A System Design to Reduce the Amount of Organic Waste Disposed in Trash

by

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Abstract

The current trend in modern society is to use, consume and discard. People typically generate large portions of trash without fully understanding what they are actually disposing of. The majority of the trash people in the United States dispose of finds its way to landfills where it is buried indefinitely. Organic waste is one of the leading components that is discarded into trash and is buried. As large landfills are a relatively new concept, little is fully understood about the extent of the long-term environmental impact this has on the environment.

The purpose of this thesis is to develop a system to alter the amount of “organic waste” people discard in trash that is not already recycled on a mass scale. This will reduce elements allocated to landfills, prolong their life, and help improve the environment.

The creation of this system will target organic waste that is discarded at residential and commercial properties, and will be the focus of this thesis. The following information will provide consumers with a foundation for understanding the impacts organic waste has on the environment and their opportunities to lessen that impact. This thesis will also provide designers a process to develop systems to reduce substances that are disposed in landfills.

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Table of Contents

Abstract ii

Acknowledgments iii

List of Figures viii

List of Interactions xi

List of Abbreviations xiii

Chapter 1. Introduction to Problem

1.1 Problem Statement 1

1.2 Need For Study 3

1.3 Objectives of Study 4

1.4 Definition of Terms 5

1.5 Assumption 10

1.6 Scope and Limitations 11

1.7 Methods and Procedures 12

1.8 Anticipated Outcome 16

Chapter 2. Introduction to Research

2.1 Overview of Waste Produced 18

2.2 Food Waste in Trash

2.2.1 Overview 20

2.2.2 Why it's So Bad 22

2.2.3 Landfill Gas 23

2.2.4 Landfill Leachate 25

2.3 Composting

2.3.1 Overview 26

2.3.2 Yard Trimming 28

2.3.3 Home Composting 28

2.3.4 Commercial Composting 29

2.3.5 Composting Problems 29

Chapter 3. Research to Waste Disposal Facilities

3.1 Trash Collection

3.1.1 Overview 31

3.1.2 Process 32

3.1.3 Costs 33

3.1.4 Problem 35

3.2 Landfills

3.2.1 Overview 37

3.2.2 Construction 40

3.2.3 Problem 43

3.3 Waste-To-Energy

3.3.1 Overview 45

3.3.2 Construction/Process 46

3.3.3 Problem 49

Chapter 4. Profitability of Waste Case Study: Sustainable Municipalities and Companies that are addressing the waste crisis

4.1 San Francisco

4.1.1 Overview 50

4.1.2 Figures 51

4.1.3 How it's Possible 51

4.2 Recology

4.2.1 Overview 52

4.2.2 Figures 53

4.2.3 Success 54

4.3 Oregon

4.3.1 The Problem 55

4.3.2 The Facts and Benefits 56

4.4 Eco-Cycle

4.4.1 Overview 57

4.4.2. Statistics 59

4.4.3 Education 60

4.5 TerraCycle

4.5.1 Overview 62

4.5.2 Consumer Support 64

4.5.3 Corporate Support 66

Chapter 5. System Development

5.1 The Social Movement

5.1.1 Overview 68

5.1.2 The Impact ... 69

5.2 Systems

5.2.1 Definition of a System ... 70

5.2.2 Our Current System ... 71

5.2.3 System Requirements ... 72

5.2.4 Ideal Systems ... 74

5.3 New System Design

5.3.1 Requirements ... 76

5.3.2 Hercules System ... 79

5.3.2.1 Waste Collection Service ... 81

5.3.2.2 Landfills ... 82

5.3.2.3 Waste-To-Energy ... 83

5.3.2.4 Business ... 84

5.3.2.5 Consumer ... 85

Chapter 6. Organic Solutions Business Model

6.1 Overview ... 86

6.1.1 The Players ... 87

6.1.2 Waste Collection Service ... 88

6.1.2.1 Point of View Interaction ... 89

6.1.3 Waste Disposal Locations ... 91

6.1.3.1 Point of View Interaction ... 92

6.1.3.2 Organic Solutions' Product ... 94

6.1.3.3 Organic Solutions' Product Distribution ... 95

6.1.4 Business and Educational Entities 96
6.1.4.1 Point of View Interaction 97
6.1.5 Consumer 99
6.1.5.1 Point of View Interaction 100
6.2 Flow and Interaction of Entities
6.2.1 Organic Waste Stream 102
6.2.2 Trash Waste Stream 103
6.2.2.1 Trash Waste Stream Rebates 104
6.2.3 Organic Solutions' Collection Bins 105
6.2.4 Organic Solutions' Product Distribution Stream 106
6.2.4.1 Secondary Organic Waste Stream 107
6.2.4.2 Organic Solutions' Revenue Stream 108
6.2.5 Opportunity for Profit Sharing 109
6.3 Impact Conclusion
6.3.1 Current Waste System 110
6.3.2 Consumers and Future Generations 111
6.3.3 Restorative/Cyclical Economy 112

References 114

List of Figures

Figure 1: Hercules System 79

Figure 2: Cradle-To-Grave Life Cycle of Food 80

Construction Image – Farm and Tractor (n.d., 2013)

Construction Image – Food on Plate (WFAE, 2013)

Figure 3: Closed Loop Life Cycle For Food Waste – Hercules System 80

Figure 4: Hercules System – Waste Collection Service 81

Construction Image (Waste Management, Inc, 2014)

Figure 5: Hercules System – Landfill 82

Construction Image (AP, 2014)

Figure 6: Hercules System – Waste-To-Energy 83

Construction Image (Covanta Energy , 2008)

Figure 7: Hercules System – Business 84

Construction Image (Winn-Dixie Stores, Inc, 2014)

Figure 8: Hercules System – Consumer 85

Construction Image (Healthy Kids Today, n.d)

Figure 9: Business Model – Organic Solutions 86

Construction Image (Business model brainstorm kit, n.d.)

Figure 10: Business Model – All Entities Involved 87

Figure 11: Business Model – Waste Collection Service 88

Figure 12: Business Model – Waste Disposal Locations 91
Figure 13: Business Model –Organic Solutions' Product 94
Figure 14: Business Model – Consumers of Organic Solutions' Product 95
Figure 15: Business Model – Business and Educational 96
Figure 16: Business Model – Consumer 99
Figure 17: Business Model – Flow of Organic Waste 102
Figure 18: Business Model – Waste Collection Drop Off 103
Figure 19: Business Model – Collection Rebate Stream 104
Figure 20: Business Model – Collection Bin Distribution 105
Figure 21: Business Model – Product Distribution 106
Figure 22: Business Model – Second Organic Waste Stream 107
Figure 23: Business Model – Flow of Revenue 108
Figure 24: Business Model – Flow of Profit Sharing 109
Figure 25: Business Model – Affect to Waste System 110
Figure 26: Business Model – Affect through Education 111
Figure 27: Business Model – Affect to Consumers 112
Figure 28: Closed Loop Food Cycle 113

List of Interactions

Interaction 1: Point of View Interaction Between Organic Solutions and Waste Collection Service 89

Construction Image 4 (Deminski & Doyle, 2013)

Construction Image 5 (Oky, 2010)

Construction Image 6 (Deminski & Doyle, 2013) &

(NY Traffic Ticket Lawer-Weiss & Associates, PC, 2007) Ticket 2

Interaction 2: Point of View Interaction Between Organic Solutions and Landfill 92

Construction Image 4&5 (Dobransky, 2011)

Construction Image 6 (Grobe, 2008)

Interaction 3: Point of View Interaction Between Organic Solutions and an Educational Facility plus Grocery Store 97

Construction Image 2 (WW-P Regional School District, 2014)

Construction Image 3 (One More Generation, n.d.)

Construction Image 4 (Recycling, 2012)

Construction Image 5 (Kittrell, 2011)

Construction Image 6 (Elementary, 2012)

Interaction 4: Point of View Interaction of a Consumer Participating in Organic Waste Collection..100

Construction Image 2 (Doyle, 2012)

Construction Image 6 (Ahsen, 2014)

Construction Image 7 (Walters & Walters, 2012)

Construction Image 8 (Accreditation, n.d.)

List of Abbreviations

BCRC	Boulder County Recycling Center
BOD	Biological Oxygen Demand
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
EPA	Environmental Protection Agency
MIT	Massachusetts Institute of Technology
MSW	Municipal Solid Waste
NIMBY	Not In My Back Yard
NJ	New Jersey
RCRA	Resource Conservation and Recovery Act
US	United States
VOC	Volatile Organic Compounds
WTE	Waste-To-Energy

1. Introduction to Problem

1.1 Problem Statement

The consumption of food is a natural biological process that all humans and living organisms must partake in to survive. Every day, people purchase, grow, cook, prepare and consume the organic matter that fuels our bodies. Once consumption is complete, the leftovers, whether they are uneaten portions, spoiled sections or scraps, find their way into the dark depths of a trashcan. "A University of Arizona study in 2004 estimated that 40-50 percent of all the food harvested in the United States is wasted; and in developing countries inadequate packaging causes 30-50 percent of foodstuffs to decay before they reach consumers" (Miller, 2012).

All organic matter holds valuable minerals, vitamins and other nutrients that when decomposed help generate new growth of organic matter, otherwise known as a lifecycle. Many of us are familiar with this concept from children's books that depict the birth, life, death, and decay of a tree and how it goes back into the ground to facilitate new life again. This tends to lead to a common misconception for consumers, that if one throws their organic waste in the trash it will simply decompose and facilitate new growth in a landfill, even possibly help decompose other items buried with it. Unfortunately, as stated by Elizabeth Royte, author of Garbage Land, "at almost every landfill in the country, this process [decomposition] grinds nearly to a halt once bagged garbage is compacted and buried. Below the top eight feet of the landfill, few organisms that require oxygen… survive" (Royte, 2006).

That means all of our food waste, lawn clippings and other organic materials that we believed to be decomposing in landfills, creating some good in this literal mountain of waste, is unfortunately doing the opposite. "Contamination of groundwater at and surrounding sanitary municipal solid waste landfills with materials such as organics and heavy metals has been documented" (Landreth, 1997). Two main byproducts of organic matter disposed of in landfills are leachate, otherwise known as "garbage juice," and methane. These two byproducts can poison the groundwater and air supply located near landfills. "Ferry reports other instances where groundwater contamination from organics has occurred at municipal solid waste landfills in states such as Oklahoma, California, New Hampshire, Wisconsin, and New York" (Landreth, 1997).

Current data and knowledge tell us that most modern day landfills appear to do their best to minimize the hazardous effects in landfills by implementing water treatment plants, gas collection facilities and "capping" the trash with what the industry claims to be an "impermeable" top. What we fail to realize is that "the primary sources of man-made methane are landfill sites for waste disposal, where it is emitted by any material derived from plants or animals, including food waste, paper, card, moulded pulp and bioplastics" (Miller, 2012).

Consumers today are most familiar and generally agree with the importance of recycling paper, plastic and metal but are unaware of the importance of diverting organics as well. "According to Recycle-More, the weight of food that is in landfilled exceeds that of packaging waste. This is only just being widely seen as an environmental issue" (Miller, 2012). The goal of this thesis is to develop and design a system to alter the flow of organic matter that is disposed of in the trash by consumers to reduce the environmental impact of landfills. Further research and exploration will be needed to design a method for producing a valuable organic byproduct from this collected food waste.

1.2 Need For Study

Research has shown "since 1960, the nation's municipal waste stream has nearly tripled, reaching a reported peak of 369 million tons in 2002. That's more stuff, per capita, than any other nation in the world" (Royte, 2006). A service that is not free even though many might think it is, "Garbage costs are staggering: New York City alone spent $2.2 billion on sanitation in 2011. More than $300 million of that was just for the transporting of its citizens' trash by train and truck" (Humes, 2013). Unfortunately the majority of Americans have no idea what they discard and toss into the murky hole that is their trashcan. If something is no longer desired or useful it is discarded to the trash with very little thought to its effects on the environment. As stated by Elizabeth Royte, author of *Garbage Land*, "I was obsessed with throwing things away. Transferring objects – whether food scraps, the daily newspaper, or a lamp – from my house to the street made me feel lighter and cleaner, peaceful even" (Royte, 2006).

One of the largest components of this "stuff" is organic waste. According to the EPA, "In 2011, Americans generated about 250 million tons of trash [36.25 million tons is just food waste] and recycled and composted almost 87 million tons of this material, equivalent to a 34.7 percent" (Environmental Protection Agency , 2013). Of these 87 million tons of recycled material, only 1.6 percent was recycled food waste [1.4 million tons] (Environmental Protection Agency , 2013).

After everything was recycled in 2011, 164 million tons of trash was discarded and buried in landfills, of which “food waste is the largest component of discards at 21 percent [35 million tons]” (Environmental Protection Agency , 2013). The need for this thesis is to develop a system that diverts the amount of food waste (organic material originally intended to be consumed) that is discarded into landfills by consumers, currently causing negative affects to the environment. This thesis will provide consumers, producers, government leaders/policymakers and other individuals with information as to the negative effects of discarding organic matter in the trash. It will also give them current information to identify areas of waste as well as methods and alternatives to lessen their impact on the environment.

1.3 Objectives of Study

The objective of this document is to study the reason organics are disposed of in landfills. The research will identify current disposal systems of waste and consumer behavior/trends when disposing of organics. It will identify current options for composting organic waste as well as identifying systems currently trying to address the disposal of organics in trash. Taking the best aspects of current systems and products addressing organic waste, this document will allow the development of a new system to easily and efficiently address organic waste disposal. This new system can then be implemented by municipalities, or other entities, allowing for the production of a viable product, while reducing organic components in landfills.

Study Objectives:

- Study amount and type of organic waste disposed in landfills.
- Identify environmental impacts organics have when disposed improperly.
- Discover relationships between consumer behavior and public sanitation.
- Research possible flaws with current waste disposal systems.
- Create a guideline that properly explains how to formulate a system based on multiple inputs and parameter with the purpose of decreasing organic constituents slated for landfills. This system will be applicable for consumer, producer, corporate, and public and private institutes.
- Develop a system from the applied guidelines set forth by this documentation that incorporates effective techniques and disposal strategies for reducing organic waste discarded in trash. This new system should be tailored to the entity that is generating the organic waste and should take into consideration these peoples' current means of operation within their system.

1.4 Definition of Terms

Biological Process: A natural reaction developed by nature

Bioplastics: Plastic created by plant material that is designed to decompose

Capping: The process of covering and sealing a landfill

Capture Systems: The act or process of gathering fumes

Cellulose: Plant matter

Collection Systems: The act or process of gathering

Composting: A microbial process in which organic materials are aerobically decomposed under controlled conditions to produce a humus-like product

Conglomerates: A wide variety of material

Consumer: An individual that purchases and uses a material

Contamination: The process of becoming unusable

Cradle-To-Cradle: Restoring something back to its original form; the process of creating no waste

Cradle-To-Grave: The process of production and consumption of a material that is not recycled or reused

Cyclical: A closed circle loop

Decomposed: The breakdown of a substance

Design Junkie: Job title for a designer employed by TerraCycle

Disposal Sites: Locations that waste and trash are discarded

Dry Scrubbers: The process of submerging hot gas emissions in a very fine powder lime. This action allows acid gases to become neutralized

Ecology: The scientific study of how organisms and nature interact

Entities: Consumers, Businesses or Community groups

Environmental Degradation: The process of causing harm to a natural system

Erosion: The removal of soil or dirt

Facilities: Designated areas of operations

Federal Superfund Program: A waste clean-up program created by the Department of Environmental Conservation

Food Waste: The process of disposing food that does not allow for reuse or proper decomposition

Garbage: A synonym for trash

Geotextiles: Durable cloth-like sheets that prevent the material of one layer from mixing with the material of the adjacent layer, yet allow liquids to pass through

Government Piecemeal: The process of leaving recycling regulations to local councils, authorities and officials to implement their communities' recycling programs

Grass-Roots: The process of running a business with the most basic of essentials

Greenhouse Gases: Gas molecules that trap heat and the sun's rays in the atmosphere, warming the environment

Hazardous Waste: Waste or trash that can cause damaging affects to living organisms

Heavy Metals: Metal particles that can enter and damage living organisms

Hydrophobic: Molecules that will not dissolve in water

Impermeable: The ability to not allow liquids or other molecules to penetrate, or pass through

Impermeable Synthetic Membranes: Plastic sheet only a few centimeters thick to prevent contamination of surrounding environment

Incineration: The process of burning

Industrial Waste: Waste produced by manufactures

In-vessel Compost: Organic material that is fed into a drum, silo, concrete-lined trench. The environmental conditions are controlled for the production of compost

Landfill: Location where trash is buried for final disposal

Landfill Fees: The price landfills charge trucks to dump their waste

Leachate: Many different organic and inorganic compounds that are typically either dissolved or suspended in the wastewater

Lifecycle: The time and transformation of a product's birth, life and death

Mega Landfills: Extremely large landfills with an unprecedented amount of trash and waste

Methane: A highly combustible greenhouse gas produced from the improper decomposition of organic matter

Mulch: Organic material spread around or over a plant to enrich or insulate the soil

Municipal Solid Waste: Collected sum of or a community's waste

Organic Matter: Material that was grown/grew

Organic Waste: Matter created from cellulose that was improperly disposed of

Product: Something produced for sale or consumption

Raw Materials: Material extracted from nature for the purpose of production

Recycled Material: Material collected for repurposing

Refuse: The combination of trash and waste items mixed together

Renewable Resource: A resource that can be reprocessed or delivered back to its original state prior to growth or creation

Restorative: The process of rejuvenation or making well again

Sanitary Landfill: An Engineered method of disposing of solid wastes on land by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with soil at the end of each day

Sanitation: The process of cleaning

Static Pile Composting: Perforated pipes push or pull oxygen and moisture through organic material to facilitate decomposition.

Stream: The flow of material

Superfund: Large landfills

System: A regularly interacting or interdependent group of items forming a unified whole

Synthetic Materials: Artificially developed items from the use of chemicals

The Hercules System: A sub-system designed to join an existing waste disposal system to allow the formation of a cradle-to-cradle system for a specific material

Tonne: A unit of measure for a metric ton

Transfer Vehicles: Large trucks that carry waste and trash long distances

Trash: Material that consumers and industry discard that can no longer be used or repurposed

Turned Windrow Compost: The manual turning of a compost pile

Upcycling: Taking a used item or product and reusing it in a way not originally intended

Waste: Material that is disposed in trash that still contains value, through reuse or reprocessing

Waste Management: The process of organizing and maintaining trash, waste or recyclables

Waste-To-Energy: The process of burning trash for the production of electricity

Wet scrubbers: A series of large, porous bags through which gases, but not particulates, can pass

Yard Trimmings: Organic matter such as grass, leaves, bushes, and trees

Zero Waste: Diverting 90% of waste from landfills without the use of incinerators

1.5 Assumption

It is assumed that all information collected from Books, Journals, Online Databases and Websites that are put forth for the completion of this system are accurate and up to date. It is assumed that no producers or consumers of food and other organics, or the landfill sites where the mass majority of food scraps and organic waste are trucked to are intentionally trying to negatively affect the environmental or surrounding population. It is assumed that all the information from these sources is factual, based on accurate research, and will provide significant improvement to the final system in development. Lastly, it is assumed that our actions today directly affect future generations and without change, hard times lay ahead.

1.6 Scope and Limitations

The scope of this thesis is geared to the home and commercial consumer of edible and non-edible organic products. This thesis will study and identify how consumers of organics inadvertently dispose of this renewable resource in landfills. It will study the effects organics have on landfills and the surrounding environments. This thesis will look at current disposal methods of organics and the practical uses of its byproduct (compost) once correctly disposed of. This study will also look at the consumer's psychology and perceived outcomes/effects of disposing organics in the trash, as well as identify how or why a consumer might willingly change a system that they are currently using. This study will not include all the other negative and harmful constituents disposed of and found in landfills.

The limits to the study are as followed:

- This thesis will explore the construction of landfills and other trash disposal methods. Non-organic materials and their effects on the environment will not be considered unless direct interaction with organics is unavoidable.
- A system design that alters the flow or organics to landfills will be developed through the completion of this thesis.
- The testing and prototyping of this system is limited to a 3D rendering that shows basic interaction and system layout.

- Final model is a preliminary concept and would need further testing in a large-scale community environment to become a working system.

1.7 Methods and Procedures

Step 1:

Procedure: Research production of waste by consumers.

Method:

a. Library, Online Resources
b. Examine overall quantities of what was produced
c. Examine overall quantities or recycled material
d. Analyze collected data and present findings in coherent manner

Step 2:

Procedure: Research the production of food wastes in trash.

Method:

a. Library, Online Resources
b. Identify why it winds up in the trash
c. Isolate its negative impacts on humans and the environment
d. Research causes and effects of leachate
e. Research causes and effects of Landfill Gas
f. Analyze collected data and present findings in a coherent manner

Step 3:

Procedure: Explore the current solutions for organic waste.

Method:

a. Library, Online Resources
b. Product examination
c. Identify applications and options consumers can use at their area of residence
d. Explore other organics that can end up in the trash other than consumable food
e. Identify organizations currently addressing organic waste
f. Analyze collected data and present findings in a coherent manner

Step 4:

Procedure: Research current systems addressing the removal of waste.

Method:

a. Library, Online Resources
b. Examine current system of waste removal
c. Examine consumer interaction
d. Examine service being offered
e. Identify areas of conflict for both consumer and service provider
f. Examine differences for both services provided by private and commercial industries
g. Analyze collected data and present findings in a coherent manner

Step 5:

Procedure: Research and analyze the construction and operations of landfills and effects they may have on environment.

Method:

a. Library, Online Resources
b. Review and examine how landfills are constructed
c. Explore the history of landfills and how they arrived at current form
d. Collect data on current benefits, problems, and dangers of landfills
e. Collect and examine data on the affects landfills have on human population and environment
f. Analyze collected data and present findings in a coherent manner

Step 6:

Procedure: Research Waste-To-Energy (WTE) facilities and analyze the construction and operations, and any effects they may have on the environment. Method:

a. Library, Online Resources
b. Review and examine how WTE facilities are constructed
c. Explore the history of WTE facilities and how they arrived at current form
d. Collect data on current benefits, problems, and dangers of WTE facilities
e. Collect and examine data on the affects WTE facilities have on human population and environment

f. Analyze collected data and present findings in a coherent manner

Step 7:

Procedure: Identify human behaviors that explain current habits of consumers and quantify the value of the “waste” they produce.

Method:

a. Library, Online Resources
b. User observation
c. Identify current trends
d. Identify why and how people change behavior
e. Research the value of items discarded in the trash
f. Discover and identify the degree of knowledge consumers have on the effects their waste has on themselves and the environment
g. Identify areas and methods to inform and change consumer habits
h. Analyze collected data and present findings in a coherent manner

Step 8:

Procedure: Discover and identify the systems approach of companies addressing waste in an eco-friendly manner and how they are successful.

Method:

a. Library, Online Resources
b. Interviews and discussions with people in the industry
c. Identify differences as to how they identify and address the issue of waste

d. Find trends and overlap to data that can explain how they get participants to “buy in” and participate
e. Clearly identify areas of difference between their approach and the current/standard waste management system
f. Analyze collected data and present findings in a coherent manner

Step 9:

Procedure: Develop approach for a new organic waste collection system.

Method:

a. Identify and demonstrate benefits for all parties currently involved in waste management, i.e. collection agencies, landfill companies, WTE facilities, agricultural industries, consumers and producers of waste
b. Create system
c. Develop visual models to depict interaction at every level
d. Establish guidelines for development of system
e. Provide examples to help with analysis
f. Clearly illustrate how all parties, consumers, and environment benefit from the implementation of the new system

1.8 Anticipated Outcome

By identifying current habits of consumers and why they do or do not participate in recycling, this thesis will develop an effective system to collect food scrap so it may be disposed of properly and delivered back into the environment in a sustainable method, utilizing all of its nutrients and recyclable properties.

In addition, the methods used by this thesis will provide designers with insightful information on how to better design systems for collecting valuable material by applying research of consumer habits, tailoring collection processes, and creating systems that address habits and trends of consumers, producers and policymakers. The implementation of this knowledge will explore ways to significantly decrease the amount of organic waste trucked and buried in landfills, providing a decrease in potential environmental degradation and produce revenue from an untapped and generally overlooked resource.

2. Introduction to Research

2.1 Overview of Waste Produced

The removal of trash to many is the pinnacle of cleanliness. When items are rendered useless, cluttered, dirty, broken, outdated, unwanted or just plain ugly, more often than not they find their way to the trash. It has become America's go-to move for dealing with unwanted items as stated by Edward Humes, Author of Garbology: "Americans make more trash than anyone else on the planet, throwing away about 7.1 pounds per person per day, 365 days a year… 50 percent more garbage per person than other Western economies with similar standards of living (Germany, Austria and Denmark, among others), and between two and three times the trash output of the Japanese" (Humes, 2013). Edward Humes also states that the EPA drastically underestimates the amount of trash produced and over-estimates the amount of recycling, stating the EPA strictly uses mathematical formulas and does not actually collect data from disposal sites. Research conducted by Columbia University and the journal BioCycle finds the yearly output of trash is more closely in line with 389.5 million tons (Humes, 2013).

Regardless if one uses the figures produced by the EPA or Humes, the disposal of trash has led to some significance such as overall cleanliness, decreases in disease and creates employment for the plethora of workers that haul, transport, (in some instances) separate and dispose of the trash across the United States. Unfortunately this action is overwhelming and just flat out wasteful. "Trash is such a big part of daily life that American communities spend more on waste management than on fire protection, parks and recreation, libraries or school-books" (Humes, 2013).

While Americans are continuing to grow and improve the current recycling infrastructure, recycling paper, plastic, metal and glass it is not expanding to the overwhelming majority of other conglomerates that are disposed of on a daily basis. An even more disturbing trend is how much Americans are actually wasting.

> *"We may badly underestimate how much stuff we're burying, but we do have a good handle on what it's made of. And we also know what it's worth – some $50 billion in value chucked each year, lost to us now, but waiting to be recovered if only we could somehow make the transition from waste management to materials management"* (Humes, 2013).

One of the biggest components wasted is food waste. "Total MSW [Municipal Solid Waste- Things commonly used and then thrown away by household or commercial entities] recovery in 2011 was almost 87 million tons. Similar to generation, organic materials are the largest component of MSW recovery. Paper and paperboard account for 53 percent [46.11 million tons] and yard trimmings account for about 22 percent [19.14 million tons] and food waste accounts for [about only] another 2 percent [1.75 million tons]" of recycled material (Environmental Protection Agency , 2013). As of 2009, San Francisco is the only city successful at collecting food waste and diverting it from landfills, but this is largely in part due to a steep and rigorously enforced $1,000 fine to the residences if found not separating (Humes, 2013).

2.2 Food Waste in Trash

2.2.1 Overview

Edward Humes states that Americans, on a yearly basis, dispose in the trash over 96 billion pounds [48 million tons] of food; if we were able to redirect 5% of this total waste, it would be enough to feed 4 million people for a year (Humes, 2013). This new-age phenomena of waste is unprecedented, “125 years ago the kitchen trashcan didn’t exist. [It was not] until municipal collections were organized in the late 1880’s” (Royte, 2006) did our current love affair with disposing trash manifest. Currently according to the EPA “after MSW recovery through recycling and composting, 164 million tons of MSW were discarded in 2011. Food waste is the largest component of discards at 21 percent. Plastics comprise 18 percent; paper and paperboard make up 15 percent; and rubber, leather, and textiles account for 11 percent of MSW discards. The other materials account for less than 10 percent each” (Environmental Protection Agency , 2013).

In 1993 it was estimated that the increases of food waste generated would be at a slow steady rate, starting at 6.7% of the total stream (13.8 million tons) and projected to reach only 6.4% in 2000 (14 million tons) and percentage wise, would continue to decline through significant source reduction (Landreth, 1997). But with the EPA stating 21% (roughly 35 million tons) of the MSW was food waste in 2011 that was sent to landfills, the opposite has unfortunately occurred.

It is a staggering statistic as to how much food is wasted on a daily basis, through not finishing a meal, forgetting about leftovers or just not using food in time before it goes bad. And what's even more troubling is the number of people that are oblivious to this:

> *"Thirty percent of the milk produced in America is thrown away because of inefficiencies that let it expire or spoil before it can nourish anyone. All that energy, all that shipping, all that cattle feed, all that refrigeration, all that effort – nearly a third of it is wasted, thrown away, trashed. The rest of our food supply suffers similar losses – in a world where hunger is a growing, deadly problem, at least a quarter of the total American food supply is fated to become garbage. And we're paying for that, every day – in higher food prices, high utility bills, pollution and debt"* (Humes, 2013).

This is staggering considering how easy and beneficial it is to recycle organic material. Anyone that has ever owned a home garden and used compost on a regular basis can attest to the significant improvement to soil and food quality it produces. "Composting has a variety of beneficial properties: composting provides a solid amendment that returns organic-rich material to the land, helps soil retain moisture and nutrients, increases soil fertility, reduces erosion, and soil compaction" (Landreth, 1997).

2.2.2 Why it's So Bad

"When we purchase a product we do not think about the raw materials, irrigation, energy, fuel and pollution in its wake. We simply see the product, which we use" (Miller, 2012). The idea and implementation of "mega" landfills in terms of human history is a relatively new concept. No one truly knows the long-term consequences of these super-sites (large scale landfills) but predictions and fallouts have already started to surface. There were "sixteen thousand authorized disposal sites in 1970 to just over 1,200 sanitary landfills in 2011. The old sites have long since been buried, capped over and, in several hundred instances, slated for extensive hazardous waste cleanup through the federal Superfund program"[a waste clean-up program created by the Department of Environmental Conservation] (Humes, 2013).

Two main problems landfills generate are leachate, which is defined as "many different organic and inorganic compounds that are typically either dissolved or suspended in the wastewater" (Landfill Leachate Treatment, 2014) and methane; a highly combustible greenhouse gas. These two landfill by-products are in large part due to the improper decomposition of organic matter in landfills. Both these constituents have led to considerable land degradation through contaminated water supply, air pollution and ultimately human injury, and not to mention costing municipalities and taxpayers large sums of money for clean-up and "prevention" tools. "It wasn't until the 1980s and 90s that the Environmental Protection Agency, through its Resource Conservation and Recovery Act [started] requiring leachate and methane collection systems" (Royte, 2006).

> *"A Connecticut court case decided a municipality can be held liable for cleanup costs at a Superfund site as a result of its contribution of solid waste… mean[ing] that if household trash trucked to landfills or other contaminated sites can be shown to have hazardous constituents, local government and, therefore, local taxpayers must share cleanup costs"* (Landreth, 1997).

"On its own, my trash might be harmless to me, but combined with the output of several million others, it could be lethal to many" (Elizabeth Royte, 2006).

2.2.3 Landfill Gas

With polar ice caps melting, mega "100 year storms" and prolonged summer droughts becoming a yearly occurrence, it can be argued that humans have directly impacted the course of the world's climate by continually pumping "greenhouse gases" [gas molecules that trap heat/sun's rays in the atmosphere warming the environment] that far exceed levels naturally produced in nature. Research has shown nationally, landfills are the largest man-made source for methane, resulting in 32 percent of the total methane emissions in 2002 (Royte, 2006). These emissions have a direct impact on human life.

> *"When organic matter decomposes, it creates methane and carbon dioxide, both greenhouse gases. As it filters up through layers of buried garbage, methane can pick up carcinogens like acetone, benzene and ethyl benzene, xylenes, trichloroethylene, and vinyl chloride. These compounds are borne on the breeze into nearby homes and offices"* (Royte, 2006).

As cellulose breaks down, if the environment is not right for decomposition to take place, acids such as acetic, lactic, and formic form. This is then followed by methanogens, which converts acid and menthanol into methane, carbon dioxide, and water (Royte, 2006). Current landfills are implemented with gas collection systems, which are basically perforated tubes, buried within the garbage that allows landfill gas such as methane, carbon monoxide and other vapors to escape and funnel up to collection facilities. Unfortunately, this system is far from perfect and still allows a tremendous amount of methane to escape. "Even the most advanced methane capture systems (such as Puente Hills's landfill gas power station in Los Angela's) still allows 50 percent of the climate-busting methane to bleed into the atmosphere, [which] has twenty-three times the global-warming punch as the carbon dioxide produced by combustion"(Humes, 2013).

> *"A 1998 New York State Department of Health study found that escaping landfill gases contributed to an estimated fourfold increase in bladder cancer and leukemia rates in women who lived within 250 feet of thirty-eight upstate landfills"* (Royte, 2006).

2.2.4 Landfill Leachate

Leachate, more commonly known as garbage juice, is another major byproduct of organics being placed in landfills. "Leachate can consist of many different organic and inorganic compounds that are typically either dissolved or suspended in the wastewater. High concentrations of chemical oxygen demand (COD) associated, BOD, nitrogen, phenols, pesticides, solvents and heavy metals are common in these systems" (Landfill Leachate Treatment, 2014), and, if allowed to escape, would wreak havoc on an ecosystem.

> *"Leachate, is so toxic that it has to be contained by multiple clay, plastic and concrete barriers, drainage systems and a network of testing wells just to keep it dammed and prevent it from poisoning groundwater supplies"* (Humes, 2013).

This poisonous concoction differs from landfill to landfill in chemical makeup and quantity, but remains extremely poisonous; never stops flowing and "many of these chemicals are hydrophobic. That is, they hate water, won't dissolve in it and just wait for something better to come along that they can stick to" (Humes, 2013). Fresh Kills Landfill in New York City, now closed, was once the largest landfill in world. Today it excretes on a daily basis about 800,000 gallons of leachate a day and regardless of prolonged drought, it never runs dry (Royte, 2006). Even more troublesome is the fact no one can predict when these products will stop flowing from the depths of the garbage mountain. This means that even though a landfill site may be closed, capped and sealed for decades and possibly centuries, water treatment facilities and leachate control must be monitored, maintained and carefully watched to prevent it from leaking out into the surrounding ecosystem. It has been documented that when these constituents do find their way into the real world, this residential trashcan be just as toxic as industrial waste (Humes, 2013).

2.3 Composting

2.3.1 Overview

"On average, we recycled and composted 1.53 pounds out of our individual waste generation of 4.40 pounds per person per day" (Environmental Protection Agency , 2013). Composting, as outlined in Municipal Solid Wastes by Robert E. Landreth and Paul A. Rebers, is a microbial process in which organic materials are aerobically decomposed under controlled conditions to produce a humus-like product, otherwise known as compost (Landreth, 1997). To achieve this there are three main methods: turned windrow, static pile, and in-vessel.

Turned windrow are large piles laid out in elongated rows generally forming a triangular shape about 5 to 6 feet high and 10 to 12 feet long. Compost is achieved by manually turning the pile with a pitchfork, tractor or installing a "turning screw" through the pile allowing aeration and exposure to moisture (Landreth, 1997).

Static piles are established very similarly to windrow piles with the exception of adding perforated pipes into the belly of the pile. These pipes allow for oxygen and moisture to be either pushed or sucked through the pile allowing decomposition without physically turning aggregate. One benefit of using this method of drawing air through the pile allows for foul smells to be relatively contained and transported through the piping to a separate location (Landreth, 1997).

Lastly, there is In-Vessel, which generally has a shorter composting time, and is more typically seen in backyards. "Organic materials are fed into a drum, silo, concrete-lined trench, or similar equipment where the environmental conditions-including temperature, moisture, and aeration-are closely controlled. The apparatus usually has a mechanism to turn or agitate the material for proper aeration. In-vessel composters vary in size and capacity"(U.S. Environmental Protection Agency , 2013).

As outlined by Laurel Miller and Stephen Aldridge, authors of *Why Shrink-Wrap A Cucumber,* "Sustainability, in the context of the environment, is the ability to replace the resources used in a product's manufacture, and so ultimately make a neutral or positive contribution to the environment" (Miller, 2012). Composting, no matter how it is achieved, is an effective tool for landfill diversion. It allows organic materials to be recovered, managed and used and by municipalities and consumers (Landreth, 1997).

> *"Recycling and composting almost 87 million tons of MSW saved more than 1.1 quadrillion Btu of energy; that's the same amount of energy consumed by over 10 million U.S. households in a year"* (Environmental Protection Agency , 2013).

2.3.2 Yard Trimming

In 2011, it was calculated that more than 57 percent of yard trimmings were recovered for composting (Environmental Protection Agency , 2013). Yard trimmings are comprised of basically everything that's green: grass, leaves, bushes, and trees. They can originate anywhere from residential, institutional, and commercial locations. "Based on a limited collection of data, the EPA estimates that nationally, on average, yard trimmings are composed of 25% brush, 25% leaves, and 50% grass (by weight). However, it is recognized that these numbers vary widely depending upon the region of the country" (Landreth, 1997).

These clippings can be used in the most practical of ways. In over half the country un-composted leaves and/or grass clippings are applied to agricultural land as a cost-effective method and alternative to a centralized composting facility (Landreth, 1997).

2.3.3 Home Composting

Home composting is a simple and effective method to deal with organic waste. All that is required is an area of land, generally located away from the house and a shovel. Some individuals construct boxes/pens or purchase elaborate rotating bins, but in the end it's all dependent upon personal preference. Currently in the United States, 50% of State Government and 80% of Local Government support programs that encourage backyard composting efforts, which include education, promotion, funding, and/or compost bin distribution (Landreth, 1997). This material is generally comprised of yard trimmings, food scraps, woody materials, non-recycled paper, and some textiles. These are only small fractions of all the material in the categories that are compostable (Landreth, 1997). In many instances, fruits and vegetables are the primary compostable materials derived from the house. It is feared that placing meat scraps, bones or other animal byproducts will attract animals and pests.

2.3.4 Commercial Composting

Nationwide there are close to 3,202 commercial composting facilities turning organic matter into compost. When centralized in this manner, it is considered recycling (Landreth, 1997). According to the EPA these facilities recovered over 20 million tons of this organic waste (Environmental Protection Agency , 2013).

Of these 3,202 facilities only about 58 compost organics derived from food services, such as grocery stores, hotels, quick service and full-service restaurants, and institutional cafeterias. These products are then mixed in with yard trimmings and/or other organic feedstock to produce viable compost (Landreth, 1997).

2.3.5 Composting Problems

One of the main problems with composting today is people and their perception of organic waste. "Bones and wasted food (13 million tons), grass clippings and yard waste (31 million tons), or even magazines and newspapers (14 million tons) do not feel as wasteful as empty vessels that once contained so much promise" (Hine, 1997).

Another main problem is the government's "piecemeal" approach to recycling. Recycling is left to local councils, authorities and officials to adopt their own community's recycling programs, rather than implementing a national strategy (Miller, 2012). This tends to lead to misinformed communities, resulting in low standards that lead to larger amounts of waste.

Currently out of the 3,202 compost facilities, nearly two thirds are producing mulch as well. Some of these facilities though are producing more mulch than compost (Landreth, 1997). Mulch is defined as "material spread around or over a plant to enrich or insulate the soil"(Oxford University Press, 2014). This process generally leads to lower biological activity required for decomposition.

When composting, air supply is of the upmost importance. When air supplies are cut off a "short-circuiting" of decomposition can occur allowing anaerobic pockets to develop in areas of excessively wet material, or material of different sizes that would have a tendency to clump (Landreth, 1997). This can drastically prolong the process of decomposition and creating of compost. "When oxygen levels fall below five percent, the aerobes die and decomposition slows by as much as 90 percent. Anaerobic microorganisms take over and, in the process, produce a lot of useless organic acids and amines (ammonia-like substances) which are smelly, contain unavailable nitrogen and, in some cases, are toxic to plants" (University Of Illinois Extension, 2014).

3. Research to Waste Disposal Facilities

3.1 Trash Collection

3.1.1 Overview

During the time of the Roman Empire, the first trash collection system was established. Local city dwellers and residents lined the streets with their refuse where it was then shoveled onto horse-drawn carts, transported out of town and dumped in a centralized location (Tammemagi, 1999). "In the United States, the modern concept of solid waste management first emerged in the 1890s in response to the sanitation problems associated with rapid industrialization and urbanization in the second half of the nineteenth century" (Tammemagi, 1999).

In 1902, the Massachusetts Institute of Technology (MIT) conducted a survey to establish the percent of American cities offering regular collections of refuse (trash and other unwanted items). That year, the data concluded that 79% of American cities offered regular collection of refuse. When the survey was repeated in 1915, it indicated 89%, and by 1930, it was concluded that virtually all major American cities had established, and offered refuse collection programs (Tammemagi, 1999).

Today it is estimated that "136,000 garbage trucks, 12,000 transfer vehicles, and 31,000 dedicated recycling vehicles haul away America's garbage (179,000 vehicles in total)," all serving our estimated "75 million homes, 7 million businesses, and 100,000 government enterprises"(Inform, Inc., 2009). Currently, 82% of the collection services offered today is owned and operated by private companies, with the remaining 18% by public entities(Inform, Inc., 2009). “Most North American communities operate streetside or “blue box” programs for fine paper, can, plastics, newspapers, and cardboard. The specific collection of household hazardous wastes –either on periodic collection days or at special collection sites –has also become a standard part of municipal waste service”(Tammemagi, 1999).

3.1.2 Process

The overall method for the collection of refuse has not varied much since the time of the Romans. Today, principles of the original system are still implemented, with some minor tweaks. The consumers that produce the trash, collect it in a centralized location (convenient for that individual), and place the entire quantity in a predetermined location, on or by a specific date. Whether it be curb-side pick up or a large dumpster located within your community, the process of creating, collecting, and passing refuse off to another individual remains the same. “Our entire elaborate waste collection, transportation and disposal system has for a century been built around this question, and the illusion that everyone’s 102-ton legacy can be picked up piece by piece, week by week, and made to disappear, when in reality we have been building mountains with it” (Humes, 2013).

Today’s trash collection trucks are designed to collect, retain and transport the most amount of refuse as possible. While some trucks utilize automated methods for picking the trash bin off the curb to empty the refuse within its storage compartment, the majority utilize man-power to lift the refuse from the curb and place it in the containment portion of the truck.

Once the waste is located within the holding section of the vehicle, large hydraulic presses squeeze and compact the trash to its smallest possible dimension. These dimensions and degree of compaction are based on the ability of the hydraulic press being utilized. Currently today, “space on the supermarket shelf is some of the most valuable real estate in the world, and there are always plenty of new packaged products vying for display”(Hine, 1997). This has lead retailers to “demands that bottlers [and other products] provide more beverages in lighter packaging that can be crushed or stored without breaking, thereby taking up less room in the store”(Landreth, 1997). This has led to packaging becoming lighter and lighter, incorporating synthetic materials, and rendering the heaviest component by volume within a garbage truck, organic matter. The organic material collects, seeps, and is extremely more dense than the light packaging that it was once contained in. “As much as 17 percent of the garbage by weight that they were hauling up in the late 1990s and early 2000s consisted of food waste”(Humes, 2013).

3.1.3 Costs

Today, “the collection program represents a significant cost as well as a formidable logistical exercise. It is essential that the waste generators – the customers – know what is to be put out and how it is to be sorted and separated” (Tammemagi, 1999). In the United States, landfill fees (the price landfills charge trucks to dump their waste) vary from location to location. Generally the charge to the garbage trucks range any-where from $25 to $70 per tonne (metric ton) and is determined by "total weight minus the weight of an empty truck times [x] per ton equals the price of entry in 2011"; in California "x" was about $38 (Humes, 2013). This is considerably lower than incineration at a WTE facility that classifies "x" anywhere between $40 and $100 per tonne (Tammemagi, 1999). This is generally because of two factors, "First, landfills involve relatively low technology [and] second, recycle centers and incinerators require up-front capital, because they must be constructed before they can be used" (Tammemagi, 1999).

But with population drastically expanding, and the dangers of containing landfills and incinerators within or by city limits, becoming more evident, once a landfill is closed, the siteing of a new location to bury trash becomes a very formidable problem. As already seen with New York and the closing of Fresh Kills, the former New York City mega landfill, New Yorkers "now, instead of paying about $40 a ton to dump waste within the city limits… pay $105 a ton to export it" (Royte, 2006), and in some cases hundreds of miles, as all its solid waste is now exported.

In Los Angeles they are currently facing the same dilemma. "Puente Hills [currently the largest landfill in America] became the most affordable [landfill] in California to dump trash. For many years it charged cities as well as private trash collection companies and everyone else who needed to dispose of waste just $18 a ton to dump. This was half of what some other public and private facilities charged in Southern California"(Humes, 2013). But as the landfill is entering its final stages of life, new locations had to be sought out. The solution that was recently approved requires “transferring trash from a new rail depot at Puente Hills to the Sanitation Districts’ newly purchased former gold mine two hundred miles away in the desert of Imperial County [and] will cost $80 a ton”(Humes, 2013) to dump waste.

With just the transportation and trucking of materials to be disposed in landfills and incinerators, it is becoming a financial burden to move this heavy amount of refuse form one location to another and should become more appealing to wean out and remove heavy such materials as organics that are driving up the prices of dumping.

Big Mike, a sanitation worker and Heavy Machinery operator at Puente Hills stated:

> *“The truly thought-provoking part of the business…is the endless tide of ordinary, everyday stuff streaming into the place, items that are not really trash at all… Or the truckloads of food that turn up daily, a good deal of it spoiled but much of it perfectly edible, some of it still packaged and brand-new, yet discarded as if it had no use”*(Humes, 2013)*.*

3.1.4 Problem

“Because of the populist nature of waste, its management is very much a social problem. It is not sufficient to understand the technical aspects; it is equally important to come to grips with the social and political issues. Interwoven with these are economic issues, and we must seek effective solutions within practical cost limitations” (Tammemagi, 1999).

Rathje, former University of Arizona Professor and father of Landfill Archaeology, “noted that when sanitation departments provide larger trashcans to households, those households immediately began to produce more trash,” which he referred to as the “Parkinson’s Law of Garbage…Parkinson’s Law, formulated by British bureaucrat C. Northcote Parkinson, who in 1957 noted that work expands in order to fill whatever time is available for its completion” (Humes, 2013).

Currently in the United States it is estimated that one out of every six big trucks on the roads is a garbage truck; if you were to line their yearly loads up, it would stretch halfway to the moon (Humes, 2013). Much of this problem has been noted to the way municipalities and companies charge for the collection of garbage (even though the majority of people have no idea what they pay).

> *“Such perverse incentives for waste permeate the economy. Most sanitation systems charge homeowners the same rate for large amounts of trash rolled to the curb as they for small amounts – on flat fee for all, whether your neighbor makes half the trash you do, or twice as much. But some communities use “pay as you throw” model: make less waste to be hauled away, use a smaller size bin at curb, and you pay less each month. Bigger trash bins receive bigger bills because there’s more to haul – an eminently fair set up. With that model, an incentive to be wasteful is replaced by an incentive to be thrifty. Give each homeowner a recycling bin and make hauling its contents free regardless of the amount of recyclables inside, and another incentive is born: an*

economic incentive to sort trash properly (which a surprising number of people resist under the what's in it for me? Objection to the minor inconvenience of sorting)… According to a slew of EPA studies, pay-as-you-throw towns send an average of 40 percent less waste to landfills than other communities. It's a fairer system, it works, it provides the most beneficial incentives, and it has been proven to reduce garbage volume dramatically – yet fewer than one in five communities in the U.S. do it" (Humes, 2013).

3.2 Landfills

3.2.1 Overview

The process and implementation of landfills is a concept that has been around for thousands of years. The earliest recorded history of this dates back to the "Minoan Civilization, which flourished in Crete from 3000 to 1000 B.C… where [trash and waste] was placed in large pits and covered with earth" (Tammemagi, 1999).

Over the years, till the mid 20th century, this process of disposing of waste remained relatively the same and untouched. It was even viewed as a way of reclaiming lands from marshes and other shallow depressions, which was a long held belief through the 1970's. Disposal sites were all based on convenience with the age-old saying "out of sight, out of mind" being the driving force. These landfills though would never get more than a few meters thick before they were covered with dirt and declared closed (Tammemagi, 1999). In 1950, this processes of covering trash with dirt was eventually coined a “sanitary landfill.” “A sanitary landfill is usually defined as an engineered method of disposing of solid wastes on land by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with soil at the end of each working day” (Tammemagi, 1999).

As populations grew, ideal site locations became “depressions such as ravines, canyons, abandoned quarries, and open pits, [areas] that could easily fill up. These locations were selected largely on the basis of convenience, with proximity to the [city] centers being served and price of land being key parameters” (Tammemagi, 1999). But by the 1980’s “there was growing recognition that landfills were causing significant contamination of groundwater. Groundwater, the supply tapped by wells, is a vitally important resource which, when used as a drinking or irrigation supply, can directly impact human health” (Tammemagi, 1999). This realization of the dangers and harm landfills can cause to human health and the environment has led to changes in the way landfills are sited and “constructed,” many of which are still being implemented today. Sites that contain bed rock, large amounts of clay, no underlining aquifers or aquifer recharge zones became some of the criteria for siteing locations for landfills that minimizes the environmental impact they may have. But by 1982, “the U.S. EPA banned reliance on clay liners alone for hazardous waste sites and specified the use of single or double liners made of impermeable synthetic membranes” (Tammemagi, 1999), which is generally a plastic sheet only a few centimeters thick to prevent contamination of surrounding environment. By 1991 it was reformed again by the EPA to "require that new municipal landfills have a minimum of six layers of protection between the garbage and the underlying groundwater. At present, an estimated two-thirds of U.S. landfills do not have [any] liners" (Tammemagi, 1999) preventing contamination.

> *"The U.S. Environmental Protection Agency estimated that in 1990, there were about 75,000 landfills in the nation, and more than 75% of them were polluting groundwater's with leachate… It was also recognized that even state-of-the-art municipal landfills with double liners and other modern leachate containment systems would fail eventually. The increased use of engineering techniques would only postpone, not prevent, the onset of groundwater contamination"*(Tammemagi, 1999).

Today "The EPA requires that dual leachate systems (one over top of the other) as well as leak detection systems be installed as part of liner systems for new landfills in the United States…[with] the lower drainage layer monitor[ing] to detect any leakage from above" (Tammemagi, 1999). Leachate, in accordance with the EPA is not allowed to reach a level of more than a foot (12in) at the bottom of a landfill. Current solutions have it being pumped to the surface where it is placed in "holding tanks and either treated on site or sent to a sewage treatment plant. Alternately, the leachate might be recirculated back into the landfill to promote decomposition" (Tammemagi, 1999).

3.2.2 Construction

Today, landfill construction is a very time consuming endeavor, which all starts with finding a suitable, and publicly acceptable location. "Landfill site selection is a complex process in which many technical factors must be considered: surface and ground water, the presence of suitable soil and natural conditions, transportation routes, topography, the presence of endangered or sensitive species, and much more. In addition, land planning and politics play an enormous role, with the latter often the dominating force" (Tammemagi, 1999).

The construction and implementation of today's landfills can be broken down into 4 steps:

1) Develop/construct an impermeable bottom
2) Construct leachate and methane collection
3) Daily covering of the garbage with soil or other inert material
4) Placing an impermeable cover over the landfill

Step 1: Construction of impermeable bottom

After the approval of an appropriate landfill site, whether it is located in a natural formation or man-made hole, the bottom is first prepared with a clay lining generally a meter or so thick and heavily compacted. Clay is the first material of choice due to its naturally impermeable properties. Following the compaction of the clay, a minimum of 6 impermeable sheets is laid over the entire base of the landfill. These impermeable layers are generally made of "synthetic materials such as impermeable high-density polyethylene…to stop leachate from leaving the landfill" (Tammemagi, 1999). Since the sheer size of landfills is so immense, these "large rolls or panels of geomembrane liners [must] be joined in the field. This critically important operation requires careful attention so that the seams do not form zones of weakness or leakage" (Tammemagi, 1999).

Step 2: Construct leachate and methane collection

When constructing the bottom layer or barrier of a landfill, engineers will construct it on a slope to one side or corner so as the trash piles up and leachate begins to collect and seep, it will gravitationally be pulled to one centralized location to be collected and pumped out. The collection areas are generally separated by "Geotextiles, [which] are essentially durable clothlike sheets that prevent the material of one layer from mixing with the material of the adjacent layer, usually to prevent a drainage layer from becoming clogged by finer particles" (Tammemagi, 1999).

As trash is delivered and dumped in a landfill, long perforated pipes are laid down and placed within the refuse. These long pipes consist of a large outside pipe, roughly 12 inches in diameter with a smaller perforated pipe laid within. This is done so as the trash compacts and settles, the larger outside pipe can bend and move (to a degree) without breaking the smaller collection pipe within (Humes, 2013). "Even the best-designed gas collection systems… at most suck up just 75 percent of emissions, according to G. Fred Lee; that number gradually declines as the equipment deteriorate" (Royte, 2006).

Step 3: Daily covering of the garbage with soil or other inert material

Today, when trash is disposed of in landfills, the waste is dumped in a very sophisticated and thought-out manner. “Landfills are generally designed in a number of cells; within each cell the garbage is placed in a series of lifts (the waste emplaced in one day)” (Tammemagi, 1999). These cells are generally constructed based on the average amount of waste received on a daily basis at a specific landfill as to insure each cell can be filled and covered at the end of the day. “As a cell is filled, refuse is generally not left uncovered for more than 12 hours. At least 30 centimeters of cover is placed if an area will not be used again for a period of a few days or weeks; generally, at least 60 centimeters is placed once an area is completed” (Tammemagi, 1999). This pattern of construction is also taken into the upmost consideration. Each cell is precisely laid out to ensure the most travel will be conducted over top of a completed section. This is to ensure and promote compaction of each cells’ refuse (Tammemagi, 1999).

Step 4: Placing an impermeable cover over the landfill

A landfill cover’s “primary objective is to isolate the interior of the landfill from the infiltration of water and thus to prevent the generation of leachate. The cap should be less permeable than the bottom liner to prevent a build-up of water inside the landfill…Clay layers and very low-permeability plastic liners (geomembranes), such as high-density polyethylene (HDPE), are used either alone or together to prevent the entry of water.” (Tammemagi, 1999). With large landfills being the norm, the final landfill covers are “designed to promote the growth of vegetation in order to protect the landfill from erosion and intrusion by humans, burrowing animals, and plant roots and also to improve the aesthetic appearance… The drainage layer diverts any infiltrating water to a collection and removal system" (Tammemagi, 1999) located at the base of the landfill.

3.2.3 Problem

Since higher and stricter regulations have been put in place and communities have protested locating sites near-by, very few new landfills have been constructed since the 1990's. This in turn has led to landfills becoming over used and utilized past their intended design. Even more troubling, we have yet to fully understand the capabilities or effectiveness of the current landfill design, the "plastic liners, [or] geomembranes, provide good containment in the short term, but they can easily be damaged by heavy equipment; moreover, we have no experience in assessing the resistance to degradation over long time spans such as a century or more" (Tammemagi, 1999).

Current landfills are only designed for 25 years after the life or use of a facility is complete, yet much of the refuse within the landfill will still be, and is projected to be, active for decades longer. It is estimated that this decomposition of organic material could take anywhere from 50-150 years, depending on the site and the levels of its contents. Even then the landfill will still posses hazards. "In a landfill, the hazard decreases with time down to base level, which is greater than zero. The hazard or risk of a landfill never goes to zero owing to the presence of inorganic material" (Tammemagi, 1999).

Landfill covers or "caps" will be subject to a considerable amount of degradation over time. As the waste below (mainly organics) continues to settle, decompose, degrade and turn to leachate and methane, the "contents, settlement will not be uniform, and stress on the cover will cause it to crack; [in addition] freeze/thaw cycles during winter, spring downpours, and wind erosion will act quietly but persistently to degrade the cover"(Tammemagi, 1999) further.

According to the RCRA (Resource Conservation and Recovery Act), hazardous waste is defined as:

> *"A solid waste or a combination of solid waste that, because of its quantity, or physical, chemical, or infectious characteristics, may cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed"*(Tammemagi, 1999).

This means landfills "near the major urban centers they service provide safety only for the short term, even when they are well sited and have the latest engineered improvements. They simply cannot withstand the long term effects of natural erosion and the remorseless encroachment of urbanization" (Tammemagi,

1999) resulting in the eventual contamination and introduction of toxic and damaging chemicals/organics.

As stated by Hans Tammemagi, author of *The Waste Crisis*: "A reduction in organic content would influence the decomposition process that occurs and could lead to smaller methane yields as well as slower rates of decomposition. For example, the waste would tend to be more compact and denser, affecting the way liners, gas collection systems, and other engineering components of the landfill are designed" to work. "The main impacts of landfills on future generations are (1) the requirement to provide ongoing guardianship and maintenance; (2) the loss of valuable land; and (3) impairment of groundwater, surface water, and the atmosphere" (Tammemagi, 1999).

3.3 Waste-To-Energy

3.3.1 Overview

The birth of incineration for the production of energy dates back to England around the "mid-1890s. By 1912, approximately 76 incinerators were generating electricity in Britain and another 17 were operating on the Continent" (Tammemagi, 1999). Seeing how effective and beneficial incineration was at producing electricity and removing waste, around 600 to 700 cities in the United States by the 1930s constructed incinerators. But with the introduction of new air emission standards and regulations, The U.S. Air Quality Act of 1967 required all incinerators to add air pollution devices such as scrubbers and precipitators, if not currently compliant.

These requirements put financial burdens on old incinerators which were already more expensive and capital-intensive. Within 5 years of 1967, nearly 100 incinerators shut down with the rest following suit a few years later (Tammemagi, 1999).

By the "early 1990s there were 160 municipal waste incinerators operating in the United States… [producing] about 0.2% of all electrical power… whereas about 58% was produced by oil and coal"(Tammemagi, 1999). Current Waste-To-Energy facilities have equivalent or lower air-emissions polluting the environment than that of coal and oil, for the production of energy on a net electricity production basis; and "For many cases, especially for the trace metals, WTE facilities generate emissions that are five to ten times cleaner than those from oil and coal plants" (Tammemagi, 1999). This is largely accredited to the improved combustion processes, better pollution control technology, and current regulations holding incinerators to a higher standard.

> *"In the United States, an acceptable incinerator for hazardous waste has been defined as one that reduces the amount of any particular toxic compound by 99.99%. This is known as the 'four nines' standard"*(Tammemagi, 1999).

3.3.2 Construction/Process

Unlike landfills, Waste-To-Energy facilities have a high upfront cost requirements. In essence the whole facility needs to be zoned, financed, constructed and operated by a plethora of workers with varying degrees and areas of specialties, due to the sophistication of the technology incorporated. The main “disadvantage of an incinerator is that it is more costly to construct than a landfill; furthermore, all of the capital cost is incurred up front, whereas landfill capital costs are spread over the operating lifetime” (Tammemagi, 1999).

The process and path of refuse in a Waste-To-Energy facility can be broken down into 6 steps. These 6 steps highlight the basic function and equipment requirements of a WTE facility.

1. *“An overhead crane mixes the refuse to provide a relatively uniform fuel and then loads it into hoppers which carry the waste onto grates in the furnace*
2. *The waste is burned at an optimal temperature of about 1100 [degrees Celsius] and remains on the grate for 45 to 70 minutes to ensure complete combustion*
3. *The gases that form are heated by supplemental fuel injection for an additional second or two to ensure complete destruction of resistant chemicals*
4. *The hot gases are then cooled by water in boiler tubes that generate steam for electricity*
5. *The gases are sent to pollution control devices, which may include ammonia injection for NOx (nitrogen oxides) control, a dry scrubber for SO2 and acid gas control, carbon injection to remove mercury and dioxin, and a baghouse to remove particulate matter*

6. *The ash that accumulates at the bottom of the furnace is removed through a water-quenched conveyor and emptied into a storage area from which it is periodically removed and transported to a landfill"* (Tammemagi, 1999)

At current rate of production and incineration, mass-burn incinerators can effectively process 90 to 2,700 tons of garbage per day, producing electricity to nearby communities. "In all incinerators, the hot gases produced by incineration must be cooled to stop chemical reactions and to protect the downstream pollution-control equipment… cooling is usually done by quenching the hot gases with large volumes of water. The water and condensate are sent to a wastewater treatment plant, which forms a necessary part of a modern incinerator"(Tammemagi, 1999).

A dry scrubbers system, also known as dry sorbent injection scrubbers, is the process of submerging the gas emissions in a very fine powder lime. This action allows acid gases to become neutralized as well as improving the efficiency of capturing mercury. This system has a low capital cost and can be added to pre-existing facilities (Tammemagi, 1999). "Wet scrubbers use the same principle as dry scrubbers, but they spray a lime-and-water mixture onto the emissions to convert the gases into liquids and solids for collection in an electrostatic precipitator. Wet scrubbers can be placed after, but not before, a bagehouse system" which is "a series of large, porous bags through which gases, but not particulates, can pass…This is important because heavy metals and organics tend to attach to smaller particles" (Tammemagi, 1999).

3.3.3 Problem

In 1977, it was discovered that emissions such as dioxins and furans, toxic organic compounds as well as heavy metals were present in incinerator emissions (Tammemagi, 1999). These compounds have been documented to wreak havoc not only on the environment but also in human body as well when exposed to minute amounts. With today's "emission control devices remove significant proportions (90% to 99%) of some of these pollutants… the U.S. EPA estimates that 95% to 99% of particulate and organic pollutants can be removed from air emissions if appropriate pollution prevention measures are taken"(Tammemagi, 1999).

The only way for this to be done is to ensure steady uniform combustion. Currently, incinerators burn refuse at or above 1000 degrees Celsius. When combusting refuse at these high temperatures the "emission of carbon monoxide, dioxins, furans, volatile organic compounds (VOCs), and other potentially hazardous compounds in the flue gas" are drastically reduced (Tammemagi, 1999). When the formation of carbon monoxide (CO) is detected, this indicates not only dioxins and furans are being produced as CO is used as their surrogate, but that the incineration facility is producing incomplete combustion; one of the main causes for this incomplete combustion and formation of dioxins is the presence of yard wastes and other materials with high moisture content (Tammemagi, 1999).

4. Profitability of Waste: Sustainable Municipalities and Companies that are addressing the waste crisis.

4.1 San Francisco

4.1.1 Overview

Currently in the United States, the collection of organic food waste is conducted on a grass-roots level; meaning someone drives around in a pick-up truck collecting from residents willing to pay a price. It is a small-scale operation with very little impact. The city of San Francisco, California on the other hand, is attempting to change that, and has been a beacon for other municipalities.

San Francisco, realizing the benefit of reducing its impact on the environment and reducing the constituents it sends to the landfill, issued a mandatory recycling and composting ordinance in 2009, "becoming the first major city to collect household food waste at the curb in separate bins along with green waste from composting" (Humes, 2013). San Francisco requires all residents and businesses to properly separate recyclables and compostables. This mandate keeps waste out of landfills in an attempt to achieve zero waste by 2020 (San Francisco Department of the Environment).

According to the environmental group, Zero Waste International Alliance, zero waste is defined as: diverting 90% of waste from landfills without the use of incinerators (Ferry, 2011). In 2010, one year after implementing the new ordinance, San Francisco claimed "to divert a nation-leading 77 percent of trash away from landfills" (Humes, 2013). Today, San Francisco's residents, businesses and city government are diverting “80 percent of what they throw away from the landfill. [It is believed] with full participation in the existing programs, San Franciscans can [be] divert[ing] 90 percent of its discards”(San Francisco Department of the Environment).

4.1.2 Figures

San Francisco is currently the driving force behind the nation’s “biggest organic composter, turning yard waste and garbage from [its] five thousand restaurants (220,000 soggy tons a year) into 150,000 cubic yards of compost that’s widely used by the vineyards of Napa and Sonoma Valleys” (Humes, 2013). This breaks down into roughly 20 large truckloads of organic waste being diverted from landfills, reprocessed, returned to farmers and ultimately directed back to human consumption. This is a process that landfills cannot complete; it is otherwise known as classic closed loop or cradle-to-cradle system (Humes, 2013).

These composting efforts, combined with other streams of recycling, have allowed the residents of San Francisco to reduce their output of trash that makes its way to the landfill to only 1,500 tons a day (Humes, 2013).

4.1.3 How It’s Possible

Similar to the majority of municipalities in the United States, “San Francisco residents receive recycling and composting service with landfill service at a flat rate.

Apartment buildings (6 units or more) and businesses pay a reduced rate for recycling and composting service" (San Francisco Department of the Environment). One company called Recology carries out all three of these services, which is made possible due to the utilization of "specially designed two-compartment trash trucks to keep the organic waste separate on board" (Humes, 2013).

When violators are discovered not properly separating their waste, they can be issued fines of $1,000, which is stated within the city ordinances (Humes, 2013). The toughest enforcers to the city's composting and recycling ordinance has been "Recology garbagemen, who leave behind a note on offenders' trash can with a reminder about properly separating waste into the correct blue (recyclables), green (organics) and black (rubbish) bins" (Humes, 2013).

4.2 Recology

4.2.1 Overview

Recology, the waste management company that services San Francisco and many other municipalities, is one of the nation's ten largest 100 percent employee-owned companies (Recology , 2014). Starting in 1935, Recology has been built on the merging and acquiring of all competitive companies. Over the course of the years, the company has changed its name repeatedly as it has continued to grow and expand.

It was not until 1986 that Norcal (now known as Recology) "was sold to its 570 employees and their Employee Stock Ownership Plan (ESOP)" to ensure its more than sixty-year tradition of independence as an employee-owned company (Recology , 2014). With more than five generations under its belt, Norcal was a pioneer of recycling. It established and displaced fifty percent of its waste “long before recycling became fashionable or mandated by law” (Recology , 2014).

“In the early 1990s, Norcal streamlined its operations and initiated changes that strengthened the corporation's position in the market. The changes enhanced its reputation as an aggressive and dynamic company” (Recology , 2014). On April 27, 2009, in a move to reflect its existing culture and commitment to sustainable practices, Norcal Waste Systems, Inc. officially changed its name to Recology Inc. (Recology , 2014).

4.2.2 Figures

As of 2011, Recology employed roughly 2,100 workers that serviced over 670,000 residential and 95,000 commercial customers in California, Oregon, Nevada and Washington (Recology , 2014). San Francisco, though, remains its biggest turf and headquarters for the massive waste management company (Humes, 2013).

Today, Recology is the leader of sustainable practices in the United States’ waste industry, as it is coordinates dozens of recycling programs to recover a variety of materials across the West Coast. Operating as one of the largest employee-owned companies in the country, and the largest by far in the waste industry, it produces annual revenues over $351 million (Humes, 2013) and is projected to grow as it continues its innovative approach to resource recovery (Recology , 2014).

4.2.3 Success

The success of Recology is nothing short of the age-old saying "*being in the right place at the right time.*" Recology's foundation in 1935 was based on finding a solution to San Francisco's overwhelming refuse, which wound up distilling the principle of separating waste (recycling) as a pillar of its current business model, well before it became mainstreamed. Fast forward to today, it can be concluded that San Francisco and the rest of California/the West Coast have a passion for sustainability that is unmatched by the rest of the United States. This has allowed Recology to flourish and strengthen its principle of recycling, which has kept it ahead of the curve in terms of its equipment and facilities used by a waste and recycling company.

Recology owns and operates a compost facility in Vacaville, CA, which is specially geared to handle the large amounts of food waste collected from the areas it services. The compost is then sold to local farmers and vineyards of Sonoma's wine county to help improve and nourish crops (Heimbuch, 2011).

As previously stated in section "4.1.3: How It's Possible," Recology's collection fleet for waste recovery is state of the art (in the terms of waste collection). Their two-partitioned trucks (one side for organics, the other for trash) allows for workers to efficiently collect the separated material. This is in stark contrast to the rest of the nation. Over 40% of garbage trucks are over 10 years old in the United States. With a life expectancy of 12+ years, garbage trucks are the oldest fleet in use; and with the average replacement costing over $170,000, any add-on (such as separate compartments, bin lifts, etc.) must be justified to the company (Inform, Inc., 2009).

These improved, cutting-edge facilities and equipment have not only allowed Recology to slash San Francisco's garbage sent to the landfill – from 730,000 tons in 2000 to 367,300 tons in 2011, a 49.7 percent reduction (IBM, 2012) – but have enabled them to reach the mile stone of "One million tons of food scraps and plants collected and composted since [they] started the green bin program in 1996; enough [compost] to fill the TransAmerica building more than 16 times"(Recology, 2011).

4.3 Oregon

4.3.1 The Problem

In 2007, in hopes to catch up with San Francisco, the city of Portland, Oregon, signed off on an ambitious plan to reduce its waste output by 75 percent in the year 2015. Two years later in 2009, a year and a half long home composting pilot was implemented, requiring 2,000 of the city's residents to separate and collect food scraps for curbside pickup, before implementing the city wide collection in 2011 (Mazzoni, 2013).

> *"Every home received an official pail with a lid for the kitchen counter to hold smelly food wastes in until they could be dumped into the curbside bin. The well-thought-out plan had a rub, however: The new weekly food scraps collection meant other trash services had to be cut. Regular garbage would be picked up every two weeks instead of weekly. Considerable civic grumbling ensued. People were upset about having to keep out pails in the kitchen and overflowing trash bins in the yard… Given these difficulties, plans to expand the food waste pickups beyond the city limits to the entire Portland Metro area may take years as residents debate the balance between convenience and environment"* (Humes, 2013).

4.3.2 The Facts and Benefit

In 2012, one year after the October 2011 rollout, "Portland's fledgling food scraps program collected 85,000 tons of organic waste [with] an impressive 37 percent decrease in trash production" (Mazzoni, 2013). By 2013, Portland was collecting curbside organic waste on a weekly basis from over 140,000 single-family households within its city limits. 80 percent of these residents effectively set out the curbside bin every week for collection (Mazzoni, 2013).

Currently, Portland's waste haulers "offer organic pickup for apartment buildings, it's up to building managers [though] to work with hauling companies to set up the logistics of collection" (Mazzoni, 2013). With 100 buildings currently participating, expanding access for renters is a key goal for diverting waste from the landfill and achieving the 75 percent reduction Portland is striving for (Mazzoni, 2013).

This organic compost collection proved to be a sweet deal for both taxpayers and budget planners. With the reduction in volume of trash, Portland was able reduce its garbage rates for its residents which took effect on July 1, 2013 (Mazzoni, 2013). Michael Armstrong, sustainability manager for the city of Portland explained and pointed out, “It was a fairly small decrease, but it’s so rare to have any kind of utility rate decrease these days that it becomes a really important point. The overall system gets more efficient when we get stuff out of the garbage and into beneficial use, and so for us that’s a really important piece of it” (Mazzoni, 2013).

4.4 Eco-Cycle

4.4.1 Overview

In 1976, a group of residents living in Boulder, Colorado started becoming increasingly concerned with the amount of resources that were needlessly being thrown away and sent to landfills. Banding together, these Eco-Cycle volunteers set out to find a solution. By the end of 1976, Boulder, Colorado became one of the first 20 communities in the United States to offer curbside recycling (Eco-Cycle: Building Zero Waste Communities, 2011).

Today, Eco-Cycle is one of the largest non-profit recycling organizations in the United States. Its “mission is to identify, explore and demonstrate the emerging frontiers of sustainable resource management through the concepts and practices of Zero Waste. [They] believe in individual and community action to transform society’s throw-away ethic into environmentally-responsible stewardship”(Eco-Cycle: Building Zero Waste Communities, 2011).

As of 2012, Eco-Cycle serves over 300,000 residents, 70 large corporations, and more then 750 businesses and organizations, which includes offices, schools, florists, restaurants and hotels of Boulder and Broomfield County (Eco-Cycle, 2012). This passion for conservation has allowed Eco-Cycle to reduce the amount of trash their county creates and increase their diversion from the landfill through recycling and composting. “In 2012, Eco-Cycle’s Zero Waste Services Program recovered 18,384,000 pounds of single-stream recyclables and 7,616,240 pounds of compostables, [for] a total of over 26 million pounds of materials”(Eco-Cycle, 2012).

Driven by the same passions and innovative actions as their founders, Eco-Cycle has been able to achieve so much through a combination of hard work on the ground and educational leadership. Eco-Cycle has created a “Zero Waste culture” with little political involvement, in a geographic area with the nation’s cheapest landfills (Eco-Cycle, 2012).

4.4.2. Statistics

Since forming in 1976, Eco-Cycle has been Boulder County's recycling processor; a position long held until 2001 when the company also officially took over operations for the Boulder County Recycling Center (BCRC) (Eco-Cycle, 2012).

> *"In 2012, Eco-Cycle and the BCRC hit a major milestone by processing a total of 500,000 tons of recyclables since the facility was [re]dedicated…by recycling instead of landfilling these materials, Eco-Cycle created 66 local jobs and helped [their] community avoid 420 tons of air pollution, two tons of water pollution, 100 tons of toxic herbicides, and 43,800 tons of toxic substances that threaten human health such as carcinogens, particulate matter and volatile organic compounds"* (Eco-Cycle, 2012).

As stated in Eco-Cycle's 2012 Annual Report, total revenue, gains and other support totaled $6,527,438 with over half its deductions ($3,625,150) being divided up between the 60+ employees' salaries and benefits. After all of the deductions were incurred, excluding depreciation, Eco-Cycle had a net income of $24,247. If those same resources were buried instead of recycled, the employment created at Eco-Cycle would have been only five jobs (Eco-Cycle, 2012).

Within Eco-Cycle's arsenal is their Eco-Leader Network of volunteers. This group of 761 dedicated Boulder County Zero Waste and recycling ambassadors plays a significant role in Eco-Cycle's outreach and education efforts. In 2012, it was calculated that they donated close to 1,000 hours of their time, which has an equated value of more then $20,000 in support annually (Eco-Cycle, 2012). This is a practice not normally seen offered to a waste collection company.

In “2012, Eco-Cycle educated 150,500 people at 26 large Zero Waste events throughout the community, such as festivals and triathlons, diverting a record average of 87% of event discards and, through composting and recycling, preventing more than 44,000 pounds of resources from entering the landfill, saving the energy equivalent of 3,301 gallons of gasoline”(Eco-Cycle, 2012).

4.4.3 Education

It has been stated that students throughout Boulder County, Colorado grow up with an unusual degree of environmental literacy. Cyndra Dietz, An Eco-Cycle Chief Administrator and School Manger for environmental education, has been the “tip of the spear” for educating Boulder and Broomfield County schools and students. Working as an environmental educator for 32 years, she and her staff since 1990 have presented and organized field trips to over 20,000 classrooms, which involved 520,000 students and staff. She has coordinated recycling collections for over 18,000,000 pounds of material, and has been credited for starting the first Zero Waste school program in America (Eco-Cycle: Building Zero Waste Communities, 2011).

An “Essential [corner stone] to Eco-Cycle's mission is teaching the next generation about recycling and the environment. Since 1987, Eco-Cycle has coordinated the Boulder County School Recycling and Environmental Education Program with funding from Boulder County, Boulder Valley School District, Eco-Cycle and various [other] grant sources" (Eco-Cycle: Building Zero Waste Communities, 2011). This program, as of 2012, has allowed the 55,000 students and staff of the 82 Boulder and St. Vrain Valley public schools to achieve an annual collection of 1.1 million pounds of recyclables per school year. This equates to 20 pounds per student (Eco-Cycle, 2012).

> In 2011, Colorado's *"Green Star Schools reduced their trash by one-third to one-half by composting non-recyclable paper and food scraps from their kitchens, cafeterias and classrooms. These schools diverted another one-third of their waste from the landfill through recycling and other waste reduction projects… Eco-Cycle is pushing the boundaries of environmental education and training [to] our future citizens with its Green Star Schools program [and] through this comprehensive, first-in-the-nation Zero Waste program"* (Eco-Cycle, 2012).

Not only are they well rooted within the educational system, Eco-cycle is also continually innovating. They have established a recycling hotline to answer recycling and waste reduction questions, and in 2006 launched Eco-Cycle Exchange; an online exchange platform that allows its community members to trade everything from windows, carpet, garden supplies, electronics, packing materials and much more. Since starting the operations in 2006, "more than 1,000 people visit the site every month, and our nearly 1,000 members have helped keep more than 13,000 pounds of materials out of landfills and in valuable use in [their] community"(Eco-Cycle, 2012).

4.5 TerraCycle

4.5.1 Overview

Tom Szaky, the owner and founder of TerraCycle, was a freshman at Princeton University in 2001 when he was introduced to a composting method for food scraps while visiting friends in Montreal, Canada. His friends had a bucket in the kitchen filled with worms that ate all the left over food. The byproduct of this, worm fecal matter, was then used to grow the household plants. Taking note of how well the plants were growing, the following year back at Princeton, Tom wrote up the idea of using worms to compost food as a business proposal for an upcoming school competition. Even though Tom did not win the competition, he had fully devoted him self to making this idea a reality (TerraCycle, n.d.).

After several years of scraping by, he finally got his foot firmly in the door in 2006 when Wal-Mart and The Home Depot placed orders for his "worm-poop fertilizer". It would not be until the following year in 2007 that TerraCycle would be permanently stamped on the map. In March of 2007, TerraCycle was issued a lawsuit by The Scotts Company, producers of fertilizers and home lawn and garden product, under the grounds of the old "World War II-era Lanham Act, which bans false advertising claims that harm another brand's business. The Lanham Act is the go-to law for big companies upset with the marketing claims of upstarts, as they are complex and expensive cases to litigate" (Humes, 2013).

Tom, not backing down, took the fight to the internet with a website dedicated to the case, called SuedByScotts.com. "The site pioneered the now common tactic of launching litigation websites as a line of defense…put[ting] even a houseful of college students on a more even footing with a well-funded corporate power"(Humes, 2013). Tom placed legal documents and photographic comparisons of Scotts Products vs. TerraCycle's, as well as comparisons from the rest of the industry, eighty different comparisons in total, were displayed for the world to see (Humes, 2013).

This wound up being the turning point for Tom and his small company. Even though the lawsuit was settled outside of the courts, with both sides claiming victory, no money exchanged hands (TerraCycle just had to change its graphic design once its supplies ran out). The publicity TerraCycle received though was priceless. "Articles on the company and the case appeared in the Wall Street Journal, the New York Times and hundreds of blogs and websites. Even in the Journal, the bible of big business" articles were written (Humes, 2013). The following year, 2008 the company became solidly profitable and never looked back. Even though TerraCycle still produces "worm-poop fertilizer" the growth and publicity it received afforded TerraCycle to pursue its main purpose, address the issue of waste. In 2009 TerraCycle had revenues in the neighborhood of $7.5 million and more than doubling to $20 million by 2010 (Humes, 2013).

In 2011, TerraCycle had "launched over 30 new waste collection programs and grew in total staff to above 100 employees globally" (TerraCycle, n.d.). By the end of 2012, Tom and his once-little campus dorm room startup was collecting recyclables in 22 countries and had a consecutive 9 straight years of revenue growth (TerraCycle, n.d.). In the summer of 2013, working as a Design Junkie Intern at the headquarters located in Trenton, Jew Jersey, the author of this thesis was fortunate enough to witness this growth first hand.

4.5.2 Consumer Support

When TerraCycle first created and started producing worm-poop fertilizer, they scoured the trashcans of Princeton looking for old, used soda bottles to fill and package the newly created liquid fertilizer. Quickly realizing the cost and environmental benefits to recycling, TerraCycle distilled in its company's manifesto to reuse and recycle, avoiding the purchase of virgin material at all cost.

To keep with its environmental image and acquire enough bottles to fill its orders, TerraCycle developed the "Bottle Brigade" program, which would become a key part of their business strategy. This program allowed "fundraising groups nationwide [to] fill TerraCycle-provided mailing boxes with twenty-ounce soda bottles, which were then shipped back [free of charge] to the company… Brigades earned donations to the schools [or charities] of their choice for every bottle collected" (Humes, 2013).

> Following the 2007 lawsuit, the *"extra publicity garnered from the suit helped TerraCycle's Bottle Brigade hit 5,000 participants (more than anyone ever imagined) in a matter of months, Tom saw this as a sign that the sky was the limit. The popularity of the Bottle Brigade lead to a new partnership: In August 2007, TerraCycle launched the Drink Pouch Brigade, with founding sponsor, Honest Tea. The new program was designed to pay schools to collect used drink pouches. Neither company knew what to expect, so 100 spaces were opened. Less than 24 hours later all 100 spots were filled…*
>
> [Today] *with help from over 40 million dedicated Brigade participants around the world, TerraCycle reached the major milestones of over 2.5 billion pieces of waste diverted from landfills and over $6 million donated to schools and charities. In 2012, TerraCycle launched 14 new Brigade programs to collect everything from deodorant tubes to coffee capsules to baby bottles"* (TerraCycle, n.d.).

The "Brigade" program is a "business model that has made TerraCycle one of the fastest-growing green business on the planet" (Humes, 2013). Tom realized though that innovation and a firm footing in the public's focal point is key to the company's success, which has lead to interesting and creative public relations. These ranged anywhere from a short TV series segment on "How I Made My Millions," as well as online broadcasts and videogames. In 2011 TerraCycle released, *"Trash Tycoon, the first online game about upcycling and recycling difficult-to-recycle trash. The game simulates the real life TerraCycle Brigade system in which food packaging such as Kraft Cheese plastic is collected and upcycled and recycled into items such as tote bags, backpacks, and park benches. Trash Tycoon had 300,000 [players] after the first month"* (TerraCycle, n.d.).

4.5.3 Corporate Support

In January of 2008 TerraCycle developed and implemented a new business model to work and strengthen its already existent Brigade program. "TerraCycle partners with Consumer Packaged Goods (CPG) manufacturers to administer free programs which pay consumers to help collect non-recyclable packaging, which is then upcycled or recycled into eco-friendly products" (TerraCycle, n.d.). In layman's terms, Tom got the companies that made the products and ultimately the waste, to pay for his company's collection program. This new business model was later coined "sponsored waste" (Humes, 2013).

With TerraCycle's publicity off the charts, and companies/manufactures eager to be seen "rubbing elbows" with this green start-up, the public and consumers' attention have been captivated. This has led to areas of innovation previously unimagined. For example, in 2008 TerraCycle "teamed up with Target to run an innovative ad campaign on the cover of Newsweek's green issue. The ad provided instructions on how to reuse the magazine cover into a returnable envelope with prepaid postage printed on the inside cover. Newsweek readers were asked to remove the cover and fill with used Target plastic bags, and over 47,000 people returned their waste bags back to TerraCycle" (TerraCycle, n.d.).

Since then, innovations range anywhere from establishing township-wide collection drives, called "Chip in for Change," which increased chip bag recycling in the Hamilton, NJ area by over 300 percent; to launching "the world's first recycling program for one of the most commonly littered items on the planet – cigarette butts, with help from Santa Fe Natural Tobacco and British American Tobacco, respectively. The collected cigarette butts are recycled into plastic pellets and used to make industrial products like shipping pallets" (TerraCycle, n.d.).

TerraCycle today "has over 50,000 voluntary collection locations in the US, including schools, offices, homes, community groups and other types of organizations" (TerraCycle, n.d.). These collection groups and other Brigade program have placed TerraCycle just shy of major waste collection companies like Waste Management, in terms of sheer volume of material handled, processed and recycled. TerraCycle's goal and projection is to surpass these companies in the years to come.

5. System Development

5.1 The Social Movement

5.1.1 Overview

Author Paul Hawken, an environmentalist and leading proponent of reform with respect to ecological practices, states we are currently in “the largest social movement in all of human history. No one knows its scope, and how it functions is more mysterious than what meets the eye” (Hawken, Blessed Unrest , 2007).

This movement, for the purpose of this thesis, will be summed up as the pursuance for environmental sustainability, and an overall ecological way of life. This movement though, has roots in every facet of human interaction with countless definitions to its intent. It can be seen in every government sector, every business, every consumer, and every social and personal way of life. There is no manifesto, overriding authority, or archive of followers; they do not identify themselves as a group or have any overriding ideologies. In short, they are fiercely independent and fit no such standard model, yet it is taking place all around us (Hawken, Blessed Unrest , 2007).

> “*Scientific experiments repeatedly show that groups of educated, urbanized people pay no attention to unfamiliar objects directly in front of them if they focus too strongly on familiar ones. What we already know frames what we see, and what we see frames what we understand. The Industrial Revolution went unnamed for more than a century, in part because its developments did not fit conventional categories, but*

also because no one could define what was taking place, even though it was evident everywhere"(Hawken, Blessed Unrest , 2007).

5.1.2 The Impact

Within the next fifty years, it is estimated that 3 billion more people will join the current population, rounding us out just shy of 10 billion. With the world already struggling to feed its current population, "by the middle of this century, resources available per person will drop at least by half" (Hawken, Blessed Unrest , 2007). As global conditions continue to change and become more dramatic, this "unnamed movement" gives us a sliver of hope. The "movement's key contribution is the rejection of one big idea in order to offer in its place thousands of practical and useful ones" (Hawken, Blessed Unrest , 2007), removing the fallacy that one "magic pill" can fix everything. "Healing the wounds of earth and its people does not require… a liberal or conservative activity; it is a massive enterprise undertaken by ordinary citizens everywhere, not by self-appointed governments or oligarchies" (Hawken, Blessed Unrest , 2007)

The availability of mass communication, and the continual improvements it receives on a daily basis, has enabled "technologies [to] revolutionize what is possible for small groups to accomplish" (Hawken, Blessed Unrest , 2007), officially changing the location of power to that of "the ordinary citizen." Paul Hawken states, that this whole "division between ecology and human rights was an artificial one, that the environmental and social justice movement addressed two sides of a single coin"(Hawken, Blessed Unrest , 2007). We just need to open our eyes.

5.2 Systems

5.2.1 Definition of A System

Merriam-Webster's Dictionary defines a System as a regularly interacting or interdependent group of items forming a unified whole, or as a group of devices or artificial objects, or an organization forming a network especially for distributing something or serving a common purpose (Merriam-Webster, Incorporated, 2014).

Open systems are defined as the "exchange of energies, information, and resources with the suprasystem. Most organizations are open systems. In that sense, the organizations do interact with their environment, and they receive inputs of some type as information, energy, or other resources that are applied to the processor" (Luchsinger & Dock, n.d.). Most organic systems (i.e. nature) are defined as being an open system.

One may not realize that the world contains a multitude of systems that interact with larger and smaller interrelating systems. Even though these systems may operate under different parameters, one can identify a few characteristics that are present and can be defined in all systems. These are

1. Organization
2. Interaction
3. Interdependence

4. Integration
5. Central Objective (Luchsinger & Dock, n.d.)

5.2.2 Our Current System

Our current system for commerce and business (on a large scale) is "based on a fascinating reversal of responsibility and accountability… if a corporation's chemicals get loose and poison groundwater, rivers, fish, and ultimately humans, it is the victims who pay" (Hawken, The Ecology Of Commerce, 2010). With today's economy and manufacturers entrenched with the existing system/idea of cradle-to-grave, their main concern is not with what happens to a product after it is disposed of, but rather with getting their customers to purchase new products. This has been revealed to be "a system of production and distribution that leaves biology out of the equation… [because] what is good for business is almost always bad for nature" (Hawken, The Ecology Of Commerce, 2010). In other words "any time a system creates by-products that harm rather than further life, it is a form of waste, and by definition it is uneconomical"(Hawken, The Ecology Of Commerce, 2010).

An example of this linear system exists in New York City where, in 2011, residents were disposing 12,000 tons of waste on a daily basis. One of the issues causing this high number is the fact that many products' end use is not designed to be properly sorted for recycling. All of this waste had to be trucked out of the state daily because the city no longer operated a landfill within its limits, causing some trucks to travel as far as three hundred miles. This amount of waste was equated to throwing away sixty-two Boeing 747 jumbo jets daily (Humes, 2013).

For the majority of these businesses, this linear system will remain operational. Unless "the incentives to continue the manufacture of waste are removed, [or] only when the risks and costs far outweigh the gains and profits, will [the] designers, engineers, chemists, and investors turn their attention to safer alternatives" (Hawken, The Ecology Of Commerce, 2010).

5.2.3 System Requirements

The design of a system and one's understanding of it is the most valuable aspect while attempting to make decisions when choosing projects for development. This is especially important when the projects for development are faced with large uncertainties. Systems are designed to not be concerned with the devices that make up the system, but rather the system's interrelations and behavior as a whole (Schaer, n.d.). A system has five fundamental implications that must be addressed in order to be a viable system:

1. *"A system must be designed to accomplish an objective.*
2. *The elements of a system must have an established arrangement.*
3. *Interrelationships must exist among the individual elements of a system, and these interrelationships must be synergistic* [related to] *in nature.*

4. *The basic ingredients of a process* [the flow of information, energy, and materials] *are more vital than the basic elements of a system.*
5. *Organization objectives are more important than the objectives of its elements, and thus, there is a de-emphasis of the parochial objectives of the elements of a system"* (Luchsinger & Dock, n.d.).

When designing a system to address a problem, the problem itself must be first viewed as a system. This problem/system must then be divided into its respective subsystems. Once the subsystems are established, they must then be refined into there basic components. There, these components will reveal interactions with their surrounding environments giving light to a larger order or system. The designer must take into account these interactions, as a change in a subsystem has influences on the whole system and vice versa (Schaer, n.d.). Thus, this can render implications well outside one individual's understanding to the system being designed.

> *"Large scale and expensive system problems require different fundamental knowledge and technology, thus a large number of people must be available for consultation according to the problem. This implies efficient team activity among the knowledge group, and the cultivation of interpersonal relationships that are both productive and satisfying to all people involved"* (Schaer, n.d.)

It is encouraged when designing systems, especially when they grow in complexity, that the designer gather groups of people with varying outlooks. These groups can effectively cooperate on key issues without subordinating themselves to another group, which would allow for the best possible system in development. This is a practice already understood by ecologists and biologists; for they understand systems achieve stability and health through diversity and not ideologies (Hawken, Blessed Unrest , 2007). In the end, a “systems design should be the ‘glue’ which binds together the enormous design effort of a major project” (Schaer, n.d.).

5.2.4 Ideal Systems

The ideal system for today’s society in regards to business, commerce, waste management or any other form of production, consumption and use, would be that of a cyclical system. A cyclical system is defined as being cradle-to-cradle, meaning every product or by-product imagined can subsequently be reverted back to its original form, prior to the creation of that entity (Hawken, The Ecology Of Commerce, 2010). Since everything is derived from nature, it should be restored back to nature and not hinder it.

> *“To restore is to bring back or return something to its original state… Above all, it means to heal, to make whole, to reweave broken strands and threads into a social fabric that honors and nurtures life around it. To restore is to make something well again. It is the mending of the world.”* (Hawken, The Ecology Of Commerce, 2010)

The idea of wealth is deceptive when one understands ecological principals. “The single greatest flaw of modern accounting is that the cost and losses of destroying the earth are absent from the prices in the marketplace” (Hawken, The Ecology Of Commerce, 2010). Business may teach us how to lower price points to reap financial gain, but in the end are meaningless and destructive if they are not based on the cyclical process of nature. “All industrial systems and designs pale when compared to the efficiency of natural [cyclical] systems of production” (Hawken, The Ecology Of Commerce, 2010).

A restorative economy, the ideal system for today’s commerce and business, would switch how the economic systems of today function. The success and validation of businesses would be based off their ability to integrate and assimilate to a cyclical system, for their means of production and distribution. Ultimately, that process of restoring the environment and making money would be one and the same. (Hawken, The Ecology Of Commerce, 2010). Unfortunately, a vital piece of information is missing on all levels of the economy. The markets do not currently support pricing of harmful vs. un-harmful materials. Today, products that are harmful are priced lower than that of those that are safe. This current economic system has existed well past its usefulness and is preventing a restorative economy from ever emerging (Hawken, The Ecology Of Commerce, 2010).

Through assistance in education, incentives, access to alternatives and overall simple community participation, a highly varied and healthy cyclical-restorative economy can be established in a community, to address their specific needs at a specific time (Hawken, The Ecology Of Commerce, 2010).

5.3 New System Design

5.3.1 Requirements

When designing and implementing an integrated waste management system, a designer must obtain full knowledge of all the parameters the system will be involved with. Taking these elements, the designer must break them down into easily understood terms for operational and economical feasibility and clearly state the social function that the system is to perform. Factors to take into consideration include demographics, market accessibility for recycled products, and the availability of land and other resources (Schaer, n.d.).

The ultimate purpose and promise of business today, should be "to increase the well-being of mankind through service, creative invention, and ethical action" (Hawken, The Ecology Of Commerce, 2010). With the size and complexity of the world continually expanding, the idea and notion that business is merely just to sell and make things has become meaningless and obsolete. The ultimate purpose is to advance and better all life; everything else will follow suit.

To achieve this goal, different organizations must come together and establish a common purpose. This convergence is necessary to address an array of issues, complex regulations, or burdensome and intrusive costs. This union of organizations will effectively become a systemic approach. It allows for development of motivating standards instead of rules and regulations, ultimately allowing evolution through creativity and the desire to better oneself (Hawken, Blessed Unrest , 2007).

The key, in effect, is for environmental issues not to be "presented to businesspeople as one more cost and one more regulation, doing the right thing [then] becomes burdensome and intrusive. And the way our economy is [currently] organized, businesspeople are sometimes correct: doing the right thing might put them out of business" (Hawken, The Ecology Of Commerce, 2010).

Our approach and development of a waste disposal system must have sustainability as a cornerstone, not only in the front-end of operations but in the back-end as well. Consumers must take pride and be willing to participate. As previously stated in chapter 5.1 The Social Movement, the desire for change exists among the population; education, incentive, and some direction can enable all the pieces to fall in place.

> *"The coolest thing about trash, and the most heartening thing about our horrifying 102-ton legacy: It is one of the few big societal, economic and environmental problems over which ordinary individuals can exert control… It can start small, a slow shift to a new normal. Little changes that, if they go viral, will carry big payoffs"* (Humes, 2013).

The 3 keys to a successful cyclical system approach to addressing waste are as follows:

1) Consumers and the general public must be educated, not only about the effects of their actions, but also about convenient methods for altering them. Consumers must be informed of any requirements that mandate their participation to help facilitate

and smooth any necessary transition. These individuals are an indispensable part of an integrated waste management system.

2) Businesses and corporations must be shown that a group of entities can come together and prosper. One company's waste or by-products may be leveraged by a second company as a resource. This process can address negative impacts on the environment, which by definition would be a prosperous-cyclical partnership.

3) Lastly, all people and entities involved must have the ethic of conservation installed within, so that people will want to participate. This can be achieved through awards to businesses, people and groups that make outstanding contributions to recycling, in the form monetary incentives and/or public recognition.

As long as environmental protection is carried out and addressed on behalf of charity, altruism, or legislative fiats, it will remain difficult in finance, growth, and technology (Hawken, The Ecology Of Commerce, 2010), ultimately stalling, and preventing a restorative economy from taking shape.

5.3.2 Hercules System

Figure 1

The Hercules System was developed to be a sub-system, which would join to an existing waste disposal system. This would allow the removal of renewable organic waste in a beneficial way for all parties and businesses involved.

It is not a competitive but a cooperative system where all parties involved (big businesses and ecologists) root for the success of the other, while effectively educating consumers.

The current waste stream for organics, such as food waste is linear. Food scraps wind up in trash where they no longer can be reutilized. This type of system is otherwise referred to as cradle-to-grave.

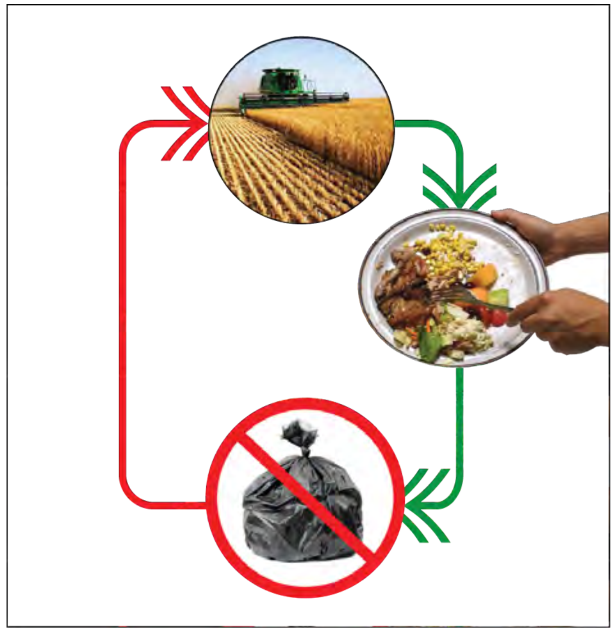


Figure 2

Implementing the Hercules System into the current food waste stream can alter the final disposal and processing option for organics. This would transform the once linear system into a closed, cyclical system, also know as cradle-to-cradle.

Figure 3

This is achieved by working with all the entities associated with food distribution, consumption and disposal to cooperatively close the loop in a way that benefits all.

5.3.2.1 Waste Collection Service

Figure 4

Organics are the heaviest component of trash. By removing organics from the waste collection system, companies that haul and transport waste would lighten their load. This would reduce the cost they incur from the disposal sites, as trucks are charged admission based upon weight.

5.3.2.2 Landfills

Figure 5

Since the 1970's, "the United States has spent over $1 trillion to monitor, litigate, contain, and curb pollution and hazardous waste" (Hawken, 2010). By implementing the Hercules system, landfills would prosper by removing damaging waste, allowing them to function as they were originally intended. As a result landfills would save money over their lifespan by increasing their time of operation, reducing maintenance, increasing efficiency, and lowering chances of legal ramification in later years, by removing environmentally damaging content.

5.3.2.3 Waste-To-Energy

Figure 6

Waste-To-Energy facilities operate at peak performance when the material they are burning is uniform and dry. Moisture present during these burn cycles creates uneven incineration. This lowers energy output and allows toxic deadly chemicals to formulate. By removing organics, the leading component of moisture in trash, WTE facilities would produce maximum energy output, generating revenue, and lowering toxic admissions that could incur legal penalties.

5.3.2.4 Business

Figure 7

Businesses that sell organics are just as vital and important to the removal of organics from our current waste stream. They are organizations that not only produce large amounts of organic waste, but they are also in direct contact with consumers, who produce additional waste. Businesses have a unique opportunity; they can reduce their own organic waste output, generating savings through rebates from the waste removal service. They also can increase consumer traffic through innovative opportunity as well as be recognized as an environmentally conscious organization within the community, ultimately increasing sales and revenue.

5.3.2.5 Consumer

Figure 8

When all business entities involved in the Hercules System participate and realize the financial benefits that ensue, the consuming body then becomes the binding glue that plays the most important role for generating a lasting impact. By participating in the Hercules System, consumers become educated about their environmental impact, learn techniques/options for organic waste reduction, receive monetary incentive through their reduction of waste, and most importantly establish and reinforce the cyclical system, thus improving the foundation for future generations.

6. Organic Solutions Business Model

6.1 Overview

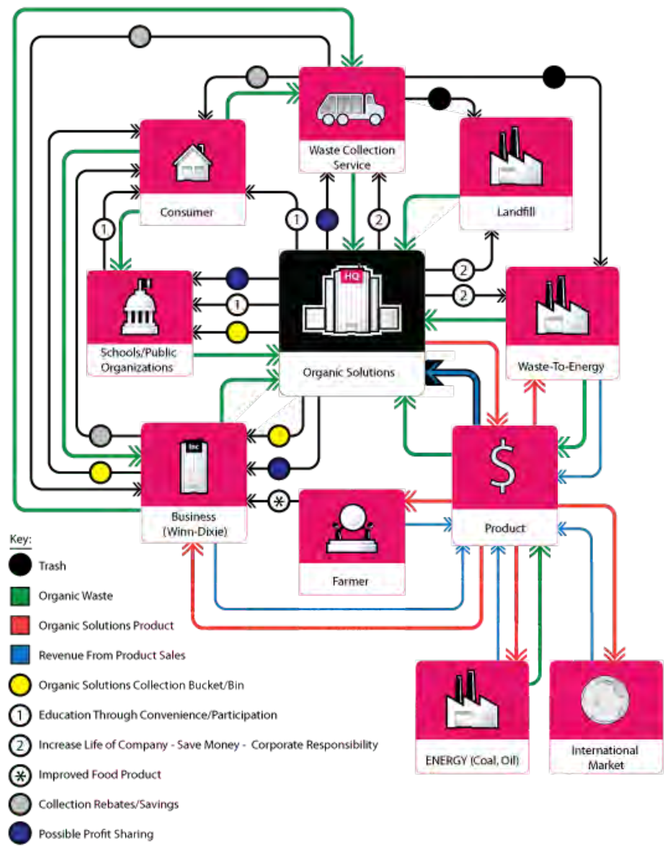


Figure 9

Organic Solutions is a business model that was designed and developed by the author to effectively demonstrate how organics would be removed from today's current waste stream. This would allow the content to be reprocessed into a viable product that would be utilized in the end by nature in a positive way, creating a closed loop system. This business model implements the principles of the previously developed Hercules System to demonstrate how removing organics from our current waste stream would benefit all people and involved parties. Designers then can utilize the guidelines set forth to develop alternative methods for addressing other issues of our waste system and disposal. Through cooperation we can bring a cyclical/restorative economy one step closer to fruition.

6.1.1 The Players

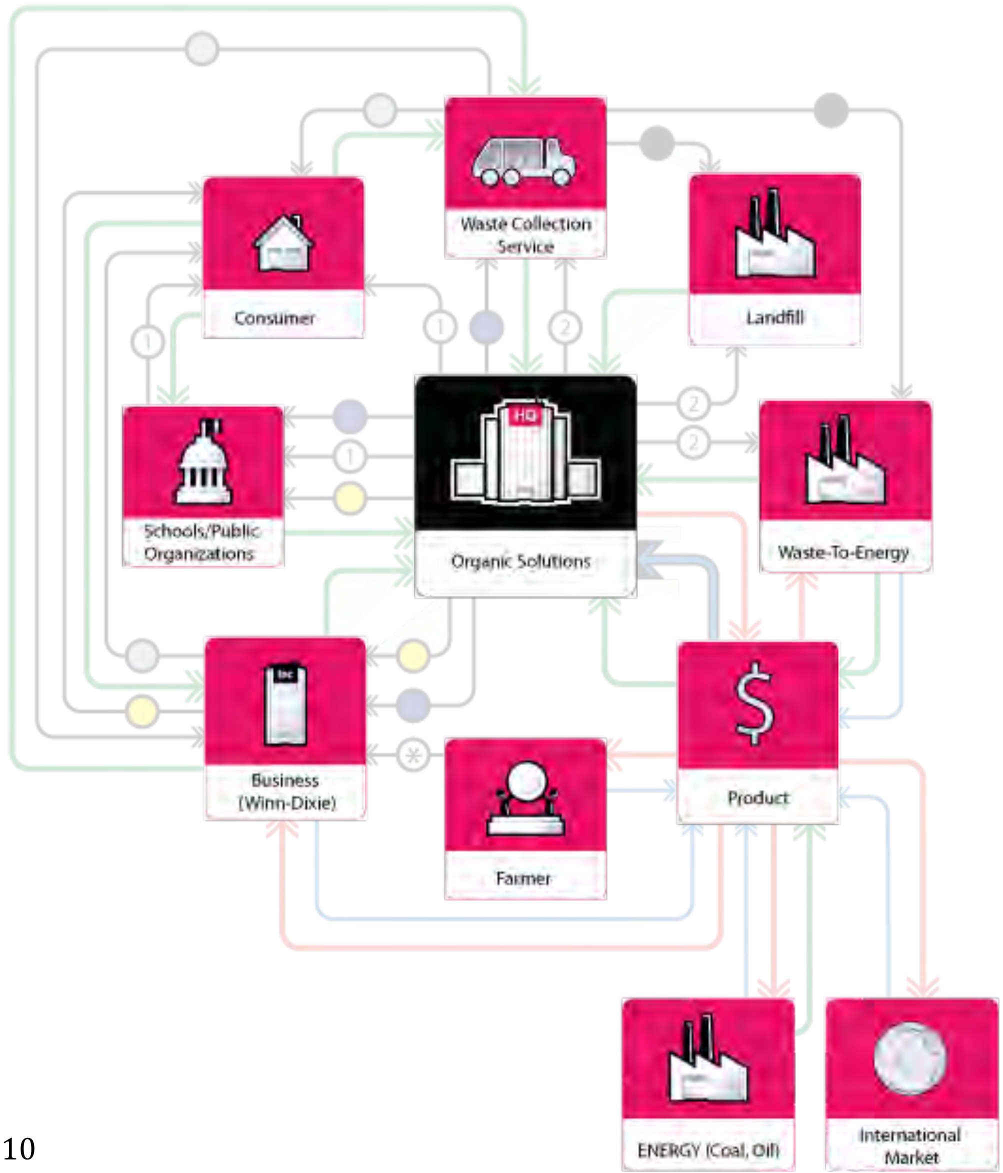


Figure 10

By identifying all entities that produce, consume and dispose of organics, the larger system of waste becomes evident. This is vitally important for not only understanding and addressing the issue of how organics become disposed of improperly, but also for understanding how the establishment of a new company, Organic Solutions, is going to interrelate with an already pre-established system.

6.1.2 Waste Collection Service

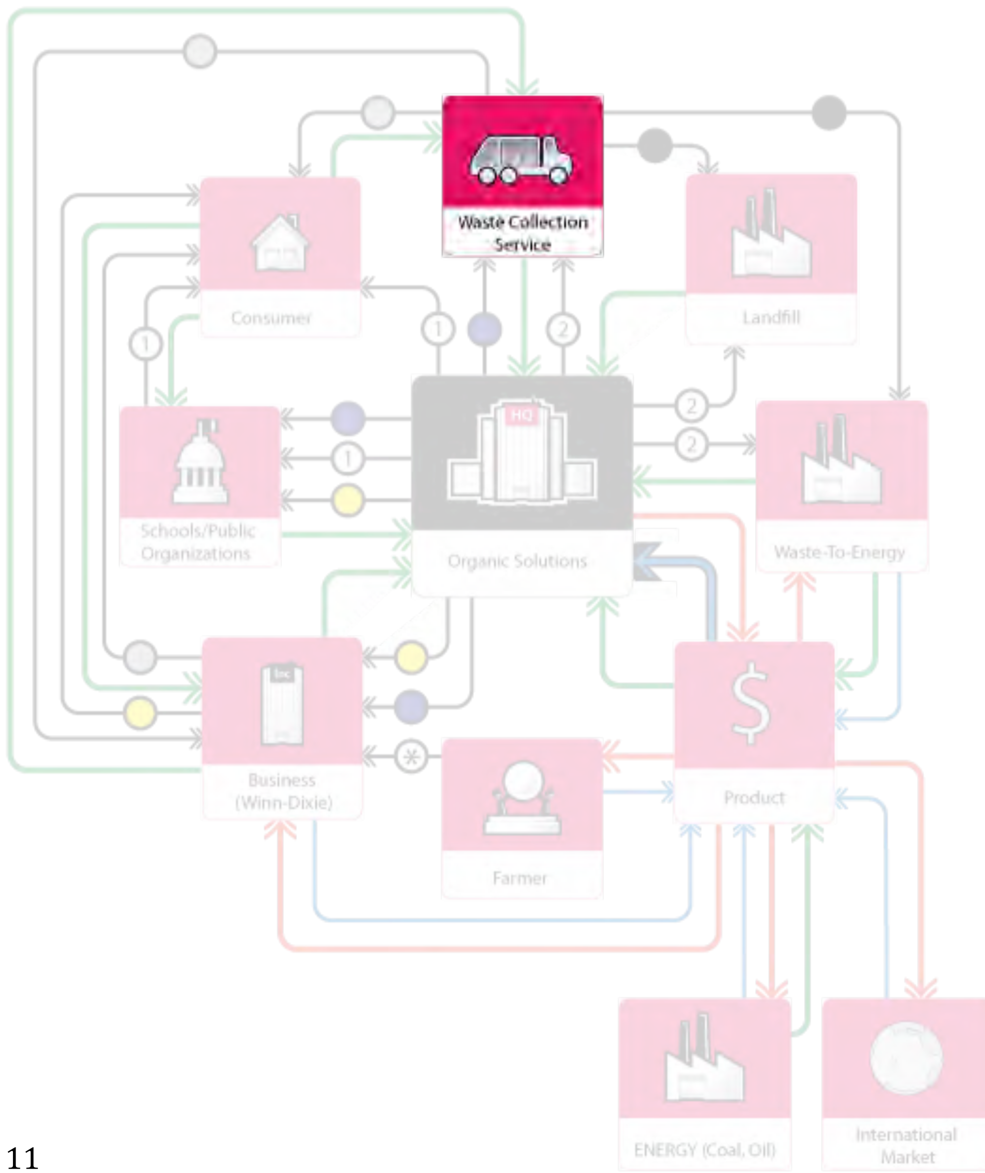
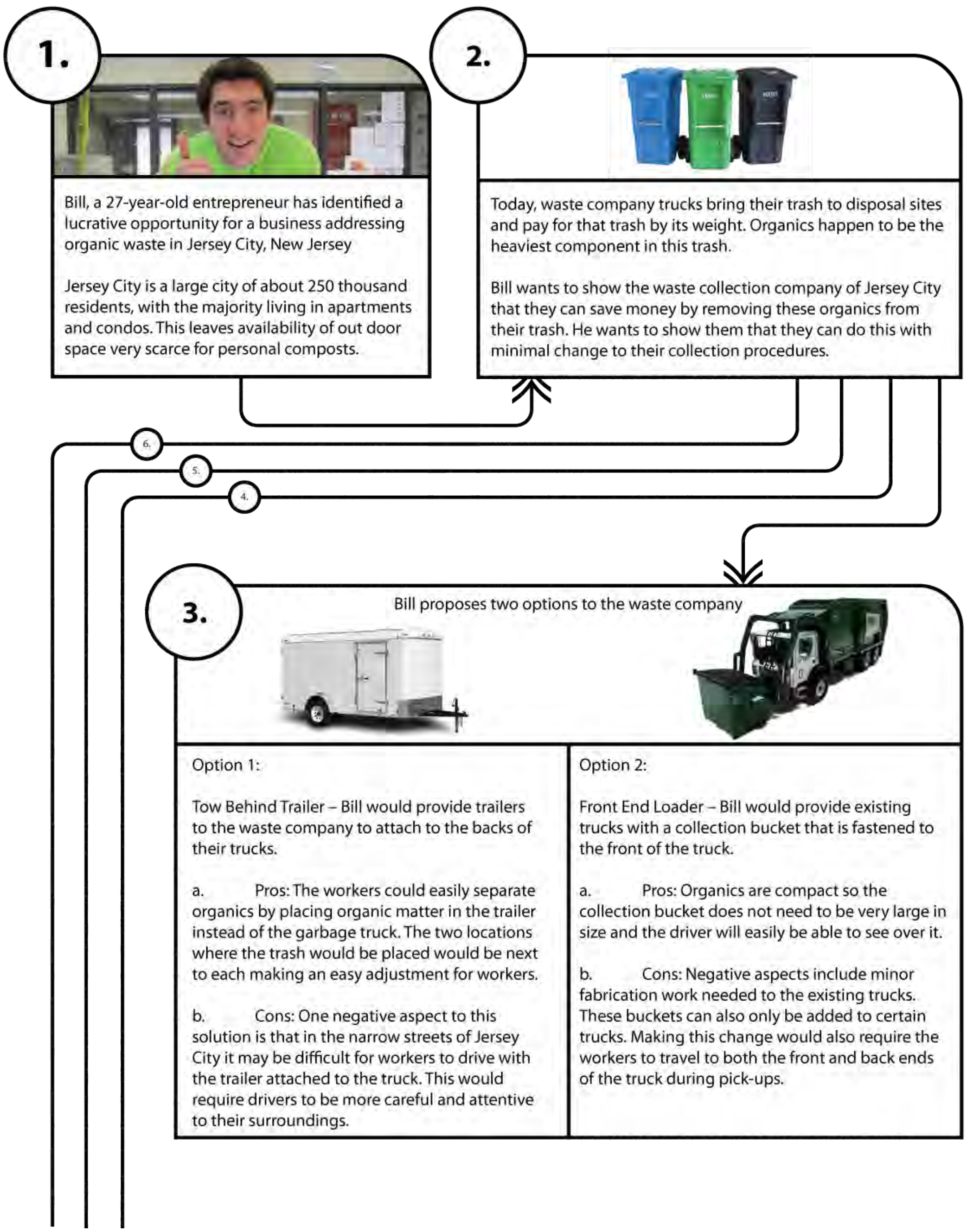


Figure 11

The waste collection service is the first hurdle and corner stone for the development and implementation of Organic Solutions. This service is the entity that collects and condenses our millions of tons of trash (164 million tons in 2011) into a single waste stream destined for landfills or WTE facilities. By demonstrating the profound benefits of their participation at minimal to no expense, their acquisition would overcome the initial inertia to officially get the ball rolling.

6.1.2.1 Point Of View Interaction

The following is a point of view interaction chart, depicting how Organic Solutions would address a waste collection service to get it involved. It clearly lays out the requirements of both parties and details the benefits the waste collection service would incur.



4.

Bill's company, Organic Solutions will create Organic Waste Drop-off Sites where the waste collection company can conveniently unload their organic waste free of charge.

The first option is to leverage Jersey City's current Waste Transfer Stations. Here, they transfer their waste to containers or larger trucks that then bring the waste to disposal sites. Organic Solutions would place one of their sites at this station so that when workers are unloading their trash, they can easily dispose of their separated organic matter.

Another option is to place drop-off sites based on the waste collection company's current routes. This will make for convenient drop-off as companies are making their pick-ups.

5.

In addition to curb-side pick-up, there are also central locations where residents drop off trash in large dumpsters. These dumpsters are currently serviced by a special dump truck that can lift the full weight of these bins. Bill's Organic Solutions will provide a second dumpster to each of these locations. This will result in two pick-up options:

1. Repurpose the necessary amount of existing trucks to be strictly used for organic matter pick-up. One truck will be able to travel to each location to pick-up all organic matter. In return for the conversion of these trucks, Organic Solution will provide profit sharing or cover cost for other vehicle maintenance.

2. Organic Solutions will purchase new trucks for the operation and take on the full cost of maintaining the trucks. This option will not include any other incentives such as profit sharing.

6.

Bill also proposes that the waste collection company could issue citations or deny collection to residents that are found not separating.

This in turn would increase consumer participation and revenue for the waste collection company.

Interaction 1

6.1.3 Waste Disposal Locations

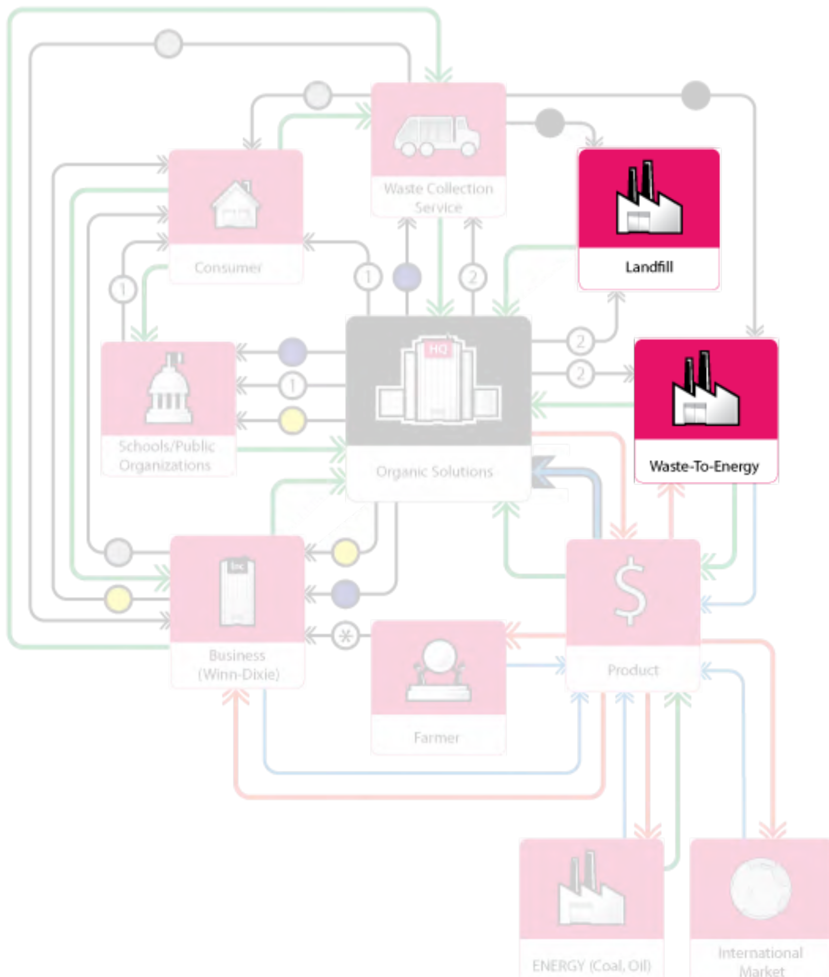


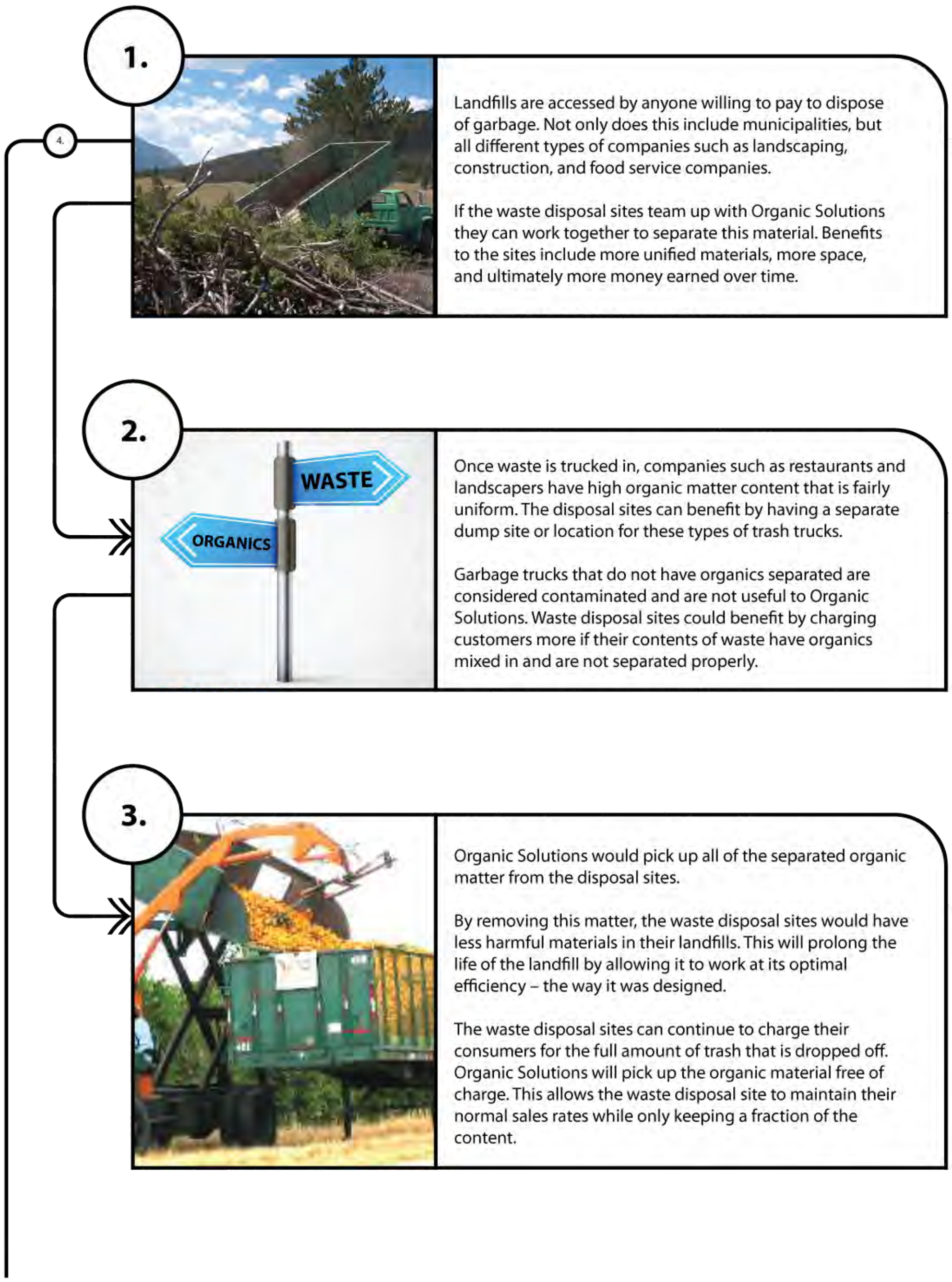
Figure 12

Waste disposal locations, such as landfills and Waste-To-Energy facilities, for years have only been concerned with getting product to their location for the purpose of burial or incineration. This is a process that wears down equipment, shortens the lifespan of the facility, and if it is found to damage the environment, can incur large legal ramifications.

With the participation of both disposal sites and Organic Solutions, the two major entities involved with trash and waste (waste removal and disposal) would generate a chain reaction that would reverberate back "upstream."

6.1.3.1 Point Of View Interaction

The following is a point of view interaction chart, depicting how Organic Solutions would address a landfill to get them involved. It clearly lays out the requirements of both parties and details the benefits the Landfill site would incur. This interaction chart also depicts how a closed landfill and Organic Solutions could benefit each other.



4.

Landfills, such as Fresh Kills, will benefit from Organic Solutions building factories on their closed land. Once landfills close, they face two major business dilemmas:

1. The landfills are no longer profitable because trash is no longer being dropped off

2. Reclaiming and utilizing the land is a difficult process because the public has high skepticism to the safety and danger landfills poses

5.

Organic Solutions will build its factory on top of Fresh Kills Landfill, a closed landfill in Staten Island, New York.

Closed landfills produce significant amounts of methane which can be used to run the factory's dehydrator.

The location of Fresh Kills will provide easy access to the company's primary service area in Jersey City, New Jersey.

6.

Organic Solutions will take the organic matter from the various locations and create a new product. To make this product, Organic Solutions will grind up all materials into small consistent particulates. Then, these particulates will be dehydrated and will be separated into two types of products

1. The first product will involve cases being filled with the dehydrated matter for farmers to use as organic compost. The fact that the material is dehydrated allows for a long shelf-life which can be beneficial to a farmer and suppliers.

7.

2. The second product will require the factory to compact the material into a brick. This organic structure can be a viable alternative fuel source to coal, oil, and other toxic substances.

When this product burns it will produce an organic ash that can be repurposed. This is different from the byproduct of other currently used fuel sources. For companies who use the new organic fuel source, Organic Solutions will come and collect that byproduct (Ash) for a lower price than the current rate.

Interaction 2

6.1.3.2 Organic Solutions Product

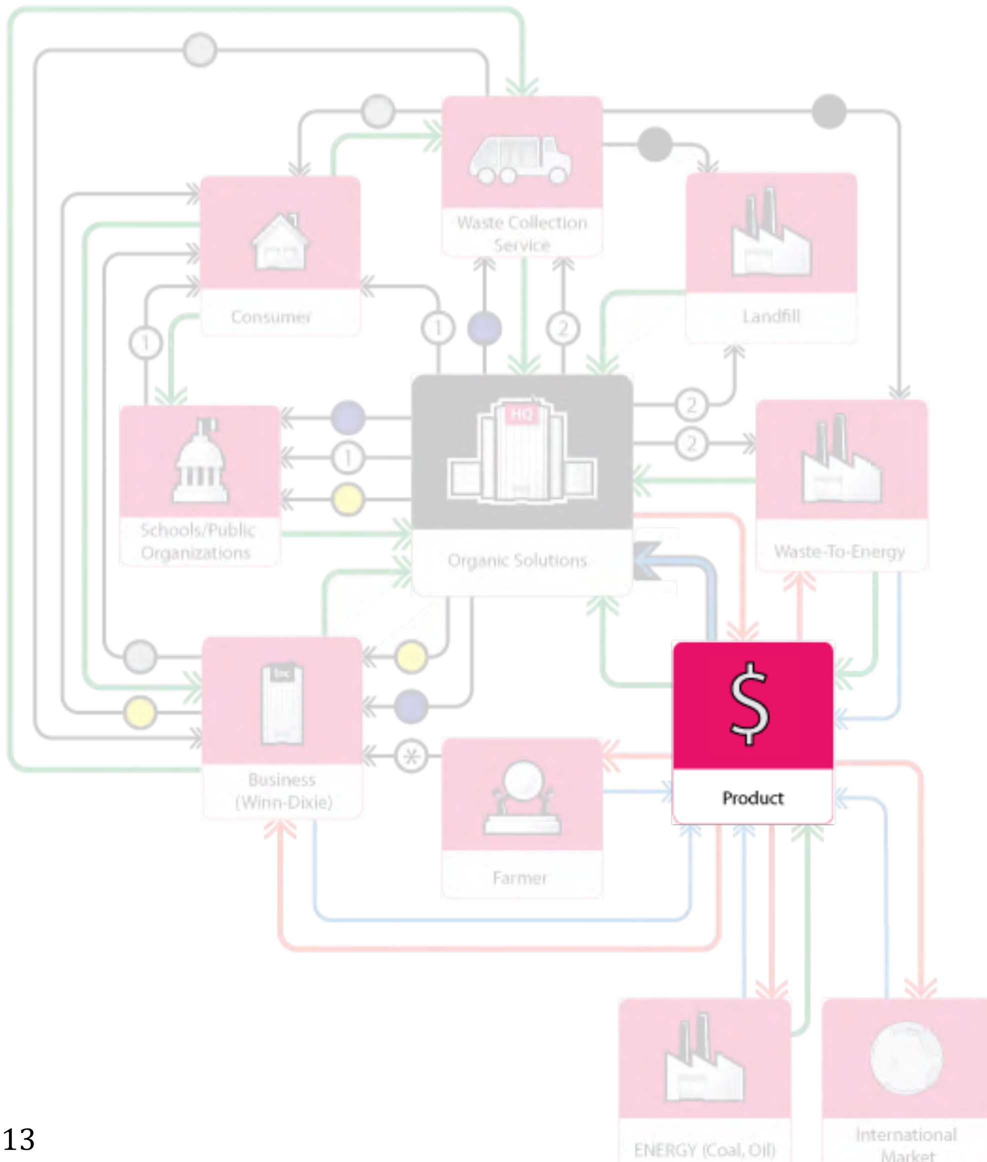


Figure 13

Understanding that acquiring capital is one of the basic foundations of the economy, two options for the production of goods were presented at the conclusion of Landfill point-of-view interaction. There is however belief that countless opportunities for economic growth exist in organic waste, as well for the other material wasted in trash on a daily basis. All that is needed is creativity, ingenuity, and the continual passion for its pursuit.

6.1.3.3 Organic Solutions Product Distribution

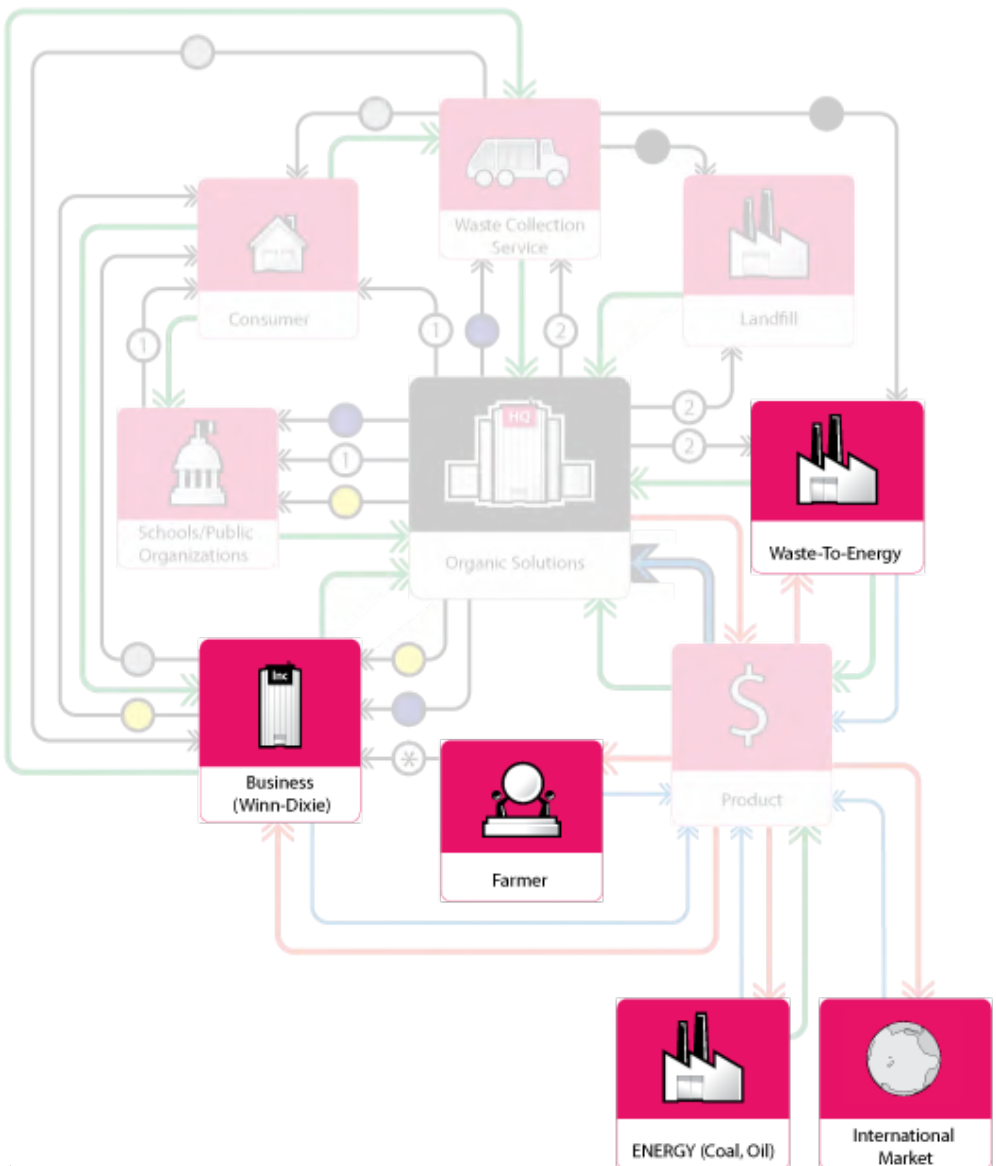


Figure 14

By previously establishing all the players involved with organics, one can identify locations for entry into the marketplace for reprocessed organics. This can uncover opportunities well outside the original system in focus, essentially creating influences well outside one's original intent. Since the product in creation is meant to be returned to nature, in a way that benefits the environment, it can be concluded that any end effect to the outside systems would be positive in nature.

6.1.4 Business and Educational Entities

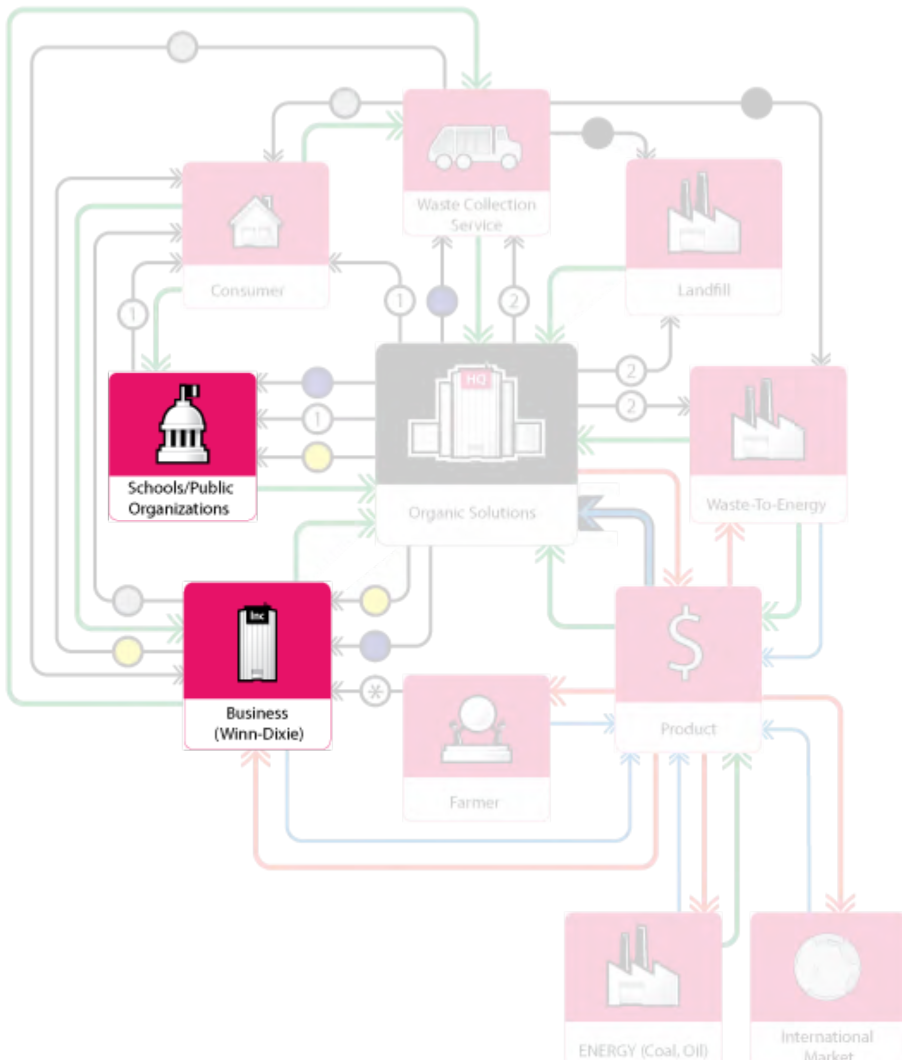
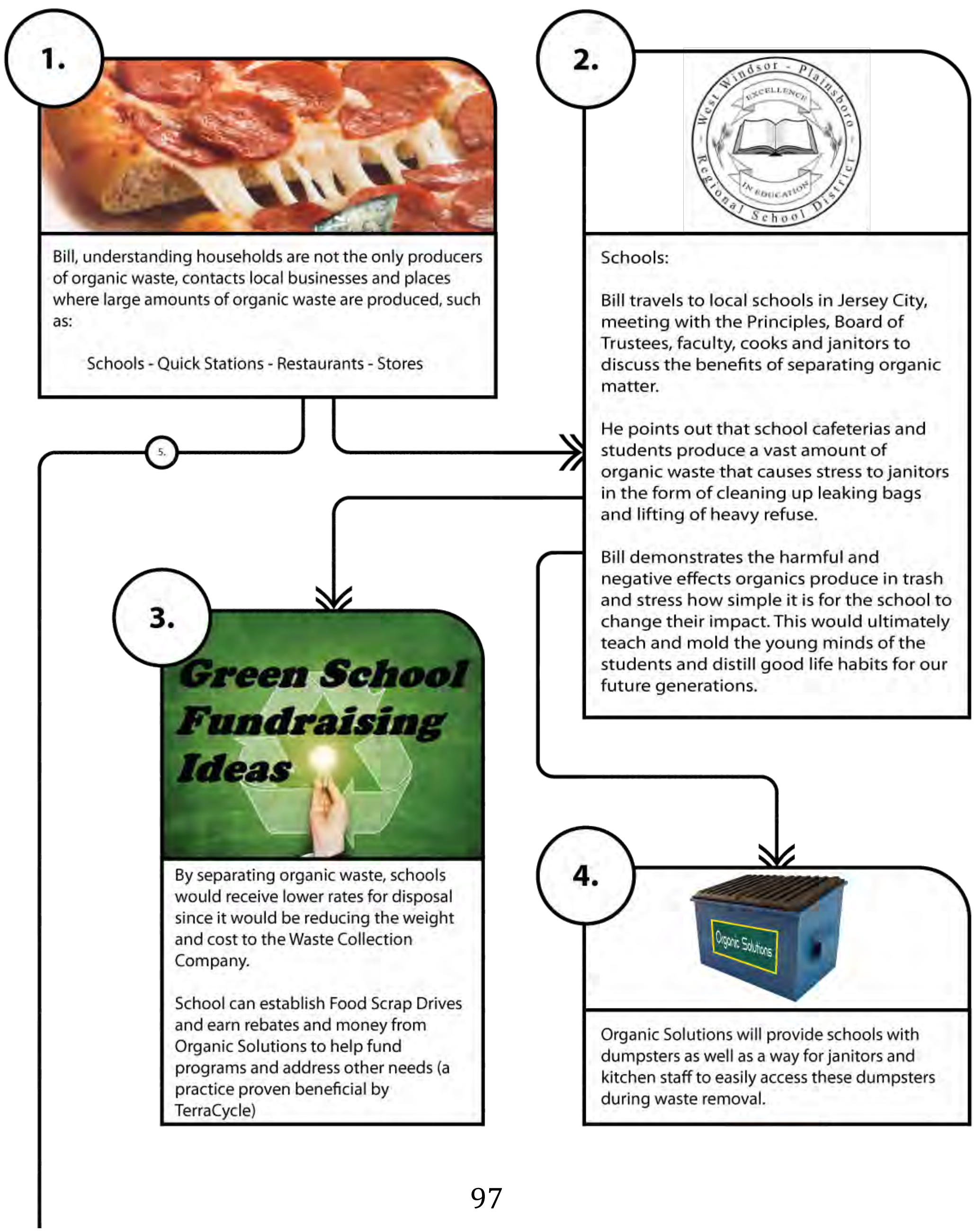


Figure 15

Schools and businesses pose a unique opportunity; one that not only reduces disposal output, but also creates wealth and changes consumer's habits. When these organizations join in and realize the benefits of participating with Organic Solutions' system, they strengthen and increase their core principles. Schools can strengthen their principles by being on the forefront in correcting and educating our future generations about our unsustainable impact. Businesses can support their models by increasing consumer traffic, which can lead to an increase in sales.

6.1.4.1 Point Of View Interaction

The following is a point of view interaction chart, depicting how Organic Solutions would address a school and grocery store to get them involved. It clearly lays out the requirements of both parties and details to the benefits they would receive from participation. The example of a school and a grocery store depicted in the point of view chart are only 2 organizations of many that produce large amounts of waste.



5.

Stores:

Bill meets with the managers of the local Winn-Dixie and informs them of a great business opportunity.

Bill shows the managers that by participating in Organic Solutions' waste separation program, the store could receive rebates on waste removal, increase their customer traffic, increase their sales and become established as an environmentally conscious organization within the community.

All of these incentives will come at no cost to the store because Organic Solutions will provide the dumpster for the organic waste.

6.

Bill also proposes that stores become a collection center for customers' organic waste.

Organic Solutions would provide "Organic Solutions Buckets" free of charge for consumers. The buckets will be located near registers at check out.

Winn-Dixie would then accept all returned Organic Solutions Buckets and their contents.

The customers would be rewarded with monetary incentives in the form of credits that could be redeemed on future food purchases at Winn-Dixie.

7.

By separating waste the store will begin to save additional money. A portion of these savings will be directed back to the consumer in the form of credits.

The customers can then use these credits towards purchases made in the store.

Bill also leaves the door open for a possible profit sharing opportunity from Organic Solutions. This opportunity would be based off of how efficiently the store separates their waste and the number of participants that the store has in the collection program.

8.

WIN
WIN

Ultimately, customers are rewarded with monetary incentives and feelings of joy for helping the environment. Customers will receive store credits and rewards for their Winn-Dixie location, ultimately increasing Winn-Dixie's sales.

Interaction 3

6.1.5 Consumer

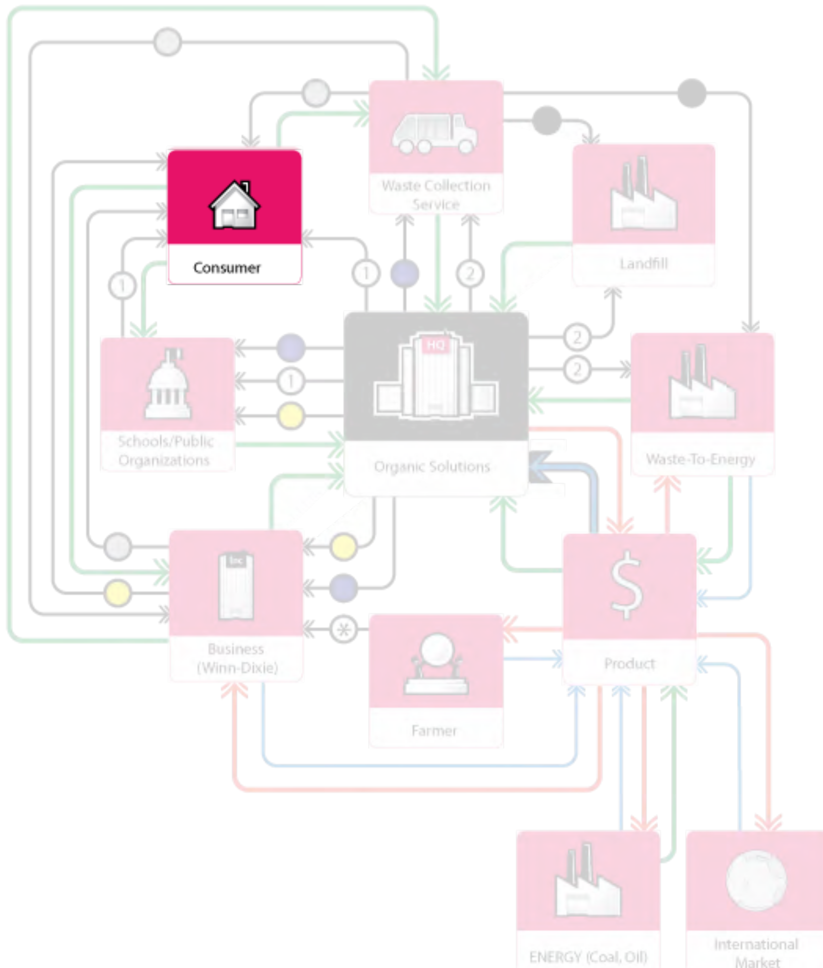
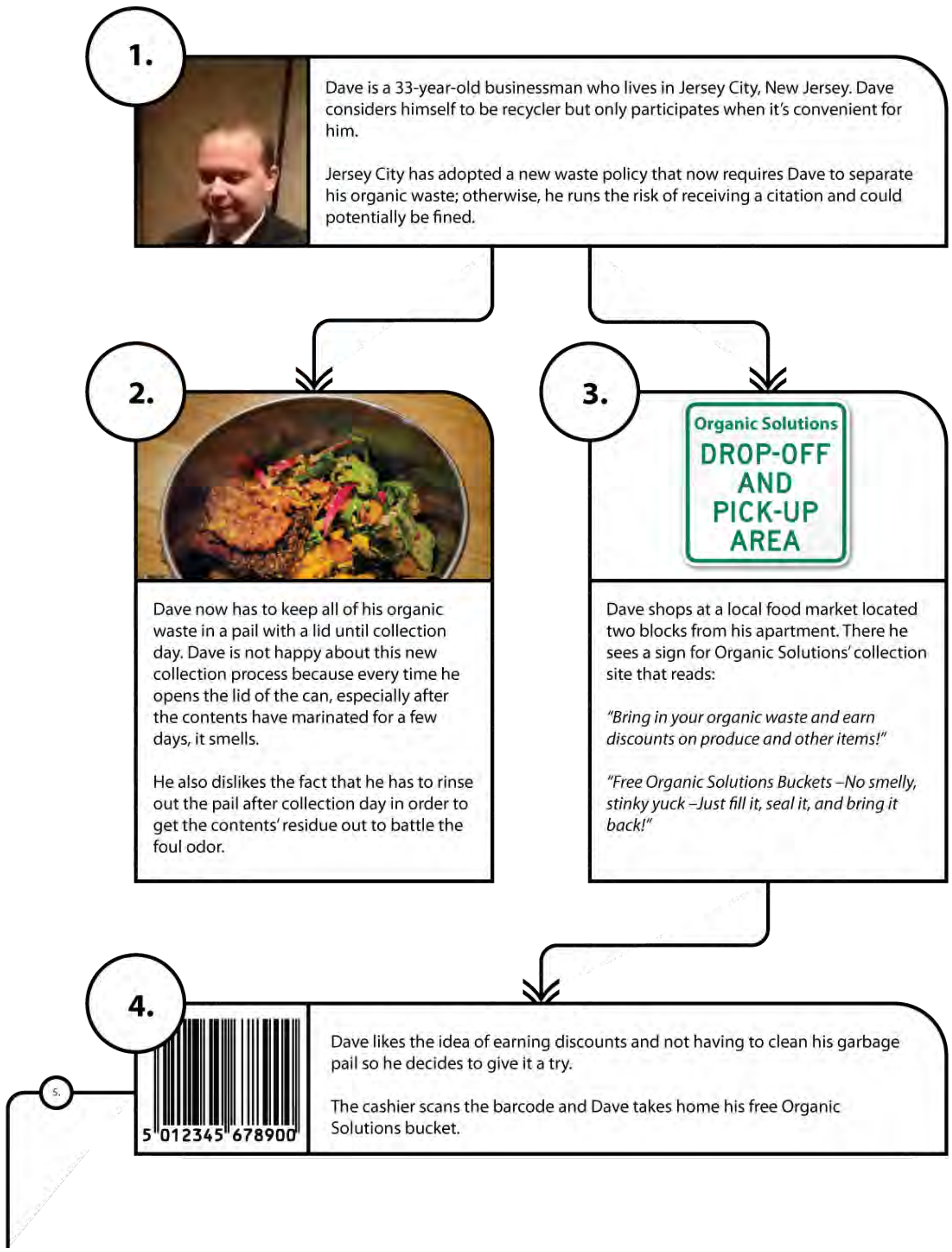


Figure 16

Finally, the consumer is the most important foundation piece to instilling, growing and reinforcing Organic Solutions' collection system. With Organic Solutions working with every entity in the larger system of organic waste, the consumer then receives continual reinforcement and encouragement to participate in organic waste separation. This eases transition, provides options for disposal/separation methods and distills good life habits that become, for a lack of a better word "common" sense, not to mention the fact that consumers will receive rebates, and other monetary incentives.

6.1.5.1 Point Of View Interaction

The following is a point of view interaction chart, depicting how Organic Solutions' interactions would be facilitated through a grocery store to positively address the consumer. Not only will Organic Solutions encourage participation, but they will offer options for a disposal system that is efficient for that individual, lowering any previous stress or frustration.



5.

Dave fills the Organic Solutions bucket over the next couple of days.

Once the bucket is full, Dave brings it back to the store where he purchased it. Upon returning the bucket to the collection station, the barcode is scanned to indicate and document a returned item.

The barcode also provides Organic Solutions with data on average amount of time consumers keep and fill buckets and other analytics.

6.

Dave is then given a rewards option for returning his bucket. He can either have his credit printed on a coupon or he can sign up for an Organic Solutions membership card to redeem his credits.

The card is free of charge and only email is required to sign up. A phone number can be given so that the customer does not need his or her card to use/collect rewards.

7.

Dave is ecstatic that he can now "return" his food waste to save on his next purchase. He finds himself scrutinizing every little bit of waste making sure all food goes into the right bin.

8.

The email that was provided also allows Dave to get monthly updates on his waste collection, national statistics, how Organic Solutions is impacting the environment, and other recycling information.

Interaction 4

6.2 Flow and Interaction Of Entities

6.2.1 Organic Waste Stream

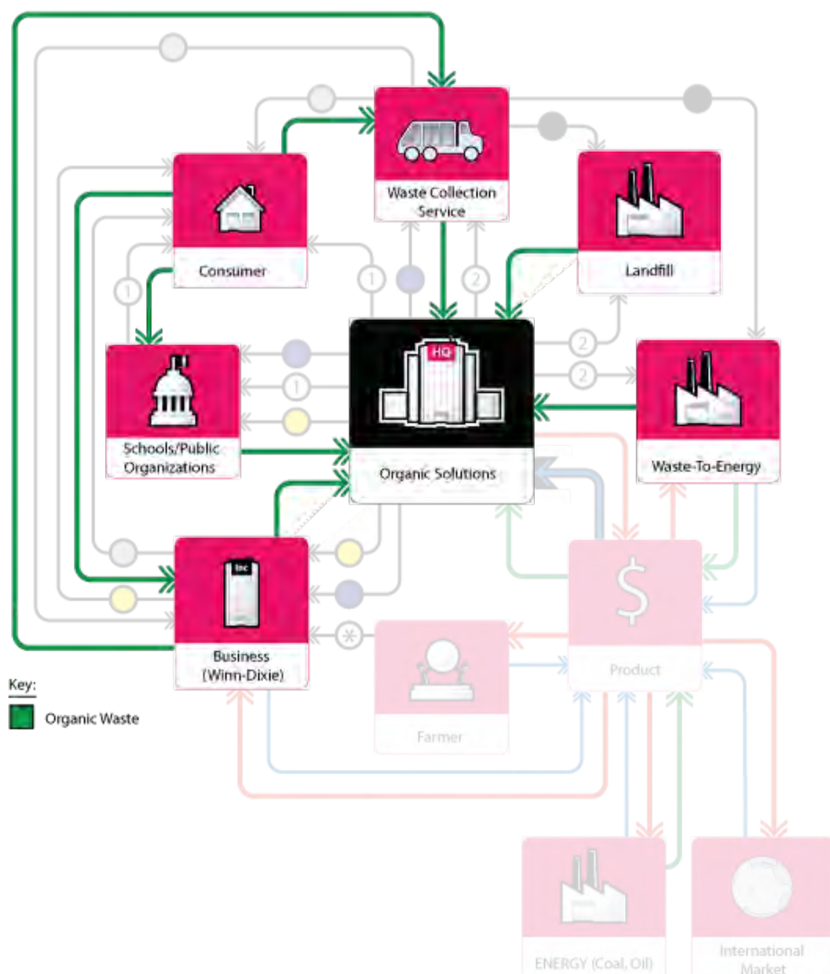


Figure 17

The collection stream for organic waste was designed to allow consumers, the mass producers of waste, the most possible options for proper disposal. These options reduce pain points that consumers may have with the new system. The waste is then consolidated, regardless of which stream the consumers decided to use, before being collected and sent to Organic Solutions for processing. This flow and consolidation of organics allows for the most possible participants while keeping collection cost minimal to Organic Solutions.

6.2.2 Trash Waste Stream

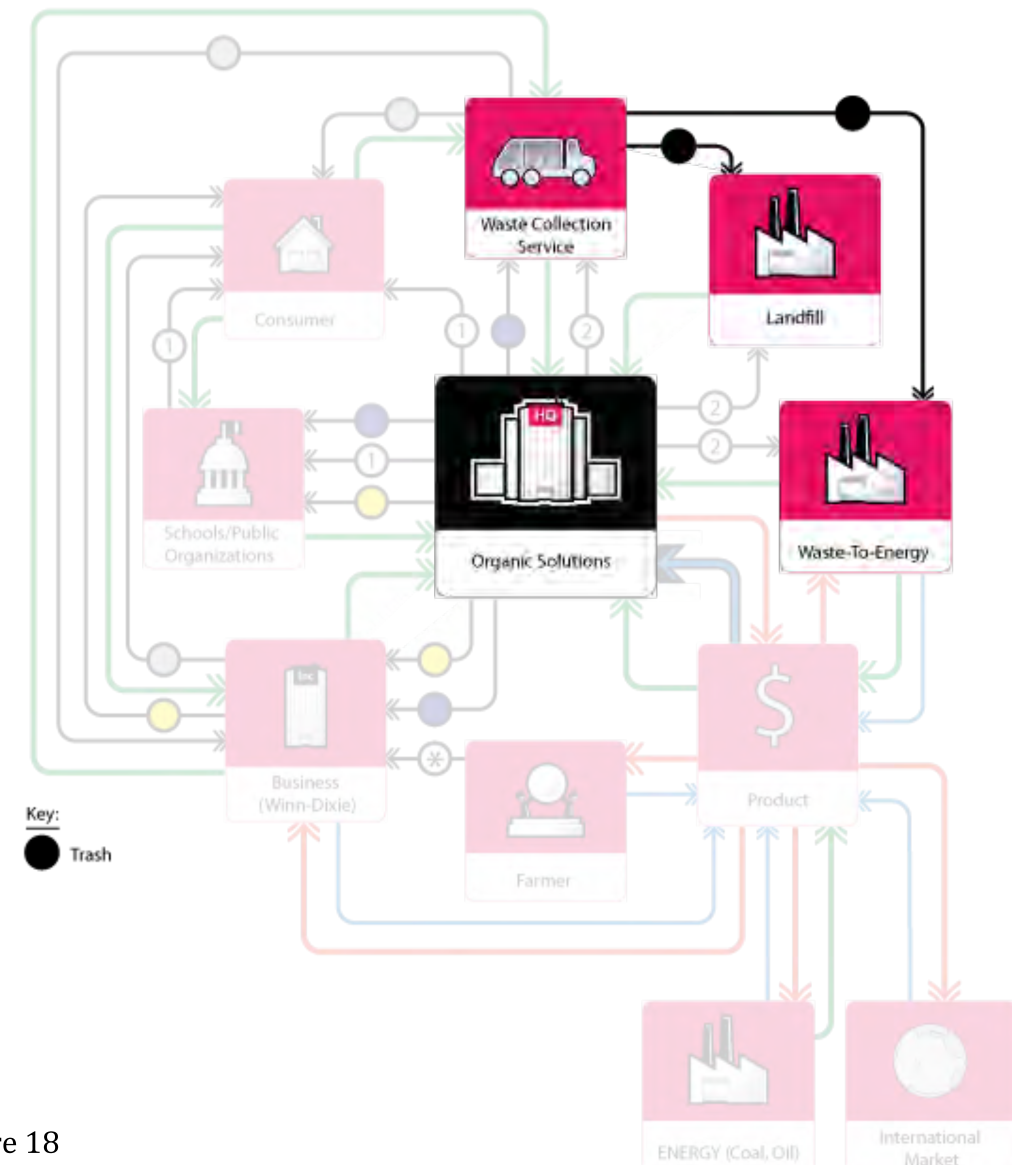


Figure 18

By reducing the weight Waste Collection Services brings to disposal facilities, an increase in savings will accumulate.

6.2.2.1 Trash Waste Stream Rebates

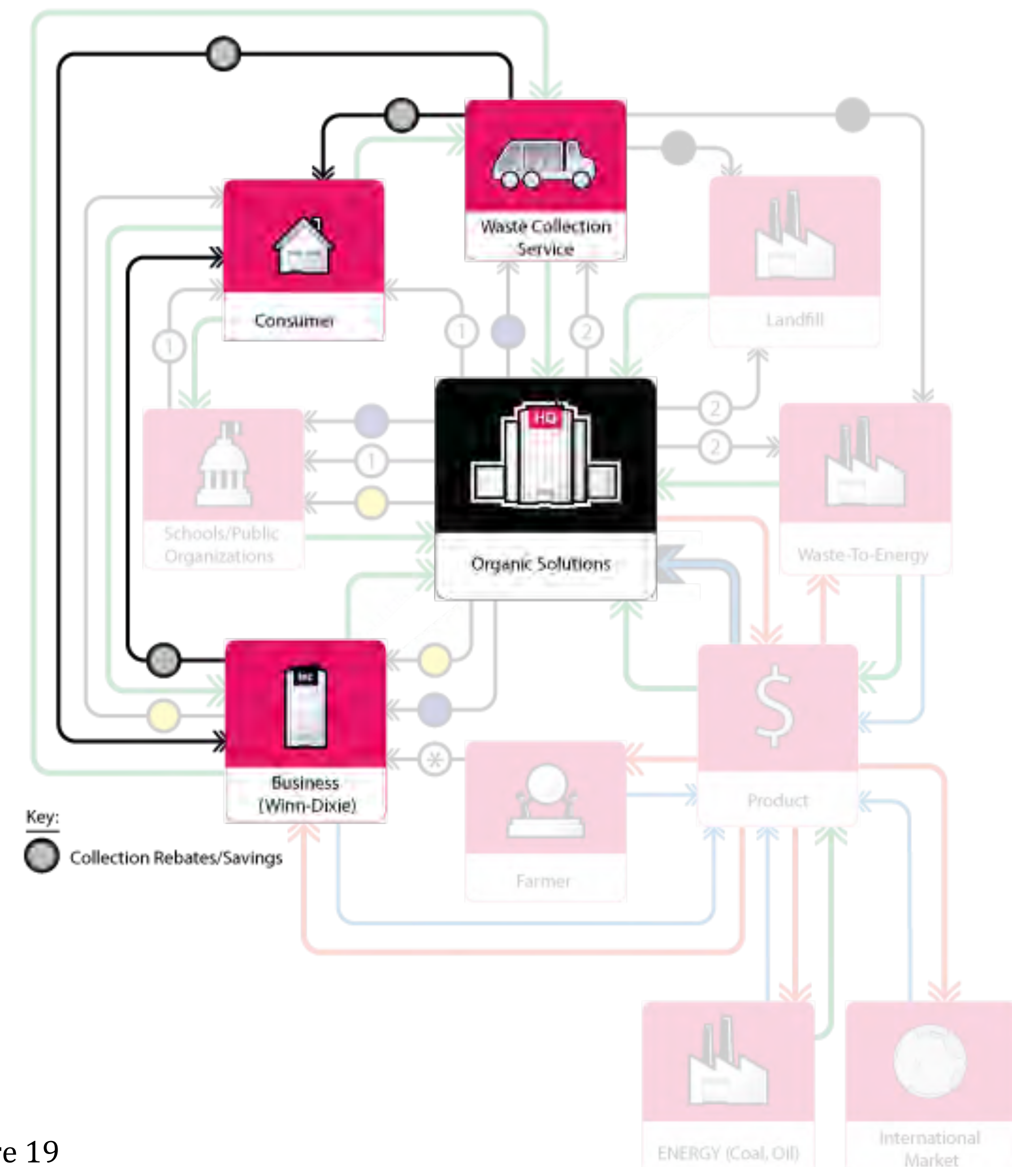


Figure 19

By lowering their total weight of admission at the disposal facilities, the collection service saves money. Wanting to keep operation fees low, they must keep the people they serve enticed to continue reducing/separating their waste for collection. To do this, the collection service company issues rebates and discounts based off a percentage of savings it receives from the waste disposal facilities.

6.2.3 Organic Solutions' Collection Bins

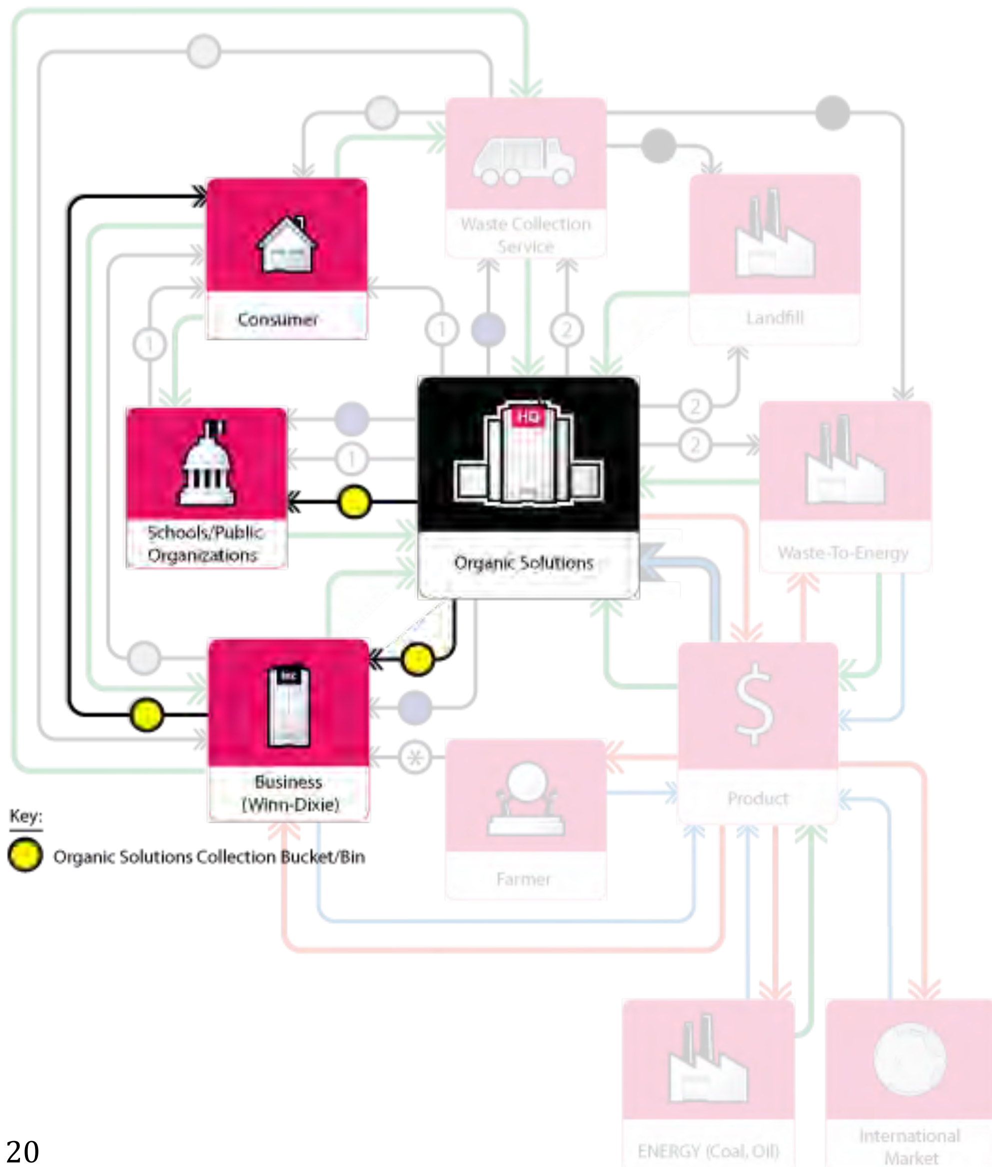


Figure 20

Understanding that increased pain points can drastically hinder separation, Organic Solutions identifies areas and locations where they must provide special dumpsters and/or home collection kits/buckets. To distribute these most efficiently, Organic Solutions provides them in bulk to public and business entities. There, the individuals can collect and drop off kits/buckets as needed.

6.2.4 Organic Solutions' Product Distribution Stream

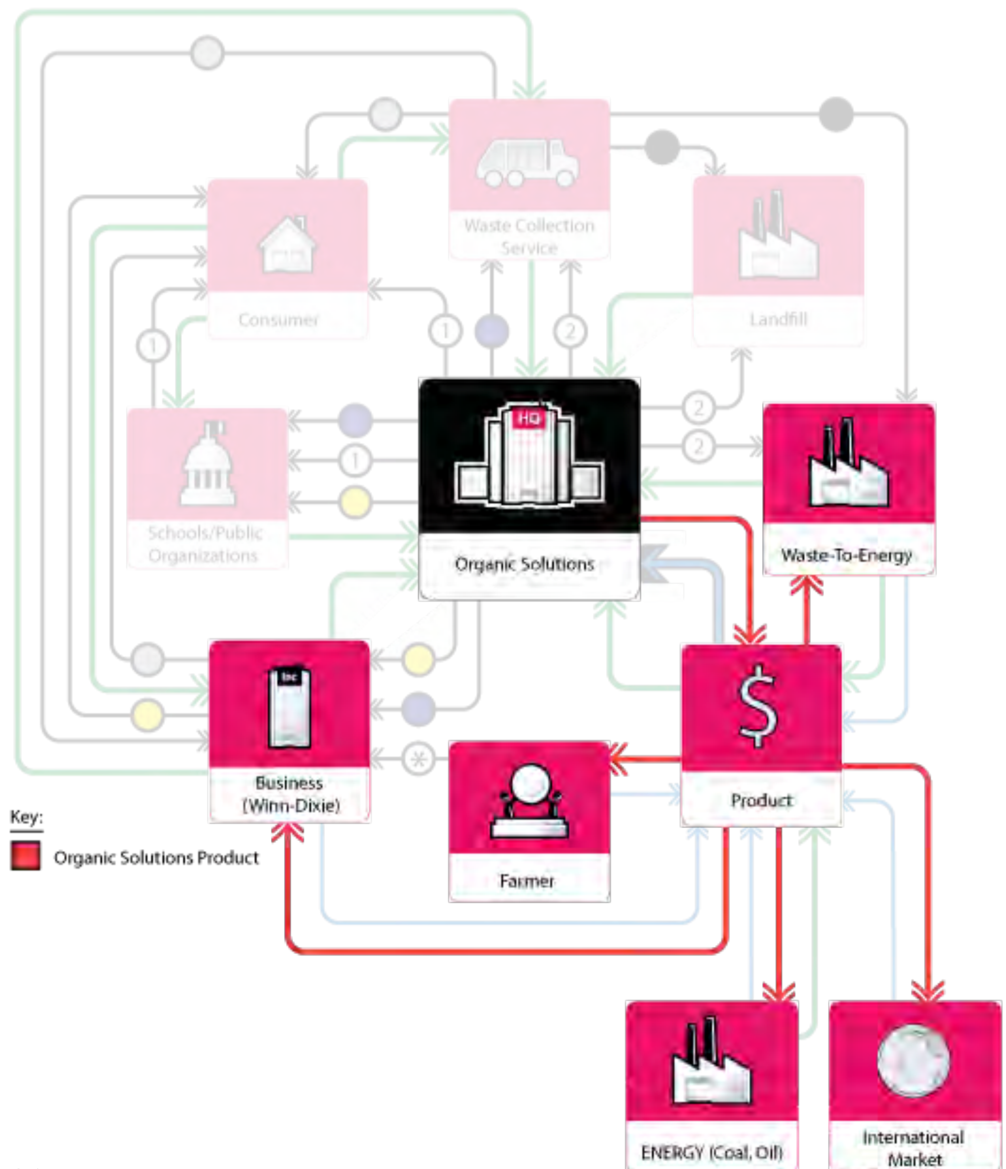


Figure 21

By identifying the flow of product, Organic Solutions can visually identify the areas and opportunities for further growth as well as identify secondary collection streams for organic waste.

6.2.4.1 Secondary Organic Waste Stream

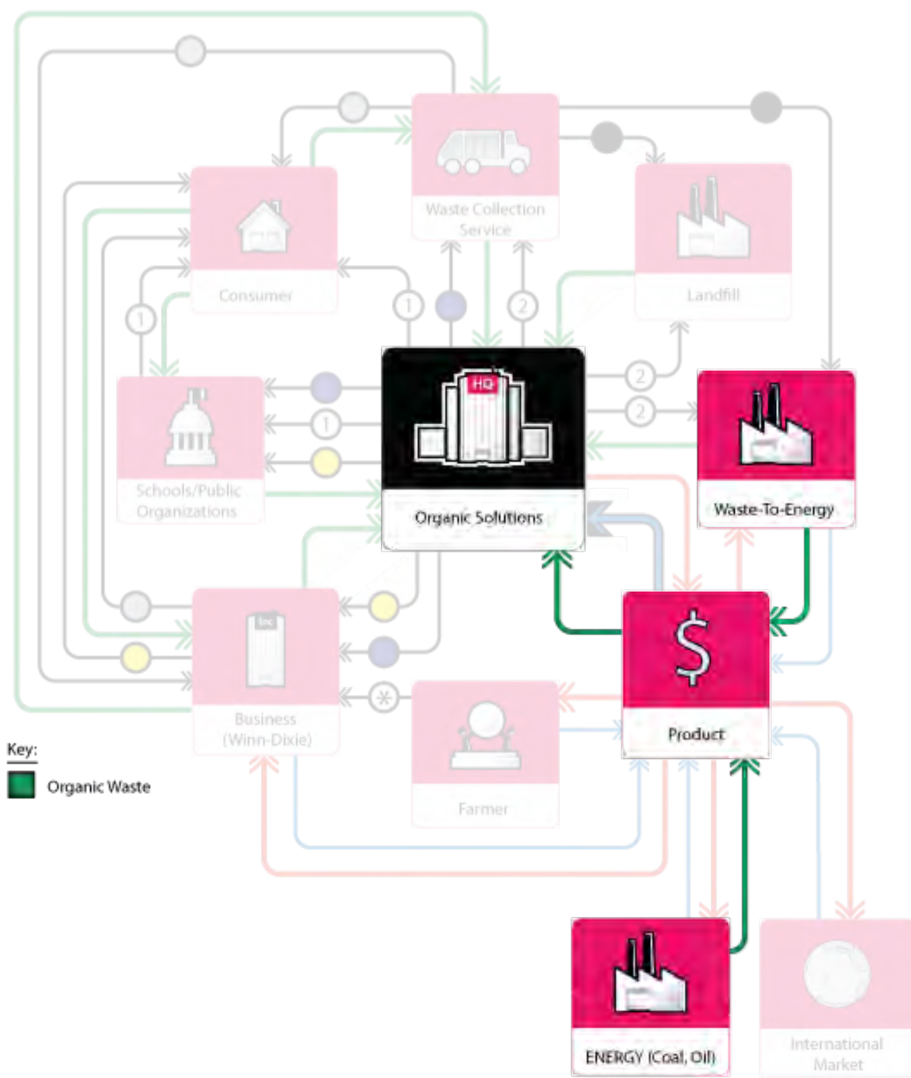


Figure 22

The development of an organic fuel source for an energy plant allows Organic Solutions to expand its positive impact. Energy facilities that burn trash, coal, and other items that contain heavy metals such as cadmium, lead, mercury, arsenic, beryllium, zinc, copper and other toxins have to be collected and shipped to landfills where the ash is buried. When these facilities use Organic Solutions' product instead, the ash can be repurposed, granting energy producers a lucrative ash disposal option.

6.2.4.2 Organic Solutions' Revenue Stream

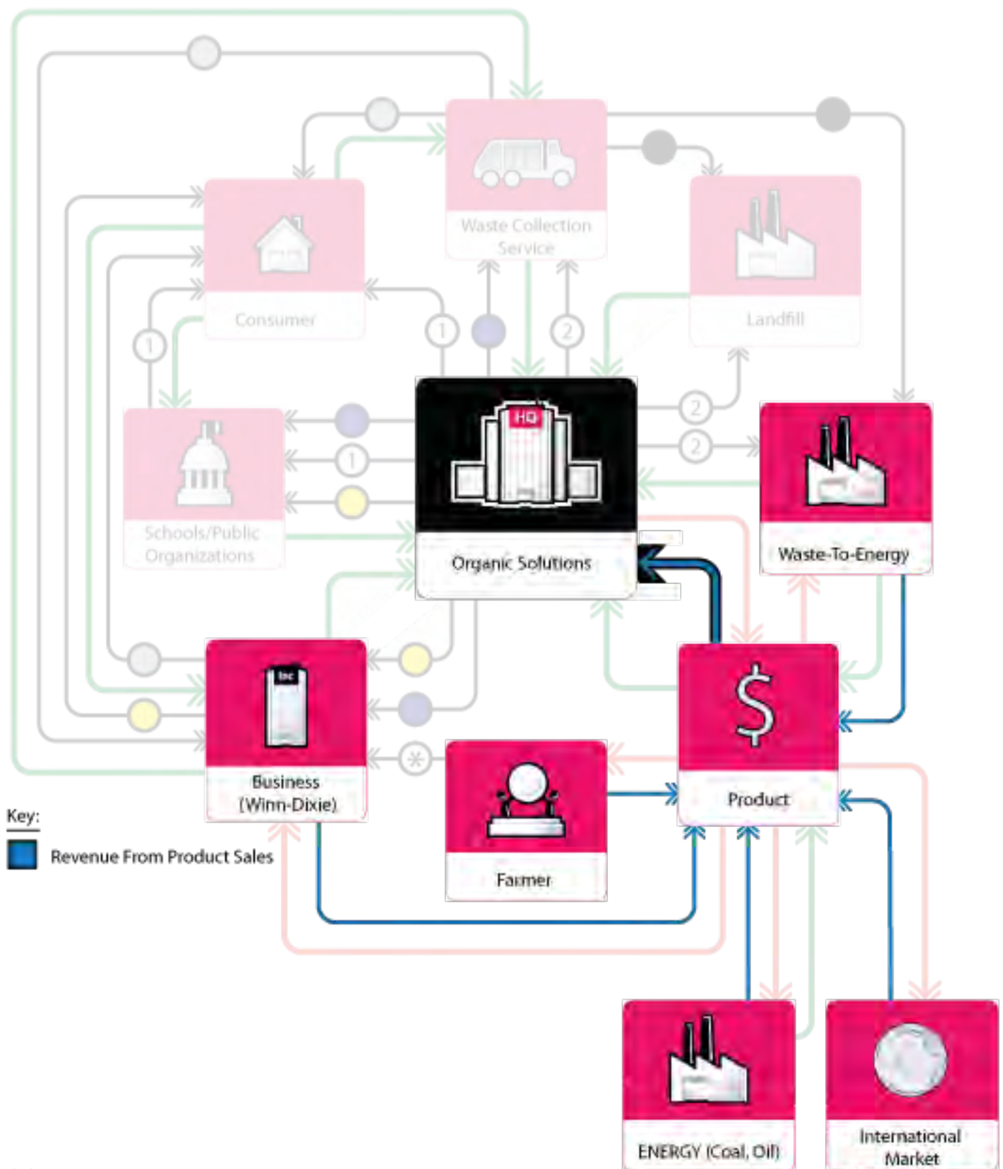


Figure 23

Organic Solutions' product distribution ultimately identifies where the company will derive its capital.

6.2.5 Opportunity for Profit Sharing

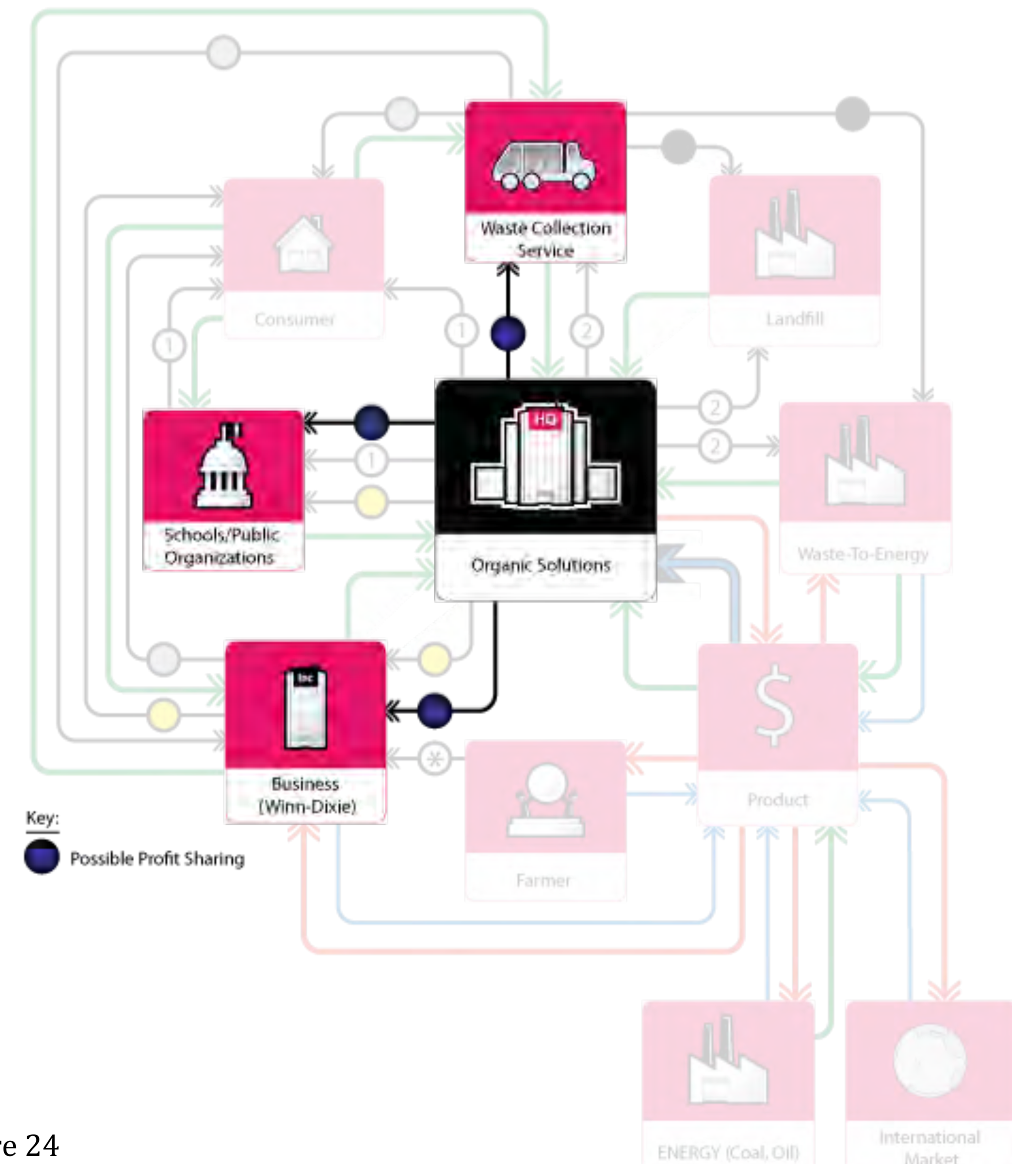


Figure 24

Organic Solutions' business model also identifies that our economy is based off the action of creating revenue, meaning the action of saving money alone may not be enough incentive in a permanent operation. Organic Solutions' business model identifies key components where the possibility for profit sharing can be established.

6.3 Impact Conclusion

6.3.1 Current Waste System

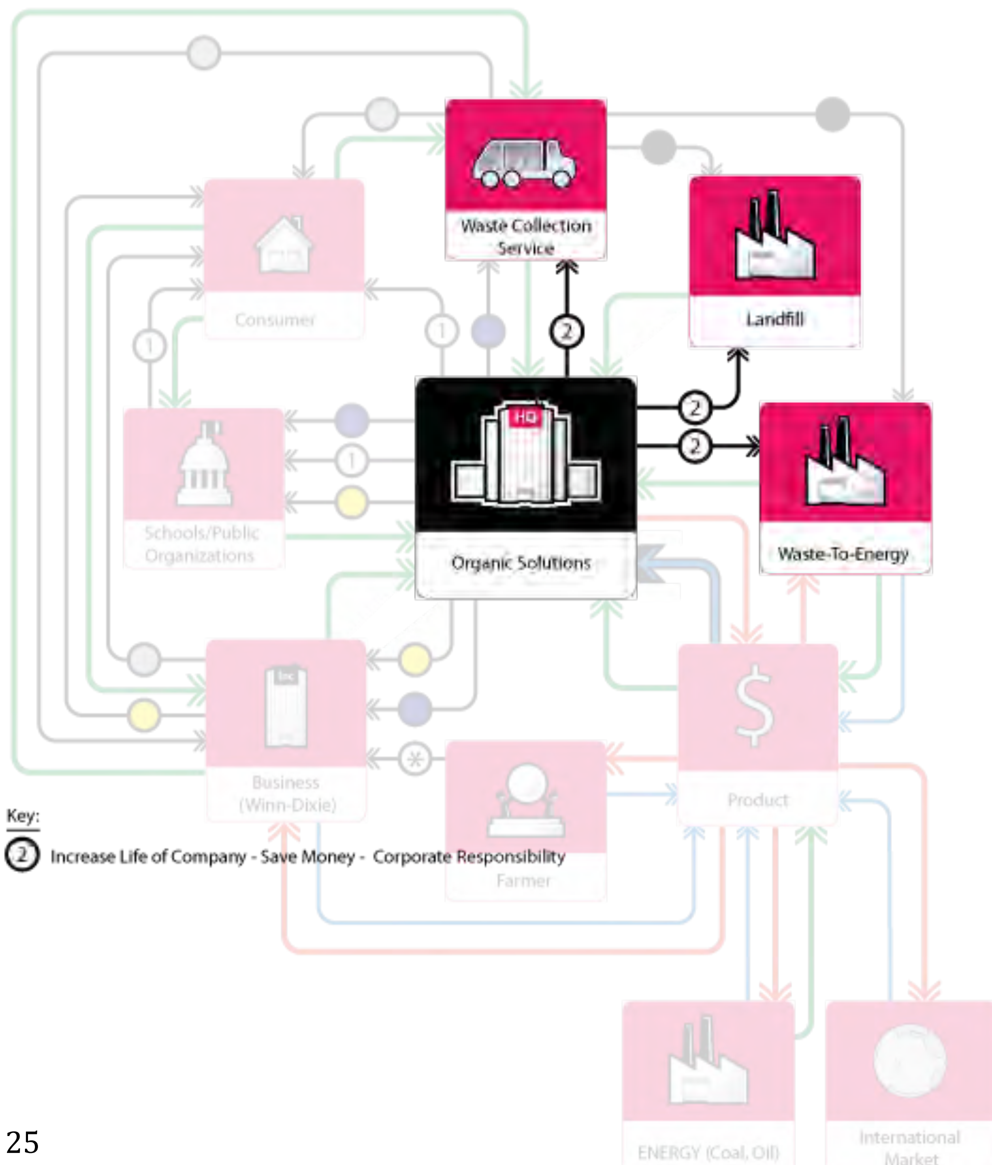


Figure 25

In the end, Organic Solutions lowers financial cost and improves operations of our current waste collection system. Most importantly, Organic Solutions identifies the benefits of altering our current mode of operation from disposal to renewal. Under the restorative economy, financial growth and stability increase for every entity involved as product and material disposed of is depleted.

6.3.2 Consumers and Future Generations

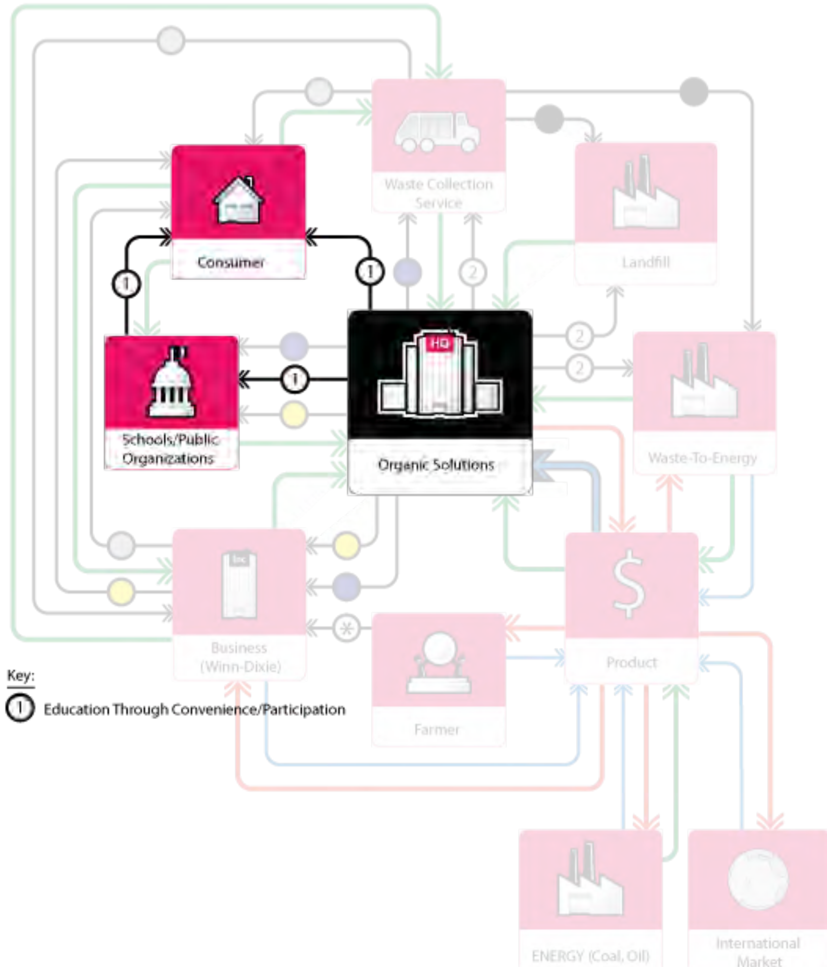


Figure 26

Organic Solutions' mission and goal is two-fold. Not only is the company addressing the need for removing organic waste from today's trash stream so it can be delivered back to nature as intended, but it is also focused on educating consumers and businesses on how to establish a cyclical, for-profit company buy utilizing cooperation and the Hercules System. It is only through education and teaching good life habits to students and adults in our current population that the growth and strengthening of the cyclical/restorative system, so desperately needed in our economy, will occur. Our world cannot support our continued depletion of resources and degradation it currently sustains.

6.3.3 Restorative/Cyclical Economy

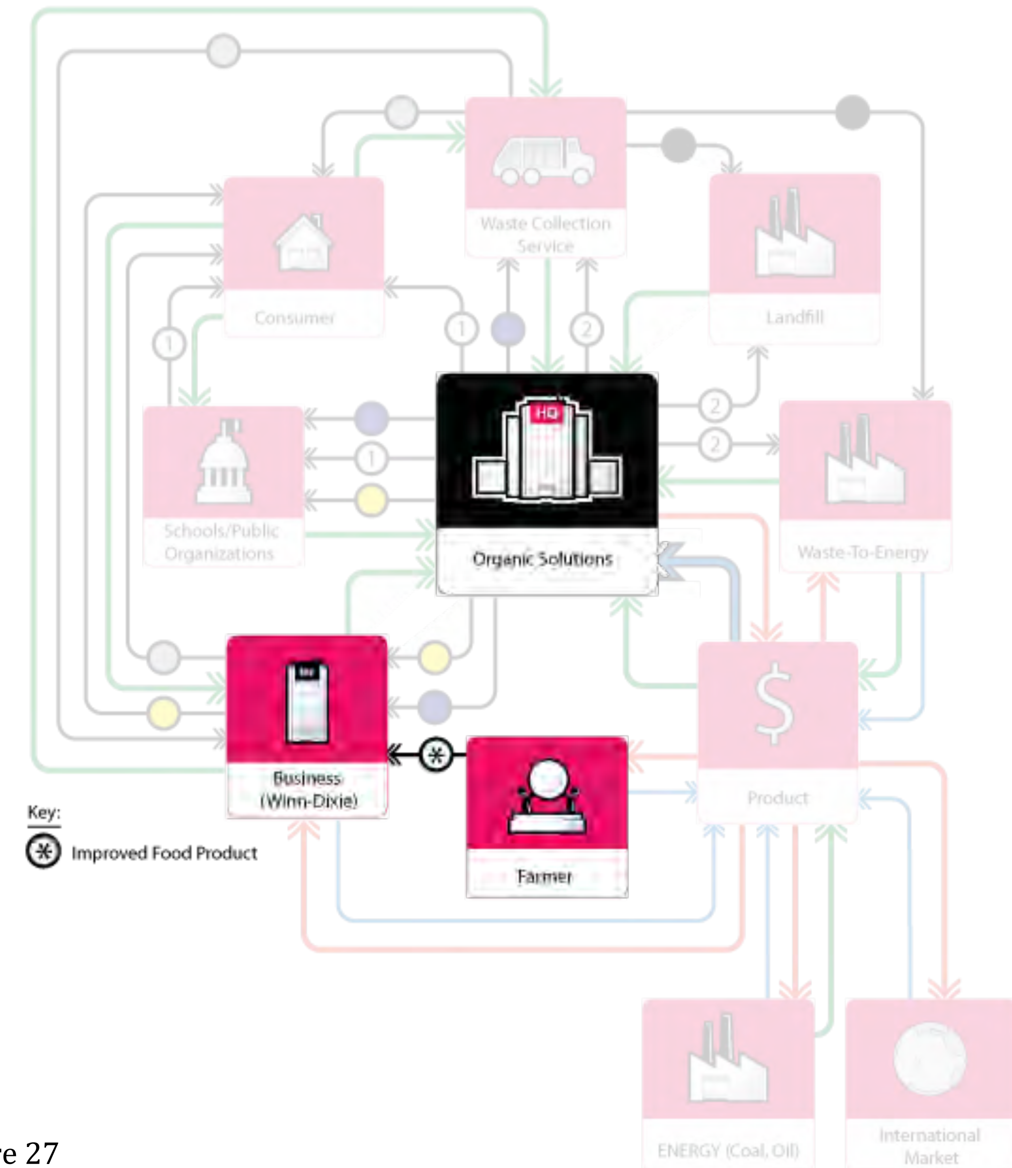


Figure 27

Finally, by implementing, operating and educating all entities involved, Organic Solutions becomes established as a for-profit company that creates a product for the purpose of generating revenue. This, in turn, results in improvements in the environment and the removal of organics from our current waste disposal stream. Organic Solutions' new product will promote nourishing the land, improving soil, and producing a better crop without the use of chemicals, thus, potentially giving farms better crop yields that are then supplied back to us, the consumers, in the form of healthy, natural, inexpensive organic food.

By doing this, we can officially close the loop to our food waste.

Figure 28

References

Accreditation. (n.d.). *Information systems - keys to delivering quality care*. Retrieved June 5, 2014, from Accreditation.org: http://www.accreditation.org.au/education/information-systems/

Ahsen. (2014, February 13). *Membership Card*. Retrieved June 5, 2014, from Plastic Printing Resource: http://www.plasticprintingscout.com/membership-card/

AP. (2014, March 30). *Falla de Puente Hills mas peligrosa que de San Andres*. Retrieved May 10, 2014, from Tellediario.mx: http://www.telediario.mx/internacional/falla-de-puente-hills-mas-peligrosa-que-de-san-andres

Business model brainstorm kit. (n.d.). Retrieved June 6, 2014, from Board of Innovation: http://www.boardofinnovation.com/business-model-templates-tools/

Covanta Energy . (2008, March 2). *Waste-to-Energy Power Plants in New Jersey & New York*. Retrieved May 10, 2014, from Power Plants Around The World: http://www.industcards.com/wte-usa-nj-ny.htm

Deminski, & Doyle. (2013, February 27). *A List of Should-Be-Offenses that Could Be a Great Source of Income for NJ*. Retrieved June 2, 2014, from New Jersey 101.5: http://deminski1.rssing.com/browser.php?indx=8440599&item=11

Dobransky, M. (2011, February 18). *World's Largest Landfill to Become Massive Park*. Retrieved June 5, 2014, from Earth911: More Ideas, Less Waste : http://www.earth911.com/living/art-entertainment/worlds-largest-landfill-to-become-massive-park/

Doyle, C. (2012, December 4). *Takeaway: Food Storage, No Trash Shopping*. Retrieved June 5, 2014, from notrashproject: Working toward a package-free, waste-free life: http://notrashproject.com/

Eco-Cycle. (2012, n.d. n.d.). *2012 Annual Report .* Retrieved June 14, 2014, from EcoCycle.org: http://www.ecocycle.org/files/pdfs/About%20Us/Eco-Cycle_Annual_Report_2012.pdf

Eco-Cycle: Building Zero Waste Communities. (2011). *About Us*. Retrieved from ecocycle.org: http://www.ecocycle.org/aboutus

Eco-Cycle: Building Zero Waste Communities. (2011). *Eco-Cycle's School Program* . Retrieved May 22, 2014, from ecocycle.org: http://www.ecocycle.org/schools

Eco-Cycle: Building Zero Waste Communities. (2011). *Zero Waste Services For Businesses* . Retrieved from ecocycle.org: http://www.ecocycle.org/businesses

Elementary, M. (2012, September 9). *Drop-Off and Pick-Up Policy*. Retrieved June 3, 2014, from Mokapu Elementary : http://mokapu.k12.hi.us/dropoffpolicy.html

Environmental Protection Agency . (2013, May). *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2011* . Retrieved January 21, 2014, from epa.gov : http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_508_053113_fs.pdf

Fearer, M. (1997, July/August n.d.). *Is recycling a waste?* Retrieved June 14, 2014, from Nexuspub.com: http://www.nexuspub.com/articles_97/recycle_97.php

Ferry, D. (2011, September 12). *The Urban Quest for 'Zero' Waste.* Retrieved June 12, 2014, from Recologymedia.com: http://www.recologymedia.com/press_room/articles/pdf/2011/Urban_Quest_for_Zero_Waste.pdf

Grobe, H. (2008, December 26). *File:VW-factory-wolfsburg hg.jpg*. Retrieved June 5, 2014, from Wikimedia Commons, the free media repository: http://commons.wikimedia.org/wiki/File:VW-factory-wolfsburg_hg.jpg

Hawken, P. (2007). *Blessed Unrest .* New York , NY, USA: Penguin Group .

Hawken, P. (2010). *The Ecology Of Commerce.* New York , NY: HarperCollins Publishers .

Healthy Kids Today. (n.d, n.d. n.d.). *Get More Out of Your Grocery Dollars* . Retrieved May 10, 2014, from Healthy Kids Today Magazine: http://healthykidstoday.org/2014/02/get-more-out-of-your-grocery-dollars/

Heimbuch, J. (2011, September 9). *600 Tons of Compost Collected A Day?! How San Francisco Deals With It All*. (L. MNN Holding Company, Editor) Retrieved June 13, 2014, from Treehugger.com: http://www.treehugger.com/clean-technology/600-tons-of-compost-collected-a-day-how-san-francisco-deals-with-it-all-video.html

Hine, T. (1997). *The Total Package: The Secret History and Hidden Meanings of Boxes, Bottles, Cans, and Other Persuasive Containers.* USA: Back Bay Books .

Humes, E. (2013). *Garbology: Our Dirty Love Affair with Trash .* New York , New York, USA : Penguin Group .

IBM. (2012, May 31). *Media Kits/New Releases*. Retrieved June 13, 2014, from RecologyMedia.com: http://www.recologymedia.com/press_room/index.php

Inform, Inc. (2009). *Facts on Greening Garbage Trucks: New Technologies for Cleaner Air*. Retrieved May 19, 2014, from Inform.org: http://www.informinc.org/fact_ggt.php

Kittrell, M. (2011, December 19). *Updated: Bi-Lo buying Winn-Dixie supermarkets, creating biggest grocer in South*. (T. A. Press, Producer) Retrieved June 3, 2014, from AL.com: http://blog.al.com/wire/2011/12/bi-lo_buying_winn-dixie_superm.html

Landfill Leachate Treatment. (2014). Retrieved February 13, 2014, from EVOQUA Water Technologies, LLC: http://www.water.siemens.com/en/applications/groundwater_remediation/landfill-leachate/Pages/default.aspx

Landreth, R. E. (1997). *Municipal Solid Wastes: Problems and Solutions.* Boca Raton, Florida: CRC Press, Inc.

Luchsinger, B. P., & Dock, V. T. (n.d.). The Systems Approach and Concepts. *The Systems Approach: A Primer* .

Maps, G. (2099, n.d. n.d.). *Map of Doubletree Hotel Jersey City, Jersey City* . Retrieved June 2, 2014, from Destination360: http://www.destination360.com/north-america/us/new-jersey/jersey-city/doubletree-hotel-jersey-city/hotel-map

Mazzoni, M. (2013, September 17). *Two Years In, Lessons from Portland's Composting Program* . Retrieved June 13, 2014, from Earth911.com: http://www.earth911.com/home-garden/portland-composting-lessons/

Merriam-Webster, Incorporated. (2014). *System Definition*. Retrieved May 23, 2014, from merriam-webster.com: http://www.merriam-webster.com/dictionary/system

Miller, L. &. (2012). *Why Shrink-Wrap A Cucumber: The Complete Guide To Environmental Packaging .* London , UK: Laurence King Publishing Ltd.

n.d. (2013, December 15). *Africa Still Suffers High Food Crop Losses*. Retrieved May 10, 2014, from Danjir News: http://danjirnews.com/2013/12/15/africa-still-suffers-high-food-crop-losses/

NY Traffic Ticket Lawer-Weiss & Associates, PC. (2007, April 2). Retrieved June 2, 2014, from YellowBot.com: http://www.yellowbot.com/ny-traffic-ticket-lawyer-weiss-associates-pc-new-york-ny.html

Oky. (2010, August 25). *Review: 7599 Garbage Truck Getaway*. Retrieved June 2, 2014, from Eurobricks.com: http://www.eurobricks.com/forum/index.php?showtopic=45626

One More Generation. (n.d.). *Curriculum Fundraiser*. Retrieved June 2, 2014, from One More Generation.org: http://onemoregeneration.org/curriculum-fundraiser/?/Account/Register

Oxford University Press. (2014). *Oxford Dictionaries* . Retrieved March 1, 2014, from Oxford University Press: http://www.oxforddictionaries.com/us/definition/american_english/mulch

Pfeil, E. (1960's and 70's). Prospects Of Change: A Challenge In Design Education . *Auburn Design* .

Recology . (2014). *History*. Retrieved May 23, 2014, from Recologysf.com: http://www.recologysf.com/index.php/recology-history#90-years-of-leadership

Recology . (2014). *Our Story* . Retrieved May 25, 2014, from Recologyst.com: http://www.recologysf.com/index.php/recology-our-story

Recology. (2011, November 22). *Media Kits/New Releases*. Retrieved June 13, 2014, from RecologyMedia.com: http://www.recologymedia.com/press_room/index.php

Recycling, J. R. (2012, November 14). *What You Should Not Put in a Front Load Dumpster*. Retrieved June 2, 2014, from John's Refuse & Recycling: http://www.johnsrefuse.com/blog/bid/240360/What-You-Should-Not-Put-in-a-Front-Load-Dumpster

Royte, E. (2006). *Garbage Land: On The Secret Trail of Trash .* New York , NY: Back Bay Books .

San Francisco Department of the Environment. (n.d.). *Mandatory Recycling and Composting Ordinance*. Retrieved May 23, 2014, from SFEnvironment.org: http://www.sfenvironment.org/article/recycling-and-composting/mandatory-recycling-and-composting-ordinance

Schaer, W. (n.d.). Reflections On Systems Design. *Auburn Design* (11-12).

Tammemagi, H. (1999). *The Waste Crisis: Landfills, Incinerators, And The Search For A Sustainable Future .* Oxford , New York: Oxford University Press, Inc. .

TerraCycle. (n.d.). *TerraCycle's History*. Retrieved May 20, 2014, from terracycle.com: http://www.terracycle.com/en-US/histories.html

U.S. Environmental Protection Agency . (2013, October 17). *Types Of Composting .* Retrieved February 23, 2014, from EPA.gov: http://www.epa.gov/compost/types.htm

University Of Illinois Extension. (2014). *Science Of Composting.* Retrieved February 23, 2014, from Composting For The Homeowner: http://web.extension.illinois.edu/homecompost/science.cfm

Walters, A., & Walters, A. (2012, April 3). *A Green Idea: Composting Your Trash*. Retrieved June 5, 2014, from biozine.com: http://biologybiozine.com/a-green-idea-composting-your-trash/938

Waste Management, Inc. (2014, n.d. n.d). *Waste Managment For Business*. Retrieved May 10, 2014, from WM.com: https://www.wm.com/business/commercial-waste-and-recycling-collection.jsp

WFAE. (2013, July 17). *Food Waste Reduction*. Retrieved May 10, 2014, from WFAE 90.7 Charlotte's NPR News Source: http://wfae.org/post/food-waste-reduction

Winn-Dixie Stores, Inc. (2014, n.d. n.d.). *Home*. Retrieved May 10, 2014, from Winndixie.com: https://www.winndixie.com/Pages/Home.aspx

WW-P Regional School District. (2014, February 23). *About West Windsor-Plainsboro Regional School District*. Retrieved June 3, 2014, from Facebook.com: https://www.facebook.com/pages/West-Windsor-Plainsboro-Regional-School-District/108151775879769