



WPI



MÁS COMPETITIVIDAD, MÁS EMPLEO

Zero Waste to Landfills Initiative

in San José, Costa Rica



Zero Waste to Landfills in San Jose, Costa Rica

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in
partial fulfillment for the Degree of Bachelor of Science.

Submitted to:

Sponsors: Akira Hidalgo Segura y Vinicio Zamora, La Cámara de Industrias de Costa Rica

Project Advisors: Professor Ulrike Brisson and Professor Creighton Peet

Submitted by:

Adele Brochu

Caitlin Coumounduros

Payton Dean

Natalia Wierzbicki

Date Submitted:

March 4th, 2022

Abstract

La Cámara de Industrias de Costa Rica promotes sustainable development of the industrial sector and supports the competitiveness of their associated member companies. This project sought to produce educational materials about alternative waste management methods and how to obtain a zero waste to landfill certification. We produced materials for CICR to send to interested associated member companies in order to make steps towards achieving their own certifications.

Acknowledgements

We would like to thank the following individuals for their contribution to this project

- Akira Hidalgo Segura for being our liaison and giving us the opportunity to help La Camara de Industrias de Costa Rica
- Vinicio Zamora for being a resource that provided company insights
- Sara Araya for reserving spaces for our collaboration
- Employees of La Camara de Industrias de Costa Rica for their assistance in the office place
- Astek, Dos Pinos, Pozuelo, Intel, FIFCO, SCS Global, and 6 other companies for expressing their interest in our project and participating in our interviews
- Apartotel Tairona for providing daily meeting room space
- Professor Peet and Professor Brisson for their guidance through this project
- Professor Belz for directing this project center
- Lori Ostapowicz-Critz for her assistance and guidance in conducting research
- Google for the creation of Google Docs which aided the group in collaboration and create a report
- Canva for the creation of a graphic design program which helped the group create a resource guide

Authorship

- **Title Pages.....AB & NW**
- **Abstract.....AB**
- **Acknowledgments.....AB**
- **Authorship.....AB**
- **Table of Contents.....ALL**
- **Table of Figures.....AB**
- **Executive Summary.....AB**
- **Chapter 1.....ALL**
- **Chapter 2**
 - **2.1.....AB**
 - **2.2..... AB**
 - **2.3.....NW**
 - **2.4.....CC**
 - **2.5.....PD**
 - **2.6.....CC& NW**
- **Chapter 3**
 - **3.1.....ALL**
 - **3.2.....ALL**
 - **3.3.....ALL**
 - **3.4.....ALL**
 - **3.5.....PD**
- **Chapter 4**

- 4.1.....PD
- 4.2.....NW
- 4.3.....AB
- 4.4.....AB & NW
- 4.5.....NW
- 4.6.....AB & NW
- 4.7.....AB
- 4.8.....PD
- **Chapter 5**
 - 5.1.....AB
 - 5.2.....AB
 - 5.3.....ALL
 - 5.4.....ALL
- **References**
- **Appendices**
 - **Appendix A**AB & PD
 - **Appendix B**.....CC
 - **Appendix C**.....AB & CC
 - **Appendix D**.....PD
 - **Appendix E**.....AB & PD
 - **Appendix F**.....ALL

Table of Contents

Title page: Zero Waste to Landfills in San Jose, Costa Rica.....	i
Abstract.....	ii
Acknowledgments.....	iii
Authorship.....	iv
Table of Contents.....	vi
Table of Figures.....	ix
Executive Summary.....	x
Chapter 1: Introduction.....	1
Chapter 2: Background.....	4
2.1 Zero waste.....	4
2.2 Circular economy.....	4
2.3 Plastic management in Costa Rica.....	5
2.4 Relevant waste management processes.....	6
2.4.1 Anaerobic digestion.....	6
2.4.2 Incineration.....	8
2.4.3 Pyrolysis.....	11
2.4.4 Co-processing.....	13
2.5 Zero Waste to Landfill certifications.....	13
2.5.1 SCS Global.....	14
2.5.2 Intertek Zero Waste to Landfill.....	15
2.5.3 NSF Landfill-Free Verification.....	16
2.6 Summary.....	16

Chapter 3: Methodology.....	17
3.1 Determined what Costa Rican companies are doing currently to keep their waste out of landfills.....	17
3.2 Identified existing Zero Waste to Landfill certifications in Costa Rica.....	19
3.3 Identified why companies would be interested in starting this process and what obstacles they are facing.....	19
3.4 Determined the most effective ways to provide resources for companies and others to start achieving a zero waste to landfills outcome.....	20
3.5 Summary.....	21
Chapter 4: Results and Analysis.....	22
4.1 Knowledge about certifications.....	22
4.2 All companies currently divert some amount of waste.....	23
4.3 Success of Zero Waste to Landfill certifications.....	25
4.4 Interest in obtaining certification.....	26
4.5 Obstacles to certification.....	26
4.6 Educational reference tool.....	26
4.6.1 How to obtain a certification.....	28
4.7 Companies' concerns.....	29
4.8 Analysis.....	31
Chapter 5: Conclusions and Recommendations.....	33
5.1 Recommendations for certification company selection.....	33
5.2 Recommendations for good waste management practices.....	33
5.3 Recommendations for closing research gaps.....	34

5.4 Looking forward.....35

References.....37

Appendices.....41

Appendix A: Timeline of C Term.....41

Appendix B: Pre-Interview Assessment Tool.....42

Appendix C: Interview Protocol.....45

Appendix D: Definitions.....48

Appendix E: Equations.....49

Appendix F: Educational Reference Guide.....50

Table of Figures

Figure 2.1: Barstow’s Farm-Powered Anaerobic Digester.....	8
Figure 2.2: Schematic Diagram of the MSW incineration process.....	9
Figure 2.3: South-southwest view of District Heating Plant, Spittelau, Vienna.....	11
Figure 2.4: Simplified flow diagram for typical pyrolysis unit.....	12
Figure 4.1: Level of Knowledge of Zero Waste to Landfill certifications among selected companies.....	23
Figure 4.2: Waste separation at the University of Costa Rica San Pedro campus.....	24
Figure 4.3: Waste separation at El Museo Nacional de Costa Rica.....	25
Figure 4.4 The most requested topics to be included in an educational reference tool from nine different companies interested in getting Zero Waste to Landfill certified.....	27

Executive Summary

Countries around the world fill up their landfills faster than they can create new places to store waste. The landfills of many countries are reaching maximum capacity and will have limited options for waste disposal once they are filled. Costa Rica has 13 landfills that are all reaching capacity. To help combat this problem the government of Costa Rica is pushing for a more circular economy and encouraging companies to become zero waste. Some companies are looking to become certified as zero waste as it could be beneficial to them.

Several Zero Waste to Landfill certifications are available with the goal of reducing a company's waste by reusing byproducts to prevent them from ending up in landfills. The certifications are distributed by several different companies, and it is unclear to Costa Rican companies where they can obtain certifications from and what the requirements to move toward zero waste to landfill is. La Cámara de Industrias de Costa Rica is looking to create a guide to communicate the available options for Zero Waste to Landfill certifications in an effort to help companies reduce their waste that ends up in landfills.

Through interviews with companies who have obtained a zero waste to landfill certification and companies who are interested in obtaining this certification, our team was able to determine the best ways of supporting companies through the certification process. We determined that a PDF educational guide that focused on the differences between certifications, a step-by-step application process, the costs of the certifications, and a page of suggestions and best practices for waste diverting was the best way for us to educate and encourage companies to gain a certification. Our team was able to create an educational reference guide that was shared with the associate members companies of CICR. This guide was sent by our liaison to other members of CICR so it could be posted to their website in the near future.

1. Introduction

Landfills are the most used method for solid waste disposal worldwide. It is one of the proper ways for disposal of solid waste and getting it out of the public's view. However, the reliance on landfills is not very efficient, and they can be very harmful for the environment. Materials dumped into landfills can break down and release harmful compounds, such as methane gas into the air and other toxic compounds into the soil, and eventually into the water table and aquifers, polluting the surrounding areas and contributing to climate change (United States EPA, 2021). Aside from air pollution, other negative effects of landfills include odors, smoke, insects, and rodents. The World Bank predicts that by 2050 global waste will increase by 70% if urgent action is not taken (Lui & Schrader-King, 2018). Smaller countries are being impacted because they are running out of space to put new landfills.

Despite Costa Rica's recognition for its sustainability and the actions taken to earn this reputation, there is a major lack of sustainable waste management in Costa Rica. As a result, the country's 13 landfills will be nearing their capacity and within the next several years will be full (CICR, 2021). There has been a social push for a more circular economy in Costa Rica to combat the landfill concerns (The Tico Times, 2021). Individual companies are interested in becoming zero waste and want to become zero waste to landfill certified. That certification could be advantageous for them because it provides them with a third-party verification of their sustainable practices. So far, however, there are only a small number of companies that have been Zero Waste to Landfill certified in Costa Rica.

There are multiple organizations that give Zero Waste to Landfill certifications with different levels of auditing and expectations. Some of those certifications include the SCS Global Services (2021) zero waste certification, the Intertek Group (2021) zero waste to landfill, and the

NSF International (2021) landfill-free verification. These certifications are beneficial to companies because consumers prefer companies that have been third party certified (Purt, 2014). To make these changes new waste management processes need to be introduced (SL Recycling, 2021). Some options include anaerobic digestion, incineration, and pyrolysis.

Unfortunately, there is no single source of information to help companies find out about different certifications, weigh them against one another, and get suggestions on how to implement changes. La Cámara de Industrias de Costa Rica, (CICR, 2021), is an organization that seeks to promote sustainable development in the industrial sector and support their associated member companies. CICR is currently pushing for small to midsize companies to become zero waste certified. Some of their associated member companies are the Costa Rican office of larger international companies. CICR is looking to create an educational reference guide to help companies understand what criteria are being evaluated and what resources can be used to make the changes they need. There is no easily accessible source of information into how companies get certified, what changes need to be implemented, what is the most effective way to deliver that information to companies, and how CICR can support them.

The goal of this project was to identify the most effective ways to educate small to midsize associate member companies of CICR on Zero Waste to Landfill initiatives and the necessary requirements and process for them to get certified. We obtained the information we needed through interviews with 11 Costa Rican companies. We delivered a guide that highlights the pros and cons of different Zero Waste certifications to help companies find the best one for them. We researched alternative waste management methods, identified certifications, determined the current waste management practices in Costa Rica, and determined the better way

to deliver our findings to receptive companies. Our project helped provide the resources for companies in Costa Rica to move towards using zero waste practices.

2. Background

To properly create a guide that CICR can-distribute to Costa Rican companies to aid them in diverting waste from landfills, in this chapter we explain the purposes, benefits, and downsides to the process, as well as present steps other countries or cities working towards this goal have taken or are currently taking. In this chapter, we define what a circular economy is and what benefits of reducing waste in landfills. We review various alternative waste management methods, discuss how selected cities have tackled this issue, and describe what certifications for diverting waste from landfills exist and what their qualifications look like After presenting what has been achieved globally, we focus on Costa Rica and how some companies have been able to divert waste from landfills.

2.1 Zero waste

The term “Zero Waste” was originally coined by Paul Palmer in 1973, when he founded Zero Waste Systems, a company that had a primary business of reusing chemical byproducts, rather than letting them go to waste (Veleva, et. al, 2017). The concept of zero waste campaigns is linked to the idea of a circular economy. This idea represents that nature is regenerative, and human systems can mirror natural processes by designing them to restore natural capital to the biosphere. Zero waste is focused on designing out waste, separating nutrients to be put back into the biosphere that can later be reused.

2.2 Circular economy

Circular economy conceptions date back to closed-loop economy arguments, better known as a zero waste economy, in the 1970s (Fitch-Roy, et. al, 2021). These ideas were then

adopted into waste management practices and resource usage. A circular economy is an economic model that is designed to minimize resource input along with waste and emissions production and is considered a regenerative economic system (CFI Education, 2019). Adopting a circular economy requires measures be taken across the entire value train, from production and consumption to waste and resource management (MSE, 2019).

The concept of a circular economy is based upon three main principles (CFI Education, 2019). The first principle is the minimization of waste and pollution to reduce the damages caused by economic activities. The next principle is the extension of the useful life of products and materials. This goal of the extension of life is achieved through the reuse, repair, and remanufacturing of products and materials utilized in the economy. The final principle is the regeneration of natural systems. This effort aims to enhance natural capital and creates necessary conditions for the regeneration of natural systems.

A circular economy involves both technological and biological cycles (CFI Education, 2019). Technological cycles involve the management of finite resources. This includes the reuse, repair, and remanufacturing of material and resources. Biological cycles are concerned with the management of renewable resources. This includes the restoration of nature itself in order to provide renewable resources. An example of this is the breaking down of compostable food to be used as nutrients for new plants.

2.3 Plastic management in Costa Rica

One of the largest problems with the current waste disposal system in Costa Rica is the improper disposal of plastics. In 2018, Costa Rica produced 550 tons of plastic waste daily (Smith, 2021). Only 9% of that waste was recycled properly. Eleven percent was sent to landfills

with the non-recyclable trash and 80% ended up littering Costa Rica's waterways. A large contributor to this inadequate recycling of plastics is the lack of centralized waste management in Costa Rica as waste management is carried out by municipality.

2.4 Relevant waste management processes

Without urgent action, the amount of global waste will increase by 70% by 2050 (Lui & Schrader-King, 2018). Worldwide initiatives, such as Zero Waste to Landfill, partner with and promote alternative methods of disposing and treating waste. Recycling and reusing materials that still have value is a common way to divert waste from landfills, as well as to limit the creation of new waste. Relatively newer processes use chemistry and biology, paired with engineering and technology, to create systems that, through complex processes, will transform certain types of waste (food, organic matter, etc.) into energy sources (Miandad, et al., 2021). Waste-to-Energy processes have strict emission standards that must be met in order to keep the emissions relatively low and regulated ("Waste-to-Energy", 2021). These processes include anaerobic digestion, incineration, and pyrolysis.

2.4.1 Anaerobic digestion

Anaerobic digestion is a process of organic matter being broken down by bacteria in the absence of oxygen in a container called a digester (Premo, 2020). It is one of the most promising waste management techniques that convert organic substances, such as manure, food waste, and agricultural waste, into energy sources (Tayabi, et al., 2021). A few different processes occur in the digester. Digestate is the product of the matter being separated and treated properly (Premo, 2020). This produces solid and liquid coproducts such as fiber-based products, fertilizer,

compost, soil, and flush water. The digestion process will also produce a biogas, mostly methane gas, which can be contained within the digester and combusted to generate electricity and heat (Public Works Department..., 2021). Additionally, this biogas can be processed and refined within the digester into compressed renewable natural gas and transportation fuels. These processes have been proven to be more efficient when the waste is organic, meaning it is biodegradable and comes from an animal or plant.

A successful example of this alternative waste management technique is Barstow's Dairy Farm and Bakery in Hadley, MA (Barstow's..., 2021). They properly collect and store the hundreds of pounds of manure produced by their cows daily (9,000 tons annually) and combine it with over 14,000 tons of food waste they receive annually from food manufacturers, processors, and users such as Cabot Creamery, HP Hood and McDonald's, into their 600,000-gallon anaerobic digestion tank.

The organic matter is converted into biogas, mainly methane, by bacteria found in the tank (Barstow's..., 2021). The biogas is then combusted and powers a 300kW engine and annually produces more than 2,100 Mwh of electrical energy, 7,040 MMBTUs of thermal energy, and 30,000 tons of odor-free, organic, liquid fertilizer. The methane gas produced can be burned to heat water that generates electricity through a turbine, which is used to provide low-cost electricity for farm buildings and family homes, as well as delivering renewable energy to surrounding communities in partnership with Eversource Grid. Their investment in farm-owned digesters (Figure 2.1), as well as the proper storage and delivery of organic waste has allowed their farm to become a zero waste and closed-loop system.

Benefits of the closed-loop, circular economy that Barstow's (2021) has created for themselves through the use and investment in digesting their waste include having farm-based

energy and electric power their buildings and operations, saving money in the long-run from the energy their farm produces (Barstow's., 2021). The waste from their farm that would traditionally be sent to a landfill is being transformed into an energy source that aids in the operations of their business. Additionally, Barstow's is able to market their production process and waste management as sustainable, which attracts consumers to their bakery.



Figure 2.1: Barstow's Farm-Powered Anaerobic Digester. Reprinted from New England Farm Energy Collaborative (Barstows..., 2021, 'Blog Posts'). Copyright 2017 by Denise Barstow Manz. Reprinted with permission.

2.4.2 Incineration

Incineration is a popular mass-burning technology that will turn municipal solid waste (MSW) into energy (Sabbas et al., 2003). Mixed and unrecycled MSW is collected, stored properly, and brought to an incineration plant, also known as a waste-to-energy facility ("Incineration", 2021). MSW will then be inserted into the incinerator, essentially a furnace, where it will be combusted at temperatures greater than 850°C. The heat that is generated from this burning process is then used to produce steam in a boiler. This steam drives a turbine, which

generates electricity to be used in residential and commercial buildings (Lam, et-al., 2010). This process is depicted in Figure 2.2.

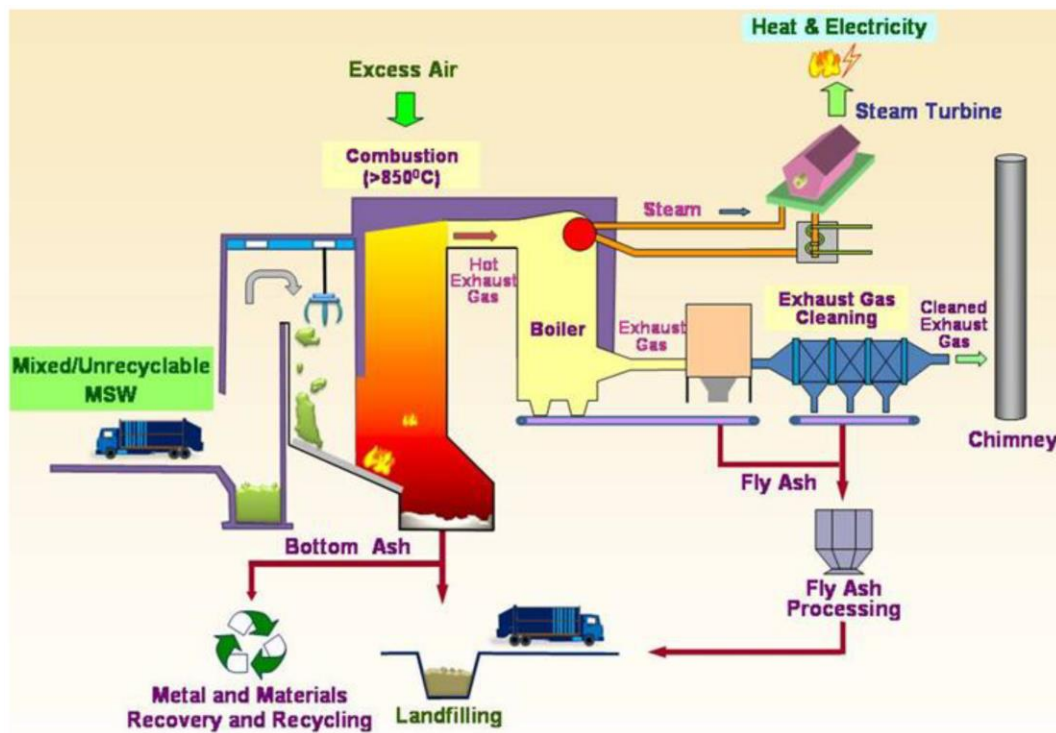


Figure 2.2: Schematic Diagram of the MSW incineration process. (Lam et al., 2010, 'Abstract'). CC-BY-NC-SA-

3.0.

There is a small amount of ash waste produced from this process that does not combust completely and can be used in an alternative scenario other than generating electricity (Lam, et. al, 2010). This ash waste is commonly from larger metals or materials that were not able to completely vaporize in the incinerator. This waste is treated in various forms based on its concentration, including washing, leaching, thermal treatment, and separation processes among many. Based on the outstanding concentrations or utilizations of this leftover ash, it can be used in road pavements, cement and concrete production, glass, ceramics, and agriculture. If there is

no further optimization, the material will be sent to a landfill, however, in an extremely decreased volume than the waste to begin with.

Although the goal of the initiative is titled ‘Zero Waste to Landfill’, incineration still complies (“Waste to Energy”, 2021). The goal of the Zero Waste to Landfill initiative is to divert as much waste as possible from landfills, with the realization that some materials that have no utilization in terms of recycling and reusing in some capacity must be sent to a landfill (SL Recycling, 2021). Incineration does decrease the amount of waste in mass by 70% and in volume by 90% (Lam, et. al, 2010). The process of incineration converts the majority of MSW into electricity that can be used where needed in areas near the facility.

One famous facility is the Spittelau Incineration Plant in Vienna, Austria (Figure 2.3) (Brownlow, 2020). It was made in the 1960s and updated in the 1980s by architect Friedensreich Hundertwasser. Aside from its stature as an architectural marvel and popular tourist site in Vienna, the municipal incinerator produces 60GWh of electricity and 500GWh of green heat each year by processing 250,000 tons of Viennese household waste annually (Wien Energie GmbH, 2021). This large amount of waste is brought to the plant, and after proper storage, placed in the waste furnaces, the incinerator, by a gripper arm. The hot gasses that are produced and passed between a heat exchanger create steam, which is used to drive a steam turbine and generate the district’s heating and electricity. Excess flue gas from this process is cleaned through the Spittelau’s state-of-the-art cleaning systems, and once purified, released from the chimney of the structure. In addition to the electricity produced, 6,000 tons of scrap iron and 60,000 tons of clinker, ash and filter cake are produced each year from the excess solid waste.



Figure 2.3: South-southwest view of District Heating Plant, Spittelau, Vienna. Exterior Design by Friedensreich Hundertwasser. Late afternoon picture at low sun angle. 12 October 2006. (“Waste to Energy”, 2021, first page) CC

BY-SA 3.0

2.4.3 Pyrolysis

Pyrolysis is a common waste management technique used to convert waste into energy through thermal degradation of waste at various temperatures in the absence of oxygen to produce materials such as bio-oil, gas, charcoal, and biogas (Miandad et al., 2019). The objective of this process is to yield high-value energy products that can supplement non-renewable fossil fuels. This process includes transforming an organic and/or carbon-based biomass into energy rich mass, oil and gas that can be used in the form of heat, transportation fuels, and specialty fuels. The two main types of pyrolysis are Fast and Slow (Zaman, et al., 2017). Fast pyrolysis, (a) in Figure 2.4, produces biochar and bio-oil by having the initial heating time at a lower temperature be less than the final retention time at the peak temperature, typically around 500°C.

Slow pyrolysis, (b) in Figure 2.4, transforms biomass into biochar and heat by increasing the time of heating for the entire process and lowering the temperature of the system.

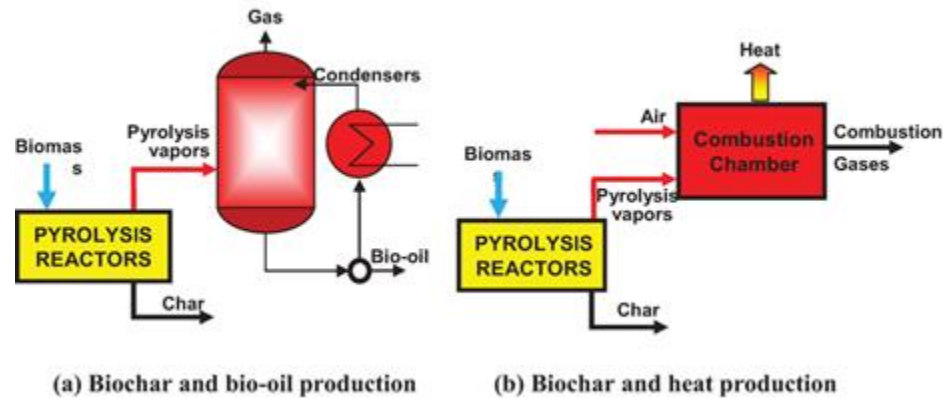


Figure 2.4: Simplified flow diagram for typical pyrolysis unit. (a) Biochar and bio-oil production. (b) Biochar and heat production. (Zaman et al., 2017, 'Introduction'). CC BY 3.0.

A New Zealand Waste-to-Energy company uses a Fast Pyrolysis Reactor (FPR) in order to properly conduct the pyrolysis process for their clientele (Waste-to-Energy New Zealand, 2021). These FPR's have been tested and are able to process municipal solid waste (MSW), biomass such as wood chips, walnut shells, and switch grasses), poultry litter, coal, tires, and plastics. Their specific FPR's have over 28,000 hours of commercial use supplying 110MWe into their national grid and reducing fuel consumption by 70% and emissions by up to 90%. Once the system generates electricity through the combustion of the produced gasses the reactor powers itself using the circular energy created. The benefit to the FPRs that Waste-to-Energy uses is that the overall system efficiency is over 90% due to the amount of liquid product that can be produced and restored. This Waste-to-Energy company prides itself in diverting 100% of non-recyclable waste from ending up in a landfill and reducing its carbon footprint globally by assisting companies in decreasing their waste going to landfills. Although not 100% of waste can be diverted from landfills, this company does an excellent job at using pyrolysis techniques to

ensure that materials that still have value will be converted into energy and reused in an effective and efficient manner.

2.4.4 Co-processing

Co-processing is the waste management process that utilizes a cement kiln to cleanly burn waste as an alternative energy source while making use of the leftover ash in cement production (Ton-To-Ton, 2020). Co-processing is similar to incineration as the waste that is burned will be converted into energy, however it differs in the sense that the leftover ash is used in cement production. This process creates a zero-waste management system that eliminates non-recyclable plastics and hazardous waste, while using the entirety of the waste for energy production or cement material. Globally, it is required that co-processing cement kiln factories are certified by a third-party in order to regulate practices and ensure the system is both safe and environmentally friendly. The majority of co-processing that occurs in Costa Rica is in a cement kiln (Akira Hidalgo, personal communication, February 9, 2022).

2.5 Zero Waste to Landfill certifications

The concept of zero waste campaigns is linked to the idea of a circular economy (SL, 2021). Its goal is to obtain net-zero waste. Obtaining a Zero Waste to Landfill certification can save businesses money on waste management methods that are cheaper than paying a landfill tax. Having environmental credentials may make a company more desirable than another company. Customers may be attracted to the idea of company efforts towards environmental conservation.

Zero waste certifications are a way for companies to create more transparency between themselves and the consumer. The process of getting a certification also creates a guideline for companies to have resources to know where they can make changes to their waste management systems (Purt, 2014). There are many zero waste certifications that companies in Costa Rica have access to. Many of them follow similar guidelines and verification processes, which involve a written application and a follow-up audit. Since some Costa Rican companies are already looking for ways to go to zero waste, these certifications offer consumer transparency and an advantage over competitors. While parts of the processes are similar, the requirements and potential benefits differ among certifications.

2.5.1 SCS Global

SCS Global offers a 3rd party verification of the waste diversion achieved by a company over a 12-month period (SCS Global Services, 2021). The expectation by SCS Global for the definition of zero waste is based-on their own equation for 99% diversion, which can be seen in Appendix E, Equation 1.

The verification process includes an annual assessment that details the facility's waste processes over a 12-month period. The report includes the percentage of waste diversion, along with each method of diversion and a breakdown of the amount each method uses, the progress made in waste diversion expressed as points taken from the difference in percentage diverged from the previous 12-month period, and whether the company currently stores any waste. Diversion can fall into any of the following methods: recycling, composting, re-use, reclaiming, prevention, and waste-to-energy. SCS Global will also audit hazardous waste disposal on a case-by-case basis instead of including it with the rest of the waste. Waste by re-design, meaning

waste no longer generated because of a change in processes, will count as diverted waste for the next 12-month period. Facilities are certified individually based on the diversion rate achieved by that facility, and each facility's specific divestment statistics will be stated on the certification. Any facility can qualify if the waste management activities are all under the purview of the applicant. SCS offers a participation certification for companies/facilities diverting a minimum of 50% of their waste for a 12-month period. The SCS Zero Waste Standard allows for multi-site certification where individual sites are visited on a sample basis each year while data and management documents are reviewed for all sites to be included in the certification.

2.5.2 Intertek Zero Waste to Landfill

Intertek's zero waste to landfill certification (ZWL) is beneficial because it allows for different levels of certification at different diversion rates (Intertek Group, 2021). The four ranges fall between 99% and greater for full certification, 95-99% for a "near-zero waste" certification, 85-95% for an "advanced diversion" certification, or a custom verification based on a plan worked out with an Intertek auditing team. The ZWL certification is available to any manufacturing organization, office or service company, or companies with subcontractors given that they demonstrate their supplier or subcontractors' commitment to sustainability (Eves, 2019). Intertek has a Sustainability Certification Directory in which companies with the full ZWL verification are highlighted. They also provide a verification mark for a company and its products to designate they have met the applicable standards.

2.5.3 NSF Landfill-Free Verification

The National Sanitation Foundation's (NSF) Landfill-Free Verification establishes a criterion to evaluate if an organization sends less than 1% of their waste to landfills (NSF International, 2021). Once a company applies, NSF will review the submitted documents, and once approved, they will conduct an on-site audit, which will result in corrective feedback or verification. Their verification includes a verification mark that the company can put on their website or use any products they create.

2.6 Summary

Costa Rica is a country filled with beautiful beaches, rainforests, and wildlife, where tourists come from all over the world to experience its natural beauty. With Costa Rica's vast range of biodiversity, protected wildlife refuges, national parks, and reserves, ecotourism has been an increasingly successful industry. Costa Rica is also recognized for its sustainable practices by using hydroelectric power and geothermal technology, resulting in 98.53 percent of its energy output being renewable in 2018 (International Trade Administration, 2021). However, the lack of sustainable waste management has caused concerns for the country. The government's solution is a push for companies to convert to zero waste, but they have not provided the resources to do so. CICR is working to create those resources and encouraging those changes in companies' waste management (Akira Hidalgo, personal communication, November 10, 2021). In the next chapter, we discuss how we helped CICR increase the number of companies working towards getting Zero Waste to Landfill certifications.

3. Methodology

The goal of this project was to create a guide for Costa Rican companies that work with CICR to begin diverting their waste from landfills, with the eventual goal to achieve Zero Waste to Landfill certification. Our objectives to achieve this goal were:

- Determined what Costa Rican companies are doing currently to keep their waste out of landfills;
- Identified existing relevant Zero Waste to Landfill certifications for Costa Rican companies;
- Identified why companies would be interested in becoming certified in Zero Waste to Landfills and what obstacles they are facing;
- Determined the most effective ways to provide resources for and motivate small-to-medium size companies to move towards a Zero Waste to Landfill goal.

See Appendix A for the timeline we used to complete these steps. In this chapter, we will explain and justify the research methods we used to achieve our objectives and thus our goal.

3.1 Determined what Costa Rican companies are doing currently to keep their waste out of landfills

We got the bulk of our information by carrying out interviews with representatives of Costa Rican companies. Eleven companies were chosen by CICR and that have previously expressed their interest in participating in our project. We interviewed both companies that are already certified and that are interested in becoming certified to have a well-rounded perspective on the process. In a pre-interview assessment tool (see Appendix B) sent out at the start of the research period, we included a question asking what each company is currently doing to be

conscious of their waste and what efforts they are making to divert their waste from landfills. We also asked companies if they were aware of the Zero Waste to Landfill initiative. This helped us understand what the companies were already doing about this issue and how knowledgeable they were concerning Zero Waste to Landfill.

CICR gave us a list of companies to interview; 9 of which are interested in starting the process including but not limited to: Astek, Dos Pinos, Pozuelo, Intel, and 2 of which are already certified, including FIFCO. All these companies were sent a pre-interview assessment tool (see Appendix B) to begin their thinking about the questions we asked them during an interview (see Appendix C). We used Google Forms to set up a pre-interview assessment tool with some basic questions we asked companies to respond to prior to the interview. We arranged for representatives from CICR to email this pre-interview set of questions to appropriate companies in the form of a link. CICR had approved our pre-interview assessment tool and interview questions before we used them.

Through interviews with 11 companies, we established a baseline of what current alternative waste management methods they are already utilizing to divert their waste. In our Background chapter we revealed how different processes of Zero Waste to Landfill efforts have succeeded on a worldwide scale (see Background sections 2.6 and 2.7) which helped us understand the measures Costa Rican companies had taken. Knowing about these alternative waste management methods guided us in creating a guide for companies on available waste management methods and zero waste to landfill certifications. We were able to account for the already diverted waste when evaluating the best certifications for these companies.

3.2 Identified existing Zero Waste to Landfill certifications in Costa Rica

In order to propose certifications that companies identified by the CICR could attain, it was important for us to determine their complexity and limitations. We identified three different existing certifications that all relate to Zero Waste to Landfill (see Background section 2.5), and then conducted interviews with these certification companies. We evaluated the pros and cons of each of the certifications based on the priorities and problems we found through surveying companies. No certification system is exactly the same, so we needed to identify those differences to report back to Costa Rican companies so that they could make the most informed decision possible. By specifying the details of each certification system, we were able to help give Costa Rican companies a thorough idea of what would be best for them and how the different application processes would work for each certification.

3.3 Identified why companies would be interested in starting this process and what obstacles they are facing

In order to communicate what certifications companies can obtain, it was important to determine why companies would be interested in starting the process to obtain a certification. We had identified the providers of various certifications, but this information did not include specifics regarding company interests. The pre-interview assessment tool mentioned in section 3.1 helped identify general information about company progress and interests, but not very specific information. We conducted interviews to get more detailed information (see Appendix C).

A question about doubts companies have about achieving zero waste to landfills, specifically financial barriers, was included in the assessment tool mentioned in section 3.1 (see

Appendix B). We discussed doubts and limitations more in-depth in the interviews conducted (see Appendix C for interview protocol). We did not have our assessment tool contain any open-ended questions as we felt those would be better discussed in interviews.

We got the companies we interviewed from associated members of CICR's environmental and social responsibility sector of CICR. Because of this they are more actively involved in minimizing their environmental impact. We interviewed companies in many different industries such as food, textiles, medical devices, etc. This wide range of industries allowed us to obtain more diverse responses regarding waste diversion and guide preferences.

3.4 Determined the most effective ways to provide resources for companies and others to start achieving a zero waste to landfills outcome

Compiling our information from interviews and the questionnaire, we were able to understand:

- How knowledgeable small-to-medium sized companies are on the Zero Waste to Landfill initiative
- How interested companies are in diverting their waste from landfills
- How interested companies are in obtaining certification that attests to their commitment to Zero Waste to Landfill
- What limitations or doubts exist about the process, and how they can be addressed those most efficiently in the educational reference tool
- Companies preferred medium and way of accessing the educational reference tool

3.5 Summary

Our methods mainly consisted of a pre-interview set of questions and an Interview with companies interested in getting certified, already certified companies, and certifiers. Our interviews focused on determining what the companies we talked to were currently doing to keep waste out of landfills, why companies would be interested in getting certified and what obstacles they have been facing, and the most effective ways we could deliver and format a guide for them. Our interviews with certifiers helped us identify which certifications are viable for Costa Rican companies to obtain. Through our interviews, the results of which we will talk about in our next chapter, we were able to discover what we needed to accomplish our end goal of creating a guide for companies interested in gaining a Zero Waste to Landfill certification.

4. Results and Analysis

The goal of this project was to aid CICR in creating educational resources about different Zero Waste to Landfill certifications that can be accessed by associated member companies of CICR. We found that companies had a range of knowledge about certifications from knowing about specific ones to not knowing anything. All of the companies we talked to divert some amount of waste already and were interested in achieving a third party certification. Companies shared the obstacles they were facing in becoming zero waste and questions and concerns they had about the certification process. And they gave us feedback about how they wanted to receive the guide and what information they wanted prioritized on the guide. The companies we interviewed had similar responses to our questions. The feedback we received helped us determine how to present data on zero waste to landfill certification.

4.1 Knowledge about certifications

A majority of the companies we interviewed reported that they were at least familiar with the concept of Zero Waste to Landfill (75%). Only 3 companies however, reported they knew of existing Zero Waste to Landfill certifications for which they could apply. One of the companies we interviewed had even applied for a certification in the past but ran into problems because one of their waste diverting processes had not been approved by the certification company. As seen in Figure 4.1, two companies we talked to were very new to the process and knew very little about zero waste certifications overall.

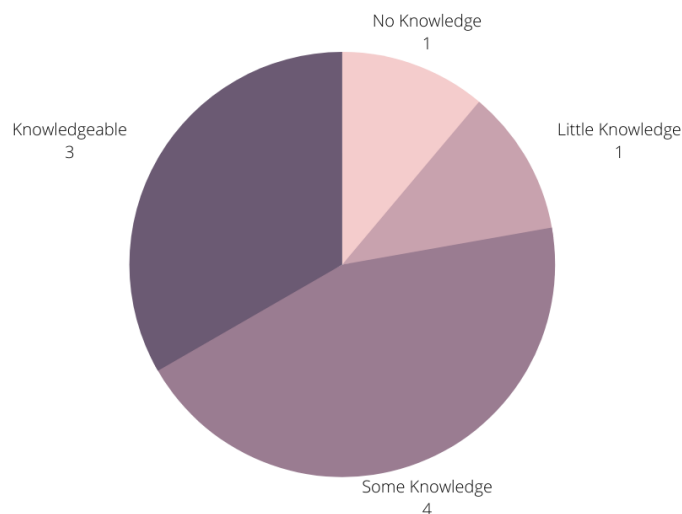


Figure 4.1: Level of Knowledge of Zero Waste to Landfill certifications among selected companies

4.2 All companies currently divert some amount of waste

Through interviews, we learned that most companies currently divert some amount of waste from landfills. Out of the 11 companies we interviewed, all companies, excluding 2, diverted at least 84% of their waste from landfills. One of these companies sends 90% of their waste to landfill and the other sends 60% of their waste to landfill, however both companies intend on lowering this percentage. In addition, 5 of these companies have already obtained ISO 14001 certification, which is a certification where organizations use its requirements to enhance their environmental performance. Because most companies have obtained this certification, it will be easier for them to go through the Zero Waste to Landfill certification process due to their familiarity with the system. Since all of the companies we talked to divert some amount of waste prior to interacting with them the scope of our project was limited. We only talked to companies that already had Zero Waste goals and departments dedicated to sustainable practices.

We asked how companies divert their waste. We learned that co-processing, or the use of waste as a raw material, is the main way companies are diverting waste from landfills. Co-processing is mainly used for the disposal of hazardous waste and non-recyclable plastics and aluminums. The main form of co-processing used in Costa Rica is for cement production. Other methods companies use include recycling, mainly used for plastics and aluminums, composting, mainly used for organic waste, and the reuse of materials like glass, PVC pipes, cardboard, and wood pallets. Large scale institutions, such as the University of Costa Rica, San Pedro (Figure 4.2) and El Museo Nacional de Costa Rica (Figure 4.3), promote the division of waste appropriate to what types of waste are created within.



Figure 4.2: Waste separation at the University of Costa Rica San Pedro campus



4.3: Waste separation at El Museo Nacional de Costa Rica

4.3 Success of Zero Waste to Landfill certifications

Zero Waste to Landfill certifications have successfully influenced companies to find alternative methods of waste disposal besides sending waste to landfills. Every company we interviewed diverted their waste from landfills. The highest percentage of waste diverted from landfills was 99.94% and the lowest percentage was 6%. Currently, 8 of the 11 companies interested in obtaining a certification that were interviewed will be eligible to immediately apply for certifications. Companies that have not yet met full zero waste requirements may be eligible for a participation certification from SCS Global while companies with higher percentages of diverted waste are eligible for any of the certifications we have outlined.

4.4 Interest in obtaining certification

Every company that we spoke to about obtaining a certification is interested in doing so. We also learned that 9 companies, including Astek, Dos Pinos, Pozuelo, and Intel, have a company initiative to achieve zero waste by a certain date. All companies were aware of zero waste to landfills certifications, but they needed help finding the right certification to apply for and more information about the process of achieving that certification.

4.5 Obstacles to certification

Companies ran into many similar problems while trying to divert their waste from landfill. Five companies we talked to utilized mixed plastic materials, like PVC pipes, and sterile packaging for medical companies, which cannot be recycled in recycling facilities. They cannot change materials very easily because, given the size of Costa Rica, there are very few suppliers overall and even fewer for specific types of materials.

Other forms of waste that companies are not often able to divert from landfill include toilet paper, sanitary products, and paper towel waste. Toilet paper is not flushed in almost all Costa Rican toilets, because it is considered a biohazard. This waste is produced by company employees and occurs on more of a scale of individual people rather than production lines. Companies are concerned that employees need to be better educated on proper waste disposal and recycling.

4.6 Educational reference tool

When asked about what information companies would want in an educational reference tool, there were many similar answers. Figure 4.4 below shows what information companies

wanted us to prioritize. A majority of the companies (about 56%) wanted us to include the cost of obtaining a zero waste to landfill certification in our educational reference tool. Other information that was requested by companies included methods companies can use to further divert waste from landfill, instructions on how to obtain this certification, and types of facilities that can be certified. This shows that most companies do not have many specific concerns, they are just interested in obtaining general information on the zero waste to landfill certification.

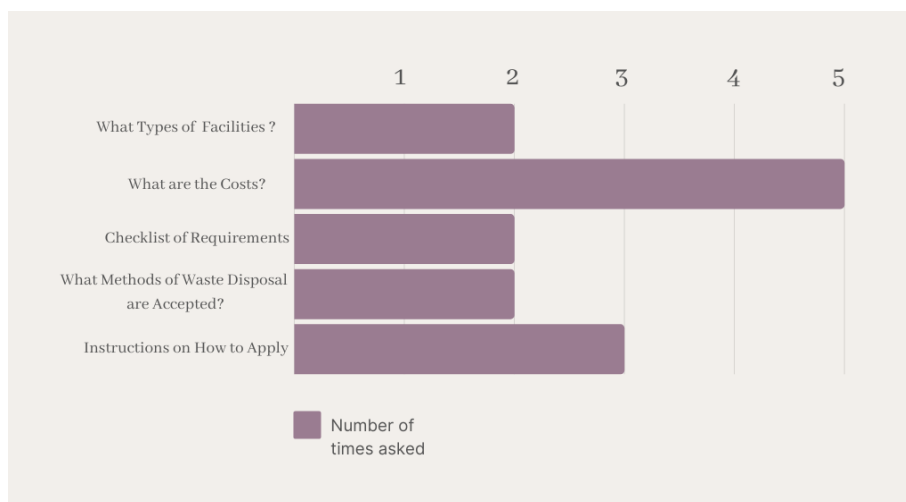


Figure 4.4: The most requested topics to be included in an educational reference tool from nine different companies interested in getting Zero Waste to Landfill certified.

It was determined in our interviews that companies preferred a PDF guide for sharing information about getting a certification. Companies wanted this PDF to be delivered to them through email and it should be made available in both Spanish and English, so it would be more accessible to different companies. CICR would also like this guide to be available on their website, so companies that were not included in our research could have access to this information. This portion of the website has not been created yet and will not be up and running by the time this project is completed. This guide will also be posted to the CICR Facebook page and any other social media accounts they think would be appropriate.

The guide will also include contact information for CICR as well as the certification companies that allowed us to share their contact info. Akira Hidalgo will be the point of contact at CICR for any questions and her contact information will be listed on the guide. This will ensure that companies can have their questions answered after the conclusion of this project.

4.6.1 How to obtain a certification

The process for obtaining a certification is similar regardless of the certification that a company chooses to pursue. Companies must compile data, for at least the last six months, about their waste diverting processes, which most of the companies we talked to already have. Then, they can fill out their chosen certifier's auditing form where they must put all information for each facility they want audited and attach all documents that verify the accuracy of their waste management processes. The certifier will then reach out to the company and organize an auditing period where they will send a person, or during COVID times they have been auditing remotely, to some number of their facilities to ensure that the data provided by the company was correct. Assuming everything is approved, companies will be certified under the standard that they applied for and gain the benefits of a third-party certification for the period the certification lasts. After the certification runs out, companies will turn in their new data for waste diversions since the certification began and the certifier will do a random audit of a percentage of the company's facilities and confirm that they are still maintaining certification standards and renew their certification if they are.

4.7 Companies' concerns

Each company was given the opportunity to express its concerns about the certification process for achieving Zero Waste to Landfill. Every company had at least one of the following questions:

- Will a new certification cancel out an existing one?
- Do the certifications have any extra incentives?
- How much will the certification cost and are there annual fees?
- Is co-processing accepted by the certifications as a way to handle waste appropriately?
- What kinds of facilities do they certify?
- What percentage of our waste needs to be diverted from the landfill?
- How long will it take to obtain a certification?
- How do we obtain a quote from these companies?
- What is the timeline of the IQP project?

We were able to answer all these questions through our research and meetings with certification companies. We have found that none of the certifications cancels out any existing ones and that companies can also add more certifications, for example a carbon neutrality certification, on top of their Zero Waste to Landfill certification.

Different certifications offer different incentives which include: a logo companies can add to products and their website, being added to a database with all the companies that are certified, and access to resources and consulting through the certification company.

A major priority most companies asked about was the cost of achieving a certification. We found that SCS Global would charge varying amounts per facility depending on size and the price per facility is reduced as the number of facilities go up. Unfortunately, the other two

companies did not share their costs with us, but more details can be found by reaching out to the certifications companies directly.

Companies can use co-processing as an option for diverting waste. Other waste management methods like recycling and composting are also an acceptable form of waste diversion and can count towards each of the three certifications.

Many different types of facilities are certified by these companies including, office facilities, manufacturing facilities, etc. Facility certification may vary on a case-by-case basis and questions should be directed to the certification bodies.

Percentage of waste that needs to be diverted from the landfill is different for each certification. SCS Global has an equation, which can be seen in Appendix E, that they use to determine a company's percentage of non-diverted waste. While you need 99% or more to be diverted to achieve the full certification, companies can participate with a partial certification from 50% waste diverted and upward. Intertek offers a tiered certification for between 85-99% waste diversion. Intertek will also work with a company to create a custom verification plan if they can provide evidence of their consistent improvement. NSF expects companies to demonstrate that they send less than 1% of waste to landfills.

The time a certification will take to achieve also varies for each certification company. The SCS Global certification takes around 12 months and must be reevaluated every year to ensure that this effort of waste diversion is still being achieved and maintained. Intertek needs to recertify each company every 3 years. We were not able to obtain this information for the NSF certification, but we recommend reaching out to the NSF directory for any further questions.

To obtain a quote for a certification, each certification company can be contacted directly. The necessary information about further steps and forms to be completed that applying

companies will need to fill out are located in the resource guide, see Appendix F. Contact information for each certification company has been listed in the guide or a general contact information link was provided.

We shared our timeline for completing the reference guide with each company. Other companies that were not included in our interviews will have access to the guide after it has been posted to the CICR website.

4.8 Analysis

The main takeaway we got from all the data we collected was that the main barrier to trying to obtain a Zero Waste to Landfill certification is the lack of knowledge companies have about how to obtain the certifications. Even though we talked to companies already interested, many of whom already had an ISO certification and diverted enough waste to qualify, almost none of them knew about certifiers and how to go about getting a certification. Even the companies that knew about certifiers ran into knowledge barriers. For example, one of the companies we talked to had attempted a certification in the past but had issues with co-processing not being accepted. However, through our research we found that the type of co-processing done in Costa Rica is considered waste to energy and is accepted by all certification companies we contacted. It is possible that the language barrier was a factor leading to that misunderstanding. We hope that the baseline of knowledge we are offering will help to overcome that barrier and make Zero Waste to Landfill certifications more common in Costa Rica in the future.

We utilized the priorities and concerns companies gave us to create our guide. After finding the answers to their common questions and priorities we turned them into a checklist so

that companies will be able to compare certifications for their company's specific needs. Some of the companies would benefit by being added to a database of similar companies, like the manufacturing companies we interviewed; however, that is not a priority for the consulting and medical companies we interviewed. We also found that some companies that relied on waste prevention as part of their diversion numbers so those companies are more likely to not choose NSF as they only include actually diverted waste in their calculations.

5. Conclusions and Recommendations

After the conclusion of our research and interviews, we have compiled some recommendations that we will share with the companies we interview. We provided them with recommendations for different certification companies to choose from, recommended good waste management practices, and recommendations for how companies can close their research gaps.

5.1 Recommendations for certification company selection

We have recommended that companies examine certifications from SCS Global, Intertek, and NSF. Each of these certifications have been outlined in better detail in our reference guide which can be seen in Appendix F. We recommend that Costa Rican companies use these certifying bodies when trying to achieve zero waste to landfill. Our reference guide is a good tool to determine which certification best fits the needs of each specific company and best suits their goals.

5.2 Recommendations for good waste management practices

To divert waste from landfills, we recommend that Costa Rican companies practice more sustainable waste management practices and look into obtaining a Zero Waste to Landfill certification of their own. One waste management process we recommend is co-processing. Co-processing involves the process of burning waste to be used as a material of cement.

In order to ensure that company individuals properly dispose of ordinary waste, we recommend that companies provide specific training courses. These courses should be specified for how to dispose of toilet paper, feminine hygiene products, and paper towel waste in

bathrooms. It should also cover how to recycle and or dispose of other general waste such as plastics and food scraps. Posters should be placed round company offices to remind employees of what waste is acceptable where and how they can separate their recyclable materials and waste. We believe that these recommendations can help increase ordinary recycling within the office space as well as reduce overall ordinary waste. We also recommend that company offices consider implementing air powered hand dryers. These dryers are currently not commonly being used due to the fear of spreading Covid-19 germs and particles through the air. We recommend that companies assess the use of paper towels and implement these hand dryers once Covid restrictions have been lessened or companies feel comfortable making the switch to air powered hand dryers.

5.3 Recommendations for closing research gaps

To better address the landfill problems in Costa Rica, a project should be carried out with companies that do not already divert a large amount of waste to landfills. The main focus of our project shifted from the alternative waste management methods and promoting diversion of waste from landfills to how to obtain a certification and the requirements involved. This is what the interviewed associate member companies of CICR wanted and the natural trajectory of our project. However, we would recommend that CICR do research that investigates the landfill problems in Costa Rica and how to promote alternative waste management methods to companies that divert little waste from landfill and don't know where to get started on that process.

We recommend that CICR encourage the Costa Rican government to accept waste-to-energy processes such as incineration, anaerobic digestion, and pyrolysis. Waste-to-energy

methods are currently not allowed to take place in Costa Rica since they are deemed as environmentally harmful. However, since it is an accepted practice by the certification companies and is a commonly used practice in other locations globally, we believe it would be beneficial for the Costa Rican government to reassess these practices.

5.4 Looking forward

In the future, we expect that many different Costa Rican companies will become more interested in learning about and obtaining a zero waste to landfill certification. Since this project will, hopefully, close much of the knowledge gap, companies that did not work with us should now have an easier time achieving a certification. Much like the ISO 14001 certification, zero waste certifications have become a goal for Costa Rican companies to achieve within the next several years. We also believe, based on interviews, that this certification is just a steppingstone for some companies that hope to achieve full carbon neutrality and full zero waste certifications. As social pressure continues to mount for companies to work towards a circular economy, hopefully the government of Costa Rica will also begin to create more laws encouraging this behavior from all companies in Costa Rica.

Laws that permit the use of waste-to-energy practices such as incineration, anaerobic digestion, and pyrolysis, among many, would be a good perspective for the Costa Rican government to examine for the future. These waste-to-energy waste management methods (see chapter 2.4) have been proven in other areas of the world to have minimal environmental impact and contribute to the creation of a circular economy. We believe that these practices should be reviewed by Costa Rican environmental lawmakers, and that the push to permit them should come from companies that struggle with waste management and could benefit from their usage.

Once lawmakers make the ultimate decision to approve them, the ultimate success of these practices will rely on the companies that are seeking to achieve Zero Waste to Landfill and contribute to a circular economy.

References

- Barstow's Dairy Store and Bakery. (2021). *Barstow's anaerobic digester: Farm Powered*.
 Barstow's Longview Farm. <https://www.barstowslongviewfarm.com/anaerobic-digester/>.
- Brownlow, Mark. (2020, December 17). *The Spittelau Incinerator*. Visiting Vienna.
<https://www.visitingvienna.com/footsteps/spittelau/>.
- Cámara de Industrias de Costa Rica (CICR). (2021). *Quiénes Somos: Misión y Visión*. Cámara de Industrias de Costa Rica. <https://cicr.com/quienes-somos/#valores>.
- CFI Education. (2019, December 2). *Circular Economy*. Corporate Finance Institute.
<https://corporatefinanceinstitute.com/resources/knowledge/economics/circular-economy/>.
- Fitch-Roy, O., Benson, D., & Moniciardini, D. (2021). All around the world: Assessing optimality in comparative circular economy policy packages. *Journal of Cleaner Production*, 286, 1-11. <https://doi.org/10.1016/j.jclepro.2020.125493>.
- Incineration. (2021, October 29). In *Wikipedia*. <https://en.wikipedia.org/wiki/Incineration>.
- International Trade Administration, (2021). *Energy resource guide*.
<https://www.trade.gov/energy-resource-guide-renewable-energy-costa-rica>.
- Intertek Group. (2021). *Zero Waste to Landfill Certification Programme*.
 Intertek. <https://www.intertek.com/detail.aspx?id=34359796182>.
- Intertek Group. (2021). *Zero Waste to Landfill – Sustainable Landfill Diversion Solutions*.
 Intertek. <https://www.intertek.com/assurance/zero-waste-to-landfill/>.

- Lam, C.H.K., Ip, A.W.M., Barford, J.P., & McKay, G.(2010). Use of incineration MSW ash: A review. *Sustainability*, 2(7), 1943-1968. <https://doi.org/10.3390/su2071943>.
- Lui, A., & Schrader-King, K. (2018, September 20). Global Waste to Grow by 70 Percent by 2050 Unless Urgent Action is Taken : World Bank Reports. *The World Bank*.
<https://www.worldbank.org/en/news/press-release/2018/09/20/global-waste-to-grow-by-70-percent-by-2050-unless-urgent-action-is-taken-world-bank-report>.
- Miandad, R., Rehan, M., Barakat, M.A., Aburiaza, A.S., Khan, H., Ismail, I.M.I., Dhavamani, J., Gardy, J., Hassanapour, A., & Nizami, A.S. (2019). Catalytic pyrolysis of plastic waste: Moving toward pyrolysis based biorefineries. *Frontiers in Energy Research*, 7, 27.
<https://doi.org/10.3389/fenrg.2019.00027>.
- MSE (2019) *What is Circular Economy?* Towards Zero Waste Singapore.
<https://www.towardszerowaste.gov.sg/zero-waste-masterplan/chapter2/circular-economy>.
- NSF International (2021) *Landfill Free Certification*. SU Landfill Free Case Study.
<https://nsfinternational.widen.net/s/clhr6zwdbr>.
- Premo, Brian. (2020, January 13). *Anaerobic Digestion: A Solution to Diverting Wasted Food*. Center for EcoTechnology. <https://www.centerforecotechnology.org/anaerobic-digestion-a-solution-to-diverting-food-waste/>.
- Public Works Department of Signal Hill, California. (2017, Sep 22). *Organic Recycling*. City of Signal Hill California.
<https://www.cityofsignalhill.org/Search?searchPhrase=organic+waste>.

Sabbas, T., Poletini, A., Pomi, R., Astrup, T., Hjelmar, O., Mostbauer, P., Cappai, G., Magel, G., Salhofer, S., Speiser, C., Heuss-Assbichler, S., Klein, S., & Lechner, P. (2003). Management of municipal solid waste incineration residues. *Waste Management*, 23(1), 61-88. [https://doi.org/10.1016/S0956-053X\(02\)00161-7](https://doi.org/10.1016/S0956-053X(02)00161-7).

SCS Global Services. (2021). *Zero Waste Certification*. SCS Global Services.
<https://www.scsglobalservices.com/services/zero-waste-certification>.

SL Recycling. (2021). *Zero Waste to Landfill - What Does it Mean?* SL Recycling.
<https://www.slrecyclingltd.co.uk/zero-waste-to-landfill-what-does-it-mean/>.

Smith, Eric. (2021, October 16). Recycling in Costa Rica:Combating Renewable Waste Issues. *Tico Times*.
<https://ticotimes.net/2021/10/16/recycling-in-costa-rica-combatting-renewable-waste-issues>.

Tayabi, S., Monlau, F., Bargaz, A., Jimenez, R., & Barakat, A. (2021). Synergy of anaerobic digestion and pyrolysis processes for sustainable waste management: A critical review and future perspectives. *Renewable and Sustainable Energy Reviews*, 152.
<https://doi.org/10.1016/j.rser.2021.111603>.

The Tico Times. (2021, March 18). Waste Management ‘one of biggest environmental problems,’ Costa Rica says. *Tico Times*.
<https://ticotimes.net/2021/03/18/waste-management-one-of-biggest-environmental-problems-costa-rica-says>.

Ton-To-Ton. (2020). "Why Co-Processing in Cement Factories is the Key to Plastic Pollution".

Ton-To-Ton. <https://tontoton.com/why-co-processing-in-cement-factories-is-the-key-to-plastic-pollution/>.

United States EPA (2021, February 23). *Basic Information about Landfills*. United States

Environmental Protection Agency. <https://www.epa.gov/landfills/basic-information-about-landfills>.

Veleva, V., Bodkin, G., & Todorova, S. (2017, March 31). The need for better measurement and employee engagement to advance a circular economy: Lessons from Biogen's "zero waste" journey. *Journal of Cleaner Production*, 154, 517-529.

<https://doi.org/10.1016/j.jclepro.2017.03.177>.

Waste-to-Energy. (2021, November 9). In *Wikipedia*. <https://en.wikipedia.org/wiki/Waste-to-energy>.

Waste-to-Energy New Zealand. (2021). *Our Zero Waste Initiative: Delivering seamless waste-to-energy solutions across multiple sectors*. Waste to Energy Co New Zealand.

<https://www.waste2energy.co.nz/pyrolysis-waste-to-energy/>.

Wien Energie MgbH. (2021). *Landmark of Vienna*. Positionen.

<https://positionen.wienenergie.at/en/projects/spittelau-waste-incineration-plant/>.

Zaman, C.Z., Pal, K., Yehye, W.A., Sagadevan, S., Shah, S.T., Adebisi, A.G., Marliana, E.,

Rafique, R.F., & Johan, R.B. (2017). Pyrolysis: A Sustainable Way to Generate Energy from Waste. *Intechopen*. <https://www.intechopen.com/chapters/56034>.

Appendices

Appendix A: Timeline of C Term

	Week 1 (remote)	Week 2 (remote)	Week 3	Week 4	Week 5	Week 6	Week 7 (remote)	Week 8 (remote)
Dates	10/1	17/1	24/1	31/1	7/2	14/2	21/2	28/2
Meeting dates:	12/1	19/1	26/1	2/2	9/2	16/2	23/2	3/2
Send out questionnaire								
Schedule interviews								
Conduct remote interviews								
Conduct in-person meetings								
Compile information								
Create guideline								
Create final report								
Create final presentation								
Send reference guide								

Appendix B: Pre-interview Assessment Tool

Section 1: Privacy

Acknowledgment: The responses to this questionnaire are anonymous and will serve the purpose of helping students from Worcester Polytechnic Institute in Worcester, MA, USA working alongside La Cámara de Industrias de Costa Rica, CICR, work on a graduation-requirement project that focuses on creating a guide that will aid Costa Rican companies in diverting waste from landfills. The purpose of this questionnaire is for the student group to gain insight into the current perspectives of Costa Rican company representatives concerning Zero Waste to Landfill.

1. Are you comfortable with us using your responses anonymously in our final report that will be published by our university's library? (Circle one)
 - Yes
 - No

Section 2: Send back to us by XX/XX/XXXX (date TBD - CICR approves)

2. How knowledgeable are you about the global Zero Waste to Landfill initiative? (1 being nothing, 5 being an expert)

1 2 3 4 5

3. Does your company actively make efforts to divert waste from landfills in your waste management methods?

- Yes
- No
- I don't know

4. Are you aware of any Zero Waste to Landfill certifications that exist to attest to a company's commitment to the initiative?

- Yes
- No
- Somewhat

Section 3: Questions to think about for the interview- Already certified

These are some questions we may ask during our interview. Please look over these questions and compile any information you are willing to share.

1. How much waste does your company produce annually (Including waste diverted from the landfill)?
2. What percentage of your waste gets sent to a landfill?
 - a. How do you divide up the waste not sent to landfill?
3. What certification does your company hold?

- a. What does the certification cover?
 - b. What was the process you took to become certified?
4. How interested would your company be in sharing the steps you've taken to help educate other companies?
 - a. Feel free to come to the interview with steps taken, alternative waste management processes used, and any additional information about how your company upholds the certification.
 5. What were the biggest obstacles your company faced about starting the process of diverting waste from landfills through alternative waste disposal methods?
 6. The ultimate goal of our project is to create a guide-map for small-to-medium sized Costa Rican companies to follow to start working towards diverting waste from landfill and obtaining a certification. What information do you think is most valuable for companies beginning the certification process to know?

Section 4: Questions to think about for the interview- Interested in getting certified

These are some questions we may ask during our interview. Please look over these questions and compile any information you are willing to share.

1. How much waste does your company produce annually?
2. What percentage of your waste gets sent to a landfill?
3. How interested would your company be in beginning efforts to divert waste from landfill?
4. What current obstacles is your company facing about starting the process of diverting waste from landfills through alternative waste disposal methods?
5. How interested would your company be in working towards, or learning about, obtaining a Zero Waste to Landfill certification?
6. What would you want a guide map that gives resources for working towards diverting waste from landfill and obtaining a certification to include? What would be the best way for your company to access the information included in a resource?

In the email or letter sent out with the questionnaire:

Hello [Company representative name],

Thank you for agreeing to work with us. We are a team working with La Cámara de Industrias de Costa Rica on the Zero Waste to Landfill project, with our main objective being aiding Costa Rican companies in achieving Zero Waste to Landfill through a well-detailed guide

map. Your thoughtfulness and time spent reviewing these questions pre-interview and collecting data will greatly help the progress of our project and give us the information we need to compile an informative guideline. Thank you for your time in aiding CICR and us with this project.

Please let us know when you are available between 24 January and 16 February 2022 to set up an interview with our team. We will be available during those times in San Jose, Costa Rica at the CICR office, or virtually via Zoom or any other virtual meeting platform. Please email gr-cicrsanjosec22@wpi.edu as well as ahidalgo@cicr.com with your preferred meeting date, time, and location (in-person or virtual). Your responses to Section 2 prior to the interview will aid us in being adequately prepared, and we do request that you come to the interview with some information we have asked in Section 3 to help yourself be prepared and to minimize the time needed for the interview. Thank you very much and we look forward to our conversation!

Best,
Adele Brochu
Catie Coumounduros
Payton Dean
Natalia Wierzbicki

Appendix C: Interview Protocol

Section 1: Privacy

Acknowledgement: This interview will serve the purpose of helping us, students from Worcester Polytechnic Institute in Worcester, MA, USA working alongside La Cámara de Industrias de Costa Rica, CICR, work on a graduation-requirement project that focuses on creating a guide that will aid Costa Rican companies in diverting waste from landfills. The purpose of this interview is for us to gain insight on the current perspectives of Costa Rican company representatives concerning Zero Waste to Landfill.

1. Are you comfortable with us using your company's name and your responses in our final report that will be published by our University's library? Your individual name will not be listed.
2. If not, are you comfortable with your results being shared anonymously in our final report that will be published by our University's library?
3. Are you comfortable with us recording your voice?
4. Are you comfortable with us transcribing notes during our interview today?

Section 2: Already certified interview questions

These are some questions we may ask during our interview. Please look over these questions and compile any information you are willing to share.

1. How much waste does your company produce annually (Including waste diverted from the landfill)?
2. What percentage of your waste gets sent to a landfill?
 - a. How do you divide up the waste not sent to landfill?
3. What certification does your company hold?
 - a. What does the certification cover?
 - b. What was the process you took to become certified?
4. How interested would your company be in sharing the steps you've taken to help educate other companies?
 - a. Feel free to come to the interview with steps taken, alternative waste management processes used, and any additional information about how your company upholds the certification.
5. What were the biggest obstacles your company faced about starting the process of diverting waste from landfills through alternative waste disposal methods?

6. The ultimate goal of our project is to create a guide-map for small-to-medium sized Costa Rican companies to follow to start working towards diverting waste from landfill and obtaining a certification.
7. What information do you think is most valuable for companies beginning the certification process to know?

Section 3: Interested in becoming certified interview questions

These are some questions we may ask during our interview. Please look over these questions and compile any information you are willing to share.

1. What is your company size?
2. How much waste does your company produce annually? Do you know what type of waste your company produces? (i.e., carbon)
3. What percentage of your waste gets sent to a landfill?
4. What does your current waste management system that includes diverting waste from landfill look like?
5. Have you made changes to your production to reduce your end waste? Why or why not?
6. What current obstacles is your company facing about starting the process of diverting waste from landfills through alternative waste disposal methods?
7. How interested would your company be in working towards, or learning about, obtaining a Zero Waste to Landfill certification?
8. What would you want a guide map that gives resources for working towards diverting waste from landfill and obtaining a certification to include?
9. What would be the best way for your company to access the information included in a resource guide?
10. Do you have any questions, concerns, or comments for us?

Section 4: Certification companies

1. Can you please explain your process of obtaining a certification?

2. Can you give us a cost breakdown or an equation that is used to estimate quotes?
3. How would a company approach receiving a quote?
4. Is there a step-by-step process that companies must follow to be certified?
5. Is there anything else you can add that would be beneficial for companies interested in obtaining your certification?

Section 5: Post-interview email

Hola!

On behalf of our WPI research group and CICR, we wanted to thank you for participating in our Zero Waste to Landfill project. We appreciate your honest responses and time taken to speak with us virtually. Please feel free to reach out to any of us (Adele, Catie, Payton and Natalia), or Akira from CICR if you have any more questions, concerns, or input with this project. We will have the final reference guide to you within the next week.

Pura Vida!

Adele Brochu (aibrochu@wpi.edu)

Catie Coumounduros (cgcoumounduros@wpi.edu)

Payton Dean (padean@wpi.edu)

Natalia Wierzbicki (ntwierzbicki@wpi.edu)

Akira Hidalgo (ahidalgo@wpi.edu)

Section 6: Email containing our deliverable

Dear [Company Representative],

Thank you for participating in our Zero Waste to Landfill project. We sincerely appreciate your time and effort that contributed to the success of this project. Attached is the Zero Waste to Landfills: Certifications & Good Practices Guide, which will aid your company in starting the process of achieving Zero Waste to Landfill. We hope you have a successful completion of this process.

Pura Vida!

Adele, Catie, Payton, and Natalia

Worcester Polytechnic Institute

Appendix D: Definitions

Diverted Waste: Waste made by the company is that diverted from the landfill (examples of diversion include recycling, reusing, combustion-to-energy)

Residuals: Waste that is not/cannot be diverted from landfills

Prevented Waste: The estimated theoretical waste saved by a structural change to the process or system the company is using.

Total Waste: Diverted waste + Residuals

Appendix E: Equations

Equation 1: SCS Global Diversion of Waste Equation

$$\frac{\text{Diverted Waste} - \text{Residuals} + \text{Prevented Waste}}$$

$$\text{Total Waste} + \text{Prevented Waste}$$

Appendix F: Educational Reference Guide
English Version



Zero Waste to Landfills: Certifications & Good Practices Guide



Protect the environment
Business advantages
Contribute to a circular economy

Certification Companies

Click on the logo for more information! Contact representative to get a quote and learn about the certification process for your specific company needs and goals.

Intertek



Contact: Refaya Priya | business.assurance@intertek.com

National Sanitation Foundation (NSF)






Use 'Contact Us' function on webpage (click logo!)

Scientific Certification Systems (SCS) Global



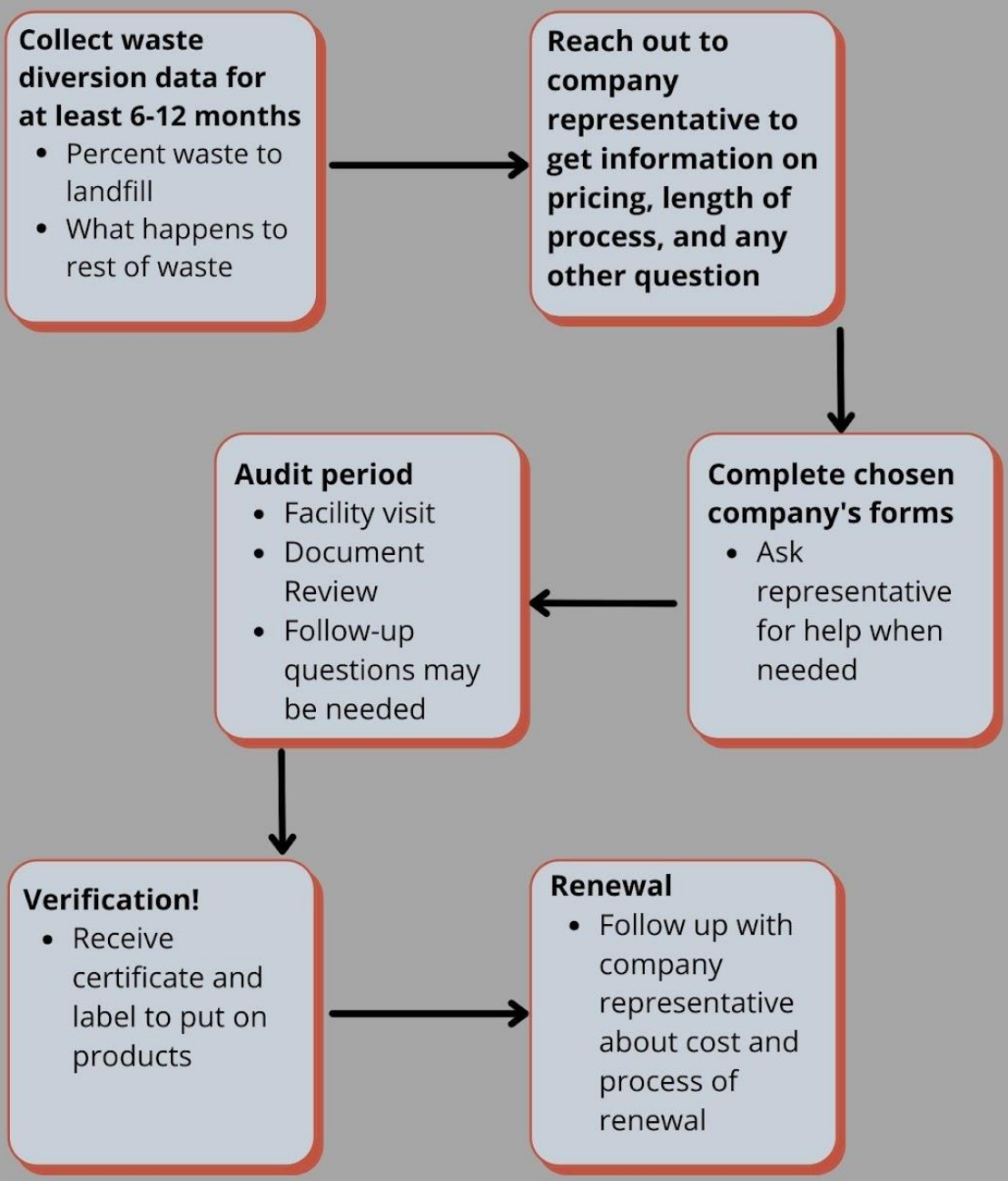
Contact: Inna Kitaychik | ikitaychik@scsglobalservices.com

Certification Company Comparison

ATTRIBUTES			
GLOBALLY ACKNOWLEDGED	✓	✓	✓
FACILITIES CERTIFIED INDEPENDENTLY	✓	✗	✓
MULTI-FACILITY CERTIFICATIONS	✓	✓	✓
APPROVES RECYCLING	✓	✓	✓
APPROVES COMPOSTING	✓	✓	✓
APPROVES CO-PROCESSING	✓	✓	✓
PREVENTION OF WASTE	✓	✗	✓
PROVIDES CERTIFICATION LABEL	✓	✓	✓
ADDED TO A DATABASE	✗	✓	✗
OFFERS CONSULTING SUPPORT	✗	✗	✓
KEEP EXISTING CERTIFICATIONS	✓	✓	✓
NECESSARY WASTE DIVERSION FROM LANDFILLS	<ul style="list-style-type: none"> • 99% : FULL • 95-99% : NEAR ZERO WASTE • 85-95% : ADVANCED DIVERSION 	<ul style="list-style-type: none"> • LESS THAN 1% TO LANDFILL 	<ul style="list-style-type: none"> • 99%* • PARTICIPATION ALLOWED IF MORE THAN 50%* <p><small>*based on their equation</small></p>

Certification Process

--Varies based on company, see webpages for company specific processes--



Good Practices

Use Co-Processing for hazardous waste
& non-recyclable plastics



Train employees on importance of
initiative & their commitment

Separate ordinary waste
(plastic, glass, paper &
cardboard, organic) with
clearly marked individual bins
in all populated spaces



- Separate toilet paper and paper towel waste in bathrooms
- Look into sterilization of products before co-processing
- Be transparent about management of this waste

Developed by:

Adele Brochu, Catie Coumounduros, Payton Dean and
Natalia Wierzbicki

of

Worcester Polytechnic Institute (WPI)

in partnership with

La Camara de Industrias de Costa Rica (CICR)

With Questions, Contact:

Akira Hidalgo

Asesora en Sostenibilidad, Ambiente y Responsabilidad Social

La Camara de Industrias de Costa Rica

ahidalgo@cicr.com



Pura Vida!

Spanish Version – Translation by CC



Cero Residuos a los Rellenos Sanitarios: Guía de Certificaciones y Buenas Prácticas



Protege el medio ambiente
Ventajas del negocio
Contribuye con una economía circular

Empresas de Certificación

¡Haga clic en el logotipo para más información! Contacte con un representante para obtener información sobre precios y aprender más sobre el proceso específico para su compañía.

Intertek



Contacto: Refaya Priya | business.assurance@intertek.com

National Sanitation Foundation (NSF)



Use la función 'Contact Us' en el sitio web (¡haga clic en logotipo!)

Scientific Certification Systems (SCS) Global



Contacto: Inna Kitaychik | ikitaychik@scsglobalservices.com

Comparación de las Empresas de Certificación

ATRIBUTOS			
RECONOCIDO MUDIALMENTE	✓	✓	✓
CERTIFICA INSTALACIONES INDEPENDIENTES	✓	✗	✓
CERTIFICACIÓN DE MULTIPLES INSTALACIONES	✓	✓	✓
AUTORIZA RECICLAJE	✓	✓	✓
AUTORIZA COMPOSTAJE	✓	✓	✓
AUTORIZA COPROCESAMIENTO	✓	✓	✓
PREVENCIÓN DE RESIDUOS	✓	✗	✓
PROVEE ETIQUETA DE CERTIFICACIÓN	✓	✓	✓
PARTE DE UN BASE DE DATOS	✗	✓	✗
OFRECE APOYO DE CONSULTORÍA	✗	✗	✓
GUARDA CERTIFICACIONES EXISTENTES	✓	✓	✓
RESIDUOS NECESARIOS DESVIADOS DE RELLENO SANITARIO	<ul style="list-style-type: none"> • 99% : FULL • 95-99% : CERCA BASURA CERO • 85-95% : DESIVADOS AVANZADO 	<ul style="list-style-type: none"> • MENOS QUE 1% TO LANDFILL 	<ul style="list-style-type: none"> • 99%* • PUEDE PARTICIPAR SI MÁS QUE 50%* <p>*basado en su ecuación</p>

Proceso de Certificación

--Varía según la empresa, vaya a los sitios web para los procesos específicos--

Obtenga datos sobre residuos disposicionados en últimos 6-12 meses

- Porcentaje a rellenos sanitarios
- Qué sucede con el resto de los residuos?

Contacte a un representante de empresa para obtener más información sobre el precio, duración del proceso, y cualquier pregunta relacionada

Período de auditoría

- Visita de instalación
- Revisión de documentos

Complete documentos de la empresa escogido

- Utilice el representante para ayuda y apoyo

¡Verificación!

- Recibe certificado y etiquetas para poner en sus productos

Renovación

- Sigue la comunicación con la empresa sobre el precio y proceso de renovación

Buenas Prácticas

Use coprocesamiento para residuos peligrosos y plásticos que no pueden ser reciclados



Enseñe a los empleados sobre la importancia de la iniciativa y su compromiso

Separe residuos ordinarios (plástico, vidrio, papel y cartón, orgánico) con recipientes marcados en zonas pobladas



- Separe el papel higiénico y papeles absorbentes en los baños
- Investigue sobre la esterilización de papel higiénico antes del coprocesamiento
- Sea transparente sobre la gestión de estos residuos

Desarrollado por:

Adele Brochu, Catie Coumounduros, Payton Dean and
Natalia Wierzbicki

de

Worcester Polytechnic Institute (WPI)

con

La Cámara de Industrias de Costa Rica (CICR)

Si tiene preguntas, contacte a:

Akira Hidalgo

Asesora en Sostenibilidad, Ambiente y Responsabilidad Social

La Camara de Industrias de Costa Rica

ahidalgo@cicr.com



¡Pura Vida!