ZotBins-A Smart IoT Management Infrastructure for Zero Waste

Authors: Grace Seung-Mi Choe (gschoe@uci.edu), Jesse Lin Chong (chongjl@uci.edu), Kathy M. Nguyen (kathymn1@uci.edu), Owen Kai Yang (okyang@uci.edu)
Advisors: Dr. Sharad Mehrotra, Dr. Nalini Venkatasubramanian, Dr. Luyi Gui, PhD Candidate Primal Pappachan
University of California, Irvine
UCI TIPPERS - Zero Waste Anteaters

One of the most significant waste problems faced today is in regards to trash management. Due to the inefficient handling and sorting of trash, trash has become a major contributor to greenhouse gas emissions. According to the EPA, landfills are the third-largest source of anthropogenic methane emissions. To be specific, landfills contribute approximately 14.1 percent of these emissions in 2017 [1]. Another difficult waste problem is recycling contamination. According to the University of Michigan, when a certain percentage of non-recyclables are placed with recyclable materials, the whole batch is considered contaminated and all of the items are sent to the landfill [2]. Both of these problems has led to our country's low diversion rate of 35% [3]. In an effort to remedy these problems, we must go back to where trash originates from and revisit the concept of the waste bin.

For years, the concept of the waste bins have mostly stayed the same. People have waste they want to get rid of and they dispose of it in these bins and probably never think about it again. However, to address the problems stated above, the current waste management systems in cities and communities need to be smarter. To implement a smart waste infrastructure, there are 3 methods to implement: (1) a monitorization of bins to better learn patterns of waste disposal from users, (2) optimization and improvement of waste management through operations planning from the waste studies, and (3) having interactive resources to adjust inaccurate waste-habits for producers and consumers. ZotBins, our smart waste bin infrastructure, implements all 3 of these methods and helps keep communities clean, make waste management efficient, and encourages the practice of zero waste. Our goal in this project is to explore a new socio-technical approach to zero waste that integrates emerging smart internet-of-things

(IoT) technologies with waste management to bring transformative improvements in waste diversion and assist communities towards achieving zero waste.

This Zotbins project is a smart bin system that incorporates sensors and software to provide useful data on waste weight and fullness of the bin. The software component is the website which allows users such as students and facility management to obtain easy access to the data in real time. With ZotBins' real-time data collection system in place, facilities management can optimize custodial schedules to full waste bins to prevent overflowing of trash on campus. This data can be used to calculate diversion rates, measure change in weight of waste per unit of time, and keep track of bin fullness level. As a result, Zotbins is able to utilize internet of things to assist people with being more sustainable with their waste.

Zotbins has the potential of producing a significantly greater cost benefit from recycling and composting relative to traditional waste bins. By calculating the monetary value of the weight compost and recycling waste streams from anaerobic digestion facilities and California recycling programs, we show that the current ZotBins system deployed in the University of California, Irvine is beneficial to the campus. A regular composting bin would generate $2,330.01 over 10 years, and a regular recycling bin would result in $13,311.80 [4][5][6][7]*. Data collected from Zotbins indicate that the 10 year revenue of a compost-type Zotbin would be $6,210.29 and $16,624.00 from a recycle-type Zotbin, which is a 22.72% increase in revenue from composting and 5.53% for recycling [4][5][6][7][8]*. With environmental concerns in mind, ZotBins highlights the potential of smart waste systems deployed in other communities as well.

**Assumptions: 1 pound of recycling = $1.60 in materials fee [4], 7.2544 GJ/ton of compost for anaerobic digestion facilities = 1.007555556 kwH/lb [6], $0.184 per kwH (the rate of electricity in the city of LA) [7], Yearly cost of Digital Display Energy = $8 [8], There are 52 weekends in a year.*

[1] *Globalmethane.org*, 2020. [Online]. Available: https://www.globalmethane.org/documents/landfill_fs_eng.pdf. [Accessed: 03- Jan- 2020].

[2] "Recycling Bin Contamination", *Planet Blue*, 2020. [Online]. Available: http://sustainability.umich.edu/environ211/recycling-bin-contamination. [Accessed: 03- Jan- 2020].

[3] J. Paben, "National statistics show stagnant U.S. diversion rate - Resource Recycling News", *Resource Recycling News*, 2020. [Online]. Available: https://resource-recycling.com/recycling/2018/07/30/national-statistics-show-stagnant-u-s-diversion-rate/. [Accessed: 03- Jan- 2020].

[4] *CalRecycle*, 2020. [Online]. Available: https://www.calrecycle.ca.gov/docs/cr/bevcontainer/notices/2017/2018attach1.pdf. [Accessed: 03- Jan- 2020].

[5] "CR&R Anaerobic Digestion Services", *CR&R Environmental Services*, 2020. [Online]. Available: http://crrwasteservices.com/sustainability/anaerobic-digestion/. [Accessed: 03- Jan- 2020].

[6] Shaffer B, Lane B, Fong A, Samuelsen GS. Task 3 Report: Assessment of Alternative Fuels in a Decarbonized Natural Gas Future. 2019.

[7] "Average Energy Prices, Los Angeles-Long Beach-Anaheim – November 2019 : Western Information Office : U.S. Bureau of Labor Statistics", *Bls.gov*, 2020. [Online]. Available: https://www.bls.gov/regions/west/news-release/averageenergyprices_losangeles.htm. [Accessed: 03- Jan- 2020].

[8] [7]*Image-us.samsung.com*, 2020. [Online]. Available: https://image-us.samsung.com/SamsungUS/PVI/business_energy_guide/common-energylabel-lh40dceplga-go-energylabel.pdf. [Accessed: 03- Jan- 2020].