UPR/MIT/TU Professional Development Program
Transportation Technology Transfer Center
University of Puerto Rico at Mayagüez
Mayagüez, P.R.

Executive Summary

A STREAMLINED LIFE-CYCLE ANALYSIS METHODOLOGY FOR THE ENVIRONMENTAL PERFORMANCE EVALUATION OF TRANSPORTATION MODES IN THE SAN JUAN METROPOLITAN AREA

by

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Executive Summary

Introduction

The transportation problems of Puerto Rico, and especially those of the San Juan Metropolitan Area (SJMA) are of great concern among government and community. But the greatest concern about these problems is the associated environmental impacts.

Excessive use of transportation imposes a great burden on the environment. Transportation mode use produces different types of effluents, such as: solid waste (cardboard, parts), liquid residues (motor oil), and gaseous residues (Carbon Monoxide, CFC's). These in turn, cause different environmental impacts such as:

- global climate change (greenhouse effect)
- photochemical smog (ground level ozone)
- stratospheric ozone depletion (interaction of CFC's and ozone)
- acid rain (Sulfuric Acid produced when sulfurs combine with water
- human health hazards (respiratory problems)
- visibility deterioration (light scattering due to suspended particulates)

Current Alternatives

Current alternatives which are available to solve the problem are mass transportation systems such as:

- Buses: provide area-wide service to the SJMA; fleet has an average of 154 vehicles divided in 34 routes.
- Trolleys: owned by the municipalities, these provide local service within downtown areas.
- "Aquaexpreso": currently out of service due to the dredging of the Martin Peña Channel.
- Tren Urbano: heavy rail system scheduled to begin service in 2002.

Justification

Current alternatives provide accessible transportation to the residents of the SJMA, but still produce environmental impacts. Therefore, several question must be answered:

- How could environmental impact of transportation modes be assessed?
- How does one mode compares against another in terms of environmental performance?

In order to answer these questions, a methodology for the assessment of the burdens imposed on the environment by the use of transportation modes in the SJMA is essential. Such methodology would enable to evaluate and compare modes, and evaluate effect of transportation-related decisions and policy.

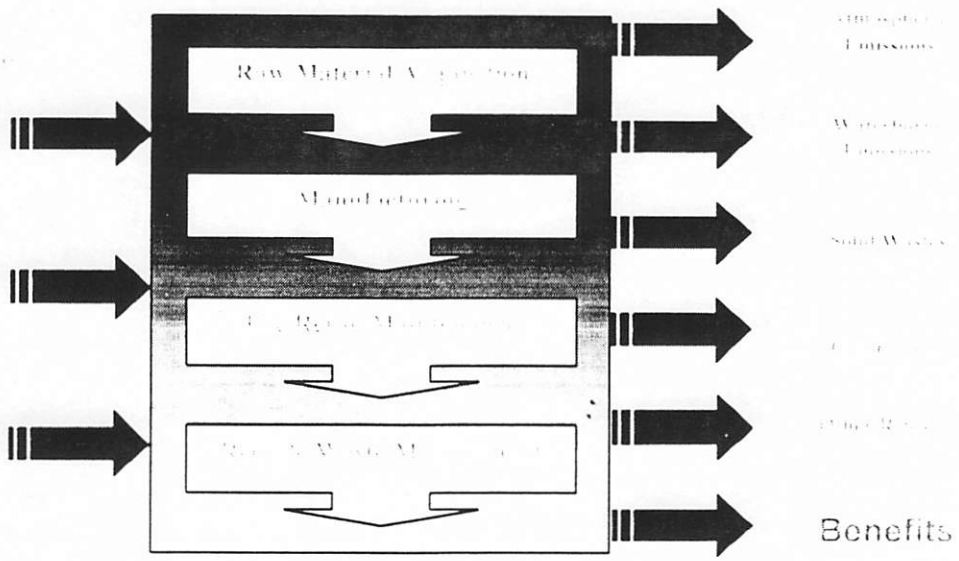
Life-Cycle Assessment (LCA)

Life-Cycle Assessment is an objective tool used to evaluate the environmental effects of products, processes, systems and/or activities. The technical framework for LCA's was developed by the Society of Environmental Toxicology and Chemistry (SETAC) in 1990, and it has received a lot of attention in the environmental field since then. Life-Cycle Assessment was originally developed manufacturing, but current and potential applications include: design, decision-making, and public policy.

Life-Cycle Assessment has three fundamental components:

- Inventory Assessment: all inputs and outputs are accounted for; principles like mass and energy conservation are applied.
- Impact Assessment: outputs are related to their associated environmental impact, and an environmental impact indicator is obtained.
- Improvement Assessment: identify area of life-cycle that need improvement, and find alternatives to decrease impact potential.

The diagram below depicts the concept of LCA. Materials, energy, and natural resources that input all life-cycle stage are considered. Then, this inputs are converted into outputs (emissions) and benefits. The main goal of this method is to decrease the outputs while keeping benefits constant or increase them.



Research Objectives

The main objectives for this research are as follows:

- Develop a methodology to compare the environmental performance of transportation modes in the SJMA.
- Combine available LCA approaches and incorporate valuation factors such as public perception and toxicological knowledge.
- Run an example to test the methodology and show its applications.

Literature and Sources

During the literature review to similar work to the one being done was found. However, work has being done related to life-cycle assessments and different aspects of the methodology. Literature has been found in the following areas:

- Methodology Development
  - Society of Environmental Toxicology and Chemistry (SETAC), 1991-1994
  - ISO 14040 Series, Currently
- Methodology Application
  - Graedel and Allenby, 1995, 1998
    - Developed matrix-based techniques for performing LCA's
    - Apply Design For Environment (DFE) and LCA concepts to the automobile.
  - Allenby, 1996
    - Defines the concept of Industrial Ecology, its goals, and discusses applications.
- Methodology Importance
  - Curran, 1996
    - Establishes the importance of LCA's, applications and discusses case studies.
  - Field et al, 1993
    - Describes LCA as an excellent tool for regulators and policymakers.
- Key Challenges of LCA Use
  - Wells et al, 1994
    - Discusses the main challenges of measuring environmental performance; these are: data quality, data availability and uncertainty.
  - Heijungs, 1996
    - Discusses the key issues for improving LCA reliability; suggests the use of screening to identify most important areas, and suggests uncertainty analysis.
  - Kaebernick and Paul, 1995

        - Ranking scheme to compare environmental impact of pollutants in terms on severity, time of exposure, and mode of exposure.
    - Curtiss and Rabl, 1996
        - Develops methodology for the valuation of impact of air pollution based on site dependence and pollutant removal rate.
    - Owens, 1997
        - Risk assessment technique to valuate human health stressors based on time of exposure, mode of exposure and dose/response relationships.
- Different Methods
    - Dohnomae et al, 1996
        - Input-Output method: calculates life-cycle inputs between industries backwards; from outputs to inputs.
    - Kalisvaart and Remmerswaal, 1994
        - MET-points method (Materials, Energy, Toxic Emissions): uses effect scores for valuation, and points to measure performance.
    - Emblemsvåg and Bras, 1997
        - Activity-based LCA method: uses traditional economic analysis
    - Hogan et al, 1997
        - Threshold Inventory Interpretation Methodology (TIIM): accounts for threshold pollutant concentrations and whether this concentration has an observable effect or not.
- Data and Information Sources
    - Environmental Protection Agency (EPA)
    - Bureau of Transportation and Statistics (BTS)
    - Federal Highway Administration (FHA)
    - Federal Transit Administration (FTA)
    - Departments of Transportation (USDOT, DTOP)
    - Tren Urbano Office (TUO)

Work Progress

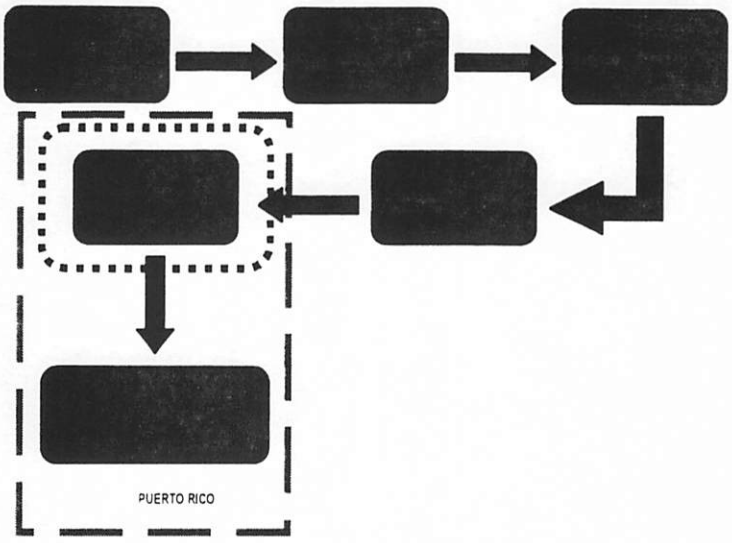
The first step was to establish the scope or extent of the analysis. This is done because complete LCA's are time-consuming and expensive; besides fast and relevant results are desired, thus performing a complete LCA wouldn't serve such purpose.

The scope of the analysis will focus on the use stage of the transportation mode's life-cycle. The reasons for choosing the use stage are:

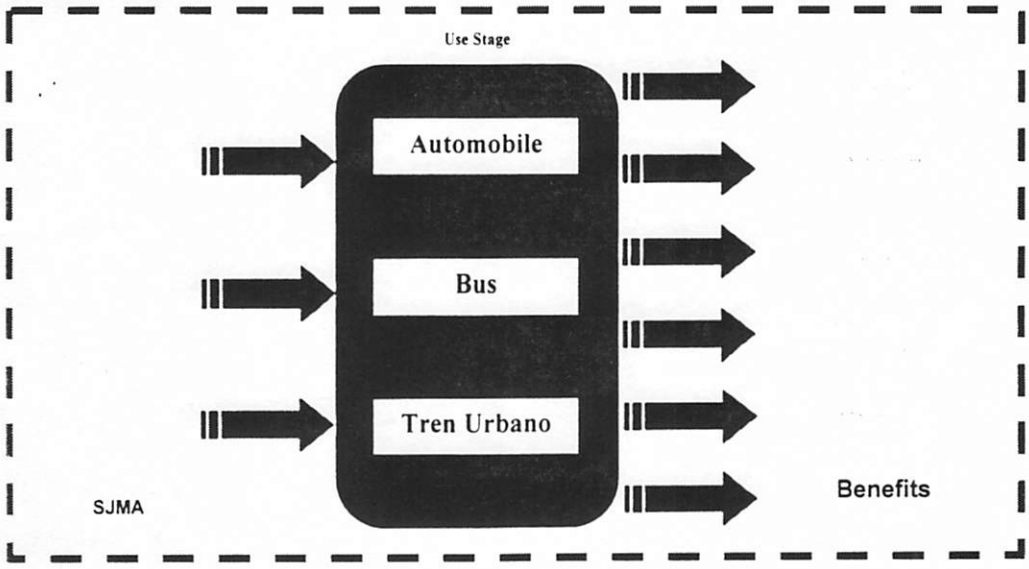
- The use stage is the one that has the greatest impact and is the longest, ranging between 10 and 15 years.

- All stages prior to the use stage are not conducted in Puerto Rico which is the spatial boundary of the analysis.

The following diagram shows the analysis scope.



Then looking inside the red-dotted boundary, the scope or extent of the analysis for that boundary must be established. The analysis will focus on the SJMA, and will consider the use of the automobile, the buses, and Tren Urbano. This scope is depicted in the following diagram. Note it is the LCA diagram for the boundary selected.



Also, the inventory assessment has been started. For this, required data sources have been identified and contacts have been made. Dr. Nigel Wilson, from MIT, helped contact Mr. Tony Kinnehan, MBTA Red Line Superintendent, for technical information about Boston's red line which is the closest technology to the one being implemented in San Juan.

Dr. Antonio González, from UPR-Mayagüez, helped contact Ms. Freya Toledo, from the DTOP, for technical information on the buses used by AMA in the SJMA.

Visits to gather data on the facilities are being arranged, and corresponding permits requested.

Emission factors that will be needed during the inventory assessment have been identified and are being collected.

Future Work

The next step on the research is to complete the inventory assessment. Once this assessment is completed, the impact assessment will be developed. For the impact assessment resources needed will be identified and contacted, data will be gathered, and then the assessment performed. Later, the improvement assessment will be developed.

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