Dovetail Partners Consuming Responsibly Report No. 17

Household Waste Recycling:

Why it is Important and Why Change is Needed to Increase Effectiveness

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Household Waste Recycling: Why it is Important and Why Change is Needed to Increase Effectiveness

Executive Summary

What difference does it make if that aluminum beverage can goes into the trash rather than the recycling bin? Same with that steel soup can, coat hanger, plastic water bottle, or Sunday newspaper? It turns out that recycling (or lack of recycling) has significant implications for a number of society's top-of-the-list environmental and social concerns: energy consumption and future supply, climate change, land use change, environmental degradation, water quality, and future raw materials availability.

In this report we examine the environmental benefits of recycling and impacts of not doing so. We examine recovery of recyclables from municipal solid waste (MSW) from both environmental and economic perspectives, shed light on arguments against recycling, and consider proposals for change to current recycling practices. We conclude that recycling is essential, but that changes in recycling guidelines and collection systems are needed.

A Brief History of Recycling

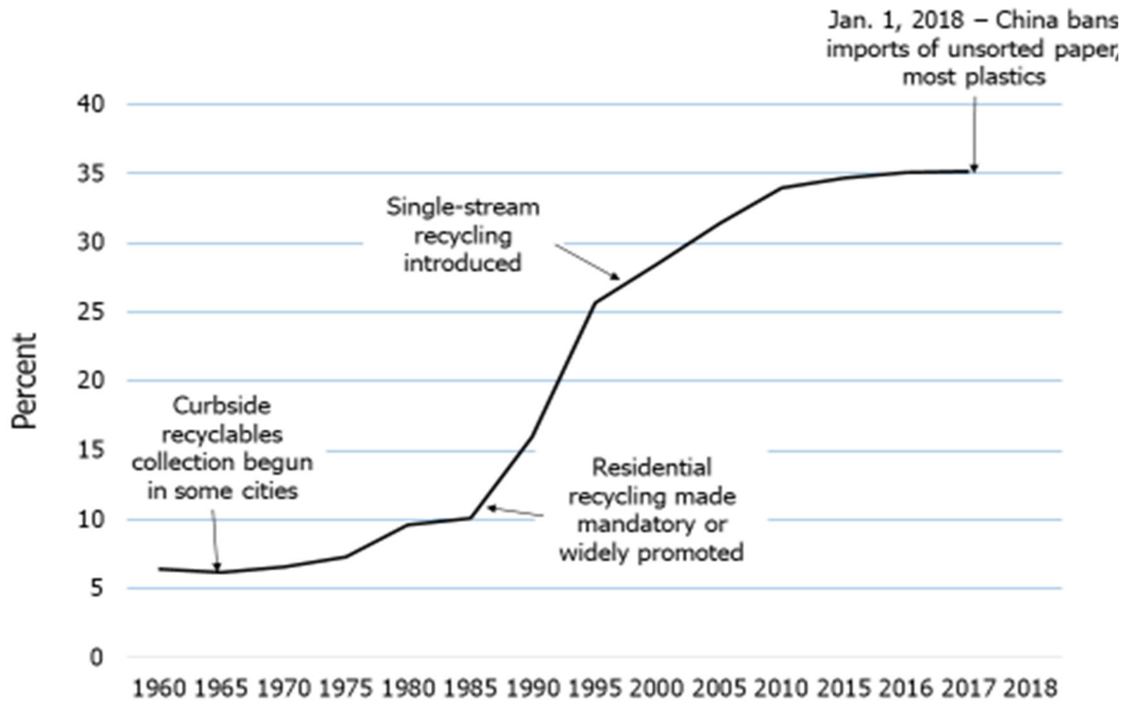
Widespread recycling is relatively new in the United States. While there were massive, federal government-led campaigns for post-consumer collection of tin, rubber, steel, and paper during World War II, only 6% of MSW was recovered for recycling in 1960. By 1980 that number had risen to 10% as a result of initiation of curbside collection of recyclables in several large cities. The first mandatory recycling law, which required residents to separate recyclables from their trash, was enacted in New Jersey in 1987. This, and similar initiatives by municipalities all over the country resulted in a sharp increase in materials recovery from MSW. The introduction of single-stream recycling in the late 1990s pushed recyclables recovery even higher (Figure 1).[1, 2] Over a nine-year period beginning in 2005, the percentage of American communities utilizing single-stream recycling rose from 29% to 80%.[3]

The U.S. Environmental Protection Agency (USEPA) reports a materials recovery rate of 35.2% in 2017 – the most recent figure available. On the one hand, a clear picture of success in comparison to 1980. On the other hand, a disappointingly low recycling rate despite surveys which indicate strong citizen support for recycling[4], many decades of promotion of recycling by governments and citizens groups, and widely available curbside recycling programs in cities across the country. By comparison, the European Union (EU) realized a 47% MSW recycling rate in 2017.[5]

[1] Northeast Recycling Council (2019)
[2] USEPA (2019b)
[3] Koerth (2019)
[4] Carton Council (2017)
[5] EuroStat (2019a)

Figure 1

U.S. Percent of Waste Generation Recycled and Composted, 1960-2017



Source: USEPA (2019b)

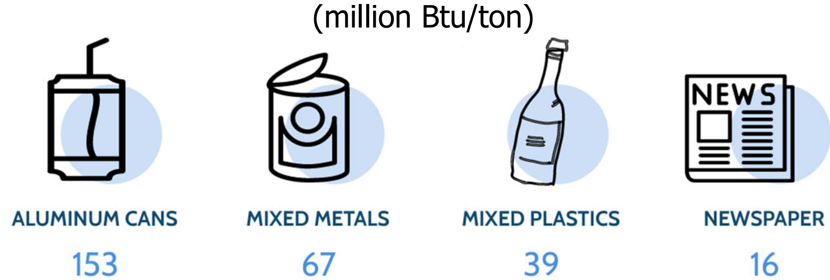
Does Recycling Matter?

There are all sorts of industrial-size statistics available regarding the benefits of recycling. For instance, in addition to avoiding the need to mine additional quantities of bauxite and alumina as well as the accompanying environmental impacts of mining and processing virgin minerals, recycling a ton of aluminum cans avoids the consumption of 153 million Btu of energy – more energy than the average American consumes in a year for all purposes. Recycling a ton of newspaper rather than sending to landfill avoids consumption of about 17 million Btu of energy, a ton of mixed plastics about 40 million Btu, and a ton of mixed metals about 67 million Btu[6] (Figure 2). These are stunning numbers. But what relevance are such numbers to most of us who do not deal with tons of materials?

Figure 2

Energy Savings from Recycling a Ton of Various Materials

(million Btu/ton)



Source: USEPA (2019a)

[6] USEPA (2019a)

A life cycle assessment tool developed by the Environmental Protection Agency – the Waste Reduction Model (WARM), is available in a version (iWARM) which provides information for various quantities of individual materials. As an example we can find out using this source of information that discarding a single aluminum drink can, rather than recycling, results in the unnecessary expenditure of 2.97 thousand Btu, or enough energy to power a laptop computer for 5.8 hours, or a 60W equivalent CRT lightbulb for 22.3 hours. Energy savings are in addition to avoidance of mining replacement aluminum. Similar numbers, all obtained from iWARM are shown in Table 1.

Energy values as reported in Table 1 are based on full life cycle assessment which includes expenditure of energy from raw material extraction or collection for recycling through product use and disposal. In assessing differences between landfilling and recycling, energy used in transporting materials to landfill or alternatively collecting materials for recycling, and processing recovered materials for reuse or resulting emissions from the landfill (if any), are included.

Table 1

Energy Savings Resulting from Recycling Rather Than Landfilling Various Items

Item	**Energy consumption avoided by recycling vs. landfilling (1,000 Btu)***	**Number of hours that device could be run on energy saved**	
		60W equiv. CFL** lightbulb	Laptop computer
1 aluminum beverage can	2.97	22.3	5.8
1 steel soup can	1.33	10.0	2.6
1 metal coat hanger	1.43	10.8	2.8
1 wine bottle	1.43	10.8	2.8
1 plastic milk jug (1 gallon)	5.27	39.6	10.3
1 20 ounce. water bottle	1.37	10.3	2.7
1 corrugated cardboard box (2′ x 2′ x 2.5′)	17.20	129.2	33.6
1 daily newspaper	3.76	28.2	7.3
1 ream of printer paper	25.20	189.4	49.2
1 cereal box	1.74	13.1	3.4
1 plastic grocery bag	0.2	1.5	0.4

* This Table is intended to illustrate the impact of recycling common household items. It is important to note that there are large differences in the quantities of various materials compared. Consequently, there is no relationship between the magnitude of the numbers herein and impacts of different materials. For instance, a ream of printer paper weighs about 5 pounds, while a single aluminum beverage can weigh 0.02866 pound or $1/35^{th}$ of a pound. There are similar, but less dramatic, differences between other items on the list.

** Values in this column are for compact fluorescent light bulbs which deliver the equivalent of 60 watts. Were the comparison made in terms of hours of running a light-emitting diode (LED) bulb, the values would be even greater.

Source: USEPA, iWARM (2016)

Energy savings are accompanied by retrieval of materials for reuse and avoidance of the environmental impacts of additional mining, forest harvesting, primary processing of basic materials, and depletion of non-renewable resources.

What the numbers clearly show is that casually tossing a beverage can into a waste bin rather than taking a moment to find a recycling container has significant impacts. The same is true when other common items are relegated to the trash. There is no question that recycling is important and that it matters.

Recycling – Current Status

Municipal Solid Waste Overview

Municipal solid waste is generated by households as well as organizations of all kinds. Material is collected as either trash or separated from trash as recyclables. Considerable recovery for recycling of pre- or post-consumer waste occurs on a business-to-business level or outside of the MSW stream. For example, printing companies and publishers routinely return paper trim and scraps to paper mills for recycling; coal-fired power plants sell ash and boiler slag for use as aggregate in lightweight concrete masonry and as a raw material in production of Portland cement; salvage companies process junk vehicles for recovery of reusable and recyclable components; appliance retailers send old trade-in units to companies for dismantling and recycling of components; and cell phone companies collect traded-in units for resale and reuse in developing countries. None of this activity is accounted for in MSW statistics.

However, when paper, old tires or car batteries, cell phones, or appliances are discarded by consumers as trash, these do become part of national waste statistics. Some of these wastes are recovered from the waste stream, while others are not.

In 2018, 268 million tons (243 million metric tons) of MSW was generated in the United States, a quantity equivalent to 4.5 pounds (2.1 kg) of material per capita per day.[7] In comparison, while most other nations generated significantly less.[8] Daily waste generation per capita in Europe for 2018 averaged 3.0 pounds (1.3 kg) in 2018.[9]

In general, recycling histories for materials of all kinds show ongoing increases in recovery and recycling, in both absolute volumes and percentages of apparent consumption. But the record also shows far less than complete recovery for most materials. The U.S., for example, recycled 35.2% of MSW in 2017, a figure that includes food and yard wastes which were composted. The comparable figure for Europe was 47.0%.[10]

The 35.2% U.S. recycling rate adds up to over 62 million tons of materials recycled, and another 27 million tons composted. Materials recovered include metals, paper, plastics, glass, textiles, rubber, leather, and more. Another 34 million tons (27%) of waste was combusted with energy recovery.[11] The impact was substantial. A 2017 life cycle assessment (LCA) of

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[7] USEPA (2019b)
[8] OECD (2019)
[9] EUROSTAT (2019a)
[10] EUROSTAT (2019a)
[11] USEPA (2019b)

the environmental impact of MSW recycling, composting, and combustion with energy recovery in the United States showed reduction of annual carbon dioxide equivalent emissions by 184 million metric tons ($MMTCO_2E$), comparable to taking over 39 million cars off the road for a year.[12]

While the energy and emissions benefits of MSW recycling are impressive, recycling levels, and especially of some key materials, are quite low. For most materials, less than one-third, and often less than 20%, of the volume generated is recycled (Table 2). While recycling recovery data for individual items is for the most part not reported, some are, and these provide interesting insight into consumer behavior. A case in point is aluminum beverage cans.

Table 2

U.S. Generation, Recycling, Combustion with Energy Recovery, and Landfilling of Materials in MSW, 2017 (in millions of tons and percent of weight generated)

	Millions of tons				**% of weight generated**		
Material	Generated	Recycled	Combusted with Energy Recovery	Landfilled	Recycled (%)	Energy recovery (%)	Landfilled (%)
Paper/ paperboard	67.0	44.2	4.5	18.4	66.0	6.5	27.5
Glass	11.4	3.0	1.5*	6.9	26.6	-	60.4
Metals							
Steel	18.9	6.2	2.3**	10.4	44.8	-	55.2
Aluminum	3.8	0.6	0.6**	2.7	30.8	-	69.2
Other non-ferrous	2.3	1.5	0.1	0.7	69.1	-	30.9
Total metals	25.1	8.3	2.9**	13.8	44.9	-	55.1
Plastics	35.4	3.0	5.6	26.8	8.4	15.8	75.8
Rubber/ leather	9.1	1.7	2.5	5.0	18.3	27.4	54.3
Textiles	16.9	2.6	3.2	11.2	15.2	18.8	66.0
Wood	18.0	3.0	2.9	12.1	16.7	16.1	67.2

* Glass which winds up passing through energy recovery facilities is discarded with ash.

** Many of the metals which are mixed with other trash and which pass through energy recovery facilities are eventually recovered for recycling and are included in the reported recycled percentage.

Source: USEPA (2019b)

MSW Material Specifics

The percent of waste generation that is recycled has increased for most types of materials in recent decades. However, recycling rates for some materials are quite low, having changed little over time. Comparisons of reported U.S. recycling rates with those in the EU show consistently lower rates in the U.S (Figure 3). Although post-2017 data is not readily available, new numbers for plastics, when they become available, are likely to show sharp declines from 2017 due to the implementation of China's ban of importation of most plastic waste on January 1, 2018.

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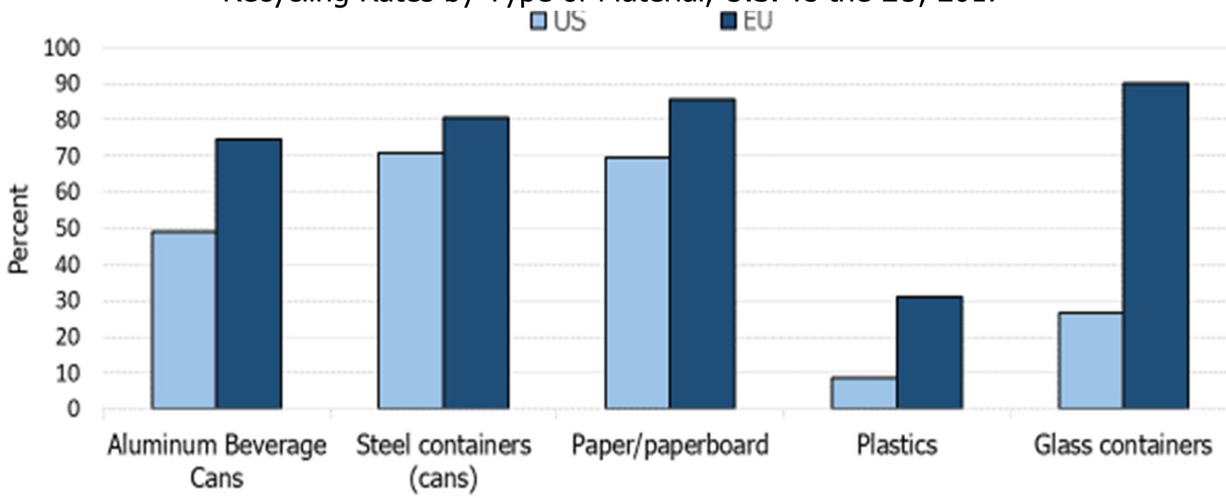
[12] USEPA (2019b)

A 2017 life cycle assessment of the environmental impact of MSW recycling, composting, and combustion with energy recovery in the United States showed reduction of annual carbon dioxide equivalent emissions of 184 million metric tons, a drop in emissions comparable to taking over 39 million cars off the road for a year.

Figure 3

Recycling Rates by Type of Material, U.S. vs the EU, 2017



Sources: Aluminum Association (2010, 2014), CanTech (2019), European Parliament (2018), Metal Packaging Europe (2019), Packaging Europe (2019), Eurostat (2019a, b), USEPA (2019 b, c, d, e, f, g, h)

Aluminum Beverage Cans

The aluminum Americans discard to trash each year includes beverage cans (about one-third of aluminum discards); foil and baking trays, and pie plates; and various durable and non-durable goods such as kitchen appliances (e.g., toasters, blenders, and coffee-makers).

Among aluminum discards to MSW, the most recycled is beverage cans.[13] In 2017, about 77 billion aluminum cans containing beer, soft drinks, flavored water, and other beverages were sold in the United States. About one-half of the used containers were recycled (49.8%), but roughly 39 *billion* (or 117 for every person in the U.S.) were discarded to trash and sent to landfill. In addition to creating the need for additional mining and associated impacts to replace metals lost to further use, unnecessary discard of aluminum cans results in additional energy demand equivalent to the total annual energy consumption of 300,000 residential homes. In contrast to the U.S., recycling of aluminum beverage containers in Europe in 2017 averaged 74.5%.[14]

Steel

Steel sent to MSW includes steel contained in appliances, furniture, tires, food containers (cans), steel strapping, drums, and more. The greatest realized recycling rate is for steel cans (70.9% in 2017). Recycling of ferrous metals from large and small appliances, furniture, and

[13] USEPA (2019e)

[14] Metal Packaging Europe (2019)

tires, all of which present recovery and recycling challenges – especially when discarded to trash – was much lower, with only 27.8 percent recycled in 2017.[15] The steel packaging (cans) rate in the EU in 2017 was 80.5%.

Other Non-Ferrous Metals

The "Other nonferrous metals" category includes such metals as lead, copper, and zinc. Lead in lead-acid batteries accounts for 70% of these metals, of which 99% is recovered for recycling, the result of laws making it illegal to dispose of these in the trash. Very little of the other types of metals is recycled. Included among the other types of metals for which little is recovered are precious and rare earth metals commonly found in batteries and consumer electronics, including cell phones.[16] Despite being high environmental impact metals, less than 1 percent of these are recovered when they enter the waste stream, a problem that exists worldwide.[17]

Paper and Paperboard

With a recycling rate of 65.9% in 2017 (68.1% in 2018), more paper and paperboard is recovered from the MSW stream for recycling in the U.S. than any other material. Additional quantities are combusted for energy recovery. That said, 18.4 million tons were discarded to trash and subsequently sent to landfill in 2017. While some of this is unavoidable, such as paper food wrappers and paper towels, much of the volume of paper going to landfill is avoidable through more care when discarding. In this case, recovery for recycling could be improved if clean paper were always placed in recycling bins rather than the trash, and if greater care were taken to keep food and liquids out of the recycling bin which can contaminate paper and make it unrecyclable. The 2017 paper and paperboard recycling rate in the EU was reported at 85.8%.[18]

Plastics

Plastics present a special challenge. The volume of plastic discards is growing steadily. Huge volumes are placed in the trash (over 35 million tons in 2017), with less than 10 percent of generation to MSW recycled. The problem here is twofold:

1) A large portion of plastic discards – much of which is plastic bottles – are placed in the trash rather than in recycling bins.
2) There are relatively few opportunities for recycling plastics, and consequently a lack of markets for plastic waste, which often results in plastic going to landfill, including that which is initially placed in recycling bins.

While there has been progress in plastic waste recycling over the past several decades, which appears impressive if viewed as a single statistic (Figure 2a), there has been far greater growth in volumes of plastic waste that are not recycled, a reality that serves to place gains in recycling in context (Figure 2b). A lack of markets for waste plastic, coupled with ongoing

[15] USEPA (2019d)
[16] MIT (2012), Gutiérrez-Gutiérrez et al. (2015)
[17] UNEP (2011)
[18] Packaging Europe (2019)

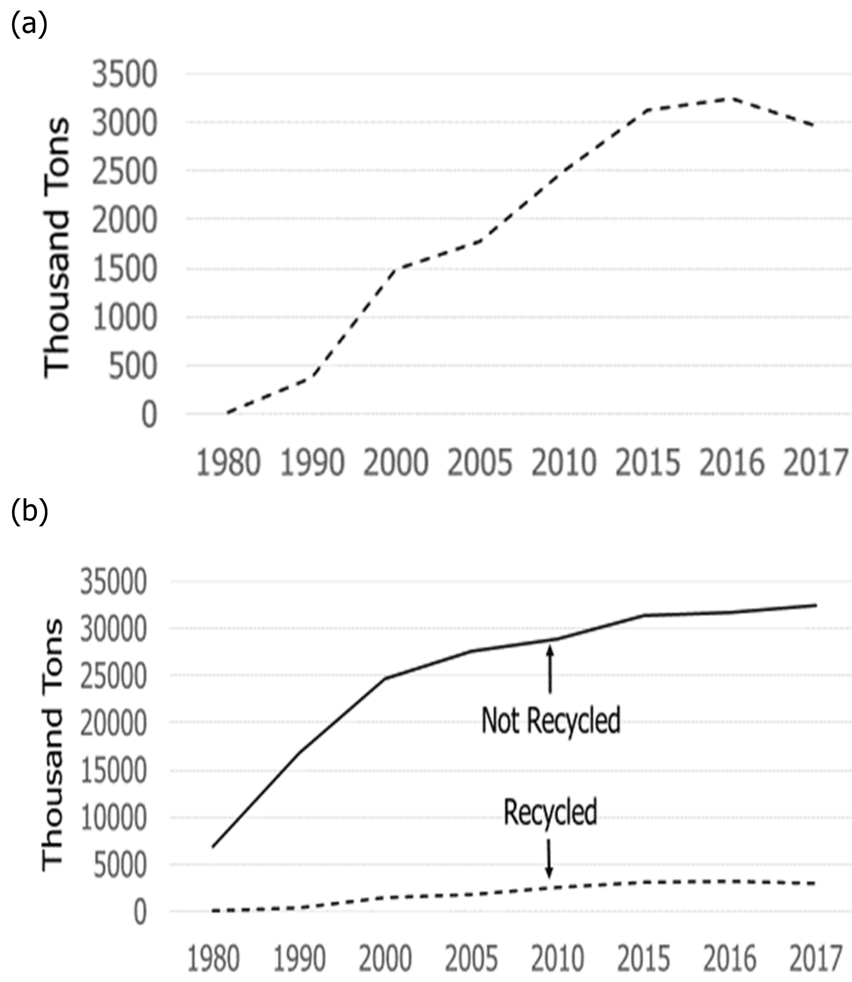
growth in production of plastic containers and other products, has resulted in a virtual tidal wave of plastic discards. In Europe, 30% of waste plastic was recycled in 2016.

A significant fraction of plastic discards are combusted for energy recovery in both the U.S. and EU, a practice that some believe should be expanded. This is discussed later in this report.

China's early 2018 decision to stop accepting plastic waste shipments from the U.S. is not reflected in Figure 4.

Figure 4

Volumes of Plastic Waste Recycled (a) and Volumes of Plastic Recycled vs. Not Recycled (b) 1980-2017



Source: Based on Data from USEPA (2019g)

Glass

Glass which winds up in MSW is primarily in the form of beverage bottles, and jars for food, cosmetics, and other products. Minor quantities of glass in MSW occur as parts of furniture, appliances, consumer electronics, and other durable goods. Of more than 11 million tons of

U.S. glass generation to MSW in 2017, less than 30% was recycled, with most sent to landfill.[19] The U.S. glass recycling rate is far lower than in other countries.

Questions about the Worth of Recycling

Just Not Worth It

Rather than working to push the U.S. recycling rate higher, some question why household waste recycling is being pursued at all. To these people, recycling represents a waste of both time and money, or worse.

John Tierney, a former reporter and columnist for the New York Times, and noted contrarian, famously wrote in a 1996 New York Times Magazine column that "Recycling does sometimes make sense -- for some materials in some places at some times. But the simplest and cheapest option is usually to bury garbage in an environmentally safe landfill . . . Recycling may be the most wasteful activity in modern America: a waste of time and money, a waste of human and natural resources.[20] He doubled down on this theme in a more recent article.[21] Others have expressed similar views. One, for instance, referred to recycling efforts as "naive, pro-recycling propaganda that has been used to successfully brainwash millions of American school children for the last quarter century." [22] TV personalities Penn and Teller also heaped scorn on recycling efforts as part of a 2004 broadcast. Another concluded that "some areas of the recycling industry not only harm the environment, but directly impair our health as well."[23]

Recycling is Important, But . . .

Still others have criticized recycling in more nuanced terms, expressing the view that while recycling of some materials is clearly beneficial, efforts to recover and recycle others are clearly not.[24] Critics are particularly focused on plastics recycling.

Dr. Andrew McAfee, a principal research scientist at MIT, argues in a recent book that attempting to sort plastic for recycling is ultimately a waste of time and energy, that recycling plastic uses up a lot of unnecessary resources, and that after all of the hauling around, sorting, and processing of bottles and containers, it is often ultimately thrown away or burned. His view is that plastics should be simply disposed of in carefully managed landfills.[25] Another perspective that is gaining traction, even among some environmental groups, is that in view of growing volumes of plastic waste despite efforts to increase recycling, combustion for energy recovery is a viable option. As most plastics are made from fossil fuels, primarily natural gas, and embody considerable volumes of energy, there is, in fact, significant potential for energy recovery from combustion. About one-sixth of U.S. plastic waste is currently burned for energy recovery, with this practice even more common in Europe. There

[19] USEPA (2019f)
[20] Tierny (1996)
[21] Tierny (2015)
[22] Perry (2015)
[23] Tsang (2018)
[24] Payton (2015)
[25] McAfee (2019)

are, however, technical and logistical issues which must be overcome to expand energy recovery, including the fact that plastics burn hotter than other components of MSW.[26]

Opponents of burning for energy recovery argue that recycling plastic for reuse saves considerable energy compared with producing virgin plastic, and that developments in research may soon lead to broad scale recycling solutions.[27] Supporting this argument is a late 2019 announcement by the U.S.-based Eastman company that it had begun operation of a commercial-scale chemical recycling process that diverts mixed waste plastic from landfills and converts it into simple molecular components that are then reintroduced in the production of a variety of Eastman products. The company has also announced development of a chemical recycling process specifically for polyester waste, including colored PET and copolyesters, which produces virgin-like materials.

One recent study found that the potential annual energy savings that could be achieved from recycling all global plastic solid waste is equivalent to 3.5 billion barrels of oil, worth approximately $176 billion dollars.[28] Another found significant environmental benefits from recycling vs. incineration for power generation.[29]

Others question collection of glass for recycling, citing breakage and contamination of mixed materials, relatively low energy benefits of recycling compared to other materials, and abundance of the raw material used in making glass – sand. For these reasons, an increasing number of municipal recycling programs have recently stopped accepting glass.[30] Yet, in Europe, the vast majority, 90%, of glass is recycled.

Barriers to Greater Recycling

The Single Stream Problem

The rise in U.S. recycling participation illustrated in Figure 1 is largely attributed to a shift from multiple stream to single stream recycling.[31] The change was aided by a 2006 Government Accounting Office study of recycling which identified three key strategies for increasing citizen involvement: 1) make recycling easy and convenient, 2) offer financial incentives, and 3) increase public education and outreach.[32] This study stimulated a spate of Congressional and state legislation to promote recycling which played a role in the rapid rise in single stream adoption after 2005.

The shift in community adoption of single stream systems, from 29 percent to 80 percent in less than a decade, and the accompanying improvement in recycling participation, was widely hailed as a great achievement. However, the shift also triggered a change in citizen behavior. While public education and outreach efforts which accompanied introduction of single stream

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[26] Tulio (2018)
[27] Shen et al. (2010), Thunman et al. (2019)
[28] Rahimi and Garcia (2017)
[29] Bergsma et al. (2011)
[30] Anonymous (2018), Sloan (2019)
[31] Single stream recycling systems do not require the sorting of materials. Mixed materials to be recycled are collected in a single container (single stream). Sorting and separation of materials by category (paper, plastic, metals, glass, etc.) occurs at recycling centers.
[32] GAO (2006)

systems were successful in raising awareness of recycling, increased interest in recycling, coupled with widespread distribution of large household recycling containers, also led to an increase in contamination of recyclables.

Contamination of recyclable materials can take the form of thin plastic bags that gum up separation systems in recycling plants, light bulbs which shatter and become pressed into surfaces of paper, strings of Christmas lights which create multiple problems, liquids that can saturate paper and cardboard and ruin its recyclability, batteries, soiled food containers, used napkins, and so on.[33] Placement of used diapers in recycling bins is a significant problem which can result in diversion of an entire load of recyclables to landfill.[34] In 2009, as the rapid shift to single stream systems was getting underway, recycling contamination in the U.S. averaged 7 percent. By 2014 that figure had increased to 16 percent, and by 2018 to 25 percent.[35] Some communities report significantly higher contamination levels. Large quantities of otherwise recyclable materials can be ruined by contaminants, resulting in diversion to the landfill. Moreover, the costs of pick-up, hauling, separation, and disposal of a quarter or more of materials collected adds to the costs and environmental impacts of recycling.

A 2015 study of practices in the EU, where recycling rates are substantially higher than in the U.S., showed that only two of the 28 countries which were then part of the EU employed single stream systems. A primary finding of this study was that separate collection leads to higher recycling levels.[36] This factor alone likely explains much of the large difference in recycling success. Another factor is likely education and tradition. One observer explains that whereas Europeans have been recycling for many years, and children there are educated about it at school and at home starting at a young age, there is far less attention to this issue in U.S. schools.[37] Some European countries also employ trash collection systems which incentivize recycling. In France, for instance, customers pay each time the trash can is emptied. Not by weight, but by the size of the trash can.

The contamination problem is leading more and more people to the conclusion that the U.S. needs to replace single stream systems with dual stream systems, wherein aluminum and steel cans, glass jars and bottles, and plastic bottles are place in one bin, and all forms of paper are placed in another, or some variation of this.[38] There is also increasing recognition that greater attention to education regarding what to recycle, and what to keep out of recycling bins is needed. In this regard, a Recycle Act bill was introduced in the U.S. Senate in November 2019 (S 2941) which would provide $75 million to recycling education programs across the country. Some of those who support this effort note that high rates of contamination are not necessarily a given with single stream recycling, and that education can bring contamination rates down regardless of the system employed. As of this writing,

[33] Koerth (2019), Bell (2018)
[34] Koerth (2019)
[35] Toto (2019)
[36] European Commission (2015)
[37] Jacoby (2019)
[38] Jacoby (2019), Fitzgerald (2019), Container Recycling Institute (2015), Toto (2019)

this bill, which has a companion measure in the House of Representatives, remains under discussion.

Limits to Recycling/Closed Loop Recycling

Obtaining 100% recycling (or complete closed loop recycling) is virtually impossible even if collection systems are optimal. For this reason, success in recycling needs to be viewed through this lens.

Some paper, for instance, is lost to recycling when it is used as tissue or for wrapping food or is flushed. In addition, the fiber that makes up paper degrades a bit with each reuse, with the result that a flow of virgin fiber is needed in each round of recycling.

Material which goes into long-term use, such as steel, aluminum, or wooden timbers used in building construction is not available for re-use for a considerable period. Therefore, if in any given year the quantity of a particular material put into long-term use exceeds the rate of addition of that material to the waste stream, then the recycling rate for that year will by necessity be less than 100%.

For other materials, the problem is contamination. Steel, aluminum, and copper are all commonly described as infinitely recyclable. And that is true in theory. However, unless used in pure form and never mixed with other materials, both steel and aluminum are prone to increasing contamination with each cycle of reuse. The problem has to do with purposeful combination with other metals to form alloys and subsequent impossibility of separation of metals in recycling at current levels of technology. Copper contamination of steel is a serious problem, and the result is negative impact on steel after repeated recycling as well as loss of copper to production of more copper. Metals can also become contaminated with other materials in mixed waste collection systems.[39] The contamination issue explains why, for example, the US is a net importer of steel while at the same time a net exporter of scrap steel.

Taking Steps to Improve Recycling Rates

What Individual Consumers Can Do

Many of the difficulties in seeking greater recycling success are linked to attitudes, knowledge, and behavior of individuals. As a result, collective action by individuals within a community can go a long way to improving recycling performance.

Things that you can do include:

- Paying attention to and following local recycling guidelines.
- Never placing plastic bags, liquids or liquid-filled containers, food waste, food papers, used tissue, dirty diapers, rags, and other problematic materials into recycling bins.
- Never discarding aluminum or steel cans in the trash.
- Carrying a spare bag in vehicle glove boxes for use when waste is generated and recycling bins are not available.
- Teaching children the importance of recycling, as well as dos and don’ts.
- Encouraging attention to recycling in middle school and high school curricula.

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[39] Reck and Graedel (2012), Chandler (2012), Daehn et al. (2017), Nakajima et al. (2010), Söderholm and Ekvall (2018), Televisory (2020)

- Supporting local, state, and national initiatives to expand curbside collection of recyclables to communities in which such service is not available.
- Encouraging and supporting community efforts to improve recyclables collection and recycling efficiency, including community education.
- Encouraging and supporting community exploration of conversion from single stream to dual stream recyclables collection.
- Encouraging and supporting efforts to improve recycling efficiency in the workplace.
- Be open to new approaches to dealing with plastic waste, including the possibility of waste to energy.

Summary

Recycling reduces the amount of waste sent to landfills and incinerators, conserves natural resources, increases economic security by tapping a domestic source of materials, reduces the need to collect new raw materials and the environmental impacts linked to raw material extraction, saves energy, reduces emissions of greenhouse and other gases, supports local manufacturing and conserves valuable resources, and helps to create jobs domestically. Comprehensive life cycle assessments confirm that there is significant environmental benefit to recycling.

Recycling performance in the U.S. lags other developed countries, in part because of systems used and consumer knowledge and habits. There is significant potential for improvement with shifts in policy, practice/culture, and education of both children and adults.

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