RECYCLING IN THE GCC:

Securing Valuable Resources for a Sustainable Future

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1 THE CIRCULAR ECONOMY IN THE GCC

1.1 The Circular Economy Paradigm

The global economy has grown rapidly and countries in the Gulf Cooperation Council (GCC) have enjoyed similar growth, especially in the decades since oil was discovered in the region. This development has been accompanied by significant population growth and urbanization and has posed additional pressure on the environment. That finite planetary resources impose limits to growth is increasingly being recognized at both global and regional levels therefore the sustainability of current economic practices is being questioned.

The so-called circular economy paradigm offers an answer. It promises to overcome previous limitations by minimizing resource consumption and maximizing resource value. However, increasing resource circularity is more difficult than it sounds, as the global economy has largely been structured according to a linear economic paradigm of 'take → make → waste'.

Leading companies across industries globally are seeing, however, that a circular economy can generate significant business opportunities throughout the value cycle (Exhibit 1). They can earn economic and social benefits, for instance by producing materials that are regenerative or recycled, or by designing products that are recyclable and reusable.

Exhibit 1

The circular economy provides opportunities along the value cycle

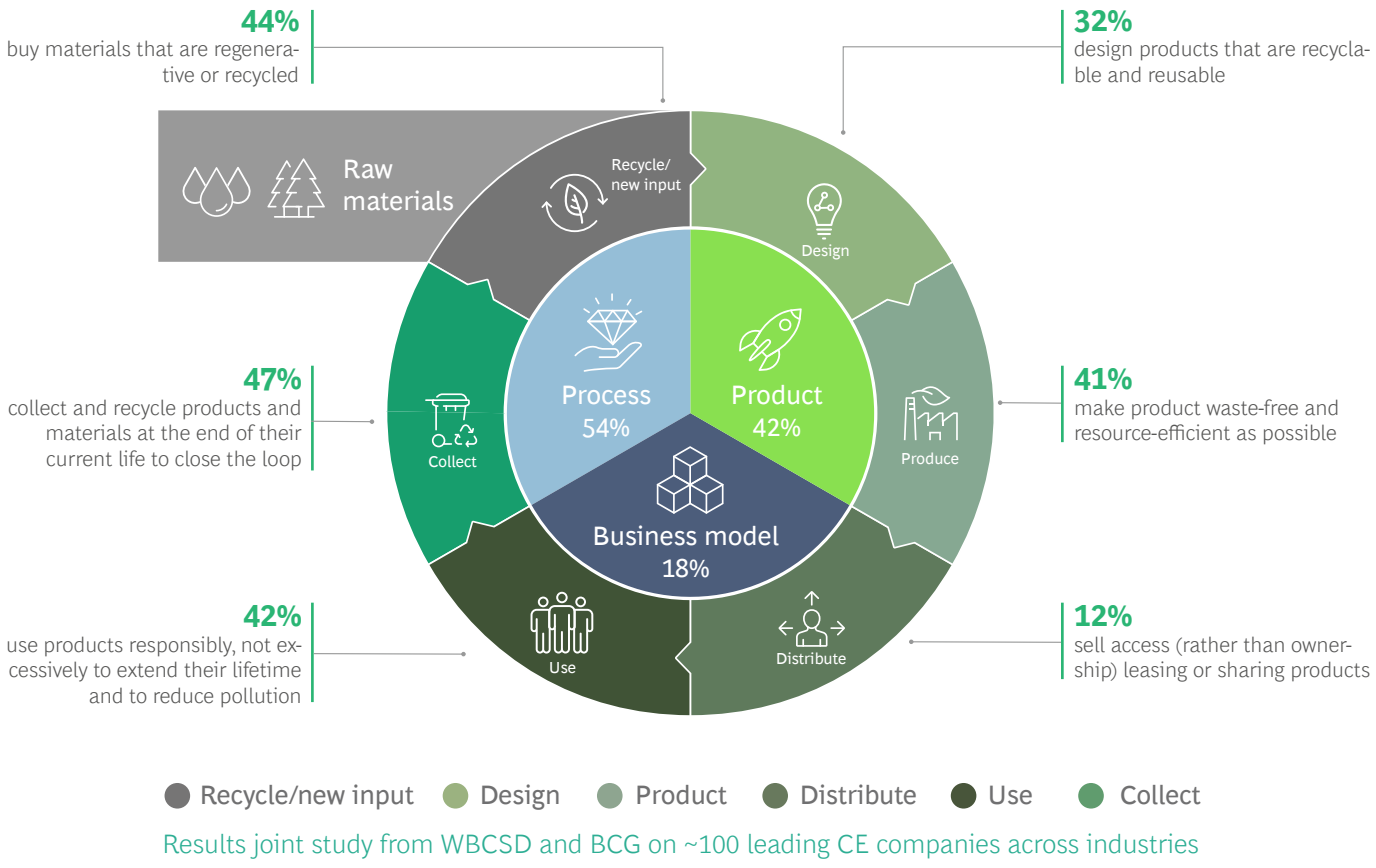


Exhibit 1 - Source: BCG analysis

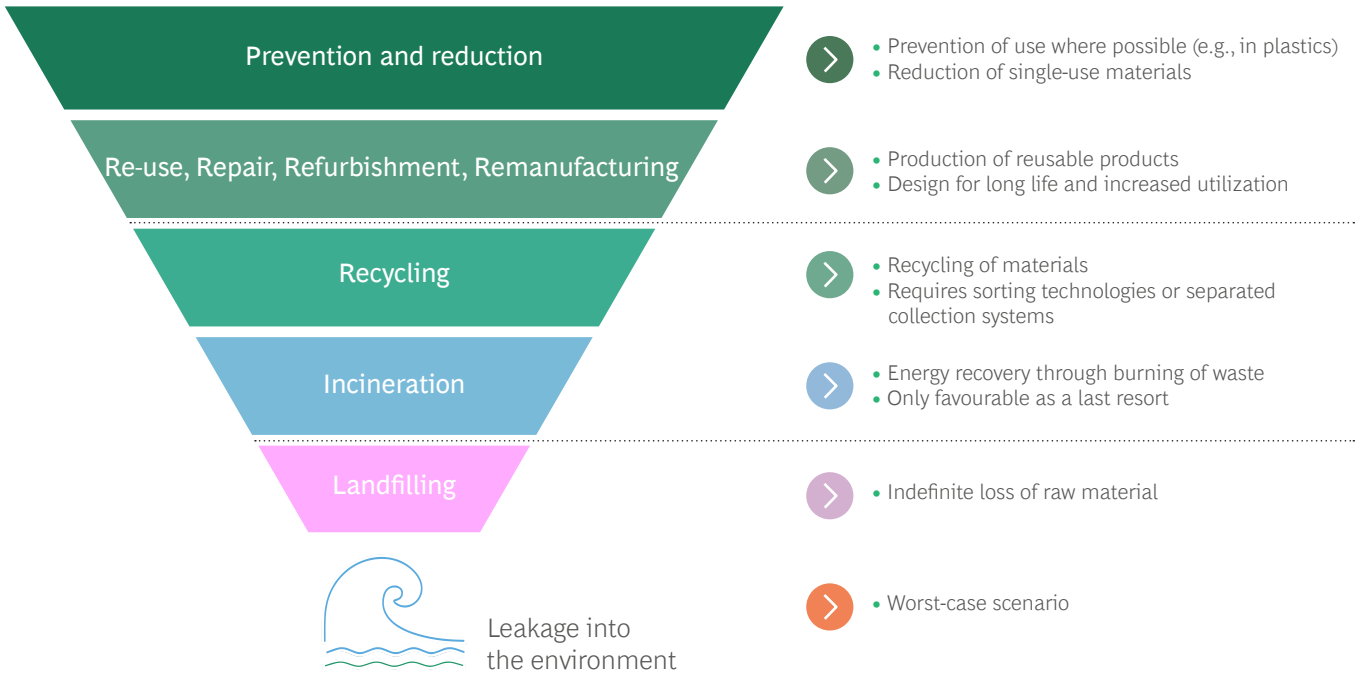
Governments, consumers, and society at large are also becoming increasingly aware of the challenges the planet faces if a circular economy paradigm is not adopted. Linked environmental concerns, including marine pollution from plastic waste and methane emissions from bio-waste on landfills, are globally acknowledged (EEA, 2021). But change is slow and achieving increased circularity is complex, demanding the cooperation of multiple stakeholders and a major overhaul of established practices.

However, the direction seems clear. A circular economy is designed to prevent or reduce the loss of value.

This implies dramatically reducing landfill waste, and instead of preventing it via waste treatment. Key measures include composting, recycling, and other forms of valorization like biogas conversion. Incineration and waste-to-energy are considered last-resort measures. For the waste management industry, increasing circularity means a paradigm shift away from increasing landfill diversion, and towards reducing waste generation and increasing its treatment and valorization (Exhibit 2).

Exhibit 2

A circular economy sets new priorities for waste management



This paradigm promises significant environmental and systemic benefits. A growing circular economy entails profound changes to the structure of industries that positively impact the quality of life, job creation, and the economy (see chapter 4 for more details).

1.2 The State of Circularity in the GCC

With efforts to diversify GCC's economy away from oil, and additional momentum towards sustainability and zero-waste from Dubai 2020 Expo, Dubai Circular Economy Strategy, Saudi Arabia's G20 Presidency, and Saudi Arabia's circular economy for carbon policy have become a priority topic for leaders in the region. Along with many countries across Europe, Asia, and the US, several GCC states are seeking a paradigm shift. The United Arab Emirates (UAE), for instance, has published its Circular Economy Policy 2021-2031 and the Kingdom of Saudi Arabia (KSA) issued a Circular Carbon Policy in line with Vision 2030. Several GCC governments have also introduced ambitious targets aimed at reducing landfilling (diversion of 80-100% of waste from landfills) and increasing waste treatment, recycling, and composting to up 77% of all waste streams by 2035. KSA, for instance, has published targets of 82% landfill diversion, 42% recycling, and 35% composting by 2035 under its waste management national regulatory framework.

These targets acknowledge the challenges ahead. They are ambitious considering that it has taken some G20 countries 20-25 years to achieve such high landfill diversion targets from a starting point comparable to that of the GCC today.

[1]Excluding bio-gas conversion.

As in many developed regions, high waste generation is a source of concern for GCC countries. While daily per capita waste generation in GCC is 0.6 and 0.7 times lower than in the United States (US) and the average of Organisation for Economic Co-Operation and Development (OECD) states respectively, it is 1.2 times higher than in Europe (The World Bank Group, 2022). With the huge expansion of GCC urban areas, regional municipalities are challenged to handle the ever-increasing waste generation through the existing landfill strategies and must allocate significant budgets every year for waste management (World Economic Forum, 2020).

Many GCC cities are already investing to improve their waste management (World Economic Forum, 2020). In KSA, for instance, the Public Investment Fund (PIF) plans to invest USD 11 billion by 2035 to increase recycling through the Saudi Investment Recycling Company (SIRC, 2019). Overall, KSA has earmarked USD 27 - 32 billion for investment to meet its landfill diversion targets (SIRC, 2019). Several municipalities are also increasing recycling efforts. In Sharjah, for instance, Bee'ah waste management company has achieved 76% landfill diversion. Aluminum Bahrain (Alba), in partnership with the Australian company Regain, has begun treating hazardous waste and converting it into raw materials for the construction and steel industries. The Dubai Green Building System, a new set of regulations to increase recycled content in construction projects, has recently been issued in Dubai.

Despite these commitments and efforts, a recent joint study by the World Business Council for Sustainable Development (WBCSD) and Boston Consulting Group (BCG) finds that securing finite resources for future generations and minimizing environmental impact will depend on further increasing waste collection and recycling targets globally as well as across the GCC. Recyclability of material streams should not stand in the way of such enhancement, as respective technologies either exist already or innovation is underway. Rather, a coordinated effort of actors throughout the value cycle is required to drive implementation. To meet this aspiration and define sustainable and practically implementable collection and recycling targets for the GCC region, we must identify key material value streams in the region's waste composition.

According to official estimates, GCC countries generate between 105 and 130 million tons of waste per annum, primarily from Municipal Solid Waste (MSW), Construction and Demolition Waste (CDW), and agricultural waste, with KSA and UAE accounting for approximately 75% (GCC Statistical Center, 2022; GPCA, 2016; GreenBusiness, 2022; The Economist Intelligence Unit, 2021; The World Bank Group, 2022; UN Environment Programme, 2019). While these estimates are based on official reporting, GCC countries face additional challenges from limited waste tracking and illegal waste dumping, in particular agricultural waste and CDW (Environment Agency – Abu Dhabi, 2017; FPI, 2021; SIRC, 2022; UN Environment Programme, 2019). Actual waste generation is estimated to be as high as 150 - 190 million tons annually according to regional waste management experts, driven by large infrastructure and real estate development projects in the region.

Exhibit 3

A view on waste generation in the GCC

KSA and UAE ~75% of 103-135 million tons waste generated annually in GCC

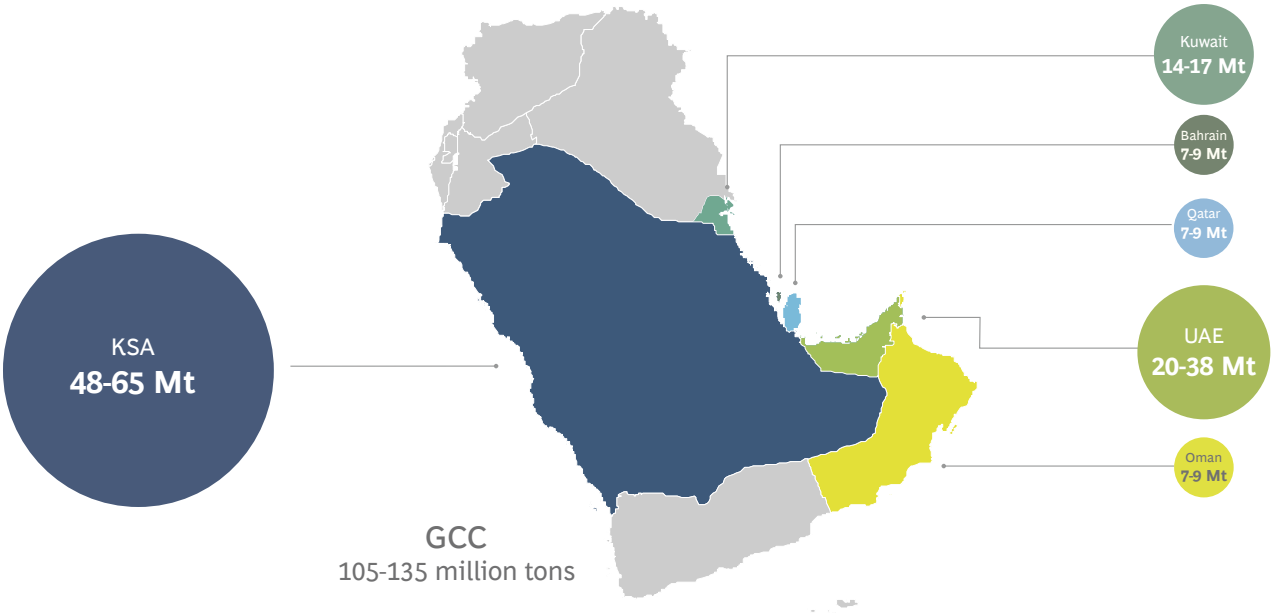


Exhibit 3 - Source: GCC Statistical Center (2021), UAE Federal Competitiveness and Statistics Centre (2019), UN Environment Programme (2019), SIRC in ArabNews (2021), Economist (2019), WorldBank (2016), BioEnergy Consult (2021), GPCA (2016), WMOWA (2016), Frost & Sullivan (2021), Industry Expert Interviews, BCG Analysis

[2]Referring to municipal solid waste from household, as well as industrial and commercial sources. Other sources of waste with minor contribution can include for instance industrial or other hazardous wastes, lubricants, sewage sludges, used cooking oils, batteries, end of life vehicles, radioactive or military waste.

Based on population growth expectations between 1-2% and GDP growth expectations between 3-7% in different GCC countries (Oxford Economics, 2022), driving the growth of municipal, agricultural and construction, and demolition waste respectively, it is further estimated that waste generation could increase to up to 420 million tons annually by 2040. A substantial amount by itself, it does not count the existing backlog of uncollected waste from previous decades, estimated by regional waste management experts at approximately 100 million tons, primarily CDW.

Considering the composition of MSW, CDW, and agricultural waste across the GCC, it is estimated that four key material streams comprise approximately 70% of its content: cement & concrete, plastic, metal, and bio-waste.

These material streams constitute key-value pools, currently not used to their full potential given low collection and recycling rates in the region. While official collection rate estimates vary between 90-100% across GCC countries (UN Environment Programme, 2019), the recent joint WBCSD-BCG study estimates the effective waste collection rate at approximately 60%. Estimated rates vary by material streams: 50% - 60% for cement & concrete and plastic waste, approximately 70% for metal waste, and just 30% for bio-waste.

Further value losses are incurred after collection when waste is illegally removed before treatment. Regional waste treatment experts believe this can result in volume losses of 10% of waste collected. Estimates of recycling rates in GCC range between 5-15% across all waste streams (GPCA, 2016; GreenBusiness, 2022; UN Environment Programme, 2019). The WBCSD-BCG study estimates recycling rates to be approximately 20% across all waste streams, as additional recycling or reuse of material happens through the informal sector.

Estimated rates vary again by material streams – approximately 10% for cement & concrete and plastic waste, approximately 70% for metal waste, and below 5% for bio-waste. High collection and recycling rates for metal, for instance, are driven by the fact that pure metal has similar properties to virgin material making it easy to valorize.

1.3 Setting Sustainable Targets

The recent joint WBCSD-BCG study found that for the Earth to continue regenerating its renewable resources, and for finite resources to last several more generations, a recycling rate of 80-90% by 2040 across all key waste streams globally is required. Based on an assessment of technical feasibility as well as informed predictions of innovations that are needed and can be achieved, average recycling and collection rates of 80-95% across key streams by 2040 globally is possible.

Potential, however, varies by value stream, as materials have different constraints on their recyclability. For instance, the use of virgin / non-recycled aggregates is indispensable in the closed-loop recycling of concrete, and alloys like copper result in unavoidable contamination of metal scrap. Recycling of plastic is limited by the complexity of end-products making it difficult to sort and recycle due to composites, mixes, and certain additives used in polymer products. Bio-waste collection and recycling are challenged by heterogeneous waste materials (vegetal vs. animal and mixed food waste vs. animal feces/urine/manure), difficulties in tracing, and low levels of separation at the collection stage.

Based on international best practices, concrete & cement and plastic could potentially be collected at 95%, metals at 97%, and bio-waste at 90% in the GCC region . The ultimate ambition for recycling rates for concrete & cement should be 95%, plastic 75%, metal 95%, and bio-waste 80% in the region.

Given projected GCC waste volumes, meeting these collection targets implies collecting approximately 280 and recycling approximately 320 million tons of additional waste by 2040 compared to 2020. This implies a 91% collection and 87% recycling and composting rate across all waste streams by 2040. It means significantly expanding existing ambitions – for instance, KSA would need to increase its recycling and composting target of 77% by 10 percentage points across all waste streams.

2 BARRIERS TO CIRCULAR IN GCC

Current waste management practices across the GCC region, however, present multiple barriers to achieving increased circularity targets.

Scale and fragmentation. The GCC waste management sector is fragmented and still emerging. Historically, waste management was limited to collection, transportation, and disposal. It has been conducted by regionally focused, often small-scale collection companies, operating primarily in high-density population areas. Large KSA municipalities like Riyadh, Jeddah, and Madinah have recently established partnerships with private local as well as foreign waste management providers such as WASCO, SIRC, and Bee'ah. These providers increasingly deliver integrated waste management services including the collection, sorting, treatment, and disposal. While previously waste management in GCC meant either being a landfill operator (disposal), waste collector, or small-scale specialized treatment provider, these newer players operate large-scale facilities able to treat multiple types of waste.

Despite these positive developments, several challenges remain. Newly developed policies and targets in the GCC imply the clear intention to address them going forward.

Data availability and tracking. The lack of consistent and reliable data on waste generation in the GCC region is preventing full baselining and visibility into the composition of waste streams, hindering optimal capital deployment. Data on waste generation and composition are critical for improving its management and treatment, since it strongly influences infrastructure choices, for instance for recycling or energy recovery. Full waste traceability further limits the potential for illegal practices.

Regulation. This lack of data is closely linked to challenges around waste management regulation. Several environmental and sustainability policies have been introduced across the region, like Dubai's Green Building System or KSA's National Environment Strategy linked to Vision 2030. However, most GCC countries still do not have a comprehensive framework to regulate the adoption of circular economy practices across all sectors and material streams in particular, such as the formal recycling of metals and cardboard (The Economist Intelligence Unit, 2021). Existing environmental legislation and enforcement also may not be implemented to their full effect, which in turn limits waste traceability (The Economist Intelligence Unit, 2021).

Financial incentives. Financial incentives do not always promote the implementation of increased circularity. Taxes or levies may fail to provide the right financial incentives. For example, low fees for landfilling and low prices of virgin materials in comparison to recycled materials do not reflect associated societal and environmental costs or incentivize circularity. Like in Europe – where margins from incineration and landfilling ranged from 15% to 40% compared to 3-5% in waste collection, 5-10% in waste sorting, and 10-15% in waste recycling for mixed MSW – low landfilling fees in the GCC discourage circularity from reaching its potential. Financial incentives that discourage landfilling and incineration are required to incentivize the recycling industry, similar to what has been done in Europe.

Landfill standards. Non-sanitary or un-engineered landfills present a fifth challenge across the GCC. In KSA, for instance, estimates suggest that approximately 98% of landfills are not engineered according to international standards (FPI, 2021). Lacking appropriate engineering and sanitary standards for collecting and treating gas and leachate, can cause significant environmental damage, for instance through significant methane emissions due to high organic residues or fires at their sites.

Material sorting. In the absence of regulation, many regions across GCC also still use a one-bin system for collection – including in urban centers such as Dubai, where such systems are still observed in many residential and commercial skyscrapers. This means no separation of material streams, and contamination of waste streams, which increases the costs of sorting plastics for recycling (also see Chapter 4).

Circular design. Limited consideration of key steps in "closing the loop", such as thinking about recyclability from a product design or end-user perspective, creates further barriers to full circularity. Circularity is still rarely part of product design considerations in most industries globally and GCC. This leads to common recyclability issues due to complexity, the chemical composition of end-products, or the addition of pigments in the case of plastics.

Consumer awareness. Finally, GCC consumers still lack awareness of circularity issues and practices. This is driven by a dearth of education, for instance, about separating waste or the environmental consequences and "price" of plastic pollution, and limits consumers' willingness to pay a premium for recycled products or sorting efforts (The Economist Intelligence Unit, 2021). Despite younger generations being much more sensitive toward waste and sustainability topics, holistic educational programs could go a long way to support better circular practices.

[3]In line with Middle East and Africa. [4]Including other forms of valorisation such as bio-gas conversion
[5]i.e., some fully integrated, focussed usually either only on paper or only on plastic, glass or metal

3 INVESTING WHAT IT TAKES

Stakeholders in the GCC region will need to implement a range of actions to meet ambitious circularity targets. In this chapter, we look at "what it will take" in terms of developing or deploying technology and investing in infrastructure expansion to keep the GCC region within sustainable global resource limits across the four key value streams: plastic, concrete & cement, metal, and bio-waste.

The joint WBCSD-BCG study estimates that it will take **USD 60-85 billion invested in the four key waste streams** across the GCC region over the next 20 years to meet targets. This investment would cover design, collection, sorting, and recycling investment across these four key waste streams. The largest capital requirement, accounting for approximately 65% of the total investment, is for developing or deploying technological innovations in recycling and expanding recycling capacity. Collection and sorting infrastructure will require approximately 20% and 10% of investments respectively, while the remaining 5% will be needed to improve product design.

Plastics: USD 11-16 billion over 20 years. The key challenges of overconsumption due to unnecessary single-use packaging and lack of recyclability in plastic product design should be addressed with at least a USD 1 billion investment. For example, manufacturers should develop products that are easier to sort and use single polymers when possible. Investments of a further USD 1-2 billion need to be made to deploy more collection vehicles and bins, and an additional USD 2-3 USD billion in sorting facilities across the GCC. Much of this should go toward developing sorting techniques for individual polymers, such as near-infrared (NIR) sorting, which would allow more plastics to be mechanically recycled. The largest share of plastic investment, USD 7-10 billion, is required for advancing recycling technologies, assuming approximately 60% mechanical and 40% chemical recycling of plastic waste recycled. Current profit margins support mechanical processes as the optimal way to recycle plastics; these need to be scaled up and further developed to maximize quality. Chemical recycling technology can offer a complementary alternative to mechanical recycling as it allows for a larger variety of plastics to be recycled and converted into high-quality, virgin-like products that can be recycled multiple times, without degradation. Chemical recycling also allows the treatment of contaminated plastic waste streams that cannot be treated with mechanical recycling.

Concrete & cement: USD 3-4 billion over 20 years. Investments should aim to achieve higher recyclability through material design, improved collection rates, sorting and deconstruction facilities, and enhanced mobile and stationary recycling facilities for mixed concrete. Substantial investment is needed only at the recycling stage; current collection networks can be used, especially as crushing is done mostly at a local level, and for sorting only smaller investments in dismantling of buildings to identify materials for reuse are required. However, concrete & cement technical limitations practically limit the use of concrete aggregates to 15-30% compared to new aggregates. Technically, for structural concrete, based on performance standards, using 50 to 90% recycled aggregates is possible. For example, Advanced Dry Recovery (ADR) technology, which removes fine-grained impurities, has the potential to increase this percentage to 79%. Increased use of ADR could therefore reduce the need for new aggregates and landfilling of waste. The technology is well advanced, but more regulatory support is needed to develop it and incentivize its wider use.

Metals: USD 11-15 billion over 20 years. These high capital requirements are driven by the cost of the heavy machinery required to convert scrap metals into steel, and the investments needed to increase currently low bio-waste collection and recycling. A key challenge in metals recycling is contamination by other metals, such as copper, due to difficulty in separating metal products not specifically designed for circularity. This reduces the purity of the starting material and thus the quality of recovered metal. To mitigate this problem, product design investments must focus on purity in production and melting processes. Manufacturers also need to develop take-back systems that allow for convenient collection of their used steel products at end-of-life.

Biowaste: USD 35-50 billion over 20 years One of the most important technologies for recycling biowaste is upgrading it with a substrate conversion process. The biogas conversion process includes pre-treatment and anaerobic digestion (AD). Future technological innovations may improve the recyclability of biowaste in additional ways. For example, they could reduce the amount of waste by improving product utilization and distribution. Innovations could improve sorting by separating biowaste from mixed waste streams and improving recycling with higher-value recovery methods. New technologies for biowaste management include bioethanol (liquid biofuel) production, volatile fatty acids (VFA), biohydrogen, phosphorus recovery, pyrolysis (to produce high energy density biofuels), gasification (for fuel or chemical production), hydrothermal carbonization (solid fuel or soil amendment), and fermented animal feed production from food waste.

4 REALIZING PRICELESS BENEFITS

Meeting bold targets and increasing circularity in the GCC region will yield multi-dimensional benefits. Beyond the obvious environmental value, the transition to a circular economy promises economic gains linked to job creation, economic growth, diversification, self-sufficiency, and independence from external regulatory pressures.

It is estimated that contributing to such global targets as 80-90% recycling would not only save 0.9-1.5 billion tonnes of CO2 emission by 2040 in the GCC, helping to reduce global warming, but also protect nature through the conservation of water, land, and biodiversity. Quality of life in the GCC could also be enhanced through reduced air pollution and cleaner, more liveable surroundings.

Studies show increasing waste circularity also aligns with environmental and economic benefits since recycling creates over 50 times as many jobs as landfills and incinerators (Gaia, 2021). Given additional waste volumes of approximately 255 million tons across the four key waste streams, making up 75% of all waste streams to be recycled in 2040 across GCC, this means potential for at least 200 - 300 thousand jobs in the GCC region.

As well as potentially increasing GDP by approximately USD 95 -105 billion across the GCC region from the four key waste streams, optimizing circularity will accelerate economic diversification away from fossil fuel resources. It will increase independence from environmental regulatory pressures on key regional export goods, like the pressure on plastic resins and other packaging materials exerted by single-use plastics bans and carbon border taxes recently issued or planned in Europe and Asia. Circularity also supports economic independence from import goods such as fertilizer through bio-waste recycling.

How such changes translate into business benefits, however, must also be considered. Collaboration along the waste value chain is required. Consider the example of plastic waste: margins at the sorting stage suffer if waste streams are contaminated by bio-wastes, or plastic materials are mixed during collection. Mixed plastic streams only offer margins of 5-10% at the sorting stage instead of 5-25% for single streams, as they require higher levels of processing and often provide lower quality output. Today, specific mixed plastic waste streams can only be recycled using chemical recycling, for example by pyrolysis or gasification. Chemical recycling methods like pyrolysis and depolymerization/monomerization have emerged and are expected to become more prominent as economies of scale are discovered. Improvements at the collection stage can thus open up increased business potential throughout the value cycle, a call for joint action.

5 A CALL TO JOINT ACTION

Joint action around the value cycle is needed to realize the potential benefits of a circular economy, requiring the cooperation of multiple stakeholders and a partial overhaul of established practices.

Government ministries. The state must take a leading role in enhancing regulation and providing financial incentives, as well as increasing transparency of waste tracking. Environmental regulators and municipalities need to enact regulatory measures and impose penalties that create stronger incentives for circularity and higher recycling rates. Financial regulators should encourage business and household recycling through taxes and subsidies. Landfill and incineration regulations should be designed to limit the amount of waste landfilled or incinerated. A paradigm shift away from landfill diversion toward waste recycling and reuse is key. Increasing landfill gate fees is a clear first step. The sale of secondary materials and the use of recycled materials can be encouraged through subsidies or minimum recycling quotas. Policies should be put in place that favor formalized recycling companies and their employees. Enforcement of regulations to reduce illegal waste dumping as well as illegal waste diversion from valorization is necessary. Authorities can also invest in improving and expanding recycling facilities and infrastructure, and introduce extended producer responsibility (EPR).

> **Case-in-point:** Governing bodies in Dubai recently introduced the Dubai Green Building System, which includes a set of mandatory requirements for all new buildings to use 5% recycled content in construction as well as recycle or reuse at least 50% by volume or weight of waste material generated during building construction and/or demolition . It also proposes the option of a second chute for recyclable material, such as plastic and metal, in buildings with one general waste chute. In February 2022, the Dubai government also ordered a major rise in the cost of depositing non-recyclable waste in landfills from approximately USD 2.70 per visit to approximately USD 27.00 per tonne of non-recyclable waste deposited, to increase recycling and discourage landfilling.

Consumers. Government agencies and industry players should step up efforts to educate consumers on waste reduction and circular products. This includes ways to participate in takeback and collection programs, avoid informal recycling, and follow at source waste separation guidelines. Producers acting as industry leaders should be at the forefront of driving demand for recycled or recyclable products, with marketing campaigns that showcase the value of their recycled materials.

Waste managers. The industry should take a leading role in promoting circularity throughout the value chain, in line with governmental guidance and improving transparency and reliability of data on waste generation and composition. They can strengthen the industry and its influence by further encouraging and engaging in PPPs, involving informal actors as participants in the process, and supporting their transition to formalized entrepreneurs. Landfill operators should ensure their assets are engineered according to international standards. Recyclers should focus on developing cost-efficient sorting, pre-processing, and recycling operations to produce valuable feedstock for producers in the petrochemical and building materials sectors. Improving collection rates and sorting quality could provide high-quality feedstock and inputs to a range of agricultural, oil and gas, chemical, and steel producing companies. Recyclers can also supply inputs to consumer-packaged goods companies or manufacturing companies in the region for direct deployment of recycled products.

> **Case-in-point:** Bee'ah, established in 2007 through a public-private partnership in Sharjah, has built a Waste Management Centre with a 600 thousand tonne material recovery facility able to obtain metals and plastics from municipal solid waste. It also includes a 500 thousand tonne recycling facility able to turn contaminated construction and demolition waste into recyclable products and aggregates, a 200-tonne biomass facility generating alternative fuels , and a metal shredding facility creating new input for steel mills. Bee'ah also operates two engineered landfills with a capacity of 3.1 million cubic meters and 2.5 million cubic meters of waste for periods of ten and eight years respectively, with professionally engineered leachate monitoring and collection systems. Bee'ah and Unilever have undertaken a feasibility study to jointly invest in a new plastic recycling facility, with the capacity to recycle plastic waste and produce 14,400 tonnes of recycled high-density polyethylene and polypropylene annually. The plastic would come from vending machines where people have returned their bottles. The companies have also introduced an educational program to promote plastic bottle recycling. Closing the value cycle, Unilever plans to directly incorporate produced post-consumer resin in its product packaging.

> **Case-in-point:** SIRC, founded in 2017 as a subsidiary of KSA's Public Investment Fund (PIF) to meet the objectives of Vision 2030, hosts treatment solutions for MSW. In 2019 it acquired Global Environmental Management Services (GEMS), Saudi Arabia's leading industrial waste management company with expertise in hazardous waste management, and industrial and engineering services in the oil, petrochemical, and other industries. Leveraging GEMS' industrial waste recycling presence in several cities, SIRC now offers material recovery facilities that allow the sorting and capturing of recyclables, as well as composting, which reverts organic waste into fertilizers capable of re-use in regional agriculture.

O&G and chemical companies. Producers in the oil and gas and chemical industries should assess opportunities for participation in the upstream value chain of plastic waste sorting and treatment. For example, they could partner with local municipalities on mechanical recycling driven by joint incentives. In addition, they can invest in

[6] For all new buildings except in the central business district.

[7] e.g., curb stones or interlock

[8] e.g., wood chips

chemical recycling internationally, where waste management infrastructure has already advanced enough to achieve scale and technology advantages, or regionally where they could have the right-to-win building scale. Many are already under pressure to rethink their strategy and purpose in line with the energy transition; circular considerations can give rise to completely new business units or models. These industries must continue to grapple with input technology and quality issues. Producers should invest in R&D aimed at solving such issues or promote and deploy innovations from abroad. Further, they should assess opportunities for participation in the downstream value chain. Consider how to appropriate new, emerging value pools offered by customers' and manufacturers' demand for circular products, and thus get closer to key customer brands.

Case-in-point: Sabic has recently launched TRUCIRCLE with the vision that "plastic should never end up in the environment, landfill or our oceans and instead is reused and remade into new products". The TRUCIRCLE portfolio and services include the design for recyclability, mechanically recycled products, certified circular and renewable products leveraging recycled or bio-based feedstock [9], and closed-loop initiatives along the value chain to create virgin materials and help prevent valuable used plastics become waste.

Case-in-point: Sabic and Plastic Energy have announced their joint venture SPEAR, to construct and operate a chemical recycling unit producing circular polymers. Sabic has not only started to collaborate with European recycling companies but has also announced plans to partner with SIRC in KSA on their first chemical recycling project domestically. SIRC will source, collect, sort, and supply the feedstock for the facility from MSW. Chemical recycling technology offers the advantage of having the quality of resins comparable to virgin resins (vs. downgrading of mechanical recycling) and leveraging a process that is closer to chemical companies than mechanical recycling, where companies can differentiate themselves by leveraging a competitive advantage based on scale and technology innovation. One example of end-to-end value chain integration leveraging SABIC's Joint Venture SPEAR, is the partnership between Sealed Air, Bradburys Cheese, and Tesco to recycle plastic collected from Tesco customers into new food-grade packaging, i.e., made from plastic pellets that are as safe and effective as virgin plastic.

Case-in-point: In 2020 Agilyx launched Cyclyx, a new consortium business model aimed at increasing the recycling of post-use plastic, in which ExxonMobil acquired a 25% stake as the founding partner. Cyclyx focuses on chemical recycling aggregating and pre-processing large volumes of post-use plastic waste leveraging leading-edge technology, data analytics, and predictive modeling to help drive up plastic recycling rates. The process output will be used as raw material to manufacture petrochemical products, including naphtha and chemical intermediate pathways. Cyclyx plans to develop a system to collect, sort, and recycle 300,000 tons of plastic waste per year by 2025, with an ambition of reaching 3 million tons of international processing capacity per year by 2030.

Case-in-point: A different approach, focused on mechanical recycling, has been adopted by international players like Borealis, who has recently acquired mtm, a European mechanical recycling company focused on polyethylene. Borealis is also conducting R&D activities on high-value-added recyclable plastics (PP and PE). Meanwhile, LyondellBasell has established a JV with a leading waste management player, Suez, to enter into PE/PP mechanical recycling.

Real estate developers. Representing another key industry, real estate developers should seek to design with circularity in mind and incentivize the use of recycled materials. They should design their buildings with facilities that foster recycling, including separate garbage chutes and waste sorting rooms. As buildings are constructed, developers should work with contractors to identify recycled materials and set minimum recycling targes on the construction site. Supporting standardized material tracking and traceability platforms for all the materials deployed in their building projects is key. As real estate operators, they should train property and facility managers on recycling processes collaborate with waste managers to ease collection. Alternative uses for CDW in case of demolition could be explored.

Case-in-point: Holcim has launched its aggneo brand, which provides high-quality aggregates processed from recycled concrete. When aggneo partnered with Bouygues Construction to renovate two heritage buildings in Paris, they were able to convert 100% of the construction and demolition waste into ready-to-use concrete products (18%) and road gravels (82%). HeidelbergCement has co-founded ReWinn, a concrete and gravel recycling center located in Amsterdam's harbor area. Rewinn produces up to 250,000 tonnes of aggregates per year by recycling clean concrete from demolition sites, as well as waste concrete from regional ready-mix plants, and roof and ballast gravel.

Case-in-point: Madaster has created a web-based data platform that automatically generates Material Passport for building(s) and infrastructure. They try to give materials an identity, so they become a resource for reuse instead of ending up in landfills. The Material Passport platform enables stakeholders in the construction and real-estate sectors to create transparency about their material assets. Together with an ecosystem of partners, Madaster provides data management tools and insights that enable sustainable decision-making, including calculations of embodied carbon and residual value. With an open data model and a not-for-profit governance structure, Madaster facilitates data accessibility, ensuring construction materials remain available for reuse.

[9]Not in competition with human food chain

Case-in-point: The Wallasea Island Wild Coast Project in Essex, UK – a new wetland habitat – is a landmark conservation initiative created from 3 million tonnes of CDW from the London Crossrail tunnel excavation. The CDW has been recycled and reused to raise the land level to create Europe's largest wetland natural reserve.

GCC companies across key industries are asked to understand what a shift to a circular economy paradigm means to them and its key implications. They should seek to:

- Define holistic organizational objectives and ambition concerning circularity
- Baseline their current circularity performance and identify potential expansion opportunities throughout the circularity value chain
- Assess each opportunity based on its market attractiveness and its right to win as an organition
- Identify an operating model to fit their purposes. Would circularity require a separate, dedicated company? A separate business unit? Or should it be fully integrated with existing business units?

At both government and company levels, the GCC can contribute to a global economy that will use the earth's materials responsibly and preserve its resources for future generations.

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