

**Economic and Social Council**Distr.: General
24 August 2021

Original: English

**Food and Agriculture Organization
of the United Nations****Economic Commission for Europe
Committee on Forests and the Forest Industry****Food and Agriculture Organization
European Forestry Commission****Seventy-ninth session**

Rome, 22 to 25 November 2021

Item 3(g) of the provisional agenda

Forty-first session

Rome, 22 to 25 November 2021

Circularity concepts in forest-based industries – key findings**Note by the Secretariat***Summary*

This document serves to provide background information regarding item 3 (g) of the annotated provisional agenda for the Joint Session of the United Nations Economic Commission for Europe (ECE) Committee on Forests and Forest Industry (COFFI) and the Food and Agriculture Organization of the United Nations (FAO) European Forestry Commission (EFC). It details the key findings from the “Circularity concepts in forest-based industries” study (ECE/TIM/2021/INF.3; FO:EFC/2021/INF.3) and includes recommendations for the future work of the ECE/FAO Forestry and Timber Section (joint section) regarding forests and the development of a circular economy for consideration by the Joint Session.

Based on the recommendations from the study (included in section II of this document) the Committee and the Commission are invited to advise on the future work of the joint section in this area.



I. Review of circularity concepts in forest-based industries

1. The joint section analyzed circular approaches across value chains in a pilot study entitled "Circularity concepts in forest-based industries" (ECE/TIM/2021/INF.3; FO:EFC/2021/INF.3) to help determine what circularity means across different forest-based value chains. The information gathered has application for how circular approaches can be achieved for material such as wood, which deteriorates over time and cannot be as readily recycled as glass or various metals.

2. Although the focus of the pilot study has mainly been on the material flow, it demonstrated that a transition to a circular economy requires systemic transformation across entire value chains. It has shown that circularity requires new business models, connections across sectors and companies, as well as the application of new technologies and management tools as a circular economy necessarily, redefines the processes involved in product design, manufacturing and consumption. Furthermore, the analysis also demonstrated that forest-based industries have numerous interpretations of what a circular economy is and each value or supply chain is confronted by its own set of limitations, challenges and opportunities.

A. Woodworking sector

3. From a long-term perspective, wood as raw material can already be seen as used in a circular manner, primarily because it can return as nutrients to the biosphere. Being a bio-based and non-toxic material, it follows a natural cycle even though the loop may stretch over many decades, meaning wood has significant advantages over other non-biodegradable materials. However, unlike materials such as many metals, wood cannot be transformed or renewed (e.g. through chemical processes) in closed production loops as its cellulose fibers can only be reused a limited number of times. The circularity of wood is, for this reason, often seen through a perspective of the cascading use of transformed products, some details of which are briefly covered below.

1. Sawn wood

4. The sawn wood sector operates in what is commonly described as the solid wood value chain. It is a resource-based sector, maximizing resource efficiency has therefore been a critical condition for its economic viability for a long time. For this reason, sawn wood or associated side streams, are commonly used for a wide range of products such as wood-based panels, solid wood products, various construction products (such as beams, windows, and doors), wood chips and sawdust for bioenergy. Additionally, wood waste generated by the sawn timber production process can be a source of raw material for producing either particle boards or pulp with the quantity of wood co-products directed to side streams dependent upon the type of wood being sawed.

5. Resource efficiency is enhanced by using sawn wood in one stage for as long as possible before moving on to the next in a cascading model. However, in practice, there are several limitations to this approach, including its environmental and economic viability.

6. There is no single solution for transitioning to circularity – or closing the loop – for the sawn wood sector as such a transition requires system-wide innovation and coordination across the entire supply chain. Nevertheless, genuine potential exists for improved system efficiency concerning both the material use of sawn wood residues and sawmills reducing their imbalances between the material and energy used in connection with residues. This can include applying intelligent wood cycles, where "intelligent" refers to improved sorting processes that increase the volume of waste wood suitable for cascading use meaning that residues from sawmills and recycled wood are more effectively utilized.

2. Wood in construction

7. To facilitate more post-consumer wood entering the supply chain, systemic developments are needed to enhance the sorting, separating and recovering of such wood (e.g., efficient recycling/demolition is critical) to ensure that product waste can be cycled back as efficiently as possible at its end-of-life stage. This requires increased integration

across the value chain, including deconstruction operators and primary to tertiary processing procedures. Furthermore, moving away from the business-as-usual approach requires cross-cutting and networked systems with more robust collaboration between business ecosystems (e.g., municipalities, architects, designers, builders and end-users). Finally, there is the issue of the logistics and infrastructure surrounding the recovery process. For example, to recycle contaminated wood, attached metal needs to be removed by hand and, if further milling is required, additional metal detection processes need to be in place before processing to avoid damaging milling tools. This also applies to wood used in construction to hold concrete in place while it hardens. In both cases, it is difficult and costly to remove metal and concrete from the wood manually.

8. Another opportunity for the construction sector relates to the design of mass timber buildings for greater durability, including steps to hold materials in place for longer and prolonging the lifespan of the wood used to reduce the demand for new materials. This could, for example, entail standardized modular elements that could be reused and recycled more easily by gluing, dowelling or nailing major sections of a building and using preservatives or applying a protective surface coating. This would require that the entire wood life cycle is considered when constructing new buildings to allow for more efficient usage of side products (e.g., recovered wood). However, while these actions may prolong the life of wood used in construction, they may also affect the prospects to reuse and/or recycle wood later in its life cycle. For example, treating wood to increase its durability may make reuse more complex and also increase pollution. This highlights an essential concern about circularity: making a value chain more circular does not necessarily lead to increased sustainability, indeed, it can have a detrimental impact on the environment. To avoid this, all raw materials used to treat wood in construction would need to be renewable and non-toxic, and the wood itself would need to originate from sustainably managed forests. Moreover, different techniques used to increase the durability of wood will need to be adapted to specific criteria for sustainability (e.g., infrastructure that allows for material separation and recycling) to avoid negative externalities.

3. Bioenergy

9. Bioenergy products can come from various sources across the supply chain, including both upstream and downstream stages. In the ECE region, wood energy currently comes primarily from wood processing residues.¹ For example, a sawmill may have an integrated biomass power plant that uses waste residues from the milling process to supply energy for the mill's operations. From a circularity perspective, this is not the optimal use of generated waste but from the sawmill's perspective, it means valorizing what used to be waste and lowering production costs. Furthermore, from a sustainability perspective, using the waste locally (e.g., directly in the sawmill) may also lower the environmental impact (e.g., no transport or further processing). This again demonstrates that circularity does not necessarily equate to sustainability as optimizing the reuse of material can generate otherwise avoidable environmental costs.

10. Another issue for the woodworking sector relates to the increased competition for raw materials generated by the growing demand for renewable energy. In this regard, several international and national regulatory measures across the ECE region encourage solid biomass extraction (including woody biomass) for bioenergy use to reduce dependence on fossil-based products. However, renewable energy policies, which have been instrumental in advancing the bioenergy sector, have negatively impacted woodworking value chains and increased raw material costs. In addition, these regulatory measures have significantly increased the demand for wood fuel, drawing the supply of wood residues away from products with potentially higher cascading use-value. While this may be a positive development in some respects (e.g., increasing profitability), it also provides incentives that may limit the prospects for a circular woodworking value chain.

¹ <https://unece.org/circular-economy/press/products-and-residues-form-increasing-part-wood-energy-consumed-unece-region>.

B. Furniture manufacturing

11. Compared to the woodworking value chain, the furniture sector uses a much wider range of materials (e.g., sawn wood, wood-based panels, leather, fabrics, plastics, foam and metal). This imposes significant limitations on recycling (e.g., recycled wood streams are often contaminated with hazardous substances such as glues, nails and varnish). This, in turn, generates both dangerous working conditions and additional costs for recyclers. Consequently, waste management infrastructure capacities have a significant role to play when it comes to making the furniture sector more circular.

12. Design strategies (such as those involving disassembly, modularity, recycling, material recovery, reuse and remanufacturing, maintainability and end-of-life) need to consider the complete life cycles of the various materials used in furniture. While maximizing opportunities for the recycling and recovery of materials, design strategies also need to consider the needs of end-users. Currently, the responsibility of producers for the product normally ends when the furniture is sold while end-users are generally not given guidance on maintaining and repairing furniture (e.g., to extend the product's lifespan) or do not necessarily have access to such services if provided by the producer. This is commonly seen with essential parts ensuring a product's functionality often not made to last and spare parts not being available on the market. Compounding these problems in many countries is the fact that growth in the furniture industry relies on shortening the replacement cycles by stimulating consumers to buy new furniture before their existing pieces becomes unusable with marketing urging consumers to buy new furniture to have the latest design or follow current fashion trends. This is exemplified by the weak demand for second-hand furniture and a highly competitive furniture sector where low-cost product segments have developed, specifically addressing the increasing demand driven by a rising interest in interior design.

13. It can also be noted that the price difference between new and second-hand furniture is not significant enough to drive more sustainable purchasing behavior. This is coupled with poor awareness about the impacts of the ever-increasing production and consumption of new furniture. However, producers are neither the source of all the problems nor the source of all the solutions as there is still a prevailing linear trend ("take, make, use, dispose") amongst consumers. Attitudinal improvement and use behavior require concerted action among many different actors both within and external to the industry (e.g., market regulators) to address such issues affecting end-users and producers.

C. Pulp, paper and cellulose manufacturing

1. Pulp, paper and paperboard manufacturing

14. The complexity of the pulp and paper value chain makes any transition towards circularity a difficult prospect. This said, the sector needs to further reduce fibre loss and virgin resources utilized in paper production. This can be best achieved by preserving the value of the recycled fibers while entities within the paper and pulp sector partner with related actors (e.g., producers of inks, dyes and glue) to co-design additives that are easier to separate from paper and, if possible, non-toxic by-products from other industrial processes are used to produce paper. In parallel to the foregoing, improved coordination across the various value chains (or sectors) may be required to allow for recycling plants that can handle these new materials.

15. It can be reasonably argued that circularity and sustainability start with design. In the case of pulp and paper, the product design should focus on recyclability. This may include rethinking the materials' composition to influence products' physical structures or reactions to the inks when applied. Another avenue for increased sustainability is the viable sourcing of raw materials, not only from recycled paper but also from sustainably managed forests. Circular approaches can also include improved traceability for existing and new materials (e.g., those used in packaging) and the standardization of new fiber-based materials with a view towards quality management and suitability for recycling.

16. End-users also play a central role in the circularity of paper products. Indeed, including the end-user (e.g., consumer) in the material flow structure is vital to increase

recycling rates and for this reason, it is crucial to build public awareness about recycling. This said, policy measures that encourage recycling will succeed only if there are markets for recycled paper products and if the segregation and disposal of used paper products are cost-efficient. In addition to all of the above, consideration should also be given to the environmental impact and quality of the final product coming out of all new processes.

2. Cellulose-based fibers

17. Recent innovations in the use of cellulose-based fibers have expanded the potential use of materials from the forest-based industries, adding value to the forest sector and helping to address the growing demand for recyclable, responsible and ecologically sustainable fibers. Cellulose-based fibers may deliver better environmental benefits than synthetic fibers in terms of biodegradability, as well as cotton given its land area and water footprint. However, it should be noted that the reported environmental impacts from viscose, cotton and polyester often depend upon the emphasis put on different criteria in lifecycle analysis studies which are often produced by businesses with an invested interest. For example, the production of cellulose-based fibers, in particular viscose, requires a large number of chemicals in a process that raises several concerns. These chemicals can cause significant health problems for factory workers through direct exposure and present a high risk of acute aquatic toxicity lethal to many aquatic organisms if they leak into bodies of water. These two concerns alone demonstrate that the benefits of cellulose-based fibers may warrant further investigation.

18. Given the low rates of recovery and recycling of textile fibers, the textile industry would benefit from an improved system that combines reuse and the cascading use of worn fabrics wherever it is economically viable. Current technologies allow for the recovery of 50 per cent of raw cellulose fibers in textiles which can be replaced with alternative feedstocks, the latter of which can be recovered from agriculture and municipal residues, recycled textiles and other sources. As such, a greater focus is needed on establishing recycling schemes and improving recycling technologies (e.g., to separate materials) to address the complex and sizeable waste streams in textile production, a prerequisite for moving production towards the next generation of fibers. Nevertheless, it should be recognized that the recovery of irregular material streams with inconsistent quality may be economically and environmentally unsustainable as a commercial undertaking. Furthermore, the recyclability and biodegradability of cellulose-based fibers should not serve to justify the overproduction and overconsumption of textiles, hence, the primary sustainability imperative for the sector should be to produce less and to recycle more.

3. Cellulose-based plastics

19. Bio-based plastics provide an alternative to fossil-based plastics, particularly considering that such plastics are, in most cases, non-toxic, renewable and biodegradable. Bio-based plastics can be divided into three categories, plastics that are (1) bio-based and non-biodegradable, (2) bio-based and biodegradable, and (3) fossil-based and biodegradable. This section is primarily concerned with cellulose-based plastics produced from wood pulp (although bio-based plastics can also be made from other materials, such as food waste).

20. It can be noted that while the global demand for bio-based plastics has increased, it still only represents a small niche market. For example, the European Union (EU) actively promotes bio-based plastics, however, only one per cent of the plastic produced annually in the EU is bio-based. Furthermore, bio-based plastics sector is highly heterogeneous and cellulose-based plastics are only one type of bio-based plastics. Therefore, information about cellulose-based plastics is rarely distinguished from other types of plastic, which means that the analysis of the value chains in this section will be based on the bio-based plastics sector in general.

21. Challenges exist with bio-based plastic because the various types are very diverse and the little infrastructure that exists for their collection is highly fragmented. Furthermore, while new sorting and reprocessing technologies have been developed, they have not been implemented at a commercial scale yet. For example, there are techniques available to break down plastics into their base-chemical building blocks which can then be rebuilt into new products, however, the industrial composting infrastructure that does this is scarce and

requires considerable new investment. Additionally, the need to modernize waste disposal plants and new technologies to improve the separation and sorting of multi-material products only adds to this infrastructure deficit.

II. Recommendations

22. The analysis undertaken by the joint section was designed to be a starting point for the review of possible circular approaches available to the forest sector. Based on its key findings, further analytical work is recommended and briefly detailed as follows:

23. Knowledge building for informed policymaking:

(a) Based on the pilot study entitled “Circularity concepts in forest-based industries” prepare a series of smaller studies on circular models and their practical application by specific forest-based industries covered by the pilot study would be beneficial. Such studies could include a more detailed examination of how circularity concepts are being applied by specific forest-based industries, the identification of possible case studies, a consideration of existing and foreseeable obstacles as well as the lessons learned.

(b) A definition of a circular economy in the forest sector should be developed for possible adoption by the ECE Committee on Forests and the Forest Industry and FAO European Forestry Commission.

(c) Guidelines on good practice for the implementation of the principles of a circular economy, tailored to the forest-based industries in the ECE region should be developed. Such good practice should be based on the case study analysis of the actual value chains mentioned above and could also include information on how different forest-based industries can collaborate in an industrial ecosystem to avoid silo approaches and thus further enhance the circular use of natural resources.

(d) A strategy for implementation of the principles of a circular economy in forest-based industries should be developed that consider the specificity of individual industries and wood-based products.

24. Tools for data collection:

(a) There are no internationally recognized definitions and classifications for wood waste. Definitions of wood waste used in EUROSTAT classifications do not correspond with those of the World Customs Organization and hence there is a need to facilitate coordination. The annually issued Joint ECE/FAO/ITTO/EUROSTAT Forest Sector Questionnaire (JFSQ) has its own definitions. The joint section should continue exploring the possibility of developing a wood waste classification system, involving all relevant organizations. Such classification should serve as a tool supporting data collection and facilitating trade.

(b) Currently, key data is not collected by member States but calculated based on material inputs and outputs in production chains, meaning the data used are actually estimations that require a resource-intensive and complex process to determine. Capacity building in data collection for a circular economy in the forest sector would be both expedient and provide a more accurate picture.

(c) There is still significant variation in national capacities to report on forests and forest sector-related data within the ECE region. While some countries have developed advanced reporting systems, others still struggle to generate even basic information. As such, intensive capacity-building work is required to reduce these discrepancies.

25. Soliciting input from member States:

(a) An assessment of ECE member States’ priorities and needs in transitioning to a circular economy would be very useful – a survey to identify additional activities and policy tools, with particular focus on renewable materials should be conducted.

26. The Committee and the Commission are invited to recommend to:

- (a) Prepare a series of studies further reviewing the application of circular models in forest-based industries, including through the identification of case studies and lessons learned.
- (b) Develop a definition of a circular economy in the forest sector for possible adoption by the next Joint Session.
- (c) Develop good practice guidelines on how to implement circularity principles in forest-based industries.
- (d) Develop a strategy for the implementation of a circular economy in forest-based industries for possible adoption by the next joint COFFI and EFC session.
- (e) Continue work on a wood waste classification system for the ECE region.
- (f) Undertake capacity building activities in data collection for a circular economy in the forest sector.
- (g) Assess ECE member States' priorities and needs in transitioning to a circular economy.

Annex I

Background for the analysis

1. In the face of today's pressing socio-economic and environmental challenges as well as the ever-increasing use of natural resources, the concept of a circular economy has emerged as a promising economic system aimed at minimizing waste and making the most of economic inputs. It is a concept that has been attracting significant public and private interest which is, amongst other things, being reflected in new policy instruments and strategies, research, as well as private sector commitments to circularity. Reference to circularity principles can also be found in the Sustainable Development Goals (SDGs), in particular Goal 12² which calls for responsible consumption and production, the EU Circular Economy Action Plan³ and the Platform for Accelerating the Circular Economy (PACE),⁴ launched by the World Economic Forum. However, while the potential for a circular economy is increasingly recognized in both policy and science, there is no clear and commonly accepted definition of what circularity means, often being confused with complementary concepts such as sustainability and the bioeconomy.

2. A circular economy as a concept is often characterized as an approach that can reduce resources consumption by slowing, closing or narrowing natural resource loops⁵. For example, the Ellen MacArthur Foundation has defined a circular economy as an "industrial economy that is restorative and regenerative by intention and design" and an approach for "gradually decoupling economic activity from the consumption of finite resources".⁶ This conceptual construct relies on three principles, namely, to design out waste and pollution; to keep products and materials in use; and to regenerate natural systems. In contrast, the European Commission (EC) has defined a circular economy as a process by which "the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimized". From these two somewhat different perspectives, it can be noted that a circular economy is built upon the responsible and cyclical use of natural resources while minimizing the creation of waste and pollution.

3. One notable advantage for circularity and a circular economy stems from the fact that it can viably replace the prevailing linear economic models (e.g., "take, make, use, dispose") that depend on the unsustainable extraction of materials that are processed into goods, used for a relatively brief period and then typically disposed of as non-recyclable waste. While it should be recognized that the linear economy has delivered high standards of living and wealth in some parts of the world, this has been achieved by paying high socio-economic and environmental costs. For example, the global use of materials has almost tripled since 1970 and continues to accelerate with the global consumption of materials, such as biomass, fossil fuels, metals and minerals expected to double from their current levels in the next forty years if the world's economy continues with its 'business as usual'.

4. The above can be framed in another perspective, namely that the current rate of natural resource use means that 1.75 Earths are needed to support our current global demand for natural resources⁷ and despite the recent surge of interest in circularity, the linear production model still dominates the economic landscape. The 2020 Circularity Gap Report⁸ demonstrated this when it noted that only 8.6 per cent of the global economy, in terms of the

² www.un.org/sustainabledevelopment/sustainable-consumption-production.

³ European Commission (2020) Investing in the circular economy: A blueprint for a green recovery. DG Environment, Brussels.

⁴ <https://pacecircular.org>.

⁵ Slowing a resource loop implies extending the life of a product to slow down resource use. Closing a resource loop means creating a circular flow through recycling. Narrowing a resource loop means using fewer resources per product.

⁶ <https://www.ellenmacarthurfoundation.org/circular-economy/concept>.

⁷ www.overshootday.org.

⁸ www.circularity-gap.world.

share of cycled materials as a proportion of the total material inputs, was circular⁹ In addition, it is worth noting that according to the report, the degree of circularity dropped from 9.1 per cent, as calculated in the first report in 2018. Furthermore, the increase in material use contributes significantly to climate change, while the extraction and production of materials have adverse effects on land use, ecosystems, and freshwater quality. This exemplifies why society and industry have been calling for systemic change.

5. These trends demonstrate that current economic models cannot sustain linear processes of production and consumption based on the projected levels of natural resource use, and arguments for a transition towards circular value chains are linked to the increasing scarcity of natural resources and the ecological impact of human activities. This has led to the realization that a circular model is needed to replace linear production and consumption processes.

6. The role of the forest sector in the transition to such a system is related to wood being a biodegradable raw material and a strategic natural resource that can be used for creating reusable and recyclable materials. Moreover, wood is not a finite, energy or carbon-intensive raw material as compared to, for example, aluminium, steel, glass or petroleum products. Wood-based products and production residues can be used, reused (in a cascading system), recycled, and biodegraded.

7. This material efficiency, well embedded in the forest sector production processes, can be used in other value chains. The forest-based industries can thus help transform strategic sectors, such as construction, textiles or packaging industries, towards a circular system with a reduced environmental footprint. Therefore, there is a need to explore what the circular system means, also for the forest-based industries, and how circularity may affect the use of forest resources. In addition, it is crucial to analyze what circular practices are already in place in the forest sector and what possible limitations for the development of the circular economy may be.

⁹ Cycled back implies that the material is collected, sorted and processed in the same or other manufacturing processes. This includes maintaining/prolonging, reusing/redistributing, refurbishing/remanufacturing and recycling but excludes incineration or discharges to land, water or air which threaten the environment and/or human health.

Annex II

What is a circular economy?

1. Circularity has been influenced by several concepts and ideas over time and it remains a contested concept with a range of conflicting approaches, as seen in one systematic analysis which identified 114 different definitions for a circular economy.¹⁰ This highlights that the literature is awash with the various perspectives presented by individual authors and actors of what constitutes a circular economy at a conceptual level. There is, for example, one line of reasoning that wants to operationalize circularity within the boundaries of the current economic system, while another sees circularity requiring the transformation of the socio-economic order. They differ fundamentally in their views regarding the capacity of society to overcome resource limits and decouple ecological degradation from economic growth. These opposing perspectives reveal that a dominant concept that forms the foundation of the circular model is yet to emerge. This remains a key criticism of the concept and may have contributed towards limiting its overall appeal and impact in various political, economic and social spheres. This clarity issue is further compounded by some milestone publications, such as the Circularity Gap Report, which employ a wide range of definitions makes it difficult to measure or determine whether an industry is circular or not.

2. Despite the considerable diversity in the details of what many consider circularity to be, most definitions of a circular economy have a focus on material use and system change:

(a) Definitions that focus on material use commonly follow the three guiding principles of reducing (minimum use of raw materials), reusing (maximum reuse of products), and recycling (high-quality reuse of reclaimed raw materials). This is also known as the three Rs of sustainability or the 3R-approach.

(b) Definitions that focus on system change concentrate on closing production cycles while using renewable energy and applying system thinking.

3. The 3R-approach may arguably relate more to a reuse economy; however, in a closed-loop system, it is not only necessary that materials are recycled correctly but that the resultant products and raw materials retain a high quality. The number and sequence of the components in the R-approach have consequently evolved. Most recently, a more comprehensive 9R-approach has been developed as a result of the combination of several approaches that focus on both material use and system change.¹¹ The 9Rs include: Refuse, Rethink, Reduce, Re-use, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover (Figure 1).

4. For the needs of the analysis undertaken by the joint section, the focus was on the material flow across different forest-based value chains to consider the prospects for a circular economy in forest-based industries. The 9R-approach was used for value-chain analysis as it was deemed that it could capture the life cycle of forest-based products in the most complete way. The analysis covered value chains of wood-based materials produced by forest-based industries, such as sawn wood, paper and pulp as well as the derivatives of both. It can also be noted that the emphasis of the analysis was made on the circularity of the material flows amongst forest-based industries rather than on forests and forestry in general.

5. When considering circularity in the forest sector, it is crucial to recognize that certain materials are not recyclable. For example, and as previously mentioned, wood fibers deteriorate over time and cannot be recycled more than five to seven times.¹² For that reason, forest-based industries tend to employ a model of cascading use of wood-based materials. This is typified by the paper and pulp industry's co-production of heat and power that often use by-products, such as black liquor, created during the production process. Furthermore, while it was beyond the scope of the undertaken analysis to consider the carbon cycle as part

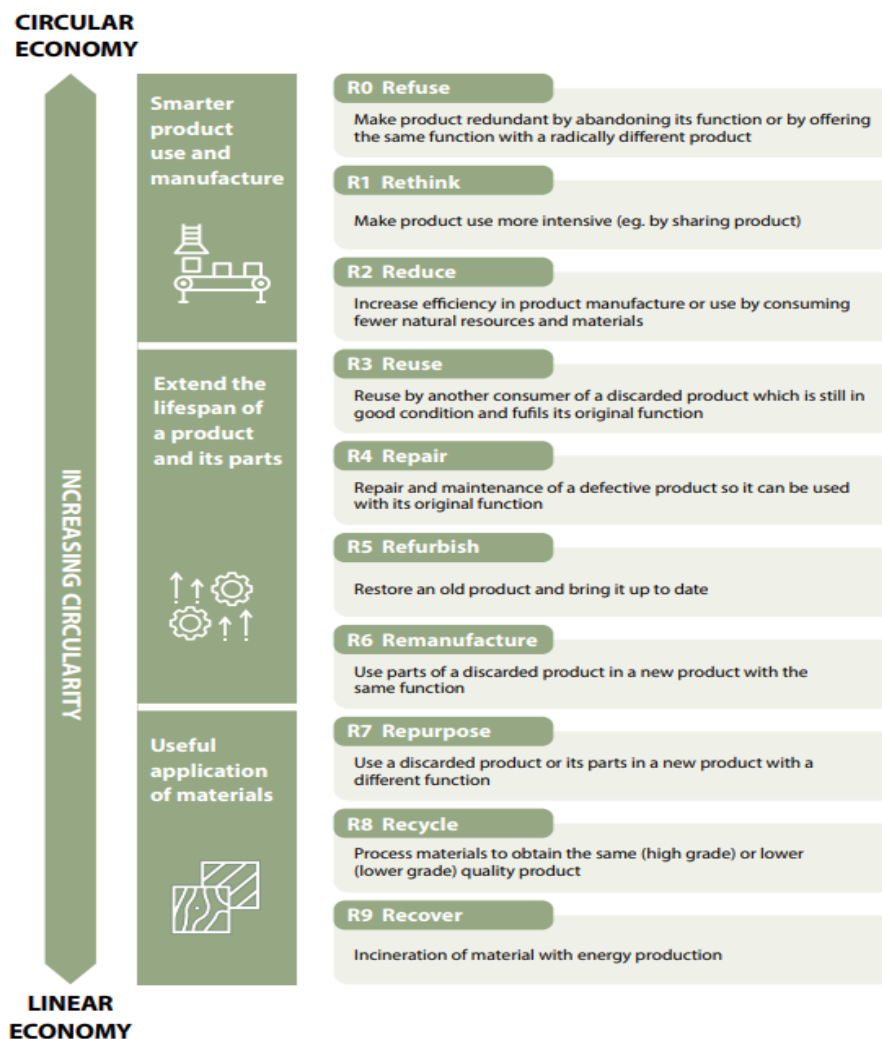
¹⁰ Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling* 127, 221-232.

¹¹ <http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf>.

¹² <https://www.worldatlas.com/articles/how-many-times-can-paper-be-recycled.html>.

of the circular model, it is a highly relevant issue for the forest sector. This relevance arises not only because of bioenergy production but also because the inherent characteristics of wood means that a cascading approach to its use may be more appropriate.

Figure 1. Circularity and the 9Rs



Source: Own figure adapted from Ellen MacArthur Foundation (see <https://www.ellenmacarthurfoundation.org>).

6. Bioenergy production needs a special mention at this point. Since it is not possible to recycle energy (e.g., heat), there is no consideration of energy cycles in most circular system concepts. In fact, many circular approaches (and definitions) do not consider energy production from biomass as being circular. This is based on the argument that once biomass is used to produce energy; it cannot be cycled back unless the entire circular carbon cycle is accounted for. In the forest sector, however, the wood energy cycle is an integral part of the carbon cycle and, in that sense, can be considered as a circular process.

7. Although there is no commonly agreed definition of what constitutes a circular economy, there are a few which are more commonly used than others. For example, the previously cited definition put forward by the Ellen MacArthur Foundation describes a circular economy both in terms of material use and from a systems perspective. The focus is on the design of materials, products and systems while drawing on cradle-to-cradle principles and system thinking. The idea is that circularity is considered at every stage of a product's lifecycle, from conceptualization, design and development through to use, disposal and reuse. This forms the basis for the 9R-approach, a closed-loop where the overall goal is to minimize the resources and energy put into the system and turning what was once considered end-of-cycle waste into start-of-cycle inputs. The model distinguishes between technical and biological cycles in that circularity involves materials of biological origin that can return to

the biosphere as feedstock, such as biomass products, and technical materials such as plastics and metals which cannot biodegrade but can circulate in closed loops. It is further assumed that problematic emissions associated with resource extraction and waste management will decrease in line with the reduction in resource extraction and waste production.

8. Another definition has been proposed by the European Environment Agency (EEA), where a circular economy is defined as a concept that can be "applied to all kinds of natural resources, including biotic and abiotic materials, water and land. Eco-design, repair, reuse, refurbishment, remanufacture, product sharing, waste prevention, and waste recycling are all important in a circular economy".¹³ It can, however, be noted that the approach to a circular economy on the EU level focuses mainly on resource efficiency and technological change as the way towards circularity. Most measures and targets are geared towards the recycling of different types of waste coupled with repair and eco-design regulations for a few products, including extended producer responsibility, although there are no set targets for repair and reuse activities

9. The joint section applied the understanding of circularity based on the concept developed by the United Nations Environment Programme (UNEP).¹⁴ Using these parameters, a circular economy is characterized as three value retention loops (see Figure 2). These loops, covering the life cycle of a product and/or material from extraction to production and end-of-use (or end-of-life), include:

(a) User-to-user loop: This covers value chain stages where a product and/or material provides its functions to end-user(s) (Figure 2, purple line). This may include reusing furniture so that it can be used as long as possible before the wood is recycled.

(b) User-to-business loop: This covers the value chain stages where a product and/or material is upgraded, in the form of repair, refurbishment or remanufacture, meaning producers are involved again (Figure 2, green line). This may include dismantling furniture to use its parts in new furniture with the same functions.

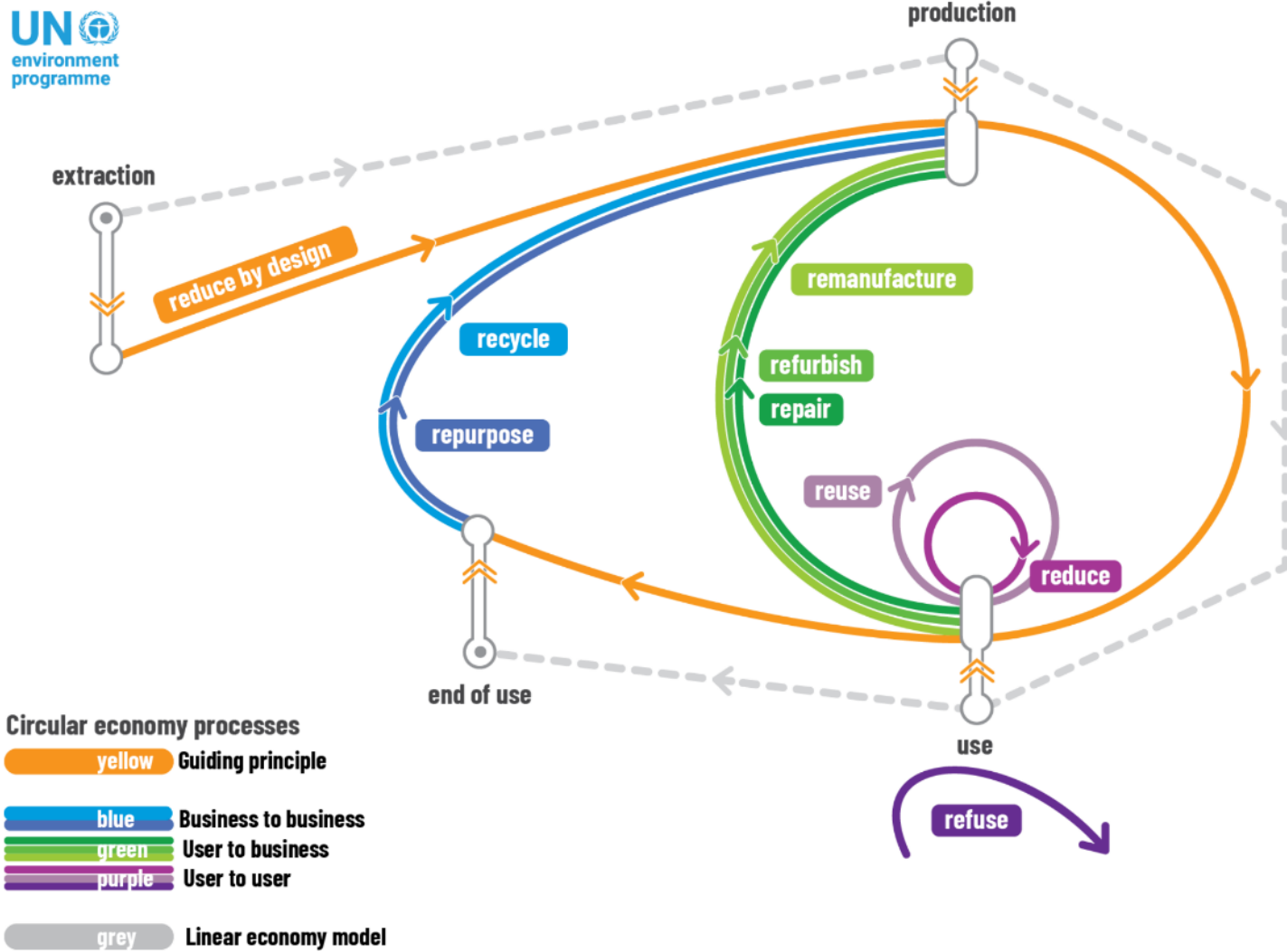
(c) Business-to-business loop: This covers value chain stages where a product and/or material reaches the end of its life and can be recycled or repurposed into a raw material that can be used in a different manner (Figure 2, blue line). This may include recycled pulp made out of used paper that is used as a raw material in paper manufacturing or used clothing given to businesses that make new clothing from the old textiles.

10. The UNEP circularity concept uses the 9R-approach when considering ways for the economy to become more circular. More specifically, circularity can be achieved within the respective loops (user-to-user, user-to-business, and business-to-business) and, crucially, through design. In this model, the number of materials used can be reduced mainly through design, which is considered a guiding principle from the earliest stages of the production model to the end-of-life for products. Within the respective loops, it is possible to further encourage reducing material requirements and reusing products within the user-to-user loop while the user-to-business loop focuses on repairing, refurbishing and remanufacturing. In contrast, the business-to-business loop focuses on repurposing and recycling to achieve circularity. With regard to all of the foregoing, it is important to note that specific pathways are not represented in this model, including the production of energy from waste.

¹³ EEA, 2016. Circular economy in Europe: Developing the knowledge base, EEA Report No 2/2016. European Environment Agency, Copenhagen.

¹⁴ <https://buildingcircularity.org>.

Figure 2. Circular economy model by UNEP



Source: <https://buildingcircularity.org>.