HINTERGRUNDPAPIER | RAW MATERIALS POLICY | CIRCULAR ECONOMY

Circular Economy as an important pillar of raw material supply

Analysis of selected material flows and recommendations for action

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Contribution to securing the supply of raw materials through the Circular Economy

Circular Economy must and will play an important role in the future in securing the supply of raw materials within the framework of the "Three Pillars of Raw Materials Supply". The Circular Economy is an indispensable step towards stabilizing value chains as well as strengthening economic resilience by reducing dependence on imports and contributes to conserving primary raw materials and, just as importantly, to achieving climate targets. **It will not be possible to do without primary raw materials for the time being.** Strengthening the Circular Economy must be considered in the context of domestic raw material production and imports.

Effective framework conditions are needed to drive the use of Circular Economy Raw Materials. This includes improving both the supply and demand side of recyclates, industrial by-products and biological raw materials and products. Demand and supply in turn depend on many different factors, including the existence and organization of structures for collection, sorting and take-back, quality standards and the availability of significant quantities of raw materials for a recycling / recovery process. **This is because, in principle, only what is available in terms of waste can be recycled.**

Since products made from quality-assured recyclates are generally equivalent to products made from primary materials, quality-assured recyclates should be given product status and consequently included in the official production statistics of the Federal Statistical Office ('Güterverzeichnis für Produktionsstatistiken', GP for short) so that the recycling success can be measured. **Consistent application of the waste code numbers is also essential for taking note until the product status is reached.** In addition, the use of digital technologies in companies and enforcement authorities should also be promoted. These technologies, in combination with the further development of indicators at company, national and EU level, can help policymakers and companies to better monitor the use of recyclates, industrial by-products and biomass. Hurdles or market obstacles must be identified in the individual material flows.

We recommend setting up a test scheme for the impact assessment of measures in two steps, each of which maps the objective and feasibility in practice. The conditions in the markets for Circular Economy Raw Materials are difficult to compare, the price situations are different and the

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already established or just not yet established collection and processing procedures bring further differences. **This makes it clear that there cannot be a single instrument for improving the Circular Economy - rather, a mix of measures is needed that must be designed differently depending on the material flow.** When using Circular Economy Raw Materials, conflicting goals in the Circular Economy (e.g., preparation for reuse vs. more use of Circular Economy Raw Materials) must be considered and the interfaces of waste, product and chemicals legislation must be coordinated in a uniform manner.

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1. Initial situation

In 2019, the European Commission presented the Green Deal as the European Commission's growth strategy, which is also intended to contribute to the implementation of the United Nations' 2030 Agenda. Alongside strategies for climate protection and for Non-Toxic-Environment, the Circular Economy is a core strategy of the European Commission in the Green Deal. In the first and second Circular Economy Action Plan (CEAP) from 2015 and 2020, a wide range of measures were announced to promote the Circular Economy. Even though the Commission wants to engage all industrial sectors in a transformation towards a more Circular Economy, according to the Green Deal it focuses on resource-intensive sectors such as textiles, construction, electronics, and plastics.

Raw materials are the foundation of all value creation. As a strong industrial nation, Germany needs a holistic and sustainable policy that ensures securing raw materials supply. This is made clear by the following points:

- **The demand for raw materials is increasing worldwide.** The further foreseeable increase in the world population is a demand driver for a variety of raw materials, such as food and construction raw materials. In addition, the energy transition, and new technologies such as e-mobility, wind turbines, solar technology and battery storage are further demand drivers. For graphite and lithium, which are classified as critical raw materials by the EU Commission, the World Bank forecasts an increase in demand of over 500 percent by 2050 compared to 2018.[1]
- Also, Russia's war of aggression on Ukraine with massive distortions on the energy and gas market led to drastic economic consequences in Germany and in the entire EU internal market. In particular, the raw material-intensive basic industry had to make changes in the portfolio of a narrowed supplier structure in a very short time, partly accompanied by further delivery delays.
- Even before the war in Ukraine, the COVID-19-pandemic also exposed vulnerabilities in global supply chains and led to delivery difficulties. For example, there were shortages of intermediate electronic goods such as semiconductors and chips, which are needed for economic sectors such as the electrical and automotive industries.

These points make it clear that industry and society must not only undergo far-reaching internal transformation processes, but also make enormous efforts to meet global challenges. In addition to a secure and globally competitive energy supply, resilient supply chains and a successful industrial base in Germany and Europe require all three pillars of our raw material supply, including not only domestic and imported raw materials but also Circular Economy Raw Materials.

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[1] ***World Bank Group. (2020).*** Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf

CIRCULAR ECONOMY RAW MATERIALS

The goal of the use of Circular Economy Raw Materials is to conserve and / or replace primary raw materials, including fossil fuels, and to return raw materials to the product cycle. In this way, import dependencies on primary raw materials and CO_2 emissions are to be reduced and greater resilience achieved in value creation networks.

Circular Economy Raw Materials include recyclates and waste for material recovery in general, which are returned to the cycle, but also by-products, renewable raw materials and CO_2 extracted from processes and the air, when treated according to the waste hierarchy pursuant to the German Circular Economy Act (‘KrWG’) § 6.

The raw materials pillar of the Circular Economy Raw Materials must be significantly strengthened. The use of recycled materials is already very high in the glass, paper, and metal industries, combined with well-functioning market structures. However, there is still potential to increase the use of plastics and technology metals.

In a first step, this background paper analyses selected material flows that are wood, paper, plastics, minerals, biowaste, glass (container glass, flat glass), metals (non-ferrous metals, technology metals) and steel. This is to simplify the status quo of the use of Circular Economy Raw Materials, to identify material flow-specific hurdles and to derive recommendations for action. A selection of factors that can prevent or strengthen the use of recyclates and industrial by-products is used for these material flow-specific considerations. In a second part of the paper, commonalities and differences of the material flows are briefly presented and guidelines for the expansion of the raw materials pillar of the Circular Economy are provided.

2. Ways to increase the use of Circular Economy Raw Materials

The availability of Circular Economy Raw Materials is essentially determined by supply and demand.

Parameter	Question
Availability	- How much waste and by-products are generated? - What is the situation of demand and supply for recyclates or by-products?

How high demand and supply ultimately turn out depends on various parameters.

Parameter	Question
Ecological advantageous-ness	- Does the use of recyclates or by-products contribute to the various environmental policy goals? (e.g. primary raw material conservation and CO_2 savings?) - Are there only diversions in material flows and CO_2 emis-sions or do the balances improve overall? * Does an increase in the recycled content of product X lead to a lower recycled content in product Y, which improves the CO_2 balance for product X but worsens it for product Y? - Is there a rebound effect? * Does an increasing supply of recyclates lead to lower raw material prices and thus to higher overall consumption?
Price / Costs	- Is the recyclate or by-product competitive from an economic point of view? - Does the recyclate or by-product have a positive market value? - What are the production costs? *(e.g. energy, material and production costs, R&D costs) - What is the supply and demand ratio for the primary raw ma-terial? - How high are transaction costs? * Costs of using the market, e.g. those incurred in initiating business and transferring goods (e.g. information costs, search costs, transport costs, contracting costs, etc.). These are particularly high when market transparency is low. - Can end users recognize the (benefit of) the use of recy-clates (labelling) and are they prepared to pay higher prices? For which material flows does labeling make sense? - How high are investments in secondary material separation and what capacities of secondary raw materials are being built?
Quality	- Which safety / functional / quality requirements must recy-clates or by-products fulfil for the product?
Standards / Norms	- Have minimum requirements already been developed? - What are the minimum requirements?
Measurability	- Is the proportion of recyclates or by-products in the product traceable?

	- Is the quality of recyclates or by-products measurable?
Technology	- What are the technical hurdles in the recycling process?
Infrastructure	- Is there a sufficient identification system in the waste market to easily recognize materials and separate them efficiently in waste separation? - Are there adequate and sufficient sorting, (separate) collection and take-back systems for the material stream? - Are there already functioning market structures for recyclates or by-products (e.g. sufficient producers / suppliers) that the processing industry can fall back on?
Political legislation	- Which material law requirements stand in the way of the use of Circular Economy Raw Materials and how can material, product and waste law be synchronized?

Table 1: Own illustration. Parameters for markets for Circular Economy Raw Materials.

The list represents a non-exhaustive selection of parameters and guiding questions that provide a systematic orientation for the evaluation of individual substance streams in the following chapter and are to be specifically scrutinized for the different substance streams.

3. Focus on selected material flows - recording the status quo

The material flow profiles only provide an initial orientation and snapshot in the respective material flows and do not claim to be complete. The influence of exogenous factors such as the Corona pandemic and geopolitical conflicts must also be taken into account with regard to the parameters. The situation in the material flows is not static and must therefore be regularly reassessed, which makes long-term agile monitoring necessary.

3.1 Wood

Key figures: Before the pandemic in economically strong years (high consumption, high waste wood accumulation): Every year, about ten million tonnes of waste wood are accumulated in Germany, of which up to 1.5 million tonnes are used for material recycling and the rest for energy generation. Landfilling does not take place. The VHI assumes a waste wood volume of about seven million tonnes for 2023.[2]
▪ The **supply of waste wood exceeds the demand for material recycling; the waste wood is mainly used for energy generation**. The volume of waste wood is very dependent on fluctuations in the economic situation. The slowdown in the economy and especially the slump in the construction sector are currently leading to less rather than more waste wood.

[2] According to estimates by the ***VHI Verband der Deutschen Holzwerkstoffindustrie***. The 10 million t / year are calculated for 2016 and include 1.4 million t net import, cf. p. 59 of the UFOPLAN project. https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_95-2020_evaluierung_der_altholzverordnung_im_hinblick_auf_eine_notwendige_novellierung.pdf

Just under one fifth of the waste wood produced is currently recycled, the rest is used for energy generation, especially in biomass power plants. In the winter of 2022, the development of energy prices led to price overheating and predatory competition to the detriment of material recycling. Both are currently leveling off.

- The recycling of the material stream is associated with rather **low operational costs.** The transaction costs for acquiring recyclates have been low in the past but are currently rising. In the past years, waste wood was characterized by a rather low-cost price structure, except for the special effects of the year 2022, in which energy recovery pushed material recovery into the background. A trend reversal can be observed here due to the transformation and an intensified competitive situation can be expected, especially in view of the emerging bioeconomy.

- Cascade utilization describes the multiple, material use of a raw material and is established in the wood industry. In this process, the raw material wood is used in the material flow for as long as possible and is only utilized energetically at the end of its life when material recovery is no longer technically or economically feasible.

- There are **low technical hurdles** for recycling processes. However, the mechanization of the processing plants requires high investments. Up to now, waste wood has only been used as a material in wood-based materials, where waste wood is glued together with fresh wood, pressed (possibly coated) in standardized processes.

- **Quality requirements and safety requirements can be met**. The required quality in the recyclates can be measured. Quality standards are available. The Waste Wood Ordinance specifies a classification of the various materials into waste wood categories and thus determines their possible uses and limit values in the annexes. EN / DIN standards are available for the various wood-based products.

- Secondary material is accumulated, primary material must be generated (in this case harvested). The use of waste wood is, thus, per se an advantage in terms of primary raw material conservation, resource efficiency and climate protection factor by extending the carbon sequestration when using waste wood. However, the collection, sorting and processing of waste wood involves additional energy and transport costs.

- There are **good collection structures** for separate collection and a functioning EU internal market.

Evaluation / Summary:

Waste wood accumulates due to the economic situation and is not produced - so if large new demanders come onto the market now (keyword: coal-fired power plants), established material and energy recovery routes will be displaced. Established material and energy recyclers currently divide the quantities among themselves, peaks are cushioned by import / export.

Instead of a pull effect on the demand side, a push effect on the supply side is needed to improve the availability of waste wood for recycling. The goal should be to effectively collect the accumulating quantities (ideally sorted by type) and to leverage potentials. There is potential for improvement especially in the involvement / education of waste producers (awareness of the secondary raw material) and in the collection of bulky waste. Between 1 - 1.5 million tonnes of bulky waste are currently still being incinerated. Harmonized European regulations are needed to improve the supply side of waste wood for recycling.

3.2 Paper (paper for recycling)

Key figures:

In 2020, paper production in Germany comprised 21.4 million tonnes, with a use rate of waste paper (paper for recycling) of 79.2 percent, varying depending on the type of paper. For example, the use rate of paper for recycling for packaging paper and board was 101 percent, for graphic paper 53 percent, for tissue paper 48 percent and for paper and board for technical and special uses (including core board) 44 percent. [3]

- The **demand for** paper for recycling **exceeds the supply**. In Germany, less paper for recycling is accumulated than the industry demands, which is why paper for recycling is also imported.
- The recycling of waste paper into new paper is associated with **low operational costs.** The market value of paper for recycling is also positive. The **transaction costs to** acquire paper for recycling **are high**, due to complex responsibilities in household collection.
- There are **no technical barriers to** recycling processes, except for paper with certain special applications (e.g. art printing and filter paper).
- **Quality requirements and safety requirements can be met**. Quality standards exist (e.g. DIN EN 643 waste paper sorting list), the required quality of paper for recycling can be measured.
- Paper for recycling may offer a **better overall CO_2 balance** than the extraction of primary material. The use of paper for recycling also reduces the consumption of energy, water and chemicals.
- There are **good collection structures** for separate collection and a functioning EU internal market.

Evaluation / Summary:

The total amount of separately collected waste paper in Germany is already recycled and the recycling rate is high. There is still room for improvement in the use of paper for recycling as a recyclate in the production of paper for certain special applications. However, these types of paper only account for a small percentage of the overall paper production. New approaches in product design can increase the share of paper for recycling in paper for special applications (e.g. brown-colored sanitary paper instead of white-colored paper) and are already being developed and implemented in the industry. Reducing technological barriers to recycling art paper / filter paper can also help, for example through R&D.

Since the fibers shorten with repeated recycling of the paper, a steady inflow of primary fibers is necessary to stabilize the material flow, despite the high use rate of paper for recycling in paper production.

[3] ***Umweltbundesamt. (2022).*** Waste paper. https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/altpapier#vom-papier-zum-altpapier

3.3 Mineral construction and demolition waste

3.3.1 RC building materials

Key figures:

In Germany, an average of around 208 million tonnes of mineral construction and demolition waste was produced per year between 1996 and 2020. At around 125 million tonnes, soil and stones made up the largest share of this waste. Another 82 million tonnes came from the dismantling of buildings and was largely used to produce recycled building materials. Today, almost 86 percent of the soils and stones and 94 percent of the construction waste are already recovered in an environmentally sound manner, especially in road construction and earthworks.[4]

- The **demand for** R-concrete in building construction **has been low so far**. Due to changes in public tenders and the linking of sustainability assessments to building subsidies (keyword: Quality Seal for Sustainable Construction, 'QNG'), **the demand for R-concrete is currently increasing significantly**. The federal state of Baden-Wuerttemberg also supports the use of R-concrete through targeted subsidies.

- The **use of** RC aggregates in R concrete **has been regulated by standards and building authorities for over 20 years.**

- A redirection of secondary materials, which are used today e.g., as frost protection layer in road construction, into a concrete does not necessarily have to lead to an additional contribution in terms of resource conservation, but can make a contribution to climate protection, with appropriate pre-treatment.

- In order to leverage these climate benefits, the processing of concrete and concrete-containing waste would have to be changed. Instead of processing the waste into a fine and a coarse fraction, it would generally have to be processed into **three fractions** so that the hardened cement paste, the sand and the coarse aggregate are separated. **Technically, this requires an additional processing stage, which has not yet been introduced nationwide due to a lack of demand.**

- There **is considerable potential in the area of crushed concrete sands** if they are used as a clinker substitute in cement production or as a raw meal substitute in clinker production. In cement production, up to 20 percent of the clinker may be replaced by crushed concrete sand in accordance with the cement standard EN 197-6, which eliminates the process emissions of this clinker component. In clinker production, around ten percent of the raw meal can also be replaced by crushed sand, so that process emissions can also be reduced in this way. If five million tonnes of crushed concrete sand were used as a clinker substitute and four million tonnes of crushed sand were used for clinker production, CO_2 reductions of up to four million tonnes and primary material savings of up to nine million tonnes per year would result in cement production.

- Materials containing lime and cement, e.g., concrete, sand-lime bricks, aerated concrete or ironworks slag, have the property of being able to absorb CO_2 from the atmosphere. During its use, an average concrete absorbs an average of around 30 kg CO_2 per cubic meter through natural carbonation. This corresponds to about 20 percent of the process emissions. There remains a further CO_2 absorption potential of about 120 kg per cubic meter of

[4] The data on mineral construction waste come from the monitoring reports of the ***Initiative Kreislaufwirtschaft Bau*** and are based on official data from ***Destatis***. www.kreislaufwirtschaft-bau.de
The data on raw material demand can be found in the raw material study of the ***Bundesverband Baustoffe – Steine und Erden e.V. (bbs).*** Published on www.baustoffindustrie.de, among other places. The studies were prepared by ***Deutsches Institut für Wirtschaftsforschung (DIW)*** in cooperation with ***SST Ingenieurgesellschaft.***

concrete that can be raised through active re-carbonatization. Here, CO_2 absorption is accelerated by crushing the materials and the resulting larger surface area, as well as by setting suitable temperature and humidity conditions. Although there is still a need for research in this area, initial pilot projects have shown that the climate protection potential through re-carbonatization is very large and can be exploited comparatively easily. Based on a waste volume of 40 million tonnes of construction waste containing lime and cement, this could result in a reduction effect of around 2.5 million tonnes of CO_2 per year.

- In order to be able to use the climate protection benefits in the context of cement production or for active decarbonatization, but also to produce the required qualities of RC building materials for use in R-concrete, **further development of the processing technology in the recycling plants is required.** The sector, which is dominated by SMEs, may need to be supported by funding to be able to make the necessary investments.

- The desired future higher-quality processing **can lead to higher costs for RC building materials** and to **higher transport costs,** as the quantities of mineral waste produced differ between conurbations on the one hand and rural areas on the other, i.e., from region to region. With a view to climate protection, decentralized processing plants close to cities are necessary to minimize transport distances.

- In addition to the extraction of aggregates from residual masses of building demolition, the wet-mechanical extraction of aggregates from processed soil fractions can also be considered (soil washing).

  Further **potential for efficiency lies in the optimization of construction methods**. This applies to both civil engineering and building construction. Through leaner constructions with less material input, both climate and resource protection potentials can be raised.

Evaluation / Summary:

In Germany, the almost complete recovery of mineral construction waste has been firmly established for decades. Excavated soil is mainly used for backfilling excavations, while granular mineral construction waste is processed into RC building materials. Today, these RC construction materials are mainly used in earthworks, civil engineering, road construction and landscaping, as all fractions (fine and coarse fractions) can be applied there.

For managing RC building materials in cycles in particular, the use in the cement and concrete industry as resource-conserving cement or concrete (R-concrete) is particularly suitable due to the large mass flows. Until now, only the coarse RC aggregate was considered, which has been allowed to be used in R-concrete for many years under conditions specified by the building authorities. Significant changes are now emerging to the effect that the fine crushed concrete sands may also be used in R-concrete in the foreseeable future. In the cement industry, too, there are already the first building authority approvals that allow the use of fine fractions as cement constituents.

But: The prerequisite for this is that the processing of concrete and concrete-containing mineral construction waste changes. Investments in processing technology are required throughout the country to be able to produce and offer the secondary material streams in suitable quality and quantity everywhere. Not every recycling plant will have the possibility to retrofit processing technology. In this respect, various impulses, including from the public sector, are necessary to actually be able to leverage climate protection potentials: From the promotion of improved recycling technologies to the initialization of green lead markets for resource- and climate-friendly cements and concretes.

However, a pure diversion of RC building materials from road construction to the production of RC concrete would lead to an increased demand for primary building materials in road construction if the construction volume remained unchanged. In order to avoid this, unbound layers that were previously produced with RC building materials would have to be substituted, i.e., for example, they would have to be produced with a lower thickness. The increased use of soil improvement and soil stabilization measures as a substitute for unbound layers would be a conceivable option.

In view of the current construction tasks in Germany, even with a more efficient use of mineral secondary materials and a more resource-conserving construction method, it cannot be assumed that secondary building materials alone will contribute to meeting demand. Thus, securing domestic raw material deposits, including limestone, gravel and sand, remains an important field of action. Since the raw materials mentioned are only extracted in line with demand and are used in particular in concrete production and can only be substituted to a limited extent by recycled building materials, the primary raw materials levy that has been called for in some cases should be rejected, since it does not have a steering effect in the direction of circular value creation, but makes construction as a whole more expensive and thus thwarts important construction policy goals (housing construction, rehabilitation of infrastructure).

The Substitute Building Materials Ordinance and the Soil Protection Ordinance ('BBodSchV') set limits on the recycling of mineral construction waste in earthworks and civil engineering regarding pollutant content. All considerations on intensifying Circular Economy approaches in the area of mineral construction waste are subject to the proviso that the handling of pollutants is regulated pragmatically. The handling of slightly asbestos-contaminated mineral construction waste can be seen as a particular challenge.

Furthermore, it would be beneficial if RC building materials reached the end of their waste status at the end of the recycling process. The use of waste in the product area can lead to considerable additional burdens for production companies due to waste and immission protection regulations.

3.3.2 RC plaster

Key figures:

Of the 741,000 t of gypsum-based construction waste generated in Germany in 2020 [, representing only 0.3 % of all quantities of mineral construction waste generated,] 442,000 t (59.6 %) were sent for recovery including recycling, while 299,000 t (40.4 %) were disposed of in landfills. Here, a clear improvement in recovery practice can be derived, as in 2018 more than 50 percent of gypsum-based construction waste was still disposed of in landfills. [5]

- There is **currently and will continue to be significantly more demand for RC gypsum than there is supply.**

- The recycling of the material stream is associated with **low operational costs** during the actual processing, but with a view to the entire chain, **the transaction costs are high** (selective deconstruction, interim storage and logistics for the RC gypsum produced, disposal costs for recycling residues).

- There are **low technical barriers to** recycling processes.

- **Quality requirements as well as safety and health requirements are high**. Therefore, the effort for quality inspections is also high.

- Regarding the CO_2 balance, a distinction must be made between processing and transport costs. The Global Warming Potential ('GWP') with regard to processing is much lower for

[5] ***Kreislaufwirtschaft Bau. (2023).*** Mineral Construction Waste Monitoring 2020. http://www.kreislaufwirtschaft-bau.de/Download/Bericht-13.pdf

natural gypsum than for recycled material, while the CO_2 emission potential for the transport effort is comparable for both raw materials.[6]

- There are **insufficient collection structures** for separate collection.
- There is an **insufficient legal framework** regarding asbestos regulations, landfilling and / or export of recyclable gypsum waste and end of waste status.

Evaluation / Summary:

Gypsum building materials can be recycled again and again (multi-recyclable) and thus kept in high-quality cycles. The use of RC gypsum is difficult to increase due to current regulatory barriers and the associated lack of legal certainty but is technologically possible and given the availability of material that can potentially be recycled. Even if the recycling gypsum potential is fully exploited, a complete substitution of the primary raw material is not possible.

A central hurdle is the lack of quality, health and safety requirements in the form of limit values and detection methods for asbestos fibers. A tolerance limit (assessment value) for potential asbestos cross-contamination must be defined in combination with an internationally recognized detection method and this must be represented to the other EU member states. The naturally occurring, unavoidable concentrations of impurities provide reference values for orientation for quality requirements for RC gypsum.

In order to minimize transport distances, which have a direct impact on the CO_2 balance of RC gypsum, logistical optimization between the recycling plants and the plants that use RC gypsum as a secondary raw material is necessary.

3.4 Organic waste from household collection (organic fertilizer)

Key figures:

In 2020, a total of 14.4 million tonnes of biogenic municipal waste was generated in Germany (including waste from the organic waste bin, garden and park waste, kitchen and canteen waste, cooking oils and fats, and market waste, excluding biowaste from agriculture or the manufacturing industry). Of this, 2.6 million tonnes of biowaste were composted by private households and 11.8 million tonnes were collected by waste management companies. Of the biogenic municipal waste from all waste management facilities, 97 percent was recycled. This resulted in 4.8 million tonnes of compost and 746.6 million cubic meters of biogas. [7]

A study by the German Federal Environment Agency also points to the high proportion of organic material in residual waste, which is 39 percent on average in Germany.[8]

- **The demand for** organic fertilizer **currently exceeds the supply**. At the latest since the beginning of the Russia-Ukraine war, the demand for organic fertilizer has increased massively, as synthetic fertilizer from Russia has risen sharply in price. The limiting factor is currently the potential quantity that can be offered.

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[6] With reference to the ***Umweltbundesamt (UBA)*** report, texts 33/2017

[7] ***Federal Statistical Office Destatis. (2022).*** Press release. 14.4 million tonnes of biowaste in 2020. https://www.destatis.de/DE/Presse/Pressemitteilungen/2022/09/PD22_371_321.html

[8] ***Umweltbundesamt. (2020).*** Comparative analysis of municipal residual waste from representative regions in Germany to determine the proportion of problematic and recyclable materials. Final report. https://www.umweltbundesamt.de/sites/default/files/medien/479/publikationen/texte_113-2020_analyse_von_siedlungsrestabfaellen_abschlussbericht.pdf

- The recycling of the material stream is associated with **low operational costs. The transaction costs for** purchasing the recyclates **are high**. However, the economic efficiency depends on many exogenous factors.

- There are **low technical hurdles** for recycling processes. The removal of foreign matter (misdirected waste, packaging from market and commercial waste) still poses technical hurdles for recycling. Experience shows that with a high proportion of foreign matter, a high proportion of organic material is also sorted out. However, with the help of new sorting technologies, such as those used in the course of the amendment of the Biowaste Ordinance (‘BioAbfV’), process losses should be minimized.

- **Quality and safety requirements are high.** The required quality in the recyclates can be measured. **Quality standards exist** (e.g., ‘RAL’ quality mark for compost). In agricultural use, the recyclates must meet the requirements of ‘DüG’, ‘DüV’, ‘DüMV’ and ‘BioAbfV’, for example.

- Recyclates may offer a **better overall CO_2 balance** than the extraction of primary material. Furthermore, their production and use are more environmentally friendly than that of mineral fertilizers (e.g., regarding heavy metal content or for soil improvement).

- There are **insufficient collection structures** for separate collection and an insufficiently functioning EU internal market.

Evaluation / Summary:

Organic fertilizer as well as biogas / biomethane are produced from biowaste. Biomass is also a carbon source and the starting point to produce bio-based chemicals / plastics.

Organic fertilizer is produced from direct composting of organic and green waste or from composting of fermentation residues from organic waste or applied directly in agriculture as fermentation residues. Depending on its origin, there are different possibilities for application, for example in agriculture or in horticulture or landscaping.

The amount and the use of organic fertilizer tend to be increasable. However, both vary greatly depending on the type / origin of the recyclates and the intended use. If the biodegradable fraction from residual waste and all other biodegradable waste not yet collected (e.g., own composting, misdirected waste and illegal disposal) were collected separately, the availability of organic fertilizer could be increased. Area-wide collection systems (pick-up) should be preferred to bring systems.

The product status is particularly important in cross-border traffic, as shipment as waste has hardly been possible up to now. Under the new EU Fertilizer Regulation, however, there is the possibility of CE marking, which removes legal hurdles. At present, institutions for certification and quality assurance are still lacking. Furthermore, restrictive regulations in fertilizer law (‘DüngeV’ stricter than EU Nitrate Directive) make compost fertilization for agricultural purposes more difficult.

Measures should aim at improving collection structures. Compared to competing material flows such as industrial and primary fertilizer as well as sewage sludge, biowaste for organic fertilizer requires more effort in collection and treatment. Their use is therefore also associated with higher costs than material flows that are available on the market for the same use as fertilizer.

3.5 Glass

3.5.1 Container glass

Key figures: The glass recycling rate in Germany has remained constant at over 80 percent for years (2020: 84.2 percent). On average, glass packaging consists of 60 percent cullet, and in the case of green glass the figure is significantly higher, up to 90 percent.[9]
▪ The **demand** for recyclates **exceeds the supply.** ▪ The recycling of the material stream is associated with **low operational costs.** In order to achieve legal requirements, the infrastructure must be further expanded. ▪ The **transaction costs to** purchase recyclates **are low.** ▪ There are **low technical barriers to** recycling processes. ▪ **Quality requirements and safety requirements can be met**. The required quality in the recyclates can be measured. Quality standards are available. ▪ Recyclates may offer **a better overall CO_2 balance** than the extraction of primary material. ▪ There are **good collection structures** for separate collection and a functioning EU internal market.
Evaluation / Summary: Container glass can usually be recycled repeatedly without significant loss of quality. Container glass already has high collection and recycling rates. The amount of recyclates can be increased to a small extent, e.g., through better collection in households. The procurement of recyclates must be cheaper than the procurement of primary raw materials.

3.5.2 Flat glass

Key figures: In 2016, around 1.670 million tonnes of flat glass were sold in Germany. Of 455,000 t of available flat glass recyclates from flat glass recyclers in 2016, twelve percent was applied in flat glass production, 52 percent in container glass production and about 36 percent of cullet went into the production of mineral wool and glass bead powder.[10]
▪ The **demand** for recyclates **exceeds the supply.**

[9] ***Umweltbundesamt. (2022).*** Glass and waste glass. https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/glas-altglas#massenprodukt-glas
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. (n.d.). Waste glass. https://www.bmuv.de/themen/wasser-ressourcen-abfall/kreislaufwirtschaft/abfallarten-abfallstroeme/altglas
[10] ***IFT Rosenheim. (2019).*** Recycling of flat glass in the construction industry - Analysis of the current state and derivation of recommendations for action. https://www.ift-rosenheim.de/flachglasrecycling

- Recycling of the material stream is associated with **low operational costs.**
- The **transaction costs to** purchase recyclates **are high.**
- There are **low technical barriers to** recycling processes.
- **Quality and safety requirements are high**. However, the required quality in the recyclates is difficult to measure. Quality standards are available.
- Recyclates may offer **a better overall CO_2 balance** than the extraction of primary material.
- When replacing building and car glass, there is usually a collection structure for separate collection. When demolishing buildings and scrapping cars, there is usually no separate glass collection.

Evaluation / Summary:

Flat glass can be recycled repeatedly without significant loss of quality. However, high quality requirements make it difficult to use flat glass cullet in production processes. Flat glass is also bound in products for a long time. Besides closed-loop recycling (flat glass - flat glass), flat glass cullet is now mainly used in container glass production. In the area of building demolition and car scrapping, there is only a small amount of cullet potential to be tapped.

3.6 Metals

3.6.1 Non-ferrous metals

Key figures:

In 2020, the production of raw metal and alloys in Germany comprised 2.24 million tonnes, with scrap accounting for 1.03 million tonnes (approx. 46 %).[11]

- The **demand for** non-ferrous metals produced from secondary raw materials is set to increase significantly in the **future** due to a strong increase in demand from customers in the overall political context of the Circular Economy.
- The recycling of the material stream is associated with **comparatively low operational costs at the collection, sorting and processing level. In contrast, the costs incurred in** the **metallurgical smelting process** necessary for recycling (technology, equipment, energy...) are **considerable.**
- The **transaction costs for** acquiring recyclates from non-ferrous metals produced from secondary raw materials are **generally low.**
- There are **low technical hurdles for preparatory processes at collection, sorting and processing level**. The technical and regulatory requirements at the smelting metallurgical level (smelters) are solved, but comparatively considerably more demanding.

11 ***WirtschaftsVereinigung Metalle. (2020).*** Metal Statistics. Setting out together. https://www.wvmetalle.de/index.php?eID=dumpFile&t=f&f=314715&token=ae6cf4b3bd20efc41f3d76bfb263e9af22798787

- **Quality requirements as well as safety requirements can be fulfilled**. The required quality in metals produced from secondary raw materials does not usually differ from metals produced from primary raw materials. Quality standards are available. - Recycled non-ferrous metals produced from secondary raw materials can generally offer **a better CO_2 balance** than the extraction of non-ferrous metals from primary material in the overall view. - There are **good collection structures** for separate collection and a functioning EU internal market.
Evaluation Summary: Non-ferrous metals (e.g., copper, zinc, and aluminum) are generally recyclable repeatedly and without significant quality restrictions. There are high recycling rates for important product groups, such as packaging, automobiles, batteries, or electrical appliances. The availability of secondary raw materials can still be increased depending on the type of metal and depends on the life cycle of the respective product. One hurdle: Depending on the product group, non-ferrous metals are bound for a short time (e.g., beverage cans) or for a long time (e.g., buildings) and in the latter case bring with them the conflicting goals of longevity and availability of metal scrap for recycling. Separate collection and / or deposit systems can potentially increase the return flows quantitatively and qualitatively. Measures should also promote new business models as well as a broad approach of CE in product design (e.g., in less material diversity, less composites, design for recycling, longevity, sharing models).

3.6.2 Technology metals (*precious metals / special metals often used in low concentrations, partly in the EU list of critical raw materials)

Key figures: Key figures vary greatly by metal type. For example, End-of-Life recycling input rates in the EU in 2021 are 22 percent for cobalt, 0 per cent for gallium, 33 percent for palladium and 7 percent for magnesium.[12]
- **The demand for** metals produced from secondary raw materials for ICT and future technologies is **expected to increase significantly** (in addition to strategic non-ferrous metals, this also applies to metals from the EU's list of critical raw materials). The reasons for this lie in a strong increase in demand from customers and a corresponding increase in demand in the overall political context of the Circular Economy and in the context of the energy / mobility and digital transformation. - Due to the mostly diffuse distribution of technology metals (TM) in low concentrations in products**, the recycling** of the material flow is associated with **high operational costs at the collection, sorting and processing level, and** thus also with **high transaction costs**

[12] ***European Commission. (2023).*** RMIS – Raw Material Information System. Cobalt. https://rmis.jrc.ec.europa.eu/rmp/Cobalt
European Commission. (2023). RMIS – Raw Material Information System. Gallium. https://rmis.jrc.ec.europa.eu/rmp/Gallium
European Commission. (2023). RMIS – Raw Material Information System. Magnesium. https://rmis.jrc.ec.europa.eu/rmp/Magnesium
European Commission. (2023). RMIS – Raw Material Information System. Palladium. https://rmis.jrc.ec.europa.eu/rmp/Palladium
End-of-Life Recycling Input-Rate: "The indicator measures, for a given raw material, how much of its material used in production consists of recycled scrap, i.e. scrap from end-of-life material. The End-of-Life Recycling Input-Rate (EOL-RIR) indicator does not take into account any scrap generated in the manufacturing process [...]", from Eurostat (2023), https://ec.europa.eu/eurostat/databrowser/view/cei_srm010/default/table?lang=de

for the acquisition of recyclates. The costs incurred in the metallurgical melting process necessary for recycling (technology, equipment, energy...) are considerable.

- **In some cases,** there are **high technical hurdles** for preparatory processes **at the collection, sorting and processing level** (selective dismantling and subsequent concentration). The technical and regulatory requirements at the smelting metallurgical level (smelters) are demanding.

- **Quality requirements as well as safety requirements can be fulfilled.** The required quality in metals produced from secondary raw materials does not usually differ from metals produced from primary raw materials. Quality standards are available.

- Recycled technology metals produced from secondary raw materials **can have a worse overall CO_2 balance** than primary metal produced in the mine. However, this varies and also depends on variables such as concentration content and thermodynamic behavior, also compared to the concentration content of the respective primary metal in the mine.

- There are **insufficient collection structures** for separate collection, but a functioning EU internal market.

Evaluation / Summary:

Major challenges lie both in the collection (collection, sorting) of material flows and in their treatment (pre-sorting, mechanical processing). Incentive systems such as deposits can potentially increase the return flows quantitatively and qualitatively. In addition, from a technological perspective, a more precise and deeper pre-sorting of the material flow, for example in Information and Communications Technologies (ICT), also makes sense and can increase the recyclates potential. More accurate and deeper pre-sorting could prevent too early shredding in the treatment of the material stream, as the metals are more difficult to recover after shredding. However, deeper pre-sorting increases the effort and cost of collection and sorting.

In contrast to base metals, it is fundamentally easier to recover precious metals such as gallium and germanium in the waste treatment stage, as they do not oxidize / go into the slag in a highly diluted form like many base metals.

To increase transparency, the collection and treatment of material flows by authorized actors should be ensured. Measures should also include a long-term increase and promotion of R&D and technological innovation and encourage new business models and a broad approach of Circular Economy in product design (e.g., in longevity, sharing models, design for disassembly').

3.7 Steel

Key figures:

The steel industry in Germany alone uses around 20 million tonnes of steel and iron scrap every year to make new products. Scrap is thus a central and sustainable raw material for steel production. In 2021, crude steel production amounted to 40.2 million tonnes, of which 17.4 tonnes of steel scrap were used (share of 43.3 %). [13]

In 2022, the foundries in Germany produced approx. 3.2 million tonnes of iron, steel, and malleable cast iron at approx. 230 active production sites. Traditionally, the foundry industry is an essential

[13] ***Wirtschaftsvereinigung Stahl. (2022).*** Steel scrap foreign trade. Statistical Report 2022. https://www.stahl-online.de/wp-content/uploads/2022_Statistischer-Bericht-Stahlschrott-Aussenhandel.pdf

part of the European Circular Economy with a very high share of scrap (secondary raw materials). In 2022, foundries purchased about 2.6 million tonnes of scrap. Including the production-related recycled material, this corresponds to a secondary raw material input of about 90 percent. [14]

- The **availability of** recycled steel scrap **is high**, but this always depends on the quality of the steel scrap supply. The **demand for steel scrap will also continue to rise**. The transformation of the steel industry goes hand in hand with the substitution of classic blast furnaces by direct reduction plants and electric arc furnaces. Iron ore will be replaced by steel scrap and will require a considerable increase in the demand for high-quality scrap from 2025 onwards. Initial studies put these additional quantities at 11 - 16 million tonnes per year. It will take at least another 50 years to meet the full demand from recycled material. Steel scrap will steadily gain in importance during this period, but the cycle will continue to require an influx of primary material until then.

- Recycling of the material stream is **associated with low operational costs**. The **transaction costs for** acquiring recyclates also tend to be **low**; existing challenges still lie predominantly in inadequate transport infrastructure. As a globally traded commodity, however, the economic viability of steel scrap depends on many exogenous factors. These include, in particular, the market behavior of steel scrap importers from third countries and trade barriers.

- There are **low technical hurdles for recycling processes**. In order to increase the quality of the recyclates, further R&D is necessary in the area of collection, sorting and processing technology, accompanied by increased digitalization. The demand for recyclates will increase due to the further development of steel production, especially climate-neutral processes. For a certain transitional period, the demand could even exceed the still increasing supply.

- **The quality and safety requirements are high but can be met**. Quality standards are in place. The steel industry in Germany requires mainly high-quality steel scrap to ensure the quality of its products.

- Recyclates may offer **a better overall CO_2 balance** than the extraction of primary material. Recycling, i.e., the melting process in the steel industry, is subject to the highest environmental standards worldwide.

- There are **good collection structures** for separate collection. Germany has a very close-meshed and comprehensive network of collection and processing facilities, and the EU internal market also functions well.

Evaluation / Summary:

The properties of steel, the multi-recyclability (99+ % recyclability) without significant quality losses, already lead to a high recycling share today. The use of steel scrap will increase in importance as part of the transformation. Steel is usually long-bonded in products and brings with it the trade-off of longevity and availability of steel scrap for recycling.

In order to improve the material cycle for iron / steel, it is not the quantity but the quality that is decisive. Suitable instruments include measures such as improvements in product design (keyword: Ecodesign), but also the intensification of R&D in the area of collection, processing and analysis technology, in order to provide, for example, steel scrap grades with a higher degree of purity or guaranteed minimum contents of desired alloying elements for the targeted production of certain steel products. Problems currently exist in particular with the bonding of different alloys as well as

[14] According to internal calculations of the ***Bundesverband der Deutschen Gießerei-Industrie e.V. (BDG)***

with composites of different materials or material groups. It is therefore important to have available data on the composition of the secondary material already at this stage.

3.8 Plastics

Key figures: In 2021, around 35 percent of all plastic waste in Germany was recycled. The share of recyclates was 16 percent for plastic products manufactured in Germany in 2021.[15]	
▪ The **demand** for high-quality recyclates **exceeds the supply.** The biggest obstacle is often the quality of the recyclates. ▪ The production of plastics from fossil raw materials is strongly linked to the oil price. **Depending on the oil price,** the recycling of the material flow is associated with **higher or lower operating costs** compared to fossil production. ▪ There are **regulatory hurdles and scaling needs with** regard to maximizing plastics recycling. Both mechanical and chemical recycling are applied to plastics. Furthermore, there is a need for accelerated developments in the field of recyclable product design. ▪ **Quality requirements are high**. Recyclates often have similar requirements to plastics from fossil raw materials in terms of quality, physical properties and appearance. Differing waste streams influence the quality of the recyclate. ▪ Recyclates can offer **a better overall CO_2 balance** than the extraction of primary material. ▪ **There are collection structures for separate collection**. Separate collection increases the sorting purity of the waste stream and improves the quality of the recyclates. Separate collection can be further improved and expanded (for example in the construction sector). **Trade in recyclates works in the EU internal market.** ▪ The **transaction costs to purchase** recyclate **are low.**	(Main) plastic types: PE-LD, -LLD PE-HD, -MD PP PS PS-E PVC PET ABS, SAN PMMA PA (PA6, PA66) PC Other Thermoplastics PUR
Evaluation / Summary: The difficulties in recycling are due to a variety of reasons, such as misdirection in waste separation (or lack of separation) and the wide range of plastics that are often used in compounds and are therefore difficult to recycle mechanically.	

[15] ***Plastics Europe. (2023).*** Material flow diagram plastics in Germany 2021: Facts and figures on the life cycle of plastics. Abridged version of the Conversio study. Available at: https://plasticseurope.org/de/knowledge-hub/stoffstrombild-kunststoffe-in-deutschland-2021/

At the same time, rapid progress is required to achieve the ambitious recycling targets of the EU, to bring the valuable material plastic more into the loop (and thus contribute to raw material independence) and to contribute to climate protection with the lower footprint of secondary raw materials.

The industry is focusing on measures for both product design and recycling technologies. In product design, the focus is on the use of mono-materials or more soluble composites so that products can be better recycled. In terms of recycling technologies, innovations are needed both in mechanical recycling plants, which recycle more material streams to better quality, and in chemical recycling processes. The latter also offer the opportunity to recycle material streams that are unsuitable for mechanical recycling and have so far been used for energy recovery. In addition, the industry is also developing solutions for tracking the properties of plastic products to improve sorting processes at the end of the life cycle. In this way, plastic waste can be sorted more precisely and mechanically recycled to a high quality.

4. Conclusions

The conditions of domestic primary raw materials, imported primary raw materials and Circular Economy Raw Materials are difficult to compare, the price situation in the various material cycles is completely different, and the collection and processing methods for Circular Economy Raw Materials, which are already established or not yet established, entail further differences. This makes it clear that there cannot be **a single** instrument for improving the Circular Economy.

However, some conclusions should be noted for the analyzed material flows:

- For most material flows, it will never be possible to do without primary raw materials - usually when demand exceeds the supply of Circular Economy Raw Materials or a product may not or cannot consist of 100 percent Circular Economy Raw Materials. For example, there are some material flows where a high proportion of recyclates is already used in production, but the use of primary raw materials will remain indispensable in the future (for example, the use of paper for recycling in paper production, waste wood in wood-based material production and gravel and sand in concrete production). We must therefore continue to secure primary raw material sources **and**, in parallel, promote the use of Circular Economy Raw Materials, ultimately triggering a Circular Economy in the holistic sense (keywords: design for circularity, circular business models, preparation for reuse).

- The situation is different for plastics - here the goal is to completely replace fossil raw materials in the long term through the use of recycled materials, biomass and CO_2. Efforts to use biomass certified as sustainable and CO_2 as raw material sources must be intensified. Carbon Capture and Utilization (CCU) strategies must be closely coordinated with climate and Circular Economy policies.

- For some material flows, the amount of waste produced varies over time and regionally, e.g., mineral construction and demolition waste or waste wood. There is a risk here that advantages associated with the use of Circular Economy Raw Materials are lost due to additional processing and transport costs, and that the overall CO_2 balance can also deteriorate.

- The demand for recyclates is already very high for some raw materials or will increase considerably in the short term. These include glass, paper, wood, non-ferrous metals such as copper and aluminum, minerals, and steel.

- Despite the average recycling rate of just under 90% in the mineral sector, the public sector should generally invite tenders for more RC building materials ("pull effect necessary"). If, in addition, policymakers aim for even higher-quality recycling and understand this to mean RC concrete, then this may have an impact on climate protection, but not necessarily on the conservation of resources.

- In the case of glass, paper, wood, non-ferrous metals such as copper and aluminum as well as steel, the demand for recyclates is already market-driven and political measures with a "pull effect" (concerning the demand side) should be avoided; minimum recycled content quotas are not conducive here. It is rather a matter of improving the supply side where possible.

- There are high requirements for recyclates, for example, for plastics for food contact materials (quality, safety and health requirements) and for flat glass. Here, "push measures" are to be preferred to possible "pull measures".

- In some material flows, the levers are in the market, in others they are in the legal sphere. Depending on the material flow, the end of the waste property and the by-product property play a central role.

- From a raw material perspective in the Circular Economy, the role of by-products that do not qualify as waste according to § 3 (1) KrWG should also be mentioned. Just like recyclates, these contribute to climate protection, the conservation of primary raw materials and the reduction of raw material dependencies, for example in the area of wood.

- In order to be able to evaluate in a holistic approach whether the use of Circular Economy Raw Materials offers a better CO_2 balance than the use of primary raw materials, the development of accounting methods for CO_2 savings along the entire value chain is necessary. For a holistic approach, it must also be considered that (adverse) effects can also arise outside the "own" value cycle.

5. Recommendations for action

The German supply of raw materials is based on three pillars: Domestic primary raw materials, imported primary raw materials and Circular Economy Raw Materials. The pillar of Circular Economy Raw Materials must be significantly strengthened.

Effective and bureaucratically lean framework conditions and fair competition rules are needed to increase the use of recyclates and industrial by-products in the raw material markets. Apart from the energy sector (bio-fuels / electricity from biomass), there are also no incentives for the material use of biomass (for chemicals / plastics / wood-based materials).

Political framework conditions and measures must pursue the goal of promoting the transformation of industry towards a Circular Economy in a holistic approach. In the face of multiple global crises, framework conditions for a Circular Economy and fair competition rules are crucial to strengthen the competitiveness of Germany as an industrial location and the resilience of industry in key stages of the value chain, to reduce dependence on imports of strategically important raw materials and to achieve climate targets. As far as possible, measures should be designed to reduce the use of natural resources and CO_2 emissions in the economy as a whole.

In the following, various recommendations for action are drawn up for Circular Economy Raw Materials.

5.1 Two-step procedure for impact assessment of measures

We propose a two-step review process for impact assessment of measures.

Step 1: For an evaluation of a material flow, it is useful to check the actual availability of recyclates and industrial by-products at the time of measurement and their possible availability (in the foreseeable future) in relation to demand:

Step 2: Availability and demand are in turn influenced by further parameters (see Table 1 - Parameters for markets for Circular Economy Raw Materials) to be considered for the individual material flows. Here, it is advisable to examine and identify the parameters which

a) improve the supply and use of recyclates and by-products in the foreseeable future. Examples are an improvement of the infrastructure for take-back and collection as well as technological openness in recycling processes. Measures that aim to improve the availability of recyclates and by-products ("push measures") are often accompanied by an increased need for investment, for which a secure legal framework is required. The aim must be to make better use of waste and by-products.

b) increases the demand for recyclates and by-products. Quality assurance measures, the development of European standards / norms, the use of track & trace and digitalization can be mentioned here as examples. They offer the potential to increase market confidence in recyclates and by-products and reduce associated transaction costs ("pull measures”).

In the overall assessment, the ecological advantage of the use of recyclates and by-products should always be examined and ensured, and possible undesirable market distortions should be kept in mind. Measures should be set up in such a way that no material shifts (switching to substitutes for materials with negative impacts on the environment and climate) or artificial price distortions or increases occur due to undersupply of raw materials for recycling processes.

5.2 Material flow-specific evaluation of "push" and "pull" measures

In order to increase the <u>demand for recyclates and by-products</u>, the following measures (also called "pull measures") are urgently needed as a matter of priority:

- **Increased market confidence - norms and standards:** A development and existence of quality standards and norms increases market confidence in recyclates and by-products. When developing norms and standards, the “bottom-up approach” is crucial, i.e., norms and standards should be developed by industry for industry.

- **More market confidence - transparency through digitalization:** The provision of funding for start-ups and companies should be increasingly evaluated in the context of the Circular Economy and digitalization. For example, digital technologies, machine learning and data such as digital marketplaces or track and trace can increase market transparency and boost demand for recyclates and by-products, thereby making an important contribution to raw material supply. For the implementation of circular technologies, contact points must also be created that can advise SMEs in particular on the use of digital technologies. Strengthening cooperation between start-ups and industry is an equally important goal to strengthen this interface.

- **More market confidence - the public sector as a role model:** In the last legislative period, the federal government amended Section 45 of the Circular Economy Act (‘KrWG’) to establish a fundamental obligation for contracting authorities to give preference to environmentally friendly products and materials, although this does not establish any legal claims by third parties. According to this, preference is to be given to products that have been manufactured in resource-conserving, energy-saving, water-saving, low-pollution and low-waste production processes or by preparing them for reuse or by recycling waste, in particular using recycled materials, or from renewable raw materials. In addition, Section 45 KrWG covers products that are characterized by durability, ease of repair, reusability and recyclability. However, the requirements of § 45 KrWG have demonstrably no stimulating effect on sustainable procurement in the sense of the Circular Economy. Sustainable procurement should be given binding force, legal certainty and implementability.

- **Legal equality of Circular Economy Raw Materials:** Circular Economy Raw Materials should be placed on an equal legal footing with primary raw materials, insofar as this is technically justifiable. Requirements for unavoidable cross-contamination of Circular Economy Raw Materials must also consider that pollutants can also occur in certain concentrations in primary raw materials without human intervention. These concentrations occurring in nature can serve as orientation for quality requirements for Circular Economy Raw Materials and their release from the waste regime.

- **Strengthen economic competitiveness**: In addition to availability and quality, a decisive factor for the use of Circular Economy Raw Materials is their price in relation to primary raw materials. It should therefore be examined on a material flow-specific basis whether any price differences between primary and secondary materials that exist for structural reasons should be compensated for through targeted promotion. In addition, regulations on global trade, climate and raw materials policy, for example, should include Circular Economy Raw Materials in order to take into account the pricing of raw materials on global markets.

To improve the supply side of recyclates and by-products, the following possible measures (also called “push measures”) should be evaluated:

- **Improve collection & sorting:** Collection and sorting steps have a positive impact on the available quantity and qualities of recyclates. The goal of improving collection and sorting must be achieved at European level. In this way, not only can the input of recycling processes be increased, but ultimately also the availability and quality of recyclates. In this context, potential for improvement must be evaluated on a product- and material flow-specific basis.

- **Strengthen circular product design:** Product design in particular can have a significant influence on the reparability, but also recyclability of products as well as the quality of recyclates and thus serves to improve the supply of recyclates. The industry has set itself the goal of promoting circular product design and implementing it wherever possible. Within the framework of the sustainable product and material policy of the EU, a product-specific consideration of criteria of "Design for Circularity" such as e.g., durability, reusability, reparability, recyclability is to be undertaken.

- **Establish practicable rules for the shipment of waste:** Reliable, enforceable, and practicable regulations are needed for the transport and trade of waste to produce secondary raw materials; illegal shipments must be prevented. In particular, measures to consistently simplify and accelerate waste shipment procedures within the EU are of central importance.

5.3 Proportionality of measures (view on minimum recycled content quotas)

The minimum recycled content quotas that are often demanded by the political side represent a strong regulatory intervention in the market. They cannot be implemented for all material flows or products, do not address optimal use in all material flows and can endanger the competitiveness of companies in some material flows. For those material flows for which mandatory product-related recyclate use quotas exist or are being considered by policymakers (e.g., in the Commission's proposal for an EU Packaging Regulation or for an EU End-of-Life Vehicles Regulation), a test scheme for impact assessment should be drawn up that maps the objectives and feasibility in practice (along the lines of 5.1).

If the instrument of the recycled material input quota is made binding, the availability should always be kept in view and be based on regular monitoring of the material flows, i.e., on a scientific data basis. A realistic assessment of the volume potentials in the area of Circular Economy Raw Materials is crucial for the establishment and effectiveness of measures taken. One challenge here is that the framework conditions for material flows can change quickly. Therefore, an agile, continuous monitoring of the situation is necessary.

Minimum recycled content quotas should only be considered when

a) via using the recyclates, an ecological advantage can be achieved holistically, and primary raw materials can be demonstrably protected;

b) a (potential) quantity of recyclates that can be used in the production of materials and goods can meet demand at a rate of use (in the foreseeable future) and the risk of a production stop can be excluded. This also means that underlying factors can be positively changed and, for example, the supply side of recyclates or also the demand can be improved in the foreseeable future. The duration of the implementation of measures to improve influencing factors must be taken into account in terms of transition phases;

c) quality and safety requirements can continue to be met;

d) the proportion of recyclates is traceable, i.e., measurable / ascertainable;

e) conflicts of objectives in the Circular Economy or with other areas of law are considered.

Example: Conflict of objectives: longevity vs. use of recycled materials: If, for example

a) a substance is bound in products over a long period of time;

b) there is already a high demand for recyclates in the material flow;

c) there is not a sufficiently large quantity of raw materials available for a recycling process / reprocessing compared to the demand;

d) and the availability of recyclates can hardly or hardly be increased in the foreseeable future;

then minimum recycled content quotas are not expedient. The supply of recyclates cannot simply be increased, especially in the case of material flows that are generally bound in the product for years: To do so, more waste would have to be produced. The goal here must rather be to make better use of the waste produced. In addition, incentives for 'Design for Circularity' and circular business models should be set that focus on waste avoidance (e.g., longevity, sharing models) and promote reuse, preparation for reuse and recycling of the material flow.

Example (preparation for) reuse vs. use of recyclates: If, for example

a) there is already a high demand for recyclates in the material flow;

b) there is not a sufficiently large amount of raw material available for a recycling process / reprocessing compared to the demand;

c) the availability of recyclates can hardly or hardly be increased in the foreseeable future;

d) and products of the material stream can be prepared for reuse;

then minimum recycled content quotas can exacerbate the existing trade-off between recyclate input and the preparation for reuse step. In this case, products are not sent to the preparation for reuse step in order to achieve high recyclate input rates. However, the ecological advantages of preparation for reuse compared to recycling should always be examined.

In the case of minimum recycled content quotas with the aim of increasing demand ("pull measure"), it must be ensured that the availability of usable recyclates in the production of materials and goods can also be guaranteed demonstrably and in the foreseeable future in the required quality. This is because improving the supply side of recyclates usually requires high investments, for example in infrastructure, R&D and technological openness in recycling processes, for which a secure legal framework is needed. The measure of a mandatory recycled content quota should not be applied in material flows where more waste would have to be generated in order to increase the supply of recyclates. Minimum recycled content quotas, which (as a "pull measure") aim to increase the demand for recyclates, should only be considered for material flows in which market potentials on the supply side are not yet (or cannot be) exploited, i.e., although sufficient Circular Economy Raw Materials that can be used for the production of materials and goods are or would be (foreseeable) available. Obstacles to this must be identified and removed.

Quality standards and mandatory recycled content must be uniformly defined on the European internal market and apply to all products that are introduced to the European market. Only in this way, a level playing field and fair competition rules can be established.

The goal of the Green Deal, the climate neutrality of the European Union by 2050, as well as Goal 12 (Sustainable Consumption and Production) and Goal 13 (Climate Action) of the 17 Sustainable Development Goals of the United Nations, are the cornerstones of our current economy. Political measures and framework conditions aimed at increasing the use of Circular Economy Raw Materials must always be designed with a holistic view of the three pillars of sustainability (economy - ecology - society). For example, a product-specific mandatory recycled content quota is only effective if its introduction does not in turn foreseeably increase the share of primary raw materials in another product group and thus merely shift CO_2 emissions in the economy as a whole. This is also accompanied by the need to develop accounting methods for CO_2 savings along the entire value chain.

5.4 Improving the data situation for better monitoring of material flows

A better data situation is indispensable for the adoption of suitable measures and framework conditions that are also effective in the right places for the functioning of the raw material markets for recyclates and industrial by-products. Only in this way, companies and policymakers can better monitor material flows in the Circular Economy in order to find out where challenges in the market or regulatory hurdles hamper the use of recyclates and industrial by-products and what measures can be taken to counteract this. If we improve digitizing material flows, then this is automatically linked to some form of "monitoring". Therefore, the use of digital technologies in companies and enforcement authorities should be promoted. These technologies, in combination with the further development of indicators at company, national and EU level, can help policymakers and companies to better monitor and control the use of recyclates, industrial by-products and biomass. The state should take on a role as a "promoter and rule-setter" in the area of monitoring / digital capture of data flows.

Recyclates should also be included in the official production statistics of the Federal Statistical Office (GP) so that the recycling success can be measured. Consistent application of the waste code numbers is also essential for awareness until product status is achieved. Furthermore, reliable indicators for a holistic approach to the Circular Economy must be developed, which cover underlying aspects of the raw material markets. A continuous recording and assessment of the situation in the individual material flows makes sense and can be supplemented, if necessary, by a consideration of product group-specific characteristics. Only in this way can effective and actually implementable measures be drawn up by companies and policymakers and, if necessary, subsequently corrected in the event of misjudgments regarding potential improvements in the availability of Circular Economy Raw Materials.

The plausibility of indicators must be constantly checked. This is underlined by the example of the Circular Material Use Rate (CMU), which is published annually by the EU Commission for the EU and its member states. According to the Commission's comments on the CMU, it is primarily a high recycling rate, but also low material consumption in the country, favored by low imports of raw materials and high exports of raw materials, that leads to a high CMU of a country. However, the plausibility of high CMU must be questioned, because if a country has a low total demand, this also means that little is produced. The CMU increases if a high share of recyclates is used when the demand for raw materials is low. A CMU across all materials is also highly aggregated and hardly comprehensible, as the indicator is weight-based, for example.

5.5 Coordination of the interfaces of waste, product and chemicals legislation

For substances recovered in recycling processes, the EU chemicals regulation REACH applies the privilege under Art. 2(7) d: The substances do not have to be registered if they are identical to already registered substances and prescribed information in Art. 31 (safety data sheet) and 32 is available. The interfaces between waste, product and chemicals legislation under REACH must be coordinated, especially with regard to the end of waste status. There must be no multiple regulations, overlaps or legal uncertainties. For substance law requirements, this means, for example, that the information requirements for substances on the REACH candidate list should be specified exclusively in the REACH Regulation.

5.6 Landfill ban on untreated municipal waste in the EU

In the European Union, considerable amounts of municipal waste are still directly landfilled and thus not recycled. This deprives the raw material cycle of valuable resources. In 2020, almost 30 per cent of municipal waste in the EU was still directly landfilled. In some Member States of the Union, the amount of municipal waste landfilled is even far above 50 percent.[16] In the sense of a holistic Circular Economy, it is imperative that the regulations on the disposal of waste in the EU are adapted in such a way that no recyclable municipal waste is sent to landfill by way of a pre-treatment ban. This is the only way to eliminate economic incentives for the direct disposal of municipal waste and at the same time reduce CO_2 emissions from landfills.

[16] Own calculation. Data from ***Eurostat. (2023).*** Available at https://ec.europa.eu/eurostat/data-browser/view/ENV_WASTRT/default/table?lang=de&category=env.env_was.env_wasgt / https://ec.europa.eu/eurostat/databrowser/view/env_wasgen/default/table?lang=de

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