Abstract

This paper examines stagnant recycling rates in the U.S. and explores what actions can be taken to improve them. It seeks to answer the question: what can be done to increase the likelihood that an individual would participate in a recycling program? Through a series of informal interviews and online research, the author identified the underlying issues. They involved both the psychological and physical aspects that are involved in the act of recycling, concluding that recycling must be made simpler by addressing both physical and mental effort perceived. At the conclusion of the paper, the author details a concept for the creation of a dual trash/recycling container that should significantly increase household recycling.

Executive Summary

Through a meeting with the City of Cincinnati's Sanitation Department, the author became aware of the city's efforts to track its recycling rates. Utilizing RFID (Radio Frequency Identification), the city monitors residents' recycling carts and determines which households are actively recycling. The data revealed a pattern that demonstrates that the wealthier neighborhoods in the city recycle at a significantly higher rate than lower-income areas.

Identifying the possible barriers to recycling was accomplished by using a combination of online research methods and informal interviews. Once the author identified the barriers, he explored possible solutions, which could broadly and effectively address the issue at hand.

The ultimate goal of this project was to determine which method(s) could be used to increase resident participation and to explore methods to overcome both the physical and mental barriers to recycling. The author concluded that the recycling process must be made easier for individuals. It must be convenient and require as little effort as possible. The following pages of this text describe how this could be accomplished by following two simple strategies addressing the mental and physical barriers to recycling within the home.

Introduction

If you want to get people to do something, make it easy. Remove the obstacles.

Richard H. Thayer and Cass R. Sunstein, 2009

The path of least resistance is a metaphorical pathway describing how making any means more accessible increases the likelihood of a person to follow it. The implication is that the more accessible option will likely eclipse the more difficult one. However, there is no guarantee that making something easy to do will succeed in changing behavior. If communities care about increasing recycling rates, they must utilize the principle of least effort by making recycling a manageable option for households.

Adventurer Robert Swan posited that "the greatest threat to our planet is the belief that someone else will save it" (as cited in Stevenson, 2012). Therefore, the motivation behind this project was a desire to make the world a more sustainable place to live by identifying the problem and attempting to solve it.

The City of Cincinnati (2016) became part of the ZeroCycle's Resident Engagement Waste Reduction Pilot Program in 2014. It is through this program that they received and analyzed data on recycling rates through the use of Radio Frequency Identification Tags (RFIT) (Waste 360 Staff, 2018). The purpose of these tags was to identify how often residents' carts were lifted or *tipped* by the recycling truck. The cart had to be tipped on at least one of the two recycling days each month to meet the criteria for active participation. The City of Cincinnati's Office of Performance and Data Analytics made this information available to the public (City of Cincinnati, 2019).

The data revealed that lower-income neighborhoods were recycling far less than wealthier neighborhoods despite the city's ongoing educational efforts to raise residential awareness on recycling. At first glance, it would appear that income was directly related to participation rates. However, the city provided the program to residents at no cost.

Increasing Individual Participation in Recycling Programs

Problem

The ultimate goal for many municipalities, including the City of Cincinnati, is to achieve zero waste (U.S. Chamber of Commerce, 2019). If communities are serious about achieving this

goal, recycling rates would need to increase significantly. Businesses are already achieving inroads into recycling their waste. However, individual households are not as successful. Therefore, individual households must be the target audience. Moreover, if the approaches currently being taken are not generating the desired results, it is time for a new strategy.

Of course, recycling is only one part of the environmental equation. However, it has the potential to be significantly improved just by using a few simple strategies. The purpose of this project was to identify a solution that would potentially have the highest likelihood of making a positive impact on participation rates. It would mean going beyond the surface of the problem and identifying its root causes. Once the author identified the causes, he explored the actions that could be taken to address those underlying issues and create change.

Some of the reasons why recycling is difficult for residents to achieve is that their kitchens do not have enough space to include a recycling can and a trash can. Conversely, residents who have access to an attached garage off of the kitchen can store an additional container. However, if the recycling bin is located in a detached garage, the resident may find it inconvenient to go outside to recycle. Then again, residents who live in an apartment complex may be required to walk their recyclables to a trash room, while others may live in a place that provides a trash valet service that may take recyclables.

For these reasons, making recycling easier became the focus of this project. The pattern of wealthier neighborhoods recycling more than impoverished neighborhoods exists. However, income level distracts from the real reasons for the recycling rate disparity. It was the author's attention to this income pattern that delayed this project over the last year.

After much study, the author's research question changed to "Would creating an environment that makes the act of recycling more convenient within the home increase the likelihood of participation?" If the answer to that question were, "yes, it would," then the next question was, "how?" The author endeavored to learn what could be done right now that would have a positive impact on the likelihood of taking non-participating homes and turn them into participating homes.

Evidence

A survey issued to residents in two counties in Ohio led to the conclusion that "Making recycling easier and more convenient is likely to increase recycling rates" (Voinovich School of Leadership and Public Affairs at Ohio University, 2012), p. 10). The survey also showed that

"information barriers" would likely be the barrier most easily addressed. The study determined that communication must be simple so that people can retain the message. Nodoushani, Stewart, and Kaur (2016) concur. They argued that too much information communicated to people would create confusion and make it harder for them to recall specific information. Moreover, they said, the result might be *information blindness* or information overload.

Moreover, the Institute of Scrap Recycling Industries conducted a poll of over 2,000 Americans to better understand their attitudes on recycling (Goldsberry, n.d.). They found that recycling is a behavior that needs to be made easier for Americans; otherwise, it may not get done. The survey also found that "Two-thirds (66%) of Americans agree that 'if a product is not easy/convenient for me to recycle, I probably will not recycle it'" (para. 1.)

Hartmann (2019) wrote that a Keep America Beautiful Survey revealed that 34% of respondents indicated that "when deciding where to dispose of an item, people default to the closest receptacle" (para. 8). The results of the survey offered a simple solution, "The design and placement of bins must adapt to consumer needs by being conveniently placed and simple enough to be used properly without focused concentration" (para. 9). Furthermore, the survey found that when recycling and trash were co-located, communities realized "15% less contamination and increased the capture rate for recyclables by 30%" (para. 10).

Garcés, Lafuente, Pedraja, and Rivera (2002) conducted a study in which they concluded that "perceived personal difficulties (space and time availability) and distance to and from the container have a negative effect" (p.1). Furthermore, they found that attitudes toward recycling and the behaviors that follow do not always draw a parallel. In fact, they found that if circumstances that enable good intentions are not ascertained, recycling attitudes will not result in the expected behavior (Garces et al., 2002).

Moreover, Lee and Ralston (2003) of the University of Utah conducted a study that examined the idea of convenience. In this study, they tested three different methods to increase recycling within the hotel industry: (a) a recycling bin inside the guest rooms, (b) in-room recycling with informational signage, and (c) a central recycling bin with signage. The researchers found that "treatment 2 (in-room recycling bin and signage phase) generated the greatest amount of recycling materials for each type of material" (p. 3). Not only did the second method generate the highest number of recyclables, but both methods 1 and 3 material collections were significantly less than method 2 (Lee & Ralston, 2003). Research conducted by

do Valle, Reis, Menezes, and Rebelo (2004) came to a similar conclusion. They found that previous research showed that the functioning of recycling services and the apparent convenience might directly affect participation levels.

Response

Arriving at the best solution meant eliminating possible causes as well as impossible solutions. The author eliminated income level as a possible cause after learning that the City of Cincinnati (2016) currently provides recycling to residents at no cost. A practical yet impossible solution that the author eliminated was a *pay as you throw* campaign (Dahlen & Lagerkvist, 2010). Although pay as you throw is one of the most effective ways to quickly motivate people to reduce their waste, the City of Cincinnati provides free waste collection, thereby making this method moot.

Strategy and Solution

The main strategies were a combination of encouraging the act of recycling by showing that waste has value, and creating a situation where the physical act of recycling was simplified. In recent years, recycling has received some bad press, much of it well deserved. China's banning of plastic and cardboard recyclable material imports from America has caused significant disruptions across the industry. (Ivanova, 2019) Therefore, improving the efficiency of the recycling process is now more significant than ever.

Demands on the planet's natural resources are on the rise, and communities must work to become leaders in decreasing both waste and material demand. For municipalities to accomplish this, they must attempt a new strategy, one that will complement efforts that are already widely in place. Communities must make recycling easier for people than it has ever been before. It must be convenient for everyone. Municipalities must create a situation within the home that ensures the separation of waste and recyclables happen at the point of disposal.

By creating an environment where recycling is easy, we remove an obstacle. Studies examining Environmental Alteration techniques have been shown to influence recycling rates positively. "By altering the environment, researchers have made recycling more convenient and easier to perform, thus reducing the response cost of recycling (Porter, 1995). Two examples of environmental alteration techniques shown to have a positive effect were increasing the proximity of the container to the potential recycler, and providing containers for curbside recycling.

Communities must consider the idea of a low-cost, single-point container that accepts both waste and recyclables at a single point within the home. People would likely recycle in a scenario with a single point of disposal rather than one where a trash container is in the kitchen while the recycling container is in the garage. Furthermore, people would likely prefer to recycle with a single-point container inside the home rather than recycling outside of the home where mobility and the elements make it more challenging.

Accompanying the container should be a flyer that provides service area-specific guidance, detailing what material is acceptable, as well as the future potential of that material. Penn State's (2019) study found that "When consumers are reminded of the products that their recyclables can be turned into, they are more likely to recycle;" for example, a "plastic bottle becomes a jacket, an aluminum can a bicycle" (para. 1).

Final Product

Funding has been an ongoing struggle throughout this project. The author's multiple moves around the U.S. and required travel meant that establishing a steady and timely funding partnership was never accomplished. Moreover, generating interest in the project with just an idea and no physical product was a problem. Therefore, the author decided to move forward without financial support with hopes of establishing a partnership after completing the final design and prototype development.

At the start of this project, there was no low-cost option on the market for dual-purpose containers. However, in early 2019, Hefty released its Dual Function XL Trash Can at a price point of roughly $25. The introduction of this new Hefty product eliminated one of the characteristics that would make the author's design unique. However, the Hefty container had weaknesses that the author could improve upon by design.

The author, working in tandem with a mechanical engineer, sought to create an end product that would be functional while maintaining low production costs and designed in a manner that would make it efficient to ship. The basic design of the new container was that it had to accept both recyclables and waste, with the recyclable side being effortless to remove for disposal independent of the waste side. This dual design was critical as it eliminates the need to use a trash bag that so many materials recovery facilities (MRF) dread. In fact, some facilities have a policy that requires transfer to a landfill of any materials received in a non-see-through plastic bag. They view the risk of introducing unknown contamination into the recycling stream

a possibility not worth exploring, and so instead landfill the bag. That is the weakness of the Hefty design that the author would improve upon in his design.

Further design details include three cutouts in the outer container that hold the recyclable container in place. The recycling bin itself has slight bulges that will lightly snap into place when inserted. The primary material of choice was ABS plastic due to its relatively stable characteristics, as well as it is a commonly used material in engineering prototyping.

Next Steps and Lessons Learned

The author created a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to examine the strengths and weaknesses of his design together with opportunities and threats of the marketplace environment. The following SWOT analysis (see Figure 1) provides the basic outline that the author used to perform his analysis.

Strengths	Weaknesses
A solution that addresses both convenience and education. A prototype that is dual-purpose, visually appealing, simple, inexpensive to produce, and inexpensive to ship. Eliminates the need for a plastic bag, thereby eliminating material contamination. A unique feature where the recyclable section is easily removed for easy disposal and easy cleaning. Adaptable design, dimensions, number of streams accommodated, the color of container, and the literature/flyer disseminated are all adaptable to individual customer needs. No matter how it is configured, the container makes recycling convenient by addressing the problem at the source of separation.	Full-scale rollout would require significant funding. Affected by recycling market forces such as the China ban and incinerators burning material for energy. No personal experience bringing a product from idea to reality.
Opportunities	**Threats**
At the start of this project, there was no low-cost dual-purpose container on the market. In early 2019, Hefty released a low-cost dual-purpose container with weaknesses that were answered through this project. The Hefty container does not have a removable section for recyclables, and, instead, is designed for the use of two trash bags simultaneously. Plastic bags for recyclables must be see-through in many municipalities. If they are not, the material often ends up in the landfill, which defeats the purpose of the container.	Easily mimicked or even improved. The costs of recycling are on the rise, with some municipalities suspending their programs altogether.

Figure 1. SWOT analysis.

The design portion of this project is a complex, ongoing process. Moreover, there is far more to creating a functional design than initially expected. The author learned that his hesitation to move forward without a funding partner put the project behind its planned schedule (for the current schedule and work breakdown structure, see Figures 2 and 3). Another lesson the author learned was to follow the evidence that was in front of him. Although the answer might be simple, there were difficulties along the road to implementation that seemed daunting.

The engineer created an *exploded view* version of the design that show the individual pieces of the assembly pulled apart, combined with two-dimensional drawings with specifications for the manufacturer (see Appendix). The goal is to have a prototype container that can be used to present to local parties who garner interest in the product. In addition to reaching out to local parties, the author intends to reach out to non-local organizations that have access to funding and investors, including the trash valets, waste management companies, and environmental-focused nonprofits.

Finally, in addition to these previously mentioned organizations, the author intends to reach out to existing waste bin companies with the experience and network in place to reach the masses. He attempted this in late 2018 by contacting both Hefty and Rubbermaid. Rubbermaid never responded to the inquiry. While Hefty responded by saying they were not interested. In hindsight, they were likely in the final stages of releasing their own affordable yet flawed dual-purpose container.

Conclusion

This project is a work in progress and will carry on into 2020. The author hopes that the final tested design will reach a broad audience by tapping into the long reach of municipalities, nonprofits, environmental groups, and trash valet companies. The world is becoming more aware of environmental issues as well as the urgency of making a change now.

Population growth and the growth of the worldwide middle class require that people change the way that they are living. The reality is that it is not just consumption habits, but what people consume as well (e.g., what is being produced by mega-corporations and provided to the world). If people are serious about this problem, they must demand that material extraction, production, and consumption practices change. It is a big problem that will require significant changes and will require pushing past serious resistance.

Recycling is but a small answer to an even bigger problem. An old proverb says, “How do you eat an elephant? One bite at a time.” If people and communities are not doing the small things, then it cannot be expected that they will do bigger things. The small things are all part of the larger picture, which is a connected system where actions mean improvements for the greater good. If municipalities and waste management companies are earnest about zero waste, they must take a step back and examine their efforts to see if they are garnering the results they desire. If they are not, then it is time to try something new. It is time to simplify the action they wish to take. They need to make recycling more manageable than it has ever been before.

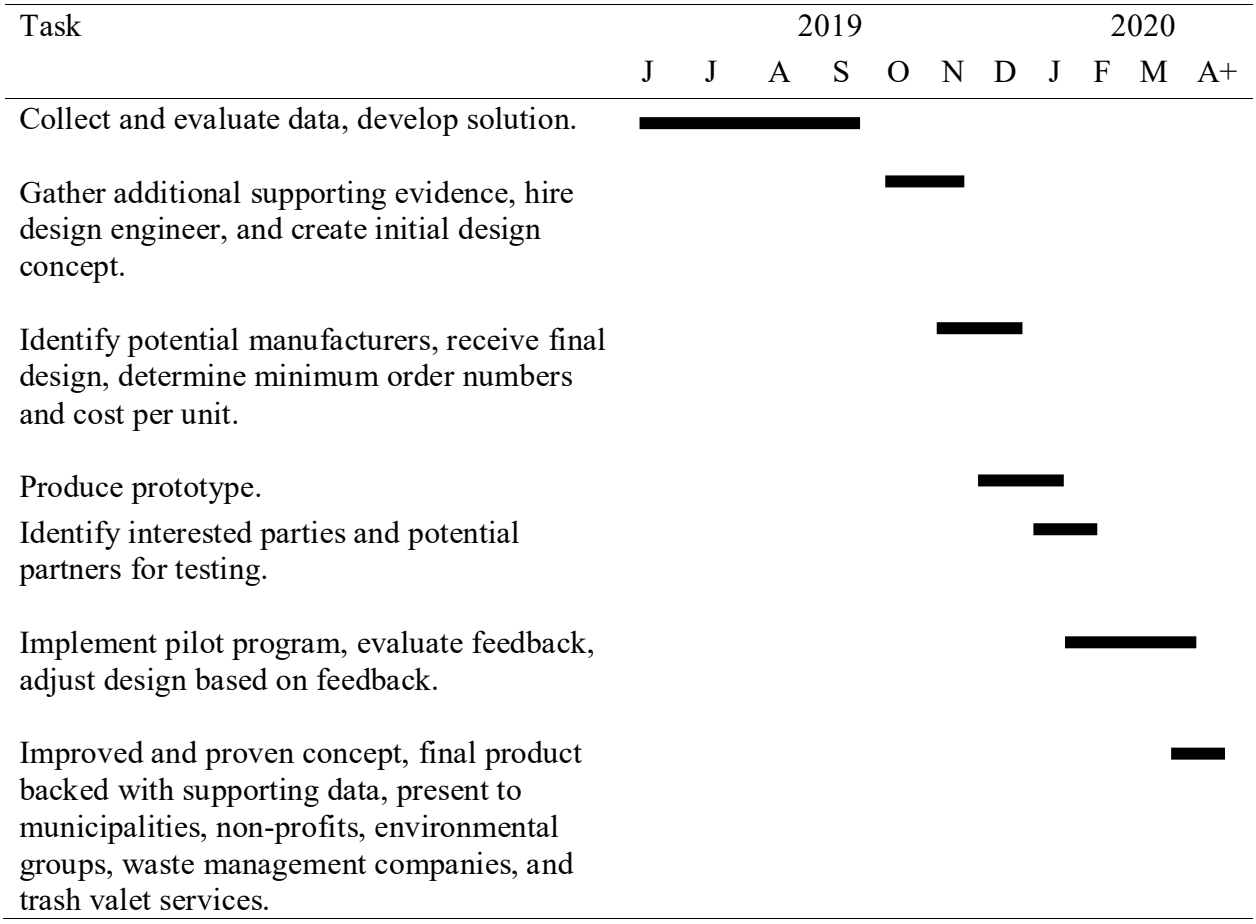

Figure 1. Project timeline.

WBS Code	Definition
1	Data
1.1	Informal Survey and online research
1.1.2	Summarize findings, determine solution
2	The idea and product development
2.1	Market research/product viability
2.1.1	Design engineer, develop basic design
2.1.2	Refine//finalize design, prototype
3	Material and manufacturer selection
3.1	Identify cost effective material
3.1.1	Identify potential manufacturers
3.1.2	Develop prototype
3.1.3	Identify cost per unit/minimum order
4	Seek parties interested in pilot
4.1	Acquire funding
4.1.1	Test for product effectiveness
4.1.2	Integrate provided feedback
5	The final product
5.1	Proof of concept/full-scale rollout
5.1.2	Licensing

Figure 2. Work breakdown structure (adapted from E. Christensen, 2017).

References

Christensen, E. (2017, Jan 23). How to create a work breakdown structure and why you should [Blog post]. Retrieved from https://www.lucidchart.com/blog/how-to-create-a-work-breakdown-structure-and-why-you-should

City of Cincinnati. (2016, July 13). Cincinnati part of Zerocycle's Resident Engagement Waste Reduction Pilot Program [Web page]. Retrieved from http://www.cincinnati-oh.gov/recycling/news/cincinnati-part-of-zerocycle-s-resident-engagement-platform-pilot-program/

City of Cincinnati. (2019). Recycling participation [Web page]. Retrieved from https://insights.cincinnati-oh.gov/stories/s/Recycling/gd3w-zpnu

Dahlén L., & Lagerkvist A. (2010). Pay as you throw: Strengths and weaknesses of weight-based billing in household waste collection systems in Sweden. *Waste Management*, *30*(1), 23–31. doi: 10.1016/j.wasman.2009.09.022

Do Valle, P. O., Reis, E., Menezes, J., & Rebelo, E. (2004). Behavioral determinants of household recycling participation: The Portuguese case. *Environment and Behavior, 36*(4), 505–540. https://doi.org/10.1177/0013916503260892

Garcés, C., Lafuente, A., Pedraja, M., & Rivera, P. (2002). Urban waste recycling behavior: Antecedents of participation in a selective collection program. *Environmental Management*, *30*(3), 378–390. https://doi.org/10.1007/s00267-002-2601-2

Goldsberry, C. (n.d.). If you want us to recycle, make it easy, says poll [Web article]. Retrieved from https://theharrispoll.com/if-you-want-us-to-recycle-make-it-easy-says-poll/

Hartmann, R. (2019, Feb 25). Impact occupant behavior to increase recycling rates [Web article]. Retrieved from https://facilityexecutive.com/2019/02/impact-occupant-behavior-increase-recycling-rates/

Ivanova, I. (2019, March 20). American cities confront a "slow-moving recycling crisis [News article]." Retrieved from https://www.cbsnews.com/news/recycling-after-chinas-plastic-ban-american-cities-face-recycling-crisis/

Lee, J., & Ralston, L. S. (2003). *The influence of signage and proximity of recycling bins on the volume of recycling materials generated at a hotel.* Department of Parks, Recreation, and Tourism, University of Utah.

Nodoushani, O., Stewart, C., & Kaur, M. (2016). Recycling and its effects on the environment. *Target Journal: Competitive Forum*, *14*, 65–69.

Penn State. (2019, July 10). Awareness of product transformation increases recycling: When consumers are reminded of the products that their recyclables can be turned into they are more likely to recycle. *ScienceDaily*. Retrieved from www.sciencedaily.com/releases/2019/07/190710121549.htm

Porter, B. E., Leeming, F. C., & Dwyer, W. O. (1995). Solid waste recovery. *Environment and Behavior*, *27*(2), 122–152. doi: 10.1177/0013916595272002

Stevenson, A. (2012, May 01). Robert Swan OBE: "The greatest threat to our planet is the belief that someone else will save it [Web article]." Retrieved from https://www.huffpost.com/entry/robert-swan-antarctica_b_1315047

Thayer, R. H., & Sunstein, C. R. (2009). *Nudge: Improving decisions about health, wealth, and happiness.* New York, NY: Penguin

U.S. Chamber of Commerce Foundation. (2019, May 22). U.S. Chamber Foundation expands 'Beyond 34' recycling initiative to Cincinnati [Web page]. Retrieved from https://www.uschamberfoundation.org/press-release/us-chamber-foundation-expands-beyond-34-recycling-initiative-cincinnati

Voinovich School of Leadership and Public Affairs at Ohio University (2012, Sept). Zero Waste Residential Survey (2012) [Report]. Retrieved from https://www.ohio.edu/voinovich-school/news-resources/reports-publications/zero-waste-residential-survey-results

Waste 360 Staff. (2018, Feb 26). Zerocycle releases new recycling analytics dashboard [Web article]. Retrieved from https://www.waste360.com/recycling/zerocycle-releases-new-recycling-analytics-dashboard

Appendix

Project Design: Combination Trash Can/Recycling Can

Engineer: Daniel Mangu

Summary

The purpose of this design work was to 3D model and draw a design for an inexpensive combination receptacle for both standard and recycled trash to support recycling by the community. The design incorporates a "can-in-can" design, where the recycling canister is a separate insert and is removable from the outer shell can. The can-in-can design is compact, which can likely be manufactured inexpensively, based on material selection and vendor.

Design Considerations

The chief constraint on this design project was the manufacturing cost. While other constraints had an influence, they were driven by that of manufacturing cost. The primary goal was to create a combination trash and recycling can that would encourage recycling by a given community in which it is marketed and sold, where cost is considered a primary factor.

Cost

There were several parts of the design process for which cost was a driving constraint. It influenced the material choice of the part (but not wholly deciding it), design complexity, and manufacturability. Material choice is heavily cost-dependent. Some materials are cheaper to buy but more expensive to work with, while others are cheap to work with, but more expensive to buy. Cost also affects manufacturability because some locations for some materials have different capabilities than others. It also affects design complexity since certain materials cannot be formed or manufactured into a shape (or manufactured easily, e.g., one can easily create a complex part from aluminum by extruding like a chef would extrude pasta. The same can be done with titanium, which is a much stronger metal but at a much higher cost). When considered in the context of other trash can models, it was most reasonable to assume that this design would be molded in some fashion rather than another method (e.g., 3D printed using plastic or resin), which would help to contain the cost.

Aesthetics

Another primary consideration was that of aesthetics. It was necessary to maintain a balance between inexpensive manufacturability and reasonably attractive appearance. This led to the rectangular design for both the outer can and the recycling insert. It will fit within most kitchen designs easily and can be readily placed in a corner to be out of the way. The rectangular handles on the recycling insert set this design apart from others while serving a functional purpose (many people would enjoy having handles on such a can for those situations when their recycling can is overfilled). The design also includes three triangular wedges and corresponding cutouts on the main can. These are simple features that serve to align the recycling insert within its spot in the main can and provide a small but noticeable difference between this design and others. In addition, the recycling container is approximately the same size as the standard trash compartment. While not necessarily an aesthetic consideration in the sense of making this design attractive, it serves to make the concept of recycling more attractive to the market. Keeping that in mind, the standard trash compartment has two cutouts to allow a trash bag to be placed in and remain at the top of the container without falling inside.

Material and Design Choices

Material choice was the consideration which had the most freedom. There are several options for a material choice that would serve the purposes of this design from the standpoints of sturdiness, strength, manufacturability, and cost. Plastic was the most cost-effective material by far since it is readily and cheaply available compared to a variety of metal choices (all of which would require more manufacturing costs to form). Narrowing down the plastics was dependent on finding a balance between cost and material properties. At the time of writing, locations for manufacturing and sale have not yet been chosen. The choice of these locations limits the use of some materials (e.g., some plastics may not be permissible for certain household items in some cities/regions of California). However, some materials could be seen as safe choices until these can be finalized, namely polyethylene, polypropylene, or ABS plastic. The first two are commonly used for trash can manufacturing (as well as other household items) and are generally lightweight, strong, and flexible. ABS plastic is also lightweight and strong (it has been used in many industrial applications and can be exceptionally difficult to break). However, it is sturdier and less flexible. The properties of ABS seemed to be more attractive for this design in that the handles of the recycling can insert will not break easily even under conditions of an overfilled

can. The choice of wall thickness complements the aesthetic. While admittedly an “until decided otherwise” value, the wall thickness of both the outer can and the recycling insert were chosen to be 1/16 inch. This thickness should be far more than sufficient, reducing the possibility of the can breaking under heavy use/misuse.

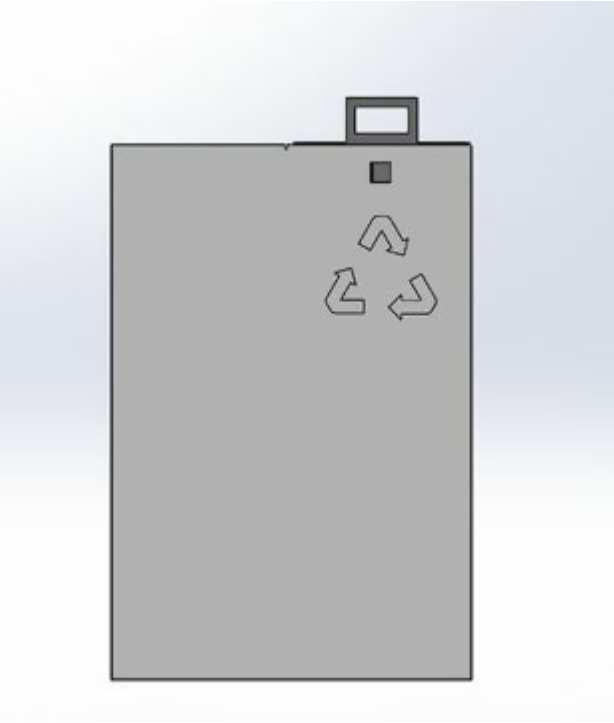

Figure 4. Assembled view front.

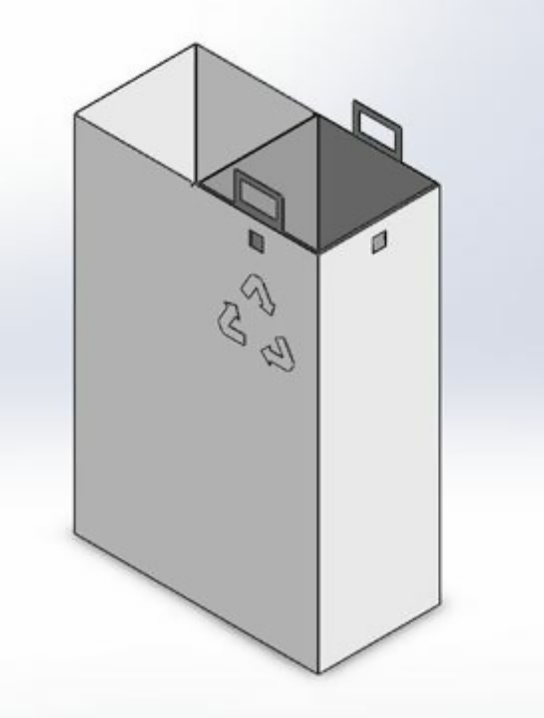

Figure 5. Assembled view isometric.

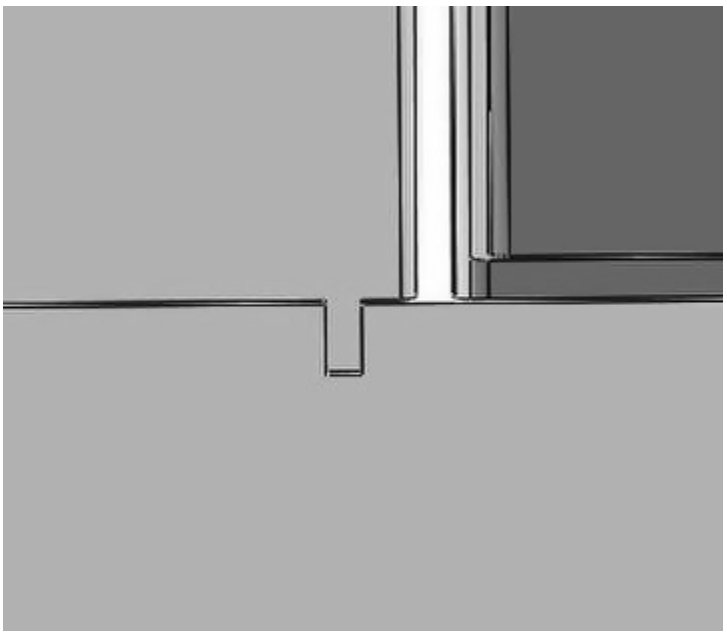

Figure 6. Assembled view trash bag cutout.

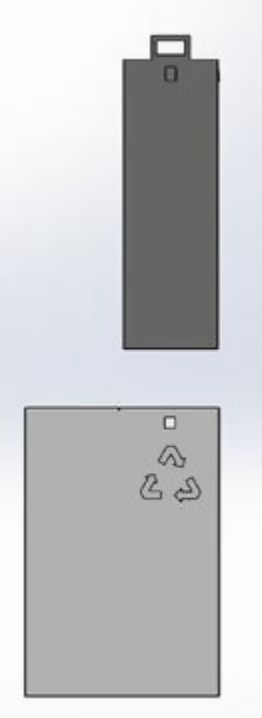

Figure 7. Assembly exploded view front.

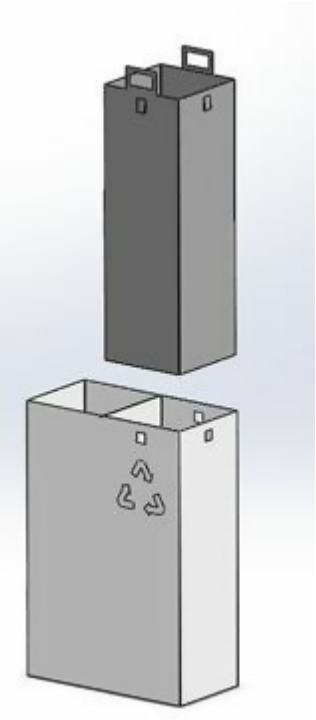

Figure 8. Assembly exploded view isometric.

Figure 9. Assembly wedge cut out close up.

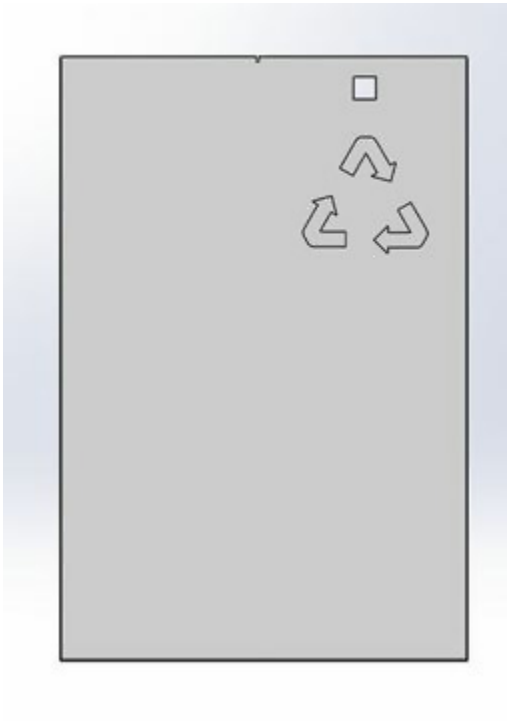

Figure 10. Outer can front view.

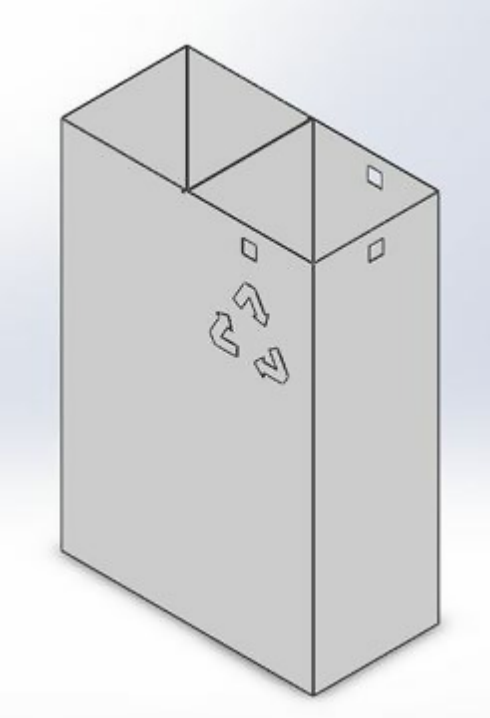

Figure 11. Outer can isometric view.

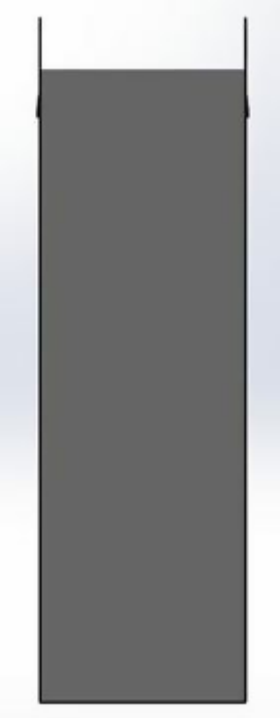

Figure 12. Recycling can front view.

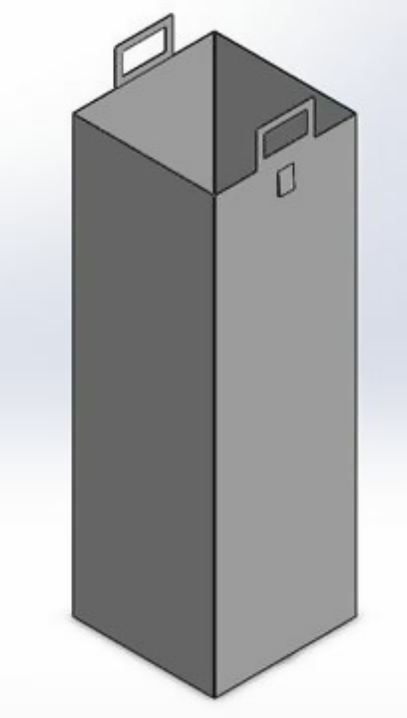

Figure 13. Recycling can isometric view.

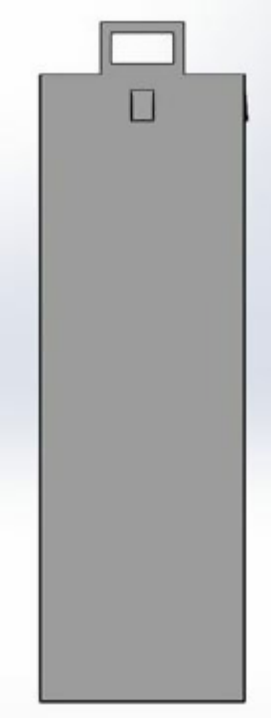

Figure 14. Recycling can right view.

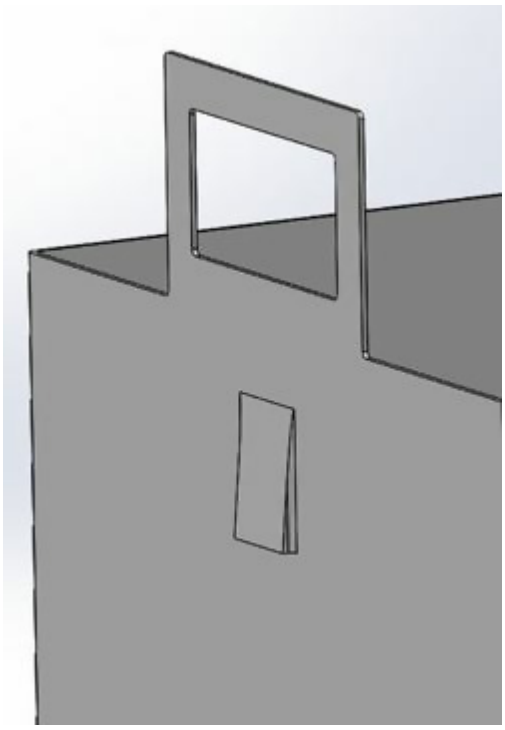

Figure 15. Recycling can wedge close isometric view.

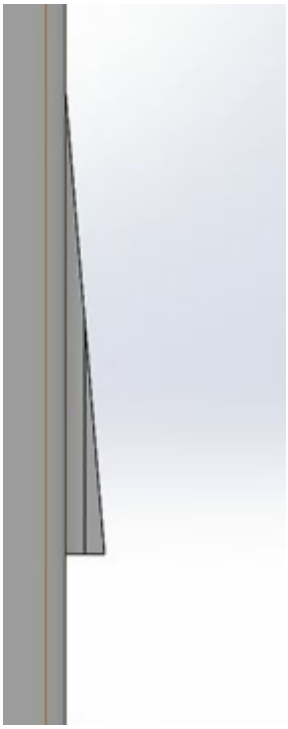

Figure 16. Recycling can wedge close view.