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GREEN DESIGN INITIATIVE

Life Cycle Models of Conventional and Alternative-Fueled Automobiles

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Introduction:

The automobile sector is a major component of the economy, using vast quantities of resources and discharging large quantities of residuals. Greenhouse gas emissions, conventional pollutants, toxic substances, and the use of materials and fossil fuels cannot be managed satisfactorily without considering the manufacture, use, and disposal of automobiles. Knowing the life cycle (LC) implications of particular designs and materials is essential for intelligent management and policy decisions.

Since the 1960s, legislation and regulations have reduced or eliminated much of the automobiles' environmental discharges by reducing new car tailpipe emissions by 90 to 95 percent, doubling fuel economy and eliminating CFCs in new car air conditioners. Further reducing the environmental effects of cars while preserving their attractiveness to consumers is difficult. It is easy to be deceived about the environmental benefits of a change that reduces the discharges of one LC stage, but transfers these discharges to another stage or medium. If changes to the design of automobiles and their associated products are to improve environmental quality, society needs to consider their full LC.

Objectives of Research:

The results of life cycle analyses (LCA) of conventional cars (gasoline and diesel-powered) provide information to set priorities for lessening their environmental impact. The evaluation of automobiles fueled by alternative fuels (e.g. methanol, natural gas, electricity) indicates the viability of these alternatives to enable a shift to a transport system that retains the current benefits but lessens environmental impacts. As well, our research highlights priorities for the future development of personal transportation options.

Approach:

We model a set of 'comparable cars' with alternative fuel/internal combustion engine combinations, based on the characteristics of a 1998 gasoline-fueled Ford Taurus sedan, the baseline vehicle for the analysis. We obtain estimates of potential thermal efficiencies compared to the baseline for the various fuel/engine combinations. A LC assessment framework is developed to summarize the array of data generated by the Economic Input-Output Life Cycle Analysis (EIO-LCA) model, the primary tool we use in our analyses. The data is aggregated into three assessment parameters; economics, externalities, and vehicle attributes. The externalities include economics, externalities (air pollution, global issues, and resource use), and vehicle attributes (vehicle interior space, curb weight, and fuel economy).

Results:

To a first approximation, there are no significant differences in the assessment parameters for the vehicle manufacture, service, fixed costs, and the end-of-life options. However, there are differences in the vehicle operation life cycle components and the state of technology development for the combinations.

Overall, none of the alternatives emerges as a clear winner, lowering the externalities and improving sustainability, while considering technology issues and vehicle attributes. Much of the attractiveness of the alternatives depends on the focus of future regulations (e.g., emissions standards, fuel requirements), government priorities (e.g., importance given to greenhouse gases, imported fuel supply issues), and technology development. Our work demonstrates the importance of systems level analyses in leading automobile manaufacturers and regulators to favor vehicle options with the potential to improve the sustainability of our personal transportation system.

Representative Publication:

"A Life-Cycle Model of an Automobile", Heather L. MacLean and Lester B. Lave. Environmental Science & Technology. Vol. 3. No. 7. 1998. p.322A-330A

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