

Tau Beta Pi Fellowship Proposal
2 April 2009

Optimizing Factories for Recycling of Electronic Waste

Liz Theurer
229 Vassar St #733-1
Cambridge, MA 02139
jtheurer@mit.edu

Graduating June 2010

BS in Mechanical Engineering
BS in Mathematics

Abstract

Electronic waste (e-waste) is the fastest growing waste stream in the world. According to the EPA, not even 16% (by weight) of e-waste is recycled. Groundwater contamination and airborne pollutants are only some of the dangers associated with dumping e-waste in landfills. Due to a lack of environmental regulation in the United States and the high cost of recycling e-waste (companies have to pay to dispose of broken equipment), many companies opt for the less expensive option: shipping their e-waste overseas to dump in developing nations.

RECYCLA is an e-waste recycling company in Santiago with a goal to expand their business and process 50% of the e-waste in Chile. Besides the environmental benefits to expanding their services, RECYCLA will also hire more workers from a local prison to help reintegrate criminals back into society. My part in this project will be to devise a new factory layout to allow RECYCLA to expand efficiently and effectively and provide a model for processing e-waste.

Introduction

I have witnessed the processes used by electronic waste (e-waste) recycling in the United States and in Chile; the similarities between the two are striking. While a few companies in the United States have invested in multi-million dollar equipment to process e-waste, companies that decompose e-waste by hand throughout the world are very similar. Unsorted material comes in by truck; most of it is obsolete technology that is repaired and resold. The rest, un-repairable e-waste, must be decomposed into its component parts - plastic, printed circuit boards, power sources, cathode ray tubes, etc - and distributed to the appropriate facility for recycling. Finding a market for these materials, especially the cathode ray tubes (with high concentrations of lead), is very difficult.

RECYCLA has passed the initial stages of a start-up enterprise. They have been operating since 2003 and processing about 500 tons per month of local material from companies. Within the past 5 years, RECYCLA has been able to raise awareness about the environmental impacts of e-waste and enact change in the national government. RECYCLA is now poised to expand their business; however, given the fragility and small profit margin of this business, it is essential that RECYCLA expand intelligently.

Community Needs

E-waste accounts for 70% of environmental toxins in landfills. While there are strict regulations and large fines for dumping toxic materials in landfills in the United States, many developing countries do not have legal repercussions. When companies take advantage of third-world countries, the environmental impacts are life-threatening. For example, the citizens of Guiya, a city in southern China, are plagued by the highest dioxin rates in the world, the reason behind high cancer and miscarriage rates in that area. RECYCLA only processes 5% of the e-waste in Chile. By expanding their factory, RECYCLA will be able to process more e-waste and reduce the hazards of dumping and burning e-waste in Chile. Figures 1, 2 and 3 are representative of e-waste treatment seen in many third-world countries.



Labels

Figure 1 (above): Toxins from e-waste contaminate drinking water

Figure 2 (top right): High lead concentration in cathode ray tubes require significant protection. Many recycling processes used in the third world are not up to health and safety regulations.



Figure 3 (bottom right): Burning e-waste releases hazardous chemicals into the air



The Chilean government has passed an ordinance that requires industry and government organizations to process their waste instead of dumping it into the Mapocho River. While the government is having trouble enforcing this law, they are making steps in the right direction to address the pollution problem. The expansion of RECYCLA will only provide more resources for the government to draw on when they more effectively enforce these laws.

Finally, RECYCLA is committed to making an impact in the community of Santiago, Chile. The majority of RECYCLA's labor force is former prisoners. By giving former criminals a source of steady income, RECYCLA is helping these individuals regain respect in their communities and providing an alternative to their former life of crime. Although in comparison to the rest of South America, the crime rates in Chile are relatively low, RECYCLA provides a model of reintegration as well as recycling that can be applied in other countries.

Project Aims

E-waste recycling is a relatively new industry and, in general, decomposition of electronic materials has been done on small scales by hand. There are many opportunities to increase efficiency and e-waste decomposition rate. However, the goal of this project is to improve the efficiency of e-waste recycling in RECYCLA's factory by the end of the summer. From preliminary research, it seems a reorganization of the factory floor will create the biggest impact on processed e-waste per month. In the next two months, I will verify that reorganization is where the most efficiency can be gained by talking with e-waste recycling experts around the world. Armed with expert advice and a theoretical background, I will have complete control over the direction of this project. During August, the factory will be shut down and potential designs will be experimented with. I will produce a report on the different designs and their process efficiencies. By the end of August, I will leave the company in the most efficient configuration as determined by experimental data.

Project Timeline

March

- Contacted recycling centers in the United States and interviewed them to determine how the United States deals with e-waste
- Interviewed Florida Department of Environmental Protection

April

- Develop intimate understanding of reasons behind decisions made in e-waste recycling factories in the United States
- Connect with faculty at MIT doing research on e-waste recycling manufacturing processes
- Investigate the legal code in Chile with respect to the disposal of hazardous waste
- Communicate with RECYCLA to determine the status and configuration of factory in Santiago

May

- Make preliminary design of RECYCLA factory floor
- Communicate with RECYCLA to determine feasibility of design

June

- Visit German e-waste recycling centers
- Understand the reasons behind the factory set-up in Germany
- Created diagrams of floor plan in Germany recycling centers

July

- Finalize designs of RECYCLA factory
- Communicate with RECYCLA to determine feasibility and logistics of design for factory floor

August

- Implement different designs at factory in Santiago, Chile
- Collect efficiency data
- Leave RECYCLA's factory floor in the most efficient configuration
- Write and deliver a report

Technical Approaches

Germany has one of the most advanced recycling systems in the world. The best way to create an e-waste recycling system is to learn from the best. I will be working this summer for Continental, an automotive company in Lindau, Germany. I have negotiated with my company for time off to explore the recycling facilities in Germany. Before going to Germany, I will have visited two recycling centers here in the United States. Through several interviews and plant tours, I will gain experience and insights into how best to conduct an interview in order to get the maximum information.

In addition, it is important to understand the theory associated with factory floor design. I have been introduced to the terms and basic concepts behind factory part flow and organization through my coursework. With this background knowledge, I am currently seeking the advice and recommendations of faculty at MIT to further plan my curriculum.

The design of the factory floor at RECYCLA will follow the model of lean manufacturing. The plan will make use of quality management tools and queuing theory to optimize the recycling of e-waste without neglecting the quality of service. It is important that the material sent to specialized recycling facilities is not contaminated with improper materials. Simple changes such as the processing only one type of material at a time will allow workers to reach their highest efficiencies instead of alternating types of parts. Another design possibility is creating specialized deconstruction tasks in which one worker is responsible for removing the printed circuit boards while another takes off the plastic. Reorganizing work stations and placing tools in easy-to-reach and convenient locations will make significant increases in processing time. The final design will incorporate these ideas along with other changes.

It is important that the factory design is appropriate for the culture of the company. As more detailed designs are drawn, communication with RECYCLA will become more frequent and important.

Anticipated Impacts

The reorganization of the factory floor has many impacts. First of all, more e-waste can be processed per month. This increase gives more companies the opportunity to decompose and process their e-waste in a local facility. It is RECYCLA's goal to move from recycling 5% of the e-waste in Chile to 50% of the e-waste. If this project proves effective, RECYCLA will begin expanding the company and hiring more workers. Finally, it is important to note that RECYCLA is committed to environmental friendliness and community development. As the e-waste market in one city becomes saturated, RECYCLA will open satellite branches in other locations instead of importing the e-waste to a central facility. As much as possible, RECYCLA is committed to local decomposition of e-waste.

Personal Motivations and Qualifications

I have always been interested in the interplay of statistics and optimization. As a major in mechanical engineering and mathematics, my career interests focus on operations research and industrial engineering. This project of redesigning a factory floor for efficiency falls directly into my anticipated future field. The environmental aspect is the main reason I am interested in this project. While optimizing systems for greater output and profit is valuable; making a positive environmental and social impact is both valuable and satisfying.

My coursework in design for the developing world, probability, and manufacturing has given me the theoretical tools to tackle this problem. One of the most important considerations in this project will be appropriate technologies. While multi-million dollar machinery will process thousands of tons of e-waste in a year, it is not advisable that a company as young as RECYCLA makes a large investment. While this decision may seem straight forward, there are several more nuanced situations in which a technology could replace jobs. The tradeoff between the social good (jobs to prisoners) provided by RECYCLA and the environmental and public health benefits to more waste processed will have to be evaluated. My participation in Amy Smith's D-Lab Design course has given me experience in making such decisions. Since the objective of this project is to create a factory floor plan that allows waste to be decomposed in the most efficient manner possible, it is important to have a background in probability and manufacturing. An understanding of the psychology of the worker and the requirements of the manufacturing industry are necessary to enact a lean manufacturing like process in the recycling industry. This background will be important when evaluating the floor plan of the RECYCLA factory.

Finally, I make no claim to understanding this business with just a basic theoretical knowledge of the processes involved. It is necessary to get hands-on exposure to e-waste recycling. In the past month, I have visited an e-waste recycling facility in Melbourne, FL and have collected 10 minutes of video of the plant in addition to interviews with the warehouse manager and a senior member of the administrative staff. Also, I have been in contact with the Florida Department of Environmental Protection. In a phone interview, I procured detailed information on the flow of e-waste out of the factory and into specialized recycling facilities. Contacts with these companies will provide information on how their plants are organized and how they prefer receiving products from decomposing companies like RECYCLA.

In addition, living in India for three months has given me exposure to how government systems and companies in third world countries are operated. Chile is not immune to these government inefficiencies, and I will proactively address signs of unhealthy practices from both the private company, RECYCLA, and the government disposal facilities. Tau Beta Pi's support will help me achieve my goals and improve the lives and environment of many in Santiago, Chile.

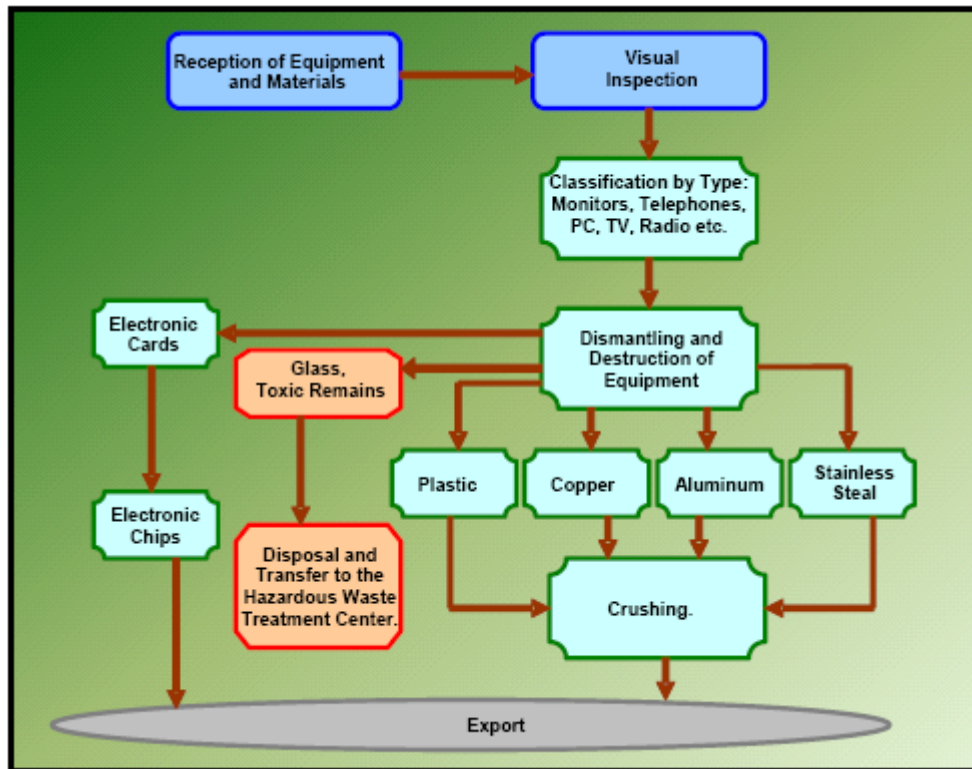
Appendix

RECYCLA's E-Waste Flow
Budget
Letter of Recommendation from Faculty: Dr. Whitney
Letter of Interest: RECYCLA
Resume

RECYCLA's E-Waste Flow

Figure 1 presented below shows the flow of e-waste through the factory. This theoretical flow chart will help inform the ideal factory floor plan.

Figure 4: E-Waste Flow



Budget

Expenses	Cost
Travel to Recycling Facilities in the United States	\$ 200
Travel to Recycling Facilities in Germany	\$ 300
Travel to Santiago, Chile	\$ 1500
Living Expenses in Chile	\$ 500
Remainder of stipend will help offset costs of shutting down the factory for a week to reorganize the factory floor	\$ 2500



April 1, 2009

To: The Tau Beta Pi Fellowship Committee

From: Daniel Whitney

Subject: Fellowship Application from Liz Theurer

Ms Theurer is applying for a fellowship to aid an organization in Chile in automating a recycling factory. This factory will employ low-skill people and serve as a model for setting up similar operations elsewhere in Chile. This sounds like a worthy project and one that will add to Liz' education and work experience.

This is her description of the project from her opening e-mail to me:

I have been speaking with Fernando Nilo, CEO of RECYCLA, an e-waste recycling company in Santiago, Chile. He is looking for students to help automate the recycling plant through its various stages, re-model and re-design processes at the recycling plant to achieve higher efficiencies.

I interviewed Liz for an hour before agreeing to be her advisor. I found that she understood the factors involved in setting up such an operation from several points of view (factory layout, ergonomics, economics, training) and was able to answer all my questions in a sensible way. She identified classroom work that she had done that would be relevant. She understood completely that "automating" does not mean replacing the workers with machines but rather making it easier, safer, and faster for them to do their work, which is too complex and costly to do with machines. She did not have all the knowledge necessary to carry out her project but she knew what was missing from her knowledge. This means that she had already thought through most of the challenges and was ready to use her time between our interview and the period of the internship in Chile this summer to fill her knowledge gaps.

I told her to make a project plan, which she has already submitted to me. It has all the necessary elements.

She is an intelligent and systematic person and I am confident that she will be successful in her project. I strongly recommend that you give her a fellowship.

If you have any questions, do not hesitate to call me.

Yours truly,

Daniel E Whitney

Tau Beta Pi Fellowships
77 Massachusetts Ave.
Bld. 4-136
Cambridge, MA 02139

To Whom It May Concern:

RECYCLA is pleased to initiate a relationship with MIT under the RECYCLA Patagonia project and Liz Theurer. Liz Theurer is very valuable to the continuing efforts that RECYCLA is making to solve the E-Waste problem in Chile.

RECYCLA will commit to the RECYCLA Patagonia project by the involvement of our personnel and in-kind contributions as office space and room and board if necessary at the beginning. It is clearly a priority for us, and our student will be well served.

The Patagonia project is under Pia Barros supervision and so will be the student. The project goal is to achieve the highest performance and efficiencies possible through lean systems philosophy. The idea is to apply reengineering and automation to current processes that will let us scale up with the highest standards.

The project supervisor will direct and support the student in all aspects of the project as required to maximize the student potential. Pia Barros has extensive experience in this type of projects and is looking forward to introducing the student to the team.

In closing, I would like to say that I am proud that RECYCLA and MIT have embraced this project.

Sincerely,

Fernando Nilo
Founder & Schwab Entrepreneur

281 SW 129th Terrace
Newberry, FL 32669

Jean E. Theurer

jtheurer@mit.edu
(C) 352.672.0860

229 Vassar Street #733-2
Cambridge, MA 02139

Education

Massachusetts Institute of Technology

Candidate for B.S. in Mathematics and B.S. in Mechanical Engineering
Minor: Earth Sciences; Concentration: Economics

Cambridge, MA

June 2010

Eastside High School, International Baccalaureate Program

Graduated, dual enrolled at the University of Florida in senior year

Gainesville, FL

June 2006

Experience

Solar Electric Light Company (SELCO) Food Cart Project

Team Member in Development Lab

Cambridge, MA

Spring 2008 – Present

- Worked in a team of three students to design and build an affordable, customizable food cart with a streamlined manufacturing process for low-income Indian citizens.
- Interviewed and photographed food cart owners in Delhi over the summer to confirm and adjust design.
- SELCO has begun building a prototype for field-testing in Bangalore.

Global InfraSys – Asia Consulting Group

R&D Intern

Guragon, Haryana, India

Summer 2008

- Created the 3rd largest power and energy presentation with over 100 slides in 60% of the time of an average ACG consultant.
- Contributed to the design and creation of 1500+ record database and 500+ slide global report.
- Received a \$2K travel grant from Indo-US Science and Technology Forum.

Massachusetts Institute of Technology

Research Assistant – Sloan School of Management

Cambridge, MA

Spring – Summer 2007

- Coded portions of probability model to assess purchasing patterns in consumer behavior.
- Produced a MySQL database of cable TV customers in the Los Angeles area.

Broadmoor Businesses Website

Team Member

New Orleans, LA

March 2007

- Interviewed returning business owners on their experiences after Hurricane Katrina, cost of reopening their business, and their current operating hours.
- Compiled information into a website for local residents using Google Maps.

All About Women: Obstetrics and Gynecology

Computer Assistant

Gainesville, FL

Summer 2006

- Created an algorithm using Microsoft Visual Basic to streamline current scheduling issues and future company expansions.
- Customized patient information software for the specific needs of an OB/GYN office.
- Designed a program to accelerate insurance billing process for the office receptionist.

Leadership/ Activities/ Awards

Burchard Scholars Program in the School of HASS

2008

Team Leader, Varsity Women's Soccer Team, MIT

- NEWMAC Rookie of the Year, Women's Varsity Soccer

2006

Executive Board Member, Student Athletic Advisory Committee, MIT

2006, 2007

Student Member, American Statistical Association

- Won 1st Place American Statistical Association Project Competition

2005

Skills

SolidWorks, MatLab, LabView, MathCad, Mathematica, Excel, PowerPoint, Windows OS

Interests

Electric Vehicle Team, Tutoring, Travel, Computers, Sustainability, Ocean Energy