



Mobilising the circular economy for energy-intensive materials

How Europe can accelerate its transition to fossil-free,
energy-efficient and independent industrial production

EXECUTIVE SUMMARY

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Dear reader,

The impacts of Russia's war on Ukraine have dramatically accelerated the urgency for Europe to phase down its use of fossil fuels, be more energy efficient and reduce the dependence of critical domestic industries. Key will be the transition of European industry to fossil free production based on domestic resources. 70 percent of EU industrial emissions come from the production of a few key carbon-intensive materials: iron and steel, aluminium, cement and lime, and plastics. These activities also account for a large and growing share of EU energy, and fossil fuel, consumption.

Existing approaches to the industrial transition tend to focus on reducing the carbon intensity of *virgin materials* production. However, the current European context requires a new approach maximising

both industrial energy and resource efficiency with the same level of importance. Increasing and improving closed-loop recycling and developing more material-efficient value chains will be essential. Furthermore, it will play to the EU's long-term competitive economic strengths, such as digitalisation, logistics and advanced manufacturing technologies.

Material circularity and efficiency would not only reduce the economic costs of the transition but also ensure that the industrial transition is technically and politically feasible within the 2050 timeframe.

I hope you find this report stimulating.

Yours sincerely,
Frank Peter, *Director, Agora Industry*

Key findings:

1	The current energy crisis makes it imperative to reduce the EU's dependency on fossil fuels and imported raw materials. Industrial production of virgin plastics, steel, aluminium and cement alone accounts for 13 percent of yearly energy consumption and 581 Mt of annual emissions. The EU also imports very large amounts of gas, oil and coal to produce plastics and other energy intensive materials.
2	Enhanced recycling and greater material efficiency hold enormous untapped potential for the transition to a fossil free production of energy-intensive materials, in both the short and long run. With ambitious policies, annual EU industrial emissions could be reduced by up to 10 percent (70 Mt) by 2030 and by 34 percent (239 Mt) by 2050 compared to 2018 levels. Plastics production alone could avoid using fossil fuels equivalent to roughly 2.7 billion cubic metres of gas and 149 million barrels of oil annually by 2030.
3	Realising these abatement and savings potentials must be a priority in the EU's new Circular Economy legislation. To synchronise energy security and climate neutrality, this legislation must spur demand for high quality recycling while boosting collection and supply of high quality recyclates. Required policy instruments are expanded quotas for recycled content; investment aid for rapid deployment of innovative recycling technologies; as well as labelling and best practice mandates for collection, sorting, recycling and re-use.
4	EU Member states can now implement key policy measures that effectively reduce greenhouse gas emissions already within the next 1 to 5 years. Examples are wider bans on single use and non-recyclable plastics, the implementation of deposit-refund schemes for plastic packages, investments into ex-post re-sorting and state of the art recycling practices.

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Conclusions and recommendations

The impacts of Russia’s war against Ukraine, on the European Union’s border, have raised the stakes for European energy and climate policy. While climate mitigation remains urgent, the current security and energy crises have underscored how dependent Europe is on imports of fossil fuels and other critical raw materials. The EU must accelerate its efforts not only to reduce its fossil fuel imports, but also to make smarter and more efficient use of its limited energy and material resources.

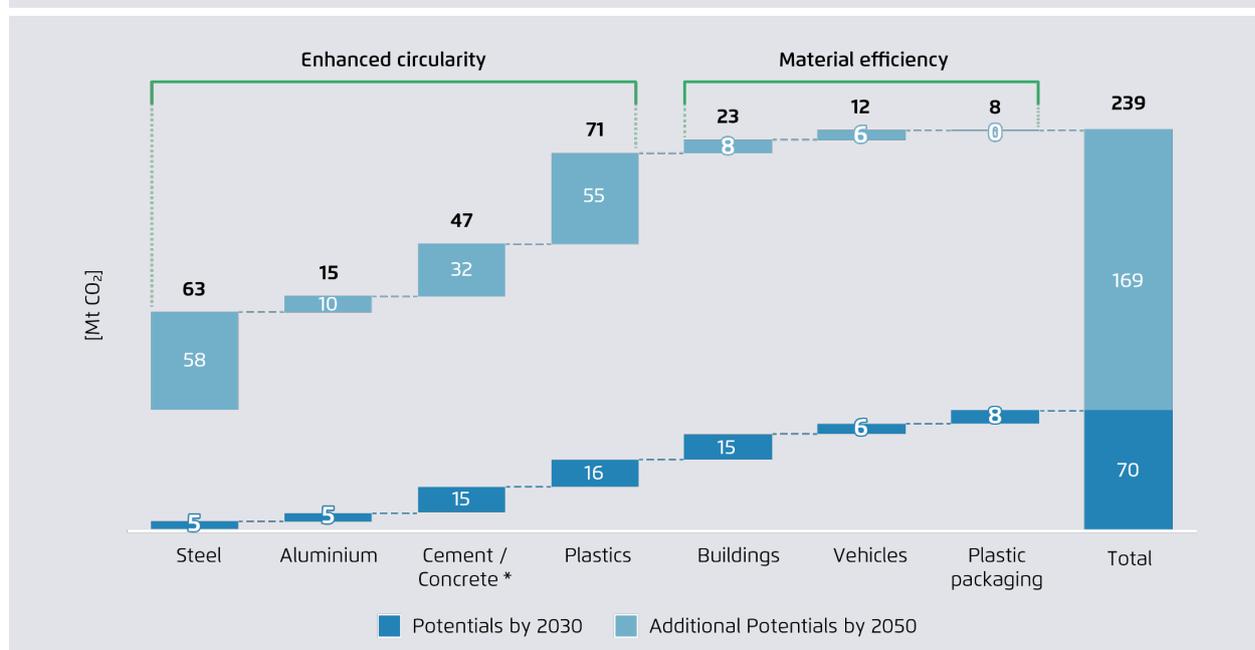
In this context, policies to enhance circularity and material efficiency must become a central part of the EU’s strategy to transition to climate neutral industry. Doing so would not only speed up the shift to fossil free production of basic materials, but also

make industry more resource efficient and strategically autonomous.

Policy makers increasingly understand the need to promote the transition to climate-neutral production of CO₂-intensive industrial materials – such as steel, aluminium, cement and plastics. In Europe, these sectors account for approximately 581 million tonnes of CO₂ equivalent emissions annually – or roughly 70 percent of all industrial emissions each year in the EU.

However, these sectors are also highly *energy and resource* intensive. In 2020, industry accounted for 26 percent of total EU final energy consumption, of which these four sectors alone accounted for approximately 50 percent – or 13 percent of total final energy consumption. They consumed 41 million

Figure ES1: Estimated abatement potentials from enhanced circularity and material efficiency by material or product in 2030 and 2050.



*Cement and concrete numbers reflect combined potentials from recirculation and recarbonation of cement and low-clinker concrete formulas. Source: Agora Industry (2022), based on modelling tools provided by Material Economics

Note: These emissions reduction potentials are estimated compared to a reference scenario based on business-as-usual. Since circularity and material efficiency potentials are taken to be substitutes for (and thus additional to) other reductions of emissions in these value chains via new lower carbon virgin production technologies, this baseline uses today’s CO₂ intensities of production for the relevant materials and products.

tonnes of oil equivalent (Mtoe) worth of natural gas, 14 Mtoe worth of oil products, and 9 Mtoe of solid fossil fuels, such as coking coal.

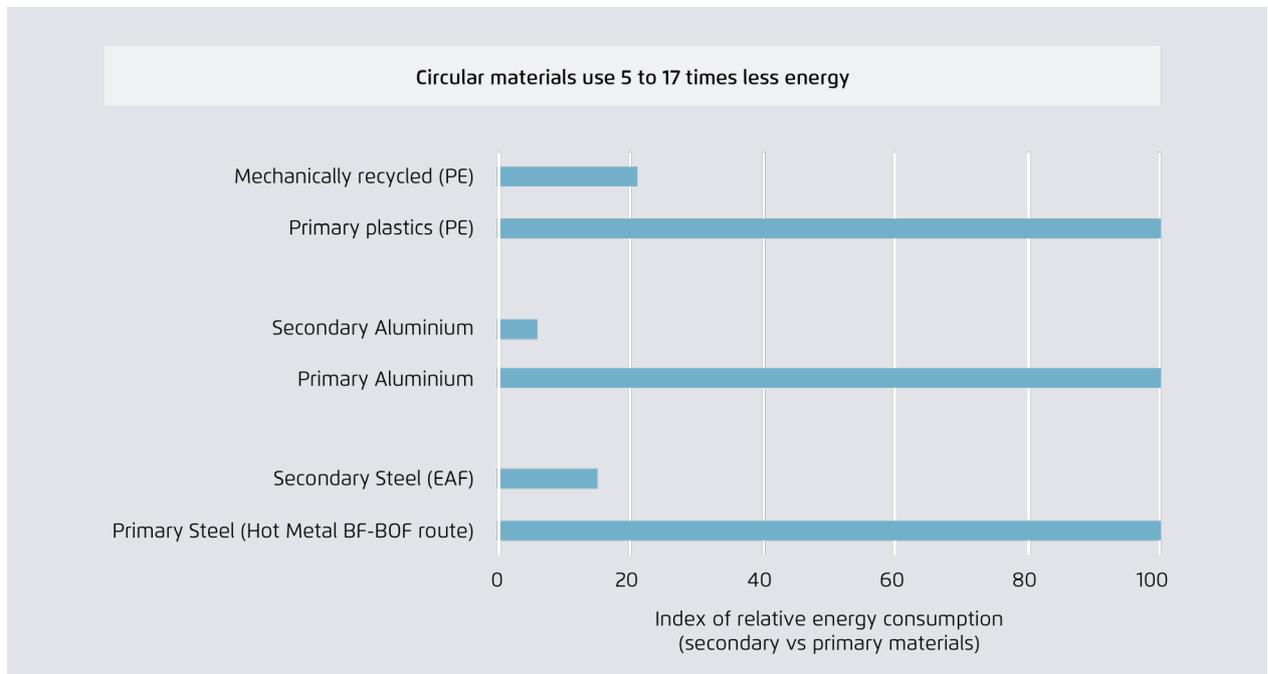
To date, emerging policy efforts to decarbonize these industries have mostly focused on how to reduce emissions from the production of *virgin*, or “*primary*”, materials (for instance by using green hydrogen). This is necessary, but there is a catch: new process to produce fossil free virgin materials does reduce carbon emissions, although it also further increases energy demand.

Fortunately, enhanced material circularity and material efficiency offers equally large potentials to reduce *both emissions and energy consumption* from CO₂-intensive materials. On the emissions side, the enhanced circular and efficient use of materials

alone could contribute up to 70Mt of CO₂ abatement by 2030, and 239 Mt by 2050, equivalent to 10 percent and 34 percent of the total required industrial abatement efforts in the EU by 2030 and 2050, respectively (Figure ES1 and Table ES1). These reductions would thus be additional and complementary to other abatement actions to reduce emissions from virgin materials production, using new, clean technologies¹. As shown in Figure ES1, the CO₂ abatement potential is significant by 2030 already, and given more time for adjustment, is even larger by 2050.

On the energy and basic materials demand side, a more circular and material efficient basic materials sector would also greatly improve energy and resource efficiency. As highlighted in Figure ES2, recycled steel, aluminium or poly-ethylene (PE) products can reduce energy consumption by a factor

Figure ES2: Relative energy savings from enhanced circularity of materials (current technologies)



Source: Agora Industry (2022)

1 Note that since these actions are additional to and complementary to other abatement efforts, enhanced circularity and material efficiency measures are calculated

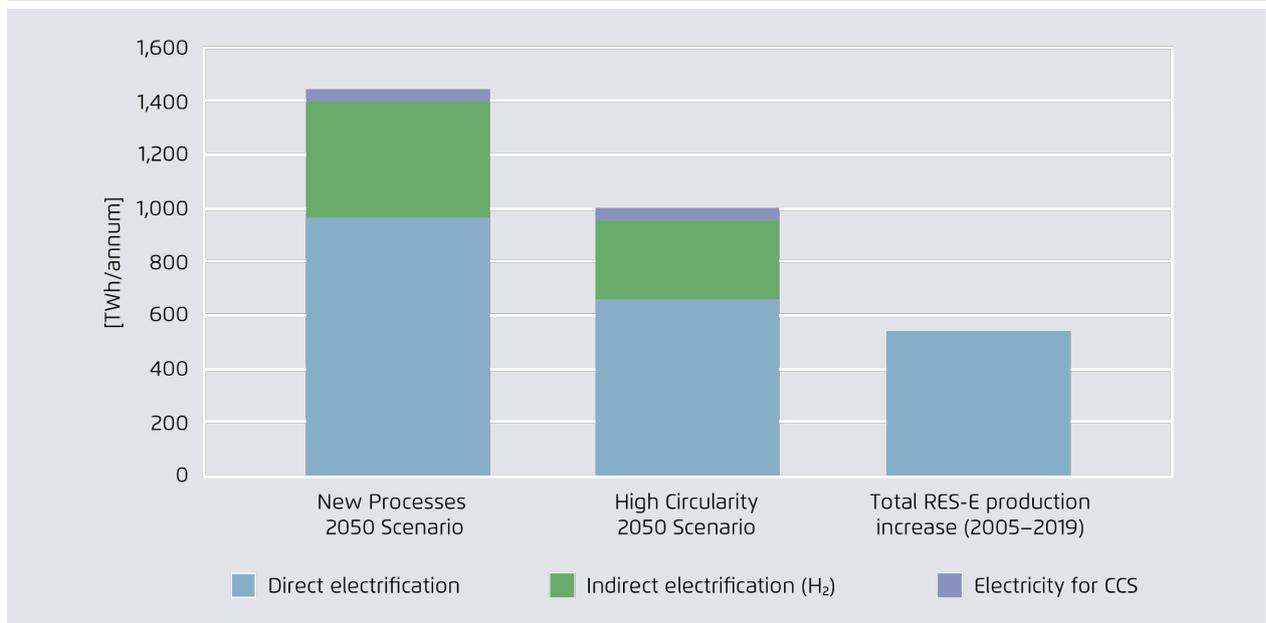
relative to a business-as-usual baseline reflecting current CO₂ intensities of production.

of between 5 and 17 compared to today's primary production processes, depending on the processes involved. This therefore helps reducing fossil fuel consumption in the short term.

Further, preliminary estimates by Agora Industry suggest that exploiting the full potentials for enhanced plastic savings and recycling as outlined in the report could save on the EU's use of oil-based hydrocarbon feedstocks the equivalent of around 149 barrels of oil by 2030 (compared to current policy settings). The EU's use of hydrocarbons sourced from natural gas, such as ethane, propane and butane, could also be reduced by around 2.7 billion cubic meters (bcm) by 2030 and by significantly greater amounts by 2050.

In the medium and longer term, more circular and efficient use of materials would further increase total energy savings compared to virgin production, since climate neutral primary production processes are generally more energy-intensive than conventional ones (due to hydrogen consumption, energy inputs into carbon capture and storage, etc.). The key is therefore to limit unnecessary increases in clean energy consumption. By 2050, for the steel, cement and chemicals sectors, enhanced circularity has the potential to reduce total clean electricity demand by over 400TWh annually – equivalent to avoiding the installation of 60 000 wind turbines for this power supply². As shown in Figure ES3, this could be a total net energy saving of up to one third compared to a scenario based on climate neutral virgin materials production and low circularity.

Figure ES3: Additional power needs for the decarbonisation of steel, cement and chemicals (high vs. low circularity scenarios)



Source: Agora Industry (2022), based on data from Material Economics (2019), Eurostat (2021)

2 This assumes an average capacity of 2 GW and an annual load factor of 0.38.

Thus, the current European industry cannot hope to successfully transition to climate neutrality by 2050 unless it leverages the full CO₂ mitigation and energy savings potentials of a genuine circular and resource-efficient industrial sector. It is necessary that the EU develops clean hydrogen for new, fossil-free industrial processes, larger amounts of clean power for electrification, and carbon capture and storage (CCS), or uses biomass as a feedstock in specific “no-regrets” applications. Nevertheless, fully exploiting the potentials for enhanced, high quality material circularity and material efficiency is critical to reduce the technical bottlenecks, costs and public acceptance challenges that come with the scaling of infrastructure for greening primary material production.

Moreover, a more circular and resource-efficient industrial sector makes competitive sense and represents a major *industrial policy opportunity* for Europe. When one considers the structural risks of higher relative energy costs in Europe compared to those of future hydrogen super-powers, using the EU’s own cheap abundant resources of scrap and material waste can be a means of remaining both cost competitive and green in energy-intensive sectors. Further, an opportunity for the EU and member states to play to their competitive strengths industrially lies in harnessing the demand for more sustainable and circular industrial and consumer products, e.g., by developing new high value-added technologies, logistics and products.

Up until now, enhanced materials circularity and efficiency measures have lacked the attention they deserve. Industrial decarbonisation policy, at both the EU and member state levels, seems to operate in silos – with one silo working on ways to reduce emissions from industry by greening primary production, while another works on the circular economy more broadly, but neglects potentials for CO₂ abatement, energy efficiency and strategic industrial autonomy.

By and large, current circularity performance for CO₂-intensive materials in Europe is far from being what it seems at first glance:

- **Downcycling is pervasive:** while up to 70–85 percent of steel, aluminium and even concrete is technically defined today as “recycled”, this almost always means *down-cycled* – limiting the ability of recycled materials to replace virgin materials in numerous product types.
- **Policy focuses on quantity not quality of recycling:** while the EU’s first Circular Economy Package made some significant strides towards tackling packaging waste, especially for plastics, scant attention has been given to enhancing the *quality* of recycling other CO₂ intensive basic materials, such as steel, aluminium, and cement and concrete. The construction and automotive value chains in particular require much higher quality recycling.
- **Statistics on plastics recycling are incomplete,** and so unreliable: while the EU records recycling rates in the order of 35 percent today, the current data and statistical methods used *fail to count an estimated 50 percent* of all end-of-life plastic waste (Material Economics, 2022: “Europe’s Missing Plastics”). The correct rate of recycling for EU plastic waste is thus closer to 15 percent.
- **Material efficiency is hardly incentivized:** new scrap tends to be defined as recycled materials, when the focus should be on high-quality recycling of post-consumer scrap while production of new scrap should be disincentivized.

The on-going process of implementing Europe's second Circular Economy Action Plan (CEAP2) is a timely opportunity to begin addressing these concerns in European circular economy and sustainable products legislation. At the same time, the complexity of the issues "on the ground" will require that member states also take a strong role.

There is no silver bullet policy. Rather, a package of measures will be required to address today's barriers to both supply and demand for high-quality recycled and re-usable materials. 9 key priorities for policy makers are summarised in Box ES1.

The highest priority is to create markets for the enhanced closed-loop recycling of key CO₂-intensive

materials across main usages. Recycled content quotas on packaging, new vehicles and new buildings are found to be the single-most effective instrument for kick-starting closed-loop value chains. By guaranteeing demand, quotas foster early investment in enhanced high-quality recycling value chains – in contrast to existing standard practices today.

Embedded carbon limits on buildings and on vehicles and packaging should be developed as a medium- and longer-term strategy, respectively. Embedded carbon limits are more effective in promoting climate-friendly and material-efficient design than direct regulation via, say, Ecodesign policies. Complementary enabling policies will be needed to unlock the full potential of the circular economy over time.

Box ES1: Key policies for the creation of highly circular and resource-efficient markets for energy-intensive materials

Market creation policies

1. Expand the use of recycled content quotas to a wider set of plastic products (not just PET bottles); to steel, aluminium and plastics in vehicles; and to concrete materials used in public construction projects.
2. Limit the embedded life-cycle carbon emissions of construction materials in new buildings, vehicles and packaging.
3. Mobilise carbon pricing more effectively: Include waste incineration in the EU Emissions Trading Scheme (ETS), gradually shift from free allocation to full auctioning and introduce a Carbon Border Adjustment Mechanism (CBAM) in order to strengthen price incentives for recycled materials.
4. Reform product standards for materials to remove existing barriers to innovation for CO₂-efficient or recycled materials (concrete and plastics, in particular) at European and, if necessary, national levels.
5. Ban exports of EU waste to countries that do not adopt equivalently stringent recycling targets and practices (beyond the relatively loose restrictions that currently apply for OECD countries).

Enabling policies to maximise the supply of high-quality recycled materials

6. Review the measurement of recycling rates, especially for end-of-life plastics, based on bottom-up analytical methods to take uncounted plastics waste misallocation into account and revise current recycling performance rates and targets.
7. Massively scale up support for breakthrough technologies in the circular economy and new virgin material production routes for energy-intensive industry.
8. Require the adoption of best-practice waste collection infrastructure and best-available material sorting technologies at the recycling plant, including post-collection re-sorting of mixed waste to extract and send for recycling the up to 75 percent of recyclable plastics in the mix.
9. Label, tax or ban inefficient material use and waste management practices, including the overuse of packaging, the sale of short-lived products, the incineration of unsorted plastic waste and the shredding of vehicles prior to copper content removal.

Highlights per product and value chain

Steel

Around 86 percent of steel is recycled today, most of which is downgraded due to the contamination of steel scrap with copper and other elements. Our modelling suggests the EU will have a growing amount of steel scrap available beyond 2030. However, the copper contamination levels of newly available scrap constrain the extent to which secondary steel can replace virgin steel. By around 2040–2050, up to 35 Mt/year of virgin steel could be replaced by clean scrap. This would be roughly equivalent to a CO₂ emission reduction of 63 Mt CO₂/year in the EU.

Enabling clean scrap flows would at least require:

- Supporting the innovation and development of advanced copper removal technologies from steel;
- Eliminating inefficient end-of-life recycling practices to maximise the overall EU scrap supply while maintaining clean scrap flows;
- Developing integrated Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) production technologies to facilitate the blending of high shares of scrap into integrated primary and secondary steel production routes and developing EAF mini-mills to process growing quantities of steel scrap into a range of different steel products.

Clean scrap flows will become one of the most important factors for competitiveness in the future EU steel industry, if not *the* most. Currently, EU steelmakers focus primarily on switching to hydrogen-based primary production routes. However, in the long run, the competitiveness of hydrogen-based DRI production will be primarily determined by the lowest costs for producing abundant renewable hydrogen. Today's iron ore exporters such as Australia and Brazil, which have abundant renewable energy potential, are soon expected to move to green DRI production and exports. In anticipation, domestic

clean scrap resources for producing high-quality steel grades will be one of the most important competitiveness factors for the European steel industry. About 5 to 6 times more energy-efficient than the current primary production routes, the secondary steel production route will also facilitate the climate-neutral transformation of the EU steel industry while maintaining its competitiveness.

Aluminium

Aluminium is a relatively new material that is used in both short-life applications like food packaging and foils, but also longer-lived applications, such as construction and vehicles. In 2019, 5 Mt of aluminium reached its end-of-life; of that, roughly 3 Mt were recycled. Secondary aluminium production emits much less than conventional primary production: 0.3 t CO₂ per tonne versus 13–16 t CO₂.

Achieving high collection rates is important. Ensuring clean scrap flows to limit downcycling means identifying and sorting sub-alloys into their respective qualities for different grades of aluminium and uses. Over time, the larger amounts of aluminium reaching their end-of-life will raise the potential for high-quality recycling to significant levels in Europe.

Enabling clean scrap flows would require:

- Supporting the rapid development and deployment of advanced sorting technologies for post-consumer scrap as a key climate technology priority;
- Designing products such as cans, vehicles, electronic appliances, information technology goods and construction products to facilitate deconstruction, sorting and recycling and minimise contamination;
- Eliminating inefficient end-of-life recycling practices: current recycling practices such as the shredding of cars or the non-separated collection from construction and other waste can be improved to maintain clean aluminium flows.

High-quality recycling would not only significantly reduce CO₂ emissions and require significantly less clean energy than a primary production route; it would also help the industry retain a competitive edge by addressing challenges ahead, such as:

- The loss of markets for downcycling products: as vehicle electrify, the market for many downcycled products made of cast-aluminium recyclates that go into vehicles are expected to disappear;
- Structurally high energy costs in Europe: achieving higher rates of recycling would help to mitigate this competitive disadvantage, since recycled aluminium uses an order of magnitude less energy than primary smelting;
- The introduction of a Carbon Border Adjustment Mechanism (CBAM), and similar initiatives to create markets for lower carbon aluminium: enhancing the share of secondary aluminium in total production sold will allow short term (direct) CO₂ intensity reductions and help address the need to reduce process as well as power emissions to be competitive.

Plastics

In the EU, 63 Mt of plastics were produced in 2019, 51 Mt were used in products sold on the European market and approximately 45 Mt reached their end-of-life (EoL). Only a fraction, 6.7 Mt, were recycled. Despite the focus on plastics collection and recycling in recent years, the EU recycled only about 15 percent of its total annual end-of-life plastics, via mechanical recycling methods. Each year, the EU incinerates around 25 Mt of plastics, after accounting for misallocated waste in mixed waste streams. Incinerated plastics typically leading to 2.8 kg CO₂/kg of plastic burned, up to 70 Mt of CO₂ per year are

emitted at present. Plastic use is expected to increase and incineration-related emissions could reach 112 Mt CO₂ by 2050 if not addressed.

Avoiding short-life plastic uses and incentivising the re-use of plastic materials with reduce-and-re-use approaches could cut around 8 Mt of CO₂ emissions in 2030 and in 2050 relative to business-as-usual scenarios. Higher levels might be possible (SystemIQ 2022³). Second, mechanical recycling is the most energy-, material- and cost-efficient recycling technology; its potentials should be maximised wherever technically feasible as a priority. Current mechanical recycling rates of 15 percent⁴ could theoretically be pushed to 35 percent.

However, as mechanical recycling relies on relatively pure waste streams, there are limits to its potential: the logistics of separate collection and sorting, limitations with certain plastic types, downgrading issues inherent to certain processes and inadequate units' location and scale. These limitations could be overcome with a comprehensive system for sustainable and high-quality chemical recycling, which optimises the rates of plastics collection from *mixed waste* streams. Up to 75 percent of mixed waste plastics could be retrieved and still be viable for chemical recycling. Widespread deployment of chemical recycling could lead to a CO₂ reduction of 4 Mt by 2030 and 44 Mt by 2050, if appropriately regulated to ensure that only the most sustainable technologies and processes gain market access.

Unlocking the full potential of a circular plastics economy requires action at each stage of the cycle:

- Revise end-of-life data collecting methods to take into account all plastics waste and related

3 SystemIQ, "Reshaping plastics – Pathways to a circular, net zero emissions European plastics economy", 2022 (forthcoming).

4 This is from end-of-life to recycled product.

emissions and appropriately adjust the sector's collection and recycling targets;

- Require post-collecting sorting and recovery of plastics in mixed waste using advanced sorting technologies (already in use in Norway and Sweden);
- Support both mechanical and chemical recycling in parallel while maximising the potential of mechanically recycled waste flows;
- Ensure a reliable and large-scale supply of high-quality feedstock by improving the collection and purity of waste streams;
- Ensure that chemical recycling deployment is consistent with broader environmental and climate goals;
- Adjust product standards that currently limit recycled plastics from being used in certain applications.

Incentivising a holistic circular economy offers the potential to develop a resource-efficient and climate-friendly plastics economy while ensuring the long-term competitiveness of the EU's chemical and plastics sector. The efficient recirculation of EoL plastics into the value chain reduces CO₂ emissions, environment pollution and the dependence on virgin feedstock imports. It gives access to large stocks of key raw material inputs, without needing to import fossil fuels or derivatives from abroad. The improved environmental footprint of plastics in Europe will lead to a market for clean products over the long term, a sustainable competitive position, local production, jobs and innovation. By moving decisively into a circular plastic economy, the EU can become an international technology leader.

Cement and concrete

Concrete is the fundamental structural component of many buildings and a large amount of infrastructure existing today. At present concrete waste is mostly downcycled to low-value usages such as back-fillers.

Circularity and material efficiency models are currently in development. They seek to:

- Recover and remake high-quality recycled inputs into new clinker or cement production using the smart separation of concrete constituents at end-of-life;
- Enhance and exploit the natural tendency of cement to "recarbonate" – when calcium-rich hydrated fines reabsorb CO₂;
- Exploit material efficiency, material substitution and optimisation of cement and concrete formulas.

Our estimates suggest that there is a significant emissions reduction potential from low-clinker cement and concrete formulations and from circular approaches in the cement sector.

Additional emissions reductions could also be found in the order of up to 16–24 Mt of CO₂ per year by 2050 if techniques for genuine cement "recycling" were to achieve commercial demonstration and be adopted more widely. Furthermore, another key possibility is the direct reuse of intact concrete components such as concrete slabs or beams. By designing such products in more modular ways and developing material databases, greater re-use of existing components could be made.

Several barriers need lifting for low-clinker cement and concrete formulations and closed-loop re-use of recycled cement fines to become technically feasible. The following measures will play a crucial role:

- Introduce embedded carbon limits on new buildings;
- Reform regulations and standards to allow the use of innovative technologies at European and national levels;
- Foster the uptake of new technologies and alternative materials with innovative public procurement and commercial-scale demonstration projects;
- Revise the current EU emissions trading system (ETS) design and implement CBAM for the

cement sector to remove the distorting effect on strategies for material efficiency through inadvertently subsidising the primary production of clinker.

Circular and efficient approaches in the cement and concrete sectors reduce the scale and the urgency of the need for other decarbonisation strategies such as carbon capture utilisation storage (CCS). Building infrastructure for CCS is costly and developing associated regulation requires some time, while circular and material efficiency approaches could in theory be implemented already today.

Material efficiency and substitution

Approximately 60 percent of greenhouse gas emissions in industry come from the production of material inputs into construction, mobility and plastics. These emissions can be reduced by enhancing the circularity of CO₂-intensive material components. However, significant potentials for material efficiency can also be achieved while producing the same level of economic value in terms of material services to consumers.

In **construction and buildings**, reducing the use of carbon intensive material can be achieved by:

- Designing projects with CO₂ and material optimisation in mind from the outset for new build (e.g. via the use of building information models optimizing for CO₂ in materials.);
- Extending the concept of “material passports”⁵ to enable a higher level of recycling
- Prolonging the lifetime of parts or of the whole building;
- supplementing energy audits with carbon-optimal assessments that include the embedded CO₂ of materials used for renovation; and

- Fostering regulatory incentives to ensure alignment of complex construction value chains with incentives to optimise CO₂ intensity (e.g. embedded carbon and life-cycle emissions limits on buildings).

In the **mobility sector**, levers to reduce the quantity and carbon intensity of materials include:

- The light-weighting of materials;
- Reducing the rate of growth of average vehicle size;
- Substituting primary materials such as virgin steel for secondary material such as steel for flat components;
- Increasing and optimising “near-net shape casting” of components to reduce high new-scrap; rates (as high as 35 percent for steel) produced during the manufacture of vehicle sections;
- Fostering new investment in more flexible mills capable of meeting demand for high flat products used in high-end vehicles.

Agora estimates that by 2050 up to 12 Mt of CO₂ emissions could be saved annually by improving the material efficiency and maximising the substitution potential of metal and plastic components in the mobility sector. This represents an approximate savings of 14 percent compared to the business-as-usual scenario in a complex sector to decarbonize.

For **plastic packaging**, mechanical and chemical recycling alone are unlikely to tackle any more than around 70 percent of the total abatement challenge of plastics. Hence, additional solutions will be needed to tackle the remaining 30 percent of emissions in the long run. The main solutions here include:

- Support the efficient use of plastics, especially with greater levels of re-use and less single use plastic;

5 See Buildings as material banks: Integrating materials passports with reversible building design to optimise

circular industrial value chains (<https://cordis.europa.eu/project/id/642384>).

- Support the greater use of bio-based plastic based on strict conditionalities for sustainable biomass management policies;
- Introduce as last resort carbon capture and storage or carbon capture and use (ideally, resulting in long-lived storage in final products) of any residual emissions from the incineration of plastics.

Significant potentials for CO₂ savings are likely and require further analysis. Initial estimates suggest that the reduction and re-use of plastics in packaging could lower emissions by around 8 Mt CO₂ by 2030 and 2050. These numbers would represent an additional 11 percent and 10 percent of total full-value-chain emissions from the plastics sector in 2030 and 2050, respectively. Accordingly, reduce and re-use have a meaningful role to play in a broader portfolio of CO₂ abatement solutions.

Table ES1 : Summary of main enhanced circularity, material efficiency and substitution levers and their technical CO₂ abatement potentials.

Sector	Enhanced circularity or material efficiency lever	Combined potential emissions savings for 2030 & 2050, in MtCO ₂ /year (share in percentage vs. BAU)	Type of lever
Steel	<ul style="list-style-type: none"> Increase recycling capacity (esp. scrap share in DRI- & EAF-based production) Maintain clean-scrap flows (copper) 	2030: -5 MtCO ₂ (2.4% savings) 2050: -63 MtCO ₂ (30% savings)	Enhanced recycling
Aluminium	<ul style="list-style-type: none"> Increase closed-loop recycling into high quality consumer products Maintain clean scrap flows 	2030: -5 MtCO ₂ (10% savings) 2050: -15 MtCO ₂ (31% savings)	Enhanced recycling
Cement & Concrete	<ul style="list-style-type: none"> Substitution with low binder formulations Recarbonation and recycling of cement fines as inputs into circular cement production 	2030 & 2050: -10 MtCO ₂ & -31 MtCO ₂ (10% and 30% savings, respectively) 2030 & 2050: -5 MtCO ₂ and -16 MtCO ₂ (5% and 15% savings, respectively)	Material efficiency, Enhanced recycling
Plastics	<ul style="list-style-type: none"> Increase mechanical recycling to 35% (from 15% today) Increase chemical recycling to 30–40% (from 0% today) 	2030 & 2050: -12 & -27 MtCO ₂ (18– 27% savings) 2030 & 2050: -4 & -44 MtCO ₂ (6–44% savings)	Enhanced recycling
Construction	<ul style="list-style-type: none"> Reduce material waste (new scrap) in design & construction Optimise application of CO₂ intensive materials Substitution 	2030: -15 MtCO ₂ (12% savings) 2050: -23 MtCO ₂ (15% savings)	Material efficiency, Substitution
Vehicles	<ul style="list-style-type: none"> Reduce material waste (new scrap) in manufacture Reduce weight via high-strength materials Increase integration of circular components Reduce average vehicle size 	2030: approx. -6 MtCO ₂ (7% savings) 2050: approx. -12 MtCO ₂ (14% savings)	Material efficiency, Substitution
Packaging	<ul style="list-style-type: none"> Reduce and re-use (esp. single-use plastics) Switch to fibre-based materials 	2030: -8 MtCO ₂ (10% savings)* 2050: -8 MtCO ₂ (11% savings)*	Material efficiency, Substitution

*This refers to the reduction and re-use of plastic packaging only.
Agora Industry (2022)



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