Implementing Circular Economy at Target Field

Capstone Paper

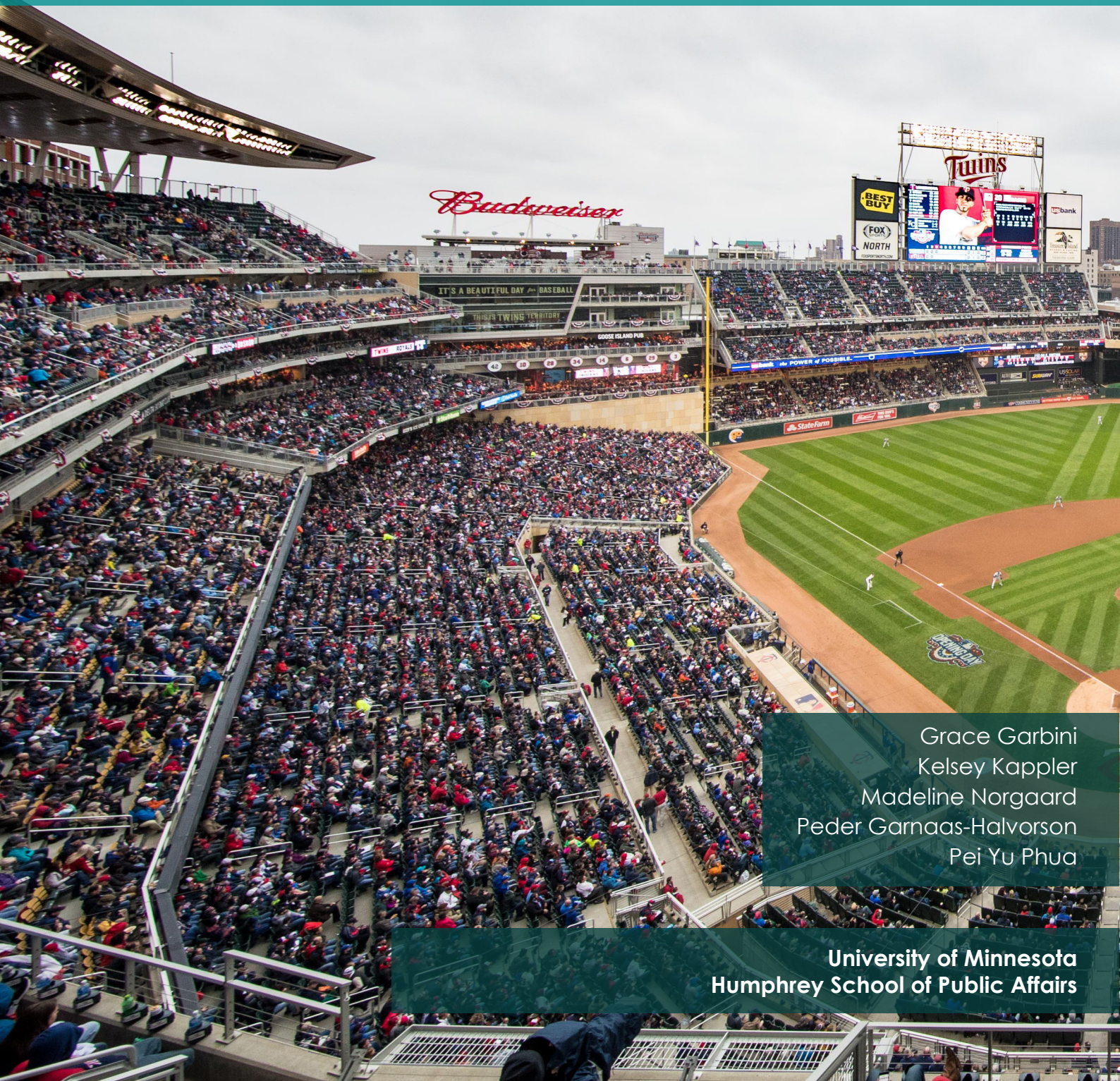
In Partial Fulfillment of the Master Degree Requirements
The Hubert H. Humphrey School of Public Affairs
The University of Minnesota

Grace Garbini
Kelsey Kappler
Madeline Norgaard
Peder Garnaas-Halvorson
Pei Yu Phua

May 11, 2018

May 11, 2018	May 12, 2018
Date of Oral Presentation	Approval Date of Final Paper
Steve Kelley, Senior Fellow	Jase Miller, Manager of Ballpark Operations
Type Name and Title of Capstone Instructor	Typed Name & Title, Client

Implementing
Circular Economy at Target Field



Grace Garbini
Kelsey Kappler
Madeline Norgaard
Peder Garnaas-Halvorson
Pei Yu Phua

University of Minnesota
Humphrey School of Public Affairs

This page intentionally left blank

Project Context

The project idea emerged out of the Minnesota Sustainable Growth Coalition (SGC), a collaborative of over 30 Fortune 500 companies working toward a sustainable environment and economy. One of the members, Target Corporation, is particularly interested in creating a future where all packaging can be recycled (or composted). While Target Corporation is a part of a national coalition working on this issue, it was keen to improve package recycling here in Minnesota. Another SGC member, Institute on the Environment at the University of Minnesota, was also excited about Target's vision as a way to make circular economy a reality. The University's connections with Minnesota's professional baseball stadium operations management, Target Field, provided an opportunity to collaborate on a demonstration project. Target Field was an ideal partner because it was also interested in increasing its recycling rate of plastic packaging. After forming this partnership, Madeline Norgaard, a graduate student at the University of Minnesota's Humphrey School of Public Affairs took on this opportunity as a capstone project in order to explore options and create an action plan. The following paper describes this issue and a feasible recommendation for moving forward.

Opportunity Statement

To help Target Field increase its waste diversion rate and demonstrate an innovative circular economy model by finding a feasible recycling solution for multi-material flexible film packaging (MMFPP), such as chip and peanut bags. Through a proof of concept, this project will inform larger efforts to expand recycling opportunities for MMFPP nationwide.

About Us

Grace Garbini is a second-year master's student studying Science Technology and Environmental Policy at the Humphrey School of Public Affairs. She is interested in bridging the gap between science and policy to inform evidence-based policies focusing on agriculture and the food system. She received her B.S. in Horticulture from Penn State and has worked on an array of research projects ranging from GMO chocolate to biomimetic squid silk.

Kelsey Kappler is a second-year master's student studying Science Technology and Environmental Policy at the Humphrey School of Public Affairs. Her interests revolve around sustainability initiatives, especially in urban areas, and creating more effective science communication. She has a B.S. in Marine Science from Eckerd College and studied Geographic Information Systems at the University of South Florida.

Madeline Norgaard is a second-year master's student studying Science Technology and Environmental Policy at the Humphrey School of Public Affairs. In 2016, she helped the MN Sustainable Growth Coalition develop a circular economy road-map, where she met some of the current project partners. She enjoys working across business, NGO, and government sectors to develop innovative, sustainable solutions.

Peder Garnaas-Halvorson is a second-year master's student studying Science Technology and Environmental Policy at the Humphrey School of Public Affairs. He is interested in the role of private actors in advancing the boundaries of sustainability, especially in the developing context. This summer he worked in Uganda to develop a business model for selling charcoal briquettes made out of waste to reduce deforestation in the country.

Pei Yu Phua is a second-year dual-degree master's student studying Urban & Regional Planning and Public Health at the University of Minnesota. She is interested in sustainable economic development, and has worked on a variety of projects, ranging from developing a floodplain communication plan to redesigning streetscapes to facilitate a sharing economy. She received a B.A. from the U of M in Economics and Environmental Geoscience.

Table of Contents

Executive Summary

This report was motivated by Target Field's desire to improve its sustainability practices, which offered the opportunity to employ circular economy systems thinking. Target Field is already a national leader in sustainability boasting a LEED Gold certification, using efficient water and energy practices, and diverting 90% waste to compost and recycling on game days. In spite of all this progress, one challenge remains: waste created by multi-material flexible plastic packaging (MMFPP) such as chip bags, candy wrappers, peanut bags, and merchandise wrappers are not recyclable or compostable. These materials make up the bulk of what is left in the 19% of waste Target Field can't divert. This report uses circular economy systems thinking to reduce waste by turning outputs into inputs to create a regenerative system. This project has proposed a solution for Target Field's MMFPP waste that adds value to and extends the life of these kinds of materials. The ultimate goal of this report is to help create a long-term recycling solution for Target Field's MMFPP waste that could also be applied to residential and other uses.

Considerations for Achieving the Objective

If simple solutions for recycling MMFPP waste existed, then there would be no need for this report. Unfortunately, the multiple layers and kinds of plastics used in many types of snack packaging makes these packages difficult to recycle in a cost-effective way. In assessing different options, we weighed both feasibility and environmental sustainability. Achieving Target Field's goal requires finding a solution that is more sustainable than its current practice of sending its MMFPP waste to a waste-to-energy site and can be implemented at a reasonable cost in the near future. The other aspect of this challenge that became apparent over the course of research was that taking steps toward a circular economy for MMFPP is not possible without strong partnerships across different industries, sectors and scales. Therefore, this report also explores potential partnerships for addressing the challenge of MMFPP recycling and sharing lessons learned across a network of engaged industries.

Recommendation

Given the current lack of accessible recycling possibilities for MMFPP and the need for partnerships to build a circular economy, we propose Target Field pursue a partnership with ReWall—a company that turns aseptic boxes and other waste into construction wall paneling—to conduct a proof of concept project. Since ReWall does not currently use the kind of MMFPP waste produced at Target Field, the main goal of this proof of concept will be to experiment with these kinds of materials to see how feasibly it can be used in ReWall's current products. The proof of concept can also be used as an educational opportunity for Target Field and ReWall to tell the story of their sustainability practices, educate the public about recycling, and build partnerships with other actors interested in recycling. It is estimated that the cost of this proof of concept project will be between $5,000-10,000.

Success Factors and Desired Outcomes

The recommended proof of concept does not completely solve the challenge of MMFPP waste at Target Field, but it does represent a step toward creating a more sustainable circular economy for MMFPP waste in the future while providing other benefits. This proof of concept will give both Target Field and ReWall the opportunity to educate the public about their sustainability work. It has the potential to reach tens of thousands of people through an installation at Target Field. It provides the opportunity for experimentation with new materials in ReWall panels, and brings together the many partners needed to create a true circular economy in the future. We propose that the overall success of this proof of concept be measured against the following criteria:

1. Ability to divert additional waste streams from Target Field in the short- and long-term
2. Proof of a feasible end-market for MMFPP sourced from sports stadiums
3. The value it brings for the partners involved
4. Awareness raised about recycling and sustainability among the public
5. Ability to open the possibility for experimentation with MMFPP for different forms of recycling in the future.

Acronyms

BOPP	Biaxially-oriented Polypropylene
GGA	Green Glove Award
GHG	Greenhouse Gases
GSA	Green Sports Alliance
HDPE	High Density Polyethylene
HERC	Hennepin Energy Recovery Center
LDPE	Low Density Polyethylene
LEED	Leadership in Energy and Environmental Design
MBOPP	Metalized Biaxially-oriented Polypropylene
MMFPP	Multi-Material Flexible Plastic Packaging
MRFF	Materials Recovery for the Future
MRF	Material Recovery Facility
PET	Polyethylene Terephthalate
PLA	Polylactic Acid
PVC	Polyvinyl Chloride

Introduction

Introduction

The purpose of this project is to help **Target Field** use circular economy systems thinking to become a national model for sustainable stadium waste management. This can be accomplished by working to expand recycling of a currently difficult to recycle type of packaging called Multi-Material Flexible Plastic Packaging (MMFPP). Furthermore, through this initiative Target Field will be leading the way towards a circular economy whereby "waste" is turned into a resource.

Target Field
Target Field is a baseball park in the historic warehouse (or North Loop) district of downtown Minneapolis. It is the home ballpark of the Minnesota Twins, the state's Major League Baseball (MLB) franchise. The ballpark officially opened with a capacity of 39,504 on April 12, 2010.

Circular Economy

The concept of a circular economy originated in the 1970s from the industrial ecology sector but has gained momentum and penetration into other disciplines[1] . A common theme within circular economy systems thinking is to value resources already being consumed while reducing pollution, avoiding resource constraints, and sustaining economic growth. The key concepts from circular economy provides a way of thinking about a problem, not an explicit, prescriptive solution[2] .

A circular economy is a regenerative system where all outputs become inputs yielding no waste in a system. Common examples of these cycles include many of the biogeophysical earth systems, like the water, carbon, and nitrogen cycles. A circular economy takes this idea of resources never leaving the system, and applies it to human-made products, like waste and plastic. Instead of buying a gallon of milk, drinking it, throwing it out, and having it decompose in a landfill, a circular system would recover the container and reuse it for something of value like another container or entirely new product, like lawn furniture or traffic cones. While recycling seems prevalent, actual volumes of recycled materials are low relative to total volume of disposed material, providing an opportunity for improvement[3] .

The challenge of creating these circular systems is finding ways to close the loops. Circular systems rely heavily on feedback loops to minimize elements that escape the system. A circular economy can't be created with just one partner, it requires finding points of connection between multiple actors to create mutually beneficial relationships. Also needed are many points of intervention for creating a circular economy such as increasing demand for recycled products, finding better ways to recycle, and getting creative about reusing. These advantages motivates our use of circular economy in this project as a framework for systems thinking.

Figure 1 shows a graphical representation of linear versus circular economy examples. In a linear economy products are created, used once, and disposed of with no chance of reclaiming the physical material or energy used to create that material. In a circular economy, products are created, and after their initial use, they are reprocessed, repurposed or reused for other functions. The material is never discarded, creating a closed loop system.

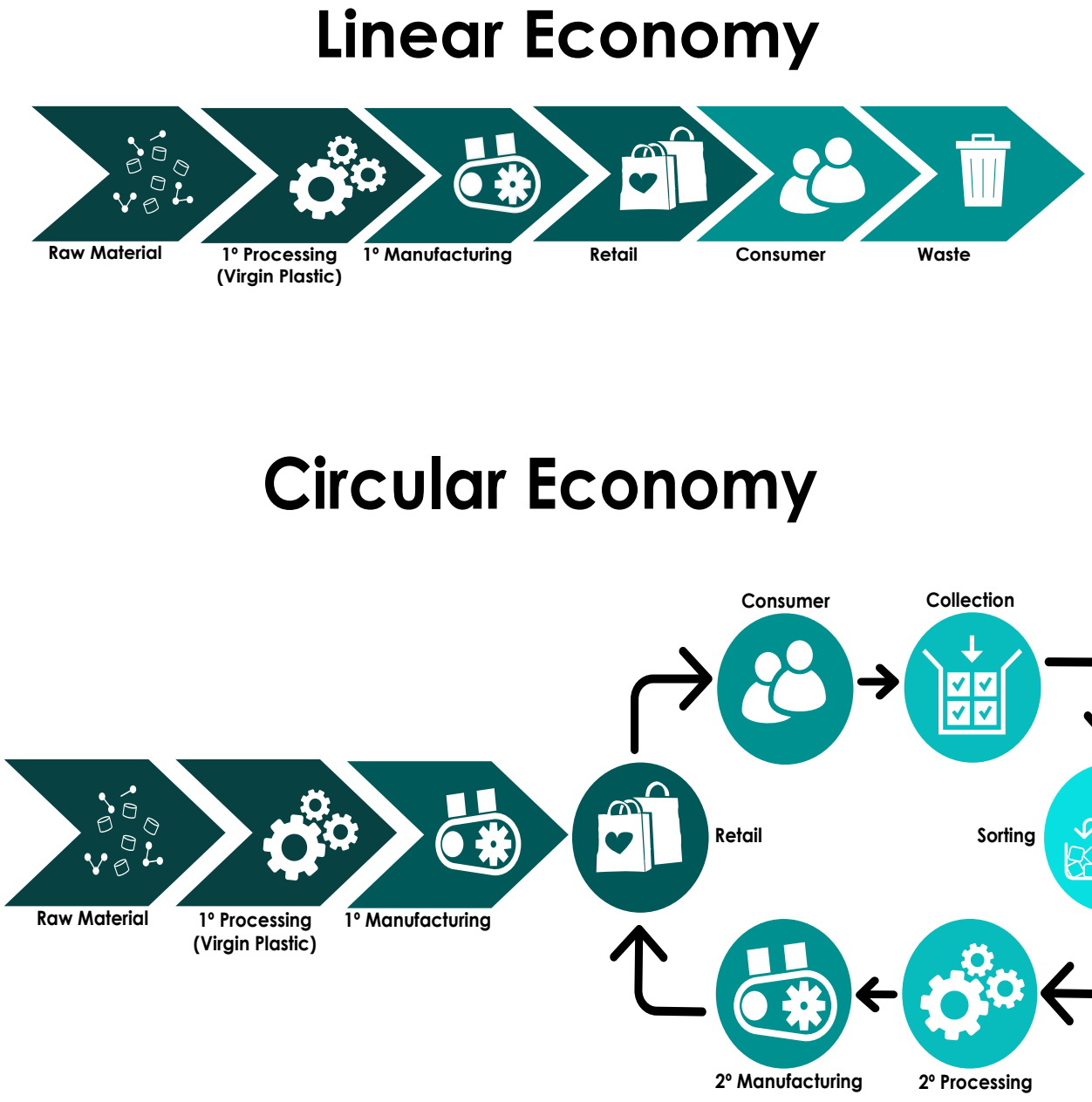
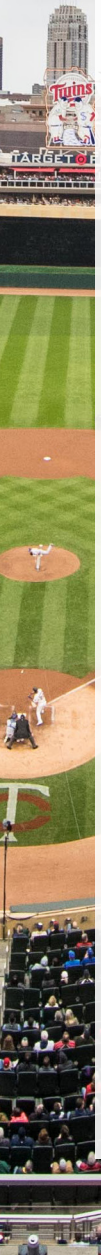


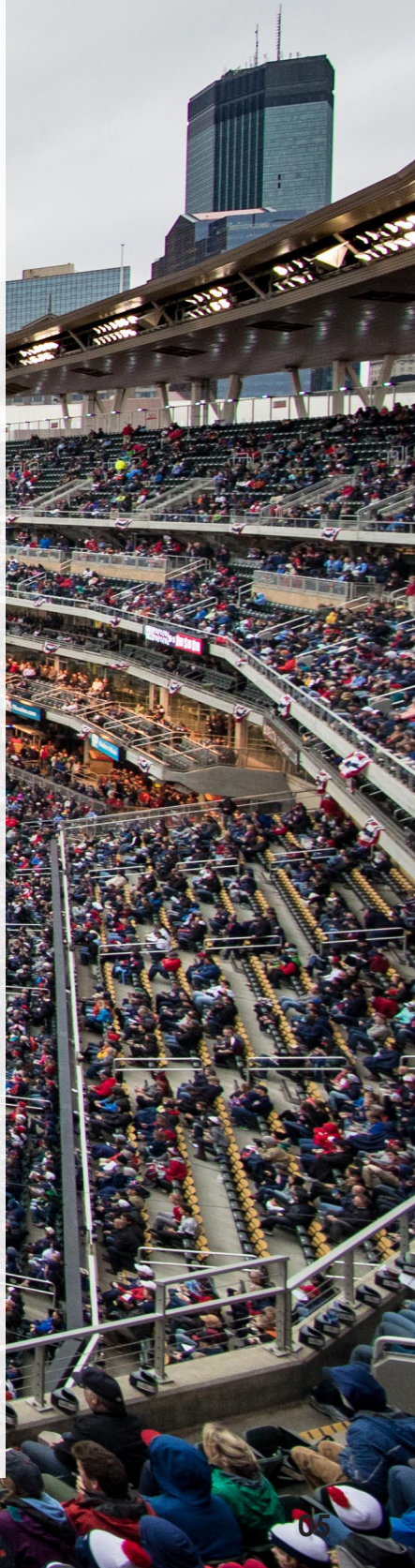
Figure 1: Comparison of Linear (above) and Circular (below) Economies


Budweiser
Twins
BEST BUY
FOX SPORTS NORTH
bank
IT'S A BEAUTIFUL DAY FOR BASEBALL
THIS IS TWINS TERRITORY
GOOSE ISLAND PUB
THE POWER of POSSIBLE.
State Farm

Sustainability at Target Field

Target Field, the home of the Minnesota Twins Major League Baseball team, is already a model for sustainable stadium design and operations. When it opened in 2010, the stadium achieved LEED ® Silver certification (Leadership in Energy and Environmental Design) and has since risen to Gold status[4] . This certification involves building with low-emission building materials, solar-reflective roofing, water efficient fixtures, high efficiency lighting, heating and cooling, and many other sustainable features[5] . Target Field also implements sustainable operations with safer cleaning products, efficient use of energy and water, and waste reduction and recycling. Improved waste reduction and recycling has been implemented by positioning well-labeled compost and recycling bins regularly throughout the stadium concourse to divert as much waste from the trash as possible. Thus far the program has been successful; Target Field diverted 8,256 tons of waste from landfills between 2011 and 2016[4] .





The impact of Target Field's sustainability initiatives goes well beyond improving environmental performance. The hundreds of thousands of Twins fans who visit the stadium each year are engaged and educated in ways they can contribute towards a more sustainable and healthy living environment. By demonstrating good practices at the stadium, fans can see what a community-based recycling scheme may look like at home. Minnesota sports fans come from urban and rural areas, range in age, and differ in political, economic, and ethnic backgrounds. Therefore, Target Field is an ideal setting to reach and inspire sustainable attitudes and behaviors of the public at large.

Target Field is also a leader in forging a path towards a circular economy. Currently, the ballpark diverts more than 90% of its waste produced on game days. In order to ensure materials end up in their proper streams, Target Field staff hand sort all compost and recycling bins after each game with 4-8 employees in 6-8 hours, depending on game attendance. Whatever waste is left over that cannot go in the compost or recycling is sent to the **Hennepin County Energy Recovery Center (HERC)**, located less than a half mile away. Here, waste from Target Field is burned and converted into energy that is fed back to the stadium. While materials that leave Target Field don't necessarily return to Target Field to create a perfect circle, their efforts demonstrate the possibility of circularity in the regional economy.

Hennepin Energy Recovery Center (HERC)
Located in downtown Minneapolis, the HERC burns garbage to create energy. HERC uses the latest technologies to reduce environmental and taxpayer costs and is part of the county's integrated waste management system.

HERC is situated at Target Field Station

Photo credits: Minnesota Resource Recovery Association

Figure 2 below shows the current path of Target Field's disposed material, as described above:

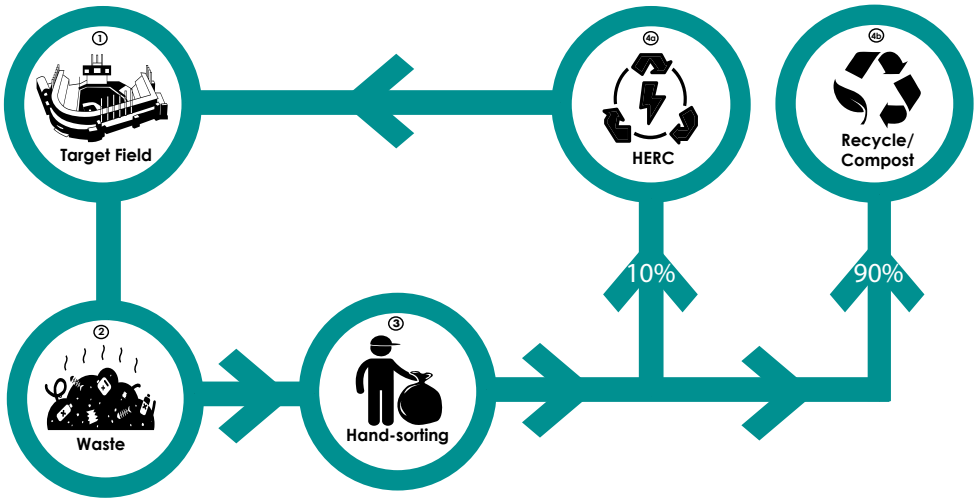


Figure 2: Target Field's Waste Management System

The Green Sports Alliance (GSA), representing nearly 500 sports teams in 14 countries, is an active organization responsible for cultivating broad and deep adoption of sustainability best practices across the world of sport (need citation). Through the Alliance, Target Field has been able to share lessons on the design and operation of its own ballpark and, in turn, has learned from other stadiums to make continuous improvements. In addition to GSA, the Green Glove Award (GGA), administered by Major League Baseball, serves as a platform for recognizing notable achievement among baseball stadiums across the United States. The Seattle Mariners were awarded the 2017 GGA for their efforts to increase the stadium's recycling rate to 96%. Nearly everything used is recyclable or compostable, and last year the stadium participated in a "Strawless September" initiative. Prior to 2017, the San Francisco Giants had won the GGA for 9 years running[6] . This project could give Target Field an extra advantage for GGAs to come.

Green Sports Alliance
The Green Sports Alliance was conceived and founded by the Seattle Seahawks, Portland Trail Blazers, Seattle Sounders FC, Seattle Mariners, Seattle Storm, Vancouver Canucks and the Natural Resources Defense Council with support from Bonneville Environmental Foundation, Green Building Services and Milepost Consulting.

Photo Credits:
Kevin Pang, Chips & Crisps

Improving Sustainability at Target Field

A majority of the waste from materials from Target Field that are not currently compostable, recyclable, or replaceable are a type of packaging called multi-material flexible plastic packaging (MMFPP), specifically chip bags, peanut containers, and candy wrappers. MMFPP is one of the most useful products of petroleum refining. It reduces packaging weight, keeps food fresher longer, and allows items to be packed more densely than if they were in cans, boxes, or other less form fitting containers[7] . The drawback of this highly efficient packaging type is that it is often made with many layers of different kinds of plastic resins and other materials (like inks, and adhesives), which makes it very difficult to recycle. These films have become so ubiquitous that increasing amounts are being thrown out even as institutions move towards zero waste.

According to the Minnesota Pollution Control Agency (MPCA), Minnesota's waste composition has changed over time. While plastic, paper and organic remain the top three waste components, the percentage of plastic and organic waste has increased between 2000 and 2013. In 2013, 522,800 tons of plastic waste were generated in Minnesota. Bag and film plastic alone accounts for 192,600 tons[8] .

Figure 3 below shows how plastic and organic recycling is increasing whereas paper and other recycling is decreasing over time. In addition, most of the plastic waste that Minnesota generates is non-recyclable, which currently includes MMFPP.

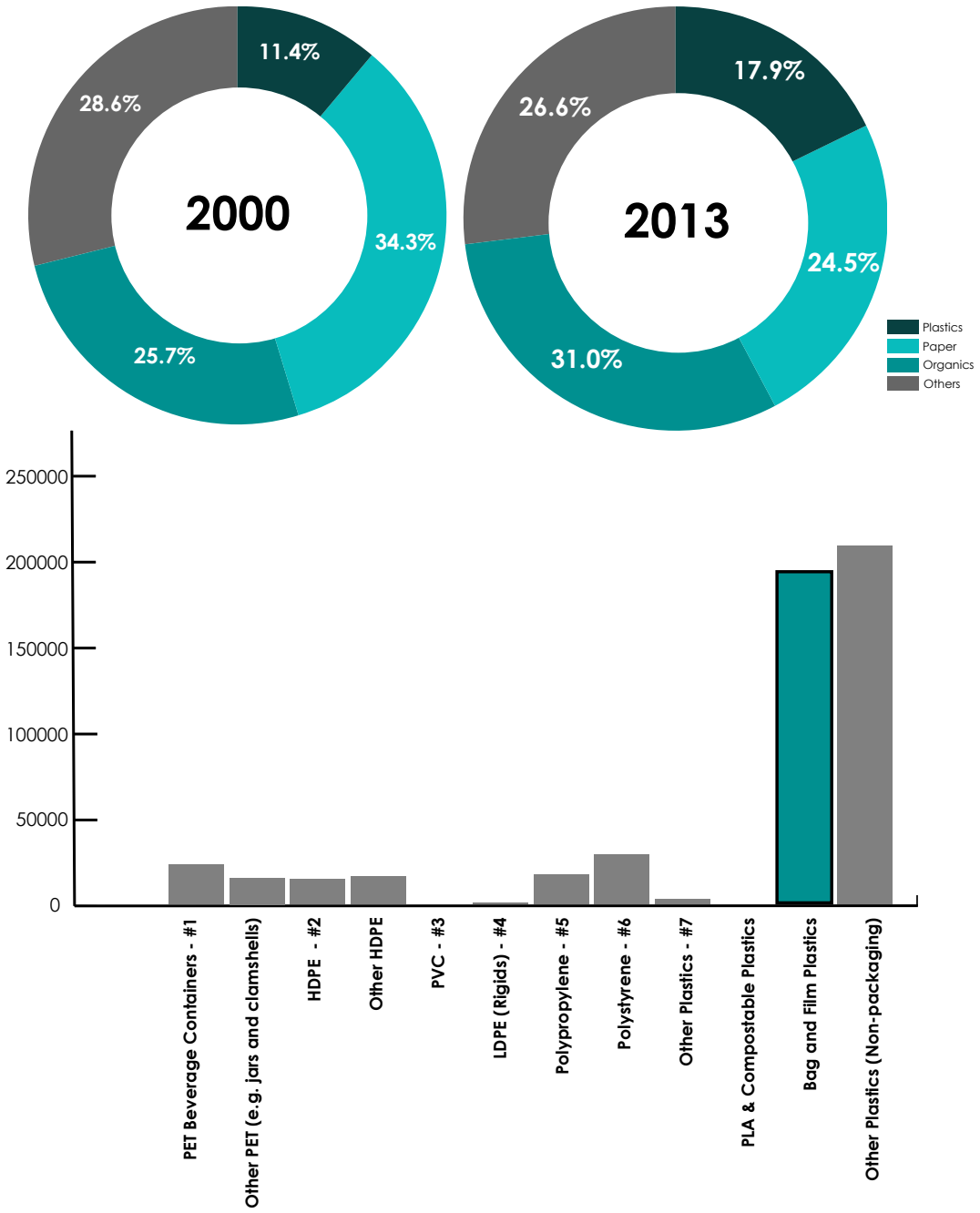


Figure 3: Minnesota's Waste Composition

At Target Field, MMFPP accounts for less than 10% of the total material leaving the field on game days[9] . About 90% of the waste at Target Field is recycled and composted leaving very little else in the bin. What remains include MMFPP as well as packaging from merchandise sold at the Stadium, and miscellaneous papers.

The photo on the left is an example of the composition of waste that is neither recyclable or compostable from Target Field on a typical game day. Note MMFPP waste in upper portion of photo.

Project Opportunity

Recycling MMFPP, including chip bags and candy wrappers, has many challenges. Target Field presents a unique opportunity to address these challenges because of its interest in improving its performance on recycling, its relatively clean stream of MMFPP waste from game days, and its existing ability to effectively sort various waste streams. This opportunity is complimented by the engagement of partners like **Target Corporation** who want to support research and development for recycling techniques that can be used for MMFPP. In addition, **ReWall**, a company that uses aseptic boxes to created pressed boards to replace gypsum drywall, has an interest in experimenting with MMFPP and expanding their brand[10] .

This portion of the report will cover the opportunities and challenges for recycling MMFPP, including options and recommendations for a proof of concept at Target Field. The report is organized by first describing the challenges and complexities, and then detailing how to implement and weigh the pros and cons of such a project.

Target Corporation
Target Corporation is the second-largest retail store in the United States, headquartered in Minneapolis, MN. Target stores sell everything from groceries and essentials to clothing and electronics. The company operates over 1,800 stores across the country.

ReWall
Founded in 2008 and headquartered in Des Moines, Iowa, The ReWall Company, LLC is an award-winning manufacturing company that converts plastic coated paper waste into healthy, high performance green building materials through a low energy, eco-friendly recycling technology.

“The Minnesota Twins organization believes our future success-both on and off the field-is built on a business model that embraces operational efficiency, environmental stewardship and social responsibility. We honor the power of sport by leading through example, and we will continue to use sport to inspire, build the best fan experience and cause no unnecessary harm, working with our fans, community, suppliers, partners and employees to have a positive influence in the world.”

Dave St. Peter
President of Minnesota Twins

Challenges

Challenges

As described earlier, MMFPP is among the most prominent types of plastic packaging in the market today, and is also the fastest growing. This being the case, why aren't they being recycled at the same rates, if not higher, as other plastics like beverage bottles or single-material plastic packaging?

The main reason MMFPP is difficult to recycle is the complexity of the packaging, which is a result of its multiple layers and its end purpose. Often, a multilayer structure can allow a package to perform a combination of functions that a single layer couldn't do. Increasingly rigorous packaging requirements call for more complex packaging, thus exaggerating the issue[11] . Due to the multiple layers, MMFPP is difficult to process, specifically because of the inconsistency and variation in materials, contamination from the product it carries, higher costs, and limited end market uses.

Figure 4 below shows a general example of the make-up of a MMFPP:

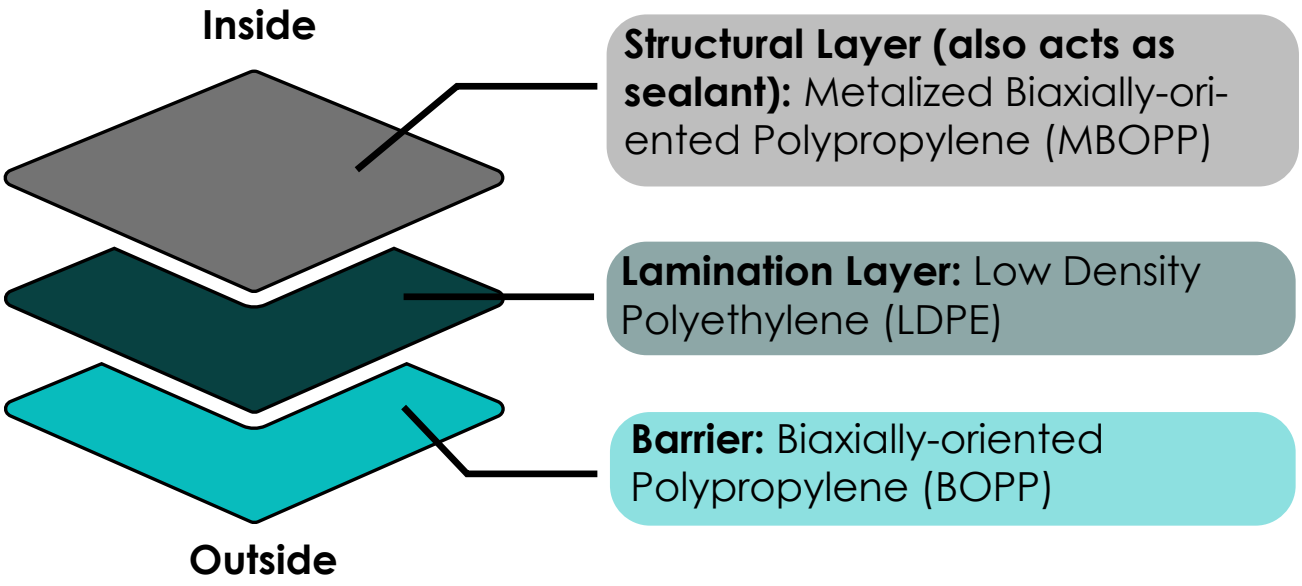


Figure 4: Example of the Make-up of MMFPP

Inconsistency and Variation

Different products have different packaging needs, so the makeup of MMFPP differs from product to product, rather than having one uniform composition. In fact, typical MMFPP products range from having three layers up to nine, and this leaves a lot of possibilities for the composition of that material[12] .

Not only do different products have different MMFPP recipes, but some may change its packaging over time. New combinations of plastic resin emerge frequently to consistently improve freshness and weight. This poses a challenge for seeking end of life solutions because of the varied composition of the material.

Contamination

Many MMFPP products are used for food packaging, such as chip bags and candy wrappers. The food necessarily comes in contact with the packaging which leaves residue like grease and food particles. This food-related contamination must be thoroughly washed before it can be processed, which is possible, but could be time consuming. Other, more rigid plastic packaging like beverage bottles must also be washed, but they are generally denser and sturdier material. The lightweight, flimsy nature of MMFPP may pose an issue for cleaning.

Even if food residue were not an issue, the current recycling technology cannot yet fully separate all different polymer types. This means that there is still the threat of contamination in any end product utilizing recycled MMFPPS due to impure, recycled polymers mixing with pure virgin plastic ones. This mixing can often affect the color and clarity of a product, and possibly its structure as well[13] .

Cost

The cost to utilize multiple layered plastics in primary products is decreasing, but the cost to actually process these materials for recycled use is high, and even higher are the research and development costs to improve the processing system. Being more complex than other forms of plastic, MMFPP requires additional processing costs to separate out the resins, whereas single-material plastics don't and are less cost and resource intensive as a result.

One of the biggest cost factors is the labor costs associated with sorting. Many facilities don't have the technology to effectively identify and separate MMFPP from other materials; because of their weight, MMFPP can get lumped in with paper products. This necessitates the need for manual labor to sort by hand, and these sorters must be paid a wage. What's more, the generally small and flimsy nature of MMFPP make them more difficult to identify and handle than larger, sturdier plastics, which translates to increased labor costs.

End Markets

Even if the technology was available to effectively deal with these products and the cost was reasonable, it still wouldn't make sense to go through the effort of recycling if there wasn't an end market for the recycled product.

Finding an appropriate end market is not an easy job because recycled MMFPP products are relatively new and untested. This requires potential end markets to take on the cost of testing out recycled MMFPP in their products, potentially risking structural integrity, quality, and aesthetics.

End Market Options

End Market Options

There are many current and potential options for disposing and reusing MMFPP. In general, the feasibility of these options is inversely related to their environmental desirability. It is therefore important to consider the optimal options that balance the needs of sustainability and feasibility.

Figure 5 below shows different options for disposing MMFPP as well as their level of feasibility:

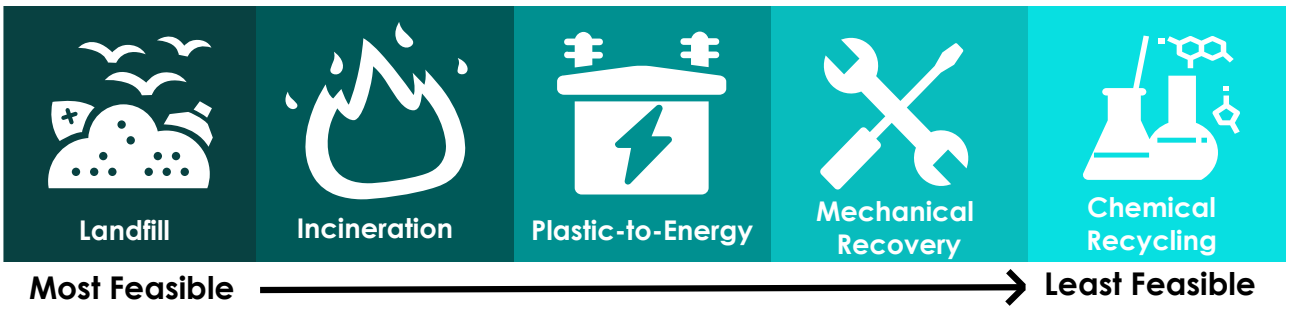


Figure 5: End Market Options for MMFPP

Landfill

Landfills bury waste in the land and are one of the most conventional approaches to waste management. However, space for landfills has become increasingly limited in recent years. Moreover, waste that is buried in landfills has the potential to pollute surrounding soil and groundwater. Landfilling perpetuates the linear economy because no value can be captured from this waste management option.

Environmental Considerations

There is not a particularly useful lifespan to evaluate with regards to landfilling waste, but the lifespan of waste within the landfill, especially plastic waste, is very long.

Landfilling plastic waste does help by consolidating waste, which might otherwise end up on streets, or in the environment--like in lakes and oceans. Though landfilling is preferred to littering, the addition of plastic waste in landfills takes up space when the waste storage option is already on its way to reaching capacity.

In the long term, landfilling continues to keep waste out of rest of environment and oceans. But it also adds to the waste storage problem, accumulates negative impacts over time, and can eventually lead to air pollution, leakage into groundwater and soil, or could cause sinkholes, all of which are public health and environmental concerns.

Incineration

Incinerating waste may be a better option than landfilling because energy can be captured and used in new processes. However, without proper oversight and management, incineration can inadvertently deposit harmful compounds in the surrounding area. This can be mitigated by ensuring tall enough smokestack heights or particulate scrubbers, but is not a perfect solution.

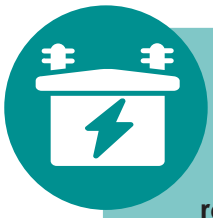
Environmental Considerations

Currently, Target Field is sending its plastic waste directly to the HERC. This means the alternative's lifespan is exceptionally short because the plastic's usefulness is used up as soon as the waste is burned, which is almost immediately after disposal.

The short-term benefit of this option is that it diverts waste from landfill and uses that material to produce usable energy. This repurposing of waste reduces the need to harvest raw materials or the use of 'dirtier' fuels. However, burning the waste produces Greenhouse Gas (GHG) emissions as well as other forms of pollution associated with energy conversion. Additional GHG emissions are associated with the transportation to HERC. Although this is negligible in Target Field's case, as the HERC is in close proximity to the field, other cases may find this more of an issue.

In the long term, the amount of diverted waste accumulates over time, which saves space in the landfill for less-recyclable materials and reduces the need to use 'dirtier' fuels or harvested materials. However, the amount of GHG emissions and pollution associated with energy conversion and transportation will also accumulate over time.

Plastic-to-Energy



Since plastics have a higher energy content than other components of municipal solid waste, energy recovery processes involving non-recyclable plastics can yield higher energy efficiency compared to traditional waste-to-energy facilities. There are a few emerging energy recovery technologies including plastic to energy and plastic pellets[14] .

Environmental Considerations

Processing plastics into pellets used for energy has a relatively short lifespan; pellets can be stored for a while, but their usefulness is used up as soon as they are used for energy production.

The short-term benefits of this alternative are that it not only diverts waste from landfills, but also produces usable energy and therefore prevents the harvesting of raw materials or use of 'dirtier' fuels. Pelletizing the plastic also increases the ability to store and transport energy, which relocates emissions away from the source of the waste. This might be a positive impact for immediate area, but negative impacts associated with incineration remain, they are just transferred to new area. Furthermore, there are GHG emissions associated with many parts of the process: with energy conversion, the transportation of plastics, and then transporting pellets as well. Lastly, production of pellets potentially releases VOCs (Volatile Organic Compounds) and other negative byproducts, which can be harmful to human health and the environment.

Over time the positive effects of pelletizing for energy production increase as it contributes more and more to waste diversion from the landfill and relieving the immediate area of air pollution. However, this also means that the air pollution in other areas accumulates with time, as do the GHG emissions and other forms of pollution associated with processing, transporting, and utilizing pellets.

Mechanical Recovery

Mechanical recovery refers to "operations that aim to recover plastics waste via mechanical processes (grinding, washing, separating, drying, re-granulating and compounding). In mechanical recycling, polymers stay intact."[15]

Environmental Considerations

The lifespan of the MMFPP to secondary product alternatives depends on the final product. These can include chairs, traffic cones, grocery carts, and drywall replacement boards. It is also important to note that most feasibly manufactured products will eventually get thrown out when they are no longer usable, except for building materials which if maintained can last for the lifespan of the building (about 50 years).

Short term benefits include diverting plastic waste (and cartons) from the landfill and incorporating them into useful products. Additionally, using recycled materials in the new product removes the need for collecting virgin material and the energy associated with extracting those materials. However, many products require other materials in addition to recycled plastic and there are energy costs associated with processing them. Furthermore, processing may require heating and pressurization of materials, which requires energy, and therefore release GHG emissions. There could be some added environmental costs associated with transportation of the raw, recycled material to the processing facility and then again when the final product is distributed.

Long term impacts of this process depend on how much additional material is used in the new products; if the process utilizes 100% recycled plastics, no new material is used, and how long the product will last. Even if additional material is required, the benefits accumulate with each product iteration when considering the amount of waste that is diverted as a result of using the recycled product. The negative impacts also depend on the proportion recycled material used in the final product, and the lifespan of the materials. In theory, there would be no additional environmental costs associated with long lasting products, but since it is essentially a lifetime extension, there would be no additional benefits either.

Chemical Recycling

This process "involves the conversion of polymers back into their original monomers through heat and other chemical reactions"[16] . Chemical recycling takes used plastic and repurposes it into essentially new plastic in place of having to extract virgin plastic from natural resources. Presently it can only be used for various, but separated homogeneous plastics: Low-Density Polyethylene (LDPE), Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC) etc. These "value-added" plastics tend to be more expensive[17] . For MMFPP it will require upstream and downstream modification such as redesigning plastic polymers to be better suited to chemical recycling, and exploring new ways to safely process plastics, respectively. Some downstream processes include thermo-chemical (melting) and catalytic conversion (adding a substance that increases the rate of a chemical reaction)[18] . Broadly, these methods break apart long molecules into smaller molecules that can be used in more ways[19] . Chemical recycling is regarded as the best environmental option because it does not require fossil fuel extraction, but this doesn't take into account life cycle analysis. Furthermore, these plastics don't contain significant amounts of oxygen which means higher carbon efficiencies can be expected (amount of carbon in a product multiplied by 100 divided by the total carbon present in the reactants)[20] .

Environmental Considerations

Since this is an emerging area, the lifespan, short term and long term impacts remain unsubstantiated. Hopefully with time and investment, chemical recycling of plastic will yield a solution where all used plastics can be recovered, converted, and reused with full functionality. This would create a system where no more raw materials would need to be sourced and no plastic would be landfilled, closing the loop for plastic recycling.

Focus:
Mechanical Recovery

Target Field's current practice of sending its MMFPP and other non-recyclable wastes to the HERC is already a preferred alternative to landfilling. However, there is an opportunity to move up the scale for diverting this type of waste. We have chosen to focus on mechanical recovery options because they are more environmentally sustainable than the current practice of incinerating waste but are also more feasible than chemical recovery.

Figure 6 below are considerations for different mechanical recovery options for MMFPP waste:

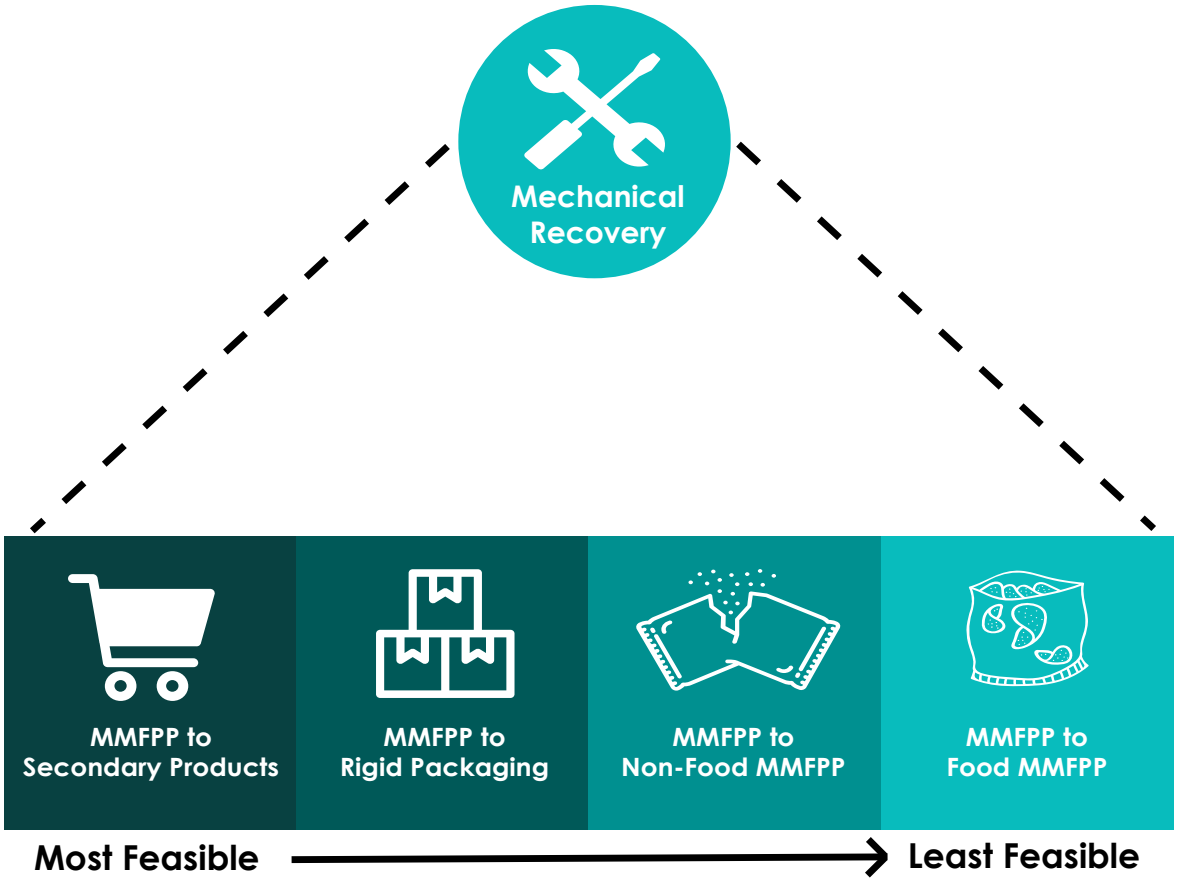


Figure 6: Mechanical Recovery Options for MMFPP
Information based on F.I.A.C.E Final Report[21]

MMFPP to Secondary Products

A certain percentage of recycled MMFPP material could be included in injection molding of secondary products such as plastic outdoor furniture or traffic cones. However, there are not established processes for melting down MMFPP and it is unknown how the chemical makeup of these types of packaging would affect the quality of products into which they are incorporated. This option is an exciting opportunity for experimentation, especially with the sorted stream of MMFPP waste that could be collected by Target Field. Shredding for other uses like insulation or wall paneling and other construction materials is a currently available, long-term waste diversion solution that adds value to MMFPP waste streams. This solution does not create a true circular economy, but it provides an extension of the usable life for MMFPP.

MMFPP to Rigid Packaging

Converting MMFPP to rigid packaging for items like small electronics or toys would circumvent the health concerns of contaminants for food and recycled MMFPP could be combined with other plastics to provide strength for these packaging applications. However, as this packaging is often required to be clear and MMFPP often includes different inks and non-transparent layers that may not be suitable for this application.

MMFPP to Non-Food MMFPP

It would also be challenging to turn used MMFPP back into flexibles as these plastics "can be highly contaminated with food remains and thus require an intensive cleaning process"[22] . MMFPP also do not have sufficient mechanical strength for film blowing after being reprocessed and would be unsuitable to be re-used as MMFPP.

MMFPP to Food MMFPP

There are major barriers preventing MMFPP from being recycled back into food applications. During the recycling process, plastics are exposed to many contaminants such as solvents, inks, adhesives and food matter. As a result, MMFPP might degrade into other substances not safe for food applications[20].

Recommendation

Recommended Option

Given Target Field's immediate desire to find a more sustainable solution for its MMFPP waste, we recommended the most feasible mechanical recovery option be explored. There are currently multiple options available to create secondary materials. ReWall, a company in Iowa, "converts plastic coated paper waste into healthy, high performance green building materials through a low energy, eco-friendly recycling technology". ReWall offers an existing technology that currently processes materials like those found at Target Field. However, ReWall's main source of material is more rigid and fibrous recycled products such as milk cartons or juice boxes. Target Field would have to work with ReWall to determine if and how much MMFPP waste like chip bags and candy wrappers could be incorporated into their product. These factors will determine how much of Target Field's waste could be diverted and whether this waste would be valuable enough for ReWall to sustainably use for new products in the future. While this option is still not "plug-and-play" it is currently the most feasible option for MMFPP and it provides an opportunity for innovation.

Since there is currently no long-term solution for Target Field's MMFPP waste (including ReWall), we suggest a proof of concept with the goals of:

1. Testing a method for incorporating MMFPP into ReWall panels
2. Building relationships between actors engaged in recycling innovation
3. Raising public awareness about recycling and Target Field's sustainability efforts
4. Developing potential long-term solutions for Target Field's MMFPP waste

To achieve these goals, it will be necessary for Target Field to coordinate its efforts with other partners that are working to increase the possibilities for recycling certain kinds of waste.

The short-term goal of this proof of concept is to successfully integrate the MMFPP waste generated at Target Field into wall panels produced by Rewall and create an installation at Target Field that educates fans about recycling and Target Field's sustainability efforts. This installation could take many forms as a wall, a small structure, or a sculpture, but it will be constructed in such a way that the public can clearly see the waste generated at Target Field incorporated into the panels. Ideally, this would be accompanied by informational material for fans to read, and learn about sustainability. Other desired outcomes from this project are relationship building between different actors that are trying to innovate in the space of recycling and the development of long-term recycling solution for Target Field's MMFPP waste.

Figure 7 below shows the recommended framework for the proof of concept. Target Field's MMFPP waste will be combined with a source of fibrous material to create ReWall NakedBoard panels that will be showcased at Target Field.

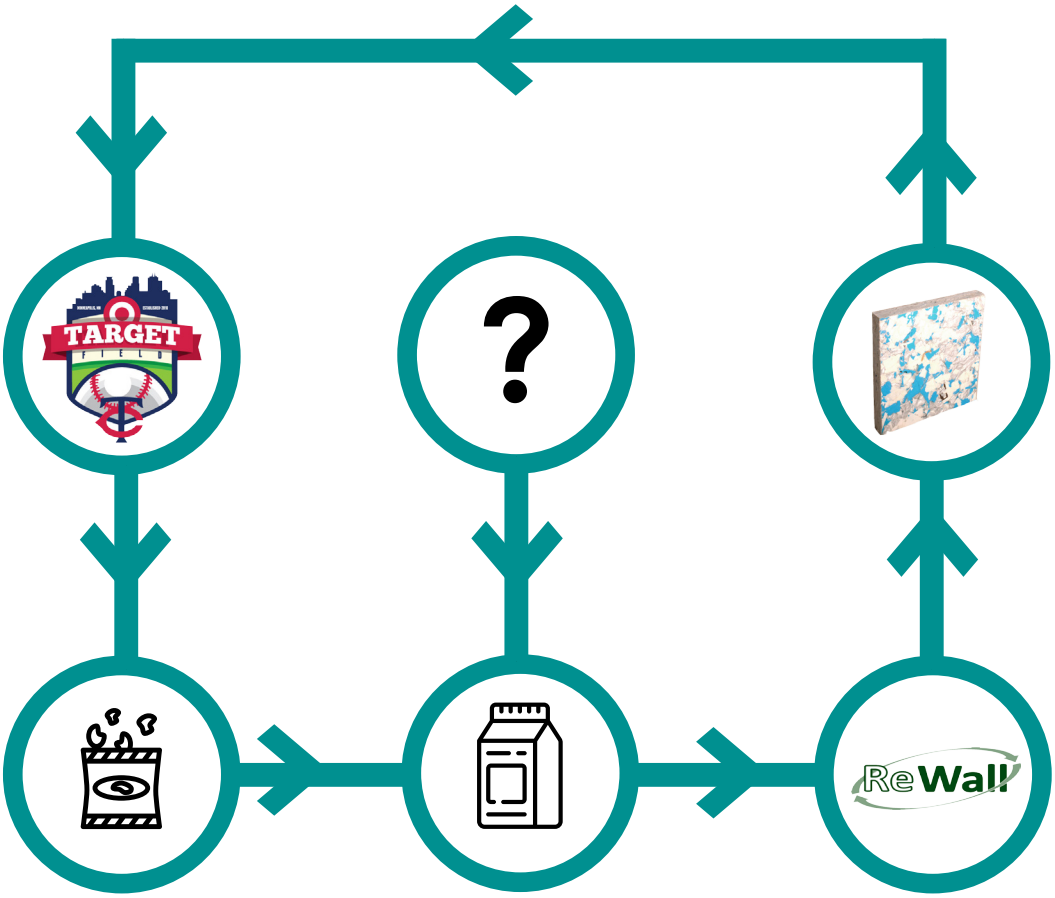


Figure 7: Recommended Framework for the Proof of Concept

Partners

Target Field

As previously stated, Target Field is an active leader in environmentally sustainable ballpark operations and management. Notably, the ballpark diverts over 90% of its waste from landfills and incineration through meticulous efforts to maximize the compostability and recyclability of consumer-items at Target Field. Staff go through the extra effort to sort all waste after each game to ensure that items are sorted in their proper streams. Target Field's efforts not only serve as an example for other stadiums to become more sustainable, but they instill sustainability awareness in the thousands of fans who visit the stadium each year.

Jase Miller, Manager of Ballpark Operations, was eager to divert even more of the waste produced during game days. According to Miller, a portion of what can't be diverted is made up of MMFPP such as chip and peanut bags. The fact that Miller and his team have already implemented an exceptional waste management program made Target Field a fitting partner to participate and lead in a proof of concept project.

This project has the potential to create a long-term solution for diverting Target Field's MMFPP, raise awareness about recycling and sustainability among Twins fans, and raise Target Field's already positive reputation as a leader in sustainable practices and management. We've estimated that over the course of the project, 200 lbs of MMFPP will be collected from Target Field over 5-6 games. With this amount, ReWall will be able to produce 40 panels when mixed with 1,800 pounds of filler material.

Target Field will then be able to incorporate this product into an educational art installation that fans will get to see to learn about innovative recycling and how Target Field is leading sustainability first-hand. If the proof of concept is successful, Target Field may be able to continue sending its MMFPP waste to ReWall and create a longer term solution.

ReWall

Based in Des Moines, Iowa, ReWall is an innovative company which manufacturers building products including roof board, exterior sheathing, and interior wallboard out of 100% recycled materials. Currently, the boards are mostly made from recycled beverage cartons. Not only are the boards high performing in moisture resistance, durability, and strength, they are made without water, additives or adhesives and emit zero Volatile Organic Compounds (VOCs), helping customers improve their environmental footprint. The products are expected to last the entire lifetime of the building. Because recyclables are turned into higher value products, ReWall is a leader in upcycled solutions.

ReWall also specializes in making a product called NakedBoard. This product is highly functional and is made without a facing material so that the shreds of the recycled material are visible, creating an attractive looking wall. The applications for this product include interior wallboard, decorative wallboard, and recycled product displays. ReWall can work with its customers to create customized boards that contain recycled material of a preferred brand.

About 400 cartons are recycled in each ½'x4'x8' board. While not widely used, ReWall has the capability to put MMFPP material into boards, though the end product has not been thoroughly tested. This project could allow for such tests[23] .

ReWall is leading the way to a more sustainable future through upcycled solution and circular economy thinking. They are a company to watch as they continue to innovate. Environmentally conscious customers can help move society towards this vision by using these building products in the construction of new buildings instead of other products that use virgin materials. Because the cost of ReWall's products (besides NakedBoard) are comparable or less than the cost of boards on the market, choosing ReWall simply makes business sense in building applications.

ReWall NakedBoard is a prefinished interior wallboard made of 100% recycled material. It is a durable, moisture-resistance sustainable solution made of a polycoated paper waste without facing material. The shreds of recycled materials are left exposed, creating an exclusive design that says "recycled" at first glance.

Photo Credits: Urban Mining and Recycling

Target Corporation

Target Corporation is engaged in making it possible for consumers to recycle more of their materials, since many of the products Target sells involve some kind of packaging with varying recyclability. Target's goal is ultimately to build a non-transactional relationship with their customers in which they can easily recycle all the packaging from products bought at Target stores and then influence how materials are reincorporated into new products and packaging.

While Target Corporation is not linked by ownership or management to Target Field, the company is committed to making a difference locally by improving recycling and sustainability. Target Corporation is an advisor to this proof of concept through information sharing and connecting the project team with other essential players. Target Corporation is involved in a national collaborative called **Materials Recovery for the Future (MRFF)** (see sidebar), that is working to overcome technical and economic challenges of recycling[24] . Through Target Corporation's involvement in MRFF it is able to leverage this proof of concept findings to a broad, and deeply engaged audience. Specifically, the MRFF network could benefit from these results and the development of new techniques for processing difficult MMFPP.

Currently ReWall uses more fibrous types of packaging than the chip bags and candy wrappers produced at Target Field. So, while Rewall offers a developed process for recycling MMFPP, incorporating the kinds of materials Target Field produces will require learning and innovation that may lead to new recycling possibilities for a range of materials.

Finally, Target Corporation could act as a potential end market for products that incorporate recycled content, including MMFPP. For example, Target Corporation could incorporate ReWall products into the construction of new or remodeled Target stores, which could create a large demand for these sustainable products. Ultimately, Target Corporation can help encourage other retailers and product designers to innovate and drive change towards a sustainable, circular economy.

MRFF
MATERIALS RECOVERY FOR THE FUTURE

Materials Recovery for the Future (MRFF)
Materials Recovery for the Future (MRFF) is a project of the Foundation for Chemistry Research and Initiatives, a 501(c)(3) tax-exempt organization established by the American Chemistry Council (ACC).

"As one of the world's most trusted brands, we believe in making smart decisions and taking action across our business to care for the planet. That means not only reducing our footprint, but going beyond to restore and improve the places where we operate for future generations. So we're committed to using resources responsibly and designing our operations, products and services to be sustainable and circular."

Target Corporation Sustainability Statement

Materials Recovery for the Future Collaborative (MRFF)

Materials Recovery for the Future Collaborative (MRFF) envisions a future where MMFPP is collected in one's home or work recycling bin, just as cardboard or plastic water bottles are today. Further, they want recycled flexible plastic packaging to be used by local producers, allowing the local community to benefit from their efforts to collect and divert this type of waste from landfills. Motivating this effort is the growing use of MMFPP because of the numerous benefits it provides to consumers and manufacturers in function and affordability. However, MMFPP is currently a problem material for Material Recovery Facilities (MRF) because they typically don't have the technology, or incentives to collect it. MRFF is a collective of companies from across the MMFPP value chain working to make this vision a reality, with notable members such as Target, Pepsico, Dow Chemical, and many others.

In 2015, MRFF kicked off the first phase of their initiative with a research project to discover how MMFPP might be collected and sorted at a MRF. Through a series of equipment tests, they found that by optimizing automated sorting technology currently in use today, MRFs can successfully capture MMFPP from a single recycling stream, and even improve the capture rate of other recyclable materials[25] . During a 2017 trial test at a Nevada MRF, the optical sorter installed in one material flow successfully ejected 96.6% of the MMFPP material[26] .

While significant progress was made in proving the technology to sort MMFPP at MRFs, the research team identified additional barriers that must be addressed to create a fully sustainable solution. One major barrier is the non-existence of a large-scale consumer-processor capable of using MMFPP. While there are some small processors capable of producing products with this material, no research to date has assessed the end-market potential for these products. Second, understanding the economics of MRF technology upgrades will need to be considered for long-term investment decisions, including impact on revenues, costs, disposal, and quality of sorting. Third, after a MRF sorts this material, it must be checked for accuracy to ensure quality of the stream, called secondary processing. For this phase, understanding the costs of quality control and cleaning, along with the value added to the newly created products are needed to inform MRF investment decisions. Before making the case to implement a demonstration project with a community and a local MRF, the research team identified the need to prove an end-product and market through trial testing to ensure that there is a sustainable, large-scale solution for this recycling stream. In 2016, the research team began investigating possible end-markets across the United States for a trial demonstration[27] .

This proof of concept will provide an opportunity for MRFF to continue building a relationship with Rewall and to explore uses of MMFPP without having to invest in retrofitting recycling centers with expensive sorting technologies. This will help MRFF make financial calculations for the sustainability of their ultimate goal of making MMFPP recyclable for everyone in their own home and it will provide an opportunity to raise awareness of their work.

Natural Resources Research Institute (NRRI)

NRRI is a non-academic unit of the University of Minnesota located in Duluth, Minnesota, reporting to the Office of the Vice President for Research. It was established in 1983 by the state legislature to rejuvenate the forestry and mineral economy of Northern Minnesota. NRRI's mission is to enhance the economy while protecting the state's natural resources. A collection of scientists and engineers achieve this mission through applied research and delivered solutions. Today, the scope of its work is much broader, spanning water, renewable energy, minerals, land resources, and the bio-economy. Another research arm exits to support entrepreneurs and business ventures.

Our group spoke with Eric Singsaas, the Initiative Director for Wood Products and Bioeconomy. While he manages a number of projects at any given time, his expertise as it relates to our project involves developing solutions for compostable packaging using biomaterials. His research teams are working on the science of compostable materials, and he even has a lab for measuring the compostability of different products. Other projects include turning recycled wood pulp into packaging products, replacing oil-based plastics with biopolymers made from cranberry waste, finding applications for industrial hemp, and many more.

NRRI serves a unique need in the regional economy. It is not enough for NRRI to conduct research on innovative ideas. The organization is laser focused on research that has engaged stakeholders on both ends of the supply chain, from source to end-market. Not only are they conducting the research but bringing together actors necessary to bring a product to market. NRRI also works on applied research involving plastics. For example, researchers have the equipment to test durability and conduct chemical analysis and produce a report on the results.

Action Plan & Estimated Costs

There are a number of steps needed for the success of this proof of concept. The first phase is the collection of waste from Target Field for the production of panels at ReWall. Second, Rewall will experiment to achieve the right mix of these collected materials to assess the feasibility of incorporating them into their product line. Concurrently, the materials will need to be delivered to ReWall in Des Moines, Iowa and ultimately brought back to Target Field for the public awareness installation. Finally, the installation will have to be designed and constructed at Target Field to raise awareness about recycling and educate the public about the sustainability efforts.

The following pages detail a list of the inputs, activities, outputs, outcomes, and estimated costs of each step required for the proof of concept.

Collecting Fan Waste at Target Field

Inputs

- Fan waste
- Trash bins

Activity

Fans will continue to put MMFPP in trash bins, which will be transferred to the stadium's sorting room.

Outputs

- MMFPP in waste stream

Outcome

Because there is no change from current practice at this stage, we expect no additional outcomes.

Est. Cost

No additional cost is likely to incur at this stage of the project.

Sorting MMFPP Out of the Waste Stream at Target Field

Inputs

- Target Field's staff time and training
- Fan waste
- Storage bins

Activity

Target Field staff will sort MMFPP out of the waste stream and store it in a designated space until it is collected by a hauler after approximately one homestand.

Outputs

- Clean Supply of 100 to 200 pounds of MMFPP

Outcome

Target Field will increase its waste diversion and increase its chance of winning the GSA's Green Glove Award.

Est. Cost

Approximately $240 for an additional 16 hours of staff time (4 hours x 4 staff, at $15/hr) over one homestand. If an additional storage bin is needed, we recommend using the Minnesota Materials Exchange or other networks to acquire a free storage bin.

Transporting MMFPP to ReWall Facility

Inputs

- A truck
- A driver
- Gas

Activity

A truck will be needed to transport collected MMFPP from Target Field to Rewall in Des Moines, Iowa. A minimum of 1 ton will be to be collected for ReWall to accept the delivery.

Outputs

- MMFPP for creating a Rewall NakedBoard

Outcome

No outcome at this stage

Est. Cost

$500-$1,500 for the truck and driver

Processing MMFPP into ReWall NakedBoard Panels

Inputs

- MMFPP from Target Field

Activity

ReWall will use MMFPP from Target Field to manufacture wall panels. ReWall needs 1 ton of combined aseptic boxes (1,800 pounds) and MMFPP (200 pounds) to make a separate run of 40 panels.

Outputs

- 40 Rewall NakedBoards consisting of MMFPP collected from Target Field

Outcome

Since ReWall does not normally use MMFPP in their fabrication process, this proof of concept provides the opportunity to experiment with new processes that could enable the recycling of MMFPP in the future. This proof of concept could also lead to relationships into the future that provides a method of recycling for Target Field and a supply of raw materials for ReWall.

Est. Cost

$1,600 for 40 Rewall NakedBoard at $40 per panel

Transporting Panels to Target Field

Inputs

- A truck
- A driver
- Gas

A truck will be needed to transport completed panels from ReWall in Des Moines, Iowa to Target Field for the construction of public awareness installation.

Activity

Outputs

- ReWall NakedBoards made using MMFPP from Target Field

No outcome at this stage

Outcome

Est. Cost

$500-$1,500 for the truck and driver

Installation of panels at Target Field

Inputs

- ReWall NakedBoard panels that shows the brands of MMFPP collected from Target Field to display the installations

Activity

The completed Rewall NakedBoard panels will be installed at Target Field to demonstrate how MMFPP can be reused and raise awareness about recycling and sustainability. Educational material will be incorporated in the installation.

Outputs

- Panels at Target Field made of MMFPP from their waste streams.
- Educational content about the sustainability efforts of participating partners and the potential for expanding the possibilities of recycling.

Outcome

This installation will raise awareness for the sustainability work of the partners and the challenges and opportunities for recycling MMFPP. There is also a marketing opportunity, especially for ReWall in displaying its product in prominent locations. Target Field has a capacity of about 40,000, meaning there is the potential to reach tens of thousands of members of the public with this information.

Est. Cost

$2,500-5,000 for the design and construction

Total Estimated Costs for Proof of Concept Project	
Activity	**Estimated Cost**
Collecting fan waste at Target Field	$0
Sorting MMFPP out of waste stream at Target Field	$260
Transporting MMFPP to Rewall Facility	$500-1,500
Processing MMFPP to Rewall NakedBoard panels	$1,600
Transporting panels to Target Field	$500-1,500
Installation of panels at Target Field	$2,500-5,000
Total Estimated Cost	**$5,000-10,000**

Photo credits: ReWall

Metrics for Success

The impetus for this project was to find a circular economy solution for the MMFPP waste generated at Target Field. The long-term success of a project with this goal would be determined by the amount of MMFPP waste diverted from the current practice of incineration to the more sustainable options described earlier in this report. However, as there are no currently viable options for recycling Target Field's MMFPP waste, the success of this proof of concept should be measured with a different set of criteria that reflects the goals of innovating and building partnerships toward the creation of recycling solutions for MMFPP. With these considerations in mind, we propose the following criteria for evaluating the success of the proof of concept:

1. Ability to divert additional waste streams from Target Field in the short- and long-term
2. Proof of a feasible end-market for MMFPP sourced from sports stadiums
3. The value it brings for the partners involved
4. Awareness raised about recycling and sustainability among the public
5. Ability to open the possibility for experimentation with MMFPP for different forms of recycling in the future.

The most important aspects of this proof of concept are learning and partnership building. MMFPP waste is a growing problem and multiple actors are working in different ways to address it. The lessons learned from this proof of concept in terms of sorting waste in a stadium context and processing MMFPP waste into wall panels can advance the work of actors focusing on the problem of sorting MMFPP for recycling from residential sources. In turn, large scale community initiatives could provide partnerships and collection options for waste from Target Field in the future. Target Field has a relative advantage for experimenting with processing MMFPP because of its large, consistent, and well-sorted supply, but it will need to be connected to a larger network to create a circular economy for MMFPP in the future. The ultimate success of this proof of concept depends on making the necessary connections and learning across sectors to build networks for sorting, collecting, processing, and developing end-use markets for MMFPP waste.

Conclusion

Target Field is already a leader in stadium sustainability, from its construction and resource use to its waste collection and disposal practices. Target Field's desire to further improve its sustainability coupled with its generation of MMFPP waste and ability to sort this material provide a unique opportunity to experiment with processes and partnerships that can drive innovation in the recycling industry. The proof of concept recommended in this report will hopefully take advantage of this opportunity while benefiting all the partners involved. This proof of concept does not offer a complete solution to the problem of MMFPP waste at Target Field, but it will help toward developing a solution to this kind of waste at Target Field and beyond in the future.

There are limitations to this proposal as it will not resolve the challenge of MMFPP waste at Target Field. However, as there are not currently existing viable options for recycling MMFPP waste from Target Field, it is important to make first steps toward creating a solution, which this project will be able to do. If successful, this proof of concept will also not necessarily lead into a sustainable option for MMFPP recycling at Target Field. The scale of MMFPP waste collected at Target Field is likely not large enough to be cost-effectively used for other products, and the current demand for MMFPP waste is not developed enough for a company like ReWall to collect this waste at a low-enough cost to compete with the current practice of sending this waste to the HERC. This is why the partnership building aspect of the project is so important. This collaboration between Target Field and ReWall can help push the boundaries of current recycling options for MMFPP and partners like Target Corporation, MRFF, and NRRI can help build networks between residential recycling, manufacturers, and potentially other stadiums. This can also increase both the potential stream of sorted MMFPP waste and the demand for incorporating this use in recycled products. While this project does not offer an ultimate solution to the challenge of MMFPP waste at Target Field it does have the long-term potential to build the partnerships and prove the processes necessary for a solution in the future.

In addition to the long-term potential of the project, there are many short-term benefits. For Target Field, this proof of concept offers the opportunity to show off its sustainability work, improve the reputation of the Target Field and Twins brands and pioneer new recycling technologies with partners. There is also a great marketing opportunity for ReWall to demonstrate their product in a space passed by tens of thousands of baseball fans every week and to innovate with new materials in their products. Finally, working with a baseball stadium also means that the final educational aspect of this project will reach a diverse group of people from all over the region. This publicity could be a great opportunity for partners like MRFF and Target Corporation to spread their vision of what recycling in the future could look like. This project has the potential to spur innovation and partnerships, create a solution for recycling MMFPP waste in the future, and have immediate impacts for partners and the public that make it well worth its costs.

Acknowledgements

We would like to especially thank the following people for their time, expertise and advice throughout the course of this project . Without them, this project would not have been possible:

Steve Kelley
Hubert H. Humphrey School of Public Affairs

Gabriel Chan
Hubert H. Humphrey School of Public Affairs

Jase Miller
Target Field

Kim Carswell
Target Corporation

Tiffany Richardson
University of Minnesota

Dr. Jennifer Schmitt
Institute on the Environment

Dr. Eric Singsaas
Natural Resources Research Institute

Toby Davis
ReWall

Brad Rodgers
Pepsico-Frito Lay

References

Introduction

1 Cradle to Cradle in a Circular Economy - Products and Systems. (n.d.). Retrieved May 10, 2018, from https://www.ellenmacarthurfoundation.org/circular-economy/schools-of-thought/cradle2cradle

2 Winans, K., Kendall, A., & Deng, H. (2017). The history and current applications of the circular economy concept. Renewable and Sustainable Energy Reviews, 68, 825–833. https://doi.org/10.1016/j.rser.2016.09.123

3 Canadian Plastics Industry Association, Continuous Improvement Fund, & Stewardship Ontario. (2018, February). Analysis of Flexible Film Plastics Packaging Diversion Systems. Reclay StewardEdge. Retrieved from http://thecif.ca/projects/documents/714-Flexible_Film_Report.pdf

4 Go Twins, Go Green Infographic. (2017). Retrieved May 10, 2018, from https://www.mlb.com/twins/fans/infographics/go-twins-go-green

5 United States Green Building Council (2018). LEED. Retrieved from https://new.usgbc.org/leed

6 Johns, G. (2017, November 28). Mariners recognized with 2017 Green Glove Award. Retrieved May 10, 2018, from https://www.mlb.com/news/mariners-win-2017-green-glove-award/c-262485822

7 Steeman, A. (2013, July 28). Flexible Packaging and its Recycling Problems. Retrieved May 10, 2018, from https://bestinpackaging.com/2013/07/28/flexible-packaging-and-its-recycling-problems/

8 Minnesota Pollution Control Agency. (2013). 2013 Statewide Waste Characterization. Retrieved May 10, 2018, from https://www.pca.state.mn.us/sites/default/files/w-sw1-60.pdf

9 Miller, J. (2018, 01). Interview.

Challenges

10 ReWall Building Materials. (2017). Retrieved May 10, 2018, from http://www.rewallsolutions.com/

11 Kaiser, K., Schmid, M., & Schlummer, M. (2017). Recycling of Polymer-Based Multilayer Packaging: A review. Recycling, 3(1).

12 Gendell, A. (n.d.). Multi-material flexible packaging recovery. Sustainable Packaging Coalition. Retrieved from https://sustainablepackaging.org/committees/multi-material-flexible-packaging-recovery/

13 Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2115-2126.

End Market Options

14 Society of Plastics Engineers. (2014, September 3). Energy Recovery with Plastic to Energy Technology. Retrieved May 10, 2018, from https://www.plasticsmakeitpossible.com/whats-new-cool/technology-science/plastics-to-energy/energy-recovery-with-plastic-to-energy-technology/

15 Sustainable Packaging Coalition. (n.d.). Resources. Retrieved May 10, 2018, from http://multi-materialflexiblerecovery.squarespace.com/resources/

16 Ragaert, K., Delva, L., & Van Geem, K. (2017). Mechanical and chemical recycling of solid plastic waste. Waste Management, 69, 24–58. https://doi.org/10.1016/j.wasman.2017.07.044

17 Fatima, S. (2014). Chemical Recycling of Plastics. American Journal of Engineering Research, 3(11), 93–108.

18 Garcia, J. M., & Robertson, M. L. (2017). The future of plastics recycling. Science, 358(6365), 870–872. https://doi.org/10.1126/science.aaq0324

19 Miskolczi, N., Bartha, L., & Angyal, A. (2006). High Energy Containing Fractions from Plastic Wastes by Their Chemical Recycling. Macromolecular Symposia, 245–246(1), 599–606. https://doi.org/10.1002/masy.200651386

20 Green chemistry metrics. (2017, January 23). In Wikipedia. Retrieved from https://en.wikipedia.org/w/index.php?title=Green_chemistry_metrics&oldid=761543750

21 Nonclercq, A. (2014, October 14). Mapping flexible packaging in a Circular Economy [F.I.A.C.E]. Delft University of Technology, Delft, Netherlands. Retrieved from https://ceflex.eu/public_downloads/FIACE-Final-report-version-24-4-2017-non-confidential-version-Final.pdf

22 Nonclercq, A. (2014, October 14). Mapping flexible packaging in a Circular Economy [F.I.A.C.E]. Delft University of Technology, Delft, Netherlands. Retrieved from https://ceflex.eu/public_downloads/FIACE-Final-report-version-24-4-2017-non-confidential-version-Final.pdf

Recommendations

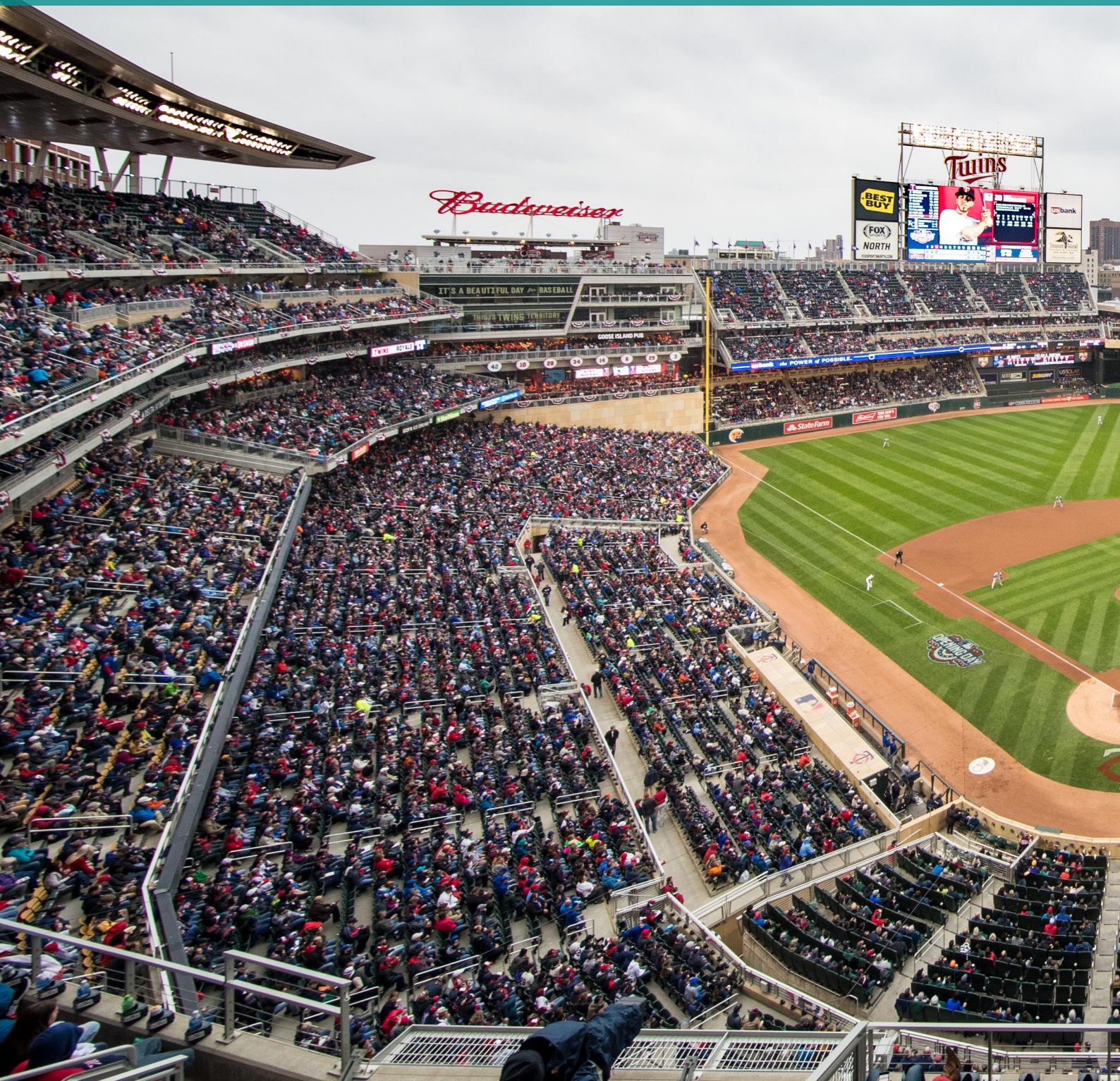
23 Davis, T. (2018, 04). Interview

24 A Plan for Recovering More Multilayer Packaging. (n.d.). Retrieved May 10, 2018, from https://www.materialsrecoveryforthefuture.com/

25 Sandford, K., & King, C. (2016). Flexible Packaging Sortation at Material Recovery Facilities Research Report (Research Report). Material Recovery Facilties of the Future. Retrieved from https://www.materialsrecoveryforthefuture.com/wp-content/uploads/2016/09/Flexible-Packaging-Sortation-at-Materials-Recovery-Facilities-RRS-Research-Report.pdf

26 King, C. (2017, August 18). Preliminary Findings: Republic South Nevada Recycling Center Equipment Testing. MRFF. Retrieved from https://www.materialsrecoveryforthefuture.com/wp-content/uploads/2018/01/MRFF-Equipment-Testing-Findings.pdf

27 Flexible Plastics Packaging End-of-life options. (n.d.). MRFF. Retrieved from http://rrsinc.maps.arcgis.com/apps/webappviewer/index.html?id=52f75c7e1a59461cb12b798fb14d8810


Budweiser
Twins
BEST BUY
FOX SPORTS NORTH
bank
IT'S A BEAUTIFUL DAY BASEBALL
THIS IS TWINS TERRITORY
GOOSE ISLAND PUB
THE POWER of POSSIBLE.
State Farm