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Progress Report

**Use of Life Cycle Assessment in the Environmental Decision-Making
Process for Transportation Infrastructure Projects.**

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Title

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Introduction

San Juan Metropolitan Area is facing one of the largest infrastructure projects in decades, the construction of a heavy rail system called Tren Urbano. In order to fulfill this task, an Environmental Impact Statement (EIS) was prepared beforehand complying both the National Environmental Policy Act (NEPA) and the Puerto Rico Environmental Public Policy Act. Because of the complexity of the EIS, people with little or no knowledge in certain field can hardly understand what the statement reveals.

NEPA is a federal policy committed to the protection of the environment. It simply requires the government to act with the knowledge of the potential environmental consequences of a proposed plan. The policy does not require the government to follow recommendations suggested by the EIS, but for every major project that requires an EIS, one must be prepared.

Once the EIS is stated, the affected public is invited to review and comment on the EIS. Different opinions arise on both the adequacy of the study leading to it and the actions and alternatives suggested as a result of the study. For this reason, NEPA offers general and nonspecific guidelines for what constitutes an EIS.

Major Problem

One of the purposes of the Environmental Impact Statement is to specify mitigation for environmental impacts due to the implementation of the Tren Urbano. It

contains an analysis on natural environment, which includes air quality, noise, vibration, ecosystem, water resources and energy. This information is available to the public in general, but it cannot be easily interpreted due to its complexity.

Research Description

The primary concern of the research is based on the natural environment assessment of the EIS. It is intended to analyze exclusively the air quality, noise, vibration and energy aspects, being energy the main interest.

Objectives

- To get acquainted with the natural environmental analysis on air quality, noise, vibration and energy of Environmental Impact Statement for the Tren Urbano.
- To evaluate the air quality, noise, vibration and energy assessments in order to develop a more comprehensible guide for the EIS by using the Life Cycle Assessment.
- To design a transparent, qualitative method of translating the EIS by incorporating the Life Cycle Assessment.

Research Justification

In a decision-making process, the stakeholders' point of view is essential. That is the major reason for which the Environmental Impact Statement is published and is available for the public. Being the neighborhood the largest number of stakeholders, they have the right to give their opinions and concerns. If this group is not capable of understanding the EIS, then the process has a flaw because not everyone could be part of the decision-making process. The decision-making process can be improved by simply finding a model to "translate" the EIS to a more uncomplicated and transparent approach. It is of great importance, maybe not for the first stage that the Tren Urbano undergoes now, but for the phases planned for the future.

Preliminary Findings

For purpose of this research, two different transportation alternatives will be considered: the automobile and the Tren Urbano, which is a heavy rail system. Being Puerto Rico an island, the scope for the analysis is the use and maintenance stage where the environment impact will be more significant.

The Life Cycle Assessment includes an analysis and evaluation of all the input and output of a system. The inputs for both the automobile and Tren Urbano systems are Materials, Natural Resources and Energy. The latter is the main interest of this research. The outputs for the system are Atmospheric Emissions, Noise and Vibrations, Solid Wastes, Waterborne Emissions, Co-products and Benefits. In this research, Atmospheric Emissions, Noise and Vibrations will be assessed. The diagram showed below shows at the left the input and at the right the output of the system.

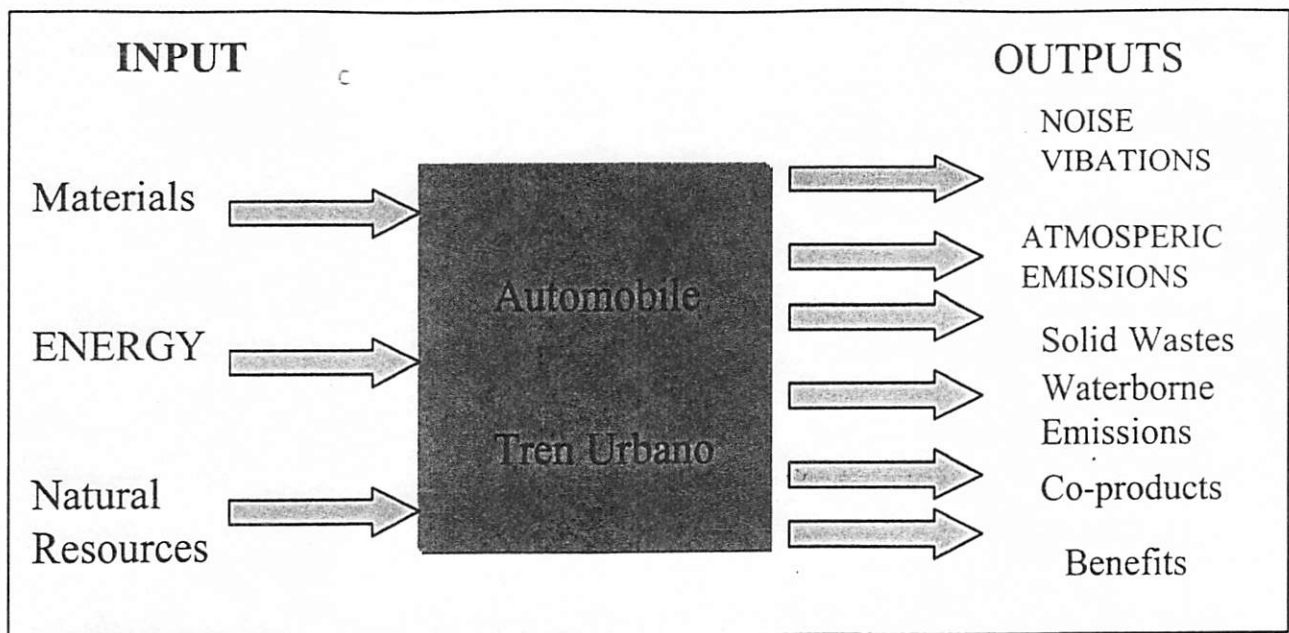


Figure 1: Diagram of inputs and outputs for both system in a LCA.

Using the LCA, a comparison between the automobile and the Tren Urbano will be achieved by evaluating:

1. Energy consumption during operation and continuous maintenance.
2. Atmospheric Emissions produced during operation and continuous maintenance.

Atmospheric Emissions result as a hazard to a series of environmental concerns, such as:

- Global warming
- Ozone depletion
- Acid rain
- Human health
- Natural resource depletion

List of products associated with the Emissions produced by the No.6 Oil combustion at

PREPA:

- Methane (CH_4)

- Carbon dioxide (CO₂)
- Nitrogen oxides (NO_x)
- Carbon monoxide (CO)
- Sulfur dioxide (SO₂)
- Lead (Pb)

List of products associate with the Emissions of an automobile:

- Carbon dioxide (CO₂)
- Nitrogen oxides (NO_x)
- Carbon monoxide (CO)
- Sulfur dioxide (SO₂)

For the automobile, the energy is produce by gasoline combustion. A medium car consumes fuel at an approximate rate of 25 miles/gallon. Tren Urbano is an electrical heavy rail system. This means that in order to quantify the energy consumption and the airborne emissions it has to be considered the energy produced at an electric power plant. The Puerto Rico Electric Power Authority (PREPA) generates electricity by fossil fuel combustion. Meaning that the environmental impact is associated with the fossil fuel combustion. The table below shows data available on the Electrical Power Generation in Puerto Rico:

Percentage of Total Electric Power Production from Fossil Fuel (%)	98.00
Percentage of Total Electric Power Production from No.6 Oil (%)	76.26
Power Generation Cycle Gross Efficiency(kWh/BBL)	569.45
No.6	491.04
No.2	548.65
Total	
Power Generation Cycle Water Consumption (gal/kWh)	1.00
Annual Average Electrical Consumption per Home (kWh)	4,949

Table 1: Electrical Power Generation in Puerto Rico (PREPA).

Taking into consideration that for both transportation systems Energy is produced with petroleum by-products, the assessment will be done regionally and locally. Since, the process of extraction and refinement of petroleum affects only globally it will not be part of the scope of the problem. If fuels such as natural gas and bio-diesel were consumed by automobiles to produce Energy, then it would have been taken into consideration. Figures below describe the process of Energy generation for a car and for an electric car.

Figure 2: Energy Generation for an Electric Vehicle

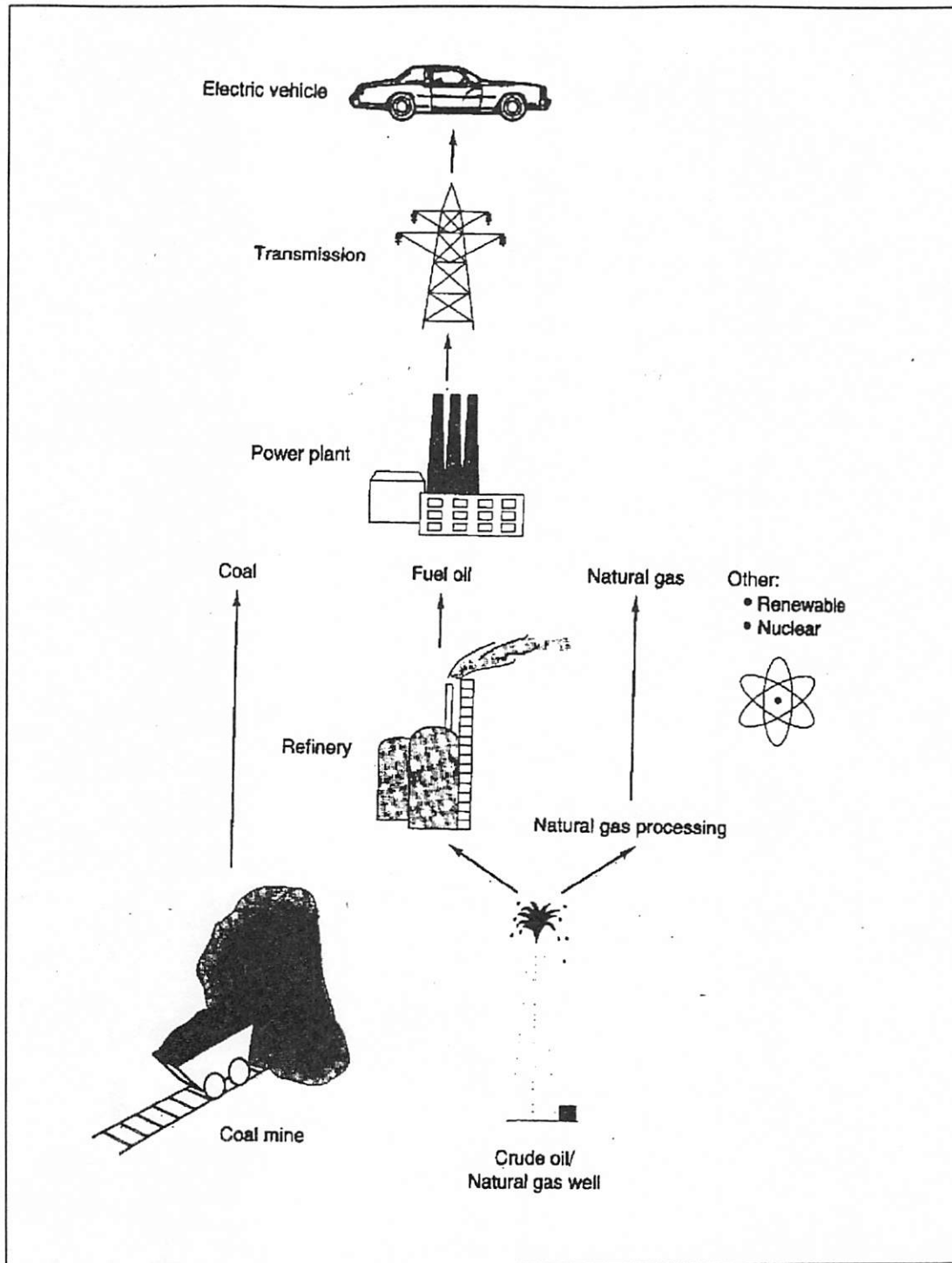
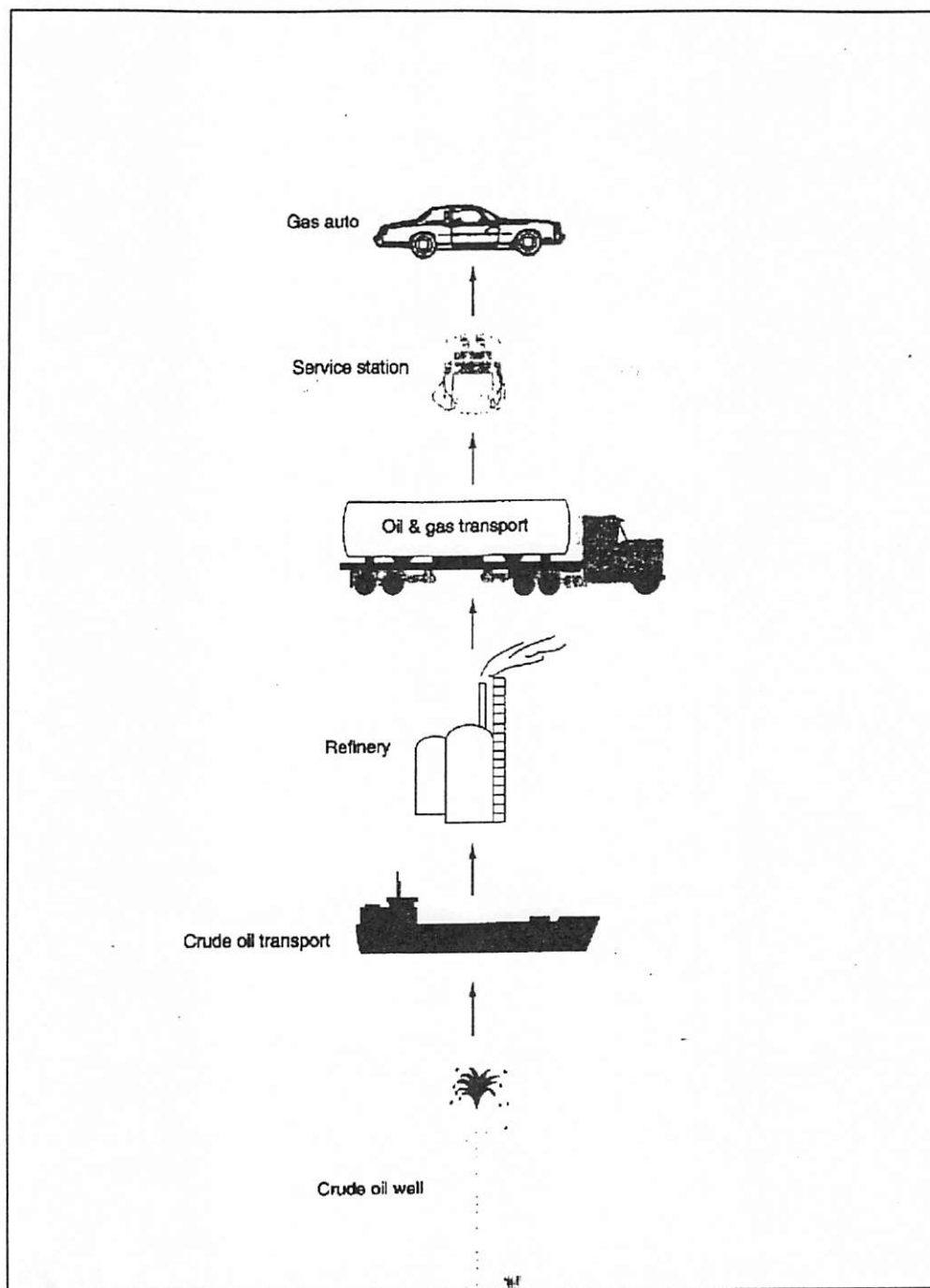


Figure 3: Energy Generation for a Gas Vehicle



A functional unit is a normalized parameter created as a baseline of comparison. For purposes of this research, the functional unit will be input or output per passenger-mile. The selection was based upon the existing parameter in the available information. An equivalent-use ratio is a parameter used to compare to alternatives by knowing how many input units of alternative 1 are needed to fulfill the same benefit as alternative 2.

If a Tren Urbano train is operating with 6 cars, and the capacity per car is 180 passengers, the train capacity is 1080 passengers. The maximum capacity of a car is 5 passengers. The equivalent-use ratio that will be is 216:1.

Conclusions and Recommendations

After making a list of stressors and impact categories for the car versus Tren Urbano in Energy and Atmospheric Emissions, the next step is to create a formal Life Cycle Inventory. Once created the weight rated method will be used to find an environmental efficiency, which will then be used to translate the EIS. The EIS information will be presented in form of tables where the ratings will be satisfactory, fair, and not satisfactory. Since the Energy assessment is more complex than the Noise and Vibrations one, the first mentioned will be completed and afterwards the latter.

As a recommendation, the total of miles for Tren Urbano alignment from Bayamón to Minillas cannot be compared using the same mileage for the car. It is very important to find the total miles traveled by a car from Bayamón to Minillas considering the principal roads. Then a equivalent use ratio can be calculated using the same concept as for the maximum passenger capacity equivalent use ratio.

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