TECHNICAL HANDOUT

Interpretation aid and recommendations for application of EU-WFD terminology

prepared by:

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intecus
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CO_2	Carbon dioxide
COM (2007) 59 final	Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products
Directive 2006/12/EC	Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste
Directive 2009/28/EC	Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC
Directive (EU) 2015/1513	Directive (EU) 2015/1513 of the European Parliament and of the Council of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources
EBRD	European Bank for Reconstruction and Development
EoW	End of waste
EU	European Union
EWC	European Waste Catalogue = European List of Waste (Commission Decision 2000/532/EC – consolidated version)
FGD	Flue-gas desulfurization
GHG	Greenhouse gas
PET	Polyethylene terephthalate
PP	Polypropylene
REACH	European Union regulation for the registration, evaluation, authorisation and restriction of chemicals = Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
WFD	Waste Framework Directive = Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

1 Introduction

1.1 Rationale for this paper

Carrying out an effective environmental protection requires to be clear and concrete about from where dangers for nature, human health and the cleanliness of air and water emanate and how these can be mitigated. Waste is undoubtedly a potential source of danger and massive burden for the environment. To have those burdens minimized and the yet generated portions of waste properly handled mark active steps in environmental protection. Clarity at first is generated by means of definitions.

Having a clear definition when things become waste is as much important as is the possibility to differentiate under which circumstances this predicate can be dispensed due to the rather low risk potential of a waste-like item, or when an environmentally benign use is made of a waste. Objects or substances defined as waste can be adequately controlled, actions can be steered along defined directions in order to become environmentally sensible processes.

The Ministry of Environment and Urbanization is the highest authority in Turkey for environmental protection matters. In this function it is also responsible for developing political strategies and draft waste management legislation as well as monitoring and enforcing the implementation of laws and regulations in the country. The EU's approach is recognized as guiding the way here. It is therefore extremely important to understand the EU waste policy and legislation well in all aspects, to achieve their correct interpretation and be able to adopt the underlying principles to domestic conditions.

With the current zero-waste program of the Turkish government, the priorities of the European waste hierarchy and concepts for more circularity are gaining in importance and attention. This also increases the need for good understanding, appropriate interpretation and communication. The ministry is already working with the EBRD to raise awareness for the end-of-waste (EoW) issue. Complementary to that, this document deals with the topic of 'by-products' and in particular with the terms that characterize the circular economy concept as the core of the EU waste hierarchy.

1.2 Definition limits in the waste management field

The EU's acquis communautaire is a comprehensive body of legislation, legal acts, and court decisions which is making consistent definitions and interpretations for all the many fields of social and economic life a huge challenge.

Biomass, for example, is classified as products, co-product(s), wastes and residues within the Renewable Energy Directive (RED) (Directive 2009/28/EC) without a clear definition of how to distinguish between the different concepts.

In other legal binding documents, such as the Waste Framework Directive (Directive 2008/98/EC) (WFD), the terms waste and by-product are defined, whereas residue and co-product are not. According to the WFD, a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste but as being a by-product under specified conditions *(☞Art. 5.1 WFD)*.

According to the Directive (EU) 2015/1513 the term processing residue applies to any substance that is not the end product that a production process directly seeks to produce and not primary aim of the production process, and the process has not been deliberately modified to produce it.

It is acknowledged that terms are not necessarily right or wrong but rather more or less suitable for the different purposes and circumstances governed by the legal documents concerned. Legal acts are also reviewed along technical progress, court decisions and strategic considerations leading to amendments and refined wording, such as can be seen for the case of the waste hierarchy too.

Interpreting EU legislative terminology and the provisions associated with that will allow different methods to be applied in principle. This can be the interpretation according to the wording, an interpretation based on the will of the legislator, interpretations according to the embedding of the individual law provision in the overall context and the interpretation according to the meaning and purpose of the law provisions. Most of these different concepts are familiar from the national legal systems but the priority in adopted perspectives varies between countries and circumstances.

1.3 Terms and definitions to be looked at

This paper cannot anticipate the primary perspective of the authorities in Turkey nor assume specific circumstances for the application of provisions from EU legislation in the country. Basically, it is based on the intention to help understanding better the will of the legislator and to facilitate the interpretation according to the meaning and purpose of the law provisions and definitions provided for certain terminology.

In this document the focus was laid on the terms '***reuse***', '***preparation for reuse***', '***recycling***' and '***other recovery***' as a terminology that is widely applied in the context of the waste hierarchy. Also the hierarchy itself is briefly introduced and links with similar concepts or approaches existing or even incorporated to it are explained. This shall help in comprehending the larger framework under which the interpretation of the above terms is usually done and their discussion taking place at present.

To complement the work that is already carried out under another project in the Turkey on 'end-of-waste'[1], this paper also touches on the term '***by-product***' in order to provide further clarification on this definition issue. Principal references for the given terms are the WFD and various communications the European Commission has published in an effort to minimize uncertainties in the use of EU terminology (e.g. COM (2007) 59 final).

Examples referring to selected materials and the practice of managing them as part of non-hazardous waste streams shall give the explanations in this document a practical illustration and make them even more comprehensible for a wider range of users.

[1] Turkey - Catalysing Near Zero Waste Investments - End-of-Waste (EoW) Criteria and Streamlining Secondary Raw Material Concept in the Turkish Waste Legislation

2 Topics directly involved

2.1 The waste hierarchy

2.1.1 What does it represent

The waste hierarchy has been made the 'corner-stone of waste policies and legislation in the EU and provides the thus far leading principle for waste and recycling management in the Member States. This hierarchy has got global recognition and despite of being non-binding in nature, it has proven as being a good tool for guiding the transition from end-of-pipe to modern waste management.

A driving force in developing the hierarchy was to shift the focus from just safe disposal (the 'end-of-pipe'-approach) to a practice of managing the waste problem with the minimum damage to health and the environment, loss in value and with recycling as principal milestone.

The terms 're-use', 'recovery' and 'recycling' are symbolic for this new paradigm and closely associated with the concept of the waste hierarchy in that they depict the different levels of management interventions and a hierarchical order by which these should be carried out.

2.1.2 Why are changes imposed to it

The most important modifications with respect to the waste hierarchy of Directive 2006/12/EC are that the previous hierarchy model, which basically contained prevention, recovery and disposal, has been expanded to five levels. '***Preparing for re-use***' was introduced and for '***recovery***' as more generic term the distinction made between '(material) ***recycling***' and '***other recovery*** options' so as to promote closed loop management and the so-called 'recycling society' as new concepts. Preparing for re-use tops the priority order of options for waste management followed by recycling which should be preferred before other forms of recovery. Whereas preparation for reuse, recycling and other recovery are roughly of equal importance in the first step away from the end-of-pipe concept, prioritizing these options is the basis for modern waste management visions.

Provisions in the WFD with regard to the waste hierarchy require that the treatment option for waste is chosen which best serves the protection of the environment and human health and that furthermore the choice is also subject to technical feasibility and economic reasonableness. Under this point of view, deviations from the hierarchy are possible and may also be necessary. Therefore, it cannot be stated in a universally valid manner that the level order of the hierarchy is a strictly fix and mandatory concept.

Still it remains criticised that the waste hierarchy is limited and even restrictive because it looks at things from a sole environmental standpoint. The vision is that it would as well take social, economic and logistic considerations more into account and strengthen the process of transition towards circularity stronger within society and on a local level.

Various organizations including EU expert panels already do contemplate and discuss about further possible modifications in the hierarchy. With the discussed modifications a further change in the mindset from waste management to resource management shall be promoted. Strong momentum for the discussion is received from the zero waste concepts and ideas underlying corresponding initiatives and movements. The waste hierarchy adjustments arising hereof are thought to introduce value preservation via designing waste out of the system as a new milestone.

2.2 Cascading use

The *cascading use* of materials is an emerging concept along the priority order of the waste hierarchy and forms one part of a broader suite of efforts contributing towards the resource efficiency agenda and to achieve circularity. Despite numerous attempts to define cascading use there is no consensus to date on how to draw system boundaries around this concept in order to separate it from other resource and waste management concepts such as the waste hierarchy. It seems clear, however, that the term cascading use refers to the sequential use of a material in various forms and applications.

Cascading therefore describes the efficient utilization of resources by using products, residues and the recycled matter of them in consecutive loops to extend total material availability within a given system. The terms product, co-product(s), residue and ***by-product(s)*** are frequently used in the context of cascading.

2.3 Material and waste flow perspective

2.3.1 Why it helps for a proper interpretation

The changing usage intentions and purposes to which a material is subject in the value chain or an economic system are primarily reasons for making terminological differences. Cascading and the differentiation in the categorization hereby adopted for a material can be best explained on the example of certain material flows.

Adopting a product or material focus can also prove useful for the proper interpretation of the terminology accompanying the waste hierarchy gradation and to understand certain deviations that are occasionally being made in applying this order in practice. Such deviations are considered acceptable for specific waste streams when life-cycle aspects let them appear justified. The WFD sets acting strictly within the priority order of the waste hierarchy equal to a practice which takes all impacts from waste generation and management adequately into account. Derogating from this priority order on the other hand constitutes an exception that shall be granted only where the environmental advantage can be shown on the basis of life cycle analysis for a waste stream.

For the purpose of this interpretation aid, a number of products becoming non-hazardous wastes at some point have been chosen along which the application of the waste hierarchy principles and differences of the propagated waste management measures and terminology will be illustrated and explained. As stated above, not all waste streams suit in the same way to deliver illustrative explanations for those subjects on which the focus for clarification is placed in this document.

Those products respectively non-hazardous wastes found suitable are accounted under the category building material/waste, packaging/waste and the category of items/wastes originating from household consumption (Table 1). They a further briefly characterized hereunder.

Table 1: Examples of materials to be looked at in more particular in this document

Product resp. waste stream	Examples selected for illustrative purposes
Building material/waste	• Bricks/roof tiles • Gypsum
Household items/waste	• Clothing/textiles
Packaging items/waste	• Bottles • Wood pallets

2.3.2 Building materials/waste

2.3.2.1 Bricks/roof tiles

Bricks and tiles baked from clayey loam traditionally form a material used in masonry work and for roof cladding and therefore can be found in old as well as in modern building structures. Where ever such structures are demolished or re-built, the question arises what to do with the used materials. Even starting a new construction with bricks and roof tiles normally results in unintended remains or cutting leftover, excess quantities or broken material, the same also happens in production. If no ways are sought or found to continue using or re-using these quantities directly, this turns into construction or production waste. The share bricks and roof tiles contribute to construction debris is considerable due to the popular and widespread use of the material. As it is the case for Germany, it is likely that also in Turkey this amounts to several million tons of non-hazardous waste material, grouped under the waste code 17 01, annually.

2.3.2.2 Gypsum

Gypsum supplies an important building material that is not only directly processed to structural elements but also used as a binder and additive in cement. In this way, very large quantities find their way into the building stock worldwide and remain there until they are released again as waste during construction and demolition works.

Waste from gypsum-based construction material is classified by the code 17 08 in the European Waste Catalogue (EWC). Gypsum waste classified by the code 17 08 02 as non-contaminated by hazardous substances primarily consists of waste from gypsum boards, which are wall or ceiling panels made of a gypsum core between paper lining (also referred to as plasterboards, drywall or wallboards). Also gypsum blocks and plaster can be found in this waste stream. In Europe it is increasingly practiced to ban the dumping of gypsum given its tendency to produce large volumes of hydrogen sulfide gas and also climate damaging methane when placed into landfills.

2.3.3 Household items/waste

2.3.3.1 Clothing/textiles

Clothing is one of the basic needs of people, serves to protect them and at the same time as an expression of their personality. Chemical fibres are now the most common materials, followed by cotton for the production of textiles and clothing. The global production volume of fibres for clothing alone is over 70 million tons per year. According to the World Bank, Turkey is one of the top ten countries in the production of clothing. The process is characterized by high water consumption and the use of many chemicals. The amount of chemicals used often exceeds the product weight by many times. Despite high exports, considerable amounts of textiles also remain for use in Turkey. According to a study commissioned by Labfresh *(☞ABCD, 2018)*, the per capita amount of textile waste in Central European countries is between 3 - 15 kg per year.

In addition to the very diverse ways how households deal with used and worn-out clothing, there often exist various offers for their collection also. By way of these arrangements other possible uses are facilitated, and some of these services are even geared towards a special type of further utilisation. However, used clothing and old textiles are present in all disposal pathways yet and thus provide a good reference to draw up distinctions when the order of the waste hierarchy is applied on this product stream.

2.3.4 Packaging items/waste

2.3.4.1 Beverage bottles

Beverage bottles are packaging and belong to packaging waste once the consumer decided to discard them. Bottles alone do not form a waste stream of their own and therefore no separate waste code has been created for them. Most common are bottles made from glass and such made from plastics, mainly PET or PP. Beverage bottles made from glass and from plastics are both abundantly present in the Turkish market. When disposed via a packaging waste collection scheme, the waste codes 15 01 02 (plastics), 15 01 07 (glass) or 15 01 06 (mixed) may be applied.

Various arrangements are known to get used bottles collected. These range from a separate collection via systems differentiating between the material type (glass collection, plastics bottle collection) to schemes for mixed packaging where the bottles made from plastic are collected with consumer packaging made from other materials. Bottle take-back under a voluntary scheme or extended producer responsibility concept is another widely exercised arrangement and such is often coupled with a deposit-return concept.

2.3.4.2 Wood pallets

Wood pallets do not also form a waste stream of their own though practically they are handled like one in Europe. This follows from the way how usage is made of these items. Usually they are representing transportation aids (transport packaging) which remain in the possession of the shipper or sender once the transported cargo or good has been unloaded and unpacked at the destination. Taking back an emptied pallet in exchange for one that is still stocked with cargo as well as realizing a deposit enables this (and the direct reuse) in a practical way.

Firms who act as owner or dealer of pallets normally give an effort to keep them in a state which allows multiple usage cycles. Pallets therefore are looked at as reusable multi-way or returnable packaging. The individual size of a pallet and applied practice of usage explain that there is no regular arrangement or dedicated system foreseen thru which pallets are separately collected when becoming waste. Wood as the material they are made from basically determines that for disposal they are dealt with like wooden waste from construction activities (17 02 01), packaging material (15 01 03) or a bulky wood fraction of commercial origin (20 01 38 / 20 03 07).

For managing used pallets along the options of the waste hierarchy is of relevance whether chemicals or just a heat treatment have been applied as a wood preserving measure during the production of the pallet. An international coding stamped on each single pallet shows this.

2.4 Term and concept of ‘reuse’

Topping the waste hierarchy is the principle that an item not having lost its functionality and/or use value and therefore being a yet “underutilised” asset of our economy should not be destined to enter the waste regime. The objective to keep things staying in a non-waste status requires the effort to explore ways for used items to go back in the economy and provide the market which prevents them from being discarded.

Reuse reproduces this effort as an act of preventing an object to become waste and therewith saving the resources that would otherwise be needed to have this object replaced. As it prevents waste to arise, it is not a waste management operation but an *‘operation by which products or components that are not waste are used again for the same purpose for which they were conceived*‘ (art. 3(13) WFD). Where an item, e.g. used piece of clothing, is taken over directly from the current owner with the intention of reusing it for the same purpose, this comprises evidence that this item is not waste yet.

2.5 Term and concept of 'preparation for reuse'

Objects may lose their functionality or value for reuse, criteria that also render them to be waste. Then a reuse may be hampered or practically impossible if no further actions are undertaken to return them in a usable state (e.g. repair clothing before wearing/washing of bottles before refilling). Reuse only becomes feasible here after a "preparation for reuse" has been carried out.

This process constitutes waste treatment and therefore is to be distinguished from the 'reuse' of items that never became waste. A corresponding treatment in the sense of the WFD definition reproduces the efforts to clean, repair and refurbish items that have become waste in order for them to become products again.

'Preparation for reuse' as defined by the WFD is a measure enabling further utilisation without any other pre-processing. However, only when the preparation for reuse has been completed, i.e. the item has been repaired and its functionality checked, an 'End of waste'-status has been reached again. Preparing the reuse of products that have become waste basically comprises three actions which may be individually or consecutively applied; *i.* testing the functionality, *ii.* cleaning and *iii.* repair (replacing defective or worn parts with new parts or repairing and then reusing them). Even if a product is to be treated as waste, its components can remain non-waste and can thus be reused (e.g. salvage of spare parts).

2.6 Term and concept of 'recycling'

Part of the EU's switch to a waste hierarchy with five stages has been to introduce a differentiated perspective (or ranking) for recovery by distinguishing recycling that must be geared to keep the value of materials, and other recovery options which are of subordinate preference.

The general idea behind recycling is that waste material is processed in order to alter its physico-chemical properties allowing it to be used for the same or other applications again. In particular however it comprises the activities to retain materials in sustainable resource management, namely to reprocess the separately collected waste into high quality secondary raw materials. Recycling may therefore include any physical, chemical or biological treatment leading to a processed material which is no longer a waste.

The WFD does not require any particular characterisation of the processing or reprocessing activity, as long as it serves the objective of generating a material which is used in the original purposes or closing the economic material circle. Material recovery and biological treatment operations on mixed waste as the new EU waste legislation demands it even in systems with high separate collection rates provide a further way to preserve the value of resources whilst minimizing disposal. A process like anaerobic digestion which results in the production of biogas (with multiple usage options) and a digestate (turned into a high-quality compost product afterwards) are consequently regarded by EU waste legislation as recycling operations.

Processing of waste which still results in a waste which subsequently undergoes other recovery steps would not be considered recycling, but pre-treatment prior to further recovery.

2.7 Term and concept of 'other recovery'

Adjusting the waste hierarchy's mid-level by introducing this term sought to acknowledge that there can be hindrances for waste to be recycled although a meaningful utilization of the material value could still be possible. Recycling may be obstructed due to the design, i.e. the composition of the products that have become waste, and the complexity or harmfulness of the materials involved. Whilst the possible presence of harmful substances is increasingly tackled by bans and other regulatory instruments such as REACH, material complexity or excessive pollution of the

waste, applying in particular to packaging, are yet big issues. They can render recycling to not be feasible or reasonable as too many resources and energy would have to be used for cleaning and separating.

The WFD does not define 'other recovery' but counts under this any operation meeting the definition for 'recovery' but failing to comply with the specific requirements for preparation for reuse or for recycling. In particular energy recovery is considered a meaningful utilization of the non-recyclable material value and desirable step before pure incineration and landfilling as the two latter options eventually result in an avoidable higher underutilization of resources. The new technologies related to chemical recycling also fit in this category as long as they deal with the residues of sorting processes and not the clean source separated material, and transform used into new polymers or comparable raw materials for example.

2.8 Term and concept of 'by-product'

The fact that various circumstances can, by definition, justify the classification as waste leads to certain conflict situations in their determination. Anything that arises when manufacturing products but was not the actual goal of the production process can, for example, be classified as waste. This may create the conflict to differentiate between the substances or items that are by purpose integrated to the production process and thus are desired part of it, and other substances/items that are just created in the process.

An essential criterion in assessing what and what not really represents waste is whether it has been planned and desired before starting the production process that these substances or items should be created and subsequently used. Where a conscious action of the manufacturer or the specific conditions or processes in production caused their generation, and even where that would have been avoidable, classifying them as waste can be omitted as long as these substances or items can purposefully and legally be used or marketed. Under these circumstances the waste status is not automatically assumed and the term 'by-product' can apply instead.

Legal certainty and a minimum of different interpretations of whether a substance or item can be regarded a by-product instead of waste derive from a generally agreed standard of requirements (Figure 1). A substance/item created in a process whose main purpose is not directed towards the production of this substance/item can be regarded a by-product where is guaranteed also that the

- further use is certain, i.e. secured opportunities for using the substance/item exist,
- substance/item is without a further need of processing or processing beyond common industrial practice directly usable,
- legality of the further use is ensured.

A by-product's further use is usually assumed certain where a positive market prognosis or supply contracts for this product exist. The industry is encouraged to adopt quality assurance mechanisms integrated in production to make sure the legality of that use. Whether a substance/item is to be classified as a by-product or as waste remain nevertheless subject to individual evaluations and the attesting by authorities. By-products also must be distinguished from a waste that has reached the EoW. By-products are not waste from the start, hence no measures of treatment equal to waste become necessary for enabling their further usage. Some examples where the term by-product applies in practice follow in this document *(*Table 2, *☞3.1.3; 3.3.3).*

Figure 1: Evaluation scheme for the classification of by-products

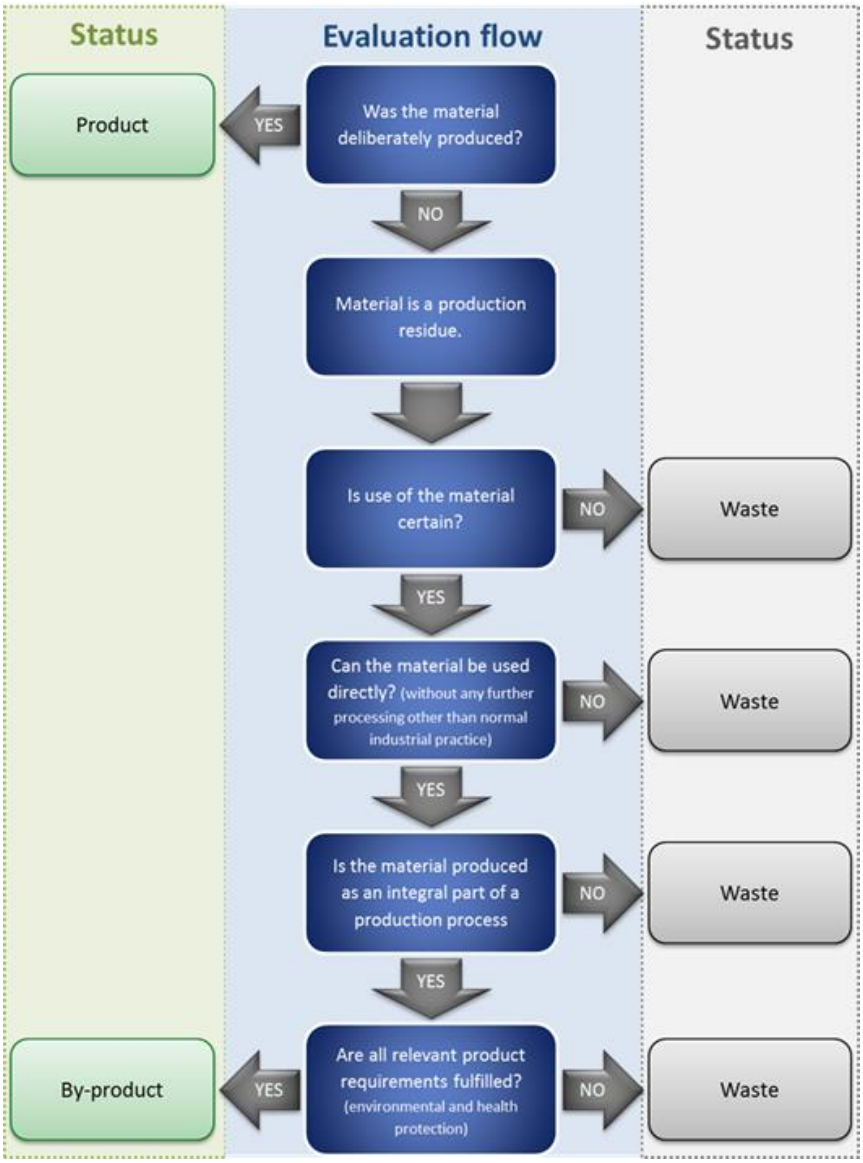


Table 2: Some production residues of mineral nature commonly categorized as by-products[*)]

Type of material	Recognized pathways of utilization
Blast-furnace slag, Class 1 granulated blast furnace slag	in road construction and hydraulic engineering, as fertilizer for the agricultural sector
Stainless steel slag	manufacture of high-performance concretes
Class 1 copper smelter residues	
Slag sand	manufacture of high-performance concretes
Melting-chamber granulate	multiple industrial applications, e.g. blasting abrasive
Limestone gypsum FGD	all industrial applications using gypsum (except of a few applications in the pharmaceutical sector), in particular gypsum plasterboard production

*) Where put and monitored under a quality assurance system an application of these materials as 'substitute building materials' is allowed in Germany. This status ensures users that the application in even water-logged areas or under circumstances marked by an exposure to moist does not cause any subsequent contamination to the soil and/or aquifer.

3 Application in the practice

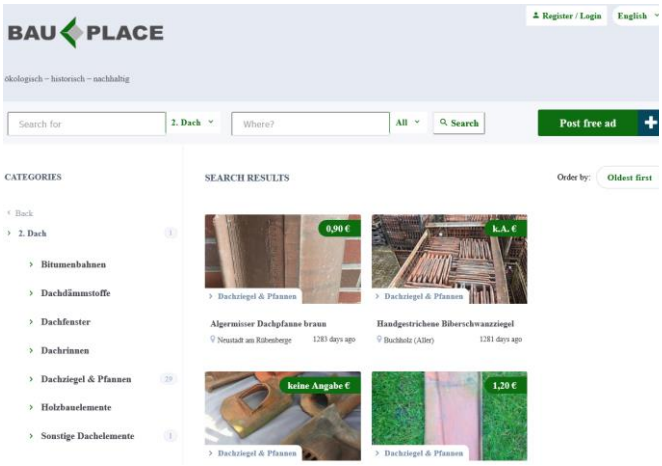
3.1 Examples in the building (waste) sector

3.1.1 Reuse, preparation for reuse and recycling of bricks and roof tiles

When adopting gentle processes and a careful handling of materials, the demolition does not have to result in the brick and roof tiles being destroyed or being excessively mixed with other building materials. In this case, they can be salvaged during deconstruction without losing their functionality, or they can also be recovered from the demolition debris in a targeted and rather sorted manner. Have the cutting leftover, broken or unused amounts of bricks and roof tiles been collected and stored cleanly and separately from other materials, this opens up almost all possibilities for further use. This also applies to bricks and roof tiles that were recovered undamaged.

The ***reuse*** option is met whenever unused quantities of bricks and roof tiles, quantities that were salvaged or recovered undamaged and even the broken amounts or cutting leftovers are directly and without further processing taken to a use that corresponds to what one could have done with an original, newly produced brick or roof tile. If, for example, the material is taken for masonry work, for roofing an object, to get an area paved, for an art installation or to pile up a wall with it, this fact is fulfilled. Online market places nowadays provide common platforms to have the like materials offered or traded (Picture 1, le.). The reconstruction or restoration of historical buildings and roofs often requires materials recovered from buildings of comparable age. Practically this is reuse. So-called salvage facilities or warehouses for historical building materials are being operated to make this possible. Used bricks, roof tiles and wooden beams make up the classic spectrum of items stored and made available by them (Picture 1, ri.).

Picture 1: Online market place offering used roof tiles (le.) **and roof tiles for reuse in a salvage facility** (ri.)



https://bauplace.de/ads/dach *© Dieter Rosen*

The same type facilities also play an important role in the preparation for reuse in that they usually engage in a necessary cleaning or refurbishment of such items, too. ***Preparation for reuse*** is characterized from a certain treatment that is required before further use in the original functionality can be made. This treatment must be of a sort that it does not significantly change properties and form of the item/material in its present state, however. When the undamaged, broken, leftover or cut bricks and roof tiles have to be cleaned first, for example to remove adhering mortar or pollutions, such processing or preparatory activity is taking place. Polishing the surface or making cuts to correct the shape or create a structure would also fall under this (Picture 2).

The reuse and preparation for reuse can be supported by taking the appropriate precaution in the design of the building products and when installing them, thus enabling these to be dismantled according to type or a simple separation into components. From this, the importance of the considerations for adapting the waste hierarchy in the sense of protecting values and resources through design can be derived *(☞2.1.2, modifications in the hierarchy)*.

Picture 2: Used bricks before cleaning (background, le.) **and piled up for sale after preparation for reuse** (ri.)

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The ***recycling*** of bricks and roof tiles takes place using techniques that often significantly change the form, structure and functionality of the present material, whereby also steps may have to be performed to first extract the material from mixed construction debris or to separate and clean it from other substances. Such procedure is taking place when mineral debris and building rubble is crushed, sieved, sorted and classified and a fraction of bricks or brick-rich material is obtained. The recycling will be considered fulfilled once the so produced secondary raw material was found quality-compliant and ready for use, for example as aggregate in concrete, as a material in road construction or as a filling material (e.g. in dams, to secure pits), thus substituting other materials.

Along the aforementioned order of usage options, gradations are occasionally made in the value of recycling. The return of the material to a use that occurs at the same or even a higher level of functionality is considered to be of higher quality (upcycling or higher-quality recycling) compared to the utilization in loose form as a road bedding material (Picture 3, ri.). In fact, however, the different values of varying recycling options can only be determined through precise life cycle analyses. It is also recycling when bricks or roof tiles, regardless of whether these accrue as waste in production or from demolition, are evenly broken or ground (Picture 3, ce.) in order to generate chippings or sand that have a use as surface cover (e.g. on tennis courts), mineral substrate (e.g. for greens roofs, ornamental gardens) or as additive in production (e.g. for new bricks, absorbent granule). For the recycling and use of secondary products is essential that the necessary quality and safety in terms of critical substance content is achieved by the process respectively guaranteed in the recycled product(s).

Picture 3: Used roof tiles separated for recycling (le.)**, chippings won from used bricks and roof tiles** (ce.) **and brick-containing recycled aggregate for a road base** (ri.)

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A form of ***other recovery*** takes place when bricks or roof tiles belong to a waste mix that is used for backfilling. Backfilling categorizes an operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials, be of proven suitability for the aforementioned purposes, and has to be limited to the amount strictly necessary to achieve those purposes. Backfilling does not have a clear assignment to the recovery (R) codes of the European WFD. Depending on the wastes used for backfilling it may be assigned to R3 and R5, however, backfilling operations are not classified recycling under this legislation.

Figure 2: Options to deal with a used object in the context of the waste hierarchy principles

slightly damaged used or leftover brick at a construction site	→ using this brick in unchanged state in another construction project	**Reuse** (before brick becomes waste and therefore an act of waste prevention)
	→ removing mortar and lightly hew this brick for that it can be used in construction again	**Preparation for reuse**
	→ this brick passes a crusher and the brick chippings obtained are used (e.g. for building purposes, as decorative material, as a plant substrate or for creating a drainage/bedding layer)	**Recycling**
	→ this brick passes a mill and the brick dust obtained is used (e.g. as floor covering, soil additive, absorbent, production additive)	
	→ this brick passes as part of the mineral debris from a construction site sifting and classifying processes and ends up in the recycled aggregate	
	→ this brick is part of the mineral debris from a construction site classified and found suitable along defined quality and safety criteria for use in backfilling	**Recovery**

3.1.2 Reuse, preparation for reuse and recycling of gypsum waste

Procedures like those described above for the salvage and reuse of bricks and roof tiles can in principle also be applied on construction products from gypsum. However, most of the gypsum in buildings is bound in cement and mortar, used as smoothing compound or present in components of limited robustness (e.g. plasterboard) so that extracting the material in a separate and intact manner would be economically challenging. Thus, there is little ***reuse*** of gypsum elements seen in practice. Against this backdrop ***preparation for reuse*** has no big meaning here either.

The chemical structure and properties on the other hand render gypsum to be one of the few construction materials which to retain in a completely closed loop by way of recycling is theoretically possible (similar to steel or glass). Gypsum waste can be turned into recycled gypsum by processing the gypsum waste in such a way that the contaminants (like the paper facing of the plasterboard) are removed through mechanical processes using special equipment.

Gypsum ***recycling*** essentially comprises steps of grinding, metal separation and classification. The main step is a multi-stage shredding, which is usually carried out using a low-speed rotor, so that larger pieces of foreign matter are retained and can be separated off. The professional recyclers are capable of handling gypsum waste with nails and screws, wall coverings and paper coating. In view of the relatively simple processing technology, it becomes clear that recycled gypsum quality is largely determined by the composition and suitability of the input material. It is typical for the gypsum recyclers to accept up to 3% of contamination from other materials only. Source separated fractions of rather pure gypsum waste are therefore an essential pre-requisite for the recycling.

However, separating gypsum waste at construction and demolition sites is just at its beginning, for example supported by take-back arrangements for source-segregated fractions offered from plasterboard suppliers. Where such material can be won and economically shipped to one of the yet very few specialised recycling facilities, gypsum of nearly pristine quality can be generated readily usable for almost all the same applications like natural gypsum.

In Germany and some other European countries, where recycling processes of this sort have been established under a very strict regime of product quality as well as safety standards and their monitoring (quality assurance mechanism), the ***end-of-waste*** has been declared and recycled gypsum awarded the product status.

3.1.3 Gypsum as by-product

In addition to its natural occurrence, gypsum can also be generated in a chemical process that is used to desulfurize combustion gases in coal-fired power plants. The sulfur dioxide contained in the exhaust gases reacts with additionally added limestone to form the gypsum (limestone-gypsum FGD). The gypsum obtained in this way is fully identical in its chemical structure to the naturally occurring gypsum. This process can be carried out with such a high degree of purity that no differences need to be made when using it, natural gypsum can be even completely replaced by this type gypsum.

The fact that the limestone-gypsum FGD is identical to natural quality, good for the same uses or to even substitute natural gypsum, and thus a marketable, highly sought commodity, places the material at product level. It must be considered on the other hand that the limestone-gypsum FGD accrues in coal-fired power plants not as part of a process targeted at its production but aimed to generate energy from the incineration of coal. The chemical process leading to its formation is thereby a step for cleaning the gaseous leftovers from burning and as such taking place in those technical units of the plant that actually deal with the environmental-sensitive emissions from energy production and where indeed wastes (e.g. filter ashes) are being generated too.

For limestone-gypsum FGD it is however clear that the criteria for a by-product fully apply (☞ Figure 1):

- A further use of the material is certain;
  This follows from the fact that limestone-gypsum FGD has a positive market value and is a highly wanted raw-material for plasterboard production.
- The gypsum can be used directly without any further processing other than normal industrial practice;
  The gypsum processing industry, such as plasterboard producers, handles the limestone-gypsum FGD just in the same way as they would do with natural gypsum.
- The gypsum is produced as an integral part of a production process;
  As outlined above, limestone-gypsum FGD is produced within a process that is integral part of the operations of a power plant aimed to produce energy in an environmentally benign manner.
- The further use is lawful;
  With the high-purity, fully identical chemical structure with naturally occurring gypsum and comparable concentrations of other substances is ensured that limestone-gypsum FGD can be used compliantly with all relevant product, environmental and health-protection requirements.

Limestone-gypsum FGD can therefore obtain the status of a ***by-product*** and must not be handled as waste of coal-fired power plants.

3.2 Examples in the household (waste) sector

3.2.1 Reuse, preparation for reuse and recycling of used clothing/textiles

Common arrangements in Europe for collecting worn-out clothing (including also shoes) are public bring banks and specially announced kerbside collection campaigns. Also take-back and buy-back offers from fashion chains and small vendors can be found. It can be assumed that more than 75% of old clothing and textile waste from households are collected this way.

Statistics say that for almost the entire quantity a utilisation within the upper four levels of the waste hierarchy is performed. The quality of the textile material and clothing at the moment of collection of course determines which option can be used. The proportions of different usage achieved in Europe shows an encouragingly high correspondence with the order of the waste hierarchy.

In many countries, there is an active market in re-selling used clothes. Charity shops offering donated clean clothes play a considerable role here. Looking at the figures from Germany, more than half the collected amount is taken to reuse whilst the material recycled share is about 40%. Far less than 10% undergo an energetic utilization, thus another recovery option *(☞bvse, 2015)*.

Acting along the order of the waste hierarchy requires the portion of used clothing and textiles not immediately reused, i.e. resold via shops or online platforms, to be instead handed to collection and sorted. Dedicated collection campaigns and special bring banks are indeed very helpful and proven means to ensure that the textiles are kept separate and in a sufficiently clean state. Sorting out the wearable items and perhaps doing some cleaning and repair means a ***preparation for reuse***. Large amounts of used textiles shipped to developing countries today as an act of charity actually fall under this categorization.

Items of inferior quality make up the material stream for ***recycling***. Sorting is also undertaken to establish the textile's composition as this affects of what durability the material is and the method of recycling that can eventually be applied. The output from sorting are grades which undergo a subsequent processing of varying intensity. One of the simplest techniques is to make industrial wiping cloths by cutting the textile. Larger mechanical efforts are needed to convert the textiles into a material suitable for fibre reclamation. Fibre reclamation mills sort textiles according to fibre type and colour. Colour sorting eliminates the need to re-dye the recycled matter. After shredding a material suitable for, e.g. insulation or furniture padding, or for use in high quality paper manufacture is obtained. The fibres can also be compressed for mattress production. Producing blends with other selected fibres is an option to obtain a recycled yarn spun ready for weaving or knitting.

A more recent development in the textile as well as plastic waste segments is the so-called *chemical recycling*. This technique has emerged as a response to the increasing presence of products made from composite materials, and to handle amounts of more polluted or even mixed waste fractions so as to enable circularity also under circumstances where separate collection comes to limits. *re:newcell* is an example in the textiles segment where in a patented process cotton and viscose is turned into high quality biodegradable dissolving pulp, from which new clothes are produced.

Chemical recycling at the moment is seen in an intermediate position between recycling and other recovery or as a technique which creates a link between both options. The opinions are varying though and a final position about this still must be found by the experts. Life cycle aspects and the energy balance in particular are hereby one of the main concerns *(☞life-cycle aspects, chapt. 2.3.1)*.

The recognition of the energetic use of used textiles or fibres as ***other recovery*** is undisputed. Textile materials generally are of high calorific value and therefore good to be utilized as a fuel. Using this option is in fact common practice. In order to fully exploit the energetic potential some mechanical processing steps, comparable to those applied for recycling, must first be carried out. Both this and the waste hierarchy principles suggest that the option of other recovery should be applied only on the textile waste that cannot be used otherwise or which remains as a residue from recycling operations.

Textiles and the various options shown above for managing them after entering the waste status provide a good reference case for cascading use. Such can also be illustrated comparably well in other waste segments with wooden pallets being here the selected example and reference section which will shed more light on this concept *(☞ Cascading use of pallet wood, chapt. 3.3.2,)*.

3.3 Examples in the packaging (waste) sector

3.3.1 Reuse, preparation for reuse and recycling of wood pallets

Repairs to replace broken or weakened planks and stands on wood pallets are usually carried out to allow multiple usage cycles and a prolonged lifetime. These are either performed by the pallet owner resp. dealer themselves or by an external service they may have commissioned. As long as this happens within usual routines that keep the pallets in the usage cycle and without that ownership on the pallet is given up, such repair acts are active measures of preventing pallets to become prematurely a waste (*waste avoidance*). When such pallet is reintroduced into its regular usage cycle after repair, its ***reuse*** is executed. Trading pallets to furthermore be used by someone else as transport packaging, and even a repair that may have to be applied on them to upheld this function, should not change anything on this categorization.

Picture 4: Street furniture from used wooden pallets *© Jan Reichenbach, INTECUS*

Does the same repair take place on a pallet which has been handed to a disposal service or the subject of a trade as a not any longer usable or wanted object (therefore fulfilling the waste criteria), a ***preparation for reuse*** can be assumed should the pallet afterwards be utilized in its original function or fulfil comparable demanding purposes. Taking or converting the pallet to serve as a furniture or separator element (Picture 4) would be such purpose and is then also recognized as ***reuse.***

Does not the function of the pallet suit or provide for the further usage option but the material(s) it is made from, then the stage of ***recycling*** is entered. In order to recuperate the wood as a wanted construction or raw material, the pallet somehow must be disintegrated or processed. Large-scale commercial use of pallet wood is made in the chipboard or particle board industry, for example. Wood chips sourced from suitable recovered (secondary) wood quantities contribute up to 90% of the wooden input for industrial particle board products (in Germany about 30% on average). Suitable secondary wood material is free of polluting substances, therefore the heat-treated wood pallets fit in particular here. They are broken in shredders, the wood is cleaned from other material components via metal separators and classifiers (e.g. plastics, paper), size sorted and dried for this purpose.

To avoid environmental harm and/or health risks, chemically treated or otherwise contaminated wood should not be kept in recycling cycles unless the dangerous substances have been removed or reduced to harmless concentration levels. The wood pallets bearing the mark for a chemical

treatment of the wood do not meet the requirements chipboard producers adopted for the safety of their wood raw material. Cleaning the wood from the chemicals is challenging, expensive and uneconomical, and this portion of pallet wood must therefore be disqualified from being recycled in chipboard production (and elsewhere).

Due to the fuel quality of this wood, combustion for energy generation is the alternative option here. Making use of this option means to undertake a form of ***other recovery***. Biomass incineration plants use pallet wood in significant quantities for the production of renewable energy.

The fact that both, the harmless heat-treated pallets and potentially harmful chemically-treated wood pallets are at the same time present on the market and considering that for each quality the environmentally best management option within the waste hierarchy should be chosen leads to a situation where the *recycling option and the other recovery provide purposeful solutions at the same level.*

It can even be argued that *recycling ranks higher for the heat-preserved pallet wood* whereas *other recovery is the economically and ecologically better option for pallet wood that has been chemically preserved*.

3.3.2 Cascading use of pallet wood vs. the waste hierarchy principle

Casdading use as a concept is worth to be looked at a bit closer in the context of this example respectively the wood market. Finding and applying the most appropriate sequence of a consecutive use of material forms the core principle of this concept.

Sawn wood is the first step of using harvested timber as raw material. Use of sawn wood can be made in multiple ways, perhaps before producing a pallet from it the wood planks may serve other purposes already (e.g. in loose form as a spacer). Once used for a pallet the wood can be serving multiple usage cycles, first as a transportation aid and later converted into furniture *(all at the level of **reuse**)*.

When these functionalities get lost, the wood can be processed and give a raw material for chipboard production ***(recycling)***. There exist even production technologies through which wood chips are pressed into the form of a pallet or to manufacture pallet stands. By recycling a pallet, a completely new pallet thus can be obtained and hence a further reuse cycle may begin again. Also the chipboard made from recycled wood can be taken to reuse as long as its functionality is going to be maintained.

A chipboard that eventually becomes waste or the pallets not suitable for producing such can be used energetically ***(other recovery)***. The wood gets hereby destroyed as material and the energy content is used. Resultant ashes may still have a value and be used as a secondary material if quality and safety standards do allow this ***(recycling)***. This whole sequence of consecutive applications describes a cascading use with multiple options for reuse and recycling incorporated to it. *Throughout this cascade reuse, recycling and recovery interchange without following a strict hierarchical system*.

3.3.3 Changing terminology during cascading use of pallet wood incl. by-product(s)

The example of pallet wood cascading use also suits well as a reference to deliver an illustrative interpretation for the further terminology used in EU legislation in relation to waste issues.

Shavings and sawing residues that occur when wood planks for pallet production and the pallets themselves are produced can be categorized ***by-products***. These comprise a material that is generated in the production processes carried out by the sawmill (to generate planks) and the

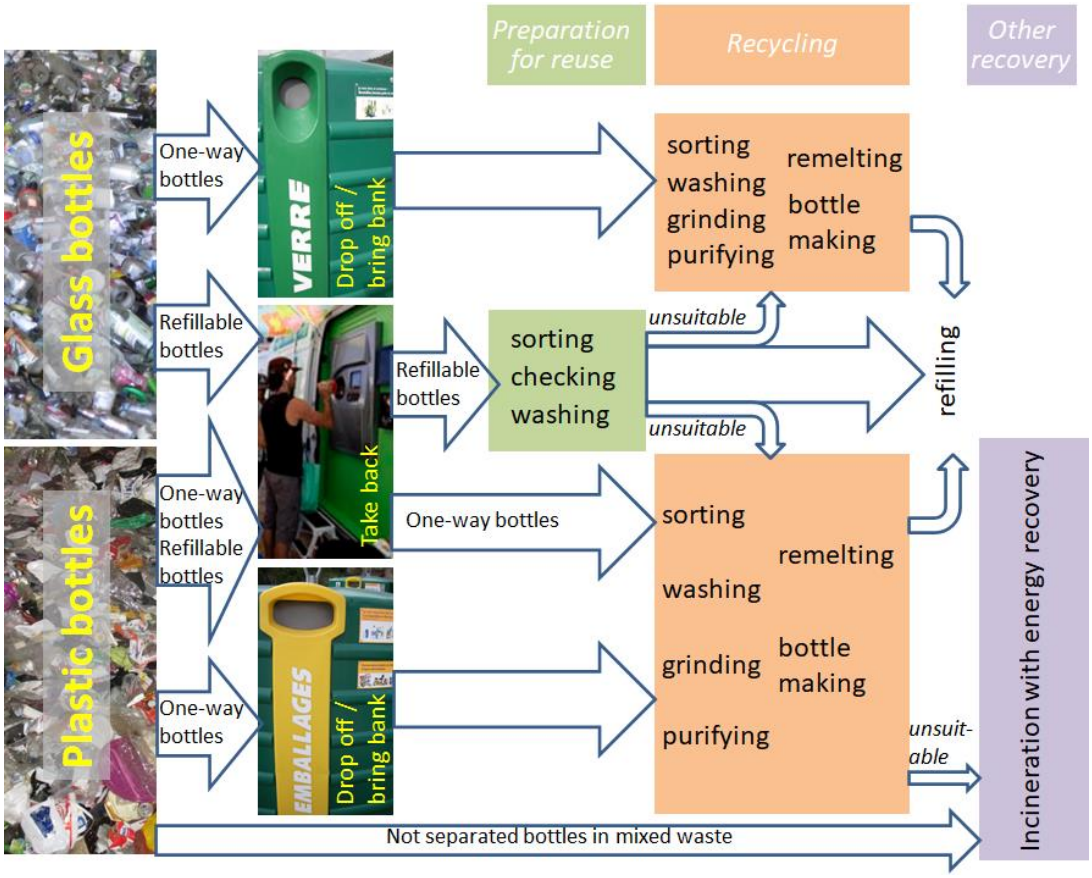
pallet producer (to manufacture pallets) and usually wanted as a raw material from further industries (e.g. chipboard manufacturers, wood pellet producers) *(☞by-product criteria, chapt. 2.8)*.

Sawmills, whose primary target produce are sawn wood and an assortment of lumber, in some cases also engage as wood pallet producers at the same time. The wood pallet then is a ***co-product*** in their production. Shavings and sawing residues which they cannot make use of or sell to other users are ***production residues*** and, if not utilized within their own business activities (e.g. taken instead of other fuels to feed the heating system or generate energy), become ***waste***. The same applies to pallets that, being production failures, do not conform to the product standard and follow the same two different ways, i.e. become either production residues or waste.

3.3.4 Reuse, preparation for reuse and recycling of bottles

The application of the different management options for bottles should be illustrated by means of the following graphic (Figure 3).

Figure 3: Management of beverage packaging and activities involved at different waste hierarchy levels



This illustration provides a display for the different kind arrangements commonly used for beverage bottles in many European countries. It can be seen that *take-back (deposit-refund) schemes applied on refillable bottles enable their reuse* whereas practising the (same) *deposit-refund for one-way bottles only enables recycling*. Sorting and washing the reusable bottles and refilling them falls under ***preparation for reuse***.

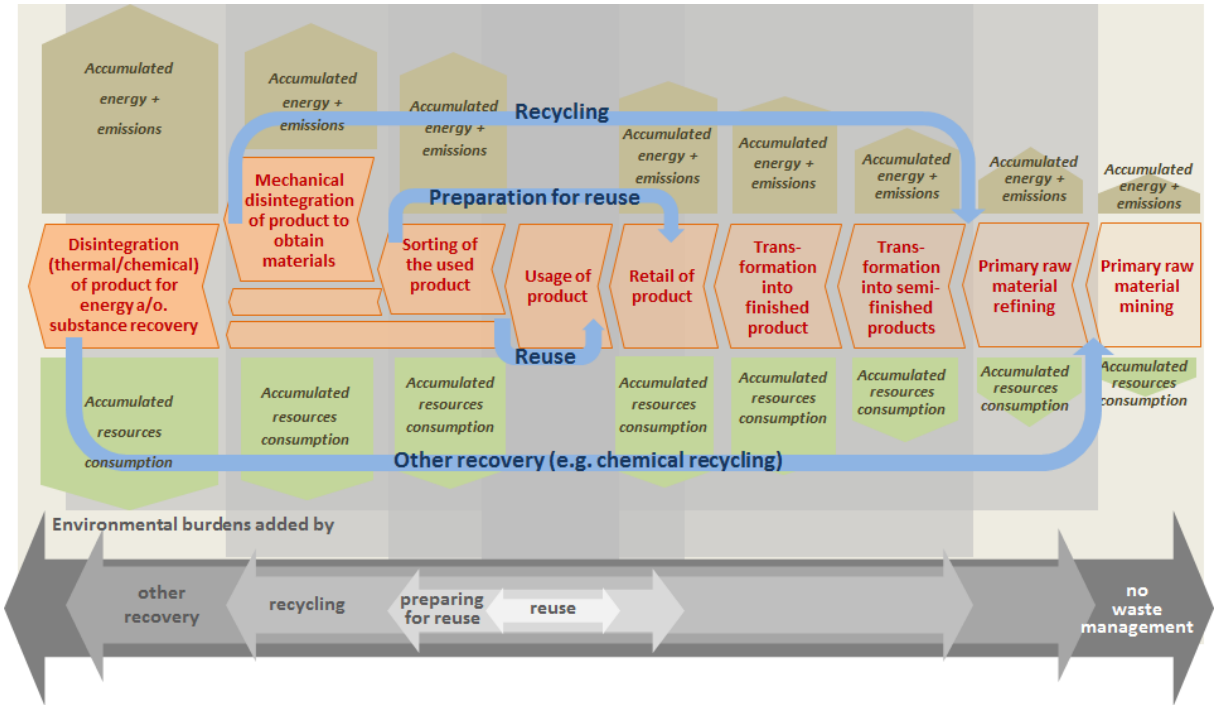
Glass cullet or plastic flakes generated from collected bottles and used as secondary raw material in either bottle manufacturing or the production of any other goods (e.g. construction elements, technical fibres) mark ***recycling***. Using the flakes or sorting/production leftovers from plastics in waste-to-energy processes mean a form of ***recovery***.

4 Conclusions and recommendations

Even though EU environmental legislation tries to give functional definitions, enforcement practice may differ between countries, depending on circumstances, administrative structures, regional or local conditions or for other reason. In practical cases similar to the examples presented, other facts may justify that a competent authority eventually is taking a different decision. The examples provided should therefore in no way be regarded as providing the perspective enforcement bodies are urged to assume as their own. In practical implementation and enforcement, specific circumstances and the context of the waste management situation, as well as the requirements of the legislation, will always need to be taken into account.

The individual perspective applied in each case does not alter the principle that the higher in the waste hierarchy action is taken the more resources are being saved and less additional loads in energy and emissions are produced (Figure 4). A properly chosen system of definitions, not creating contradictions and easy to understand has to be part of a framework to facilitate such course of action.

Figure 4: Relation of the different options for managing waste towards the value chain and created environmental burden



For a positive, resource-conscious framework that enables a high circularity continuous impetus and strengthening are indispensable. Even in the textile sector, which for many years was considered to be rather unproblematic and well positioned in this regard, additional initiatives seem increasingly important. This results from the fact that along with mass consumption and fast fashion an overall decline in product quality is observed. Due to this trend it is predicted that reuse will drop by 15% and a shift towards recycling (+10%) and other recovery (+5%) taking place in Europe in the coming years *(☞ GftZ, 2019)*.

The provision made with the WFD for a mandatory separate collection for used textiles from 2025 may not any longer be sufficient to cope with such developments. Therefore, consideration is being given to expanding the producer's responsibility to also include this product segment for that actions along the waste hierarchy are further encouraged through design and incentives for closed material loops and cascading use. Possible EU-Turkey co-operations for the closing of

material loops and enhancing circularity in the textile segment have for example been outlined in 2019 *(☞RVO)*.

Turkish SWM authorities and stakeholders for this and other reasons should be encouraged to promote all actions and launch their own initiatives that make action in the order of the waste hierarchy possible and enable circularity with the least environmental impact (i.e. narrow loops in the sense of Figure 4). There exist a tremendous range of tools which can facilitate this, in particular, economic instruments need to be mentioned here, including following options which proved already successful in numerous countries and may do so also for Turkey:

- Tax incentives (lower taxation of repair services/recycled products),
- Recycling-oriented fee and collection arrangements (e.g. user charges, advance recycling fees, deposit-refund schemes),
- Green citeria in public procurement (placing a preference on reparable/recyclable goods, products with recycled content).

Note should be taken that, by the end of 2024 the European Commission shall consider the feasibility of measures to encourage the reuse of products. By 31 December 2024, the Commission shall consider the setting of preparing for reuse and recycling targets for, among others, textile waste. Moreover, the European Commission is about to establish a common methodology to report on product reuse *(☞European Commission, 2019)*.

It has to be clear though that also reuse at some point comes to an end and recycling cannot be endlessly prolonged. ***Cascading use*** along or in combination with the waste hierarchy principle therefore can be considered a recommendable long-term visions and sustainable approach.

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