DONALD BREN SCHOOL OF
ENVIRONMENTAL SCIENCE & MANAGEMENT
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

GROUP PROJECT BRIEF

END-OF-LIFE MANAGEMENT OF CELL PHONES IN THE UNITED STATES

Project Members:
Vered Doctori
Leigh Favret
Mihoyo Fuji
Sarvy Mahdavi
Robert Miller
Joaquin Neira
Project Advisor:
Assistant Professor Roland Geyer

ON THE WEB AT HTTP://WWW.BREN.UCSB.EDU SPRING 2006

Introduction

Electronic waste is now the fastest growing waste stream in the industrialized world. Thus, the management of e-waste is emerging as a global environmental problem, mainly due to the hazardous materials contained in electronic products and increasing consumption of these products.
Cell phones are a unique niche in the e-waste waste stream, not only because of their large volume and low lifespan of 18 months, but also because they contain material that has economic value.

In 2005, 130 million cell phones were retired in the U.S., according to the Environmental Protection Agency.

If these current practices persist, the cell phone waste stream will continue to flow in the direction of landfills or incinerators.

Some countries have begun to address the e-waste problem by leading legislation to curb currently destructive practices. The European Union (EU) has emerged as a leader in e-waste management with the adoption of the Waste Electrical and Electronic Equipment Directive (WEEE) and the Restriction on Hazardous Substances (RoHS).

The EU first introduced the policy concept of Extended Producer Responsibility (EPR), which makes manufacturers responsible for the end-of-life management of their products. This legislation could in turn incentivize the concept of Design for the Environment (DfE), which is intended to encourage the design of products which are easier to recycle, disassemble, and/or reuse.

Attention has now turned to the United States to also develop a mandatory, uniform e-waste initiative. Although no federal initiative has been implemented, several states are in the process of developing/ implementing take-back policies that address electronic waste management. If states however do not coordinate their implementation efforts, they may create difficulties for stakeholders to uniformly comply with legislation.

Currently, with the voluntary take-back and buy-back system in place, only 5% of cell phones are being collected. If policy is implemented, the United States will have the following two approach options:

- *Voluntary*
- *Mandatory*

In response to the European Directives, many international companies have begun to create a variety of control measures to cost-effectively comply with the EoL management regulations. They have also begun to change the design of cell phones in order to potentially create profitable operations from the EoL management of the products.

Goals and Approach

The research and analysis presented in this paper aim to recommend an optimal end-of-life management option for cell phones in the United States. Since both legislation and design dictate the management of a product, they must be considered in addition to EoL options.

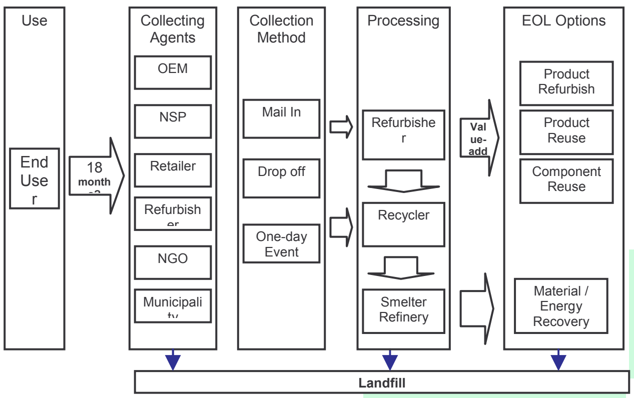
The authors of this report have divided EoL product management into three main stages:

- Collection
- Fate Determination
- Processing

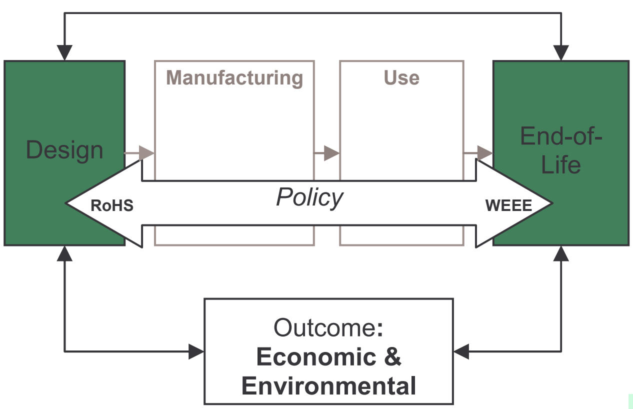
In the processing stage, the following options have been considered:

- Reuse of phones
- Reuse of components
- Recycling of materials

The full EoL process overview among all supply chain agents may be seen in the chart below:



The interaction of these three aspects (policy, design, and EoL) affects the market outcome from both an environmental and economic standpoint.



It is critical that the economic output is positive in order to obtain a self-sustaining market, but very often economic transactions are associated with environmental burdens. This research aimed at finding a balance by highlighting that option which provided the lowest environmental burden and highest economic benefit.

The authors conducted a comprehensive quantitative and qualitative analysis, along with a sensitivity analysis in order to access the problem on-hand.

Our Collection and Recycling Effort

Before conducting our analyses, the authors conducted a cell phone collection and recycling effort. The collected phone sample was sorted, shredded, and smelted.


Results from this recycling effort included:

- Average age of recycled phones in the market is approximately 6 years.
- Recycling process yielded 0.35% of precious metals and about 7% of copper per cell phone. Composition depends on sample age and design trends.
- Precious metals rendered less than $1 per cell phone. Gold represented 80% of the revenue.
- Profit margin rendered less than $0.10 per cell phone, emphasizing the importance of economy of scale in this business.
- Process profitability is highly sensitive to metal market volatility.
- Recyclers cannot afford to bear collection cost.

Economic and Environmental Analyses

In order to quantify the environmental and economic outcomes of different end-of-life options, a cost-benefit analysis was performed. Factors considered which significantly affected economic performance included quality of phone (age/condition), collection method (mail-in, drop-off bins, one day collection event), and economy of scale.

The following were the analyses findings:
Economic performance

- Collection and pre-processing account for 80% of the entire EoL cost
- Current market (65% reuse) is profitable: Only 95% of revenues come from second-hand market, 5% from recycling
- Different collection methods yield different quality of phones affecting their EoL fate and residual value, accordingly.

Environmental performance

- Material recovery increases when recycling rates increase.
- There is an aggregate amount of waste displaced in the market when recycling results in the reduction of ore mining.
- Assuming no displacement of new phone production, all processes are energy consuming. The larger the market operation becomes, the higher the energy consumption

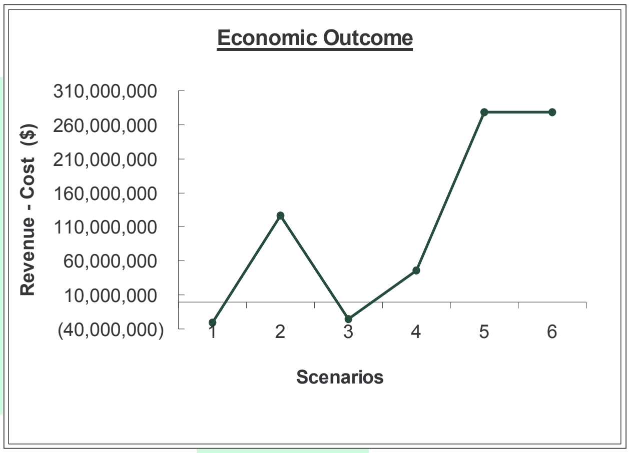
Scenario Analysis

A sensitivity analysis was performed in order to determine which factors most affected the economic and environmental outcomes. Based on dominant market factors (reuse rate, collection rate, and average second-hand phone value), six market scenarios were created using different values for the factors that change the outcome the most. The table below outlines the value of the factors that were changed in each scenario.

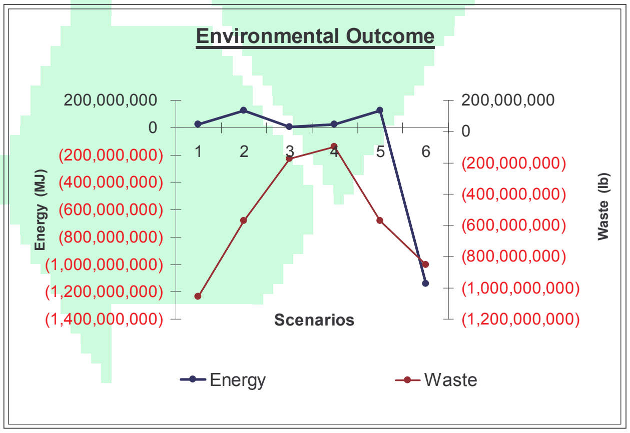
	Factors			
Scenario Number	Collection Rate	Reuse Rate (%)	Second-Hand Avg. Phone Value ($)	New Production Displacement (%)
1	High (30%)	35	16	0
2	High (30%)	65	16	0
3	Low (5%)	35	7	0
4	Low (5%)	65	22	0
5	High (30%)	65	22	0
6	High (30%)	65	22	25

- The maximum reuse rate (65%) is the baseline number. We consider this rate to be high since it is based on a free market mechanism.
- Collection rate of 5% is the baseline number and 30% is the possible attainable rate.
- The second-hand phone value is closely tied with the phone quality (model, age and condition), consequently it can continuously change reflecting the market trend. We have considered possible extreme prices both for high ($22) and low ($7) relative to the baseline ($16).
- The 6th scenario accounts for 25% displacement of new production in order to demonstrate the positive effect of a change in this factor

The following graphs showcase the economic and environmental outcomes:



- Minimum reuse rate is required to sustain a positive economic outcome
- Collection rate enhances the economic outcome
- Second-hand phone value is important but not crucial.



- High collection rates result in a large amount of avoided waste and materials recovered (if recycled), but it also results in increased energy consumption.
- If displacement is assumed, reuse is preferred since the environmental performance aligns positively with economic outcome.

Recommendations

From the quantitative and qualitative analyses, the authors devised a set of recommendations to hopefully guide market stakeholders and policy makers. The authors divided these recommendations into the following areas of EoL operations, policy, and design:

EoL Operations

1. Increase reuse rate. Stakeholders should strive to create mechanisms that increase the reuse rate as much as possible.

2. Increase collection rates. Invest in collection efforts to increase the number of high-end, second-hand phones.

3. Increase logistics efficiency. Economy of scale is important; high collection rates will help secure a net positive economic outcome all the while decreasing the current environmental impact of the associated waste.

4. Use existing infrastructures such as retailers and network service providers to interact with end-users; this mechanism will minimize capital investments and shipping transactions.

5. Share reverse logistics efforts between supply chain agents to improve efficiency.

6. Promote development of recycling infrastructures in developing countries.

Policy

1. Ensure minimum reuse targets to ensure that end-life cell phone industry will remain profitable.

2. Set minimum collection rate targets. To ensure high collection rates, OEMs should place mail-in envelopes in their packaging. Retailers should take back phones without payment. Another possibility for incentiving take back could be a tax credit for consumers.

3. Effective end-of-life cell phone management must be a multi-pronged legislative approach in order to achieve positive environmental and economic outcomes. An effective legislative approach to meet minimum end-of-life management goals must include provisions for a landfill ban, ban hazardous substances, labeling, enforcement, address legacy, historical waste, and responsible recycling.

4. Tax credits should be offered to OEM's to promote design for disassembly and recyclability R&D efforts. Create flexible mechanisms to allow OEMs to take-back their own products to incentivize DfE.

5. Once policy is decide upon and made, it must be re-evaluated periodically to make sure desired outcomes are being met.

Design

1. Design cell phones to be more easily recycle-able and/or reuse-able. OEMs should continue to examine methods including active disassembly and elimination of metal fasteners to promote easier recycling of cell phones.

2. Develop more industry-compatible technology. Cell phones sold in the U.S. are typically designed to operate on only one of the competing technologies of CDMA or TDMA. By making these systems more compatible and consumer-friendly, users are not forced to discard as many cell phones as they switch network providers.

3. Phase out certain technologies; OEMs and NSPs should work closely to avoid flooding the market with potential obsolete new phones (case of TDMA).