How to Use Life Cycle Analysis Comparisons of PHEVs to Competing Powertrains

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ABSTRACT

Life cycle analysis (LCA) techniques for evaluating the merits of advanced vehicle powertrains have been derived from the physical and engineering sciences. These techniques are contrasted to the economic project evaluation technique called cost-benefit (C-B) analysis. This paper examines the implications that C-B organizational principles could have on methods for designing future variations of LCA techniques to use for comparing hybridized powertrains to evolving conventional vehicle (CV; i.e., gasoline-fueled vehicle) powertrains. It recommends that future evaluations focus on the best market niche for various hybrid-based technologies rather than the average market for evolving CV technologies. Emerging powertrain options are numerous and complex. This paper focuses on three — full hybrid electric vehicles (HEVs), plug-in HEVs (PHEVs), and compression ignition, direct injection (CIDI) distillate-fueled vehicles. It argues that the separate "best niche" reference cases for daily driving behavior for these three powertrains involves a ranking of speed/distance combinations from lowest (HEVs) to higher (PHEVs) to highest (CIDI). Implications of the logic suggest that future LCA methods for evaluating these and other advanced powertrain alternatives be modified. Evidence is presented to support the argument that HEVs and PHEVs are, in economic terms, primarily complementary (mutually beneficial and positively reinforcing) rather than competitive with one another. For those using results from past evaluations, this conclusion implies that the proper LCA comparisons of HEVs and PHEVs should be to CVs and CIDIs and not to each other.

Given this context, we examine and discuss recent preliminary total energy cycle evaluations of charge-depleting (CD) operations of PHEVs made by using the GREET (Greenhouse Gas, Regulated Emissions and Energy Use in Transportation) model. These evaluations, which preceded the development of the logic here, did not precisely follow the recommendations of this paper. They did isolate the effect of CD operation of a PHEV, taking into account anticipated average speed during CD. However, they compared these results to simulated operation at the average (higher) speed operation of competing technologies rather than at the same speed as during PHEV CD operation.

Presented at the 8th International Advanced Automotive Battery and Ultracapacitor Conference held at Tampa, Florida, May 2008.