CLOSING THE LOOP ON GLOBAL RECYCLING

Finding a Global Solution to the Patchwork of Recycling

Citi GPS: Global Perspectives & Solutions

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CLOSING THE LOOP ON GLOBAL RECYLING

Finding a Global Solution to the Patchwork of Recycling

The ~$40 trillion global consumer economy is incredibly diverse and shaped by significant political and cultural differences. However there is one belief consumers in all regions and sectors of the global economy seem to share — recycling is good. Whether it's a shop owner in Brazil putting out recycling bins for her customers, a homemaker in Europe sorting cans, bottles, and paper into colored bins, or a local elected official in the U.S. touting the benefits of a new curbside collection program, economic decision-makers get a sense of satisfaction in recycling, feeling they are making a difference and passing on a better world to the next generation.

While the principle of resource conservation is undoubtedly good, recycling systems currently implemented across the globe vary widely in terms of basic structure, incentives, and scope. Many recycling systems are publically run, others are completely outsourced to private parties, while still others use a hybrid public/private approach. Recycling systems also vary widely in terms of basic effectiveness. Despite the good feelings consumers get tossing items into the right color-coded bin, many of these items are not truly recycled — they are simply collected, and ultimately end up in landfills, being incinerated, or worse yet, littered. This is because the cost of recycling materials is often not competitive with virgin materials, which are typically cheaper and also offer better performance characteristics.

Recycling systems have always grappled questions around profitability and ownership: What products should get recycled? Which governmental authority should mandate it? How much are consumers willing to subsidize it? However, one recent seismic policy change has thrown global recycling systems into chaos: China's decision to effectively ban the importation of half of the world's scrap plastic, paper, and metal. This drastic policy change has made recycled (i.e., scrap) materials in North America and Europe incredibly cheap — now instead of getting paid for their recycled material, many municipalities have to pay to haul away what is essentially garbage.

Recycling systems are not harmonized at the global, national, or even regional level, but rather are hyper-local — resulting in a patchwork of public, private, and hybrid systems. That said, with global consumers, corporates, and governments demanding higher environmental standards, some solutions are emerging. In this report we examine the relative pros and cons of recycling solutions including container deposit schemes, 'pay as you throw', and recycled content pledges, and think about what it will take to finally 'close the loop'.

Challenges and Solutions in Recycling

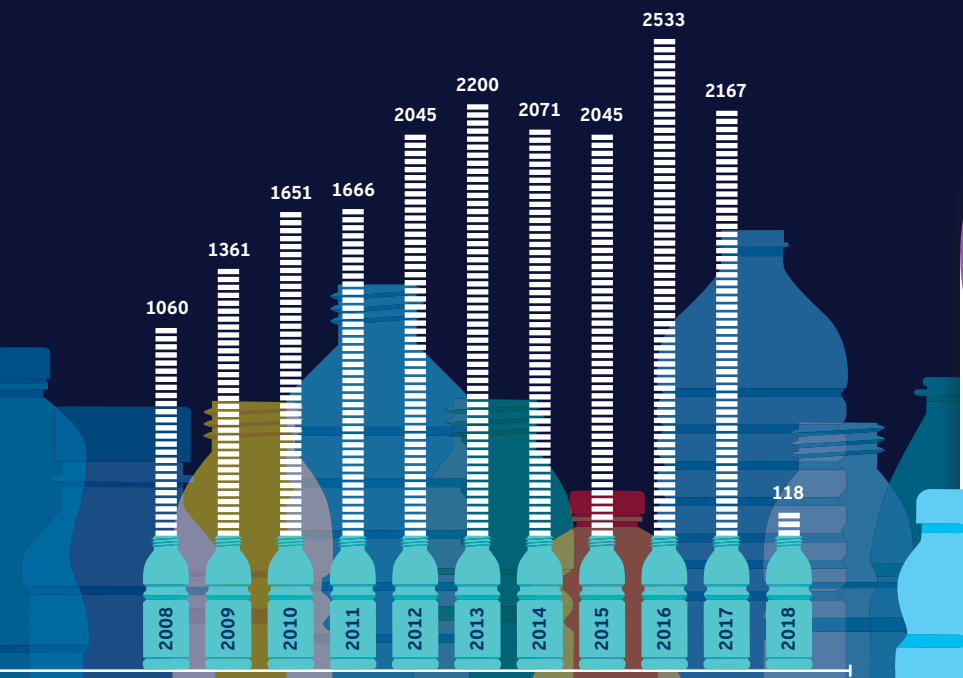
WHY SHOULD WE RECYCLE?

While the economics for recycling facilities and collectors are being strained by China's environmental policies, consumers are still interested in recycling and purchasing environmentally-friendly products. Recycling offers meaningful financial and societal benefits including:

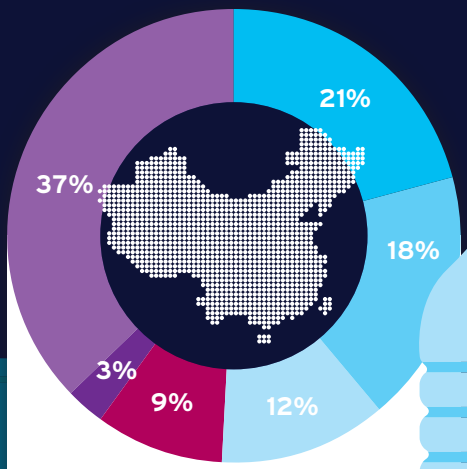
CHINA'S CHALLENGE TO GLOBAL RECYCLING

The global recycling system has been thrown into chaos following China's National Sword program, which restricts the impact of recycled and scrap materials. Prior to the program, China was importing ~50% of the world's total recyclable materials – post the program, imports dropped to low single digits, commodity prices for recycled materials have plummeted, and recycler profitability has fallen.

China Scrap PET Import ('000 metric tonnes)
Source: China Customs, Citi Research



Top Exporters of Plastic Waste to China (2017)
Source: ISWA, UN Comtrade, Citi Research



DIGGING DEEPER ON THE GLOBAL PATCHWORK OF RECYCLING

While there has been a strong push to increase recycling rates across the globe, a lack of unity throughout the value chain has created confusion on what is recyclable, how goods can be recycled, and how goods can be reused. While recycling rates have increased in developed markets, they remain meaningfully lower in emerging markets.

Municipal Solid Waste Treatment in Top 10 Countries

Source: OECD, Citi Research

Highest Percentage of Municipal Solid Waste by Country

Source: OECD, Citi Research

U.S.	Ireland	Luxembourg	Switzerland	Germany	Austria	Denmark	Israel	Australia	New Zealand
35%	40%	48%	51%	58%	65%	44%	19%	41%	0%

SOLUTIONS

Frustration-free packaging: Move towards 100% recyclable packaging, shift packaging mix from boxes to flexible plastic mailer, encourage light-weighting of boxes

Corporate pledges to use recycled content: Shift towards compostable packaging

Participate in NGO initiatives: Change the ownership model of packaging from consumer to producer

Move back to dual or multi-stream recycling: Decreases contamination of recyclables

Adopt a 'Green Dot' system: Indicates a package is environmentally friendly and abides by all recycling laws

Adopt 'Pay-as-you-throw' schemes: Charge households based on the weight of their collected waste

Embrace bottle return deposit schemes

Improve the price/ cost of recycling

Lightweighting of products: Encourage less material sent to landfills

Contents

The State of Global Recycling

Recycling is not a new concept…

Recycling — the re-use of materials — has existed in some form or another for as long as history has been recorded. As early as the Bronze Age, Europeans melted scrap metal to be continuously re-used, and there is evidence of pulp and paper recycling as early as 9th century in Japan. By the 17th century, mills in the U.S. had begun using old linens and rags to produce newsprint, while the first refundable deposit scheme for beverage containers was established around 1800 in Great Britain and Ireland. Recycling grew in scale and scope with the Industrial Revolution, but really accelerated during World War I and II, when material shortages created a pressing need for conservation and re-use. Almost all countries involved in the war effort had large-scale collection efforts for tin, rubber, steel, paper, and other scarce materials, with the government continually reminding their populace that recycling was their patriotic duty.

…but it accelerated in the 1970s

The next acceleration in global recycling systems came in the 1970's with the rise of ecological movements and soaring energy prices. Earth Day was celebrated for the first time in 1970, the same year the recycling symbol, which is still widely used today, was invented in Southern California. In 1976, the U.S. state of Massachusetts received the first Environmental Protection Agency (EPA) grant for recycling efforts, which it used to begin curbside collection for recycled goods. As recycling processes scaled up and matured, the benefits of recycling became increasingly clear. Most importantly, production processes using recycled materials required significantly less energy; for instance manufacturing a beverage can using recycled aluminum only uses 5% of the energy required to produce a new can starting with bauxite. One ton of recycled plastic saves ~5,800 kilowatt-hour (kWh) of energy, 16 barrels of oil, and 30 cubic yards of landfill space. By the 1980's, the U.S. reached a nationwide recycling participation rate of 10% and New Jersey passed the first mandatory recycling law forcing residents to place recyclable goods in a separate bin from their trash.

Europe is the global leader in recycling efforts

Jumping forward to today, global recycling systems vary widely by type of organization and effectiveness. Europe is the leader in global recycling efforts, with the EU 28 recycling 46.4% of municipal waste in 2017, up from 25% in 2000. However, this number varies widely between member states, with Germany leading the pack with recycling rates of 67.6% in 2017. Across Europe, waste legislation has a stated goal of moving up the internationally-accepted "waste hierarchy," towards prevention and away from disposal. The importance of re-use, recycling, and recovery in reducing the environmental impact of creating virgin materials is at the forefront for many European policymakers. Like Europe, South Africa follows the "hierarchy of waste" approach to reduce waste and push re-use/recycle/recover, with disposal as a last resort. Producer responsibility plays a big part in national recycling efforts, and Packaging South Africa (PSA) looks to increase targets for collection/diversion rates to 66.9% within five years, a modest uplift on 2017 recovery data of 57%.

The U.S. has made progress but has a lot of room to improve

The U.S. has made progress in boosting recycling but still has a lot of room to improve. Landfills have historically been the most used option for municipal solid waste (MSW), although that is changing — usage has declined from ~95% in 1960 to only ~52% in 2015. Recycling and composting comprises ~35% of MSW while combustion makes up ~13%. Biogenic MSW (paper, food, yard trimmings) can be converted into energy, but accounted for only ~0.2% of total U.S. energy consumption in 2009.

Why Should We Recycle?

Recycling offers meaningful financial and societal benefits

While the economics for recycling facilities and collectors are being strained by recent China's environmental policies, consumers are still interested in recycling and purchasing environmentally-friendly products. Recycling offers meaningful financial and societal benefits such as reduced energy costs, lower emissions, potentially cheaper end-products, and landfill avoidance.

Reduced energy consumption is a byproduct of recycling…

Reducing energy consumption is a key benefit of recycling, i.e., re-melting scrap aluminum is much more energy efficient and less expensive than creating new aluminum from bauxite. Producing recycled aluminum is ~95% more energy efficient than creating new aluminum therefore a 10% increase in aluminum end-of-cycle recycling rates can decrease greenhouse gas emissions by 15%. The International Aluminum Institute (IAI) estimates that recycling of post-consumer aluminum products saves over 90 million metric tons of carbon dioxide (CO_2) and over 100,000 gigawatt hours (GWh) of electrical energy. While recycled, broken, or refuse glass (aka cullet) has minimal commodity value, according to the Glass Packaging Institute, using it can save 2-3% in energy costs for every 10% of cullet used in the glass container manufacturing process.

…and this cost saving can be passed on to consumers in the form of lower-cost products

Recycling can also result in lower cost products, as producers may choose to pass along a portion of their energy and other cost savings onto consumers. In the case of paper, recycled linerboard (the main component of cardboard boxes) is produced from old corrugated containers, and is significantly cheaper than kraftliner, which is made from virgin pulpwood. A paper industry trade publication, FastMarkets RISI, publishes benchmark prices for both grades and currently has prices for recycled linerboard at a ~25% discount to kraftliner. Certain grades of recycled high-density polyethylene (HDPE) are also significantly cheaper than virgin HDPE with a -~50% price gap.

Recycling also importantly prevents landfill usage

Finally, recycling prevents landfill usage. While landfills have historically been used for their convenience, there are clear risks associated with the continuous accumulation of potentially hazardous materials. In addition to being unsightly, when mixed with rain or snow, material can flow out of landfills, possibly impacting nearby ground water and crops. The gases exuded from exposed trash can also be harmful to nearby residents.

China's Challenge to Global Recycling

China's restriction on imported recycled and scrap materials in 2017 threw the global recycling system into chaos

The global recycling system was thrown into chaos starting following the announcement in 2017 of China's National Sword program, which restricted the import of recycled and scrap materials. Prior to National Sword, China was importing ~50% of the world's total recyclable materials; today import volumes have dropped precipitously with some grades of plastic imports down 99%. This drastic decline has caused commodity prices for paper, plastic, metal, and other materials to plummet, significantly reducing the profitability of recyclers who long relied on the resale of collected goods. The import restriction has prompted broader questions on which goods should enter the waste stream in the first place and, for example, whether goods with limited resale value or use that are essentially destined for a landfill be taxed. In response to these broader questions, outright bans of certain plastic products have been enacted (e.g., plastic straws) and these bans have become increasingly popular in Europe and several U.S. states.

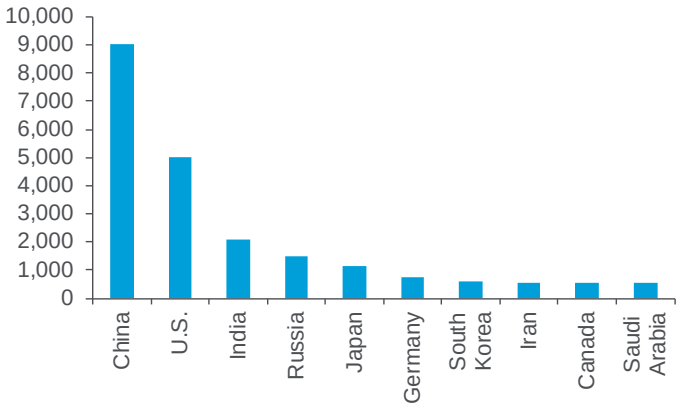
China's action on imports has accelerated the effort to limit the use of non-recyclable materials globally

While we have seen local, regional, and national efforts to limit the use of non-recyclable materials over the last 20+ years, environmental actions taken by the Chinese government have transformed and rapidly accelerated these efforts. China's environmental situation has historically been a fraught issue as the Chinese government tried to balance surging economic growth and rapid industrialization with environmental and public health concerns. China is the world's largest producer of carbon emissions by far, with over 9 billion metric tons of CO_2 emissions produced in 2015 — nearly double the United States (see Figure 1). China accounted for 28% of the world's CO_2 emissions in 2015 and had over four times the emissions as India, who has a similar population level. The high levels of pollution are largely driven by two key factors.

1. **Coal use for energy consumption:** China is the world's largest coal producer and accounts for almost half of global consumption. Coal accounts for over 60% of China's energy mix, although this has been trending lower in recent years; and

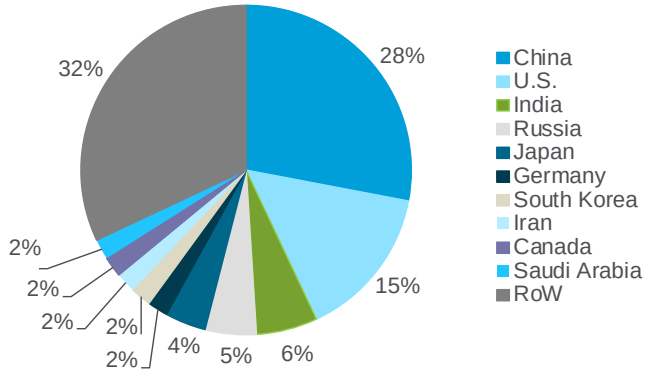
2. **Increasing Chinese car ownership:** Ownership of cars in China continues to increase with 194 million cars on the road in 2016, growing at a 13% compound annual growth rate (CAGR) over the last five years.

Figure 1. Top 10 Countries by CO_2 Emissions (mt, 2016)



Source: Citi Research, UCUSA

Figure 2. Share of Global CO_2 Emissions (2016)



Source: Citi Research, UCUSA

Pollution levels in China are high and negatively impact the economy

Air quality in many of China's major cities fails to meet international standards for health and safety. As a result of the pollution, there have been cases of school closings and halts to factory manufacturing. Water pollution is also a major concern as China accounts for ~20% of the global population but only ~7% of the freshwater supply. China's Ministry of Environmental Protection estimates that pollution negatively impacts the Chinese economy by over $225 billion annually. The environmental collateral damage from China's economic boom and its long-term health impact is a cause of worry for citizens and has been cited as a driver of popular protests.

To combat pollution, the Chinese government unveiled multiple policies to tackle rising environmental issues

China is increasingly aware of rising environmental issues and has recently unveiled multiple policies to tackle these concerns. In its 13th Five-Year Plan, China set multiple targets related to the quality of air, water, soil, and the ecosystem. It also aimed to cut emissions of multiple harmful pollutants (e.g., reduce carbon dioxide emission by 15%). In order to achieve these goals, measures have been taken including supply-side reforms, such as eliminating old, inefficient, and polluting plants and winter production controls, including lowering the run-rates of heavy industries in Northern China during the wintertime to address heavy smog.

Initially, recycled materials benefited China in supporting its growing manufacturing sector

In its war against pollution, China is also tackling the recycling industry. China began heavily importing recycled and scrap materials in the 1980's in order to support its growing manufacturing sector, however a combination of material mishandling and imported materials of poor quality contributed to high levels of pollution. Shipping waste to China made sense for some countries as China, typically a net exporter, would ship manufactured goods in large containerized cargo ships but would have nothing to bring back on the return trip. This meant importing recycled material from abroad became a more attractive proposition for China than building out the required infrastructure domestically. Recently introduced policies to restrict imports of recycled goods are part of a broader initiative to improve air and water quality as, according to China officials, hazardous waste could be mixed into the scrap materials and cause serious harm to the environment in the recycling process.

But by 2017, multiple campaigns were launched to target waste imports

Beginning in 2017, multiple campaigns were launched to target waste imports. In February of that year, China launched the "National Sword 2017" program to strictly prohibit the smuggling of foreign waste, in particular industrial goods, electronics, and plastic scrap. This broad initiative also included agricultural products, natural resources, and illicit goods like drugs and guns. In April 2017, the Central Leading Group for Comprehensively Deepening Reforms, led by China President Xi, announced the "Plan to prohibit foreign waste dumping and regulate solid waste import." This was followed in July of that year by the Ministry of Environmental Protection's one-month dedicated effort to inspect recycling processors. Hundreds of enterprises were fined for various breaches on matters like waste discharge and many had their import licenses revoked. Later that month, the Ministry notified the World Trade Organization that it would stop importing 24 types of solid waste under four categories (plastics, vanadium-containing slag, unsorted waste paper, and textiles) before the end of 2017. The authority issued a circular in August banning processors from operating in non-industrial park areas. In addition, the authority also tightened its control on waste import permits and only negligible volumes were allowed to be imported in 2018.

China recently announced a plan to effectively ban a number of single-use plastic products

In February 2018, the "National Sword 2018" program was launched to continue the previous year's effort. Most recently, China's National Development and Reform Commission and the Environment Ministry announced a plan to effectively ban a number of single-use plastic products. The act specifically phases out all non-degradable plastic bags, single-use straws, disposable foam tableware and plastic tableware (typically used for takeout); major cities will see the bans enacted in 2020, while smaller communities will see them phased in between 2022-25. The guidelines further instruct hotels to stop providing disposable plastic products, while postal delivery outlets will stop using non-degradable plastic packaging and disposable plastic woven bags by the end of 2022.

Figure 3. Solid Waste Import Ban (Plastics Only)

Types	Categories
Plastics (8 Categories)	Polyethylene (PE) Solid Waste
	Aluminized Plastics Film
	Polystyrene (PS) Solid Waste
	Polyvinyl chloride (PVC) Solid Waste
	Polyethylene Terephthalate (PET) Solid Waste (non-beverage)
	PET Solid Waste (beverage)
	Other Plastics Solid Waste (non-CD/DVD ROM)
	Other Plastics Solid Waste (CD/DVD ROM)

*Total 4 types plastics (plastics, vanadium waste, papers, textiles) of solid waste will be banned this can be further divided into 24 categories.

Source: Citi Research

This new effort to tighten waste import control is likely to stay for the long term

Unlike previous efforts, these new policies are likely to be long term given the government's determination to fight pollution. In April 2019, China's Ministry of Ecology and Environment was reported as likening its tight waste import control policy to "an arrow that has left the bow" and could not be recalled. The Chairman of China's recycling industry association indicated in a public forum that the issue of waste imports pertains to the health of China's population and employment considerations in the recycling sector may not impact the authority's implementation of the policy. The authorities had launched a similar campaign in the past — the 'Green Fence' action — to address foreign waste smuggling. It was, however, only a 10-month program and expired in November 2013.

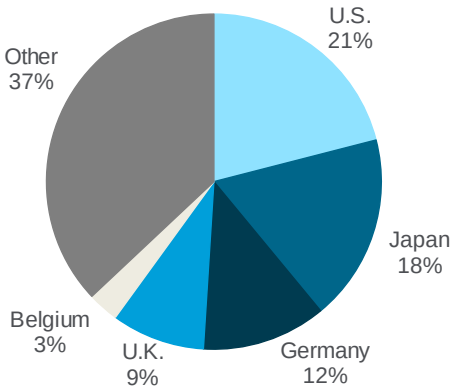
Other countries in Southeast Asia picked up some of China's waste imports but many weren't prepared for the large volume of waste

With China no longer accepting multiple types of waste and neighboring countries unable to deal with the high level of supply, exporting countries will likely be forced to expand domestic recycling and/or cut back on the level of waste being produced. A portion of the scrap materials that had been imported by China could ultimately be processed in Southeast Asia (e.g., Vietnam, Thailand, Cambodia, and Bangladesh). In March 2018, Malaysia and Thailand imported almost 200,000 metric tonnes of plastic scrap, the same volume they imported in the whole of 2016. However, these countries were unprepared to receive such a large volume of waste given limitations to ports, storage, and processing plants. This led to severe oversupply with backlogged materials sitting in ports for months at a time, driving responses from various governments with Vietnam reiterating its plan to phase out scrap plastic imports in 2025. Indonesia has seen recycled plastic exports plunge 70% given a shortage of materials following tighter restrictions on contamination levels. In June 2019, Indonesia sent back ~100 tonnes of paper waste due to contamination from plastic, rubber, and diapers.

Post the policy change in 2017, U.S. plastic waste exports to China declined almost 85%

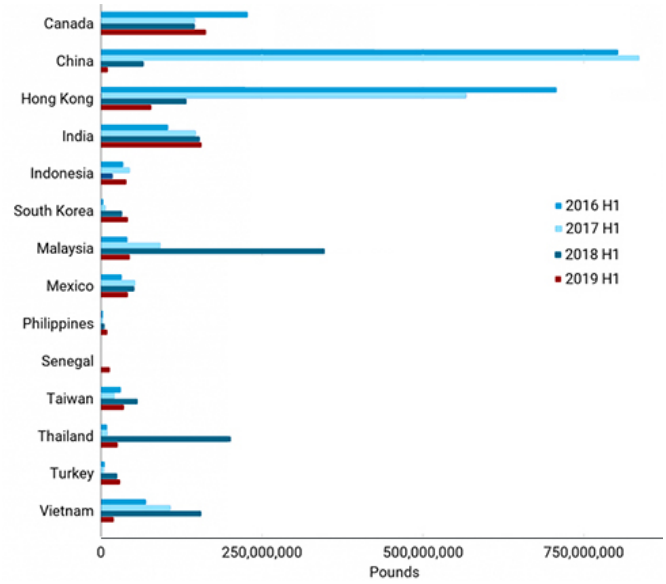
Several Western ports have seen plastic waste pile up at storage sites following the Chinese ban, with port managers using empty storage sheds or shipping containers to store the overflow of material. While the level of contamination in the waste sent to China has been disputed by some exporters, the Chinese government has not wavered. According to Resource Recycling, U.S. plastic waste exports to China declined almost 85% from January to December 2017; plastic waste exports to all countries declined ~35% as other Asian countries have only partially made up the difference.

Figure 4. Top Exporters of Plastic Waste to China (2017)



Source: Citi Research, ISWA, UN Comtrade

Figure 5. U.S. Exports of Scrap Plastic by Country (Jan-June, 2016-19)



Source: Citi Research, Resource Recycling

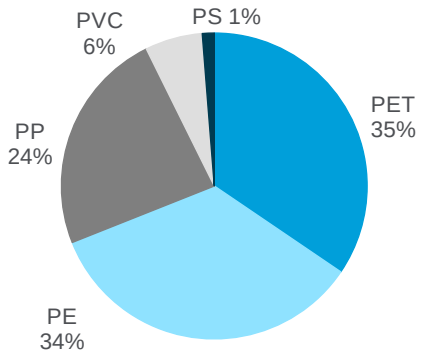
Growth in the Chinese plastics recycling market was strong, peaking in 2016 before falling to almost zero in 2018

The Chinese plastics recycling market emerged in the 2000s when plastics prices in China surged, led by rising crude oil feedstock prices and tight product supply-demand balances. Recycled plastics materials offered a much more affordable alternative than virgin plastics as the price was cheaper consistently throughout the period. According to IHS, the China recycling sector had grown at a significant rate of 23% from 2003 to 2008 before falling back to 14% thereafter. Imports of plastic scrap peaked in 2016 at roughly 8 million metric tonnes, accounting for almost half of global trade. Polyethylene terephthalate (PET) and polyethylene (PE) accounted for more than half of the total volume, with each accounting for roughly 2.5 million metric tonnes. Imports started to fall rapidly in the second half of 2017 and the volume was negligible in 2018 and through the first eight months of 2019.

Given the collapse in plastic recycling markets in China, demand for virgin staple fiber could increase

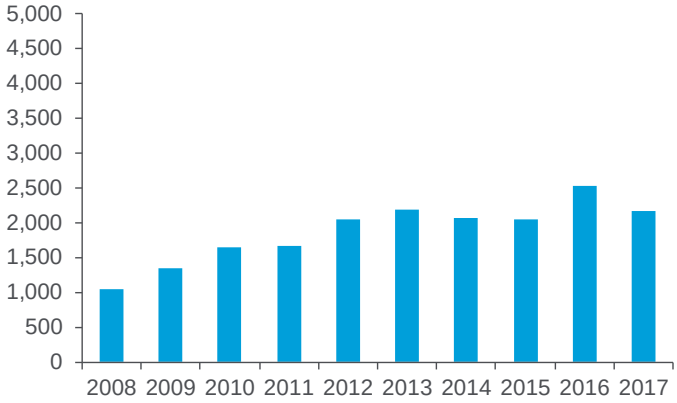
This has had a positive demand impact to the primary resins market for both PET and PE due to a substitution effect. In PET, recycled materials were previously processed into polyester staple fibers. China's policy could not only boost demand for virgin staple fiber, but also polyester condensation feedstock — paraxylene (PX), purified terephthalic acid (PTA) and monoethylene glycol (MEG).

Figure 6. China Plastics Scrap Import Breakdown (2016)



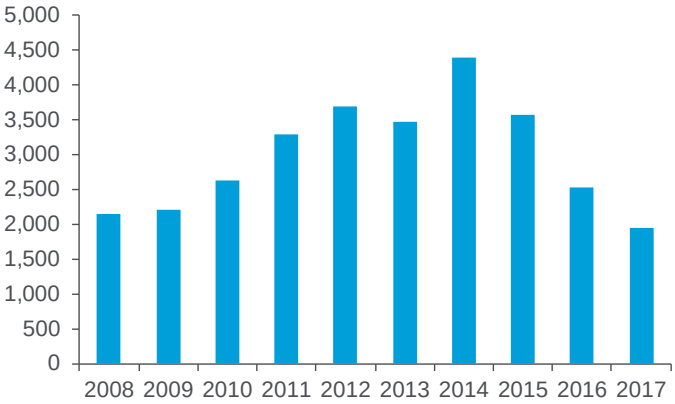
Source: China Customs, Citi Research

Figure 7. China Scrap PET Import ('000s metric tonnes)



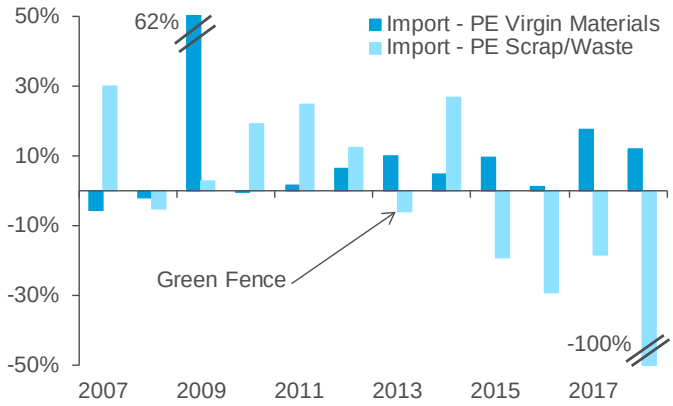
Source: China Customs, Citi Research

Figure 8. China Scrap PE Import ('000 metric tonnes)



Source: China Customs, Citi Research

Figure 9. China Virgin and Scrap PE Import Growth



Source: China Customs, Citi Research

Import replacement could also boost domestic virgin resin demand significantly

Regarding the PE market, import replacement could also boost domestic virgin resin demand significantly, as recycling PE was roughly 8% of the total market size in 2016. In 2017, China scrap PE imports dropped 23% but virgin PE imports rose 18%. The substitution trend continued in 2018 as China increased PE imports by over 2.2 million metric tonnes year-over-year (YoY), or the equivalent of ~2% of global PE demand or ~8% of China demand. However, this trend slowed in 2019 as China PE imports grew only ~1.2 million metric tonnes YoY. China PE imports are expected to slow even more this year as IHS estimates China will import just ~0.25 million metric tonnes more PE in 2020 than 2019. We see this as a negative for the global PE supply/demand balance as PE trade shows signs of softening from major plastic-consuming countries amidst an oncoming supply of new ethylene capacity, particularly from the U.S. and China.

While the timing and implementation of specific regulatory actions by Chinese authorities is not always certain, we believe the recycled plastics ban is not going away, and in our view the dramatic impacts we've seen on U.S. and European plastics producers and recycling systems may be just beginning.

Recycled Commodity Prices Have Plummeted

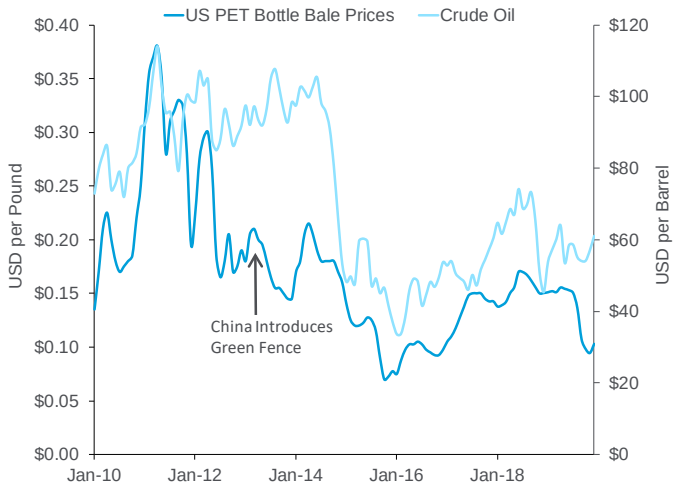
China's exit from the global recycling market has heavily pressured profitability for recyclers

China's exit from the global recycling market has heavily pressured profitability for recyclers by suppressing demand and creating a glut of oversupply. The average price per ton of mixed paper exported from North America to Asia has fallen from ~$150/ton to ~$5/ton and deeply challenged the economics of the U.S. recycling industry. Sacramento County in California used to earn $1.2 million annually by selling recyclables to private waste management companies, now the county is paying ~$1 million to offset those companies' costs. Private waste management companies are facing pressure from two sides: plummeting commodity costs are lowering the resale value of processed materials, while China's strict quality standards on the small amount of recycled material that can be imported is driving up operating costs. One major industry player noted they saw average commodity revenues had declined about 80% since the start of 2011. Further, shipping recycled material to other Asian countries besides China has driven up transportation costs. These factors have led to some consumers being charged more in order to have their recyclables picked up by their municipality or county, which could potentially dissuade recycling efforts.

U.S. PET bale prices have declined in line with China's policies vs. historically trending with crude oil prices

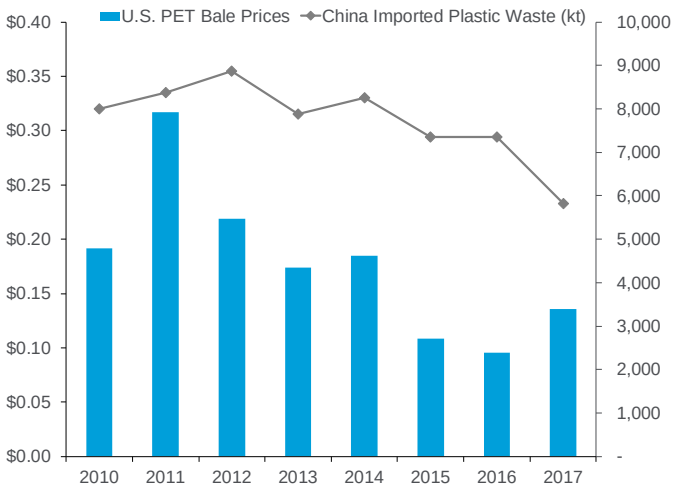
One example of the far-reaching nature of China's policies on U.S. markets is PET bottles. When PET bottles are recycled they are typically pressed into bales and then sold to recycling companies. The National Association for PET Container Resources (NAPCOR) tracks the price per pound of those PET bales in the U.S. Bale prices have been declining since 2011 consistent with crude oil prices (oil can dictate virgin PET prices) and Chinese demand for recycled plastic waste, as seen in Figure 10 and Figure 11 below. U.S. PET bale prices have fallen consistently in accordance with China's stance on imported plastics, although crude oil has been firmer of late. Per NAPCOR, when PET bale prices drop, smaller commercial collectors can sometimes reduce or eliminate collections as the business case for recycling becomes less attractive. China's exit from the plastic waste market not only eliminates a key source of processing, but could potentially drive down recovered PET prices in the near-to-medium term which may deter recycling.

Figure 10. U.S. PET Bale Prices vs. Crude Oil



Source: Citi Research, NAPCOR, FactSet

Figure 11. U.S. PET Bale Prices vs China Plastic Waste Imports

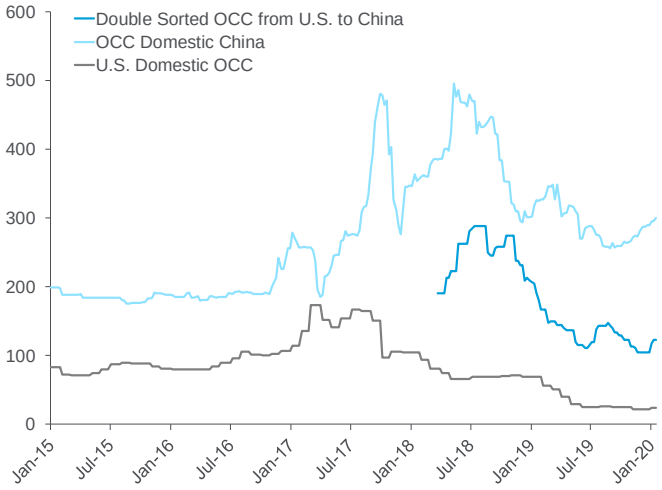


Source: Citi Research, NAPCOR, UN Comtrade

The same effect can be seen in paper, with OCC prices tracking downwards, in line with China restrictions

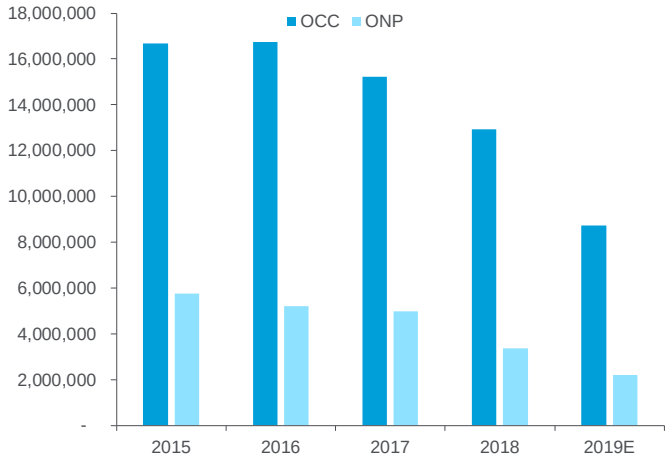
The impact of the Chinese National Sword program on recycled paper markets echoes the impact on recycled plastics markets. As part of the program, Chinese customs cracked down on the quality of mixed paper being imported, setting a 1.5% contaminant limit (most mixed paper from the U.S. pre-National Sword had been cleared with 3-5% contaminant levels). In accordance with the new program, authorities stopped issuing licenses to importers of recovered paper in China in May of 2017. As a result, old corrugated container (OCC) imports into China collapsed 47% in the fourth quarter of 2017 and continue to track ~40% lower year-over-year; OCC pricing in both the U.S. and China has diverged as a result. The gap between Chinese domestic OCC and U.S. domestic OCC averaged ~$190/ton since 2015, but has recently maintained a ~$260/ton gap over the past year as Chinese buyers bid up domestic OCC while the Chinese Environmental Ministry continues to reduce the allowable tonnage to be imported. U.S. domestic OCC prices have been bouncing at all-time lows while 2019 imports are tracking down ~35% YoY and half the level they were in 2016-17. U.S. waste companies have noted that ~30% of the containerboard they recycled used to go to China but that has dropped to ~2% post the enactment of National Sword.

Figure 12. U.S. and China OCC Prices ($/ton)



Source: Citi Research, RISI

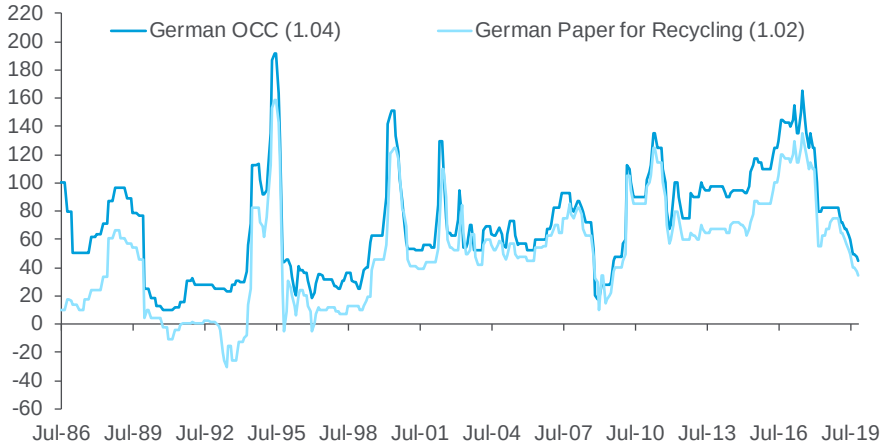
Figure 13. Annual OCC Imports From U.S. to China (tonnes)



Source: Citi Research, RISI

The picture has been more pronounced in Europe with both OCC and mixed paper prices falling to six/seven year lows.

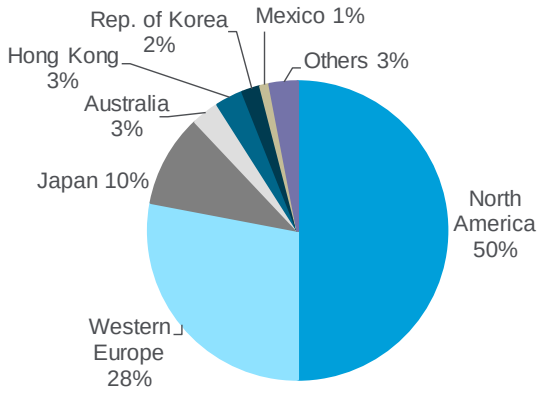
Figure 14. Recycled Paper Prices in Germany, (EUR/tonne)



Source: Citi Research, RISI

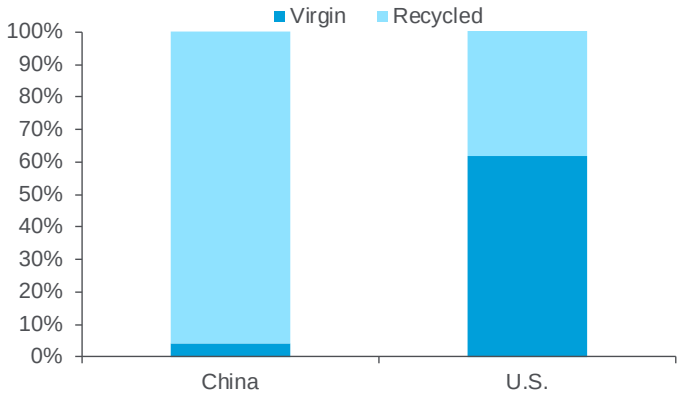
To illustrate the commitment the Chinese government has to improving the environmental situation, we point to a statement by the State Council that the Chinese government is working toward implementing a complete ban on imports of all solid waste by the end of 2020. To put that in perspective, China imported just under ~30 million tonnes of recovered paper in 2016, primarily from North America, Europe, and Japan. This recovered paper accounts for ~30% of the fiber China needs to create containerboard (cardboard boxes) As an export-focused economy, cardboard boxes play a key part in the economic chain, so disrupting this supply chain so aggressively is a testament to the commitment the Chinese authorities have towards pollution reduction.

Figure 15. Chinese Recovered Paper Imports By Region



Source: Citi Research

Figure 16. Containerboard Fiber Breakdown (China vs. U.S.)



Source: Citi Research, RISI

Squeezed by lower commodity prices and higher operating costs, recycles are looking for different ways to recycle profitably

Under pressure from China, U.S. waste management companies are looking for different ways to recycle profitably. Historically, companies would charge a fee to businesses and households for waste removal services. The collected recyclable goods were separated into different categories (metal, glass, paper etc.) and then sold to recyclers who would find a secondary use for the material. As described above, China was the largest consumer of U.S. recycled goods and its withdrawal from the market has crushed commodity prices.

One U.S. waste company noted it saw a -16% decline in recycling revenue in 2019 driven by a -23% YoY drop in recycling commodity prices. With no buyer for recycled materials, waste managers have turned to other means of driving revenue to de-risk, such as charging a processing fee for recyclables and crediting a portion of that fee back based on the profits derived from the materials. The median processing fee currently stands at ~$62/ton, per The Recycling Partnership, up ~$20/ton YoY, based on survey results. While these measures ensure waste companies receive proper value for their service, they do not ensure that all collected recyclable materials are put to use (meaning recyclable items may still be sitting unused in a port somewhere), which would limit the need for more virgin products.

What materials actually belong in the recycling stream has been the topic of recent discussion as the actual implementation of recycling low-value materials can be problematic

Another conversation recyclers are having is around what materials actually belong in the recycling stream. Fiber comprises ~60% of recycled materials, which is trending lower as the decline in use of newsprint (~15%) has more than offset steady gains in cardboard (~21%). Most Material Recovery Facilities (MRF's) were designed to handle ~80% paper and ~20% containers and the decline in newsprint has strained processing capabilities. Metal, specifically aluminum, remains the most valuable material in the recycling stream given its variety of end-uses (auto, cans, electronics, etc.). Plastics (mostly rigid) are logical to recycle given the built-in revenue stream through product re-use. However they are not without issues; light-weighing is being used by manufacturers to save money and reduce emissions, but this increases costs for MRF's as revenues are based on weight but costs are based on processing volume meaning MRF's need to process more containers to derive the same amount of revenue. Per the Recycling Partnership, assorted plastics (#3-7), aseptic & cartons and plastics films/bags are the most frequently removed categories from accepted curbside materials.

One material with a mixed economic argument for being in the recycling system is glass. In North America, in many instances glass is a low- or negative-value material where MRF's actually have to pay in order to have the material removed. While glass is an infinitely recyclable material, there is a limited resale market for it given the ample supply of raw materials to create a new bottle or jar. Some industry participants think the future of collected glass may be in construction aggregates where the bottles and jars are crushed into powder and mixed into gravel. Per The Recycling Partnership, glass containers collected from single-family homes have a per ton value of -$21/ton in the US. Despite the negative value, surveys showed that glass is being accepted at a similar or higher rate by recycling programs in 2019 as compared to 2018. There has been an increase in demand for re-fillable glass bottles, but that remains a small portion of the market. In Europe, cullet has positive economic value and better prospects for recyclability.

While it may make sense, in theory, to recycle items like glass, the actual implementation of recycling low-value materials can be problematic. For glass bottles, every 10% of cullet used in the manufacturing process saves 2-3% in energy costs. However the economics of handling glass are not compelling in North America and ultimately, recycling is a business, not a public service. While publicly-traded waste services companies do not breakout the profitability of their recycling operations, we believe margins are quite low.

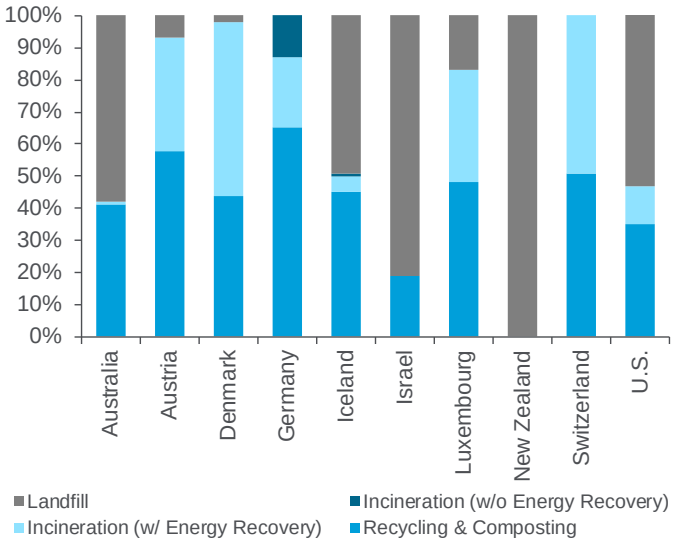
Who Are the Best Recyclers? Who Needs to Improve?

The top 10 waste-producing nations, in terms of kilograms per capita, are Denmark, the U.S., Switzerland, New Zealand, Germany, Israel, Luxembourg, Iceland, Australia, and Austria. Notably, these are all developed economies with higher income per capita and eight out of 10 countries recycle at a rate that is higher than the OECD (Organization for Economic Co-operation and Development) average.

Figure 17. MSW Per Capita by Country in (kg, 2015)

Source: Citi Research, OECD

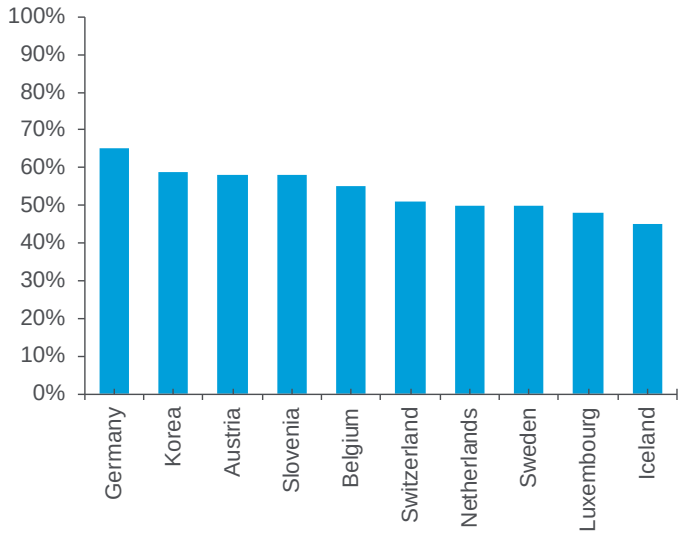
Figure 18. MSW Treatment in Top 10 Countries



Source: Citi Research, OECD

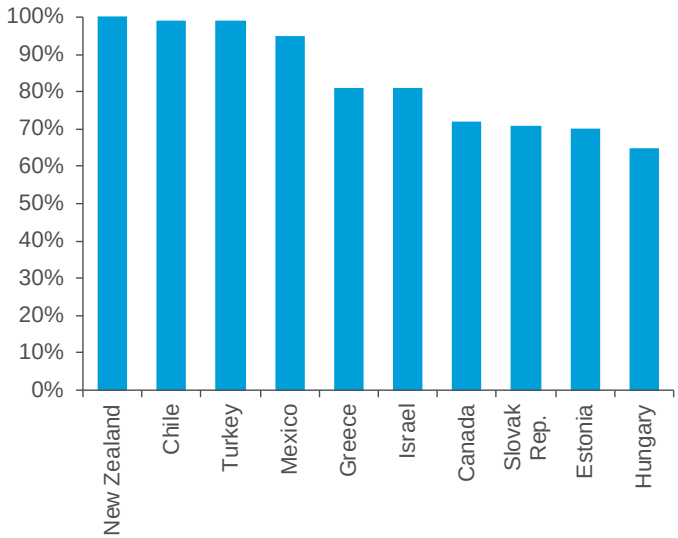
Germany is the global leader in recycling at 65%+; in total there are eight countries that recycle over 50% of their municipal solid waste. This compares to 15 out of 36 OECD countries that send 50%+ of their MSW to landfills and four countries (New Zealand, Chile, Turkey, and Mexico) send 90%+ of their MSW to landfills.

Figure 19. Highest % of MSW Recycled by Country (2015)



Source: Citi Research, OECD

Figure 20. Highest % of MSW Sent to Landfills by Country (2015)



Source: Citi Research, OECD

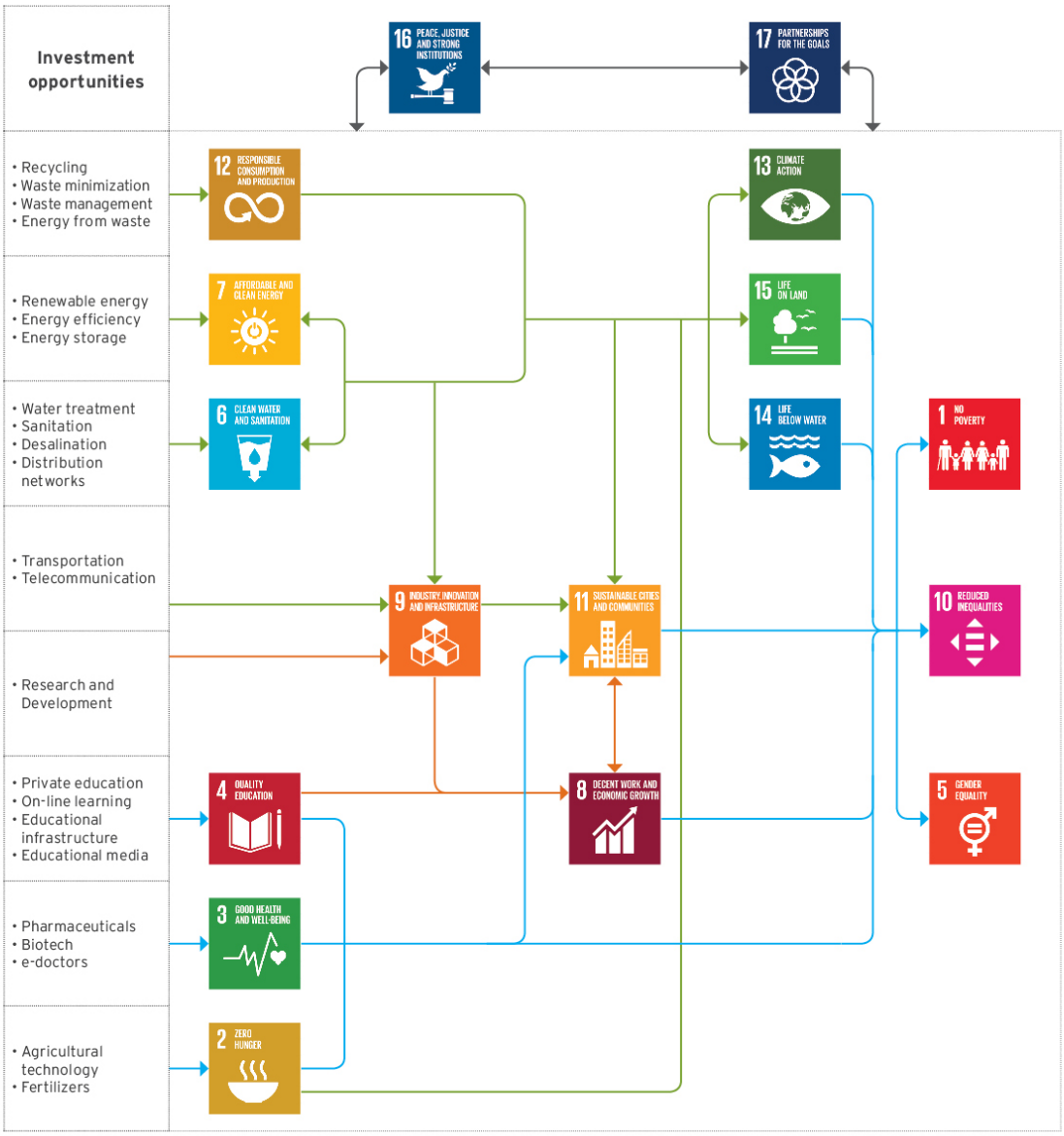
ESG Impact & UN Sustainable Development Goals

Citi believes shifting consumer attitudes towards recycling is an important investment theme, especially for asset managers with an ESG (Environmental, Social & Governance) mandate. ESG considerations are becoming more important with respect to investing decisions for many large asset managers. To assist in ESG investing efforts, Citi has created a systematic framework for approaching the UN's Sustainable Development Goals (SDGs) (see our Citi GPS report UN Sustainable Development Goals). Recycling, and its impact on the environment and ecosystem, touches upon multiple Sustainable Development Goals. SDGs directly impacted by recycling include Goal 3 (Good Health & Well-being), Goal 11 (Sustainable Cities & Communities), Goal 12 (Responsible Consumption & Production), Goal 14 (Life Below Water), and Goal 15 (Life on Land).

Figure 21. The UN Sustainable Development Goals

Source: United Nations

Figure 22. Framework for Investing in the UN Sustainable Development Goals



Source: Citi Global Perspectives & Solutions (Citi GPS)

The development of fully-recyclable packaging in particular can play a key role in the development of sustainable cities and communities (UN SDG #11) through improved recycling infrastructure and education. As urbanization continues (the UN expects ~5 billion humans living in cities by 2030 and ~6 billion by 2050) the importance of food sourcing and product logistics will only grow in importance. Food shelf life will also become increasingly important as the vast sums of produce and meats are shipped into cities to be purchased. In addition, with millions of products being shipped into cities through e-Commerce, packaging optimization, which is inherently linked to recycling standards, will reduce waste.

Figure 23. UN Metrics and Indicators for Sustainable Goal 12 (Responsible Consumption & Production)

Targets	Indicators
12.1 Implement the 10-year framework of programs on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12.1.1 Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1 Global food loss index
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement 12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	12.6.1 Number of companies publishing sustainability reports
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12.7.1 Number of countries implementing sustainable public procurement policies and action plans
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1 Extent to which (1) global citizenship education and (2) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
12.A Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12.A.1 Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies
12.B Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12.B.1 Number of sustainable tourism strategies or policies and implemented action plans with agreed monitoring and evaluation tools
12.C Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.C.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels

Source: Source: UN (2018), Global Indicator Framework for the Sustainable Development Goals and Target of the 2030 Agenda for Sustainable Development

SDG #12 (Responsible Consumption and Production) is a goal closely tied to recycling: high performance but recyclable packaging can make global supply chains more efficient and reduce food waste and spoilage. The UN Environment Program estimates ~1.3 billion metric tons of food waste is generated annually. Packaging also has the potential to create large amounts of waste, if the packaging is produced without recyclability in mind. McKinsey estimates ~95% of plastic packaging is disposed of each year after just a single use, valued at $80–$120 billion. Looking at the UN metrics in Figure 23, we believe targets 12.3, 12.4, and 12.5 further correspond to improvements in global recycling systems. The EU recently updated their Circular Economy Action Plan which includes a strategy targeted at making all plastic packaging recyclable by 2030. While there are disparate levels of progress between countries and regions, overall material usage per capita and per unit of GDP has generally increased, although there have been pockets of efficiency gains in some developed and emerging markets.

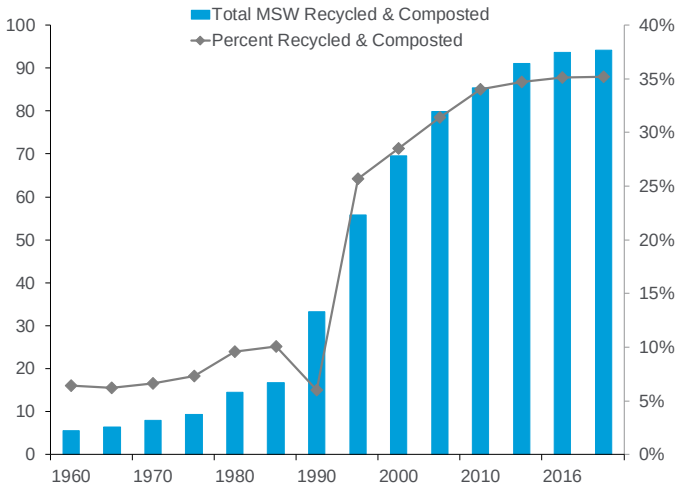
Digging Deeper on the Global 'Patchwork' of Recycling

U.S. Recycling Efforts Have Improved, But Leave a Lot to be Desired

Landfill has historically been the most popular option for waste disposal in the U.S.

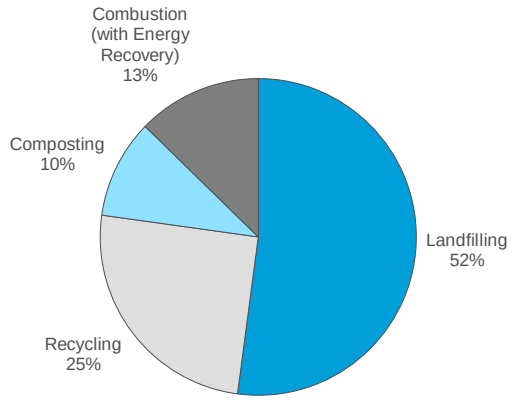
There are three ways to handle products in the waste stream: landfills, recycling & composting, and combustion. Landfills were historically the most popular option in the U.S., accounting for ~95% of municipal solid waste in the 1960's. However the popularity of landfills has decreased given contamination and land use concerns. As a result, the use of landfills has declined with just ~52% of municipal solid waste (MSW) reaching a landfill in the U.S. in 2017. Recycling & composting is perhaps the most popular option amongst consumers, but as discussed earlier, it is only viable for a certain subset of materials. Accordingly ~35% of MSW was recycled or composted in 2017. Combustion accounted for ~13% of MSW in the U.S. in 2017. Combustion (incineration) reduces waste weight by ~75% but the remaining material (ash) ultimately ends-up in a landfill. Biogenic MSW (paper, food, yard trimmings) can be converted into energy, but this only accounted for accounted for ~0.2% of total U.S. energy consumption in 2009.

Figure 24. U.S. Recycling & Composting Rates



Source: Citi Research, EPA

Figure 25. MSW Management in the U.S. (2017)



Source: Citi Research, EPA

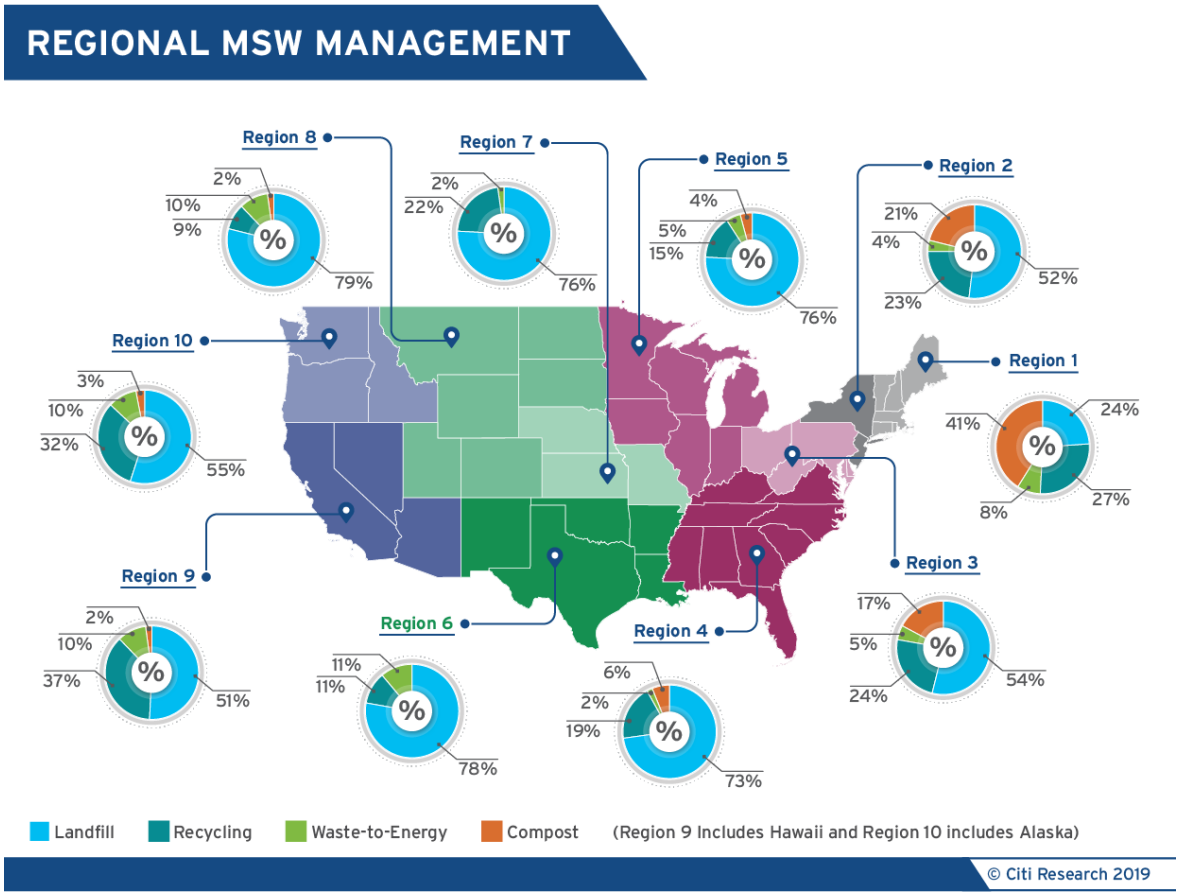
The most recycled materials in the U.S. are paper & paperboard (~66.6%) and "other nonferrous metals" such as lead-acid batteries, while plastic (~9.1%) and textiles (~15.3%) are the least recycled materials. In Figure 26 and Figure 27 we detail recycling, landfill usage and composting by region. As seen below, recycling rates are higher in the more densely populated urban areas of the country. According to The Recycling Partnership, ~27% of the U.S. does not have access to curbside recycling, ~21% of people have access to drop-off services while ~6% of people have no access at all.

Figure 26. U.S. Recycling as a Percent of Generation by Product

	1970	1980	1990	2000	2014	2015	2017
Paper & Paperboard	15%	21%	28%	43%	65%	67%	66%
Glass	1%	5%	20%	23%	26%	26%	27%
Metals	4%	8%	24%	35%	35%	34%	33%
Plastics	0%	<1%	2%	6%	10%	9%	8%
Yard Trimmings	0%	0%	12%	52%	61%	61%	69%
Selected Consumer Electronics	--	--	--	10%	42%	40%	36%
Lead-Acid Batteries	76%	70%	97%	93%	99%	99%	99%

Source: Citi Research, EPA

Figure 27. Regional MSW Management



Source: Citi Research, University of Michigan

How Does Waste Removal Work in the U.S.?

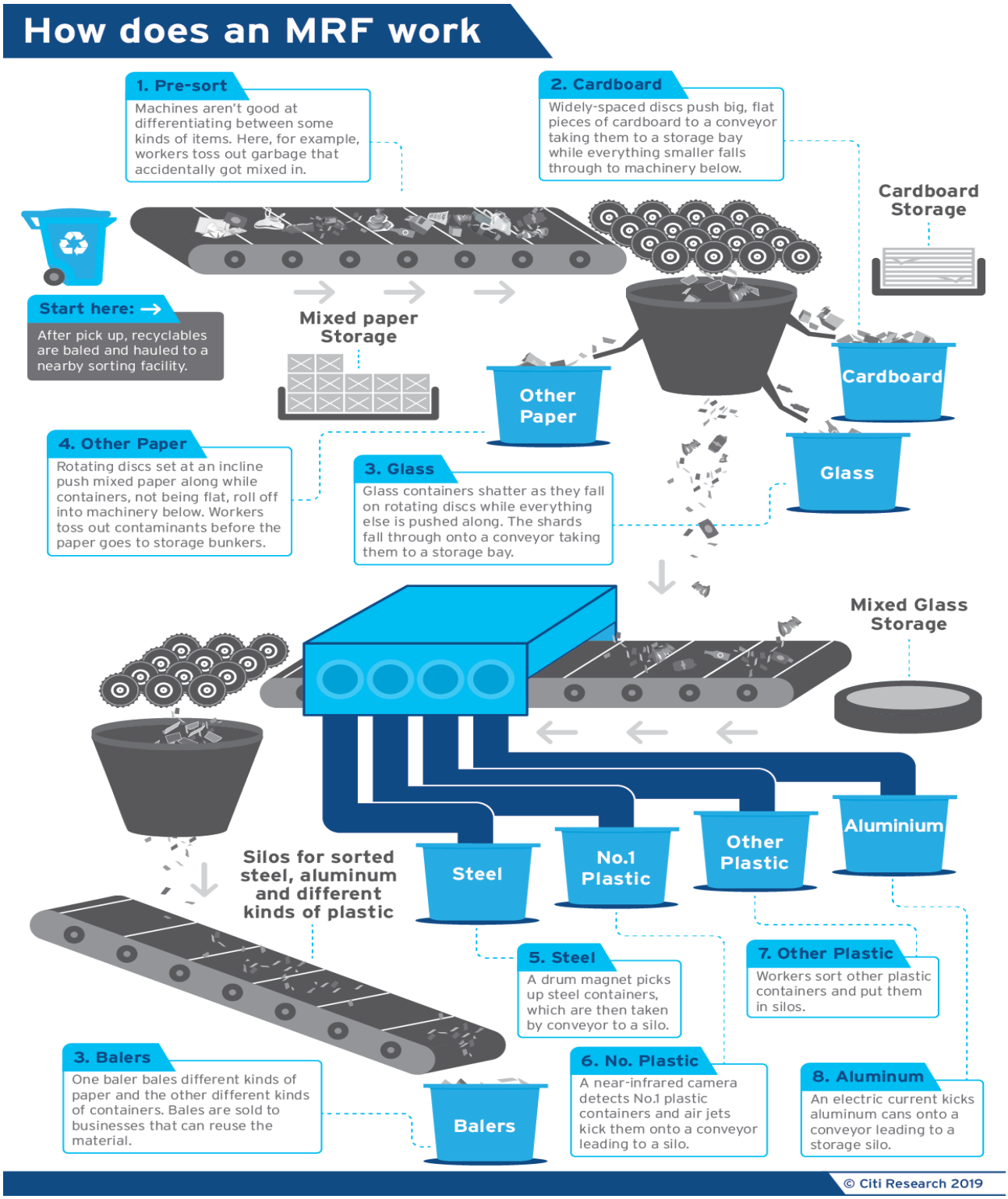
U.S. waste removal is a fragmented market

In the U.S., waste removal is a highly competitive, fragmented market with a handful of large private servicers (the top four producers have 45-50% combined market share) and hundreds of smaller, local operators. After a product is purchased by the end-consumer and is ready to be disposed of, the individual is responsible for placing the item in the correct bin (waste or recycling) and paying for its collection. The company in charge of collection then brings those items to a transfer station, materials recovery facility (or MRF) or a disposal site. If there is not an MRF or a landfill nearby, the collected items will go to a transfer station. This allows servicers to consolidate MSW (at a fee to the owner) so it can be brought to the next location in a more cost effective way.

Recyclable materials are brought to an MRF, processed in a number of steps, and then baled and potentially sold to a buyer that can re-use the material

Recyclable materials which are brought to an MRF are processed in a number of steps. In pre-sorting, items are dumped on a conveyor belt where workers manually pick through them to remove any visible trash that cannot be processed. Cardboard is removed by widely-spaced discs, and then taken to a separate storage bay. As the remaining waste is pushed onto these discs, smaller items fall through, while glass shatters, is separated and removed. A different set a discs sift through the waste at an incline, removing any non-flat items, thus separating mixed paper and containers. Waste is then run under a large magnet which removes steel. Near-infrared cameras detect #1 plastic and move them into a separate container. Workers then pick through the remaining items for other types of plastic. An electric current then kicks aluminum cans onto a different conveyor belt where they are stored separately. All of the different piles of materials are then baled, and potentially sold to a buyer that can re-use the material.

Figure 28. How Does an MFR Work?



Source: Citi Research

A majority of the waste in the U.S. ends up in one the country's 2,000+ active landfills

Disposal sites are for non-recyclable waste, or recyclable waste that inadvertently ends up in the waste stream. A majority of the waste in the U.S. ends up in one the country's 2,000+ active landfills. Given the increased scrutiny landfills face, operators are taking measures to make them safer for the environment and the surrounding inhabitants. Once approved by regulators, landfills are lined with compact clay and a geo-membrane to limit contamination in addition to drains and pipes which are further put in place to safely remove leachate (water that drains off of the waste) and filter out excess moisture. Ground water monitoring systems are installed to insure safety, while gas wells are installed to capture methane generated by the waste; this can later be converted into energy. Once the landfill is full, it is again covered with clay and a geo-membrane before being covered with soil and the groundwater continues to be monitored for quality. After 30 years (or the amount of time deemed necessary by regulators) the land can then be reused for commercial or industrial use, often becoming "green space" used for recreation.

Incineration is the highest cost option for waste but reduces waste volume while producing energy

Beyond landfills, solid waste can be incinerated. This is typically the highest cost option given the capital-intensity and skilled personnel required for operation and maintenance of these facilities. However, incineration does carry the benefit of reducing waste volume, avoiding a landfill, and producing energy. When MSW arrives at the combustion facility, collection trucks dump it into a storage bin where an overhead crane removes it and lifts it into the combustion chamber. The heat released converts water into steam, and is then sent to a turbine generator which produces electricity.

- **End-Users Bear the Cost and Responsibility of Recycling:** Unlike in Europe where some recycling programs such as Green Dot are funded by corporations, in the U.S. individuals pay for collection services and there is essentially little incentive to properly recycle. For residential collection services, waste removal companies engage in bids for the rights to all of the homes in a given municipality. Companies also offer monthly subscriptions to individual households. For commercial and industrial collection services, companies typically utilize a three-year service agreement with fees based on collection frequency, volume/weight of the waste collected, distance to disposal facilities and the type of equipment required. Often the only financial incentive to recycle is bottle and can return deposit schemes that provide 5¢ or 10¢ per item returned, depending on the state. The amount of money generated from returns is largely inconsequential for most Americans, and often doesn't provide enough of an incentive to influence behavior.

- **Large-Scale Shift to Single-Stream Recycling:** Currently ~65% of material recovery facilities are single-stream vs. 27% in 2006, per Waste Dive. This means that at the point of pick-up, consumers can mix paper, cardboard, plastic, glass, and metal all in one bin, as opposed to dual stream which means fiber (paper & cardboard) are kept separate from rigid containers (plastic, glass, and metal). Single-stream has increased in popularity largely due to ease of use. The lower burden on the end consumer is widely viewed as a positive for the recycling industry. Also, trash haulers are able to realize cost savings by cutting down on the labor required at pick-up with households moving from two bins to one, thus requiring fewer employees per truck. Dual stream requires more work on consumers' part, but is superior in limiting contamination, which we define as incorrect materials intermingling with correct materials, or correct materials being prepared for recycling incorrectly. Examples include food residue being left on containers, or a cardboard box left with bubble wrap inside of it. Another trend driving up contamination rates is the shift to recycling carts over bins.

Carts carry an average contamination rate of ~17.7% compared to ~12.7% for bins, according to The Recycling Partnership. A case study in Central Ohio showed that ~74% households that utilize carts recycle 60%+ of their recyclable materials, compared to ~52% of households that use bins. Regarding contamination, Waste Management's CFO said the following at a 2018 investor conference:

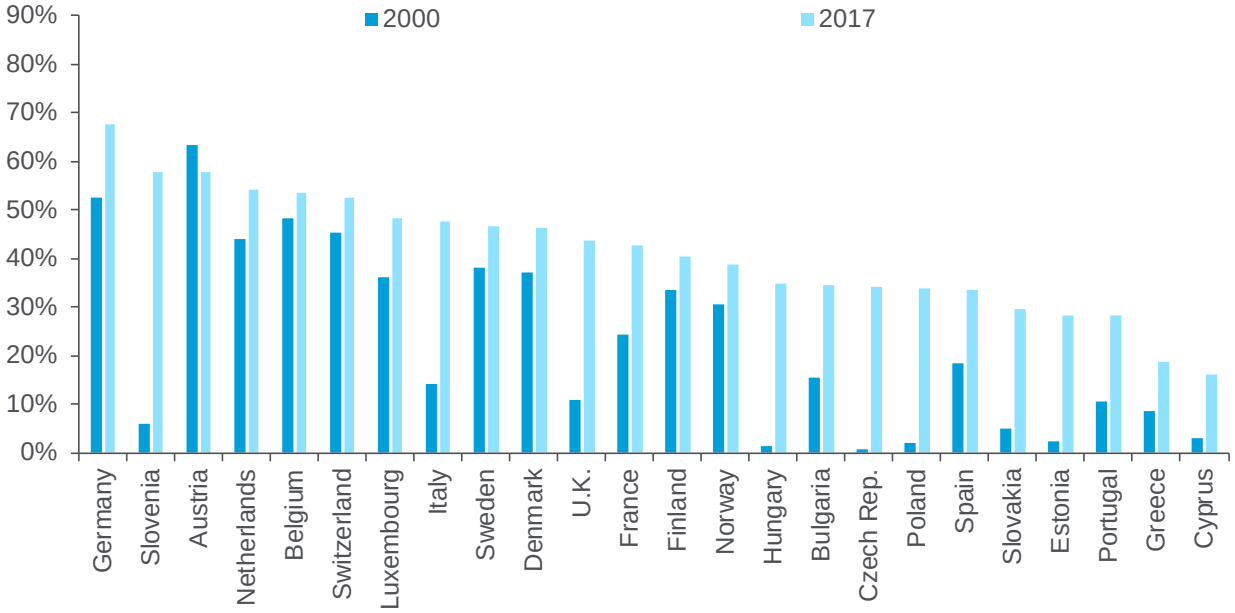
> *"Contamination is really the thing that has been the catalyst to the downturn that we are seeing today. And you might ask yourself why is it that contamination somehow came as a surprise that caused the `$0.12 to $0.15 impact on a year-over-year basis to the business. And it's not that contamination in and of itself has all of a sudden peaked and gotten worse, it's gradually gotten worse over time and moved from 10% of the stream that we were bringing in everyday in our single stream facilities to more like 25%.*
>
> *And so, if you think about that incremental 15 percentage points of the ton coming in the door being burdened by disposal costs ultimately, it doesn't have end value. Not only does it not have end market value, it has to now be disposed of at the landfill. So, put all of that aside and don't even think about the incremental machinery and equipment costs and the incremental labor costs that you're incurring in order to manage that contamination impact.*
>
> *So, job one is thinking about holding our consumers, our customers responsible for the contamination that they're bringing in to the system. And working our way back to 10%, which was reasonable and to put that into context for those of you who don't know, China's standard is 0.5%. So when we sell our bundled material at the end you've got to take that 10% all the way down to 0.5%, which is no small feat. There are people working very hard every single day to do that for us and to make up for the fact that we put 30 pizza boxes and bowling balls and a like into our recycling stream.*
>
> *So, educating the customer, but holding them accountable in a way that they've not been held accountable."*

Europe Leads Global Recycling, But Faces Some Issues

Europe is the leader in global recycling efforts but there is a wide variance between member states

Europe is the leader in global recycling efforts with the EU 28 countries recycling 46.4% of their municipal waste in 2017, up from 25% in 2000. Germany has the most successful recycling program in the world with a 67.6% municipal recycling rate in 2017; this compares to the U.S. at 34.7%. Germany has implemented strict recycling legislation including the 1991 Packaging Ordinance requiring manufacturers to take responsibility for the recycling of primary and secondary product packaging after consumer use, as well as the 1996 Closed Substance Cycle and Waste Management Act, which makes consumer packaged goods producers responsible for material's disposal, while conforming to principles of waste recovery, waste avoidance and environmentally compatible disposal. Figure 29 below shows the wide variation between EU member states on municipal waste recycling, with Germany leading the way, followed by Slovenia, Austria, and the Netherlands.

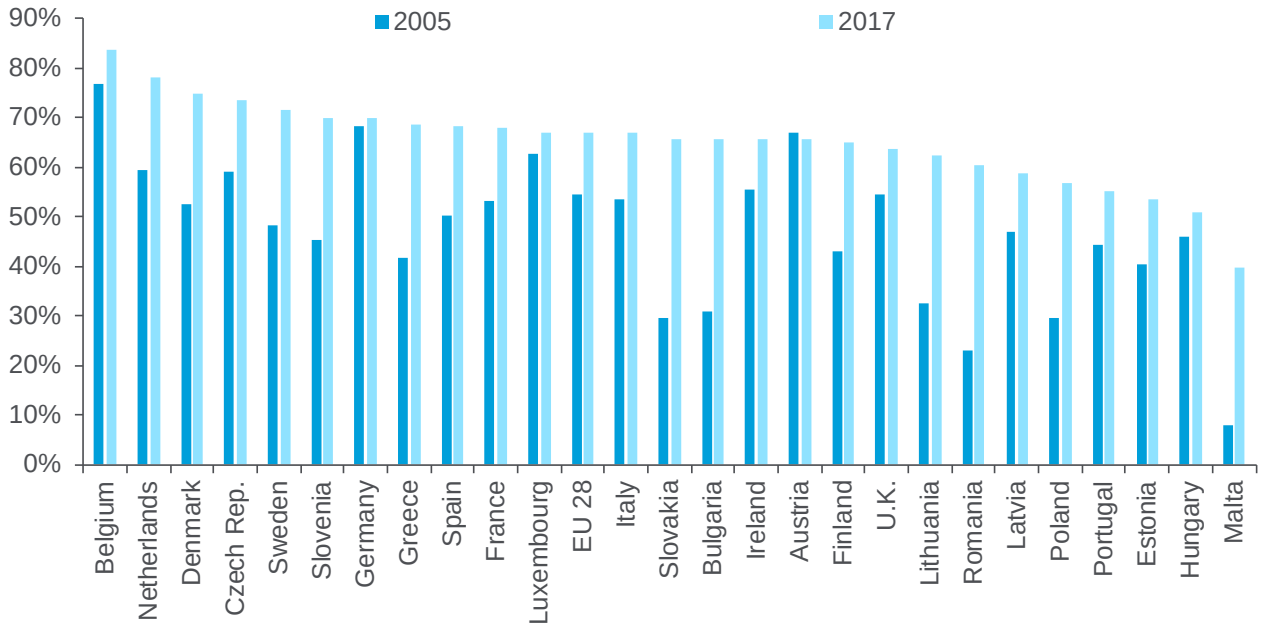
Figure 29. Municipal Waste Recycled and Composted in Europe (%)



Note: Includes composting and anaerobic digestion
Source: Citi Research, Eurostat

Looking packaging materials, Europe's recycling rate is higher than rates for MSW, with most countries achieving target recycling levels of at least 55% in 2016 with the average for the full EU-28 with at 67% (Figure 30). This highlights the effectiveness of legislation, in our view, with initial targets set for packaging waste a decade and a half before those for municipal waste driving the better performance.

Figure 30. Packaging Waste Recycled in Europe (%)



Source: Citi Research, Eurostat

Targets

Europe focuses on re-use, recycling, and recovery in reducing the environmental impact of creating virgin material

The goal of European waste legislation is to move up the internationally-accepted "waste hierarchy," towards prevention and away from disposal. The importance of re-use, recycling, and recovery in reducing the environmental impact of creating virgin materials is at the forefront in European minds.

The EUs Circular Economy Package set out new targets for European countries in 2018, including:

- Separate collection for at least paper, metal, plastic and glass.
- Separate collection for textiles (2025).
- Increase the re-use and recycling of waste materials to at least 50% by weight for household (paper, metal, plastic, glass) and 55% by weight for municipal waste (with further steps up to 65% by 2035).

The Packaging Waste Directive was strengthened in 2018 to include targets to reach a minimum of 65% (by 2025) and a minimum of 70% (by 2030) by weight of all packaging waste being recycled. This breaks down by waste stream, by 2025 (and 2030), as:

  - 50% (55%) of plastic
  - 25% (30%) of wood
  - 70% (80%) of ferrous metals
  - 50% (60%) of aluminum
  - 70% (75%) of glass
  - 75% (85%) of paper and cardboard.

Europe targets all plastics packaging placed in the EU market to be reusable or recyclable by 2030 and has acted against certain types of single-use plastics

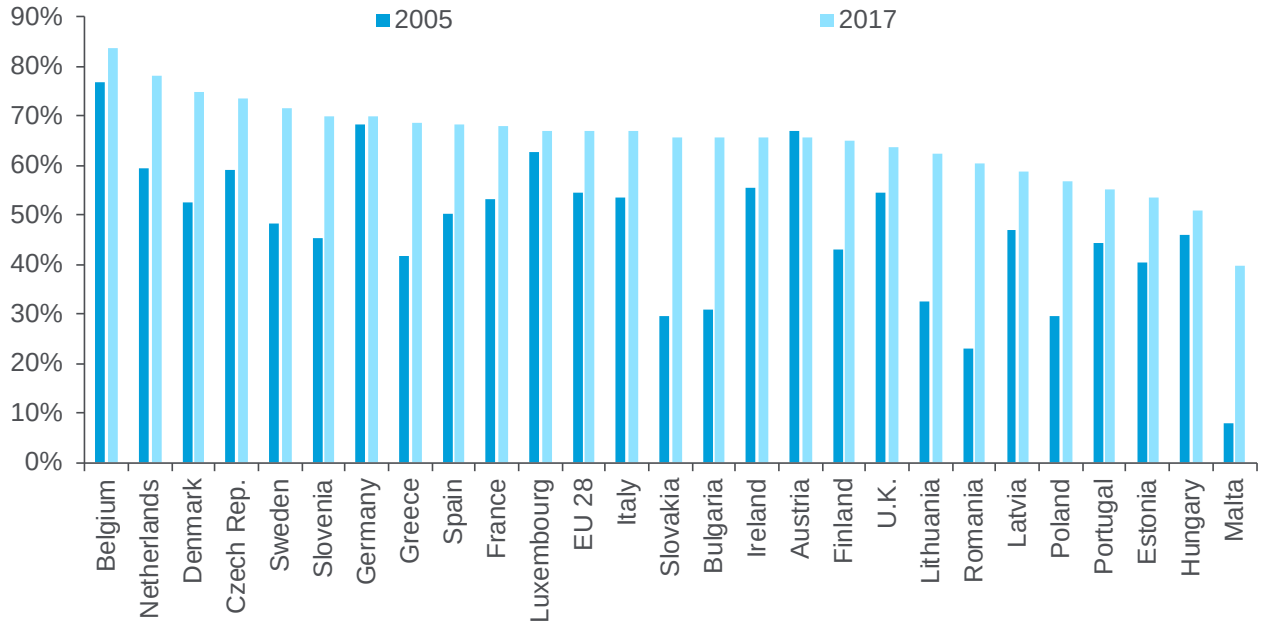
By 2030, Europe targets all plastics packaging placed in the EU market to be reusable or recyclable. The majority of countries in the region have introduced producer responsibility schemes for packaging waste, thus creating a mechanism for moving towards these targets.

Europe specifically has acted against certain types of single-use plastics, working with a set of measures designed to cut out the production, distribution, and use of the top 10 plastic items found on EU beaches (accounting for almost 70% of all marine litter). The proposed measures are:

- **A ban of the plastic content:** Banning content or elements of the plastic content, of certain products, such as plastic cotton buds, cutlery, plates, straws, drink stirrers, and balloon sticks — all of which will have to be made exclusively from more sustainable materials instead.
- **Consumption reduction targets:** Member States will have to reduce the use of plastic food containers and drinks cups.
- **Obligations for producers:** Producers will have to help cover the costs of waste management and clean-up, as well as awareness raising measures for single-use plastic items.

- **Collection targets:** Member States will be obliged to collect 90% of single-use plastic drinks bottles by 2025, for example through deposit refund schemes;
- **Labeling Requirements:** Certain products will require a label indicating how waste should be disposed, the environmental impact of the product, and the presence of plastics in the products.
- **Awareness-raising measures**: Member States will be obliged to raise consumers' awareness about the impact of using single-use plastics and fishing gear, and about the re-use systems and waste management options for all of these products.

Figure 31. Municipal Rate Recycling Rates, EU and Germany Over Time (%)



Source: Citi Research

Germany

Germany has the most successful municipal recycling program in the world

Germany has the most successful municipal recycling program in the world, with a 67.6% municipal recycling rate in 2017 compared to the EU 28 average of 46.4% and the U.S. rate of 34.7% in the same year. We attribute Germany's success to the factors outlined below.

Corporations bear the responsibility of recycling, rather than consumers

Corporations bear the responsibility of recycling, rather than consumers. In 1991 Germany passed a Packaging Ordinance establishing the Duales System Deutschland (DSD) system, which collects municipal waste. After a consumer is finished using a product, both the primary (a soda can, for example) and secondary packaging (the soda can's paperboard carrier) are now the responsibility of the manufacturer and distributor. Germany added onto the Packaging Ordinance several times including in 1996 with the passage of the "Closed Substance Cycle and Waste Management Act". The act states that the "producer, marketer, and consumer are responsible for the avoidance, recycling, reuse, and environmentally sound disposable of the waste that arises". This creates a "hierarchy of avoidance, recovery, and disposal". Germany utilizes a "Green Dot" system which indicates a package is environmentally friendly and abides by all of Germany's recycling laws and thus must be accepted by the DSD.

Each year, 460 billion packages use the green dot designation, with 25 countries now utilizing the system

In order for producers to place the green dot on their package, they must pay a fee to the DSD. Each year, 460 billion packages use the green dot designation, with 25 countries now utilizing the system. Creation of the DSD has helped increase light-weighting, which uses less raw material during the production process (packages are now 35% lighter, in some instances) and increase recycling rates (plastic recycling has increased to ~54% currently from just 3% in 1991). The most recent expansion in Germany packaging laws, the VerpackG, was enacted January 2019. VerpackG states that all distributors who place packaging (primary & secondary) into commercial circulation in Germany must comply with the dual system (the DSD). In return, the system will arrange for the collection and recovery of the packaging after use. Failure to comply can result in fines of up to €200,000. Germany plans to recover and recycle 90% of plastic, metal, paper, and glass by 2022. By placing the burden on the manufacturer to produce recyclable items and pay for proper pick-up of the items after use, the responsibility of recycling is taken on by cost-conscious organizations rather than fragmented consumers who have less incentive to recycle, absent items subject to still limited return deposit schemes. Currently the DSD is privately-owned and has since expanded well beyond Germany. In its original market, DSD holds ~35% market share as new dual system operators have entered the market.

Despite good collection rates, ensuring recycled items are made into secondary products is difficult

Despite a high recycling rate, Germany is not exempt from some of the same problems that plague other countries. Included in Germany's definition of recycling is the phrase "collected or sorted", meaning that items don't actually need to be made into a secondary product in order to "count" towards Germany's goal, they simply need to be processed. Some critics of Germany's system claim that a small fraction of the ~60% recycling rate is actually used for a second time. While this is highly effective in preventing pollution and ocean plastic waste, it does not prevent greenhouse gases (GHGs) from entering the atmosphere during the production process of a new bottle or can. Despite a far more successful collection process, if used goods are not being reused to prevent further production then it is not truly a closed loop system, in our view. China's withdrawal from global recycling has removed the largest buyer of recycled material, leaving most countries without a meaningful source of demand for recycled goods.

Germany Uses Dual-Stream Recycling Operations. Unlike in the United States, where most communities have a trash bin and a recycling bin, Germany has multiple recycling bins, requiring its citizens to do the sorting themselves. There are six different bins: blue for paper, yellow for plastic, white for clear glass, green for colored glass, brown for compost, and black for miscellaneous waste. By pre-sorting their recycling, the German system reduces the amount of contamination that can potentially ruin entire batches of recycled material.

The Netherlands also use a waste disposal hierarchy: (1) prevention; (2) reuse; (3) recovery; (4) incineration; and (5) landfill

The Netherlands has a similar system to Germany, and it works quite well. The Netherlands is another European country which is a global leader in recycling. Similar to Germany they also use a waste disposal hierarchy: (1) prevention; (2) reuse; (3) recovery; (4) incineration; and (5) landfill. The country takes contamination of soil and groundwater very seriously, and incinerators are strictly checked for emission levels during the construction process and incineration process. Thirty-five waste streams are banned from landfills, which helps keep pollution levels low. Netherlands' Waste Consultation Council was established in 1990 to manage waste policies at a national level. Recent goals include making the Netherlands entirely sustainable by 2050 and reducing emissions by 30% from 1990 to 2020.

Similar to Germany, the Netherlands uses a "polluter pays" principle

Similar to Germany, the Netherlands uses a "polluter pays" principle which means producers take on the physical and financial burden for reducing environmental pressure generated by their products; however these burdens are often included in the cost of the product meaning one could argue that end-consumers still end up paying for the disposal of the product as in the U.S. The Netherlands also utilizes multi-stream recycling initiatives with different waste streams for organic, paper, and chemicals. Some municipalities offer volume-based waste fee systems which means that disposal fees vary based on the amount of waste collected, rather than consisting of a fixed fee. These can also be classified as "pay as you throw" systems which charge citizens for plastic garbage bags; the larger the bag, the higher the cost.

U.K.

The U.K.'s Producer Responsibility Obligations (Packaging Waste) Regulations of 2007 oblige companies to recover and recycle packaging waste to meet national targets. Producers are required to evaluate whether direct registration or joining a compliance scheme better suits their situation.

Figure 32. U.K. Packaging Waste, '000 tonnes

Material	Packaging waste arising	Total recovered/ recycled	Achieved recovery/ recycling rate	EU target recovery/ recycling rate
Metal	736	525	71.3%	50.0%
of which: Aluminum	177	94	53.1%	
of which: Steel	559	431	77.1%	
Paper and Cardboard	4,749	3,754	79.0%	60.0%
Glass	2,399	1,623	67.6%	60.0%
Plastic	2,260	1,044	46.2%	22.5%
Wood	1,310	411	31.4%	15.0%
Other Materials	23	0	0.0%	
Total Recycling	11,476	7,357	64.1%	55.0%
Energy from Waste		700	6.1%	
Total Recycling and Recovery	11,476	8,057	70.2%	60.0%

Source: Citi Research, DEFRA provisional 2017 statistics

Package labeling is getting better in the U.K. and should help improve recycling rates

Labeling of packaging is getting better in the U.K. and will be important to improve recycling rates going forward. Most plastic packaging in the U.K. now carry labels regarding ease of recycling, but this does not guarantee the packaging finds its way to the correct collection point. Recycling labels on U.K. products include:

- **Widely Recycled:** This packaging is collected by 75%+ of local authorities in the U.K.
- **Check Locally:** This packaging is collected by 20-75% of local authorities in the U.K.
- **Not Yet Recycled:** This packaging is collected by <20% of local authorities in the U.K.

Figure 33. Selection of Recycling Labels on U.K. Products

Source: Citi Research, Common UK packaging recycling labels

Although this labeling is helpful, it does not guarantee accurate segregation of waste into appropriate collection streams. Greater differentiation by packaging type could help to further improve collection processes, but possibly at the risk of increasing infrastructure costs in the near term. Labeling the internationally-accepted seven types of plastic would lead to seven different plastic recycling bins (in the home or at local collection points) and seven different waste collections (more trucks and fuel costs), but would likely reduce contamination and improve recycling rates for the economy as a whole.

Figure 34. Seven Types of Plastics

Label	Plastic type	Plastic name	Recyclable?	Sample uses
1 PETE	PET	polyethylene terephthalate	Recyclable	Water bottles, soft and fizzy drink bottles, pots, tubs, oven ready trays, jam jars
2 HDPE	HDPE	high-density polyethylene	Recyclable	Chemical drums, shampoo/conditioner bottles, bleach bottles, toys, household and kitchenware
3 V	PVC	polyvinyl chloride	Often recycliable	Window frames, drainage pipes, medical devices, flooring, car interiors, credit cards
4 LDPE	LDPE	low density polyethylene	Often recycliable	Squeezy bottles, toys, carrier bags, general packaging
5 PP	PP	polypropylene	Hard to recycle	Nappies, Tupperware, Margerine tubs, bottle caps, diposable cups and plates
6 PS	PS	polystyrene	Hard to recycle	Toys, rigid packaging, fridge trays, costume jewellery, disposable cutlery
7 OTHER	Other	other types of plastics	Hard to recycle	

Source: Citi Research, ASTM International Resin Identification Coding System

Sweden

Sweden has taken a leadership role is on the subject of microplastics

Sweden if very proactive when it comes to sustainability and recycling, with seemingly strong buy-in from the majority of the population. One interesting area where Sweden has taken a leadership role is on the subject of microplastics.

Between August 2015 and June 2017, the Swedish Environmental Protection Agency conducted a study on the release of microplastics into the ocean and how to reduce discharge levels. The work concluded with six key areas to address:

- Roads and tires
- Artificial turf pitches
- Industrial production and management of primary plastic
- Washing of synthetics
- Boat hull paint
- Littering

However, the report was also forced to conclude that there was insufficient knowledge about how microplastics are transported from source to ocean and therefore it was impossible to calculate a split of microplastic pollution by source and path. Sweden has resolved to build its knowledge of these systems and raise awareness of the microplastics issues.

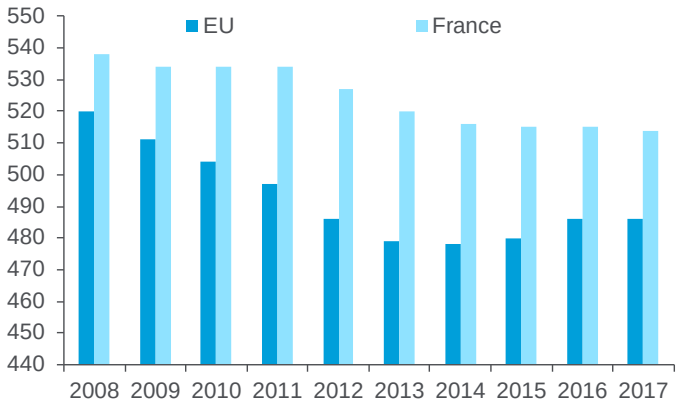
Sweden is looking to examine the possibility of developing EU energy labeling of tires to include durability and to work towards developing eco-design rules for washing machines, to reduce microfiber pollution from laundry.

France

France produces higher municipal waste per capita than the EU average but has a below average recycling rate for municipal waste

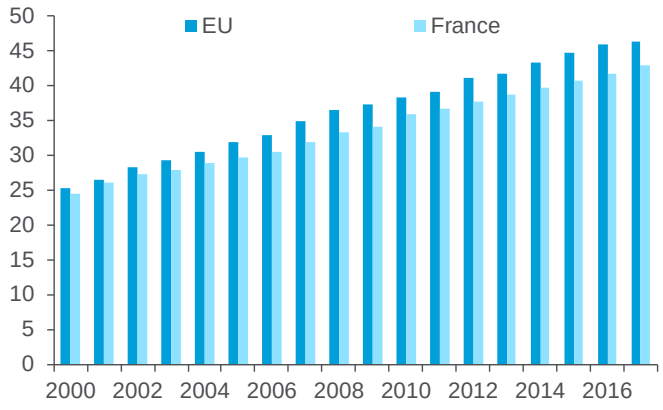
France generates higher municipal waste per capita than the EU average, although the gap has closed in recent years, and at the same time displays a below average recycling rate for municipal waste. Much of the mechanics of waste and recycling collection is left to individual authorities, although national plans have been in place since 2004 to reduce waste generation.

Figure 35. Municipal Waste Generated Per Capita (kg per year)



Note: EU 28
Source: Citi Research, Eurostat

Figure 36. Municipal Waste Recycling Rates, EU & France (%)



Note: EU 27 to 2007 then EU 28
Source: Citi Research, Eurostat

The country's Environment & Energy Management Agency (ADEME) introduced a Waste Prevention Action Plan in 2004. Legislation introduced in 2009 supported this and set out waste prevention measures and targets to reduce ordinary household waste per capita (which have subsequently been met).

Following the initial plan, the French National Waste Prevention Programme 2014-2020 was adopted on August 2014 and a series of laws have been introduced to drive further change, including the Energy Transition for Green Growth Act, the Consumer Products Act, the Food Wastage Act, and the Biodiversity Act.

For household waste, France found variable pricing and pricing incentives for waste collection work well to improve sorting and waste reduction. In one study, it found that when pricing incentives were implemented, unsorted household waste dropped by 28% and sorted waste increased by 33%. By the end of 2015, local authorities covering almost 12 million people had studied pricing incentives, and 6 million people were in areas that had implemented such incentives. The Energy Transition Act targets 15 million people covered by 2020, and 25 million by 2025. Adopting variable pricing can present quite onerous challenges for local authorities, often necessitating a complete overhaul of the existing waste collection system.

Emerging Markets Try Varying Approaches

South Africa

While emerging markets generally have lower recycling rates than wealthier countries, they have also spearheaded programs to improve recycling. Packaging SA (PSA), which represents packaging converters and associated companies in South Africa, is proactively pushing efforts to minimize the amount of packaging that is sent to landfill.

Like Europe, South Africa follows the "hierarchy of waste" approach to reduce waste and push re-use/recycle/recover, with disposal as a last resort. Producer responsibility plays a big part in national recycling efforts and the PSA looks to increase targets for collection/diversion rates to 66.9% within five years, an improvement on 2017 recovery data (see Figure 37).

Figure 37. South Africa Packaging Recycling Statistics ('000 tonnes, 2017)

Packaging Type	Consumption	Collected	Collection Rate
Glass	759	331	44%
Metal	184	139	76%
Paper	1,951	1,281	66%
Plastic	868	395	46%
TOTAL	3,761	2,147	57%

Source: Citi Research, PSA

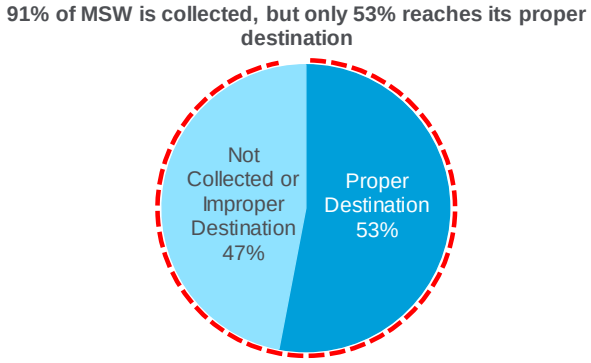
Brazil

The recycling business in Brazil is generally informal

Brazil generates 78 million tons of MSW each year and collects 71 million tons. Unfortunately only 42 million tons actually reach the proper destination as 30 million tons are sent to illegal dumps and 6 million tons are not collected at all. Per Brazil Business, only 62% of the population currently has access to regular garbage collection, and the collection of recyclable materials is quite rare. The recycling industry is generally informal, performed largely by waste pickers rather than municipalities or large corporations. The mere size of Brazil, and the distance between densely populated urban areas, present logistical problems for collection.

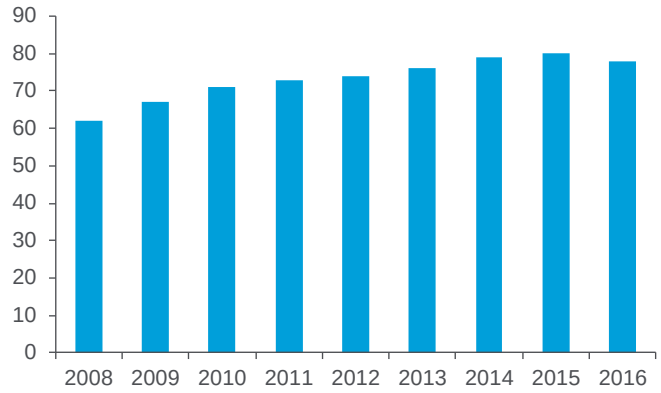
While it seem as though Brazil's environmental problems are daunting, the U.S. made rapid progress in MSW collection that could potentially be replicated by Brazil. In the 1980's ~21% of U.S. MSW wasn't reaching the proper destination but that has currently been reduced to almost 0%. The country has provided deadlines to comply with proper solid waste destinations, these dates range from July 2018 to July 2021 depending on the size of the city.

Figure 38. MSW Collection Rates



Source: Citi Research, Company Reports

Figure 39. MSW Generation by Year (million tons)



Source: Citi Research, Company Reports

Brazil is trying to divert some MSW by implementing "take-back" systems

As seen in Figure 39 Brazil's MSW generation is increasing each year as waste generation is directly linked to rising population and rising incomes. Brazil is attempting to divert some MSW by implementing "take-back" systems. Producers of certain products (pesticides, batteries, tires, electronics, packaging etc.) must create a system to collect used goods or face serious repercussions from the government. For packaging, the systems have proven to be quite effective as Brazil is the global leader in aluminum can recycling, consistently exceeding 95% recycling rates. Volatile energy prices are a potential driver behind the high recycling rate, while the value of the underlying material also provides a natural incentive for collection by individuals, even if a formal service isn't offered. Industry groups say that an aluminum can could be purchased, used, collected, recycled, and returned to the shelves within 30 days. Paperboard (~70%) & PET (~56%) are also recycled at rates well above those of the U.S. and Europe while steel cans (~49%), glass (~40%), and other plastic (~19%) are more in-line.

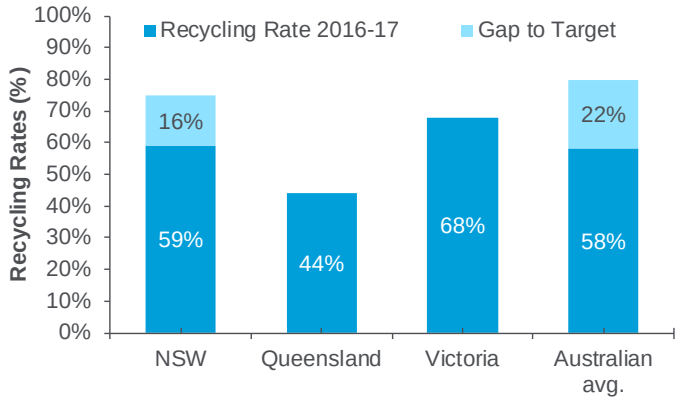
Australia

Despite having a well-developed recycling system, Australia has a long way to go to reach its recycling targets

Although Australia's recycling system is reasonably well developed, Australia has a long way to go to reach its recycling targets. The make-up of the Australian waste stream and its historic reliance on Asian demand for recycled materials means that existing policies such as waste levies and recycling targets have been insufficient to meet national targets. Like many other developed nations, Australia must now develop onshore end-markets for recycled materials if it is to increase the national rate of recycling.

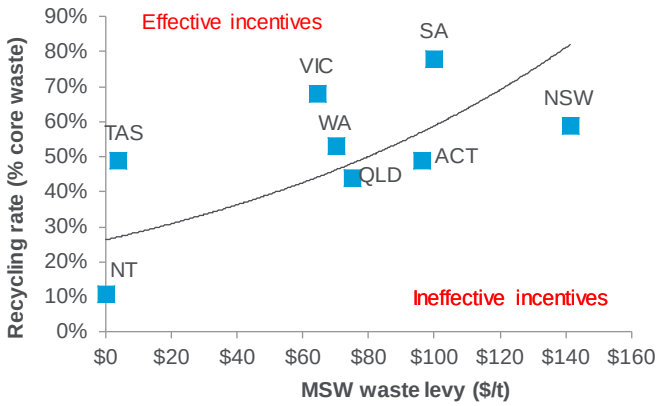
Australia generates around 14 million tonnes of MSW each year or 560 kilograms per capita, with approximately 6 million tonnes or 44% recycled every year. The reported national recycling rate for Australia is much higher at ~59%, but this also includes industrial waste streams such as building and demolition materials. Australia has deployed a top-down national recycling target of 80% in order to encourage the development and utilization of recycling capacity, however realized recycling volumes remain below these levels (Figure 40). Australia's state-based regulatory structure has also included a 'Waste Levy' with varying impacts for driving higher resource recovery rates and recycling (Figure 41).

Figure 40. Australian Recycling Performance and National Targets



Source: Australian National Waste Report, Citi Research

Figure 41. Australian Waste Levies and Recycling Performance

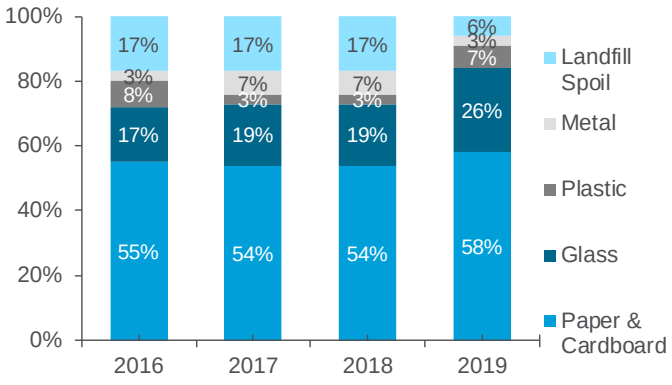


Source: Australian National Waste Report, Citi Research

The majority of municipal (local) councils in Australia deploy comingled recycling collection services which help support household recycling. As offshore commodity markets and international import regulations have changed, the purity of this resource stream has come under scrutiny, increasing onshore processing and disposal costs for MRF owners. The composition of Australia's recycling stream is skewed heavily towards Paper & Cardboard (~58%), with Glass (26%) and Plastics (8%) comprising the remainder of the recycled materials stream (Figure 42). The majority of Australia's recycled materials are still destined for export markets which consists primarily of South East Asian and Asian trading partners.

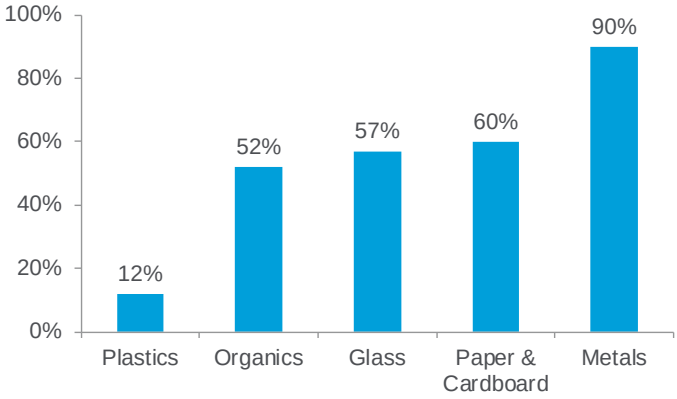
The announcement of the staged implementation of a waste export ban in August 2019 has accelerated the need to develop onshore processing capabilities and end-markets for recycled materials prior to their implementation from July 2020 when glass exports are banned. In the near term, this is likely to drive inefficiencies and dislocations in local recycling markets as additional capacity is brought online and effective end-market demand is developed by recyclers and packaging manufacturers.

Figure 42. Materials Composition of Australian Recycling Stream (%)



Source: Sustainability Victoria, Citi Research

Figure 43. Australian Recycling Rate by Material (% Total Volume)



Source: Australian National Waste Report, Citi Research

The Materials Challenge

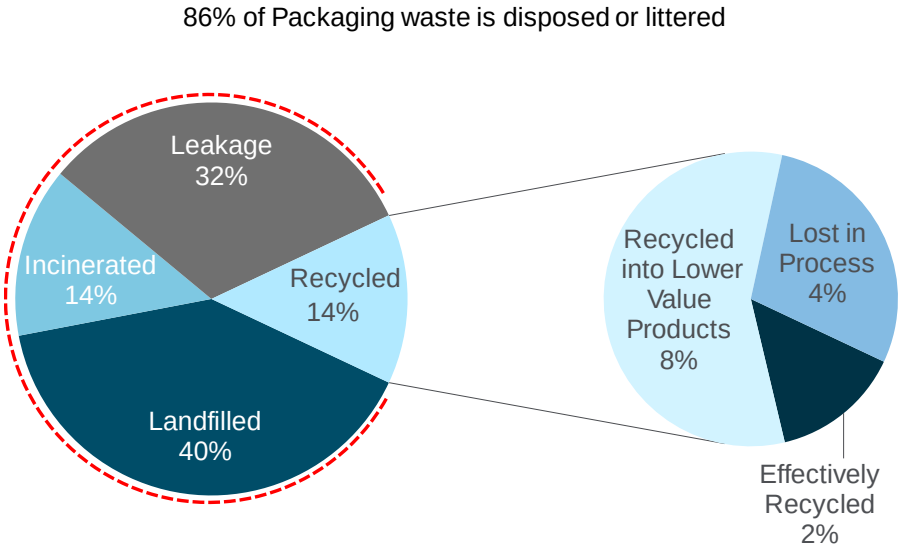
What materials enter the recycling stream is increasingly a concern

As consumers question the effectiveness of recycling, there has been increased focus on which products should enter the waste stream in the first place. Materials that are not biodegradable or made from post-consumer content have seen increased scrutiny, with plastics drawing the most criticism.

Consumer plastics can take anywhere from 500 to 1,000 years to degrade

Widely-used consumer plastics such as bags and bottles can take anywhere from 500 to 1,000 years to degrade, while only ~14% of plastic packaging sold ends up being recycled, meaning ~86% ends up in a landfill or in bodies of water. Despite being made from a naturally occurring material, i.e., oil and natural gas, plastic doesn't break down due to the unnatural manufacturing process that creates it. The heat and pressure required to turn a monomer, such as propylene, into a polymer, such as polypropylene, do not occur organically in nature; this process makes the new material unrecognizable to the organisms that break down simpler materials. Unfortunately most efforts that would allow plastic to decompose more easily would threaten one of its greatest advantages: durability.

Figure 44. Packaging Waste Disposal

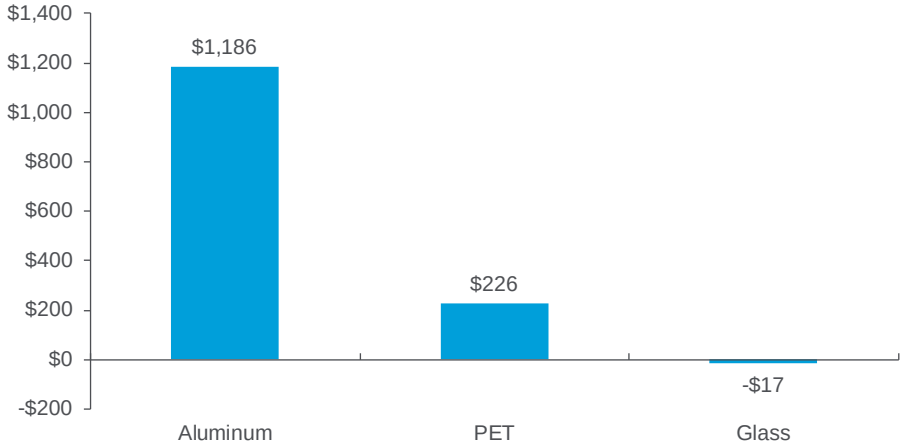


Source: Citi Research, UNEP

Plastic packaging's low price has helped drive widespread adoption but also makes it less economical to recycle

While plastic benefits from being a cost-effective solution, it is actually a double-edged sword. Plastic packaging's low price has helped drive widespread adoption enabling growth rates that are faster than GDP for over 50 years; however this same affordability makes it less economical to recycle. In looking at the price of recycled materials from 2015 to 2017 per Recycling Markets, aluminum is valued at nearly ~$1,200 per ton compared to PET at only ~$226 and glass which has zero value in the US. Based on the average weight of an aluminum can (14.9 grams), we estimate it would require ~61,000 cans to equal 1 ton of aluminum. Considering the ~50% recycling rate for aluminum cans, that means ~122,000 cans would be used by consumers. Given the lower per ton value ($226) and recycling rate for PET bottles at ~30%, it would mean consumers would have to use ~1.1 million PET bottles to generate this much value.

Figure 45. Price per Ton of Recycled Material (2015-2017)

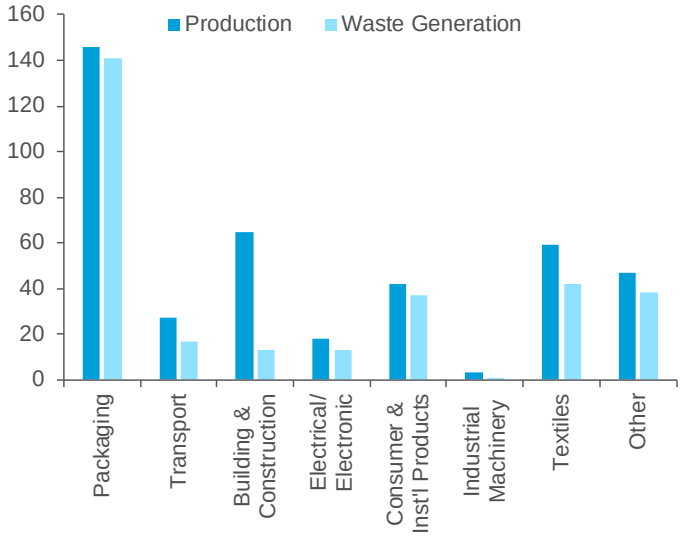


Source: Citi Research, Aluminum.org

Plastics Face Increased Scrutiny

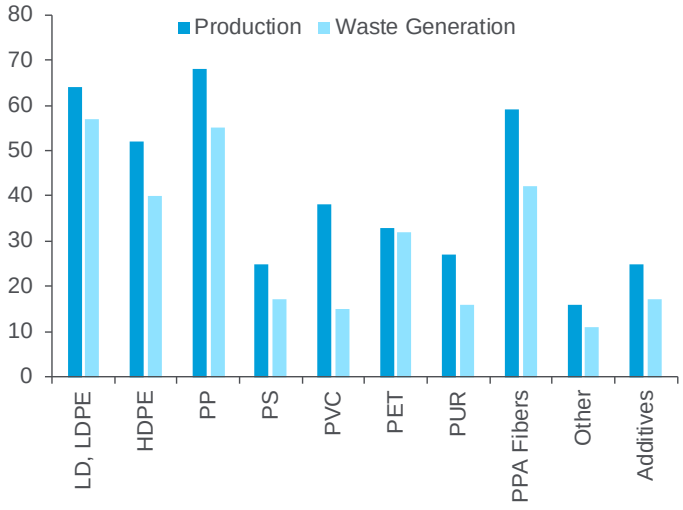
Plastics are a major source of waste in landfills, raising concerns around air pollution, groundwater safety, and quality of life issues. We estimate that ~150 million tonnes of plastic packaging waste is produced per year, and that packaging is the largest source of waste among plastic end markets, more than three times more than the next largest end use of textiles. The most common waste-generating polymers include low (LDPE) and high (HDPE) density polyethylene, polypropylene (PP) and polyethylene terephthalate (PET), which are commonly used in applications such as bottles and bags (see Figure 47). Poplyphthalamide (PPA) fibers (used in textiles) are also a meaningful generator of waste on an absolute basis (~42 million tonnes in 2015).

Figure 46. Plastics Production and Waste by Industrial Use Sector (mt)



Source: Citi Research

Figure 47. Plastics Production and Waste by Polymer Type (mt)



Source: Citi Research

Plastics can add an extra disruption in emerging markets and therefore some of the more aggressive environmental regulations against plastics are in these markets

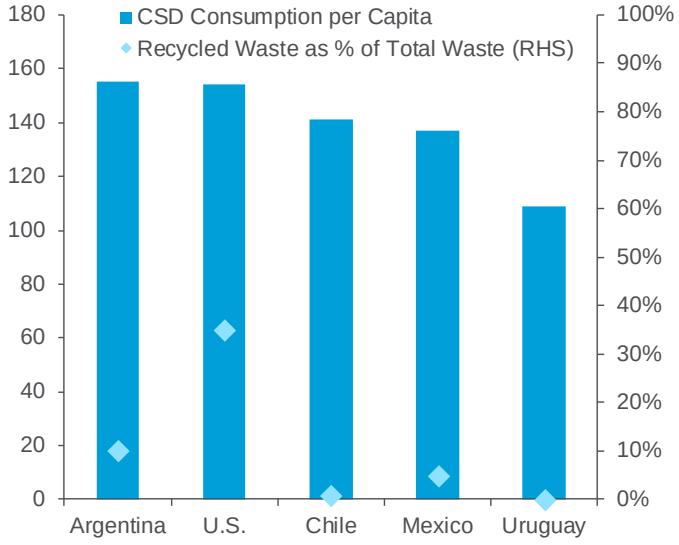
In addition to clogging landfills, plastic packaging can disrupt life in emerging economies in ways that are not always obvious to consumers in more developed markets. These include disruptions to agricultural, transportation, and sanitation processes critical for human health. For instance, in Mauritania, plastic bags were banned after more than 70% of cattle and sheep deaths were attributed to the ingestion of these products, while an official at the country's Ministry of the Environment and Sustainable Development indicated plastic makes up ~25% of total waste produced in the capital city of Nouakchott. While some may be surprised that a less developed country would implement more aggressive environmental regulation than developed nations, the problems associated with litter and poor recycling often are much more visible in countries lacking proper waste disposal infrastructure. Another rarely discussed impact of plastic bags is the risk of spreading disease; in a poorer country a bag that is left on the ground may fill with water and become a breeding ground for malarial mosquitos. Bags can also interfere with critical sanitation and irrigation functions, clogging sewers and drains. This was a prominent issue in Bangladesh during flooding in 1988. Environmental groups estimated that only ~10% of the 9 million plastic bags used each day in Dhaka, Bangladesh ended up in a landfill, meaning ~90% were littered; congested drains severely exacerbated flood damages. This led to an anti-bag campaign in the early 1990's that was initially limited to only Dhaka but eventually became the world's first nationwide ban on plastic bags in 2002.

We define single-use plastics as any plastic product used once before being disposed of, or recycled. This includes plastic bags, food wrappers, straws, coffee stirrers, beverage bottles, utensils, and caps/lids. We estimate ~400 million tonnes of plastic are produced each year, and while the majority of plastic packaging is technically recyclable, by some estimates only ~14% of packaging products are actually recycled. Many consumer plastics are 'down-cycled'; recycled into lower value products — for instance an aseptic food container being down-cycled to a plastic building product. And even when disposable plastics are properly recycled, virgin materials often need to be added or the product needs to be processed at a special recycling facility (i.e., coffee cups with a plastic liner).

Although PET bottles are fully recyclable, only ~30% are actually recycled in the U.S. vs. ~60% in Europe

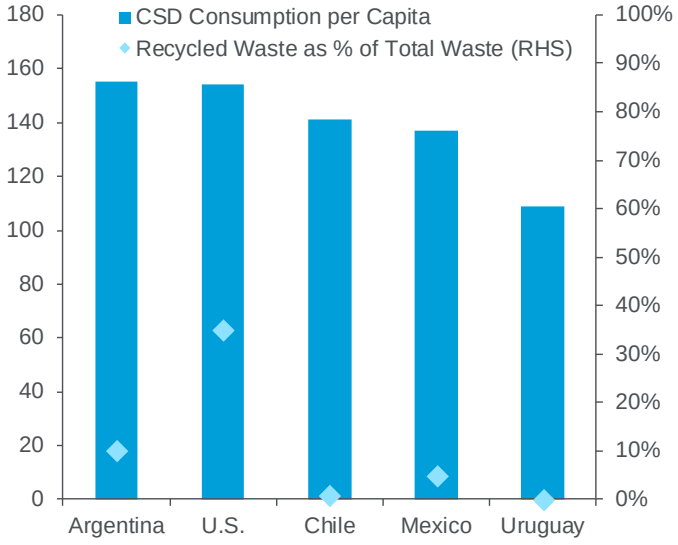
One of the leading types of single-use plastic is PET beverage bottles produced for water and soft drinks with nearly 500 billion units produced each year, an increase from ~300 billion units in 2004. This increase is driven by rising demand for bottled water (volumes up mid-single digits in recent years) along with incremental gains from substitution out of glass and metal. PET bottles are the fifth most common item found in ocean debris, comprising ~9% of total marine waste, per the Ocean Conservancy. PET bottles are in fact highly recyclable but only ~30% are actually recycled in the U.S., compared to ~60% in Europe, despite several states offering deposit refunds in the range of $0.05-$0.10 per container. In Figure 48 and Figure 49 we examine the recycling rates (recycled waste as a % of total municipal waste) for the top five consumers of carbonated soft drinks (CSD) and bottled water. We note that Germany is the global leader at ~65% and the average of all Organization of Economic Co-Operation & Development (OECD) countries is ~34%. As seen below, CSD consumption can be high in less developed countries which tend to lack the necessary infrastructure to support proper recycling. Separately, we note the fourth most common item found in marine debris are caps and lids which are likely linked to PET and glass bottle consumption and recycling rates.

Figure 48. Carbonated Soft Drink Consumption vs. Recycling Rates



Source: Citi Research, OECD, BioEnergy Consult

Figure 49. Bottled Water Consumption vs. Recycling Rates



Source: Citi Research, OECD, SEA-UEMA Project

Plastic bags are the second most common item found in ocean debris making marine contamination a key concern

Another common single-use plastic product is bags, with an estimated 500 billion to 1 trillion consumed each year. High density polyethylene (HDPE) has been the preferred substrate (over paper) for retail bags given its strength, light weight, and low cost (<$0.01 per plastic bag vs. $0.03-$0.04 per paper bag). Plastic bags are the second most common item found in ocean debris, comprising ~11% of total marine waste, per the Ocean Conservancy. Unlike PET bottles, bags are more difficult to recycle given their flexibility as most recycling facilities are better equipped to handle rigid products (PET, glass, metal, etc.). Given the limited capabilities of most facilities, the burden is on the consumer to bring their bags to collection bins at various retail locations. This inconvenience has led to a ~7% recycling rate for HDPE bags, sacks and wraps in the U.S.; some critics have called this number “artificially high” when applied to plastic bags since it includes other types of stretch films. Critics have also pointed out that plastic bags may not even be worth the cost collection, given sorting intensity and the often disappointing quality/cleanliness of the recovered product.

Beyond landfill overuse, a key concern around single-use plastics is marine contamination. For instance off the coast of Los Angeles, there are 10 metric tons of plastic swept into the Pacific Ocean each day, per Biological Diversity. Various sea creatures may eat these plastic fragments that ultimately work their way up the food chain into humans through the consumption of seafood. A study found that ~25% of fish in California contained plastic microfibers in their stomach. Accordingly microplastics, which are any piece of plastic debris less than 5 millimeters in length, have received increasing attention from environmental stakeholders. This includes broken down plastic waste, synthetic fibers and microbeads used in cosmetic & personal care products. With such a small size, they easily slip past filtration systems and end up in consumable products and tap water.

Microplastics in the food chain is another concern with plastic

A study conducted by the World Health Organization found that more than 90% of water in plastic water bottles contained microplastics. The study covered 259 bottles from nine countries (the U.S., China, Brazil, India, Indonesia, Mexico, Lebanon, Kenya, and Thailand) across 11 brands. Around 325 plastic particles were found in every liter of bottled water; roughly twice as much as tap water.

The fragments were primarily polypropylene which is used to make bottle caps; the health impacts of ingesting these plastic fragments are not fully known at this time. We also note that manufacturing single-use products is energy intensive requiring 1.4 liters of water to produce a 1 liter plastic bottle, per RecycleBank. Again when it comes to decomposition, plastics' strength can be a negative, allowing plastic fragments to travel long distances before breaking down, which can take several hundred years. Once finally breaking down, the problem continues through microplastics (discussed above) and contamination of the ocean given the petroleum base of the products and potential exposure to chemicals such as BPA (bisphenol A).

European plastic packagers have taken a leading position in defense of the plastic packaging industry, claiming <1% of microplastics are actually from the industry, while a majority are from other sources such as car tires and city dust. Producers have further estimated that only ~2% of marine plastic comes from the U.S. and Europe, while Asia is the leading contributor at ~82%. The leading countries in plastic leakage into the oceans are China, Indonesia, Philippines, Vietnam, Sri Lanka, Thailand, Egypt, Malaysia, Nigeria, and Bangladesh. This suggests that bans aimed at U.S. and European consumers may have a relatively minimal overall impact.

Response from Governments

In addition to the Chinese regulatory actions, we have recently seen a number of domestic bans and restrictions on single-use plastics across the globe

While Chinese regulatory actions have dramatically altered global trade flows of recycled plastic material, we've seen an increasing number of domestic bans and restrictions on single-use plastics dating from the early 2000's. Notably, many of the first national restrictions on single-use plastics have come from emerging economies in Africa and Asia. The first national ban was Bangladesh's 2002 plastic bag ban, which followed devastating floods in 1988 that were found to have been made worse by plastics blocking drainage systems. Africa has seen numerous national bans including actions in Rwanda (2008), Mali (2012), and Kenya (2017). In terms of implementing bans, we see authorities generally pursuing four options: (1) an outright ban on the production, sale, and use of plastic bags; (2) a tax on suppliers, producers, importers of plastic bags, this is likely passed onto retailers and consumers; (3) a tax on retailers — if a retailer chooses to use plastic bags then they pay a tax; and (4) a tax on consumers — at the point-of-sale consumers pay a tax.

In Europe, the U.K. took a leading position on preventing plastics waste starting with a 5 pence (5p) charge on disposable plastic bags in October 2015. This program has seen meaningful success, reducing the use of plastic bags by ~83%. A recent House of Commons report detailed 11 recommendations to prevent plastic bottle waste including expanding access to free water fountains, starting a deposit return scheme, implementing "a producer responsibility fee" structure that stimulates the use of recycled plastic, rewards design for recyclability, and increases costs for packaging that is difficult to recycle or reuse. The report further suggested shifting recycling incentives from tonnage, which may dissuade recycling lightweight materials, to an outright goal of a ~65% recycling rate. The U.K. government later published a 25-year environmental plan which announced intentions to eliminate all "avoidable plastics waste" by year-end 2042, extend the 5p plastic bag charge to small retail shops and encourage "plastic-free aisles" at supermarkets.

The U.K. announced its intention to ban single-use plastics by 2030

In February 2018, a month after the U.K.'s 25-year plan was proposed, Taiwan announced its intention to ban single-use plastics by 2030. The plan layers in over several decades: In 2019 fast-food chains must stop providing plastic straws for in-store use, while the following year plastics straws are banned from all food and beverage stores. Beginning in 2025 consumers will be required to pay for plastic straws for takeout purposes and in 2030 the full ban goes into effect. Plastic bags, food containers, cups and utensils face a similar ramp with a retail ban in 2020, fees in 2025 and an all-out ban in 2030.

Scotland was the first U.K. nation to ban plastic straws

Also in February, Scotland became the first U.K. nation to ban plastic straws, as part of a greater effort to cut down on single-use plastics. This announcement followed a ban on plastic cotton buds/swabs in January. Further, Scotland plans to appoint an expert panel to advise on ways to reduce single-use plastics going forward. In May, the EU proposed its first continental solution to plastic waste with potential bans on cutlery, straws, and cotton buds/swabs. Once fully implemented in 2030, the EU estimates that the changes could cost businesses over €3 billion ($3.5bn) per year.

Figure 50. Select Single-Use Plastic Bans

Source: Citi Research

Many states and cities in the U.S. have called for bans on plastic bags

In the U.S., where recycling initiatives often trail Europe, the government hasn't pushed anything at the federal level but certain states and cities have reacted to the recent wave of news. In September 2017, Seattle, Washington announced a ban on plastic straws and utensils set to begin in July 2018. Several other cities have made announcements including Davis, Malibu, and San Luis Obispo in California and Miami Beach and Fort Myers in Florida. In 2019, New York called for a statewide ban on plastic bags, which goes into effect in March 2020. In total, over a dozen U.S. cities have completely or partially banned foam cups, bowls, plates, and trays.

In June 2109, India became the latest country to move forward with a ban on single-use plastics including bags, utensils, and certain PET bottles; the effective start date is 2022. Some Indian cities have adopted these bans in advance of the national ban; one of the more notable plastic bans is in Mumbai which has banned the use of plastic bags, cups, or bottles with penalties ranging from Rs5,000 ($70) for a first-time offense and up to Rs25,000 ($350) and 3 months in jail for repeat offenders. The size of the fines is notable, with the first-time fine (Rs5,000) translating to ~$70 in a country with average annual income of ~$620. Similar to Bangladesh, one the reasons for the ban was an attempt to reduce the impacts during floods. In 2005 record rains killed over 1,000 people in Mumbai and environmental groups pointed out the negative impact of plastic bags choking off drainage systems.

Benefits of Plastic

Despite its drawbacks, plastics have a number of valuable qualities including durability, weight, affordability, versatility, and energy required to produce

While the drawbacks of plastic packaging, and its low recycling rates, have received significant attention, plastics have a number of valuable qualities. Leading plastic packaging producers are working to increase their usage of recycled content & make their products fully recyclable; packagers have also pledged to invest in consumer education regarding which products are recyclable and how.

Plastic has several advantages over other substrates, including durability, weight, affordability, versatility, and energy required to produce. Looking at durability, plastic has high strength-to-weight and strength-to-stiffness ratios, which allow it to outperform some metals on a pound-for-pound basis. This creates opportunities for plastic not only in packaging, but heavier industries such as the automotive and construction markets. A typical example of plastic's strength is its ability to hold liquids. PET bottles can weigh as little as 19 grams compared to similar sized glass containers at 170 grams; plastic also holds advantages in durability as it is less likely to break or leak in transit. Increased durability at a lighter weight creates savings throughout the supply chain on freight and handling costs, while alternative substrates to plastic can weigh at least 3.5x more on average. A more extreme example of the strength of plastic is the creation of the "plastic bottle brick" which combines old PET bottles with sand & dirt to create a basis for concrete; this has been used in various part of Asia to line cement walls or support beams.

Plastic is further able to bend into multiple shapes which makes it more efficient to ship and store. A cardboard box will always be the size and shape in which it was originally created, but flexible plastic bags can be folded, flattened, or vacuum sealed to more closely match the product it protects. For example what one truck could transport in plastic bags may take seven trucks to transport if fully replaced by paper bags. From an energy perspective, it requires 82% more energy to produce alternative products as it takes 1.82 kilowatt hours to match the 1 kilowatt hour required for plastic production. We also note that alternative products on average create 2.7x more CO_2 over their lifecycle. Accordingly plastic has several clear advantages that will make it extremely difficult to replace across different end markets.

Figure 51. Plastics vs. Alternative Substrates

Criteria	Plastic	Alternatives	Details
Energy to Produce	✓	✗	82% more energy to produce alternatives
Chemical Resistance	✓	✗	Metals may oxidize or rust
Production Time	✓	✗	Faster cycle times lower unit cost
Malleability	✓	✗	Highly flexible vs. rigid alternatives
Weight	✓	✗	Alternatives are 3.5x heavier on average

Source: Citi Research, Berry Global

Consumer product companies have indicated there is “absolutely a place” for plastic in their packaging mix

Leading consumer product companies have indicated there is “absolutely a place” for plastic in their packaging mix. Management of global beverage leaders have been positive on the potential for deposit-schemes (which historically beverage producers have been reluctant to embrace) to improve recycling recovery rates, citing the need to incentivize the right infrastructure to create a circular economy. When asked about the pressure to reduce plastic beverage packaging, the one company management responded “there is absolutely a place for PET” and that the circular economy and end-of-life of the package are problems that need to be solved.

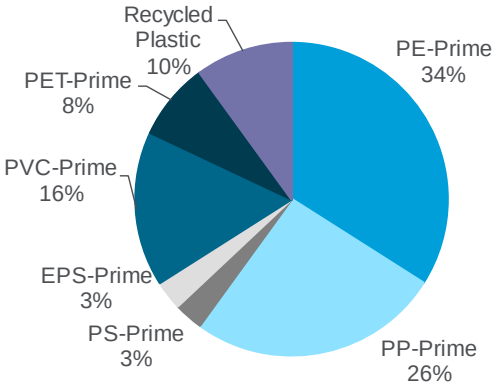
Chemicals & Plastic Recycling

Current State & Outlook

Recycled material constitute a relatively small portion of total plastics consumed worldwide

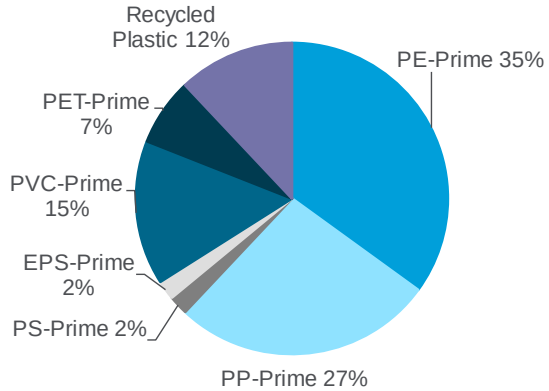
Today, recycled material constitutes a relatively small portion of total plastics consumed worldwide. In 2017, recycled plastics (PE, PP, PD, PVC, PET) accounted for ~10% of total plastic demand, according to IHS. Over the next ~11 years, the consultancy’s base case calls for growth in recycled plastic demand to outpace consumption for total plastics by >100 basis points per year; recycled plastic resins are expected to grow at a compound annual growth rate of ~5% through 2030 compared to forecasted total plastic demand growth of ~3.8% per year. This means that recycled plastics could potentially increase to ~12% of total plastic demand, or ~36 million tonne (mmt), up from ~19mmt today.

Figure 52. Global Plastic Demand in 2017 = 270mmt



Source: Citi Research, IHS Markit

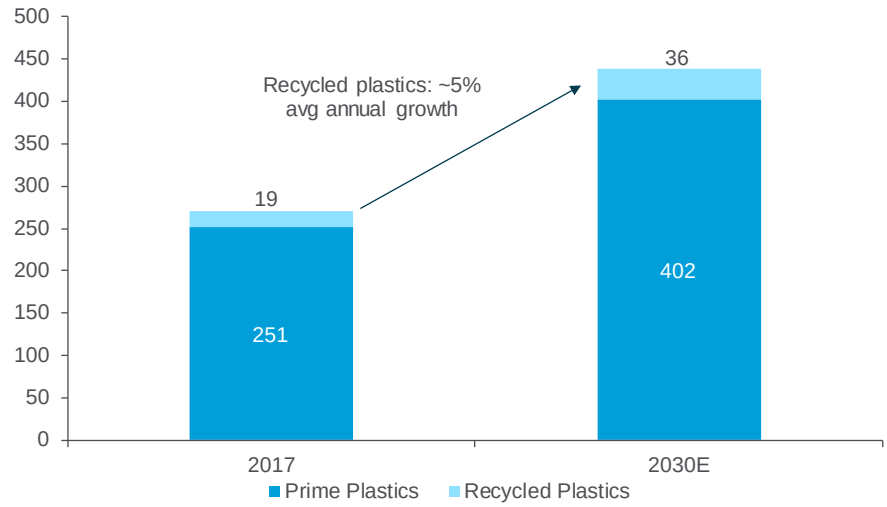
Figure 53. Expected Global Plastic Demand in 2030 = 438mmt



Source: Citi Research, IHS Markit

For polyethylene (PE), the most common plastic resin consumed, demand for recycled material accounted for ~5% of global PE consumption in 2017 or ~10 billion pounds. Recycled PE demand is expected to grow slowly to ~7% of total PE demand by 2030.

Figure 54. Prime Plastics & Recycled Plastic Demand Growth by 2030 (mmt)

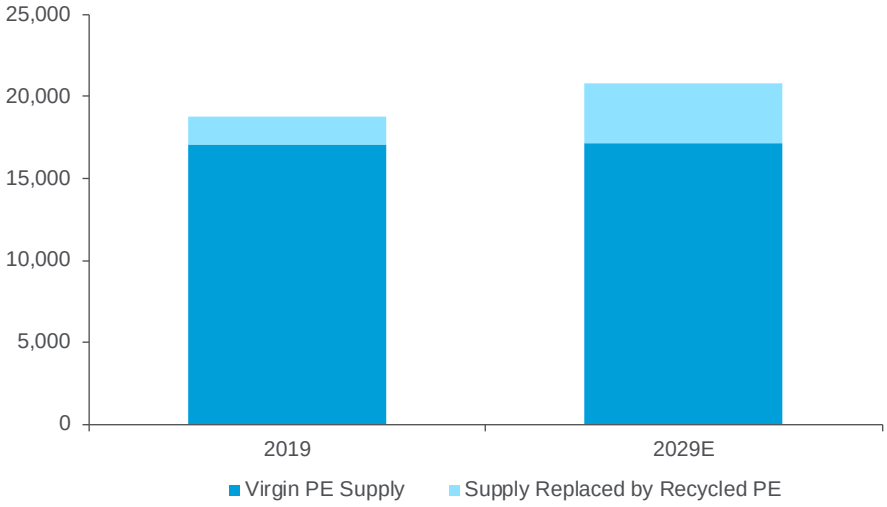


Source: Citi Research, IHS Markit

Growth in PE recycling in Europe is expected to grow to 18% by 2029

Currently, Western Europe is expected to lead the global initiative in plastics recycling with its goal for all plastic packaging in the EU market to be recyclable or reusable by 2030. For PE alone, IHS sees recycled PE consumption in the region growing from ~9% of its total PE demand in 2019 to 18% by 2029.

Figure 55. Impact of Plastic Recycling – Europe (mmt)

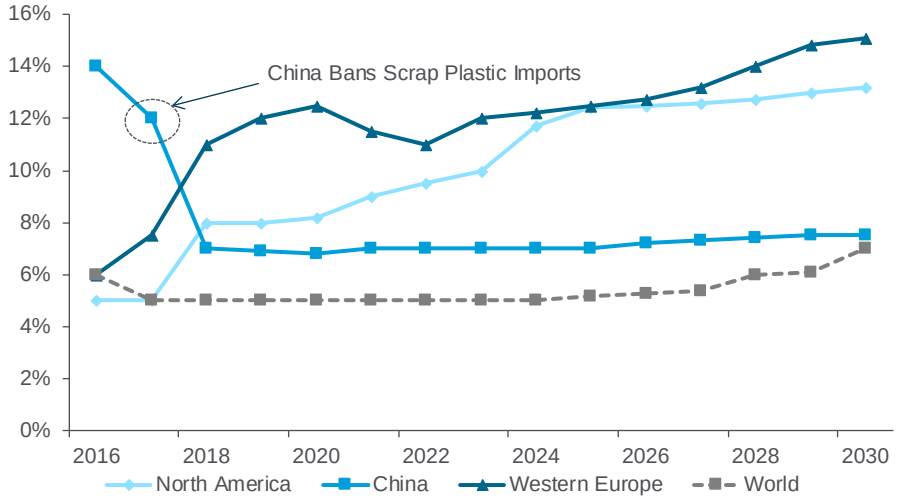


Source: Citi Research, IHS Markit

Recycled material is expected to increase by nearly 175% to ~11mmt by 2030 for total plastics

For total plastics (PE plus PP, PET, PS, among others) recycled material is expected to increase by nearly 175% from ~4mmt in 2016 to ~11mmt by 2030. As a result, recycled plastic resins could replace up to ~6mmt of virgin resin demand in Europe by 2030 (~14% local demand), up from ~1mmt in 2016 (~3% local demand).

Figure 56. Polyethylene Recycle Demand (% of Total Region Demand)



Source: Citi Research, IHS Markit

Plastic resin producers recognize both opportunities and threats from the emerging recycling market

While the impact of recycled plastic adoption may be modest over the medium term, plastic resin producers recognize both opportunities and threats from the emerging recycling market. Plastic producers as a group seek to reduce waste by: (1) designing new products for greater recycling and reuse; and (2) developing new technologies for collecting and sorting materials. Examples of new products for improved recyclability include lighter-weight plastics, replacing rigid containers with flexible pouches, and refillable plastic bottles. Looking ahead, U.S. plastic resin producers who are members of the American Chemistry Council's Plastics division, have set the following goals to recycle or recover all plastic packaging in the United States: (1) 100% of plastic packaging will be re-usable, recycled, or recovered by 2040; (2) 100% of plastic packaging will be recyclable by 2030, and (3) 100% of U.S. manufacturing facilities by members will participate in Operation Clean Sweep Blue by 2022. Operation Clean Sweep's goal is to help plastic production sites achieve zero pellet, flake, and powder loss.

Challenges & Barriers to Increased Plastic Recycling

Barriers to greater uptake of recycled plastics means there are real questions as to whether the recycled plastics market can meet consumer packaged goods producers and consumers' sustainability demands

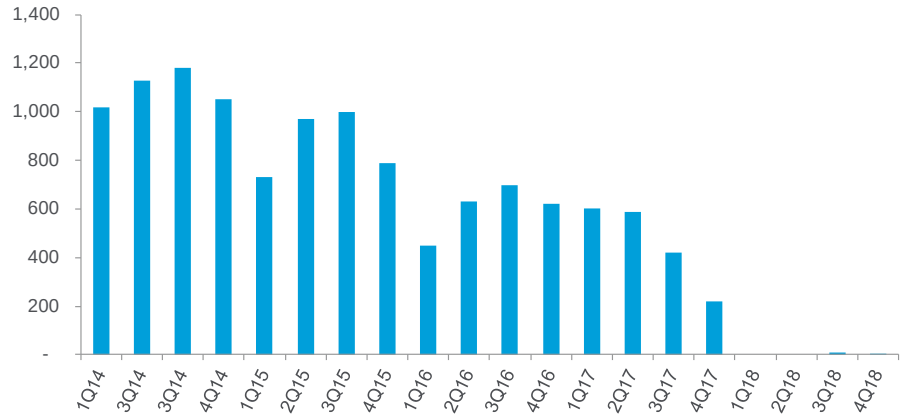
While recycled plastic demand is expected to outpace overall plastic demand over the next decade, by 2030 it may still account for just ~12% of consumption. Barriers to greater uptake of recycled plastics include:

- **Collection Obstacles:** The cost of collection and transportation of recyclable materials within cities remains high. Collection infrastructure remains underdeveloped and has tended to be slow to responding to changes in demand.
- **Technical Obstacles:** Plastic product performance can become compromised when multiple resin grades, which are common in a mix of scrap plastic inputs, are used in production. Additionally, recycled resins may have different melting indexes. Mixing batches of recycled materials with such variations in the melt index can lead to processing issues, such as yield loss.

- **Marketing Obstacles:** These obstacles vary from lack of consideration by consumers when buying packaged goods (although this may be shifting given the high amount of publicity given to plastic waste in oceans), lack of communication between buyers and sellers of recycled resin grades as to the types being traded, and low prices for virgin plastic resin (discussed below) make recyclable substitutes less attractive.
- **Elimination of China Demand:** The recent bans on scrap plastic imports by China may stall global recycling progress. Consequently, more plastics may now end up in landfills, in incinerators, or littering the environment. Up until 2018 China relied heavily on recycled material (scrap), which accounted for ~12% of total consumption in 2016. However, following the country's ban of scrap plastic imports, which started gaining traction last year, scrap plastics imported by China dropped 99% Y/Y to ~50kt.

Accordingly, there are real questions as to whether the recycled plastics market can meet consumer packaged goods producers and consumers' sustainability demands.

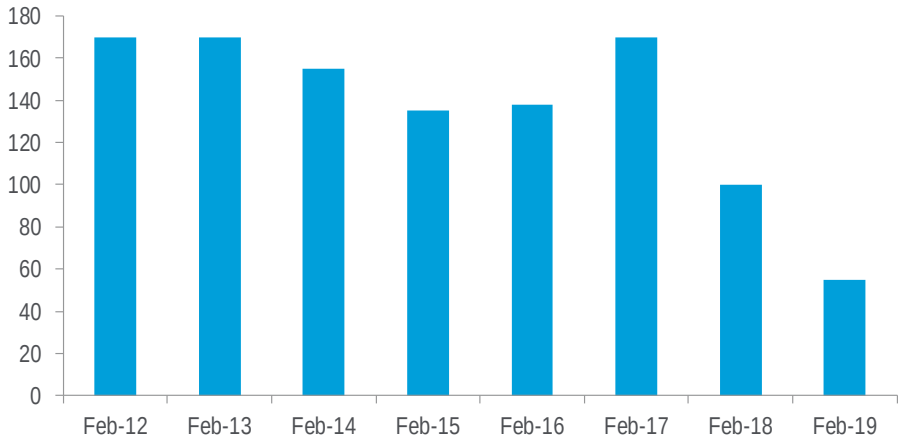
Figure 57. China Scrap PE Imports (kt)



Source: Citi Research, Resource Recycling Inc.

Before China's ban, only ~9% of discarded plastics were being recycled, while ~12% were burned and the rest went to landfills or dumped into rivers and oceans. Now, the absence of China in processing scrap plastics could potentially exacerbate the already large waste problem worldwide. In 2018, as China clamped down on scrap plastic imports, scrap plastic exports from the U.S., the largest exporters of such material, declined 35% year-on-year. Most recent trade data shows that U.S. scrap plastic exports in February fell to its lowest level since December 2003.

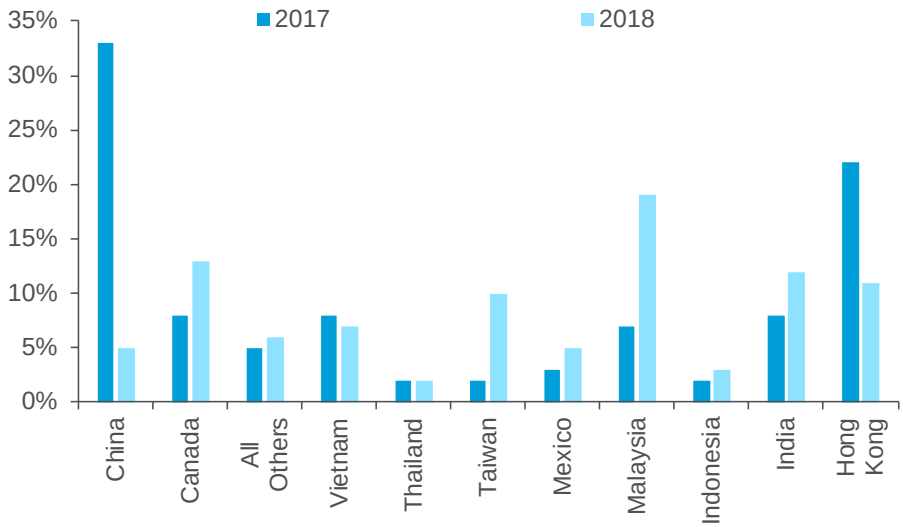
Figure 58. U.S. Scrap Plastic Exports in February (kmt)



Source: Citi Research, Resource Recycling Inc.

In March 2019, India decided to follow in China's footsteps, announcing a ban on scrap plastics citing environmental concerns and a desire to improve the quality of domestically manufactured goods. In 2018, India imported ~133kt of scrap plastic from the U.S. or ~12% of the U.S.' total.

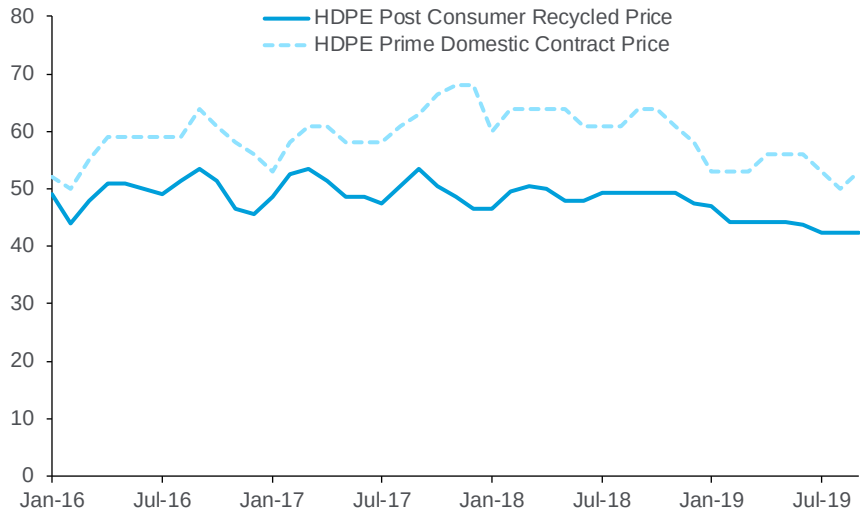
Figure 59. Destinations of U.S. Scrap Plastic Exports



Source: Citi Research, Resource Recycling Inc.

One of the key challenges in the plastic recycling market is the lack of transparency in recycled resin prices. Standardized pricing mechanisms and better clarity of cost structures across the recycled plastic resin market can pave the way for greater liquidity and improvement in trade flows. Another challenge is that recycled resin prices (denoted below as PCR grades) compete with virgin resin as a substitute and tend to be positively correlated with each other. Lower PCR prices could discourage investment in building upstream recycled plastics capacity. In 2020, Citi expects global virgin PE prices to decline by ~3-4c/lb YoY as demand is likely to remain soft and new capacity starts up.

Figure 60. North American Post-Consumer Recycled (PCR) HDPE Contract Prices (cents/lb)



Source: Citi Research, IHS Markit

Legislative mandate, rather than voluntary participation programs, are likely needed to create incentives for recycling

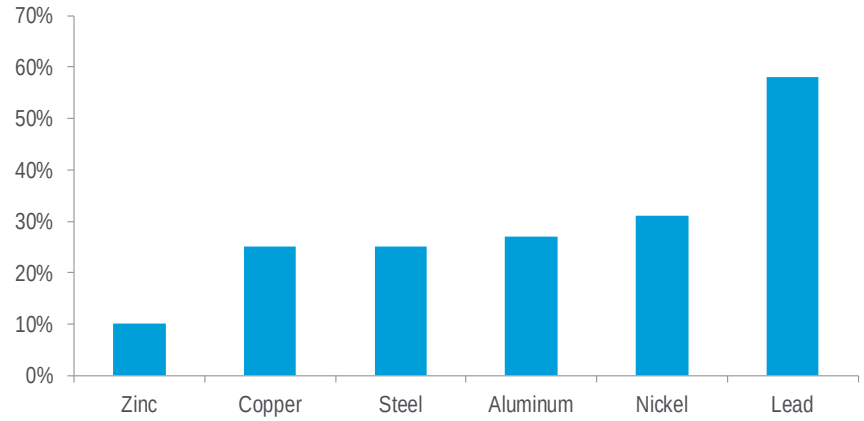
In conclusion there are several factors that need to play-out in order to incentivize more recycling: (1) Better standardization of the specs of plastics (packaging multiple colors, additives, layers etc., that make processing recycled material harder and more costly); (2) Creating a uniformed way to sort all recyclable content in different buckets; (3) Investment in the collection infrastructure (separate from chemical producer investment in processing). Legislative mandate, rather than voluntary participation programs, are likely needed to create these incentives.

In October 2019, two major U.S. PET recyclers announced they would depart from the Association of Plastic Recyclers, the industry's main trade group. The departures stem from a recent California law requiring all containers, including PET, to have recycled content, starting at 10% by 2021 and increasing to 50% by 2030. The two recyclers indicated the trade association has not provided strong enough support for higher thresholds needed to meet the growing number of recycled content pledges made by global beverage producers & consumer packaged goods producers. According to the two recyclers, which produce roughly half of the recycled PET in the U.S., more legislation is required to hit the targets being introduced. The U.S. PET bottle recycling rate is currently ~29% (compared to ~60% in Europe), and the industry is grappling with the need to raise this aggressively in a world where China isn't as actively purchasing U.S. recycled materials.

Metal – A Success Story

Metals are widely recycled globally given their high prices and costs associated with extracting and processing new ore from the ground. Accordingly ~25-30% of many industrial metals are sourced from scrap (see Figure 61). Factors affecting scrap rates include metal value, e.g., gold is incredibly valuable and rarely discarded; and ease of processing from end products, e.g., recycling lead from lead-acid batteries is relatively easy.

Figure 61. Metals Recycling Rates: % of Annual Production from Scrap

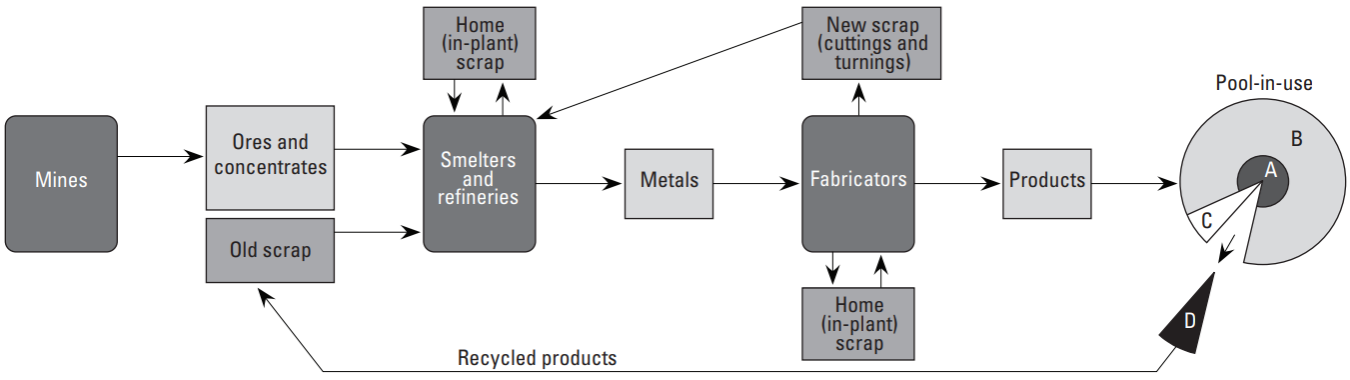


Source: Citi Research, Wood Mackenzie

Metal scrap is typically divided into three categories (descriptions below from the U.S. Geological Survey):

- **Home Scrap:** Scrap generated as process or runaround scrap and consumed in the same plant where generated. It does not enter into trade and is not considered in this study.
- **Prompt Scrap (New Scrap):** Scrap that is produced during the manufacture of metals and articles for both intermediate and ultimate consumption that is obtained from a facility separate from the recycling refiner, smelter, or processor. Examples of new scrap are borings, castings, clippings, drosses, skims, and turnings.
- **Obsolete Scrap (Old Scrap):** Scrap including (but not limited to) metal articles that have been discarded after serving a useful purpose. Typical examples of old scrap are electrical wiring, lead acid batteries, silver from photographic materials, metals from shredded cars and appliances, and used aluminum beverage cans.

Figure 62. Generalized Metals Recycling Flow Chart (USGS)



EXPLANATION

A Products made in current year
B Products made in prior years
C Unrecovered products
D Recycled products

Source: USGS "Overview of Flow Studies for Recycling Metal Commodities in the United States"

Recycling is typically more ESG-friendly than producing metal from ore

Recycling is typically more ESG-friendly than producing metal from ore. Some examples through the process are discussed below.

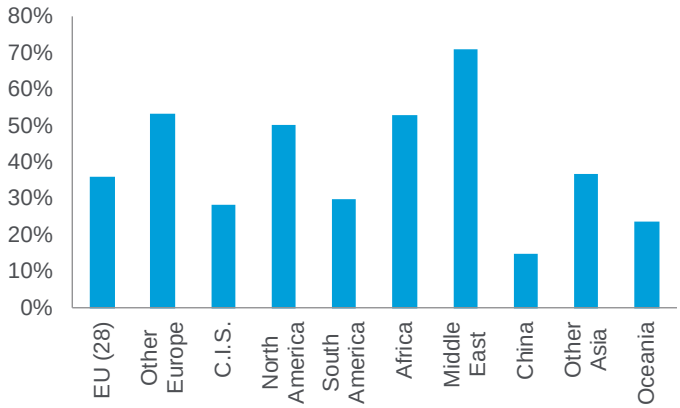
- **Mining:** Mining requires digging holes in the ground which can disrupt local communities and environmental ecosystems. Mines often have large fleets of diesel trucks creating emissions. Mines are heavily unionized and labor conflicts are common. Some mining is artisanal or unregulated and operates with sub-par safety standards.
- **Processing:** Recycled metals normally run through a furnace which is energy intensive but usually cleaner than processing extracting metal from ores. Extracting metal from rocks often requires large amounts of energy in crushing, smelting, refining etc. Some processing like leaching use of acids and other dangerous chemicals which need to be carefully controlled. Some processing requires large amounts of water and generates significant volume of wet tailings to be stored in dams.
- **Transport:** Recycling is often a local business whereas mining is more global. Mined product can be shipped over large very distances involving more emissions, e.g., iron ore from Brazil to China then steel from China to Europe.

Steel Recycling

Steel is the most recycled material in the world

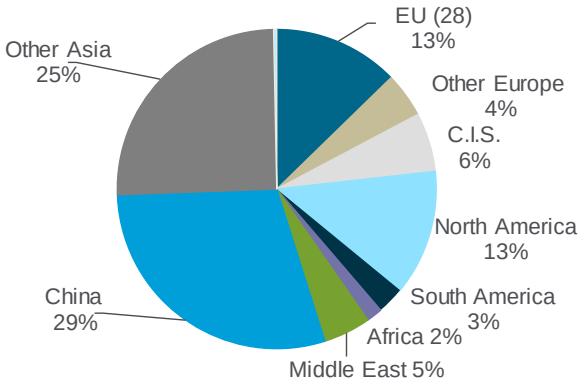
Steel is the most recycled material in the world; we estimate the amount is ~675mt per year. On average 85% of steel is recycled but with very different lifespans on each end product (e.g., appliances 10 years, vehicles 20 years, and buildings 50 years). Steel scrap is the main raw material used in Electric Arc Furnace (EAF) steel production. Blast Furnace (BF) production also uses scrap in the mix, but the main raw material is iron ore. The EPA estimates that one ton of recycled steel saves 642 kWh of energy, 1.8 barrels of oil, 10.9 million BTU's of energy, and 4 cubic yards of landfill space.

Figure 63. 30% of Steel is Made from Scrap (vs. Iron Ore)



Source: Citi Research, World Steel

Figure 64. Pct of Global Scrap Consumption — Asia Is the Biggest Consumer



Source: Citi Research, World Steel

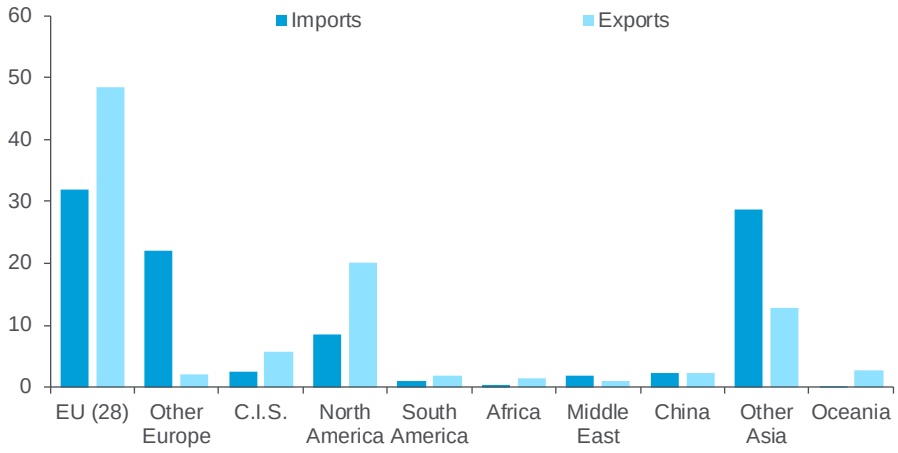
Figure 65. Global Steel Production by Process (kt)

	Electric Arc (EAF)		Blast Furnace (BF)		Total Steel		
	Steel Produced	Scrap Consumed	Steel Produced	Scrap Consumed	Steel Produced	Scrap Consumed	% Scrap
European Union (28)	67,869	48,187	100,280	2,535	168,149	60,722	36%
Other Europe	28,409	20,170	12,350	1,544	40,759	21,714	53%
C.I.S.	27,163	19,286	73,779	9,222	100,942	28,508	28%
North America	77,980	55,366	42,542	5,318	120,522	60,684	50%
South America	13,208	9,378	31,192	3,899	44,400	13,277	30%
Africa	10,097	7,169	4,463	558	14,560	7,727	53%
Middle East	32,239	22,890	--	--	32,239	22,890	71%
China	77,490	55,018	850,033	85,003	927,523	140,021	15%
Other Asia	136,098	96,630	192,195	24,024	328,293	120,654	37%
Oceania	1,224	869	5,117	640	6,341	1,509	24%
World	471,777	334,962	1,311,949	142,743	1,783,726	477,705	27%

Source: Citi Research

Scrap steel is mostly a local business by ~100mt per year is traded in the seaborne market (versus iron ore which is a ~1,400mt seaborne market). The U.S. is a net exporter of scrap.

Figure 66. The EU and U.S. are Net Exporters of Scrap: Asia is the Biggest Importer, 2017 (mt)



Source: Citi Research, World Steel

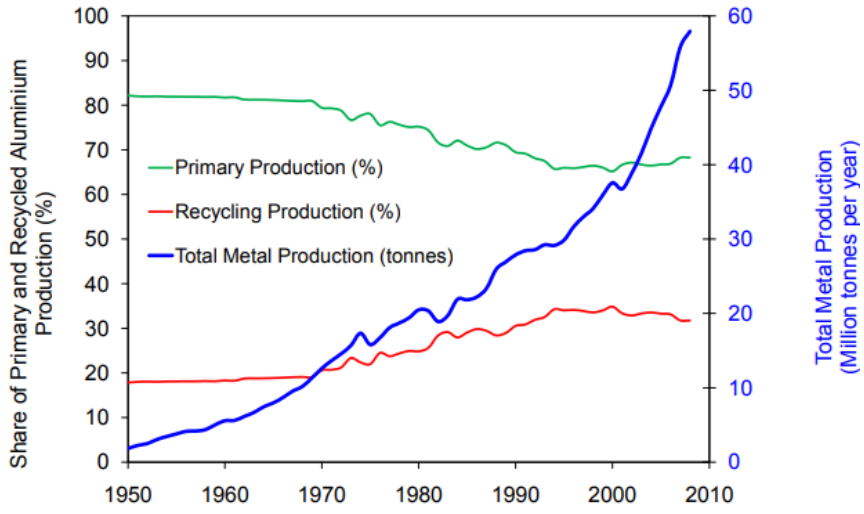
Aluminum Recycling

The amount of aluminum produced from old scrap continues to grow

Globally, aluminum production is supplied by ~65% primary metal and ~35% of recycled metal source. The International Aluminum Institute (IAI) estimates the amount of aluminum produced from old scrap has grown from 1mt in 1980 to 17mt in 2016 and continues to grow. Recycled aluminum produced from old scrap originates 40% from transport, 20% from packaging, 30% from engineering and cables, and only 10% from building applications, due to their long life times.

Roughly 75% of the ~1bn tonnes of aluminum ever produced is still in productive use. Current aluminum in use is split roughly 35% in buildings, 30% in electrical cables, 30% in transport, and the remaining in other applications including packaging.

Figure 67. Global Share of Primary and Recycled Metal Production



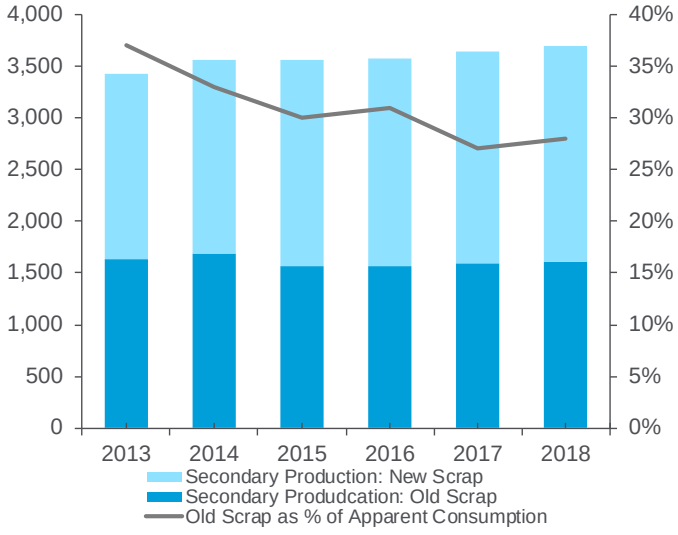
Source: International Aluminum Institute

Nearly 40% of North America's aluminum supply is created through secondary scrap production

Nearly 40% of North America's aluminum supply is created through secondary scrap production (recycling), up from ~30% in the early 1990s. The Aluminum Association estimates that the U.S. and Canada recycles >5 million tons per year.

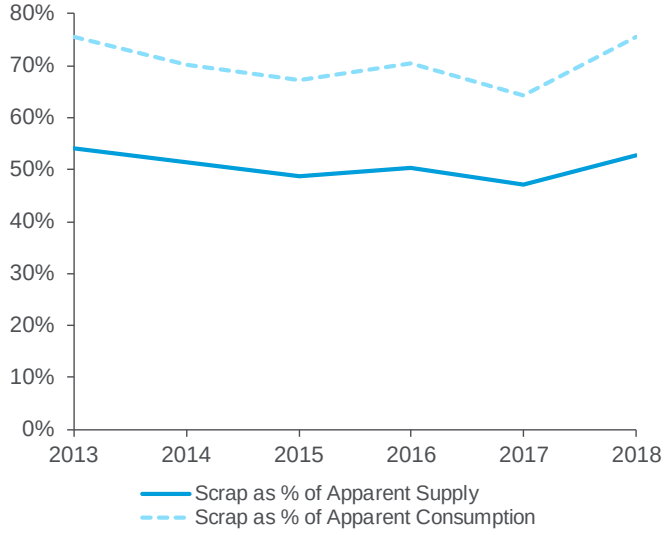
For the U.S. alone, aluminum recovered from purchased scrap in 2018 was 3.7 million tons, 58% from new scrap and 42% from old scrap. Aluminum recovered from old scrap was ~28% of apparent consumption.

Figure 68. U.S. Scrap Production (kmt)



Source: Citi Research, USGS

Figure 69. U.S. Secondary Scrap Production as a % of Supply & Consumption



Source: Citi Research, USGS

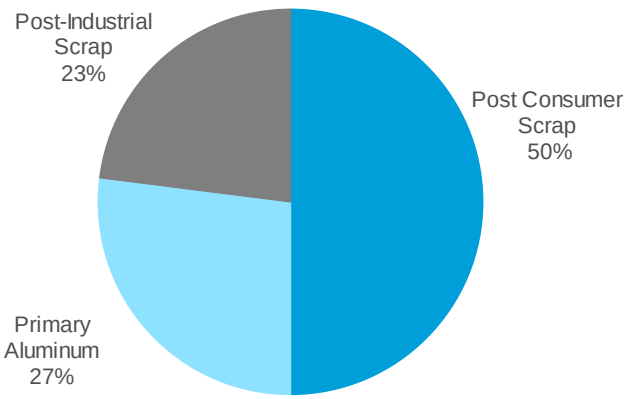
A 10% increase in aluminum end-of-cycle recycling rates can decrease greenhouse gas emissions by 15%

Re-melting scrap aluminum is much more energy efficient and less expensive than creating new aluminum from bauxite. Producing recycled aluminum is ~95% more energy efficient than creating new aluminum. A 10% increase in aluminum end-of-cycle recycling rates can decrease greenhouse gas emissions by 15%. The IAI estimates that recycling of post-consumer aluminum products saves over 90m tonnes of CO_2 and over 100,000 GWh of electrical energy.

Aluminum cans specifically are 100% recyclable and can be recycled and back on a store shelf within 60 days

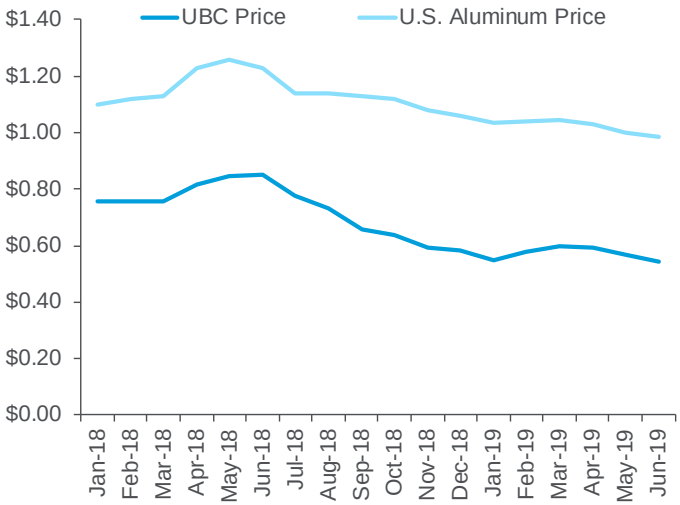
Aluminum cans specifically are 100% recyclable and can be recycled and back on a store shelf within 60 days. Aluminum cans are the most recycled beverage package in the U.S. with a 10-20 point recycling rate advantage vs. glass and plastic. The largest percentage of material in an average aluminum can is from post-consumer scrap (43%). Figure 71 shows the average prices of used beverage cans versus the U.S. aluminum price (LME + premium). One of the reasons for the widening spread has been less demand for used beverage cans as aluminum mills shift more towards auto vs. the lower margin packaging business.

Figure 70. Recycled Content of the Average Aluminum Can



Source: Citi Research, The Aluminum Association

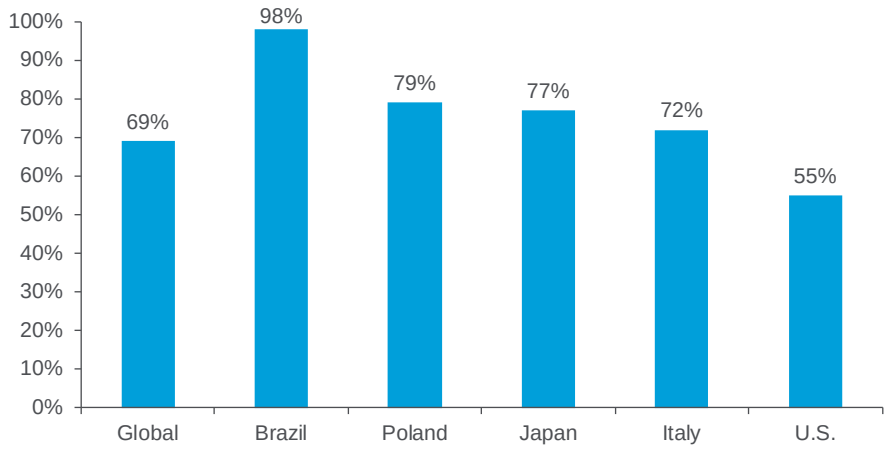
Figure 71. Used Beverage Can (UBC) Prices vs. U.S. Aluminum Price



Source: Citi Research

The Can Manufacturers Institute estimates global aluminum can recycling rates are ~69% (including 98% in Brazil, 55% in the U.S.) and that China also has a high recycling rate of >90%.

Figure 72. Global Aluminum Can Recycling Rates



Source: Can Manufacturers Institute, Resource Recycling Systems

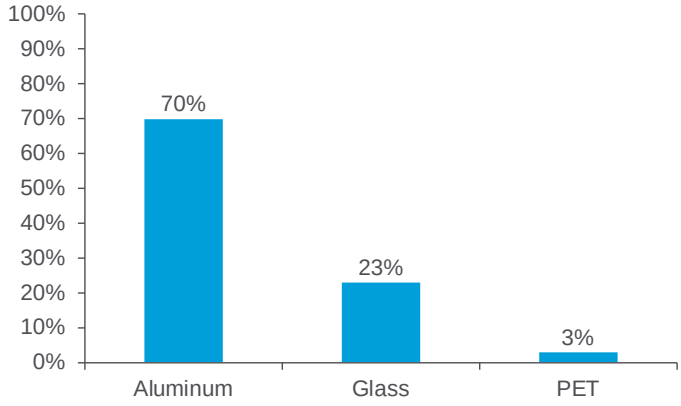
Environmental concerns are increasingly important to consumers with nearly ~75% of shoppers aged 15-20 indicating they would pay more for a product that comes from a company committed to making a positive social & environmental impact

As plastics face increased regulatory and environmental scrutiny, substrates such as metal have positioned themselves to regain lost share in some consumer staples & packaging end markets. Per a recent Nielsen global survey, environmental concerns are increasingly important to consumers with nearly ~75% of shoppers aged 15-20 indicating they would pay more for a product that comes from a company committed to making a positive social & environmental impact; this is up from ~55% in 2012. Older consumers also express a preference for environmentally-conscious products, with Baby Boomers indicating concern about the environment and willing to pay more when making purchasing decisions up from ~44% to ~51%. Moving forward we see a few potential "battleground" packaging products, including bottles for carbonated soft drinks & sparkling water, drink cups for coffee and other hot and cold beverages, protective packaging for E-commerce applications, and retail and food bags, which could see share shift between various substrates.

Single-use beverage containers for soft drinks, sparkling water, teas, and energy drinks are one application where aluminum has the potential to regain share from plastic

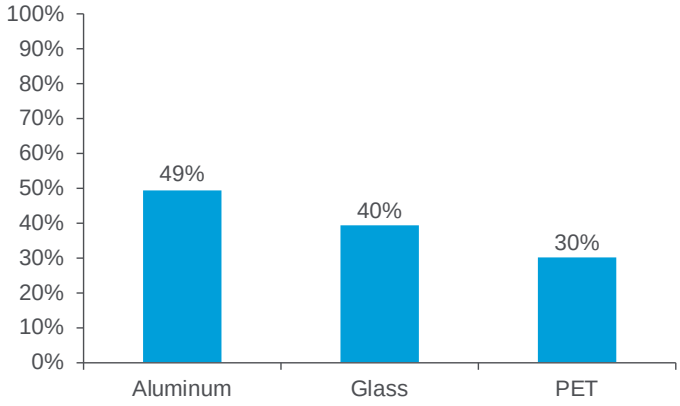
Single-use beverage containers for soft drinks, sparkling water, teas, and energy drinks are one application where aluminum has the potential to regain share from plastic. The appeal of aluminum stems from its greater recyclability, as an average aluminum can is comprised of ~70% recycled content compared to PET at ~3%, and glass at ~23%. Consumers are also more likely to recycle cans, with ~50% of U.S. cans recycled as opposed to alternative products at ~30-40%. Making a can out of recycled aluminum is less energy-intensive, requiring only ~8% of the energy needed to produce a new can, per Recyclebank. While historically beverage can producers have been hesitant to publically criticize competing substrates (which may be perceived as criticizing the choices of their top customers), we've seen Metal Packaging management teams recently become more vocal on the environmental advantages of the beverage can.

Figure 73. Average Recycled Content of Beverage Containers



Source: Citi Research, The Aluminum Association

Figure 74. U.S. Recycling Rates: Beverage Containers



Source: Citi Research, The Aluminum Association

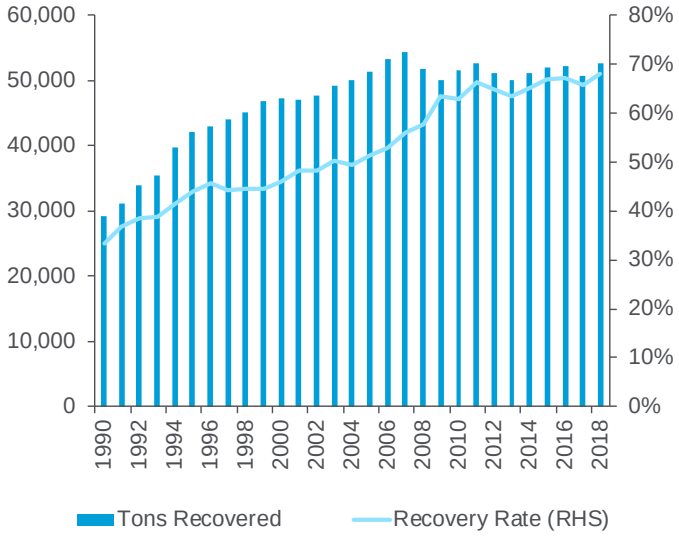
The global aluminum beverage can market is ~320 billion cans with North and Central America (~107 billion units) and Europe (~66 billion units when including Russia) being the largest markets; this compares to PET bottles just shy of ~500 billion units globally. In the U.S. soft drink market, cans have greater market share in units, they have lower share on a volume basis with PET having essentially the entire multi-serve market (>24oz per container). While aluminum can sizes beyond 24oz are rare, the larger single serve market (~78% of PET bottles) could see increased competition from beverage cans typically sized at 12-24oz.

Paper

Unlike materials such as aluminum, paper is not indefinitely recyclable

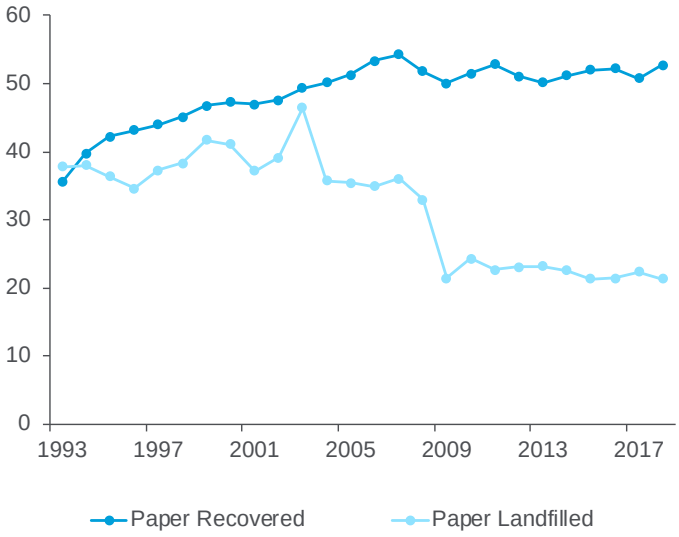
Paper recycling rates vary by grade. Grade is typically determined by fiber length, which shortens after each iteration through the recycling process. For instance, long-fiber softwood containerboard (cardboard) can generally be recycled 5-7 times before the fibers become degraded and need to be strengthened by mixing with virgin fiber. So unlike materials such as aluminum, paper is not indefinitely recyclable. Paper also often comes into contact with inks and chemicals, and therefore cannot be recycled for aseptic applications (for instance, a recycled cardboard box could be used to transport books, but not fresh protein or vegetables). Despite these qualifiers, Paper enjoys relatively high recycling rates; after dipping from 67.2% in 2016 to 65.9% in 2017, the overall U.S. recovery rate rose 220bp in 2018 to a new all-time high of 68.1%. This marks steady improvement compared to the 33.5% rate seen back in 1990, which was the base year against which the American Forest & Paper Association (AF&PA) began setting its recovery goals. AF&PA member companies are working toward a goal to increase the U.S. paper recovery rate to more than 70 percent by 2020. The amount of paper going to landfills is estimated to have declined significantly over the past ten years, from 33mmt in 2008 to 21.3mmt in 2018. This decline was partly driven by the rise in the paper recycling rate.

Figure 75. Paper & Paperboard Recovery ('000s tonnes)



Source: Citi Research, AF & PA

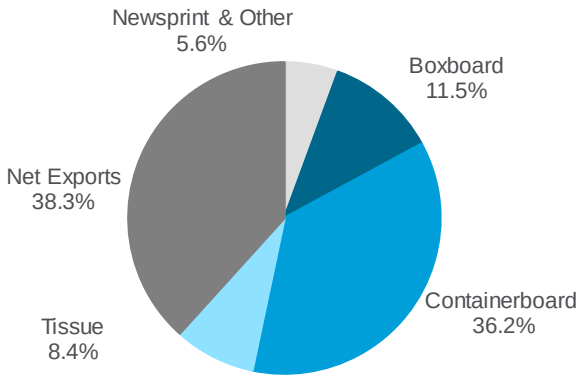
Figure 76. Paper Recovery vs. Landfill (mmt)



Source: Citi Research, AF & PA

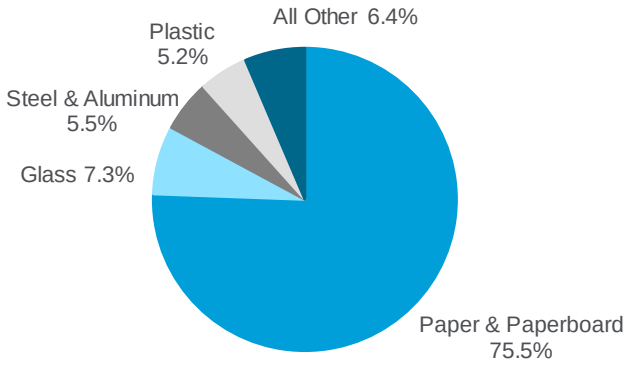
Data for the year 2018 indicate that 36.2% of paper and paperboard recovered in the U.S. went to produce containerboard (i.e., the material used for corrugated boxes) and 11.5% went to produce boxboard, which includes basestock for folding boxes and gypsum wallboard facings. Total net exports of recovered paper to China and other nations accounted for 38.3% of the paper collected for recycling in the U.S. in 2017, prior to China's effective ban of recycled paper imports. Furthermore recent data published by the U.S. Environmental Protection Agency (EPA) indicates that paper and paper packaging accounts for >75% of packaging materials recovered for recycling in the U.S.

Figure 77. Recovered Paper End-Market Uses



Source: Citi Research, U.S. Census

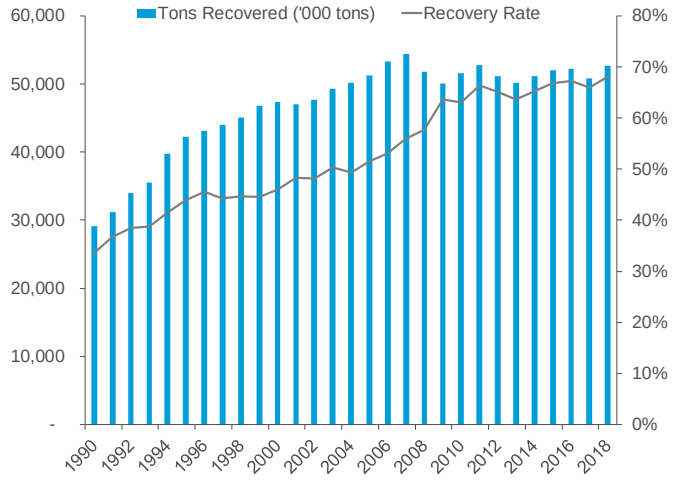
Figure 78. U.S. Packaging Recovery



Source: Citi Research, EPA 2015 Factsheet

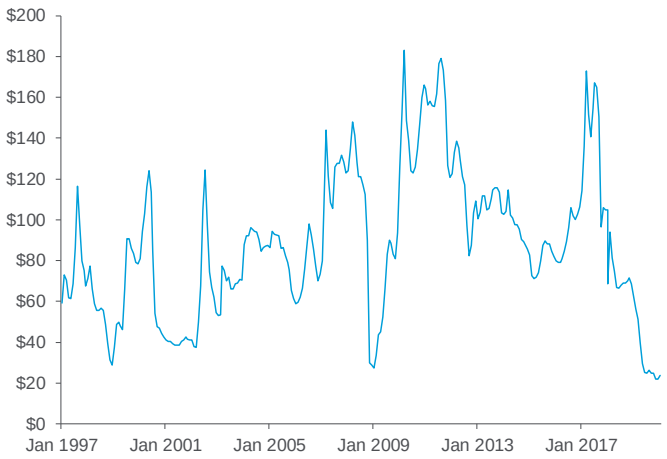
After dipping from 92.8% in 2016 to 88.8% in 2017, the recovery rate for OCC/unbleached kraft papers rebounded to 96.4% in 2018. The sharp advance was fueled by a nearly 30% surge in net exports of OCC, which have since collapsed with China's import restrictions. Given the recent volatility in OCC markets, it is notable the 3 year avg. recovery rate for OCC (2016-18) was 92.7%. China's restrictions on OCC imports have led to a collapse in domestic OCC prices: monthly recovered paper prices published by RISI show domestic OCC flat at ~$25/ton in October; by our records this is only ~$1/ton above the historical low of ~$24/ton seen in 1993.

Figure 79. Recovery & Use of OCC



Source: Citi Research, AF&PA

Figure 80. Historic OCC Pricing



Source: Citi Research, FastMarkets RISI

Solutions

In the absence of government intervention some companies are driving change themselves, thanks to a push from consumer preferences. We look at some of these changes below.

Recycled Content Pledges

Pledging to increase the use of recycled content in product packaging

Over the past year we've seen almost every major consumer packaged goods company pledge to increase its use of recycled content in product packaging (see Figure 81).

Pros: The benefits of recycled content pledges are fairly straightforward – consumer packaged goods provide a positive demand signal for recycled materials, thereby increasing the incentive for collection and recycling. Assuming recycled content pledges grow in number and size, recycling economics should improve as consumer packaged goods demand for recycled packaging grows, with consumers willing to pay a premium for sustainable packaging. Recycled content pledges have a secondary benefit of creating consumer awareness around sustainability issues, while creating a "peer pressure" dynamic that encourages other companies to use more recycled content.

Cons: Despite the obvious positives of recycled content pledges, there remain real questions as to whether recycled markets can meet sustainability demands for consumer packaged goods companies. One example is the PET container market, which enjoys relatively elevated recycling rates. Numerous beverage companies have pledged to increase their use of recycled content, some targeting a combination of reductions in virgin plastic content and making 100% of their packaging recyclable, compostable, or biodegradable. Despite the positive headlines, the National Association for PET Container Resources (NAPCOR) recently stated the current U.S. PET recycling rate is not sufficient to meet the goals brands are creating. Somewhat counterintuitively, the recycled PET market doesn't always follow normal supply/demand dynamics (i.e., higher prices don't always efficiently drive more supply). Municipal recycling programs don't always quickly respond to higher prices, and recycled PET can correlate more closely to virgin PET prices, which follow oil, than with supply. Accordingly recycled content pledges alone may not be sufficient to incentivize higher recycling rates. And of course, there are no legal consequences if consumer packaged goods companies fail to meet these targets.

Figure 81. Packaging-Related Sustainability Goals

Company	Packaging Related Sustainability Goals
Anheuser-Busch	"Our packaging sustainability journey accelerated in 2012 with a commitment to remove 100,000 metric tons of packaging material globally. We are proud that we were able to exceed this goal in 2016, removing 146,000 metric tons of material from our packaging while maintaining the quality our consumers expect. By 2025, 100% of our product will be in packaging that is returnable or made from majority recycled content. We're starting with a 46% baseline."
Coca-Cola	"Our goal is to collect a bottle or can for every one we sell by 2030, and we are working to use more recycled materials in our packaging." "We aim to make our global packaging 100% recyclable by 2025…and aspire to create packaging that contains at least 50% recycled material by 2030.".
Danone	"We aim to make packaging 100% circular. This means eliminating packaging we don't need; innovating so all the packaging we do need is designed to be safely reused, recycled, or composted, and ensuring the material we product stays in the economy and never becomes waste or pollution. Our goal for 2025 is for every piece of packaging — from bottle caps to yogurt cups — to be reusable, recyclable, or compostable. In 2018, 87% of Danone's packaging was recyclable, reusable or compostable; this is up from 86% in 2017 but still below the 2025 goal of 100%."In the company's water segment, recycled PET usage stood at 12% in 2018; up from 2017 (10%) but below 2025 goals of 2025. For the entire company, 38% of packaging is made from recycled materials with 79% of paper & board being made from recycled fiber or FSC certified fibers."
JBS	"Product packaging provides a unique challenge for our industry, as not all materials used are possible to recycle at customers' or end-users' recycling facilities. To prevent contamination, packaging materials used at production facilities that come into contact with blood, meat or fat cannot be recycled, per the ISRI standards."
Kraft Heinz	"Kraft Heinz supports the move toward a circular economy and aims to make 100 percent of its packaging globally recyclable, reusable or compostable by 2025. While the global packaging target is new, Kraft Heinz is no stranger to advancing the sustainability of its packaging. Evidenced by previous work in this space, the Company has been working for years to optimize its high-volume packaging. For example, Kraft Heinz recently exceeded its commitment to reduce the weight of its global packaging by 50,000 metric tonnes. Additionally, Kraft Heinz Europe is working to make the recyclable Heinz Tomato Ketchup PET plastic bottle fully circular by 2022, by using recycled material that can be made back into food-grade packaging."
Nestlé	"Nestlé has formed the "Nestlé Institute of Packaging Sciences" to accelerate research of recyclable, biodegradable & compostable polymers. The company is targeting 100% recyclable or reusable packaging by 2025; paper alternatives to plastic are also being evaluated. "We have placed packaging and plastics at the top of our agenda..."
PepsiCo	"The following goals make up our 2025 packaging sustainability agenda (1)Strive to design 100 percent of our packaging to be recyclable, compostable or biodegradable; (2) Strive to use 25 percent recycled content in our plastic packaging by collaborating with our suppliers, helping to increase consumer education, fostering cross-industry and public-private partnerships, and advocating for improved recycling infrastructure and regulatory reform, all of which are required to realize our ambition; (3) By 2025, PepsiCo will reduce virgin plastic use across our beverage portfolio by 35%, equating to the elimination of 2.5 million metric tons of cumulative virgin plastic when taking into account business growth. On an absolute basis, this includes a 20% virgin plastic reduction vs a 2018 baseline; and (4) In partnership with the PepsiCo Foundation, work to increase recycling rates."
Procter & Gamble	"P&G's leadership brands will enable and inspire responsible consumption through packaging that is 100% recyclable or reusable by 2030. This is an ambitious goal we will achieve via light weighting, increasing our use of recycled plastic, driving conversion to more concentrated product forms, and when it makes sense, using alternative resins. We estimate this will avoid the use of over 300,000 tons of virgin plastic." "P&G will reduce global use or virgin petroleum plastic in our packaging by 50% by 2030."
Tyson Foods	"Our packaging strategy aligns with the five "R's" – Remove, Reduce, Reuse, Recycle and Renew." "Without compromising quality or product protection, our packaging design process prioritizes increasing the use of recyclable and renewable materials, as well as minimizing packaging where possible. We stay abreast of innovations in packaging technology and ways to source renewable packaging materials."
Unilever	"In 2017, we made a further commitment on waste, ensuring that all our plastic packaging will be fully reusable, recyclable or compostable by 2025." 25% of material will come from recycled plastic content." "Since 2010 we've reduced the weight of our packaging by 18% through lightweighting and design improvements." The company uses the phrase "less plastic, better plastic or no plastic".

Source: Company Reports, Citi Research

Packaging-Light & Packaging-Free Initiatives

Policymakers seek to reduce single-use packaging

Instead of debating the relative benefits of different single-use packaging substrates, policymakers may ultimately seek to reduce single-use packaging. Notably Italy's new government is debating a plan to provide a discount to vendors, which would be passed onto consumers, for products sold without packaging. Vendors would receive discounts of up to 20% for selling food & beverage, personal care & home care items from dispensers and re-usable containers, rather than in single-use packaging. Italian Prime Minister Giuseppe Conte has stated Italy is seeking to be a leader in sustainability, while reducing the amount of packaging materials that ends up in its landfills, beaches, and incinerators. While details are limited and we don't anticipate any near-term impact to packagers, given the size of the Italian economy (fourth largest in Europe, eight largest globally in nominal GDP terms) we'll watch the proposal closely.

Pros: The benefit of packaging-free and packaging light approaches is very simple: they move up the "hierarchy of waste" to address waste prevention, rather than dealing with recycling, recovery and disposal. A related "packaging light" consumer offering that seeks to discourage waste was launched at the World Economic Forum in Davos. The concept is to gather a group of large consumer packaged goods that will use high quality, durable packaging that can be returned and refilled. The program essentially uses e-commerce to bring back the "milkman model" where products are delivered to customers while empties are collected, washed, refilled, and restocked for delivery to other customers. While starting off as an e-commerce enabled offering, the concept looks to expand to physical retailers.

Cons: Packaging-light offerings may ultimately fail to resonate with consumers, as single-use packaging offers clear convenience and value. Consumers may not want to store, clean, and maintain multiple containers for different foodstuffs. Even beyond convenience, Packaging provides clear benefits around supply chain efficiency, enhancing the shelf life of food & beverage products and reducing waste. Also the total system cost of the "milkman" approach, which includes delivery costs, related GHG emissions, and labor costs when products are delivered to customers and empties are collected, bears further study.

Container Deposit Schemes

Increased use of container deposit schemes

One of the core challenges of recycling is that many consumer products, especially plastic packaging, has little or no economic value. Increased use of container deposits is one strategy to address this challenge. According to NAPCOR, the current U.S. recycling rate for PET bottles is <30%, but states with bottle deposit schemes have seen rates as high as 65-95%. While some plastic packagers see deposits as part of a sustainability solution, historically beverage producers and retailers have resisted them, viewing them as a tax on their products. However with sustainability increasingly top of mind with consumers, this resistance appears to be fading.

Pros: Beverage containers make up 5.6% of the U.S. waste stream (per the EPA) and 20% of greenhouse gas emissions (per Solid Waste & Recycling) implying significant environmental upside to an uptick in recycling rates. One possible solution to reducing unnecessary waste is to expand the use of bottle return deposit schemes. Per the BEAR Report, in the 10 states that use deposit schemes (now up to 11), 490 containers per capita are recycled per year, compared to 191 containers per capita in the other 40 states. These trends are prevalent internationally, as well, as countries with deposit return schemes tend to recycle between 80-95% of their plastic bottles; in Norway, 95% of all plastic bottles are recycled.

For consumers that aren't naturally inclined to recycle, a financial incentive may provide a boost in participation. There is also a secondary collection market that tends to follow bottle deposit program where individuals collect returnable containers from trash bins and bring them to collection.

In the U.S., 10 states currently use deposits, with a majority of those concentrated in the Northeast. Recycling rates for this regions are in the 23-27% range, compared to 19% in the Southeast and 11% in the South. Florida introduced a bill which would implement deposits of $0.20-$0.30 on different sized containers, but the legislation ultimately failed. Arkansas is also considering introducing a deposit scheme.

Cons: Opponents of bottle return programs have historically included beverage companies fighting a price increase on their product (even though that amount is refundable) and retailers which are against designating floor space & labor to managing return programs on their property (although they receive 3.5¢ per container returned in New York State). There's also the idea that return programs are redundant, duplicating the services provided at every curbside. Bottle deposits drive revenue for the state that utilizes it by keeping the money charged at the register that is not returned and refunded to the consumer. Where the states profit, curbside programs suffer since they typically use the revenue from PET & aluminum to fund their recycling operations. Deposit programs have had a difficult time gaining traction in US states recently with bills failing in Texas, Tennessee & Massachusetts (tried to expand on existing program) based on the criticism above. In Delaware, the state repealed its 5¢ refundable fee in favor of 4¢ non-refundable fee that funds recycling grants within the state. Connecticut is considering this model with the bill citing potential revenue in the range of $57 million annually. While states that use deposit schemes have higher recycling rates (California, Connecticut, Delaware, Hawaii, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, and Vermont), those states may have residents that are more interested in recycling, regardless of the financial incentives.

In California, where stores are not required to take back bottles and cans with deposit schemes, return centers are under pressure and the largest operator in the state, rePlanet LLC, closed all of its 284 locations in August 2019 citing reduced state fees, depressed commodity prices coupled with higher minimum wage and healthcare costs. In the last five years, 40% of California's redemption centers have closed, per Consumer Watchdog. The proposed solution to unprofitable redemption centers is to force the stores that sell beverage containers to take back deposits on site.

Figure 82. U.S. Deposit Schemes by State

USA Deposit Schemes by State

State	Year Implemented	Deposit Amount	Beverages Covered	Containers Covered	Unredeemed Deposits
California	1986	$0.05 (<24 oz.) $0.10 (>24 oz.)	Beer, malt, wine and distilled spirit coolers; all non-alcoholic beverages, except milk. Excludes vegetable juices over 16 oz.	Any container composed of aluminum, glass, plastic, or bi-metal; Exempts refillables	Property of program; Used for program administration
Connecticut	1978	$0.05	Beer, malt, carbonated soft drinks, bottled water	Any sealed bottle, can, jar, or carton composed of glass, metal or plastic; Excludes containers over three liters containing non-carbonated beverages, and HDPE containers	Returned to the state
Hawaii	2002	$0.05	Beer, malt, mixed spirits and wine; all non-alcoholic drinks, except dairy products	Any container up to 68 oz. composed of alumi-num, bi-metal, glass, or plastic	Property of state; Used for program administration
Iowa	1978	$0.05	Beer, wine coolers, wine, liquor, carbonated soft drinks, mineral water	Any sealed bottle, can, jar, or carton composed of glass, metal or plastic	Retained by distributor and bottlers
Maine	1976	$0.15 (wine & liquor) $0.05 (all others)	All beverages except dairy products and unprocessed cider	Any sealed container of four liters or less composed of glass, metal or plastic	Property of state
Massachusetts	1981	$0.05	Beer, malt, carbonated soft drinks, mineral water	Any sealable bottle, can, jar, or carton composed of glass, metal, plastic, or a combination; Excludes biodegradables	Property of state general fund
Michigan	1976	$0.10	Beer, wine coolers, canned cocktails, soft drinks, carbonated and mineral water	Any airtight container under one gallon composed of metal, glass, paper, or plastic	75% to state for environmental programs; 25% to retailers
New York	1982	$0.05	Beer, malt, wine products, carbonated soft drinks, soda water, and water not containing sugar	Any sealed bottle, can, or jar less than one gallon composed of glass, metal, aluminum, steel, or plastic	80% to the state general fund; 20% retained by distributor
Oregon	1971	$0.10 $0.02 (standard refillable)	Beer, malt, carbonated soft drinks, bottled water (will cover all beverages except wine, distilled liquor, milk, milk substitutes and infant formula by 2018).	Any sealed bottle, can, or jar composed of glass, metal or plastic	Retained by distributor and bottlers
Vermont	1972	$0.15 (wine & liquor) $0.05 (all others)	Beer, malt, mixed wine, liquor, carbonated soft drinks.	Any bottle, can, jar, or carton composed of glass, metal, paper, plastic, or a combination; Excludes biodegradables	Retained by distributor and bottlers

Source: Citi Research

Adopting a "Green Dot" System

Adopting a "Green Dot" system which indicates a package is environmentally friendly and abides by recycling laws

In Europe, various countries use a "Green Dot" system, which indicates a package is environmentally friendly and abides by all recycling laws and thus must be accepted by collectors. In order to place the green dot on a package, producers must pay a fee. Overall, 460 billion packages use the green dot every year, with 25 countries now utilizing the system. Producers applying for a green dot during the manufacturing process must consider end-of-lifecycle solutions in their packaging innovations.

Pros: One of the main issues with recycling is education. Consumers often lack clarity on what can be recycled, in which situations and where the material needs to be brought to. If every recyclable product was given a green dot, and every non-recyclable product was not, the quality of recycling streams could meaningfully improve. A green dot could also sway consumer decisions at the point-of-purchase towards recyclable products.

Cons: While we think many markets could benefit from such a system, implementation may require political will. Like many issues in the U.S., views towards recycling and sustainability have become highly polarized, and the Trump administration has resisted action at the federal level. Quite the opposite, Trump's reelection campaign recently raised $200k by selling branded plastic straws, claiming "liberal paper straws don't work." That being said, consumer goods companies, packagers, and waste collectors could promote a green dot system (meaning waste collectors only accept approved packaging) without a government mandate, although it would involve a great deal of cooperation throughout the supply chain. In this event, implementation of a "green dot" could be undermined by packagers and consumer packaged goods companies not willing to comply, or pushing alternative solutions.

Implementing "Pay-As-You-Throw"

Pay-as-you-throw programs that introduce variable pricing systems for waste removal

Various European countries have had success with a variable pricing system for waste removal, better known as "pay-as-you-throw" or PAYT. The program generally involves users paying a base fee in order to have some revenue stability for the collectors, and then the remainder of the payment depends on the weight of waste collected from the household. Collectors may charge for size of the container or number of containers rather than weight.

Pros: The main benefit of PAYT is that it aligns consumers' priorities (saving money) with environmental priorities (producing less waste). In France, PAYT has been positively received with waste sorting improved, quantities falling and no meaningful rise in disregard for proper waste management rules. In the U.S., Yale University is piloting a PAYT program on its campus. One technological innovation that could assist in the implementation of PAYT is RFID or radiofrequency identification. If an RFID tag is placed on each household's recycling bin and a reader is placed on each garbage truck then governments could be able to charge households for the amount of trash they generate or conversely, communities could reward households that recycle more. Governments could further use the data obtained from RFID readers to track who is participating in recycling; this will allow for more efficient and targeted educational efforts.

Cons: The main potential drawback is that in the event PAYT is successful in reducing waste, collectors may lose revenue so the industry is unlikely to propose this plan without consumer or political pressure. Even for recycled goods, the industry relies on reselling the commodities to drive revenue so it theoretically would not be interested in reducing the stream of recycled content. Another potential negative is littering. While PAYT has been positively received in Europe, we think it is possible individuals could illegally dispose of trash (littering, in a public area or different residence) in order to avoid collection fees. There doesn't appear to be overwhelming evidence of this happening, but we note that some people could use this method.

Expanded Use of Dual-Stream/Multi-Stream Recycling

Having consumers separate their waste into multi-streams vs. missing all waste into one bin or single stream

Currently ~65% of U.S. material recovery facilities are single-stream, vs. ~27% in 2006, per Waste Dive. This means that at the point of pick-up, consumers can mix paper, cardboard, plastic, glass, and metal all in one bin, as opposed to dual stream which means fiber (paper and cardboard) are kept separate from rigid containers (plastic, glass, and metal) or multi-stream which is what Europe mostly uses. In Germany there are six different bins: blue for paper, yellow for plastic, white for clear glass, green for colored glass, brown for compost, and black for miscellaneous waste.

Pros: While dual and multi stream require more work on the part of consumers, it is superior in limiting contamination which allows for the recovery of more materials and saves on processing costs. Contamination is a key driver for China's change in policy on importing recycled goods, setting a 0.5% contamination rate compared to a contamination rate of 20-30% in the U.S., currently.

Cons: Single-stream recycling has increased in popularity largely to ease of use. By placing less of a burden on the end-consumer, participation rates have risen which is a positive for the recycling industry. Also, trash haulers are able to realize cost savings by cutting down on the labor required at pick-up with households moving from two bins to one, thus requiring fewer employees per truck. The implementation of dual or multi-stream recycling will likely come down to cost for collectors: does increased recycling yield outweigh the extra labor costs & potential drop in participation rate?

Charging for Recycling

Waste collectors could charge an additional fee to collect recyclable goods

Private waste management companies are facing pressure from several sides: plummeting commodity prices (OCC, UBC, etc.) are lowering the resale value of processed materials, while China's strict quality standards on the small amount of recycled material that can be imported are driving up operating costs. One company has reported that average commodity revenue has declined 80% since the start of 2011. Further, shipping to other Asian countries besides China has driven up transportation costs. Recycling needs to be economically viable at every stage of the supply chain, either through raising prices, lowering costs or a combination of both. Given the increased attention on recycling, waste collectors could charge an additional fee to collect recyclable goods, separate from what is charged to collect waste.

Pros: This is a straightforward approach that addresses the challenges with current recycling economics. Charging for recycling could allow collectors to offer services on currently unprofitable items such as glass. Increased revenue could further help recyclers recapitalize their processing equipment and invest in automation to improve efficiency. Most sorting lines at an MRF are manual, leading to potential workplace injuries while facing growing labor costs.

Automation in the collection process (i.e., self-driving cars) could also help, and electric vehicles could lower costs and increase sustainability.

Cons: In many parts of the world, consumers might not be willing to pay extra for recycling; they might be content allowing everything to go to a landfill. An effective solution, in our view, would be to financially punish non-recyclers as this would align consumer and environmental priorities. On the cost side, it's difficult to argue for why waste management providers should invest in a business that might not meet their return threshold, depending on where commodity prices stand at the moment.

Product Lightweighting & Supply Chain Initiatives

Initiatives to lightweight products and to recduce the amount of material being sent to landfills

In an effort to reduce material usage, which leads to lower carbon footprints and costs, producers have sought to continually lightweight their products. This involves either shifting towards lower weight substrates, such as moving from metal or glass to plastic, or reducing the total amount of material used in a product, such as making the walls of a plastic container thinner. With only ~35% of the municipal solid waste in the U.S. being recycled, reducing the amount of material being sent to landfills is paramount. Similar to product lightweighting, corporate supply chain initiatives can help drive out waste and cost. One example is "Frustration Free Packaging," of FFP. Created in 2008, FFP set out to reduce waste and improve customer satisfaction by moving towards easy to open, 100% recyclable packaging. FFP has been expanded several times, and in its current form identifies three tiers: Tier 3 items are "prep free" but still require an overbox, while Tier 2 items can be shipped in their own container. Tier 1 items fulfill Tier 2 & 3 requirements, and further receive certifications for being recyclable in curbside programs, being easy to open & using minimal packaging. The different tiers represent opportunities for vendors to reduce/remove prep chargebacks and save on packaging and transportation costs. FFP has been successful in reducing packaging material usage.

Pros: Lightweighting and related supply chain initiatives represent a rare opportunity where economic & environmental incentives are aligned: producers can save money by using less material, reducing emissions, waste and shipping expenses, while passing along some of those savings to consumers.

Cons: Lightweighting does have some drawbacks such as sortability in MRF's; scanners use light to detect a product's material and sort it accordingly. Lightweight containers or films are often multi-layer, meaning there are several different materials (can be LLDPE, then PE, then nylon, then PE again, etc.) comprising one package. The outer layer of a multi-layer product may be scanned and identified as one material but be mostly comprised of another. Mixed product grades create low quality bales, resulting in lower yields when attempting to turn recycled goods into a new product. Previously in this report we identified consistent product specs as a potential boost to recycled content usage and lightweighting makes that increasingly difficult. Regarding supply chain initiatives like Frustration Free Packaging, lighter weight products do not necessarily translate to more easily recycled products. FFP appears to have driven substitution from corrugated boxes to flexible plastic mailers, and we've seen significant investments in e-commerce from flexible plastic packaging producers as a result. While FFP incentivizes packaging that's acceptable to curbside recycling programs, most flexible plastic packaging typically needs to be brought to drop-off locations in order to be recycled; such sites are scarce especially in cities with plastic bag bans (such as Seattle). Currently <5% of plastic film used by U.S. households is recycled.

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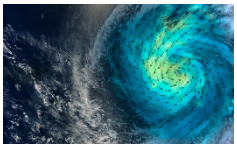

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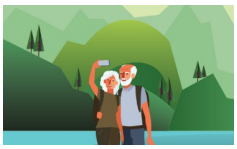

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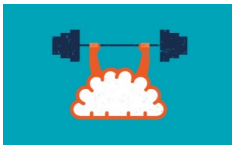

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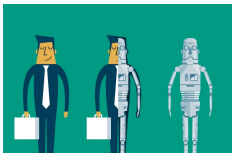

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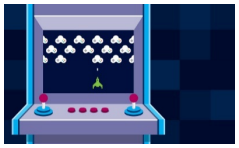

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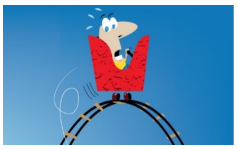

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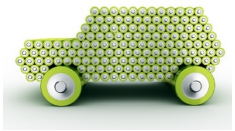

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Key Insights regarding the future of Recycling

COMMODITIES

Prior to the Chinese ban on imported recycling material, the price per pound of recycled PET bales fluctuated in line with crude oil prices and Chinese demand for recycled plastic waste. / Post the import ban, PET bale prices continue to drop, making the business case for recycling less attractive.

REGULATION

Europe is the leader in global recycling efforts with the EU 28 countries recycling 46.4% of their municipal waste in 2017, up from 25% in 2000. / The goal of European waste legislations is to move up the internationally-accepted 'waste hierarchy' towards prevention and away from disposal, stressing the importance of re-use, recycling, and recovery.

SUSTAINABILITY

The United Nations released their 2030 Agenda for Sustainable Development in 2015 with an urgent call for action and a shared blueprint for peace and prosperity for people and the planet, not and into the future. / Recycling and its impact on the environment and ecosystem touches upon Goal 3, 11, 12, 14, and 15 of the UN SDGs.