower quality of household waste and the complexity associated with the multiplicity of plastics.

Metals, such as steel, are easier to manage as waste thanks to their massification near processing sites and their short processing circuits. They can be alloyed and homogenised, but are generally not charged. Metals do not physically degrade during processing, so they can be used indiscriminately in recycled or unrecycled form. For steel, 2,310 tonnes were collected and 2,162 tonnes were recycled, giving an efficiency rate of 94%. This high rate can be explained by the good quality of the deposit, which remains largely of industrial origin.

Glass is a concentrated source, with two main sources: households and the construction industry. It is relatively homogeneous in terms of composition, but the different colours require sorting. Glass does not degrade physically during processing, which means that it can be used indiscriminately, whether recycled or not, and indefinitely. For glass, 13,558 tonnes were collected, but only 6,236 tonnes were recycled, giving an efficiency rate of 46%. This relatively low rate can be explained by the lower quality of the source material, which is largely of household origin, and by the multiplicity of colours.

The main source of **concrete** waste comes from the building and public works sector, representing around 20 million tonnes of waste. Standards categorise construction materials into different families, which are more or less mixed together in mineral waste. These include concrete waste, concrete products, mortars, concrete masonry units, mixed materials and earth and stones. As far as concrete is concerned, around 228 million tonnes of waste are produced every year in France by the construction and public works industry. Recyclability rates vary according to waste category: 60% for concrete, 30% for mixes and 75% for gravel and rock materials. However, the overall available source of concrete is limited to around 25 million tonnes per year in France, and the theoretical substitution rate would be 22%.

Point of attention: At European level, there are differences in the methods used to calculate the recycling rate, which can lead to biases in comparisons between countries. These differences may relate to the exclusion of production off-cuts in the definition of recycling, the point at which waste is counted as recyclable material, and the method used for surveying stakeholders. To avoid these biases, it is preferable to use French figures, which are subject to rigorous and harmonised verification, as European figures are less available.

Demand for secondary materials for different materials has generally been higher than supply, depending on the economic climate. While this is positive from an economic point of view, it is unsatisfactory from a technical and environmental point of view. At European level, the rate of circularity in the use of materials has risen steadily, mainly due to a reduction in the consumption of materials, while the recycling rate has remained stable at 7%. Actual demand is assessed via purchases, while potential demand is assessed on the basis of optimal incorporation rates. It is also relevant to distinguish between gross demand linked to markets, influenced by economic activities, and specific demand linked to incorporation rates. Finally, potential demand values for each product identified can be obtained by applying the maximum incorporation threshold for the material to its level of production in France. The sum of these values will give the potential demand in France for each recycled material, which can be used as a long-term target.

For plastics, demand and price are influenced by the price of oil. The gap between supply and demand varies between application sectors, with the packaging sector in the lead. Better communication could stimulate demand.

For steel, the high energy consumption of recycling makes energy prices a key factor. When energy prices are high, demand for recycled materials is strong, which can lead to imports.

For glass, the high energy consumption of recycling also means that the price of energy is an important factor. Demand is relatively strong, but depends on certain markets such as construction and beverages, and is limited to a certain proximity to processing centres due to the weight of packaging.

The concrete industry is still at an early stage of development, making it difficult to analyse demand.

Imported secondary materials can have a greater environmental impact due to transport and inferior quality. At European level, imports have increased in recent years to meet demand, reaching around 45 million tonnes a year, or 8% of total consumption. Imports of ferrous metals (steel) have risen sharply, while those of glass and plastics have remained relatively stable. France exported 12 million tonnes of recycling raw materials or recoverable waste in 2021 and imported 3.3 million tonnes, with a downward trend in imports.

To gain a better understanding of recycling processes, it is useful to describe them for different materials and according to different criteria, such as the accessibility of the recycled material, the main stages and the point of substitution, as well as logistical aspects. **The accessibility of the recycled material** is an important factor for recycling chains, as it can have an environmental and economic impact. Plastics have limited accessibility due to the selective collection of household waste and their quality. Recycled steel is limited by the immobilisation of part of the deposit in long-life applications and by the quality of household waste. Recycled glass is mainly produced from household packaging waste, but accessibility is limited by the poor performance of the selective collection system. Recycled concrete is produced mainly on recycling platforms from inert materials from deconstruction sites, but waste flows are unevenly distributed across the country. **The main stages in the recycling process** are sorting at source and in sorting centres, transformation by crushing and washing, and granulation by extrusion for plastics; melting and moulding or extrusion for metals and glass; and controlled dismantling and selective sorting, followed by a series of sorting, cleaning and crushing operations for concrete.

The logistical aspects of recycling channels can represent a significant element of their environmental footprint. Short routes with limited transport are preferable. Plastic and glass recycling processes generally involve several separate sites, while steel and concrete recycling processes often take place at the final processing site due to the density of the material.

We have thus been able to highlight their main impacts:

- Climate change: energy, transport,
- Toxicity and ecotoxicity: additives and hazardous substances,
- Water resources: washing, screening with water,
- Mineral and metal resources: substitution rate, filler addition.

As well as the challenges at each stage of the process:

- Collection: very low visibility // low issues,
- Treatment: low visibility // high issues,
- Transformation: good visibility // moderate issues,
- Integration: very good visibility // high issues.
- And the efficiency of these channels:
  - Origin of waste (sorting at source),
  - Number of sites involved (transport),
  - Share of imports (transport, quality, process efficiency).

Point of attention: **Physico-chemical recycling** is an alternative to mechanical recycling of waste materials. These processes are characterised by very low degradation of the molecules, enabling the materials to retain their technical properties. Physico-chemical processes include dissolution, depolymerisation, gasification and so on. From an environmental point of view, they are potentially more attractive than mechanical recycling, particularly in terms of low microstructural degradation, low consumption of additional fillers, economies of scale and simplicity of processing on the same site. However, they involve more production stages and still lack generic and specific data. These processes are not covered in this study.

Finally, these elements lead us to identify the main technical (and economic) criteria to be considered when choosing a recycled material or a product made from recycled material. **Criteria relating to the material** include melting temperature, density and weight, and physico-chemical degradability. The melting temperature determines the energy consumption required for each processing operation, while density and weight influence energy consumption from waste collection through to product processing and the supply chain. Physico-chemical degradability is important because it can lead to a loss of properties that must be compensated for, and limits the proportion of recycled material in a product. **Criteria relating to the supply chain** include sorting performance, energy efficiency, logistical efficiency and the proportion imported. Sorting performance is essential for acceptance by the processing industry and for limiting environmental impacts. Energy efficiency and logistical efficiency improve the sector's performance in competition with the use of virgin materials. The imported proportion can introduce additional impacts due to logistical efficiency and a risk of lower quality leading to processing problems. **Criteria relating to the product** include the rate of incorporation, demand satisfaction and value regression. The rate of incorporation of recycled material into the product is important because there is an effect of scale when the resources of the recycling chain are involved. Satisfying the demand for recycled material is an economic criterion that can be taken into account depending on the method used. The increase in the use value of the product incorporating the recycled material can also be used as a criterion, with a preference for a moderate decrease.

Conclusions of the sectoral approach

In conclusion, a good understanding of recycling processes is essential for assessing their environmental and economic impact. The accessibility of the recycled material, the main stages and the point of substitution, as well as logistical aspects, are important criteria to take into account in order to optimise recycling processes.

Based on this knowledge, optimum incorporation thresholds have been established according to technical and economic factors. The general principle of the methodology used is to take the main technical and economic constraints and try to translate them into either a 'floor' or 'ceiling' incorporation threshold for the various materials. Depending on the sensitivity of the criteria corresponding to the materials considered, a certain variability of thresholds was then established. This makes it possible to put these thresholds into perspective, depending on the context and, in particular, the materials. To get a more precise idea of these thresholds for each material, it was then possible to establish a range with an appropriate variability. The principle is, of course, to be conservative, retaining the most restrictive values as well as an average value for the variability.

Summary of incorporation rates	**Technical factors**	**Economic factors**	**Recommended thresholds**	
			Range	**FR Reality**
Plastics	Loss of mechanical or visual properties **(Max = 30%)**	Quality local availability	**Target. 30%** **Floor. 20%**	**0% - 80% [average 20%]**
	Multiple sources of waste	Long-term storage of waste **(min. 20%)**		
	Complexity of certain processes **(min. 20%)**	Depreciation of tangible fixed assets **(min. 20%)**		
Metals (steel)	Quality of supplied flows due to a lack of sorting before the process	Local availability of quality (Max = 50%)	**Target. 50%** **Floor. 20%**	**0% - 100% [average 47%]**
	Higher efficiency from a certain proportion recycled	Depreciation of tangible fixed assets **(min. 20%)**		
Hollow glass	Quality of supplied flows due to lack of sorting before the process	Local availability of quality (Max = 60%)	**Target. 60%** **Floor. 30%**	**0% - 100% [average 61%]**
	Addition of additives to white glass for coloured packaging	Depreciation of tangible fixed assets **(min. 30%)**		
Concrete	Potential loss of mechanical properties **(Max = 60% (Type 1) and 25% (Type 2))**		**Target 60% (T1) 25% (T2)**	**0 - 100% [avg. 10%]**

Recommendations

Following these two major analyses and approaches, a grid has been drawn up and proposed to guide manufacturers or purchasers of products incorporating recycled materials in their diagnosis.

It includes concrete criteria that can be easily adapted and quantified by manufacturers operating in a wide range of sectors. Until now, the data available in the literature did not allow for this, as the methodological and sectoral approaches each developed an expert vision, and did not take into account other, more qualitative criteria. This tool makes it possible to cross-reference non-LCA data, such as technical data on recycling processes, which can have a significant impact on the environment, and market data, which can also influence the choices made by manufacturers.

The grid is based on a set of economic, technical and environmental criteria relating to the purchase or otherwise of recycled products common to: 1/ one material, and therefore to all possible applications of that material; 2/ all 4 materials selected.

The two methodological and sectoral approaches were also levelled, by cross-referencing the methodological evaluation grid, the criteria derived from non-LCA methods (labels, project footprint) and the technical and economic criteria that could influence the environmental performance of recycling. The key criteria were then assembled by major theme and strengthened.

Adaptations were made to establish a generic grid covering all materials, as well as variations of this grid by material (specific grids). At the same time, these specific grids have been tested through case studies in various business sectors.

The generic grid is as follows:

Key parameters influencing environmental performance	Technical and economic criteria to consider	Plastic	Glass	Steel	Concrete
1 Percentage of recycled material incorporated	**1.1 Minimum and target/maximum incorporation rates by material**	✓	✓	✓	✓
2.Impact of the recycling process: process and logistics	**2.1 Recycling process**	✓			✓
	2.2 Thermal properties	✓		✓	
	2.3 Waste quality (type and origin)	✓	✓	✓	
	2.4 Geographical origin of secondary materials	✓	✓	✓	✓
	2.5 Supply chain (number of sites involved)	✓	✓	✓	✓
	2.6 Adding loads (modification)	✓			
	2.7 Adding value to co-products	✓	✓	✓	✓
3.Raw material substitution rate and secondary material quality	**3.1 Geographical origin of secondary materials**	✓	✓	✓	✓
	3.2 Steps prior to processing (homogenisation)	✓		✓	
	3.3 Storage life of the material	✓			
	3.4 Quality of recycled material	✓	✓	✓	✓
4.Supply/demand ratio	**4.1 Determining factor (supply or demand)**	✓	✓	✓	✓
	4.2 Recycled to virgin price ratio	✓	✓	✓	✓
	4.3 Storage life of the material	✓			
5.Avoided impacts	**5.1 Virgin/recycled impact ratio**	✓	✓	✓	✓
	5.2 Recycling for re-use	✓	✓	✓	✓
	5.3 Energy recovery by incineration	✓			
6.Influence of the following product design	6.1 New process (investment)	✓			
	6.2 Adding loads	✓		✓	✓
	6.3 Use of hazardous substances	✓			

Based on 6 parameters divided into 1 to 7 criteria, the user can identify the criteria that are most likely to reduce the environmental impact of a product and those that are most likely to have the same or a greater impact than a product made from 100% virgin materials. The key data to be tracked is quickly identified, as are the levers for eco-design and responsible sourcing.

The percentage of recycled material incorporated into a product can give a general indication, with a favourable range defined by a minimum and maximum threshold. **Recycling processes and logistics** are also important, including the number of stages and processes carried out, the thermal properties of the materials, the quality of the waste, the geographical origin of the secondary material, the logistics chain and the addition of fillers. **The substitution rate and the quality of the material** are also key factors, in particular the geographical origin, the pre-processing stage, the length of time the material is stored and the quality of the recycled material. **The relationship between supply and demand** for recycled materials is also important, in particular the determining factor, the recycled/raw price ratio and the length of time the material is stored. **The impacts avoided by the use of recycled materials** must also be taken into account, in particular the ratio of the impact of virgin material to that of recycled material, recovery through reuse and energy recovery through incineration. Finally, **the influence on the design of the next product** is a criterion to be considered, in particular the use of new processes, the addition of fillers and the use of hazardous substances at the end of life.

If all the criteria are favourable, then the manufacturer or purchaser should target an ambitious incorporation rate. If one or more of the criteria are unfavourable, in-depth LCA-type analyses are recommended. If the approach is adopted, it will enable a more detailed analysis to be carried out and updated in line with the rapidly evolving state of knowledge.

Main conclusions of the study

From the point of view of LCA approaches, the Cut-off method, the Cut-off method with credit, and the Circular Footprint Formula (CFF) present convergences and divergences, but tend towards greater complexity by integrating more parameters along the value chain.

A study of the labels reveals a lack of information on the environmental performance of finished products containing recycled materials. The project footprint approach is suggested as a way of tackling this complex subject in a more specific way than LCAs, by taking into account consequential scenarios while mobilising less data than a full LCA study.

For a material to be considered recyclable, it must be processed through organised collection channels, be technically extractable, and have a market for the recycled material. Environmental performance depends on a number of technical and economic criteria specific to materials, sectors and products.

Finally, an evaluation grid is proposed to guide manufacturers and purchasers in their diagnosis. This grid, based on 6 parameters and up to 7 criteria, makes it possible to identify the factors that favour a reduction in environmental impact and those that could lead to an impact equivalent to or greater than that of a product made from 100% virgin materials. This grid provides a basis for integrating the complexity highlighted in the study, and could be refined and updated as knowledge develops.