

NCER Assistance Agreement Final Report Executive Summary

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Student Team Members: The NJIT P3 Student Design Team consists of five Industrial and Manufacturing Engineering seniors—Javier Ortiz, Marelis Bernal, Yvette Blackbourne, Jennifer Hernandez and Fernando Albayeros—in collaboration with William Davis, an Environmental Policy graduate student, New Jersey Institute of Technology, Newark, NJ 07102. The project was embedded within the industrial engineering senior capstone design course.

Project Period: October 1, 2004 – May 17, 2005

Description and Objective of Research: Material and resource conservation are critical to sustainability; and, the ability to efficiently and effectively recover old products for reuse and recycle is an essential element in these conservation efforts. In California alone, it has been estimated that 10,000 computers and televisions become obsolete every day; and, with over 50 million more of these products sold annually, the problem is growing rapidly.

The overall objective of the project is to design a system for electronics recycling that is cost effective, operationally efficient, and operates in an environmentally safe manner. The specific objectives for this initial phase I effort are as follows:

- To review and expand previous electronics recycling system analysis tools and examine alternative collection and recycling scenarios for Essex County, New Jersey.
- To create design scale-up, economic intensity and environmental factors and drivers to scope a national electronics recycling system.
- To apply design factors to the national level in order to understand the scope and dimension of the problem for further detailed design and analysis.

Societal concerns are inherently coupled to e-waste in myriad ways, including exporting issues, new product innovation, and land use. Economic considerations go well beyond costs and benefits. The electronics industry is a major sector of the economy; consequently, care must be taken not to jeopardize, but to enhance, the vitality and viability of this important industry. In addition, electronics reuse and recycling directly impacts the environment by keeping material from entering the waste stream while reducing the need for virgin materials. People, prosperity and the planet are all fundamentally linked to the project.

Summary of Findings: The cost methodology developed for the Seattle-Tacoma study was expanded to include curbside collection options, directly estimate processing costs, and update the unit cost values. The cost per pound is important in determining the operational efficiency of a facility and in reflecting the potential economic performance of the system. For the case study considered, the average cost per pound was calculated to be approximately \$0.31, which is

close to other estimates and within the range of costs estimated in Minnesota, Massachusetts and California. The results from the Essex County, New Jersey case study were extrapolated to the national level in order to get an estimate of the required infrastructure and costs for a national electronics recycling program. The results show that over 570 million pounds (285,000 tons) of old electronics will be collected and processed each year nationally. For the estimated \$0.31 per pound, this corresponds to a total cost of over \$175 million annually

Conclusions. Societal concerns are inherently coupled to the e-waste issue as consumers generate demand for new products in the marketplace, households become storage areas for obsolete products on their way into the waste stream, and in one way or another, people will pay the cost associated with the recycling program. In this study the focus is on economic implications and environmental concerns.

Diverting electronics from land-fill. With a national electronics recycling system in place, over 570,000,000 of old electronics will be diverted from the land fill.

Reducing the amount of lead and other hazardous materials from landfills. The project's impact can be quantified in terms of reduced environmental impact and/or in terms of improved environmental health. The amount of lead and mercury from Cathode Ray Tubes (CRT's) was estimated for each state and geographic region.

Proposed Phase II Objectives and Strategies: The NJIT team is not requesting funding for Phase II; however, the team believes its initial phase was extremely successful in identifying the scope and boundaries to the design problem proposed.

The primary strategy to finalize the detailed design and analysis of a national electronics product reuse and recycling system is described below in terms of six major tasks. Each of these tasks involves research to better understand the P3 implication in each area, to select appropriate analysis tools and techniques, and collect data to support the design and analysis process; development activities to adapt this knowledge and information to the P3 design challenges for the system; and, implementation efforts to assure the final design achieves success from all perspectives including technical soundness, economic viability, and full stakeholder acceptability.

1. Infrastructure and Operational Scenario Builder: Various collection scenarios will be considered for the case study area ranging from single, large drop-off facilities to a highly-distributed set of micro-collection facilities co-located at existing retailers, charities and municipal facilities. In addition to fixed drop-off facilities, some of the scenarios may include special collection events at parking lots and other locations in the study area. Consideration of other infrastructure elements, e.g., consolidation points, transportation strategies and processor locations, and potential policy implications will be included.
2. Service Area and Collection Volume Estimator: Population databases (e.g., Census 2000) may be used in conjunction with the area highway network to map locations, determine population and the number of households within the service areas and calculate travel and transport distances. For each collection site in a scenario, an estimate of e-waste expected to be collected will be determined from which the facility and operational requirements and associated costs can then be calculated. Various

approaches to forecasting product obsolescence and estimating e-waste generation will need to be explored by the design team .

3. Material Flows and Operations Simulation: A discrete event product/vehicle flow simulation may be useful in depicting process delays, designing facilities and estimating vehicle queuing at system collection sites. From these calculations and other operational and facility data, the energy consumption and greenhouse gas impact of each scenario can then be estimated.
4. Collection, Transportation, Consolidation and Processing Cost Model: A set of cost models will need to be developed that directly estimate capital costs, operational fixed costs and operational variable costs. With these general models, the incremental and marginal costs for providing electronics collection at existing facilities or newly constructed facilities can be determined. Cost drivers can be determined and linked to operational and convenience factors leading to opportunities for cost reduction and operational improvements.
5. Financing Strategies and Policy Implications: Various options for financing the system, ranging from advanced recovery fees paid by the customer at the time of purchase to end-of-life fees paid at the time the product is dropped off at a collection site, should be explored. Each alternative has significant policy implications from both an environmental and societal perspective, as well as a political perspective that must be understood and evaluated.
6. Design Criteria Evaluation and Assessment of Sustainability: Evaluation of design criteria related to cost, efficiency, effectiveness, convenience, environmental soundness and sustainability, and flexibility will be used to assess each scenario. Program design is an iterative process in which lessons learned and analysis results from other scenarios can be used to modify designs and improve the balance between the design criteria.

Relevant Web Sites: Industrial and Manufacturing Engineering Department link at www.njit.edu has details on the project.