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A spotlight on innovation in Austrian industry

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A spotlight on innovation in Austrian industry

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SUMMARY

Policies to increase circularity in Austrian industries

This report summarises policies to foster circularity in selected Austrian industries, developed as part of the INTEGRATE project funded by the Austrian Climate and Energy Fund. The focus is on increasing the use of recycled material inputs in the production of steel, plastics, cement and timber, while at the same time reducing overall energy demand. The report first takes stock of the relevant policy landscape and Austria's current performance in the development of circular production technologies in these sectors. Then it documents the policy proposals that were developed in this project based on existing literature, expert interviews and several rounds of stakeholder interaction.

Policy inventory

The inventory of existing circular economy policies shows that in recent years, Austria has started to implement a broad policy framework in line with European Union (EU) legislation. Based on a comprehensive circular economy strategy, market price incentives were introduced and the regulatory framework has been adapted. Funding for research and development (R&D) is provided under a horizontal circularity mission, and subsidy programmes for technology adoption have been extended to circular technologies. Stakeholder engagement and information-based measures also play a prominent role.

Austria's circular innovation potential

The descriptive analysis of Austria's technological and export specialisation in international comparison provides evidence of a strong innovation potential in recycling, reuse and recovery technologies. Particularly in plastics and rubber recycling, the country has both a technological specialisation and a small export specialisation in the related industry, making it well-placed to benefit from the transition to a circular economy. At the same time, measured circularity in Austria is still low overall. Therefore, further steps are necessary to realise the full potential of the circular economy in Austria.

Policy recommendations

The policy recommendations developed with input from experts and stakeholders focus on areas that have not (yet) been addressed by national policy-makers. They include additional market price incentives to address the cost disadvantage of circular production in some industries; a phase-out of subsidies that hinder circularity; stringent implementation of EU ecodesign and minimum recycled content requirements, which should be further tightened and extended to more product groups; a revision of standards and norms for the circular economy; continued subsidies for R&D and technology adoption, especially for circular design, value chains and business models, as well as for innovative sorting and recycling technologies; improved access to private venture capital during the growth phase of circular start-ups; more awareness campaigns and training; and further initiatives for stakeholder networks along circular value chains.

ZUSAMMENFASSUNG

Maßnahmen zur Steigerung der Zirkularität

Dieser Bericht fasst Maßnahmen zur Förderung der Kreislaufwirtschaft in ausgewählten österreichischen Industriebranchen zusammen, die im Rahmen des vom österreichischen Klima- und Energiefonds finanzierten Projekts INTEGRATE entwickelt wurden. Der Schwerpunkt liegt dabei auf der Steigerung des Einsatzes von Sekundärrohstoffen in der Produktion von Stahl, Kunststoff, Zement und Holzbauprodukten bei gleichzeitiger Reduktion des Gesamtenergiebedarfs. Der Bericht gibt zunächst einen Überblick über bestehende Politikmaßnahmen und die aktuelle Leistungsfähigkeit Österreichs in der Entwicklung zirkulärer Produktionstechnologien in diesen Branchen. Anschließend werden die im Projekt erarbeiteten Maßnahmenvorschläge dokumentiert.

Maßnahmeninventar

Die Bestandsaufnahme kreislaufwirtschaftspolitischer Maßnahmen in Österreich zeigt, dass in den letzten Jahren mit der Umsetzung eines umfassenden politischen Rahmens im Einklang mit der Gesetzgebung der Europäischen Union (EU) begonnen wurde. Auf Grundlage der österreichischen Kreislaufwirtschaftsstrategie wurden Preisanreize geschaffen und der regulatorische Rahmen angepasst. Die Finanzierung von Forschung und Entwicklung (F&E) erfolgt anhand eines übergreifenden Schwerpunkts zur Kreislaufwirtschaft, und Förderprogramme für die Einführung neuer Technologien wurden auf die Kreislaufwirtschaft ausgeweitet. Zudem spielen die Einbindung von Interessensgruppen und informationsbasierte Maßnahmen eine wichtige Rolle.

zirkuläres Innovationspotenzial in Österreich

Die deskriptive Analyse der Technologie- und Exportspezialisierung Österreichs im internationalen Vergleich zeigt ein hohes Innovationspotenzial im Bereich der Wiederverwendungs-, Recycling- und Rückgewinnungstechnologien. Besonders im Kunststoff- und Gummirecycling weist Österreich sowohl eine technologische Spezialisierung als auch eine gewisse Exportspezialisierung in der verbundenen Industrie auf. Damit ist dieser Bereich gut positioniert, um vom Übergang zu einer Kreislaufwirtschaft zu profitieren. Gleichzeitig ist die Zirkularitätsrate in Österreich noch relativ niedrig. Um das volle Potenzial der Kreislaufwirtschaft in Österreich zu erschließen, sind daher weitere Schritte notwendig.

Empfehlungen

Die unter Beteiligung von Expert:innen und Stakeholder:innen entwickelten Maßnahmenempfehlungen konzentrieren sich auf Bereiche, die von nationalen Entscheidungsträgern noch nicht (oder noch nicht ausreichend) adressiert wurden. Dazu zählen zusätzliche Preisanreize, um den Kostennachteil auszugleichen, den die Nutzung von Sekundärrohstoffen in manchen Branchen hat; der schrittweise Abbau von Subventionen, die die Kreislaufwirtschaft behindern; eine stringente Umsetzung der EU-Vorgaben für Ökodesign und Sekundärrohstoff-Mindestanteile, die weiter verschärft und auf mehr Produktgruppen ausgeweitet werden sollten; die Überarbeitung von Standards und Normen; die Fortführung der Förderung von F&E und Technologieeinsatz, insbesondere für kreislauforientiertes Design, Wertschöpfungsketten und Geschäftsmodelle sowie für innovative Sortier- und Recyclingtechnologien; ein verbesserter Zugang zu privatem Risikokapital für zirkuläre Start-Ups in der Wachstumsphase; Bewusstseinskampagnen und Qualifizierungsmaßnahmen sowie Initiativen für Stakeholder-Netzwerke entlang kreislauforientierter Wertschöpfungsketten.

1 INTRODUCTION

Circular economy in the Green Deal

Transforming our current economic system from the linear model – based on resource extraction, processing, product use and waste – to a climate-neutral, circular economy is a central element of European Union climate policy ("Green Deal"). A circular economy is a model of production and consumption that minimises resource consumption and waste. Production is resource-efficient and products are designed to last longer, being shared, repaired and reused rather than owned and discarded. At the end of their life cycle, products are recycled and reintroduced into the material cycle as secondary raw materials. The overarching goal of the circular economy is to limit the rapid rise in resource consumption and waste seen in recent decades, which have contributed to pollution, biodiversity loss and climate change (European Commission, 2020).

Circularity contributes to decarbonisation

Currently, more than 60 % of global greenhouse gas emissions are caused by the extraction and processing of natural resources (IRP, 2024). Emissions in Austria primarily result from the use of fossil fuels in some industries, for example in the production of paper or chemicals. In other industries, emissions are mostly due to chemical reactions inherent in production processes, such as those for steel and cement clinker (Diendorfer et al., 2021). In both cases, circular production technologies can contribute to limiting greenhouse gas emissions. Firstly, they can reduce the amount of energy input required compared to primary production (see e.g. Dworak et al., 2022, for steel). Together with electrification, this helps limit overall energy demand, so that demand for renewables is less likely to exceed domestic supply capacity in the early stages of decarbonisation. Secondly, they can replace emission-intensive production processes.

Decarbonisation scenarios

For these reasons, circularity features prominently in long-term decarbonisation scenarios, such as the Scenario Transition 2040 for Austria (EAA, 2023). In addition to improvements in energy efficiency and a switch to renewable energy to achieve climate neutrality, this scenario includes measures to avoid energy and resource demand through longer-life products along with measures fostering the recycling and reuse of material production inputs. According to the qualitative storyline underpinning the scenario, circular product design allows for easy repair and recycling, and at the end of a product's life cycle, its resource content is recovered and recycled. Production uses as much secondary, recycled material input as possible. In the iron and steel, plastics and cement industries, the use of steel scrap, recycled plastics and cement increases considerably.

Low circularity rate in Austria

To realise this scenario, however, Austria still has some way to go. In 2023, the overall share of secondary raw material inputs in Austria was close to 14 %, which is only slightly above the EU-27 average and half the share of front-runner countries like the Netherlands, with more than 30 % (Eurostat, 2024).

The INTEGRATE project

The transition to a climate-neutral circular economy involves systemic changes to established modes of producing and consuming energy and materials. New, circular supply chains and business models based on sharing goods and services upend existing, linear production ecosystems and require new forms of cross-sectoral cooperation, as one sector's waste becomes another's valuable

input. New recycling technologies still need to be developed in some areas such as composite plastics, while in others they already exist but are yet to be more widely adopted (e.g. advanced sorting technologies for high-quality steel recycling). The INTEGRATE project focuses on the quantitative implications of this transition for overall energy demand and economic outcomes and on the policy framework needed to facilitate it.

Effects on economy and energy system

First, Kulmer et al. (2024) developed two scenarios for Austria to achieve climate neutrality by 2040.[1] In the reference scenario, decarbonisation in industry results mainly from a technological shift to renewable energy to produce hydrogen for the steel sector and other synthetic gases in chemicals and cement, including by means of carbon capture and utilisation (CCU). This scenario implies a significant increase in the demand for renewable electricity generation, particularly if future import possibilities for synthetic gases are limited, so that they need to be produced domestically. The alternative INTEGRATE scenario additionally introduces elements of circularity in industry – increased use of recycled materials in the production of steel, plastics, cement and timber – that are more energy-efficient than using primary production materials. The model simulation results indicate that these measures limit overall energy demand and raise domestic GDP compared to the reference scenario.

Co-creative policy development

Consequently, the project consortium prepared a set of policy recommendations to help realise the INTEGRATE scenario in practice jointly with the stakeholders involved. Two rounds of stakeholder feedback were gathered to support policy development. First, based on expert interviews and a review of relevant literature and policy documents, an initial policy proposal was formulated and presented to the stakeholders for comment. Second, the revised policy package was discussed in sector-specific and cross-sectoral groups at a one-day stakeholder workshop in April 2024. Finally, experts from Environment Agency Austria provided input for fine-tuning the policy package.

Transformative innovation policy for Austrian industry

This report documents the policies developed in the INTEGRATE project as input into the policy process to strengthen circularity in the production of steel, plastics, cement and timber in Austria. The focus is on innovation policy, which is understood here in the broad sense as "transformative" innovation policy, aiming to bring about a systemic transformation towards sustainability (Haddad et al., 2022). The "transformative" policy toolkit goes beyond the instruments of traditional innovation policy, such as public funding for the development or diffusion of new technologies. In addition, it includes instruments that address the economic, social and institutional setup as a whole. A comprehensive policy mix for the circularity transition should consist of an overarching policy strategy and policy instruments that induce changes to the regulatory framework, price incentives in markets, business models, social practices and the policy process itself (Rogge and Reichardt, 2016).

[1] The scenario analysis uses the recursive-dynamic macroeconomic model WEGDYN-AT (Bachner, 2024). To simulate the INTEGRATE decarbonisation scenarios, energy demand results from bottom-up sector models for buildings, transport, industry and energy supply, provided by the project consortium partners, were fed into the model.

Structure

The starting point in the next section is a survey of the existing circularity policy landscape in Austria, with a focus on the production of steel, plastics, cement and timber. This sets the scene for policy development, together with the section that follows. Section 3 provides an analysis of Austria's current innovative and economic performance in circularity technologies related to the focus industries, based on patent and trade data. This allows us to identify areas where Austria has technological and competitiveness advantages or weaknesses in international comparison, giving a descriptive indication of where policy interventions might be promising. Section 4 presents the INTEGRATE policy package for each industry based on the interactions with national stakeholders and experts. Section 5 summarises the policy recommendations and concludes.

Results and recommendations

Overall, Austria has a comprehensive policy strategy in place for the transition to a climate-neutral circular economy, as well as some promising areas of strength in circular technologies that should enable it to benefit from this transition. Its success now depends on policy implementation and on further adaptation to new developments. The following key recommendations emerge from the INTEGRATE project with respect to strengthening the use of recycled materials in the production of steel, plastics, cement and timber:

- Deploy additional market price incentives to address the cost disadvantage of using recycled materials compared to primary materials in the production of plastics and construction products
- Expand extended producer responsibility schemes to include more product groups and modulate licencing fees according to circularity criteria
- Identify and phase out subsidies that hinder circularity
- Ensure stringent implementation of EU ecodesign and minimum recycled content requirements – which should be progressively tightened and extended to more product groups – and of the digital product passport
- Revise standards and norms to enable greater use of recycled materials
- Introduce end-of-waste ordinances for plastics, concrete and mineral wool
- Enforce the ban on landfill and incineration of waste collected separately for recycling
- Mandate type-specific collection and sorting of all recyclable material waste
- Continue subsidies for R&D and investment in technology adoption, particularly for circular design, value chains and business models, and for innovative sorting and recycling technologies
- Regularly update priority areas for subsidy programmes and use sunset clauses to ensure phase-out once funded technologies are competitive
- Introduce circularity criteria into the province-level Housing Support Scheme ("Wohnbauförderung")
- Improve private venture capital access for circular start-ups in the growth phase
- Record residues from industrial processes in a waste materials catalogue

- Strengthen cross-sectoral industry networks to improve stakeholder coordination along circular value chains
- Expand awareness campaigns and training on the circular economy, e.g. on the quality and safety of recycled materials and on new technologies

2 THE CIRCULAR ECONOMY POLICY LANDSCAPE

Policy inventory

This section takes stock of the existing policy framework guiding the transition to a circular economy in Austria. The focus is on the circularity technologies considered in the INTEGRATE project – increased use of recycled materials in the production of steel, plastics, cement and timber. The inventory provides the background for developing new policies to foster circular innovation in Austrian industry. It gives an overview of relevant measures that have already been implemented or are close to implementation, as compared to those that are not yet implemented or being considered. First, the following subsection provides a summary of the literature on the combination of different types of policy instruments needed to induce systemic transformations ("policy mix").

2.1 Policy mix for the circularity transition

Policy instruments affecting innovation

Providing new, circular production technologies in all relevant sectors requires government policy to support their invention, commercialisation and diffusion. Without policy support, ideas for new environmental technologies face several obstacles,2 which can be addressed with the policy instruments outlined below.

Market price incentives

First, if producers are not required to pay for the negative environmental effects of their activities – for instance during the resource extraction, processing or waste phases of the linear economic model – the market prices they pay for their inputs are "too low" from an overall societal viewpoint. As a result, using recycled secondary instead of primary raw materials is, in many sectors, still the more expensive option. Nascent technologies like those in secondary resource use are also less productive at first, which stifles the innovation needed to reduce their cost (Acemoglu et al., 2012). Hence the current cost disadvantage of the circular model calls for an adjustment to market prices through taxes or other ways of making producers internalise the costs of their environmental impacts. Evidence suggests that price signals making environmentally harmful inputs more expensive "direct" innovative activity towards developing cleaner technologies (Aghion et al., 2016).

Funding for R&D and information-based instruments

Second, the benefit of an environmental innovation to society is often considerably greater than the benefit to the inventor alone, because knowledge about a new technology eventually becomes a public good that can also be used by other inventors. Therefore, without government funding for R&D, there is too little inventive. Third, information about a new environmental technology may initially be limited and its potential for commercial success highly uncertain, making it difficult for entrepreneurs to raise sufficient capital and slowing down widespread adoption (Jaffe et al., 2005). Standard policy instruments in this case

[2] In the economics literature, these are known as market failures. See Vollebergh et al. (2023) for an overview.

include public funding for start-ups and information-based instruments like awareness campaigns and training.

Regulatory measures and funding for technology adoption

New technologies become easier to use over time, as knowledge spreads and complementary technologies are adopted. Consequently, established technologies benefit from an ecosystem of customised infrastructure and supply chains that have developed around them. The resulting path dependency puts so-called radical innovations that change the system as a whole, such as renewable energy, electric mobility or circularity technologies, at a disadvantage and creates lock-ins in established technologies (Acemoglu et al., 2012). Besides the policy options mentioned above, subsidies for technology adoption and regulations such as targets, bans and standards are effective ways to incentivise breakthrough technologies (e.g. Rozendaal and Vollebergh, 2025). Overall, there is increasingly a consensus in the literature on the climate transition that policy-makers should use a broad mix of instruments to target the different challenges faced by new, climate-neutral technologies (Stern et al., 2022).

Policies for systemic transformations

Although technological innovation is important for the transition to a climate-neutral circular economy, it is not the only element of the current system that government policy should address. Changes to the social and institutional setup in which the economy is embedded are also needed to enable new modes of production and consumption. For example, the creation of new circular supply chains to replace existing linear production ecosystems requires finding new collaboration partners, as well as reform of the regulatory framework. New business models that enable individuals to meet their needs in resource-efficient ways, for example through social innovations such as sharing, depend on changes in social practices, norms and behaviour.

Stakeholder engagement and exnovation

Achieving systemic change therefore requires additional, "transformative" approaches that also address the policy-making process itself (Haddad et al., 2022; Rogge and Reichardt, 2016). Transformative innovation policy is guided by a strategic agenda that sets clear objectives and provides overall direction to policy-making across all relevant domains, levels of governance and economic sectors. It requires effective policy coordination and alignment. Broad involvement of stakeholders in the policy process helps to ensure the flow of relevant information from the bottom up and to establish new networks between demand- and supply-side actors. Finally, transformative innovation policy includes new approaches to innovation support, such as living labs or regulatory sandboxes, as well as phasing out detrimental technologies and practices that sustain the current system ("exnovation").

2.2 Circular economy policy in Austria and the EU

Circularity strategies

In recent years, initial steps towards circularity have been taken both in Austria and in the EU, where a substantial part of relevant legislation is passed. The key national document guiding the circularity transition is the Austrian Circular

Economy Strategy (BMK, 2022). At EU level, the Circular Economy Action Plan has set the scene for a number of policy initiatives (European Commission, 2020). Both documents emphasise the systemic nature of the transformation and propose a comprehensive mix of policy instruments addressing all stages of the product life cycle, from design to the waste phase, in key sectors like construction, plastics and waste management.

2.2.1 EU policy

EU Circular Economy Action Plan

Following on from its 2015 predecessor, the 2020 EU Circular Economy Action Plan presents a set of legislative initiatives to accelerate the transition to a circular economy, decouple economic growth from resource use and reduce waste. With these initiatives, the plan aims to mainstream sustainable products, services and business models and to establish a market for secondary raw materials. The following EU regulations and directives are relevant to INTEGRATE:

Waste Framework Directive

The Waste Framework Directive (2008/98/EC as amended in EU 2018/851) establishes the legal framework for waste management in the EU. It introduces the waste hierarchy as a priority order for waste management legislation, with waste prevention at the top, disposal at the bottom, and reuse, recycling and recovery in between. The Waste Framework Directive also formally defines **extended producer responsibility (EPR) schemes** as a set of measures to ensure the financial and organisational responsibility of producers for the waste management stage of their products' life cycle. The directive sets minimum requirements for EPR schemes and outlines criteria for end-of-waste status.

Ecodesign for Sustainable Products Regulation

The Ecodesign for Sustainable Products Regulation (EU 2024/1781) establishes a framework for **ecodesign requirements** for almost all product groups. It empowers the European Commission to specify details relating to requirements such as product durability, reusability, reparability, **recyclability**[3] **and recycled content** in follow-up legislation (delegated acts). Iron and steel are amongst the product groups to be addressed as a matter of priority. The ecodesign requirements build on the EU's existing framework of product standards and norms, some of which will have to be revised and others newly developed. This work is currently ongoing at national and international standardisation bodies with the involvement of EU member state representatives. Finally, the regulation contains general rules for labels and a **digital product passport**, which should make product-related information transparent along the value chain.

Packaging and Packaging Waste Regulation

According to the Packaging and Packaging Waste Regulation (EU 2025/40), all packaging should be **designed for recycling by 2030** and be recyclable at scale by 2035. Harmonised criteria to assess recyclability ("performance grades") are to be established and the **EPR scheme licensing fees modulated** accordingly.

[3] The ease and quality of recycling is defined based on the use of easily recyclable materials and the possibility for high-purity sorting, among others.

Separate collection and return systems and state-of-the-art sorting and recycling infrastructure are to be set up in all member states. The regulation also sets provisions **for minimum recycled content** in all plastic packaging by 2040. Packaging labelling will have to contain information on material composition and reusability to facilitate sorting for high-quality recycling.

Construction Products Regulation

The revised Construction Products Regulation (EU 2024/3110) introduces environmental sustainability requirements into a harmonised **performance-based** standardisation process for construction products, including cement and timber. It enables the European Commission to specify, in delegated acts, requirements for construction products to be, for example, **easy to dismantle, separate and recycle** and to have a certain recycled content. In addition, a digital passport system for construction products will be set up, which will also contain information on product reuse and remanufacture.

End-of-Life Vehicles Regulation

The proposed revision of the End-of-Life Vehicles Regulation (European Commission, 2023) establishes circularity requirements for the design, production and waste of vehicles to increase recycling and reuse of their components. It includes mandatory **minimum input shares** of recycled plastics, steel and other metals; a 30 % recycling target for plastics from end-of-life vehicles; a digital circularity vehicle passport; reinforced extended producer responsibility; and collection systems for and an **export ban** on end-of-life vehicles that are no longer roadworthy to increase the availability of recyclable materials.

2.2.2 Austrian policy

Austrian Circular Economy Strategy

The Austrian Circular Economy Strategy, adopted in 2022 after a comprehensive stakeholder consultation process, aims to transform Austria into a "climate-neutral and sustainable circular economy by 2050". It sets targets to reduce overall resource use and household material consumption and to raise resource productivity and the circular material use rate (i.e. the share of recycled secondary raw materials in total material input). The strategy contains more than 180 measures covering seven focus areas, including construction and infrastructure, mobility, plastics and packaging, and waste and secondary resources. Progress will be monitored by means of relevant indicators, regular progress reports (e.g. BMK, 2024a) and evaluations.

2.2.2.1 Adopted policy

A number of policies fostering circularity for plastics, metals and construction materials have recently been added to the legal framework for waste management in Austria, which in its modern form dates back to the Austrian Waste Management Act being passed in 1990. A brief overview is provided here, following the broad categorisation of instruments from section 2.1.

Regulatory measures

Austrian regulatory framework for waste management

The Austrian Waste Management Act regulates the management, prevention and recycling of waste (last amendment amended in Federal Law Gazette (BGBl.) I No. 200/2021). It includes the circular economy amongst its aims, enshrines separate waste collection and establishes the **minimum standards for extended producer responsibility (EPR) schemes** required by the EU Waste Framework Directive. The act also includes measures to increase the share of reusable drinks packaging to 30 % by 2030, and it sets recycling targets for municipal waste to be achieved by 2035.

Recycling of packaging waste

The Austrian Packaging Ordinance (last amended in Federal Law Gazette (BGBl.) II No. 597/2021) contains measures to increase the recycling of packaging in line with the targets set in the EU Packaging and Packaging Waste Directive. It defines **extended producer responsibility schemes for packaging** and mandates the separate collection of paper, glass, metal and plastic packaging. All PET bottles must contain at least 25 % recycled plastics from 2025. From 2030, all single-use plastic beverage bottles must have a minimum recycled content of 30 %. Also by 2030, all plastic packaging must be either reusable or recyclable.

Public procurement in construction

The National Action Plan for Sustainable Public Procurement has been adapted to include circular construction criteria, including the dismantling of buildings and recycling of construction and demolition waste.

End-of-waste criteria for construction products

Criteria for the end-of-waste status of recyclable construction materials are established in the corresponding ordinances for timber recycling and for recycled construction materials. New national end-of-waste ordinances are currently being prepared for excavated soil materials and gypsum. End-of-waste criteria for steel scrap have been established by an EU regulation (333/2011), and for blast furnace slag, the conditions in the Austrian Waste Management Act apply.

Landfill bans for recyclable materials

The 2021 revision of the Austrian Landfill Ordinance (Federal Law Gazette (BGBl.) II No. 144/2021) **bans the depositing at landfill sites of waste that is collected separately in preparation for reuse or recycling**.[4] From 2024, this applies not only to plastics (including composite materials) and metal waste, but also to certain uncontaminated construction and demolition waste such as demolished concrete; from 2026, it will apply to gypsum plasterboards too, and from 2027, to artificial mineral wool waste exceeding three tonnes from the demolition of buildings. Suitable waste wood, as specified in the Austrian Timber Recycling Ordinance, must be collected separately by the waste wood producer and recycled, as long as costs are not disproportionate.

Market price incentives

Extended producer responsibility schemes

Extended producer responsibility schemes exist for packaging, electric and electronic goods, vehicles and batteries. Producers must participate in waste collection and recovery systems and cover their costs, as well as those of awareness-raising measures on waste prevention. There are currently five collection and

[4] The Austrian Waste Management Act also bans the incineration of such waste.

recovery systems in Austria that handle producer responsibilities for packaging, electric and electronic goods and batteries. The first of these was established in 1993. For packaging, **EPR fees are modulated by material**, in that glass and paper packaging waste is cheaper than metals and plastics. Additional eco-modulation criteria, such as recyclability or recycled content – as outlined in the EU Packaging and Packaging Waste Regulation – have not yet been implemented, but national implementation options are currently being explored.[5]

EU "plastics tax" The EU "plastics tax" of EUR 0.8 per kg of non-recycled plastic packaging waste is a mandatory contribution to the EU budget by member states in the period from 2021 to 2027. In Austria, it is paid from the national budget rather than by plastics producers or importers, as is the case in Spain, for example.

Littering fee Since 2023, producers of single-use plastic products and packaging have been obliged to pay a littering fee to cover the costs of litter clean-up operations and treatment. In 2025, the fee amounts to EUR 225 per tonne.[6]

Deposit-return scheme A deposit-return scheme for single-use plastic beverage bottles and metal tins started operating in 2025, with a deposit of EUR 0.25 per item.

Household waste disposal fee Household waste disposal fees are set by municipalities and increase with bin volume and the number of collections. In some municipalities like Vienna, the fee per litre of waste is independent of waste volume, while in others such as Graz, it decreases with volume.[7]

Landfill levy Austria has a landfill levy ("ALSAG-Beitrag") on the depositing and incineration of waste. Revenues from the levy are used to clean up contaminated sites. Currently, the levy is about EUR 9 per tonne for incinerated waste; EUR 11 per tonne for waste deposited on landfills for excavated soil material and construction and demolition waste; EUR 24 per tonne deposited on landfills for residual waste; and EUR 35 per tonne deposited on landfills for large-scale or hazardous waste.

Funding for research and development

R&D funding initiative The Austrian government has been funding applied research through a **circularity mission** under its FTI (Research, Technology and Innovation) programme since 2021.[8] The circularity focus runs horizontally across a range of thematic fields and funding instruments, including industrial R&D. In the period from 2024 to 2026, EUR 92 million are available for the main R&D funding initiative under the circularity mission, "Circular Economy and Production Technologies" (BMK, 2024a). It addresses all stages of the value chain, from circular design and

[5] See https://www.ara.at/news/europaeische-verpackungsverordnung-ppwr-der-vierte-event-der-veranstaltungsreihe (in German).

[6] See https://www.ara.at/news/kostenersaetze-fuer-littering-abgabe-finalisiert (in German).

[7] See https://www.wien.gv.at/umwelt/ma48/tarife/hausmuell.html (in German) and https://www.holding-graz.at/en/waste/residual-waste-tariffs/.

[8] For the 2024–2026 period, see https://fti-ressourcenwende.at/en/. For the 2021–2023 period, see https://nachhaltigwirtschaften.at/de/themen/kreislaufwirtschaft/ (in German).

production to product use and recycling. Past projects have covered circular design, increased steel scrap recycling, optimised processes for mechanical plastics recycling, novel clay construction materials and buildings recycling.

Funding for the adoption and diffusion of circular innovation

Investment subsidies for technology adoption

The **Domestic Environmental Support Scheme** ("Umweltförderung im Inland") is a national funding instrument providing investment subsidies to households, companies and municipalities for adopting or implementing measures that improve environmental performance, primarily regarding climate change. In 2023, its scope was extended to measures advancing the circular economy, for example by recycling or otherwise recovering waste, or by producing or using high-quality secondary raw materials.[9] In 2024, EUR 41 million were available in subsidies under this scheme, including for circular design and for recovery or recycling facilities for certain types of construction and plastics composite waste (BMK, 2024a). Before 2024, subsidies of EUR 60 million covered investment costs for new or improved sorting facilities for plastics packaging.[10]

Start-up funding and internationalisation support

A number of additional funding schemes exist under the circularity mission of the Austrian FTI programme, among them support for innovative activities such as patenting, start-ups and international marketing. Start-up funding for circular economy projects is available from several federal and regional agencies, and internationalisation support is provided by the federal initiatives TECXPORT and go-international. A public database of all circularity-related funding schemes has also been set up ("Förderkompass Kreislaufwirtschaft").[11]

Information-based instruments and stakeholder networks

Knowledge exchange

The Austrian Federal Ministry for Climate Action has launched several platforms for knowledge exchange, stakeholder collaboration and dialogue on the circular economy. In 2023, the focus area "**circularity at the Climate Lab**" was established as one of the flagship measures in the Austrian Circular Economy Strategy. The Climate Lab serves as an innovation hub and brings together companies, policy-makers and other relevant stakeholders to develop solutions and networks across industries. Topics covered include secondary material use in the cement and steel industries and circularity in construction materials.

Stakeholder engagement

The **Task Force Circular Economy** was established in 2023 as a cross-ministerial advisory board on the implementation of the Circular Economy Strategy, with members from public administration, science, business and civil

[9] See e.g. https://www.umweltfoerderung.at/fileadmin/user_upload/umweltfoerderung/uebergeordnete_dokumente/FRL_Kreislaufwirtschaft.pdf (in German).

[10] See https://www.umweltfoerderung.at/fileadmin/user_upload/umweltfoerderung/betriebe/Sortieranlagen/UFI_Infoblatt_Sortieranlagen.pdf (in German).

[11] See https://fti-ressourcenwende.at/de/foerderungen/foerderdatenbank/ (in German).

society. A series of "progress dialogues" was held by Environment Agency Austria in autumn 2023 to coordinate policy implementation with companies, provinces, municipalities and NGOs and to collect information on barriers to be addressed. Existing circularity networks, regional cluster initiatives and **the Circular Economy Forum Austria**, an independent stakeholder platform, offer networking opportunities, seminars, information on best practices and other company support.

Awareness and information

Other initiatives include targeted awareness campaigns for consumers and a "resource check" evaluating municipalities' circularity status. A **Circular Economy Helpdesk** was established at Environment Agency Austria in 2024 to provide information and advice for stakeholders. The digital platform SECONTRADE offers an online marketplace where providers and users of secondary raw materials can trade steel scrap, recycled plastics, construction and wood waste.[12]

Education and training

Universities are beginning to integrate circularity into their curricula. Currently, three universities of applied sciences offer relevant programmes and courses, and three Viennese universities jointly offer a master's degree in green chemistry. Regional chambers of commerce run training webinars for companies.

2.2.2.2 Scheduled policy and policy gaps

The following key measures in the Austrian Circular Economy Strategy have not or only partially been addressed, partly due to the primacy of new EU legislation. There are no plans to introduce a primary resource tax, as has been done for the extraction or use of mineral resources in several European countries.

Market price incentives

The Austrian Circular Economy Strategy calls for strengthening extended producer responsibility schemes, especially by **eco-modulating EPR licensing fees** and covering more product groups.[13] Furthermore, the strategy suggests analysing the existing tax system for possibilities to incentivise the circular economy, as well as identifying and **abolishing subsidies that hinder circularity** to phase out the linear model ("exnovation"). The strategy does not explicitly include a **primary resource tax**. Similar to the carbon pricing system in Austria, the revenue from such a tax could be rebated to households and companies. In the absence of a globally coordinated resource tax, an EU border adjustment mechanism could be modelled on the carbon border adjustment mechanism.

Regulatory measures

Various measures in the Austrian Circular Economy Strategy depend on **stringent implementation of the new EU regulations** on ecodesign, packaging and packaging waste, construction products and end-of-life vehicles. For example, the strategy calls for ambitious ecodesign and recycled content requirements, which should be gradually tightened and cover as many product groups as possible. The strategy also recommends **advancing standards and norms**

[12] See https://secontrade.com/start-en.

[13] Eco-modulation is also recommended by the Task Force Circular Economy (BMK, 2024b).

to help scale up the circular economy – e.g. by developing harmonised performance and quality criteria for circular products – which is ongoing.

Funding for R&D and technology adoption

Most of the public subsidy programmes for circular R&D and investment for technology adoption that the Austrian Circular Economy Strategy calls for have been established (see section 2.2.2.1). They will need to continue to complete the circularity transition, with evolving priority areas and sunset clauses to ensure their phase-out once the subsidised technologies are competitive. The integration of circularity criteria into the province-level **Housing Support Scheme ("Wohnbauförderung")** has not yet been implemented. This programme provides subsidies for the construction of new residential buildings and the renovation of existing ones and is already conditional on energy and insulation standards. Furthermore, the Task Force Circular Economy recommends focusing public subsidies on **circular value chains and business models** (BMK, 2024b).

Information, education and stakeholder networks

Although a number of measures from the Austrian Circular Economy Strategy have been implemented, a **broad awareness-raising campaign** on the circular economy for consumers and producers is lacking so far. Furthermore, whether the planned **digital product passport** will provide consumers with better information on the composition and recyclability of products depends on stringent implementation of the corresponding new EU regulations. Finally, the Task Force Circular Economy recommends integrating circularity into curricula at all education levels, establishing **professional qualification programmes** to train skilled workers and further strengthening networks and platforms for knowledge exchange and collaboration (BMK, 2024b).

3 CIRCULAR INNOVATION IN AUSTRIA

Innovation and economic performance

Developing innovation policies to foster circularity in Austrian industry requires, first of all, an understanding of the country's current performance in relevant technologies. The aim is to gain insights into which areas need further policy attention to strengthen the development and diffusion of circular production technologies. As a small economy with strong international trade links, Austria can import new technologies in the form of machinery and know-how from abroad and does not need to develop technological leadership in all areas. Hence it is efficient to focus innovation policy efforts on areas where the country already has a competitive economic base – with the exception of strategically important technologies, to reduce import dependencies given increasing geopolitical risks. This section therefore presents a combined analysis of Austria's innovative and economic performance in international comparison.

Patent applications in reuse, recycling and recovery technologies

As a measure of innovative activity in circularity technologies, data on high-quality[14] patent applications for reuse, recycling and recovery technologies by inventor country are used. These are available from the OECD patent database for climate change mitigation technologies related to various emission sectors, including waste (OECD, 2022, 2024). Reuse, recycling and recovery technologies, a subgroup of waste management technologies, are most closely related to the circularity technologies by industry that were the focus of the INTEGRATE project: the increased use of recycled materials in the production of steel, plastics, cement (substituting Portland cement clinker) and timber. Since patent applications measure inventions, they represent an intermediate outcome of the innovation process, which refers to the successful commercialisation of an invention. Patent applications are therefore interpreted here as indicative of a country's potential for innovation.

Technological specialisation

To evaluate Austria's innovation potential in international comparison, we use the index of revealed technological advantage (RTA),[15] which measures a country's innovative specialisation in a technology relative to all other countries. The RTA index for Austria expresses a given technology's share in the country's total patent applications relative to the same technology's share in all countries' patent applications. Hence, if Austria registers an RTA value greater than one in reuse, recycling and recovery technologies, then this field accounts for a greater share of its patent applications than of those of all countries taken together. In international comparison, Austria therefore specialises in the technology or has a technological advantage. At values less than one, on the other hand, Austria is at a technological disadvantage.

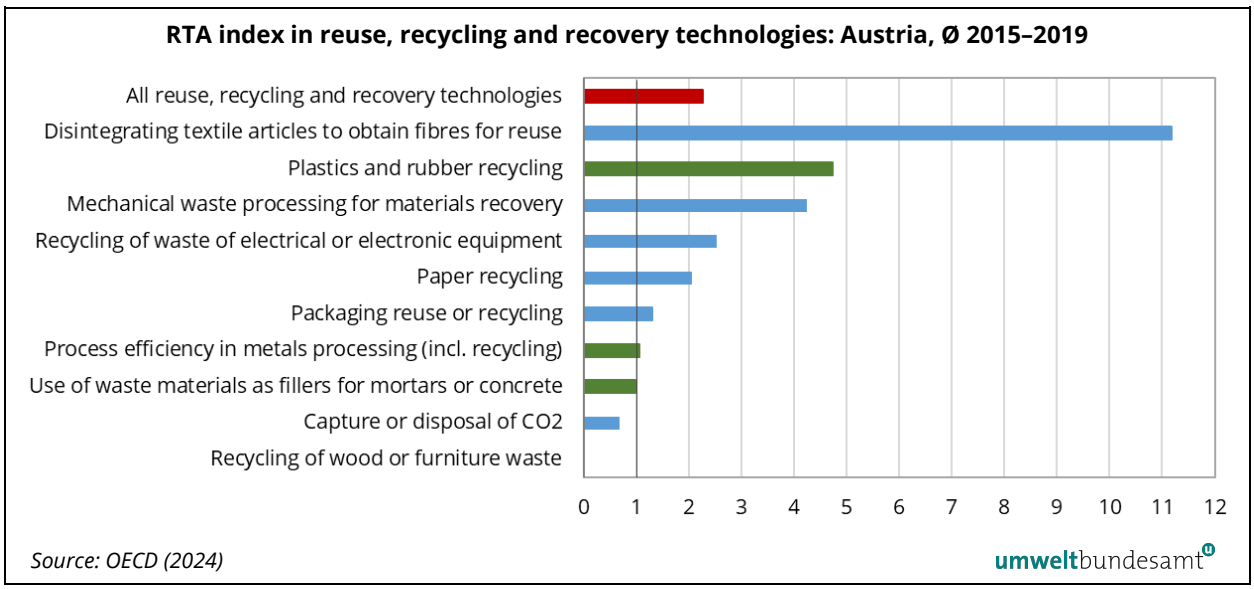
[14] To sort out lower-quality patent applications, we included only those for which applications were submitted to at least three of the world's major patent offices (triadic patents).

[15] The index is $RTA_{d,i} = P_{d,i}/\sum_d P_{d,i}/\sum_i P_{d,i}/\sum_{d,i} P_{d,i}$, where $P_{d,i}$ represents the number of patent applications of country *i* in technology *d*. See Unterlass et al. (2013) and OECD (2013).

Strong specialisation in reuse, recycling and recovery technologies

Figure 1 presents Austria's relative specialisation in the individual reuse, recycling and recovery technologies.[16] The top bar, marked in red, shows the RTA index value (2.3) for this field as a whole, indicating a clear technological specialisation. The individual technologies relevant to the industry circularity measures considered in the INTEGRATE project are marked in green. Of these, Austria registers the greatest technological advantage in plastics and rubber recycling (RTA value of 4.7). For metals processing technologies, including steel scrap recycling, the RTA is just above one, while for the use of waste materials for mortars or concrete, which also includes cement, it is just below one. Notably, the capture or disposal of CO_2 – which is not part of the reuse, recycling and recovery group but important for climate-neutrality in the cement industry and for the reuse of CO_2 in plastics production – scores an RTA considerably below one. In recycling wood or furniture waste, the RTA is zero, as Austria has not registered a patent in this technology since the start of the time series in 1990.

Figure 1: Index of relative specialisation in patenting of circularity-related technologies in Austria, Ø 2015-2019



Note: Technologies related to the INTEGRATE circularity measures in the production of steel, plastics, cement and timber are highlighted in green. The RTA value for recycling of wood and furniture waste is zero.

Results robust over longer time periods

When averaging the RTA indices over a longer time period, starting in 2009 instead of 2015, the results are practically identical for plastics and wood. For metals processing and using waste as a filler for mortars or concrete, the RTA values are higher, at 1.4 and 1.05 respectively, indicating that Austria's technological specialisation in these fields declined towards the end of the period. Overall, waste management technologies – of which reuse, recycling and recovery technologies are the largest subgroup – are among Austria's strongest categories in terms of RTA out of all sectoral climate change mitigation technologies

[16] Several technologies not relevant to INTEGRATE register RTA values of zero and are thus not shown. They include recycling of batteries and fuel cells, construction and demolition waste, glass recycling, fats and other fatty substances and waste management of vehicles.

included in the OECD database. This result is also stable over time. Related literature on Austria's specialisation in environmental technologies tends to confirm the country's strong position in waste management and circularity more broadly, albeit based on different data and classifications (e.g. FORWIT, 2024, Hofmann et al., 2024).

Favourable conditions for circularity transition

On the whole, Austria's specialisation in high-quality patent applications in a number of reuse, recycling and recovery technologies points to favourable technological conditions for the circularity transition in the Austrian industries considered in INTEGRATE. The economic performance of these industries provides useful additional information for policy development, as innovations tend to develop on the back of existing strengths. Industries that are competitive on international markets therefore have an advantage in developing and implementing new products and technologies (Fankhauser et al., 2013). The effectiveness of innovation policy targeting a circularity technology is also likely to vary depending on whether the related industry is internationally competitive or not. For example, a small technological disadvantage and a well-performing related industry indicate that policy support to improve the development or adoption of new circular technologies should fall on fruitful ground. With the same technological disadvantage in a less competitive related industry, it is harder to catch up.

Export specialisation

To assess Austria's economic performance in the industries related to the INTEGRATE circularity technologies, we use the index of revealed comparative advantage (RCA), a standard indicator of international competitiveness that measures a country's export specialisation. The RCA index is identical in form[17] to the RTA index and computed using export data at the product level from the UN Comtrade database (UN, 2024). The RCA index for Austria expresses a given product group's share in the country's total exports relative to the same product group's share in all countries' exports. If Austria registers an RCA value greater than one in a product group, then this group accounts for a greater share of its exports than it does of all countries' exports, indicating an export specialisation.

Matching technologies to product groups

To perform a combined analysis of Austria's technological and export specialisation related to the INTEGRATE circular production technologies, an RCA index was calculated for the product groups related to each of the four relevant reuse, recycling and recovery technologies. The related product groups were identified from the UN Comtrade database based on broad production industries, so that the RTA and RCA indices were linked as follows:[18]

- Plastics and rubber recycling technologies ↔ Plastics, rubber and articles thereof (including waste); machine tools for working rubber and plastics
- Process efficiency in metals processing ↔ Base metals and articles thereof (including waste); industrial electric arc furnaces and ovens

[17] The formula for this index is $RCA_{s,i} = E_{s,i}/\sum_s E_{s,i}/\sum_i E_{s,i}/\sum_{s,i} E_{s,i}$, where $E_{s,i}$ refers to the value of exports (excluding re-exports) of country *i* in product group *s*. See Balassa (1965).

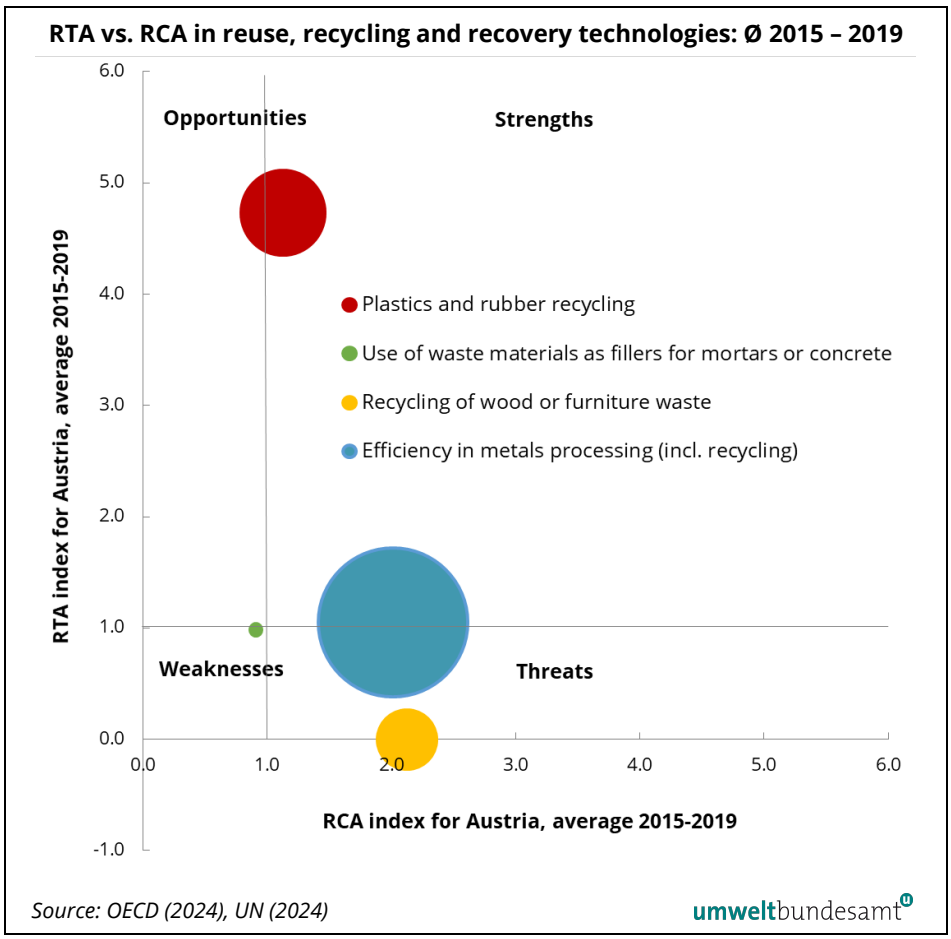
[18] Product groups in the UN Comtrade database are classified according to the Harmonized System (HS) (2022 edition, World Customs Organization). The HS codes linked to each technology field are available upon request.

- Use of waste materials for mortars or concrete ↔ Cement and articles thereof; slag, dross and similar waste; machine tools for working cement
- Recycling of wood or furniture waste ↔ Articles of wood excluding raw wood; furniture; wood waste and scrap; machine tools for working wood; presses for manufacturing particle board or fibre building board of wood.

SWOT analysis

Combining the RTA and RCA indices related to each of the INTEGRATE circular production technologies provides insights into both Austria's innovation and economic performance in these areas at the same time. Depending on whether RTA and RCA have values above or below one, the technologies can be categorised into areas of strength (RTA and RCA > 1), opportunity (RTA > 1, RCA < 1), threat (RCA > 1, RTA < 1) and weakness (RTA and RCA < 1, Steininger et al., 2021). In Figure 2 below, these are represented by the four quadrants.

Figure 2: Indices of specialisation in patent applications (RTA) vs. exports (RCA) for Austria, Ø 2015 – 2019



Note: The bubble size corresponds to the value of Austrian exports to the rest of the world in the product groups matched to each technology (€, Ø 2015 – 2019) relative to the other data points in the figure.

Technological and export specialisation in plastics recycling

Figure 2 shows that plastics and rubber recycling is an area of strength, where Austria has both a technological specialisation and an export specialisation in the related plastics and rubber industry. Although the export advantage is currently not large (RCA value of 1.13), the strong innovation potential could raise it in future, so this industry could benefit considerably from the transition to a circular economy. In metals processing technologies, including recycling, a small technological specialisation is coupled with a larger export specialisation. The fact that the RTA value has declined over time (see discussion of Figure 1) suggests diminishing inventive capacity in this field, which could in turn threaten the current export advantage. Therefore, policies stimulating innovation would be well suited here. For the use of waste materials in mortars or concrete, both the RTA and RCA are just below one, indicating innovative and economic weaknesses in international comparison. Wood and furniture has a competitive export industry but zero patenting activity in the related recycling technologies.

Policy implications

The descriptive analysis in this section allows for some initial suggestions on additional policy support that may be appropriate to foster the development and diffusion of circular production technologies in Austria. The RCA values indicate a competitive export position in the industries related to three of the four circular production technologies considered in INTEGRATE. The fourth, waste materials for mortars or concrete, is a borderline case. Overall, the existence of a reasonably competitive industrial base implies that there is potential for policy to stimulate circular innovations and their diffusion in these industries effectively.

Targeted R&D and start-up support

The RTA values suggest that, in plastics recycling, Austria is already doing well in generating new ideas that are considered worthy of a patent application. Additional policy support to develop new technologies may therefore not be necessary in this area. However, public support for start-ups – from the seed stage to growth and internationalisation – could enhance the commercialisation of new inventions and, in turn, strengthen Austria's relatively weak export advantage. On the other hand, for technologies where Austria is at an innovative disadvantage, targeted funding for research and development is called for. According to the analysis in this section, this case can be made for wood and furniture waste recycling, the use of waste materials for mortars and concrete, the disposal or capture of CO_2 and possibly efficiency technologies in metals processing, where the innovative advantage has declined and is now close to one.

Regulatory measures and technology adoption subsidies

Even where Austria's innovation potential in circularity technologies is strong, widespread diffusion of these technologies may face challenges. Regarding plastics for example, Austria is, like most other countries, still far from a fully circular economy. While in some segments like PET bottles, recycling works well and is increasingly being implemented, Austria lags considerably behind the EU target of 55 % recycling of plastic packaging by 2025. The diffusion of systemic innovations like circularity technologies requires significant changes to the regulatory framework. This includes removing barriers that favour the linear economy, updating standards and norms, and setting targets, e.g. for recycled content. In addition, subsidies for encouraging companies and households to adopt expensive new technologies can help make investments profitable. Interviews

with experts and stakeholders have enabled us to identify the key adoption barriers for each of the technologies considered and to formulate specific policies.

Limitations and stakeholder engagement

Aggregate patent data need to be interpreted with a degree of caution. In general, not all patented technologies become commercially successful innovations. Also, not all innovations are patented, as applying for patent protection is less common in some industries than in others. This may be the case for the wood processing industry for example, given that Austria has not registered a patent in wood or furniture waste recycling technologies since 1990. For plastics, the patent data do not allow for a differentiation between mechanical and chemical recycling, two methods that are used for different types of plastics and face different challenges. The process efficiency in metals processing and use of waste materials for mortars or concrete technology groups may also be too broad to effectively capture Austria's relative position in steel scrap recycling and the use of recycled materials in cement production. Finally, due to data constraints, the product groups matched to the circularity technologies for the RCA analysis are relatively broad, covering the exports of the entire related industry rather than recycled products specifically. The expert interviews and stakeholder engagement have provided crucial input for validating the results in this section and formulating the final INTEGRATE policy package, presented in the next section.

4 POLICIES FOR AUSTRIAN INDUSTRIES

INTEGRATE scenario assumptions

This section presents the policies developed in the INTEGRATE project in collaboration with stakeholders and experts. The policies should help achieve the following assumptions on energy-efficient circular production technologies that underlie the INTEGRATE scenario in the focus industries (Kulmer et al., 2024):

- **Iron and steel:** A substantial increase in the share of recycled steel scrap in steel production by 2050, achieved by switching to the secondary steel production route using electric arc furnaces
- **Plastics:** Increased use of mechanically recycled plastics in plastics production by 2050
- **Cement:** A reduction in the clinker content of cement by 2050 as in VÖZ (2022), achieved by increased substitution with granulated slag, fly ash, steel slag or other supplementary cementitious materials
- **Timber:** An increase in the use of recycled waste wood in the production of wood panels by 2050

Method

The policy package for each INTEGRATE industry was developed in four steps. First, an initial policy proposal was formulated based on a review of relevant literature and interviews with industry experts. Second, the stakeholders were invited to review the proposal. Third, the revised policy proposal was presented at a one-day stakeholder workshop in April 2024, where it was further refined in sector-specific and cross-sectoral groups. Finally, experts from Environment Agency Austria provided feedback and final improvements.

Stakeholders and experts

The experts and stakeholders who provided input into policy formulation for the INTEGRATE industries represent the following types of organisation:

- **Iron and steel:** A research organisation and an interest group (both Austrian)
- **Plastics:** A petrochemicals company and a research organisation (both Austrian)
- **Cement:** An international cement producer and an Austrian interest group
- **Timber:** A wood panel producer and a trade association (both Austrian)
- **Waste management:** Two Austrian waste management companies

Included policies

The next subsection presents overarching measures that apply to more than one industry, while the subsections that follow present industry-specific measures. The policy recommendations include measures that have not yet been transposed into Austrian law (see also section 2.2.2.2), even if they are part of the new EU legislation described in section 2.2.1.

4.1 Overarching measures

Recycled materials expensive, waste disposal cheap

Table 1 contains policies that apply to more than one of the INTEGRATE industries. For all of these except steel production, the stakeholders and experts indicated that using recycled secondary instead of primary raw materials is still the more expensive option. A waste management company representative emphasised that waste disposal is too cheap compared to recycling, which leads to recyclable materials mistakenly going into residual waste and landfill or incineration. Therefore, two key price-based measures from the Austrian Circular Economy Strategy (see section 2.2.2.2) are listed among the recommended market price incentives: reforming the existing system of taxes and fees to incentivise circular production and phasing out subsidies that hinder circular production.

More end-of-waste ordinances

In terms of regulatory policies, stakeholders suggested greater use of end-of-waste ordinances and landfill bans. For example, there are no end-of-waste ordinances for plastics, concrete or mineral wool. In addition, the landfill ban on waste collected separately for reuse or recycling should be closely monitored and enforced to avoid landfill or incineration of recycling-grade waste.

Table 1: Overarching INTEGRATE circularity policies

Market price incentives	• Reform the **tax system to incentivise circular production**, e.g. by reducing taxes and fees on recycled products and materials or by raising the landfill levy • Identify **and phase out subsidies that are harmful to the circular economy** in production and consumption
Regulatory measures	• Introduce **end-of-waste ordinances** for plastics, concrete and mineral wool • Enforce the **ban on landfill or incineration of waste** collected separately for reuse or recycling
Funding for R&D	• Continue **R&D subsidies for circular design** and **upcycling** • Continue or introduce **R&D subsidies for carbon capture and utilisation** and **carbon capture and (intermediate) storage**
Funding for adoption of circular innovation	• Improve **access to private venture capital** for circular start-ups in the growth phase, e.g. by establishing a national investment fund to mobilise institutional capital
Information and stakeholder networks	• Create **new cross-sector networks** between key actors along circular value chains, providing information on who collects and sorts which material by type and quality • Establish the **waste management sector as a central player** in new circular economy networks, linking producers, recyclers and users of waste materials • Hold an **interdisciplinary dialogue on design for recycling** among producers, waste management companies and recyclers to share information on design needs

R&D funding and access to private venture capital

Regarding the traditional instruments of innovation policy, a need for continued and increased R&D funding was expressed across industries, in particular for circular design and upcycling. Similarly, R&D subsidies for carbon capture and utilisation (CCU), carbon capture and storage (CCS) and carbon capture and intermediate storage (CCiS) technologies are considered necessary to drive the

development of a circular carbon economy across the cement and plastics industries. One stakeholder raised the issue of limited access to private venture capital, a general problem facing Austrian start-ups in their growth phase. To address this, a national investment fund could be established that mobilises capital from institutional investors such as banks, pension funds or insurers. Examples exist in France, Denmark and Germany (e.g. KfW's "Zukunftsfonds").[19]

Need for information and networks

Across the industries, several stakeholders emphasised a need for new, cross-sectoral industry networks to exchange recycling-relevant information along the value chain and to get the recyclate volumes required for running recycling businesses profitably. To scale up the circular economy, companies need to know who collects and sorts which materials by type and quality. The stakeholders consider the initiation and coordination of such new, cross-sectoral industry networks as a central task for national, regional or municipal administrations. Flagship projects were suggested as a promising way to initiate such networks, since companies are willing to invest time and money to get involved.

Waste management sector as central actor

According to a waste management company representative, this sector views itself as a central actor in such new, cross-sectoral circular economy networks. The sector could provide the link between waste producers, recyclers and users of recycled materials, for instance in the metals, plastics and construction product industries. This would change the role of the waste management sector from waste disposer to provider of secondary raw materials. For this vision to become a reality, waste management companies would need better contacts with different industries and greater involvement in stakeholder initiatives enabling exchange with policy-makers.

Interdisciplinary dialogue and awareness campaigns

For the development of circular product design standards and norms, stakeholders across the industries noted the importance of interdisciplinary dialogue between producers, recyclers and waste management and disposal companies to share information on specific product design needs. To avoid disposal of recyclable materials, awareness campaigns on waste separation were called for.

4.2 Steel scrap recycling

Improve quality of available steel scrap

The main challenge for achieving a substantial increase in the share of recycled steel scrap in Austrian steel production is the availability of steel scrap of sufficient quality. The high-performance steel varieties that have been the focus of Austrian steel production require raw materials of high purity, with a low proportion of non-metallic components, such as plastics and non-ferrous metals, in the alloy (Dworak et al., 2022). By contrast, the post-consumer scrap currently available is usually heterogeneous and contains impurities and undesirable accompanying elements, such as tin or copper from end-of-life vehicles, making the quality of steel produced from such scrap uncertain. High shares of steel

[19] https://www.kfw-capital.de/Investment-focus/Zukunftsfonds-(Future-Fund)/

scrap are therefore currently only achieved in the production of lower-grade reinforcement steel. The policies in Table 2 aim to raise the quality and use of steel scrap.[20] Since using scrap to produce steel is cheaper than primary production, the experts and stakeholders did not consider market price incentives necessary.

Standards, norms and improvements to collection and sorting

To improve the quality of steel scrap, design standards for circular steel products should include criteria for ease of disassembly and impurity content. This would facilitate the collection, sorting and recycling of scrap, as would a requirement for collection and sorting to be type-specific, e.g. with regard to accompanying elements. To encourage the use of steel scrap, a minimum share of steel scrap could be mandated, differentiated by steel quality grade. This would require revisions of safety standards based on the safety properties of steel products with different shares of recycled content. Since greater steel scrap use also leads to higher levels of accompanying elements in final products, their effects on the performance of steel products should be investigated (Dworak et al., 2022). Steel norms could then be changed from maximum permissible shares of accompanying elements to maximum possible shares consistent with performance requirements regarding strength or durability. Finally, to increase the recovery of steel from end-of-life vehicles and construction waste, illegal vehicle exports and landfill of recyclable construction waste must be prevented.

Table 2: INTEGRATE circularity policies for the iron and steel industry

Regulatory measures	• Develop **quality criteria and standards** for circular design, e.g. on impurity content and disassembly; investigate replacing norms on maximum permissible content of accompanying elements with maximum possible content • Mandate **minimum steel scrap shares** (by steel quality grade) in steel production, together with development of new safety standards • Mandate **type-specific collection and sorting**, e.g. by accompanying elements • Improve recovery of steel from end-of-life vehicles and construction and demolition waste: prevent **illegal vehicle exports** and **landfill of recyclable construction waste**
Funding for R&D	• **R&D subsidies** for **innovative steel scrap sorting and separation technologies,** especially for the removal of impurities and unwanted accompanying elements • **R&D subsidies** for **effects of non-removable elements** on the performance and applicability of steel products with different levels of recycled content
Funding for adoption of circular innovation	• **Investment subsidies** for **modernising and upgrading** facilities for steel scrap sorting, separation and recycling
Information and stakeholder networks	• Improve **labelling of steel products** by composition and recyclability, to provide information to scrap recyclers and steel producers (digital product passport) • **Training and qualification programmes** for secondary steel technologies • **Communication platforms** along the value chain

[20] They are consistent with recommendations from the IRONER project (Hackl et al., 2023; Dworak et al., 2022), funded under the circularity mission of the Austrian FTI programme.

R&D funding

There is a need for further research on advanced sorting, separation and recycling techniques. Sensor- and robot-assisted sorting technologies and automated dismantling have considerable potential, but techniques for identifying and removing the common non-ferrous metals contained in post-consumer steel scrap should also be further developed. Where removal of these accompanying elements is not possible, research is required on their effects on the performance and applicability of steel products with recycled content. Finally, research funding should be made available for the development of new steel varieties that are more tolerant to such accompanying elements.

Funding for technology adoption

In addition to the R&D support described above, a key recommendation is to subsidise the modernisation and upgrading of facilities for scrap sorting, separation and recycling with technologies that enable them to be type-specific and to remove impurities, accompanying elements and non-metallic components (Dworak et al., 2022; Hackl et al., 2023). Steel scrap sorting needs to be made more systematic and specific to achieve better scrap quality. Ideally, the scrap should already be sorted by type at source. Recyclers could resmelt different types of scrap so they can deliver steel scrap of specific quality grades.

Labelling, training and communication

The concerns regarding type-specific collection, sorting and recycling and the removal of impurities can be addressed by requiring the labelling of steel products according to their composition and recyclability, as is planned with the EU Ecodesign Regulation's digital product passport. This will provide the information needed by scrap dealers for sorting and high-quality recycling, as well as the certainty regarding scrap quality needed by steelmakers to make better use of available scrap volumes. Training and qualification programmes on new technologies for sorting, separation and recycling will also be required. Finally, the stakeholders voiced a need for communication platforms along the entire steel scrap value chain, from scrap producers and dealers/recyclers to steel producers, to coordinate the necessary logistics, innovations and processes for increased use of recycled steel in steel production (see also Hackl et al., 2023).

4.3 Plastics recycling

Recycled plastics more expensive than primary plastics

Several barriers to raising the share of recycled plastics in plastics production are related to the market for plastics recyclates. First, high-quality recycled plastics are currently more expensive on the market than primary plastics, in part because of the collection, cleaning and recycling processes involved. In addition to the market price incentives proposed in section 4.1, such as tax breaks for recycled products and materials, extended producer responsibility schemes could therefore be introduced for plastic products other than packaging, where feasible. EPR fees for plastics other than packaging should then also be modulated according to circularity criteria to provide further financial incentives for circular production. Making producers of plastic packaging pay the EU "plastics tax" for non-recycled plastic packaging waste would also provide an important price signal to increase recyclability.

Ecodesign requirements

Second, there are issues with both supply and demand for plastics recyclates. In terms of supply, recyclers need plastics waste collected and sorted by type and colour to produce high-quality recyclates. However, plastic products often consist of mixtures of different types, which impedes type-specific collection and sorting, or of complex composite materials that are difficult to separate and recycle, such as plastic car parts. In addition, demand for plastics recyclates has slowed down in recent years, partly due to the lower cost of virgin plastics.[21] Ecodesign requirements, to be developed under the EU Ecodesign Regulation, will play a key role in strengthening the market for recycled plastics. Standards and norms for the design of circular plastic products based on criteria regarding recyclability, separability and purity should facilitate recycling and thus increase the supply of plastics recyclates. Minimum recycled content requirements, already in place for plastic (PET) bottles from 2025, will also increase the demand for recycled plastics. These requirements should be progressively tightened and extended beyond bottles to all plastics waste.

Table 3: INTEGRATE circularity policies for the plastics industry

Market price incentives	• Expand **EPR schemes to plastics beyond packaging** where feasible, and **modulate EPR licensing fees** according to circularity criteria, e.g. recyclability or recycled content
Regulatory measures	• Develop **standards and norms** for circular design, e.g. quality criteria regarding recyclability, purity and separability to improve recyclability of plastics waste • Gradually **increase and extend to all plastics waste** the targets for recycling, recyclability and **minimum recycled content** • Mandate **type- and colour-specific** plastics **collection and sorting** • Extend **collection of plastics waste beyond packaging** to include all types of plastics, such as kitchenware, children's toys, sporting goods, tubes and tarpaulins
Funding for R&D	• Continue **R&D subsidies** for recycling **currently unrecyclable plastics** such as complex mixed plastics
Funding for adoption of circular innovation	• Continue **investment subsidies** for **modernising and upgrading** sorting, separation and recycling facilities for plastics waste with new technologies
Information and stakeholder networks	• Improve **labelling of all plastic products** by composition and recyclability (digital product passport) • **Awareness-raising campaigns** on the quality of recycled plastics

Improvements to collection and sorting

Waste collection should be extended beyond packaging to all plastics waste to raise available recyclate volumes. According to one expert, about half of all potentially recyclable plastics waste is currently lost in Austria because collection is only mandatory for packaging. Plastic items that are not collected include kitchenware, toys, sporting goods, tarpaulins and tubes. These usually consist of a single plastic type that is suitable for mechanical recycling (PET, polyolefins). The financing for extending plastics waste collection would need to be clarified.

[21] See e.g. https://www.plasticsrecyclers.eu/news/european-plastic-recycling-industry-growth-slower-due-to-market-constrictions/

R&D funding

Mechanical recycling technologies generally work well for clean, homogeneous plastics such as PET and certain types of polyolefins. Further research is needed, according to an industry expert interviewed, on technologies for plastic types that are difficult to recycle, such as complex mixed or contaminated plastics. Advanced recycling technologies, including solvent-based and energy-intensive chemical recycling, are still in the early stages of commercialisation. Solvent-based recycling is promising for expanded and extruded polystyrene, while chemical recycling may work for certain types of polyurethane, particularly rigid foams used in insulation and car seats. For PVC and polyamides, recycling remains challenging due to their chlorine and nitrogen content.

Funding for technology adoption

As the development of sorting, separation and recycling technologies advances, investment subsidies will continue to be important to help companies modernise and upgrade their facilities with these new technologies. While in 2021, a need was found to upgrade sorting facilities with modern robot- and sensor-assisted technologies in order to raise recyclable waste fractions (EAA, 2021a), this is now being funded from the EU Recovery and Resilience Facility. Improvements to sorting technologies offered by artificial intelligence, which are not yet available at scale, will likely lead to further adaptation needs.

Labelling and awareness

The introduction of the digital product passport, providing information on the composition and recyclability of plastic products, will facilitate type-specific collection, separation and recycling and hence also contribute to increasing the supply of high-quality plastics recyclates. One stakeholder suggested awareness campaigns to improve understanding amongst consumers and producers that recycled plastics are not per se of a lower quality than virgin plastics.

4.4 Cement clinker substitution using waste materials

New clinker substitutes necessary for decarbonisation

Reducing the clinker content of cement with recycled waste materials from the iron and steel industry or from energy generation is one of the main decarbonisation strategies of the cement industry (VÖZ, 2022). Granulated blast furnace slag and fly ash have long been used as additives replacing clinker in the grinding process that yields cement powder. However, since a fraction of clinker is always necessary in the mix for quality reasons, the clinker reduction potential of these materials is limited. Also, the availability of blast furnace slag and fly ash is set to decline as the steel and energy industries decarbonise and move away from coal. Therefore, new clinker substitutes will be required. Several options are currently under development, including steel slag and calcinated clay. In addition, cement recycling technologies are in the early stages of development (Kienberger et al., 2022).

Cost disadvantage for some recycled construction materials

Waste materials from the steel and energy industries are a cost-competitive option for reducing the clinker content of cement, as they are by-products and require no further processing. Cement recycling, on the other hand, relies on the clean separation of construction waste and on advanced processing of waste concrete to separate out the hardened cement, which is currently not standard.

As a result, construction minerals requiring high-quality recycling, like cement, still have a cost disadvantage compared to using primary materials, according to a stakeholder. To offset this, financial incentives such as tax breaks for recycled construction products could be introduced, as already noted in section 4.1.

Standards

As for steel and plastics, cement standards should be adapted to enable more circularity. Currently, European norms in this area are recipe-based, prescribing maximum permissible shares of certain types of clinker substitutes, to the disadvantage of new substitutes. These maximum substitute shares should be increased. Also, according to one stakeholder, a product with the same chemical composition as granulated blast furnace slag is currently not approved. Changing to performance-based standards, as foreseen in the revised EU Construction Products Regulation (see section 2.2.1), would stipulate only performance requirements such as strength, allowing for new substitutes and the maximum substitute shares that are technically feasible. Quality criteria for cement made with new or more recycled clinker substitutes would have to be developed to encourage their use. Mandating minimum shares of clinker substitutes could also be an option.

Table 4: INTEGRATE circularity policies for the cement and construction industries

Regulatory measures	• Revise **norms and quality criteria** for circular design, e.g. from recipe- to performance-based cement standards, enabling maximum possible clinker substitute shares that make it possible to achieve desirable properties • Mandate **a minimum share of clinker substitutes** in cement production • Improve **construction waste separation** at construction sites, e.g. by easing conditions for mobile treatment plants or mandating treatment at recovery facilities
Funding for R&D	• Continue **R&D subsidies** for **new clinker substitutes** and **cement recycling** • Continue **R&D subsidies** for advanced construction waste **separation and recycling** technologies
Funding for adoption of circular innovation	• **Investment subsidies** for **modernising** separation and recycling facilities for construction waste and for **improving logistics** • **Investment subsidies** for **upgrading** cement production facilities for the use of new clinker substitutes
Information and stakeholder networks	• Record all residues from industrial processes in a **waste materials catalogue** • Improve **labelling of construction materials**, from buildings to waste streams, by composition and recyclability (digital product or building passport) • **Awareness-raising campaigns** on the **quality** of recycled construction products • Provide **training** on **quality-preserving recovery** of construction materials

Construction waste separation and sorting

The clean separation of mineral construction waste is important for achieving high-quality, homogeneous waste streams. Ideally, this should be done at the construction site, but since it leads to higher costs for construction firms, conditions need to be improved. One option is to extend the validity period of permits for mobile treatment plants beyond six months (Kienberger et al., 2022). Alternatively, the treatment of certain construction and demolition waste streams at recovery facilities could be mandated to achieve better waste separation. Higher-quality, more homogeneous construction waste streams are

more valuable and have more use options, which makes better separation also economically attractive. In particular, separating composite construction materials is still a technological challenge and a barrier to type-specific sorting and recycling of construction waste.

R&D funding

Further R&D subsidies are needed for new clinker substitutes that are still at the research or demonstration stage. These include steel slag, slags and ashes from waste incineration and calcinated clay, which promise greater reduction of the clinker content of cement, as well as approaches to cement recycling. Research support for advanced separation and processing methods for mineral construction waste materials, especially composites, is important for achieving homogeneous construction waste streams. Finally, funding for the development of carbon capture and storage technologies is key for decarbonising cement production (see section 4.1).

Funding for technology adoption

The investment subsidies for construction waste separation and recycling facilities, provided by the Austrian Domestic Environmental Support Scheme in 2024, should be continued. In addition, improved logistics concepts for construction waste recycling could be considered. Cement production facilities will also require upgrading support for the use of new clinker substitutes, once these are available at an industrial scale.

Awareness, labelling and training

To raise awareness of the availability of secondary materials for cement production, a stakeholder suggested recording all residues from industrial processes in a waste materials catalogue. In addition, better information on the type and quality of materials used in buildings and infrastructure and on the composition and recyclability of construction waste are critical for higher-quality construction waste recycling. This could take the form of the digital construction product passport from the EU Construction Products Regulation, or of a material building passport based on building information modelling (EAA, 2021b). Awareness-raising campaigns on the quality of recycled construction products, including cement made with more or new clinker substitutes, should help encourage their use by developers. Finally, expertise on quality-preserving recovery of construction materials during building dismantling needs to be made widely available, for instance as part of the further integration of circularity into education and qualification programmes on construction.

4.5 Recycling of waste wood

Incentives for reuse of timber construction components

Waste wood from wood processing or construction and demolition waste is already recycled to a considerable extent in Austria, for example in the production of wood-based panels (chipboard and fibreboard), paper and pulp. However, recycling wood into chipboard and fibreboard is usually associated with a loss of material properties such as mechanical strength and stability. Therefore, key challenges to increasing the use of waste wood and wood products lie in the recovery, reuse and high-quality recycling of timber construction compo-

nents. Since it is currently cheaper to produce these from virgin wood, a stakeholder recommended financial incentives for the reuse and high-quality recycling of timber construction components.

Standards and regulations

As for all other product categories considered in this section, standards and norms need to be adapted to enable greater circularity of timber construction products. Quality criteria for performance, recyclability and ease of disassembly should be developed. Current restrictions on using recycled timber construction components, for example in load-bearing walls, should be reconsidered. Stakeholders also emphasised the need to evaluate the incineration of recycling-grade waste wood and to reinforce the cascading use of wood.

Table 5: INTEGRATE circularity policies for the timber industry (e.g. wood panels)

Market price incentives	• Introduce **financial incentives for reuse and high-quality recycling** of timber construction components
Regulatory measures	• Revise **standards** for timber construction, e.g. regarding restrictions on recycled timber components; develop **quality criteria**, e.g. on performance and dismantling • Enforce the **requirement to recycle** suitable waste wood
Funding for R&D	• **R&D subsidies** for improved **component-preserving recycling** of timber construction components and technologies to separate **composite materials**
Funding for adoption of circular innovation	• **Investment subsidies** for **modernising and upgrading** timber recycling facilities with new technologies
Information and stakeholder networks	• Raise **awareness of separate collection and sorting** of recyclable waste wood at source to facilitate high-quality, type-specific recycling • Introduce **labelling of timber construction components** by composition and recyclability (digital product passport)

Funding for R&D and technology adoption

Further research funding is necessary to improve technologies for waste wood recycling, especially regarding component-preserving recycling of timber construction components and separation technologies for composite construction materials involving wood fractions. Investment support for upgrading wood recycling facilities with these new technologies will also be required.

Awareness and labelling

The existing obligation to collect recyclable waste wood separately at source should facilitate high-quality, type-specific recycling. However, there is still a need to raise awareness on better sorting (EAA, 2021c). Introducing labels that provide information on the composition of timber construction components, for example with the digital passport for construction products, will also contribute to improving type-specific sorting and recycling.

5 CONCLUSION

Potential for the circular economy in Austria

The transition to a circular economy plays a key role in reducing emissions and limiting resource consumption and waste on a finite planet. Austria has significant potential to expand its circular economy, given that its circularity rate is currently only just above the EU-27 average. Unlocking this potential could contribute to meeting the country's ambitious emission reduction targets in line with European goals. This report has documented policies to increase the use of recycled inputs in the Austrian steel, plastics, cement and timber industries. These policies were developed as part of the INTEGRATE project, drawing on literature reviews, data analysis and interviews with experts and stakeholders.

Comprehensive policy framework

First, an inventory of existing circular economy policies shows that in recent years, Austria has started to implement a broad policy framework that includes elements of "transformative" innovation policy. The country has adopted a comprehensive circular economy strategy, introduced some price incentives and adapted the regulatory framework according to EU legislation. It prominently funds research and development under a horizontal circularity mission and provides subsidies for the adoption of new circular technologies. Stakeholder engagement and information-based measures also play a major role. The main element of "transformative" policy that has not yet been addressed is "exnovation", i.e. policies that actively phase out the linear economic system.

Opportunities for plastics recycling in circular economy

Second, a descriptive analysis of Austria's circularity-related innovation and economic performance indicates that recycling, reuse and recovery technologies are generally an area of innovative potential for the country. Of the industries analysed in INTEGRATE, this is particularly the case for plastics and rubber recycling, where Austria has both a technological and an export specialisation in an international comparison. Hence this industry seems especially well-placed to benefit from the transition to a circular economy. On the other hand, innovative performance is weak in circularity technologies related to wood recycling and carbon capture and storage, suggesting a need for R&D support to maintain or strategically build export advantages.

Policy recommendations

Third, despite considerable progress, policy implementation on the circular economy is still at a relatively early stage in Austria. Several new EU regulations and directives still need to be transposed into Austrian law. The main policy recommendations developed in collaboration with stakeholders and experts in the INTEGRATE project can therefore be summarised across industries as follows:

- Deploy additional market price incentives to address the cost disadvantage of using recycled materials compared to primary materials in the production of plastics and construction products
- Expand extended producer responsibility schemes to include more product groups and modulate licencing fees according to circularity criteria
- Identify and phase out subsidies that hinder circularity
- Ensure stringent implementation of EU ecodesign and minimum recycled content requirements – which should be progressively tightened and extended to more product groups – and of the digital product passport

- Revise standards and norms to enable greater use of recycled materials
- Introduce end-of-waste ordinances for plastics, concrete and mineral wool
- Enforce the ban on landfill and incineration of waste collected separately for recycling
- Mandate type-specific collection and sorting of all recyclable material waste
- Continue subsidies for R&D and investment in technology adoption, particularly for circular design, value chains and business models, and for innovative sorting and recycling technologies
- Regularly update priority areas for subsidy programmes and use sunset clauses to ensure phase-out once funded technologies are competitive
- Introduce circularity criteria into the province-level Housing Support Scheme ("Wohnbauförderung")
- Improve private venture capital access for circular start-ups in the growth phase
- Record residues from industrial processes in a waste materials catalogue
- Strengthen cross-sectoral industry networks to improve stakeholder coordination along circular value chains
- Expand awareness campaigns and training on the circular economy, e.g. on the quality and safety of recycled materials and on new technologies

Further research

At the supranational level, establishing an EU circular economy governance architecture with binding national targets, similar to the climate policy framework, has been recommended to achieve the circularity transition (EEA, 2024). Given the physical limits to recycling, a reduction in waste and unsustainably high levels of resource demand will also require refocusing policy action towards avoiding resource demand in the first place, e.g. by means of sufficiency approaches. This remains the subject of further research.

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Regulation (EU) 333/2011: Council Regulation of 31 March 2011 establishing criteria determining when certain types of scrap metal cease to be waste under Directive 2008/98/EC of the European Parliament and of the Council.

Recycled Construction Materials Ordinance (Recycling-Baustoffverordnung 2015; Federal Law Gazette (BGBl.) II No. 181/2015 as amended by Federal Law Gazette (BGBl.) II No. 290/2016). Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Pflichten bei Bau- oder Abbruchtätigkeiten, die Trennung und die Behandlung von bei Bau- oder Abbruchtätigkeiten anfallenden Abfällen, die Herstellung und das Abfallende von Recycling-Baustoffen.

Timber Recycling Ordinance (Recyclingholzverordnung 2012; Federal Law Gazette (BGBl.) II No. 160/2012 as amended by Federal Law Gazette (BGBl.) II No. 495/2020). Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über das Recycling von Altholz in der Holzwerkstoffindustrie.

Waste Framework Directive (2008/98/EC as amended by Directive (EU) 2018/851): Directive of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

Waste Management Act (Abfallwirtschaftsgesetz 2002; Federal Law Gazette (BGBl.) I No. 102/2002 as amended by Federal Law Gazette (BGBl.) I No. 200/2021): Bundesgesetz über eine nachhaltigere Abfallwirtschaft.

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The INTEGRATE project highlights the contribution of circular production technologies to achieving climate neutrality in Austria. This report presents policies to advance circularity in the Austrian steel, plastics, cement and timber industries, developed in collaboration with experts and stakeholders. Austria is currently implementing an ambitious Circular Economy Strategy and performs well in recycling technology innovation, yet overall circularity remains low and barriers remain, such as cost disadvantages for recycled materials. Key recommendations to accelerate Austria's transition to a circular economy therefore include further market price incentives, stringent implementation of ecodesign rules, continued funding for R&D and technology adoption, additional awareness and training measures and initiatives for stakeholder networks.

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