Urban Mining

Indice

01

Intro

☰

Traditional mining

Traditional mining refers to the extraction of minerals and resources from natural deposits, such as mines and quarries, typically located in rural or remote areas. It involves processes such as drilling, blasting, and excavation to extract raw materials like metals, minerals, and fossil fuels.

In our era of excessive production, numerous objects belong to the anthroposphere - offices, apartments, cars, electronics, furniture, and more. Sadly, many of these items end up as waste, causing severe environmental damage when disposed of improperly. Meanwhile, mining companies continue to harm the planet, exploit communities, and contribute to substantial CO_2 emissions in their pursuit of increased production.

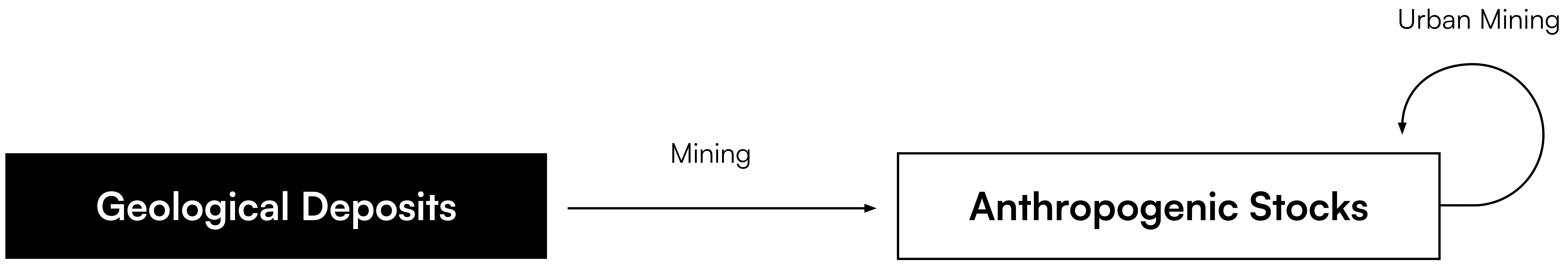
What if we could utilize existing resources instead of relying on new mining for raw materials? Is it possible to reduce the demand for ore and avoid the harmful practices associated with the mining industry, such as violence and exploitation of communities and the environment?

What is urban mining?

Urban mining refers to the process of extracting valuable resources and materials from urban areas, including buildings, infrastructure, electronic waste, and other discarded or unused materials. It involves the recovery, recycling, and repurposing of resources that are present in urban environments, with the aim of reducing the dependence on traditional mining and minimizing environmental impacts associated with resource extraction. The concept of urban mining recognizes that cities and urban areas act as vast repositories of valuable resources. These resources can be found in various forms, such as metals, plastics, glass, concrete, bricks, plastic, wood and organic waste.

Urban mining seeks to harness and extract these resources through innovative technologies and processes, enabling their reuse and integration into new products or applications. Urban mining is closely related to the principles of a circular economy, which emphasizes the importance of resource conservation, recycling, and closing the material loop. By recovering valuable resources from urban waste streams and reintroducing them into the production cycle, urban mining aims to reduce waste, conserve natural resources, and promote sustainable practices.

Urban mining



Timeline of urban mining

Early Practices

In ancient civilizations such as the Roman Empire and ancient China, materials like metals, bricks, and stones were often reused in construction projects. This can be seen as an early form of urban mining, where materials from existing structures were repurposed.

18th century

The Industrial Revolution led to urbanization and increased resource consumption, but traditional mining took precedence over urban mining.

Mid-20th century

The rise of consumer electronics and technology created a need to manage electronic waste, leading to specialized urban mining practices for extracting valuable metals.

Late-20th century

Due to concerns about resource scarcity, urban mining arose as an alternative to resource extraction, utilizing urban resources and minimizing traditional mining.

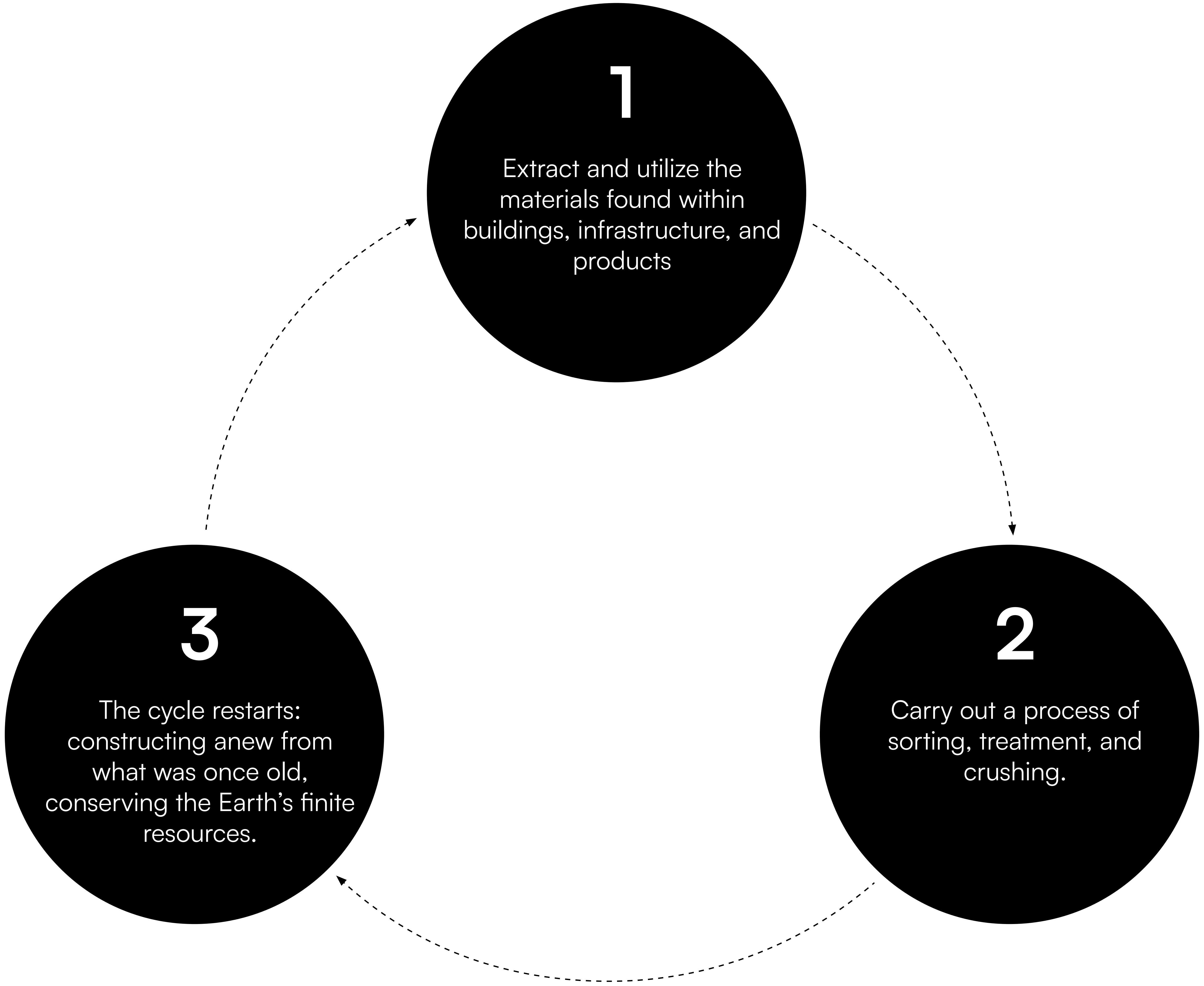
Early 2000s

The term “urban mining” gained recognition and entered academic discourse Researchers and experts began studying and promoting the concept as a sustainable solution for resource management.

Today

Urban mining is recognized as a vital component of sustainable resource management, offering opportunities to recover valuable resources from urban areas while reducing reliance on traditional mining and minimizing environmental impacts.

Urban mining



Source: NASA GISS & NOAA NCE

Urban mining offers the opportunity to reshape our cities by converting waste into valuable resources, forging the way for the adoption of a circular economy.

02

Waste and recycling

E-waste

Precious Metal Recovery

Critical and Rare Earth Metals

Construction and Demolition Waste

E-waste

E-waste, short for electronic waste, refers to discarded electronic devices or electrical equipment that have reached the end of their useful life or are no longer wanted or needed. E-waste is generated due to technological advancements, shorter product lifecycles, and consumer preferences for new and upgraded devices.

Precious Metal Recovery

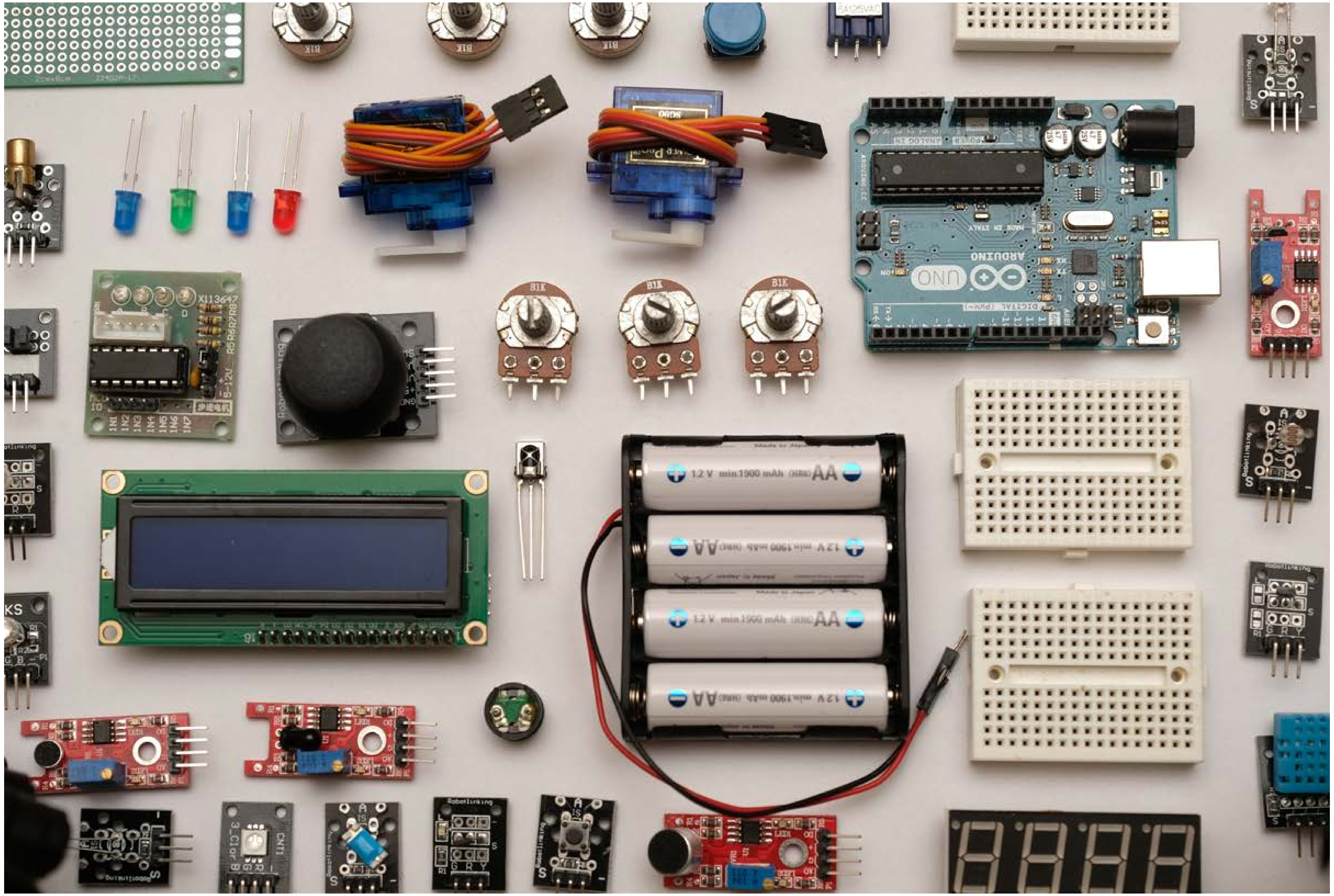
Critical and Rare Earth Metals

Construction and Demolition Waste

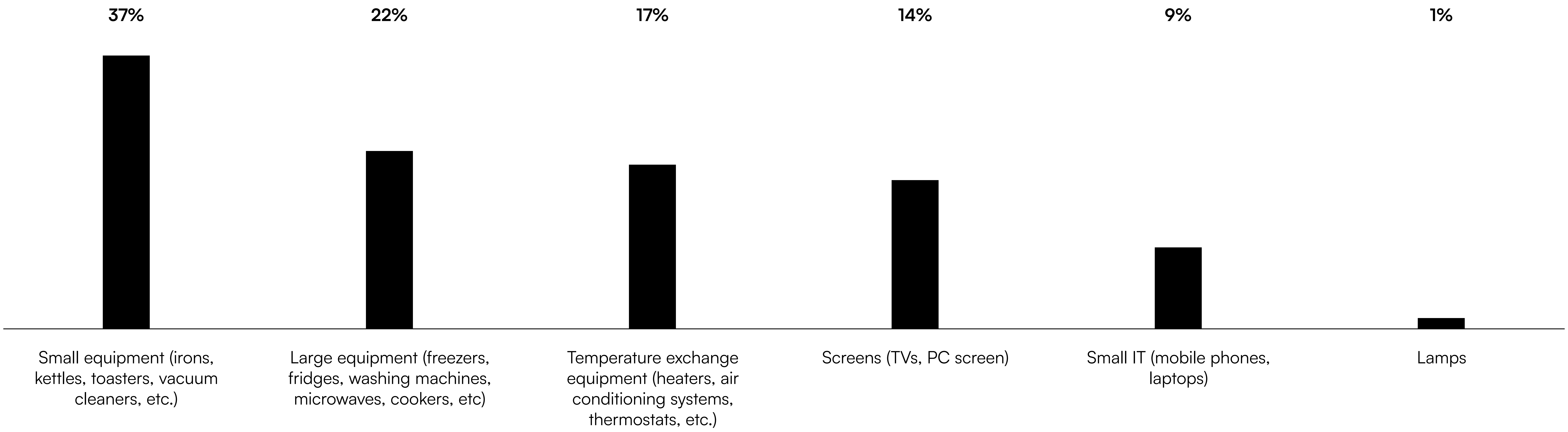
E-waste

E-waste urban mining refers to the process of extracting valuable resources from electronic waste (e-waste) through recycling and resource recovery techniques. E-waste, which includes discarded electronic devices such as computers, smartphones, and televisions, contains precious metals, rare earth elements, and other valuable materials that can be recovered and reused.
The practice of e-waste urban mining involves advanced technologies and processes for sorting, disassembling, and extracting valuable components and materials from electronic devices. These recovered resources can then be reintroduced into the production cycle, reducing the need for virgin materials, and minimizing the environmental impact of traditional mining.

E-waste urban mining plays a crucial role in resource conservation, waste reduction, and the promotion of a circular economy. It not only helps recover valuable materials but also prevents hazardous substances found in e-waste from ending up in landfills or causing environmental contamination. By extracting and reusing resources from e-waste, urban mining contributes to sustainable resource management and the efficient use of materials.



Global E-waste



E-waste

Precious Metal Recovery

Urban mining focuses on the recovery of various metals from urban sources, particularly electronic waste (e-waste). The specific metals recovered can vary depending on the types of electronic devices processed and the recycling techniques employed.

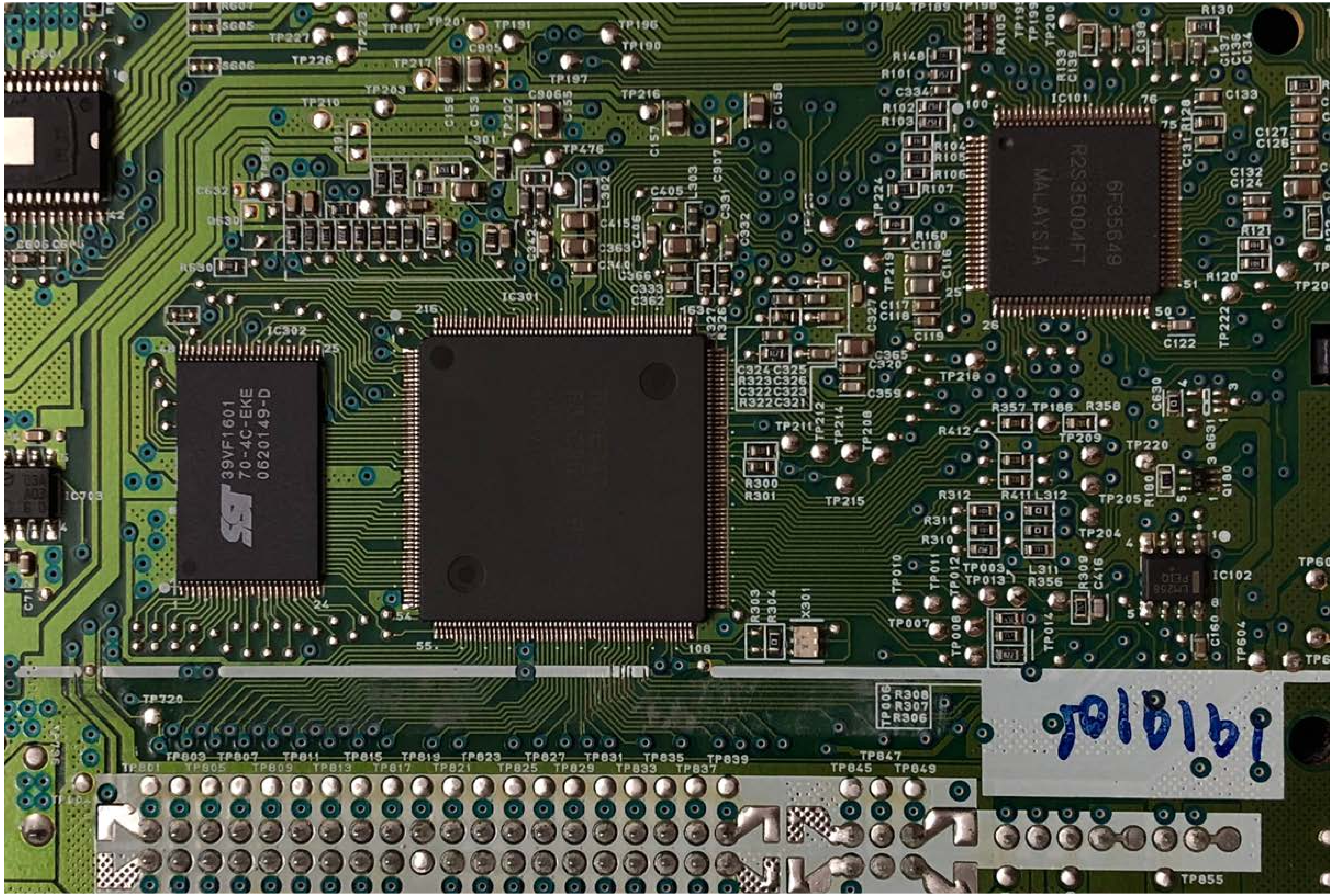
Critical and Rare Earth Metals

Construction and Demolition Waste

Precious Metal Recovery

Precious metal recovery in the context of urban mining refers to the process of extracting valuable metals, such as gold, silver, platinum, and palladium, from various urban waste streams, including electronic waste, jewelry waste, and industrial byproducts. These precious metals are highly sought after due to their scarcity, high economic value, and diverse industrial applications. The process of precious metal recovery typically involves several steps, including sorting, disassembly, and refining.

Advanced technologies, such as mechanical shredding, magnetic separation, and hydrometallurgical or pyrometallurgical processes, are utilized to extract and separate the precious metals from the waste materials. In the case of electronic waste, for example, circuit boards, connectors, and other components containing precious metals are first separated from the rest of the electronic waste. Subsequently, various methods, such as acid leaching or smelting, are employed to extract and refine the precious metals. The recovered precious metals can then be sold or reintroduced into the market, reducing the reliance on traditional mining, and minimizing the environmental impact associated with mining activities. Precious metal recovery through urban mining not only conserves valuable resources but also reduces the need for raw material extraction, thereby promoting sustainable resource management and contributing to the circular economy.



Precious Metal Recovery

Gold (Au)

Gold is a highly valuable and sought-after precious metal used in various electronic components, including connectors, contacts, and circuit boards.

Silver (Ag)

Silver is another precious metal commonly found in electronic devices. It is used in circuit boards, switches, contacts, and other electrical components.

Copper (Cu)

Copper is a widely used metal in electronics and electrical wiring due to its excellent conductivity. It can be found in various electronic devices, cables, and wiring

Palladium (Pd)

Palladium is a precious metal used in electronic components, particularly in catalytic converters, capacitors, and connectors

Platinum (Pt)

Platinum is a valuable metal used in electronics, especially in catalytic converters, sensors, and electrodes.

Indium (In)

Indium is a rare and valuable metal used in the production of LCD screens, touchscreens, and photovoltaic cells

E-waste

Precious Metal Recovery

Critical and Rare Earth Metals

While not metals in themselves, rare earth elements are a group of elements that are crucial for various electronic devices, including smartphones, computers, and renewable energy technologies. Urban mining focuses on the recovery of rare earth elements reducing reliance on primary mining for these scarce resources.

Construction and Demolition Waste

Critical and Rare Earth Metals

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Critical and Rare Earth Metals

Neodymium (Nd)

From discarded electronic devices, particularly hard drives, speakers, and headphones. These devices contain neodymium magnets, which are essential for various applications, including electric motors in electric vehicles and wind turbines.

Dysprosium (Dy)

Dysprosium is recovered from e-waste, particularly from magnets used in renewable energy technologies, such as wind turbines.

Lanthanum (La)

From hybrid vehicle batteries, camera lenses, and catalysts. Recycled lanthanum helps for various industries, including automotive and energy.

Palladium (Pd)

Palladium is a precious metal used in electronic components, particularly in catalytic converters, capacitors, and connectors

Platinum (Pt)

Recovered from flat-panel displays, lasers, and LED phosphors. Recycled yttrium ensure availability for electronics, lighting applications, and other industries that rely on its unique properties.

Cobalt (Co)

Recovered from discarded lithium-ion batteries, which power electric vehicles, smartphones, and other portable electronic devices.

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E-waste

Precious Metal Recovery

Critical and Rare Earth Metals

Construction and Demolition Waste

Urban mining also encompasses the recovery of materials from construction and demolition waste. Construction and demolition activities generate significant amounts of waste, including concrete, wood, metals, plastics, and other materials. Urban mining aims to extract valuable materials from this waste stream for recycling and reuse, reducing the need for new resource extraction.

Construction and Demolition Waste

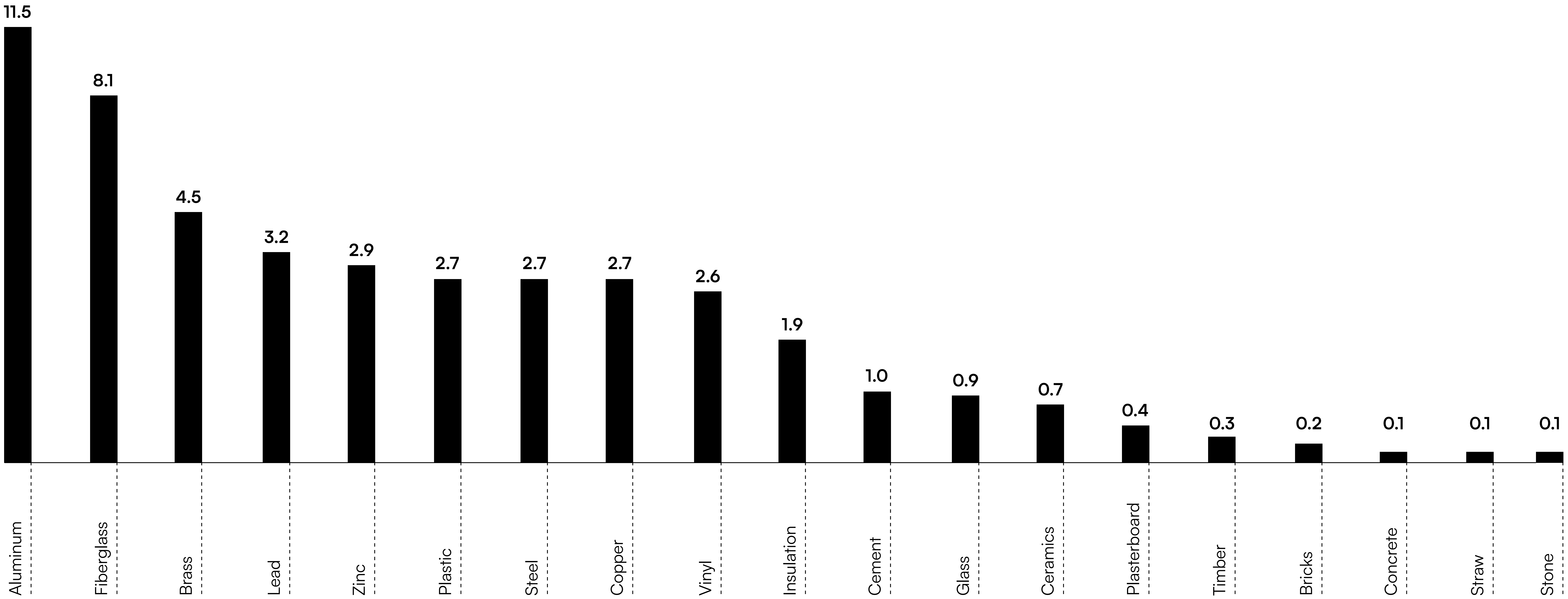
Construction and demolition waste (C&D waste) refers to the materials generated from construction, renovation, and demolition activities. This waste stream typically includes materials such as concrete, wood, metal, bricks, plaster, glass, plastics, and other construction-related debris. The management of the waste presents both challenges and opportunities for sustainable resource utilization. Instead of sending this waste to landfills, strategies such as recycling, reusing, and repurposing can be employed to reduce the environmental impact and promote resource conservation.

C&D waste can be recycled into new construction materials, such as aggregates for road base, crushed concrete for fill material, or reclaimed wood for furniture or building components. Advanced sorting technologies are utilized to separate different types of materials, allowing for effective recycling and recovery. Furthermore, the concept of urban mining is often applied to C&D waste, where valuable materials are extracted and reused. This can involve salvaging architectural elements, fixtures, or other components from demolished buildings for reuse in new construction projects. By implementing proper waste management practices and adopting circular economy principles, the construction and demolition industry can significantly reduce waste generation, conserve resources, and minimize the environmental footprint associated with construction activities.

Today, concrete is responsible for 9% of total greenhouse gas emissions and 7 metals iron, aluminium, copper, zinc, lead, nickel and manganese are responsible for 7%.

Building Materials' Embodied Carbon

CO_2/kg of building materials

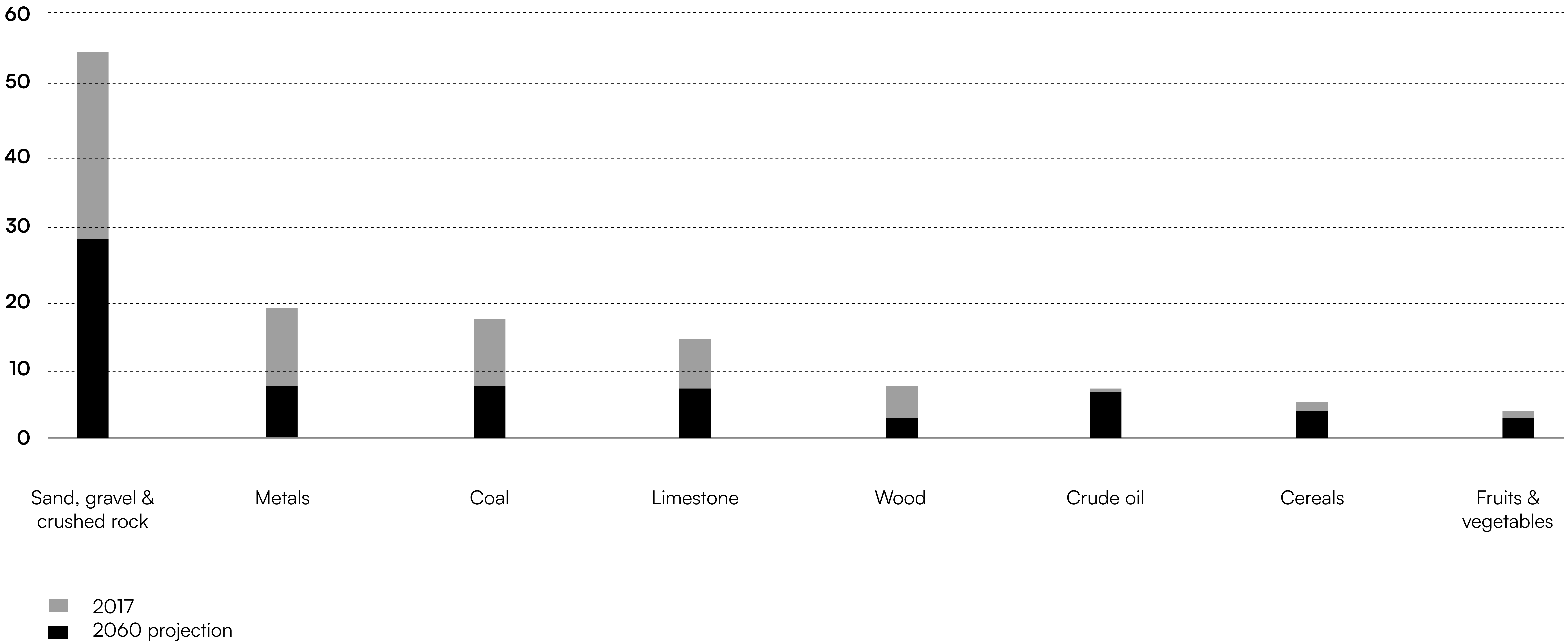


Source: Inventory of Carbon & Energy (ICE) database.

The extraction and combustion of fossil fuels, as well as the production of iron, steel, and building materials, play significant roles in air pollution and greenhouse gas emissions. Without the implementation of new policies aimed at reducing emissions, the emissions from materials management are projected to increase from 28 to 50 Gigatonnes of CO2-equivalent by 2060.

Global Material Resources 2060

Consumption in Gigatonnes



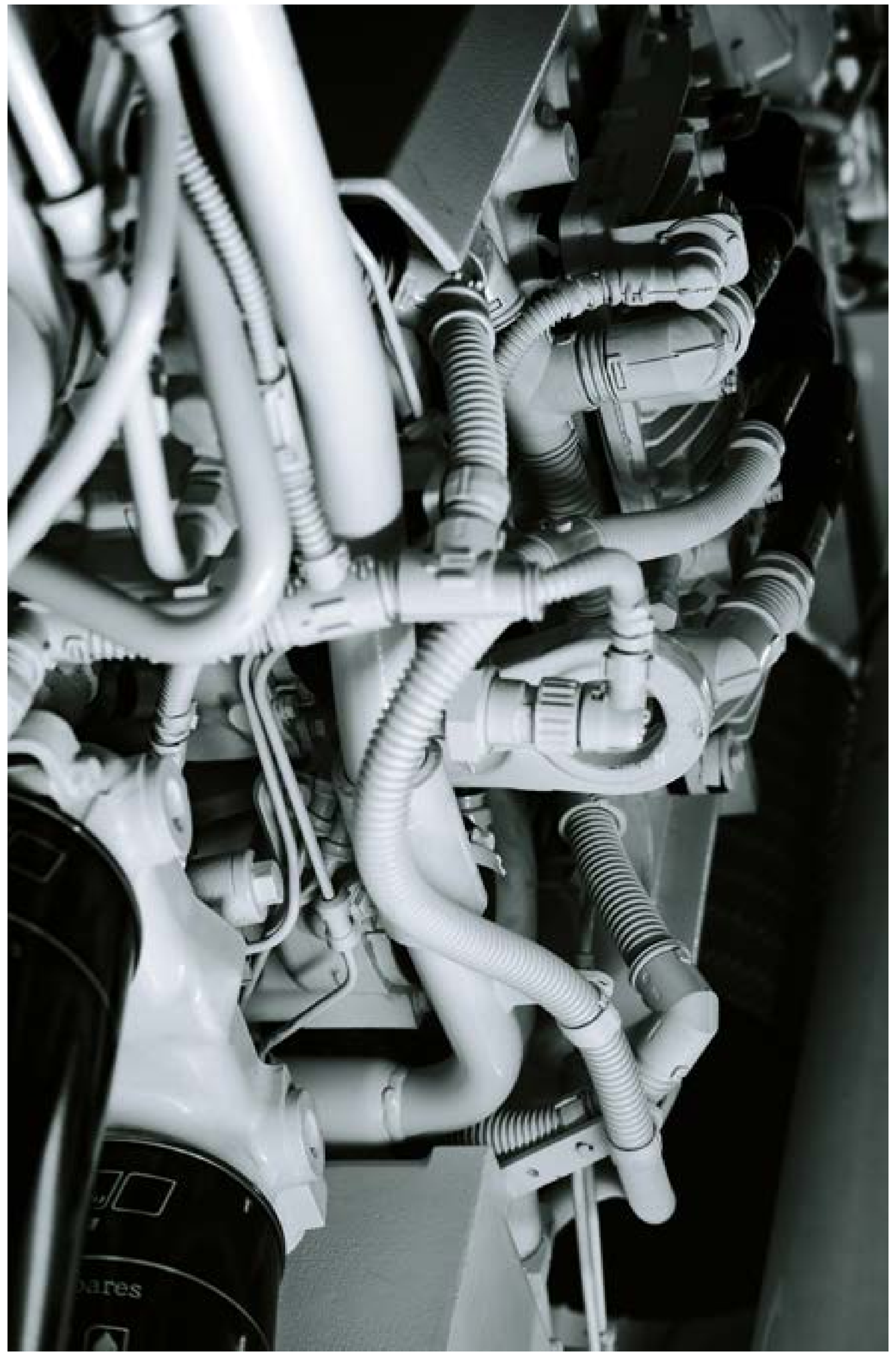
Source: OECD Global Material Resources Outlook to 2060

Construction and Demolition Waste

Concrete and Masonry: Concrete can be crushed and processed into recycled aggregate, which can be used as a substitute for natural aggregates in new construction projects.

Metals: Construction and demolition waste contain various metals, including steel, aluminum, copper, and brass. Urban mining targets the recovery of these metals through processes such as sorting, separation, and shredding.

Wood: Recovery and recycling of wood waste from construction and demolition sites. Wood can be processed and used for various purposes, such as producing engineered wood products, mulch, or biomass fuel.



Plastics: used in construction and demolition activities, such as PVC pipes, insulation materials, and packaging, can be sorted, cleaned, and processed into new plastic products or used as a fuel source in waste-to-energy facilities.

03

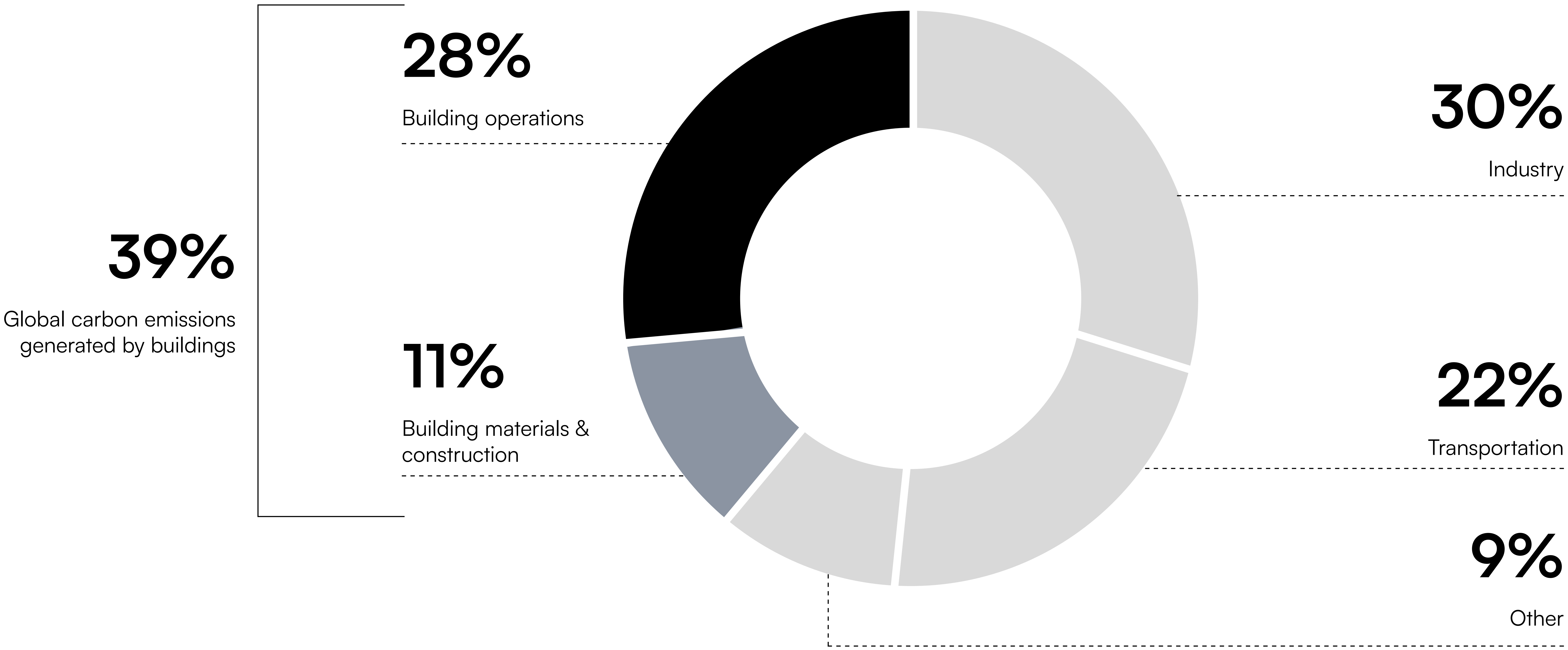
Mining in architecture

Mining in architecture

The statistics paint a clear picture: buildings are responsible for a staggering 39% of global carbon emissions, with operational emissions accounting for 28% and materials and construction contributing 11%. Notably, the peak in emissions during the construction process is primarily driven by the production and transportation of building materials. Considering the projected doubling of urban construction by 2060, resulting in a staggering 230 gigatons of embodied carbon from building materials, it becomes evident that urban mining can and should play a pivotal role in cities.

It stands as the most effective tool to address the European Union's ambitious goal of achieving a zero-carbon building stock by 2050. To achieve this significant milestone, the International Energy Agency (IEA) estimates that direct CO_2 emissions from buildings must be reduced by 50% by 2030, while indirect emissions from the building sector need to decrease by 60%. This translates to an annual reduction in emissions from the construction industry of approximately 6% until 2030.

Global carbon emissions



Source: ARCHITECTURE 2030

Waste in construction

850
millions

*Metric tons of construction and demolition waste (CDW) were created in 2020 alone in Europe

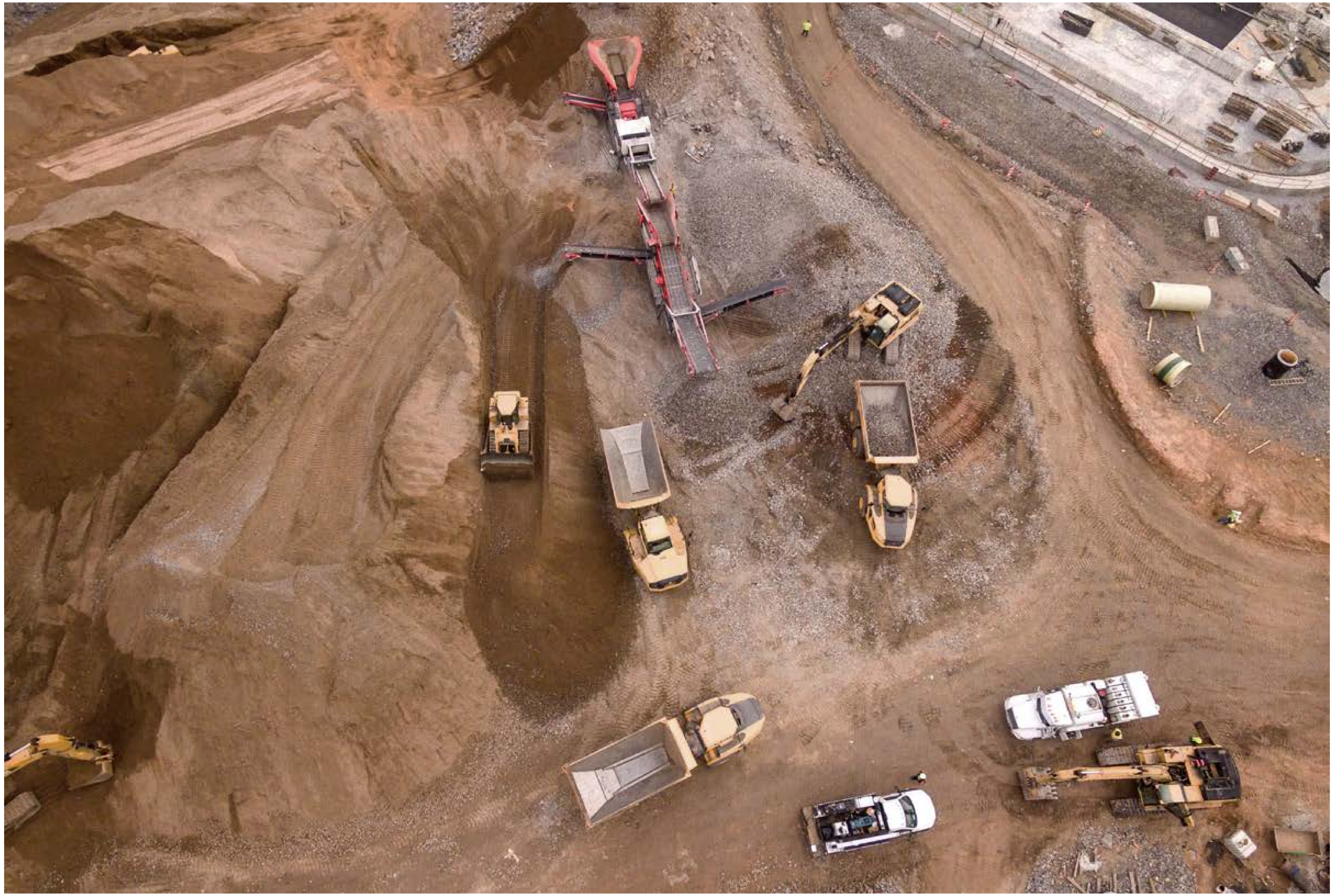
* Source: Politico EU

Why mine, produce, and transport these materials multiple times, from mines around the world, when there are abundant sources all over the cities?

Reusing materials in architecture

If they can be reused, these materials represent great value. First of all, in economic terms: in fact, we are talking about hundreds of millions of euros of saved value, a part of which concerns the reduction of so-called environmental costs. But beyond the environmental costs, the second benefit of urban mining concerns the reduction of environmental impacts. In fact, the use of recycled materials eliminates part of the emissions associated with the production and transport of new building materials.

Considering that the construction sector is responsible for extracting 50% of raw materials, if we can reuse as much of the products that are currently found in our cities as possible, then it will be possible to create fewer components from scratch and extract fewer materials, while emitting less carbon dioxide and greenhouse gases responsible for climate change. In fact, in every phase of the construction process there are production, transport and labor costs, which require time, energy, effort, emissions and therefore have a great environmental impact. Each stage of production, from mining to manufacturing and assembly, thus adds value to a construction product. This added value is accumulated in the products that are in a building at the end of its life cycle, and can be retained if we plan to tear down the buildings and reuse the products for their original purpose (or for an even higher value, according to the upcycling principle); alternatively, by carrying out a selective demolition, these products can be recycled: in this case we speak of downcycling, since there is a loss of value of the original component.



“Future cities will become huge, rich, and diverse raw materials mines. These mines will differ from any now to be found because they will become richer the longer, they are exploited; new veins, formerly overlooked, will be continually opened.”
Jane Jacobs, (1969)

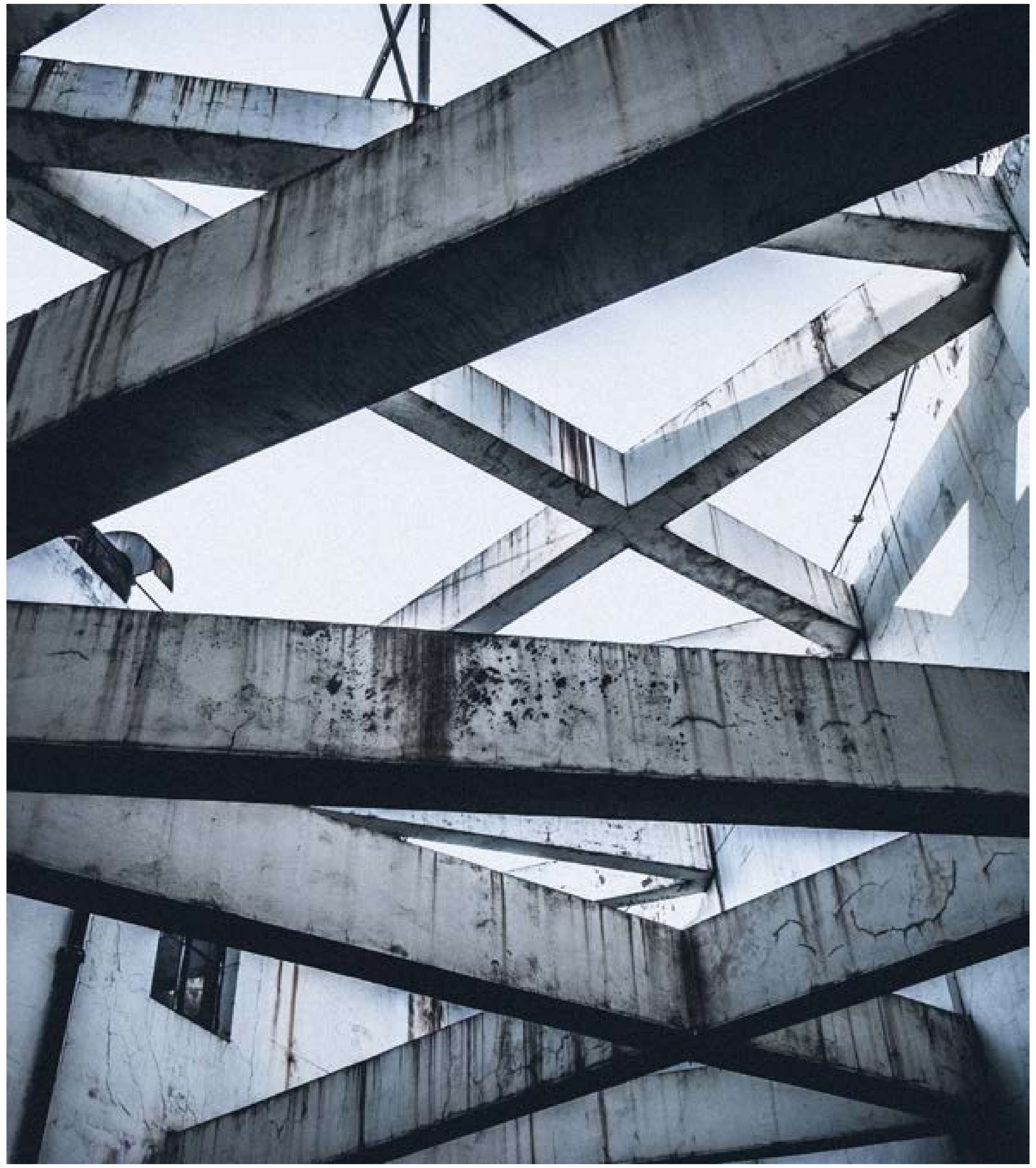
What we can reuse?

Urban areas, often referred to as “concrete jungles,” contain a vast urban mine within their buildings. These structures, comprising concrete, steel, wood, glass, copper pipes, aluminum facades, roof tiles, bricks, and even iron railings, hold significant value. These materials are already finished products that have undergone a lengthy supply chain. In essence, every urban construction project is encompassed by a wealth of useful materials and components. Urban mining in architecture enables the reuse of various materials and components, fostering sustainability and resource conservation. Therefore, we can extend the lifespan of materials, reduce waste generation, and contribute to a more sustainable and circular approach to construction.

What we can reuse?

Salvaged Building Materials: Urban mining allows for the recovery and reuse of materials from demolished or renovated buildings. This includes items like doors, windows, flooring, bricks, and timber, which can be repurposed in new construction projects.

Architectural Features: Ornamental elements, such as decorative moldings, columns, and fixtures, can be salvaged from older buildings and incorporated into new architectural designs, adding character and preserving historical significance.



Structural Components: Structural elements like steel beams, concrete slabs, and foundations can be extracted from demolished structures and reused in new construction, reducing the demand for new materials.

What we can reuse?

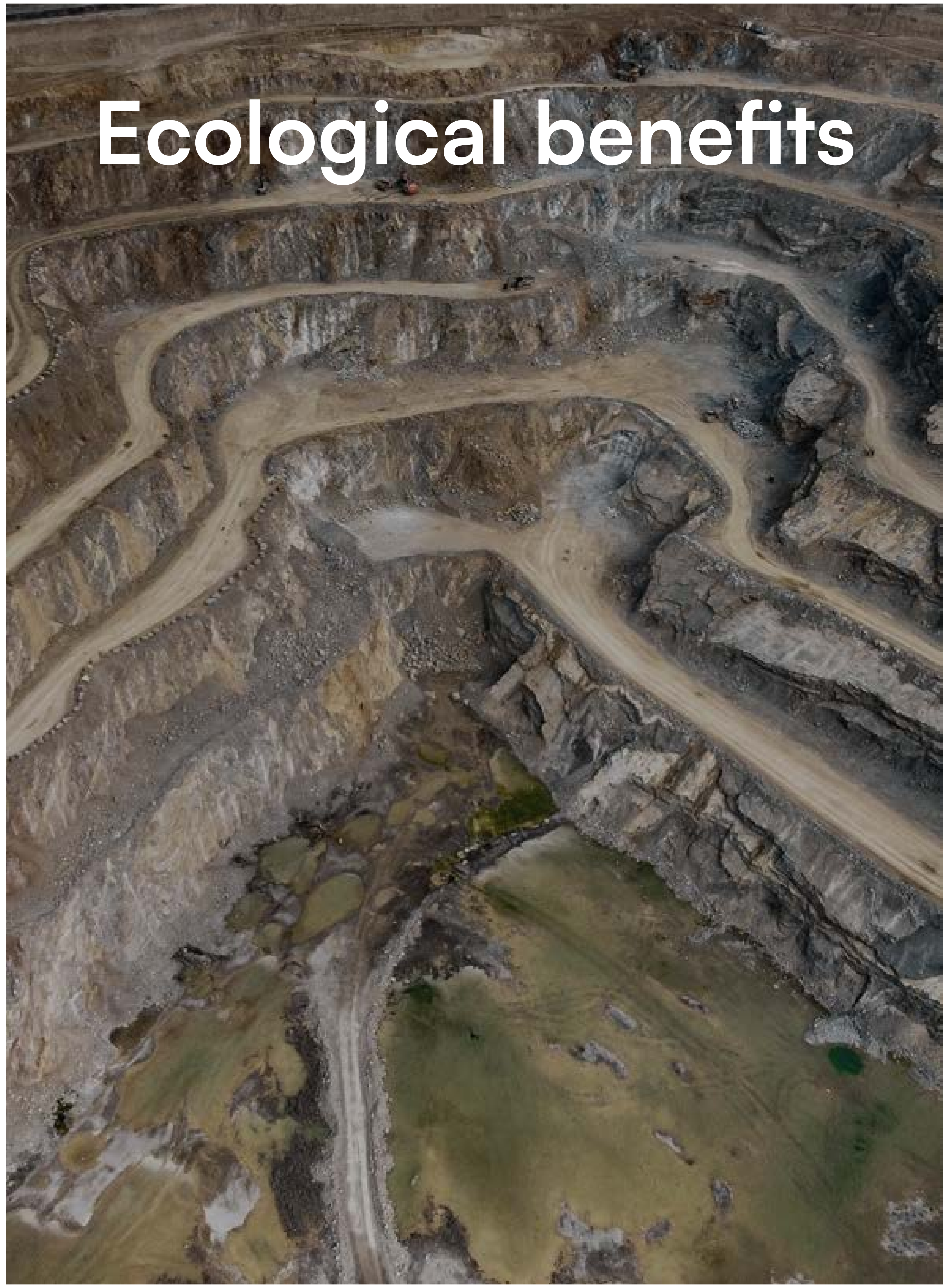
Building Systems: Urban mining enables the retrieval and refurbishment of building systems, including mechanical, electrical, and plumbing components. These systems can be tested, repaired, and reintegrated into new architectural projects, reducing waste and promoting efficient resource utilization.

Reclaimed Wood: Timber from old buildings, barns, or industrial sites can be reclaimed and repurposed as flooring, wall cladding, furniture, or decorative elements, providing a unique and sustainable material option.

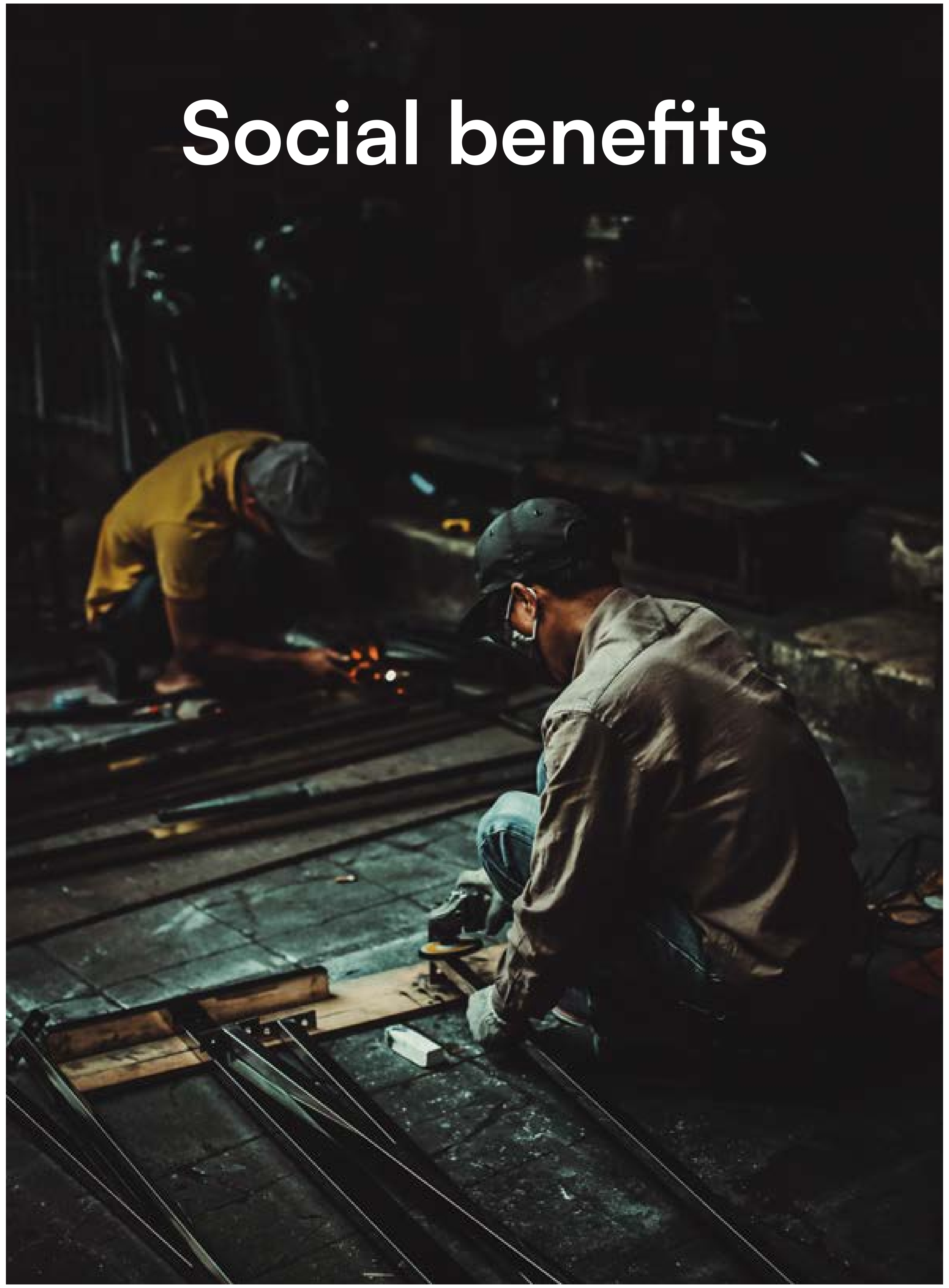
Roofing Materials: Roofing materials like tiles, slates, or metal sheets can be salvaged and reused in new construction or for repairs and renovations, reducing the need for new materials and minimizing waste.

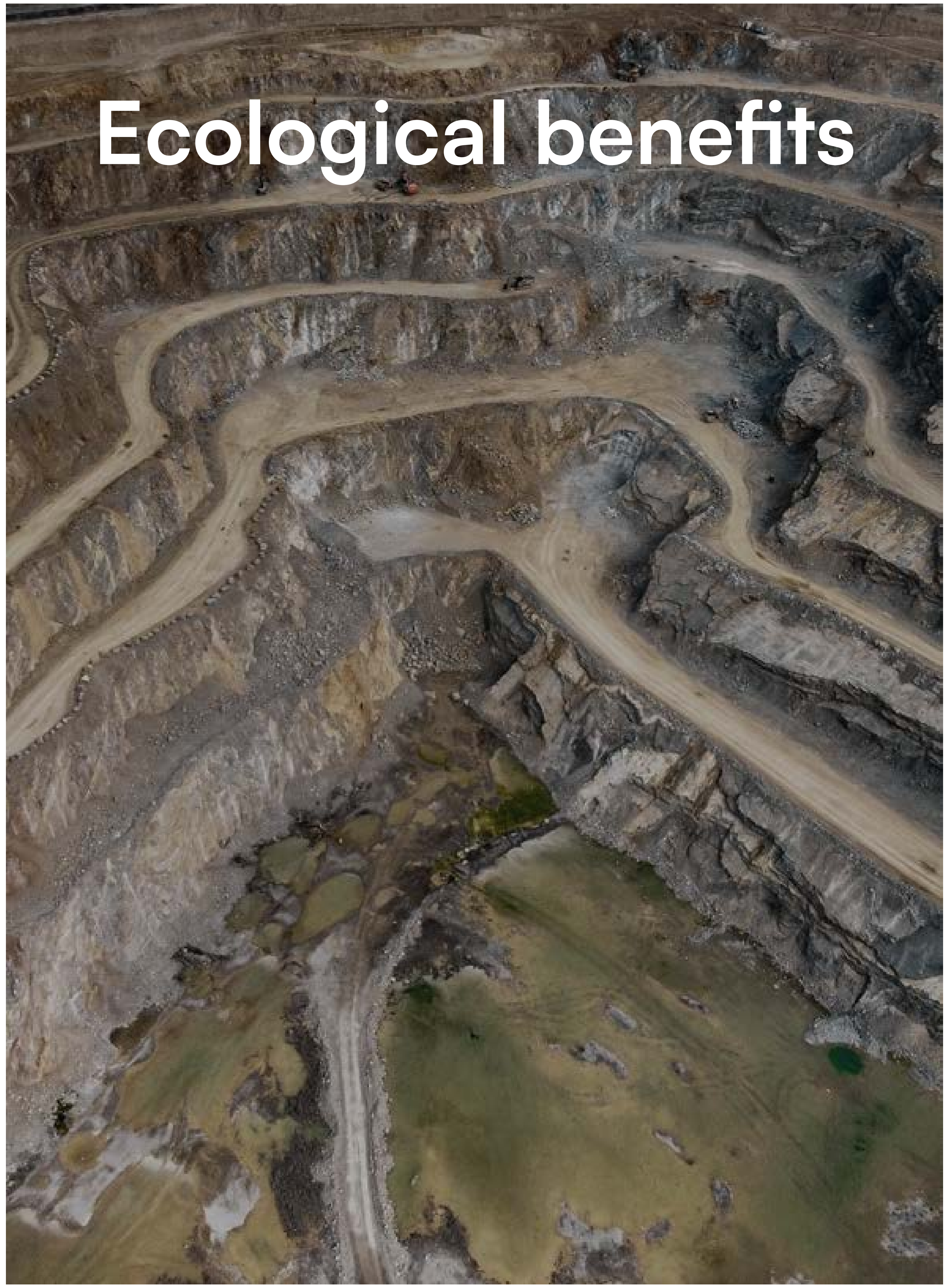
04

Benefits of Urban Mining


Ecological benefits


Economic benefits
Buy Crypto
XTZ/USDT
4.784
$4.78
24h Change
0.258 +5.70%
0.001
Total
3,860.65
2,410.12
479.14
Time


Social benefits


Ecological benefits

Economic benefits

Social benefits

Using materials sourced from urban mines in building construction reduces the embodied carbon of the structure. Conversely, when materials are reclaimed from an unsuitable building, their embodied carbon is retained rather than being emitted into the atmosphere.

Reduced Resource Extraction

Energy and Water Conservation

Reduced Pollution and Emissions

Promotion of Circular Economy

Reduced Resource Extraction

Urban mining plays a crucial role in reducing the reliance on traditional mining practices, which often involve destructive activities that harm the environment.

Energy and Water Conservation

Reduced Pollution and Emissions

Promotion of Circular Economy

Reduced Resource Extraction

Traditional mining operations, such as open-pit mining or underground mining, require extensive land clearance, leading to deforestation and habitat destruction. These activities disrupt natural ecosystems, displace wildlife, and contribute to the loss of biodiversity. By extracting valuable resources from urban areas, urban mining significantly lessens the pressure on ecosystems and natural landscapes.

Instead of expanding mining operations into pristine areas, urban mining focuses on recovering and recycling resources already present within urban environments. This approach helps preserve natural habitats, protect biodiversity hotspots, and safeguard ecologically sensitive areas from further degradation.

Reduced Resource Extraction

Energy and Water Conservation

Urban mining provides significant benefits in terms of energy and water conservation compared to traditional mining practices.

Reduced Pollution and Emissions

Promotion of Circular Economy

Energy and Water Conservation

Conventional mining operations necessitate substantial amounts of energy and water for various stages, including extraction, processing, and transportation of resources. In contrast, urban mining capitalizes on the resources already present within urban areas, reducing the reliance on these energy-intensive processes. By extracting valuable materials from urban sources such as electronic waste, construction waste, and discarded products, urban mining avoids the energy-intensive processes involved in extracting raw materials from mines.

Instead of starting from scratch, urban mining takes advantage of the energy already invested in the production and use of these materials. Additionally, urban mining minimizes the need for water consumption in resource extraction. Traditional mining activities often require vast quantities of water for ore processing, dust suppression, and other operational needs. In contrast, urban mining operations primarily focus on recycling and reprocessing existing materials, which significantly reduces the demand for water.

Reduced Resource Extraction

Energy and Water Conservation

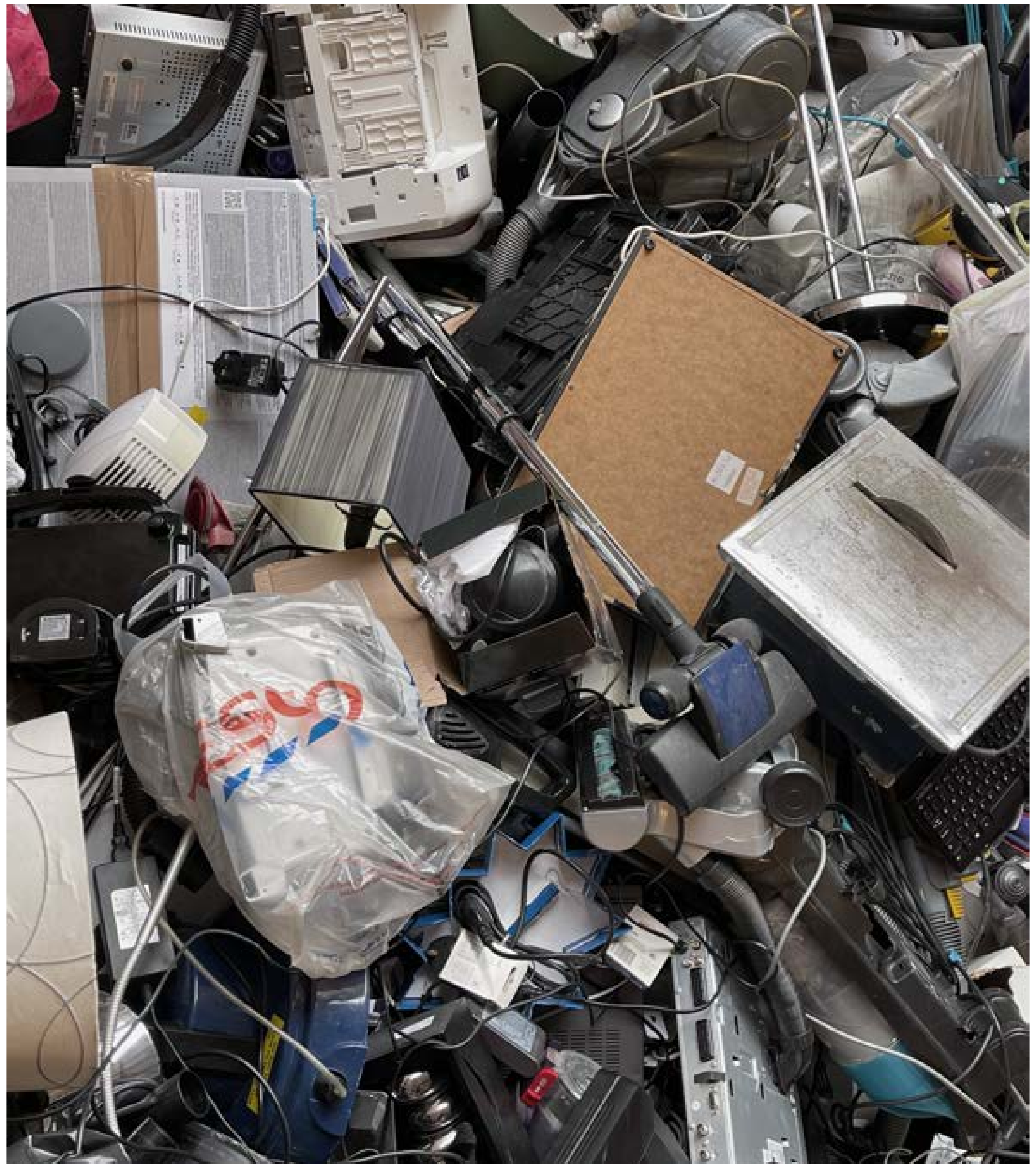
Reduced Pollution and Emissions

Traditional mining is associated with air and water pollution, including the release of toxic substances and heavy metals. Urban mining, on the other hand, employs controlled processes for resource recovery and recycling, reducing the environmental pollution often associated with raw material extraction.

Promotion of Circular Economy

Reduced Pollution and Emissions

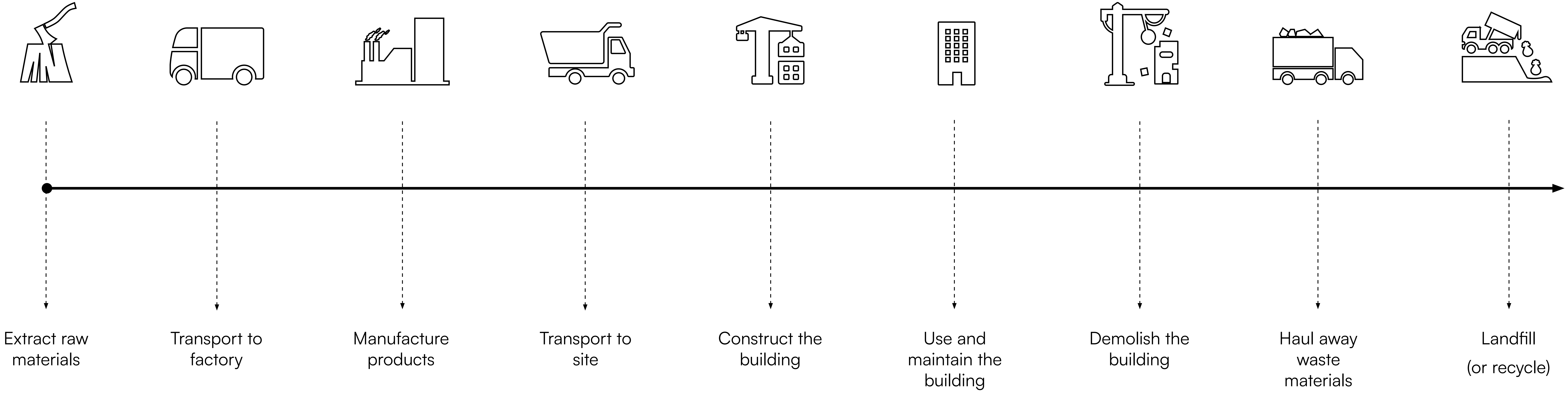
Energy Conservation: Urban mining focuses on the recycling and reuse of materials, which requires less energy compared to primary production processes. Recycling metals, for example, typically requires less energy than extracting and refining ores.



Reduced Landfill Waste: Instead of disposing of valuable resources as waste, urban mining seeks to recover and repurpose them. This reduces the volume of waste that needs to be landfilled, minimizing the production of harmful landfill gases, such as methane, which is a potent greenhouse gas.

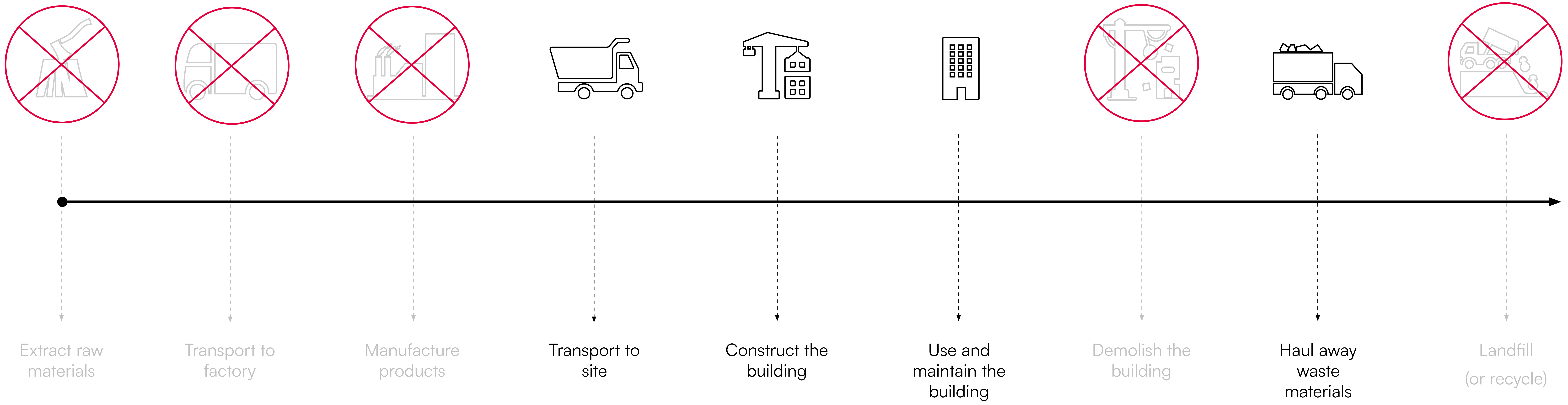
Lower Transport Emissions: Urban mining sources materials from local urban areas, reducing the need for long-distance transportation of raw materials. By relying on nearby sources, the carbon emissions associated with transporting materials over long distances are reduced.

Carbon-emitting steps generated by construction



Source: McCown Gordon Construction

Carbon-emitting steps avoided by urban mining



Source: McCown Gordon Construction

How much carbon emissions can we save?

Using circular construction materials we could save:

1.14GT

*Carbon emissions

3.55GT

*Raw materials

* Source: 2022 Circularity Gap Report

Reduced Resource Extraction

Energy and Water Conservation

Reduced Pollution and Emissions

Promotion of Circular Economy

Urban mining aligns with the principles of a circular economy, where resources are continuously reused and recycled, minimizing waste generation

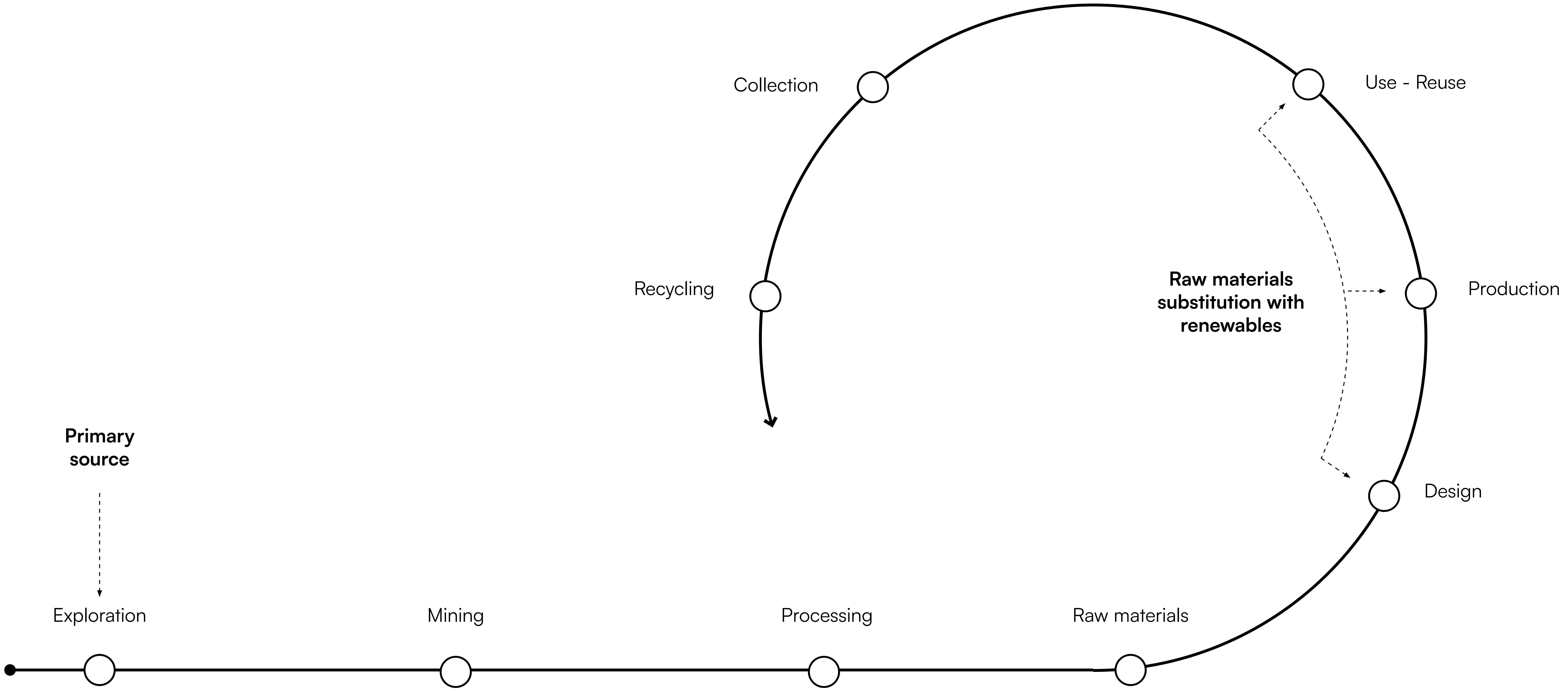
Circular economy restructures entire value chains, as waste is designed out and products are not discarded, but looped back into the material flows. Across industries circularity is an engine for new opportunities through disruptive new business models as the concept of waste is transforming to that of value.

Promotion of Circular Economy

A circular economy is an economic model that aims to maximize resource utilization, minimize waste generation, and create a sustainable and regenerative system. It is a departure from the traditional linear "take-make-dispose" model of production and consumption. In a circular economy, resources are kept in use for as long as possible, their value is preserved, and at the end of their life cycle, they are recovered and reintegrated into the production process.

By reintegrating recovered materials into the production cycle, urban mining helps close the material loop, reducing the demand for new resource extraction and minimizing the environmental impact of resource utilization. The circular economy aims to decouple economic growth from resource consumption and environmental degradation, fostering a more sustainable and resilient economy. It promotes innovative business models, job creation, and the preservation of natural resources, while reducing waste, pollution, and carbon emissions.

Promotion of Circular Economy



Source: AFRY

A circular economy could reduce global CO_2 emissions from building materials by 38% in 2050

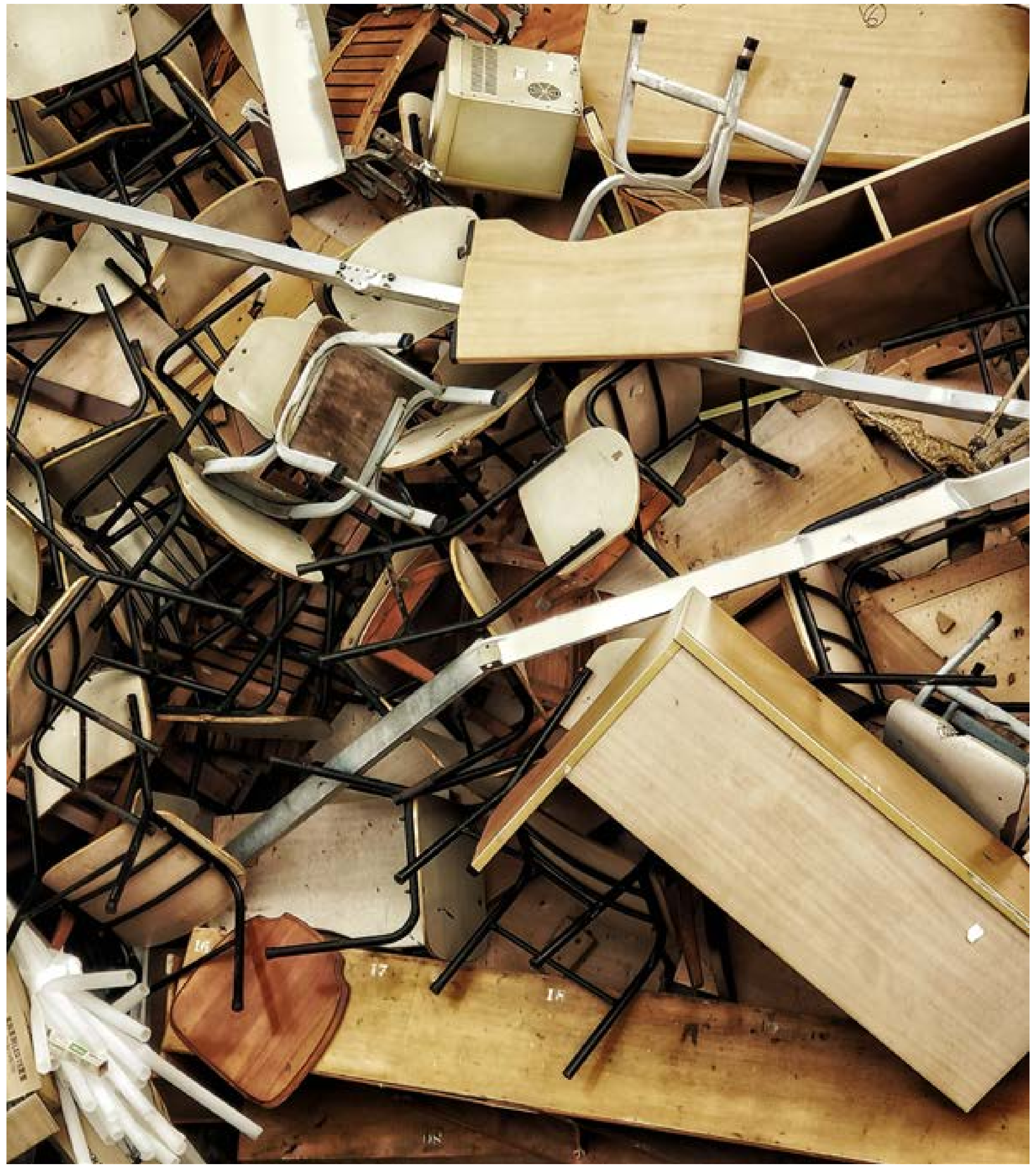
Ecological benefits

Economic benefits

Social benefits

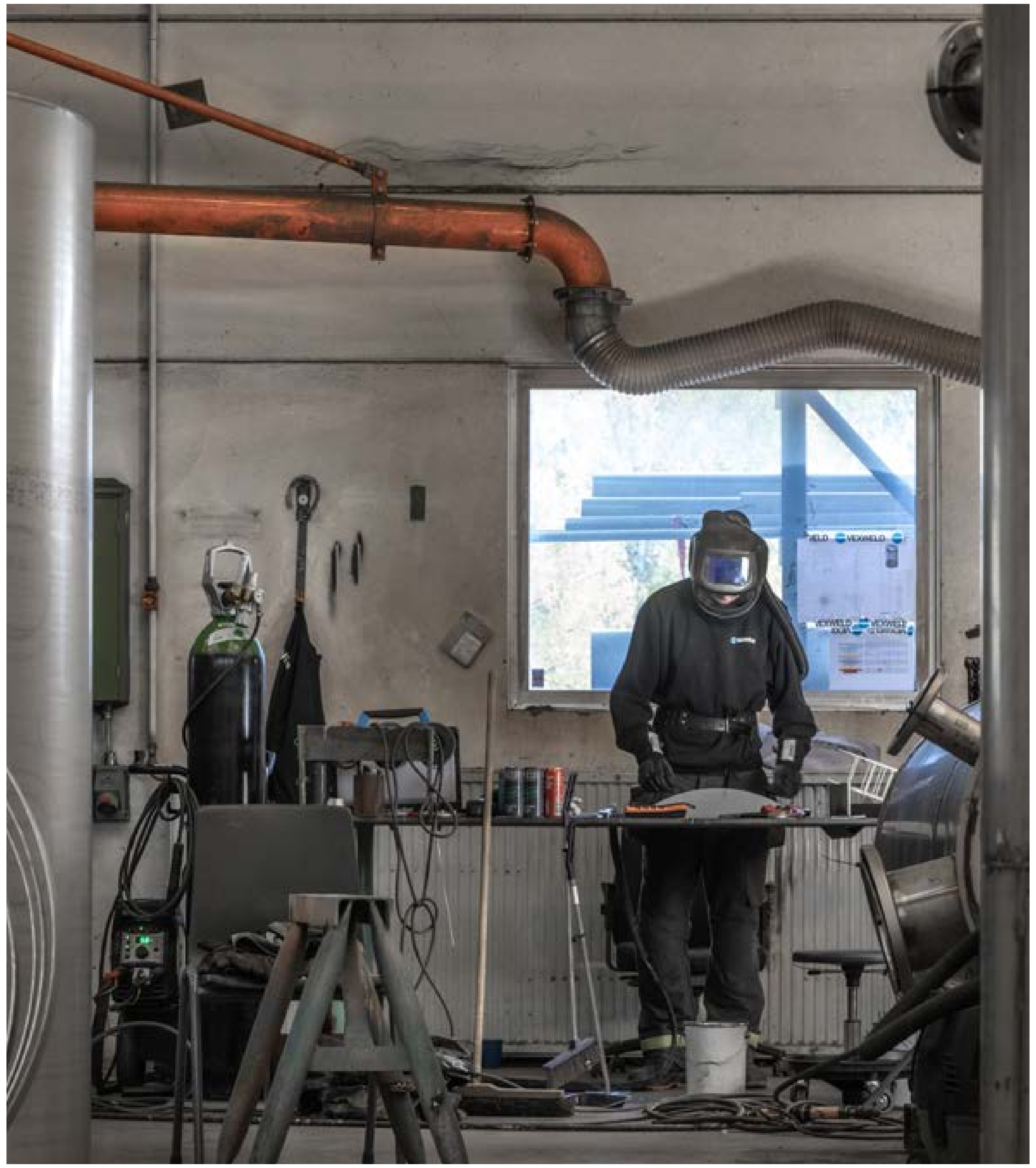
Urban mining can be a sustainable and economically viable solution, contributing to resource conservation, job creation, and a more efficient use of materials. Recovering and reusing materials can result in significant cost savings in comparison to traditional mining and production.

Economic benefits



Resource Recovery: Urban mining allows for the extraction and recovery of valuable resources from waste materials. These recovered resources can be sold or reused, providing economic value and reducing the need for sourcing virgin materials.

Cost Savings: Recycling and reusing materials can significantly reduce the costs of extracting virgin resources. It requires less energy to process recycled materials. Moreover, urban mining can also mitigate price fluctuations and supply chain disruptions by creating a more stable and localized resource supply.



Job Creation: Urban mining activities, including waste collection, sorting, processing, and manufacturing, can create employment opportunities. This can contribute to local economic development and job growth.

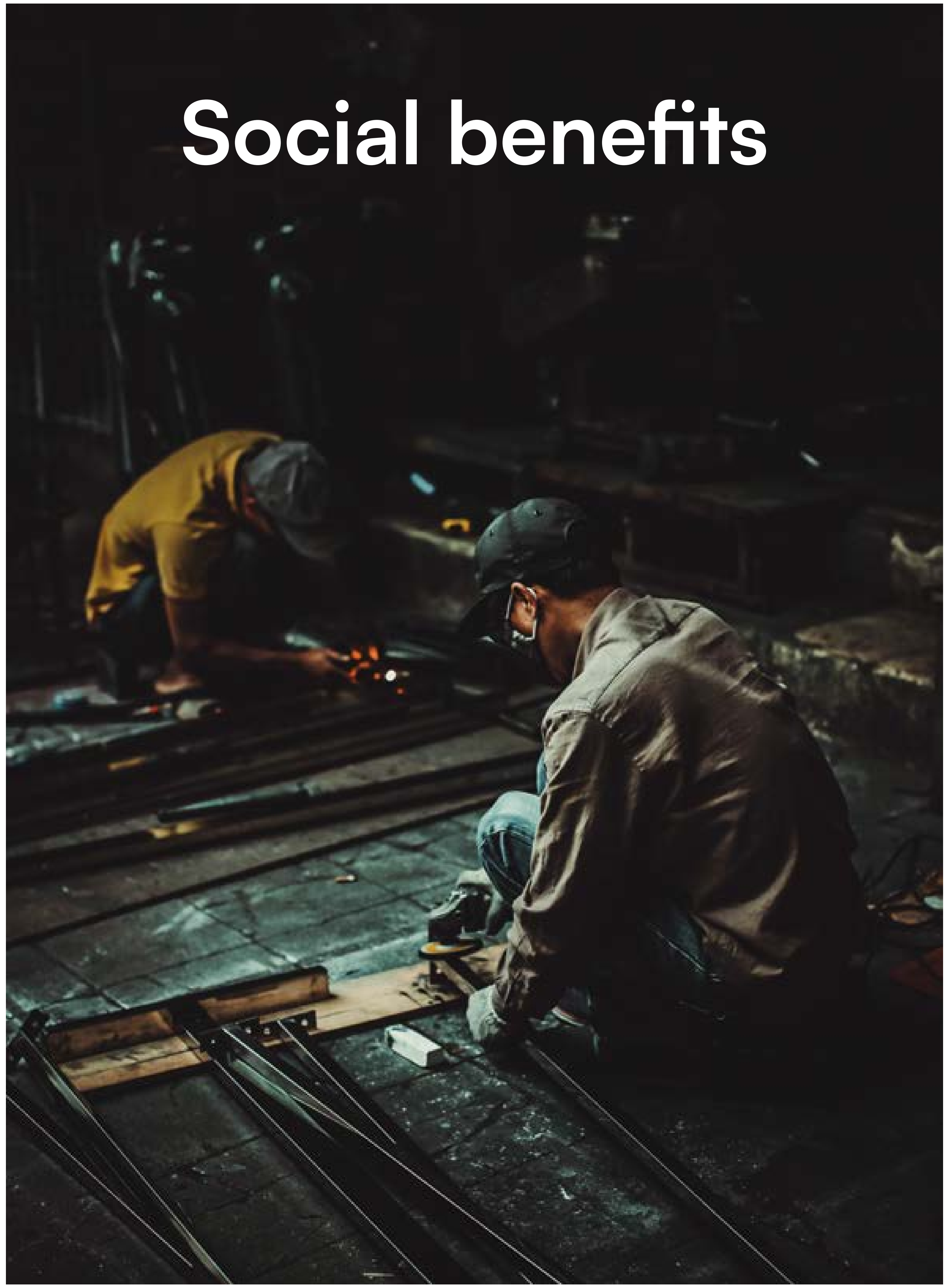
Economic benefits

Secondary Market Development: The recovered materials from urban mining can be reintroduced into the market as secondary raw materials. This contributes to the development of secondary markets, creating additional economic opportunities and stimulating new business ventures focused on recycling and upcycling.

Reduced Environmental Costs: Traditional mining and resource extraction processes often have significant environmental impacts and associated costs. Urban mining reduces the need for extensive extraction, thereby mitigating environmental damage and lowering environmental remediation expenses.

Waste Reduction: Urban mining diverts waste from landfills and incineration facilities, reducing the costs associated with waste management and disposal. By extracting valuable materials from the waste stream, urban mining extends the lifespan of landfills and decreases the need for new waste disposal sites.

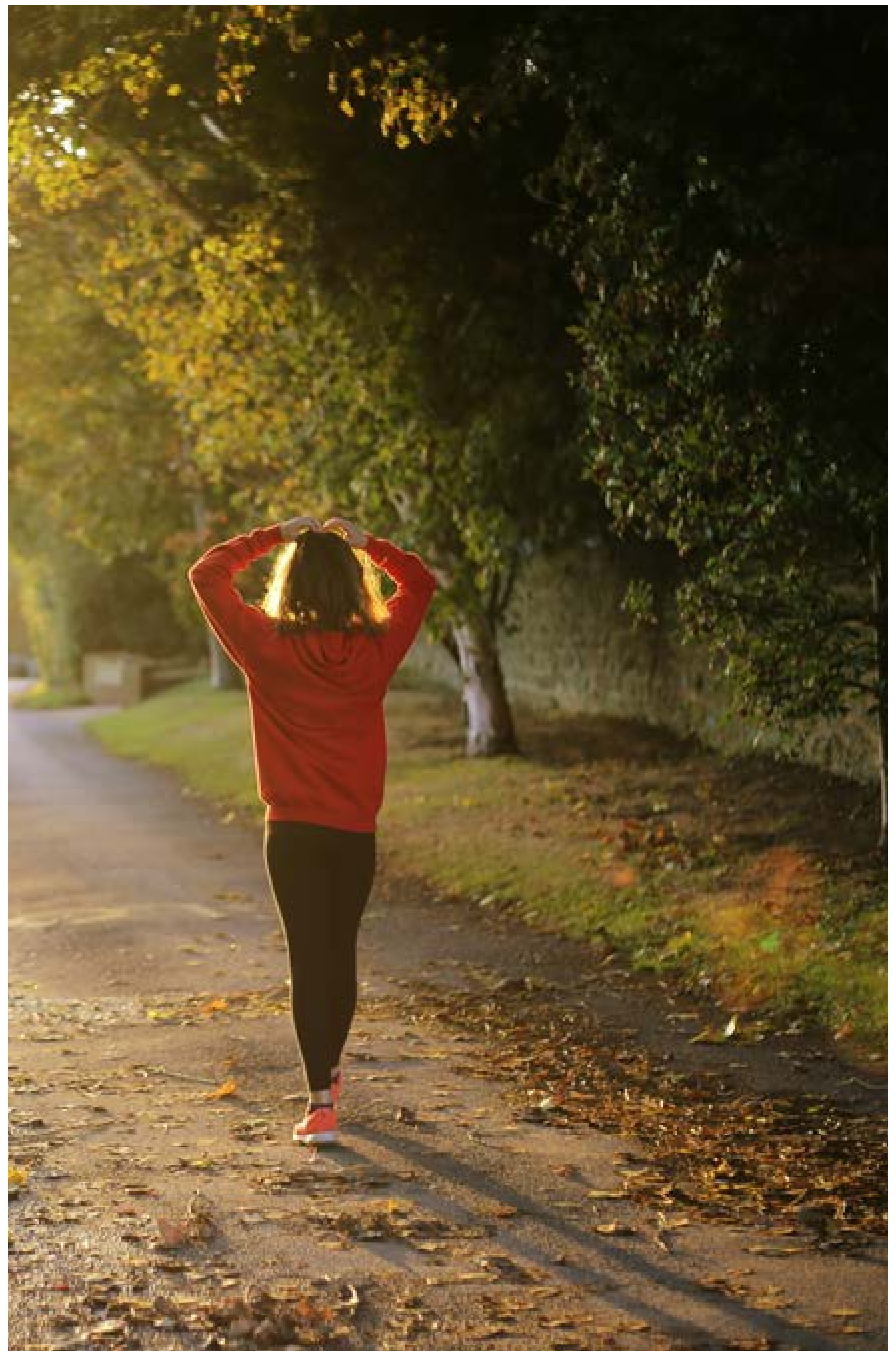
Ecological benefits

Economic benefits

Social benefits

Urban mining offers various social advantages, including community engagement, public health improvement, environmental education, social equity and inclusion, sustainable urban development, and community resilience. By involving and benefiting communities, urban mining initiatives can contribute to the well-being of urban areas.

Social benefits

Community Engagement: Involving community participation, creating opportunities for engagement and collaboration. Local residents can actively participate in recycling programs, waste sorting, and resource recovery efforts.



Public Health Improvement: By diverting waste from landfills and incinerators, it minimizes the release of hazardous substances into the environment. This, can lead to improved public health and a healthier living environment.

Environmental Education: Raising awareness about the importance of resource conservation, waste reduction, and recycling. Promoting sustainable behaviors and information about the environmental impact of waste generation.

Social Equity and Inclusion: Contributing to social equity and inclusion by creating employment opportunities and supporting local economic development. It can provide jobs including those who may face barriers to traditional employment.

Urban mining embodies circular planning and cost considerations throughout a building's entire life cycle, taking into account its ecological footprint. It represents a shift away from linear economic thinking, which focuses solely on expansion, one-sided investment costs, and landfill disposal scenarios.

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Case study

MI.C

Milano

MI.C is an urban design, landscape and architecture project that aims to regenerate the multi-faceted polarity of the Central Station. The intervention creates a new architectural complex that will give new life to the former Hotel Michelangelo, a symbol of the Milanese skyline for more than half a century. One of the main design objectives was to conceptually preserve this legacy through the virtuous reuse of part of the structural material of the pre-existing building: a targeted deconstruction process, in which the greatest possible amount of concrete from the Hotel Michelangelo will be reused, in partly in the new building and partly in the design of the public space project.

By adopting a circular system, this project integrates the understanding of utilizing existing resources, mitigating greenhouse gas emissions, and embracing the concept of urban mining. It fosters a holistic approach that prioritizes resource efficiency, environmental sustainability, and the reuse of materials within urban contexts.

MI.C

The new building is mainly composed of two adjacent towers which develop from a curtain volume which links the complex to its block. On the ground floor, the building moves back from its maximum height, generating a natural extension of the square. An articulated system of different green spaces that develops from the entrance to the common areas at the top, increases the general architectural quality of the whole system. A sort of "green spine" which, starting from the outside, rises up into the hall on the ground floor and runs inside the building to take on, in some points, a more significant dimension which defines natural indoor and outdoor spaces.

MI.C

The façade represents the most dynamic element of the intervention. It adapts and changes coherently with the development of the internal life of the building. Glass is the protagonist: both as an element of transparency and as a motif of composition, thanks to cusp elements, partially opaque and partially transparent, which change their inclination as they acquire verticality. In correspondence with the special floors, those in which the green spine emerges and leans towards the city, the façade opens up, increasing its transparent component and revealing the natural element contained within. The result is an adaptable building that changes and always looks different according to the particular experiences of which it becomes the protagonist.

MI.C embraces environmental responsibility and serves as an urban regenerator. It highlights the project's focus on innovation, fostering new social connections, and incorporating urban mining as an integral part of its concept.

Futher reading:

- Possibilities of urban mining in relation to aluminium
- We Must Understand Buildings as Intermediate Deposits of Raw Materials
- “Building stock and waste” as the important potential resources of “Urban mining”
- The circularity GAP report 2022
- Global Material Resources Outlook to 2060
- How to Recycle a 14-Story Office Tower
- The hidden value in ‘urban mining’
- Urban mining. Scoping resources for circular construction
- Urban mining and buildings: A review of possibilities and limitations

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