

Viewpoint

An analysis of U.S. federal mileage ratings for plug-in hybrid electric vehicles

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HIGHLIGHTS

- We develop a model to examine US policy on plug-in hybrid electric vehicles.
- The model is applied to a single example—the Chevy Volt.
- The US EPA inflates the mileage of PEVs by equating electrical and chemical energy.
- The US EPA fails to account for generating source emissions in PEVs.
- On a “well to wheels basis,” PEV performance is similar to gasoline vehicles.

ARTICLE INFO

Article history:

Received 12 April 2014

Received in revised form

16 June 2014

Accepted 17 July 2014

Available online 5 August 2014

Keywords:

US CAFE standards

PHEV mileage ratings

Automobile well-to-wheel efficiency

ABSTRACT

With the introduction of plug-in hybrid electric vehicles, the US Environmental Protection Agency developed a rule to calculate “miles per gallon equivalent” (MPGe) for electric vehicle window stickers and the US Department of Energy created a separate procedure for calculation of fuel economy for use in the federally mandated corporate average fuel economy (CAFE) standards. The EPA rule fails to account for inefficiencies in or emissions resulting from the production of electricity and as a result greatly overestimates the life cycle efficiency of covered vehicles, which would be evident using “exergy analysis.” The DOE rule accounts for conversion efficiencies, but includes a long-standing, policy based factor (originally developed to reduce oil consumption by promoting alternatively fueled vehicles). This factor disproportionately raises the calculated performance of electrically powered vehicles. As a result, both the EPA and DOE rules incentivize policies that are not substantiated by the immediate technical merits.

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1. Introduction

In 1975, The US Congress mandated that all manufacturers who sold vehicles in the US must meet corporate average fuel economy (CAFE) standards or pay a penalty, which is passed on to consumers in the form of higher vehicle purchase prices. The Environmental Protection Agency (EPA) developed a miles per gallon of fuel (MPG) window sticker program to educate the public and support the CAFE requirements. With the growing market penetration of plug-in-hybrid electric vehicles (PHEVs), the EPA has established new rules to calculate miles per gallon equivalent (MPGe) of PHEVs for use in its window stickers ([EPA Sample Label for Electric Cars](#)). In announcing its new rule, the EPA asserted that the required window labels allow comparative analysis of the operational cost and environmental

impacts of electric and traditionally powered vehicles ([New Fuel Economy and Environment Labels for a New Generation of Vehicles, 2011](#)):

The redesigned Fuel Economy and Environment Labels will provide the public with new information on vehicles' fuel economy, energy use, fuel costs, and environmental impacts. For the first time, comparable fuel economy and environmental ratings will be available for all new vehicles, including advanced technology vehicles such as electric cars.

The methodology employed by the EPA in determining MPGe window stickers, which assumes that all energy forms are equal in value, has received some criticism in the press ([Meyer, 2010](#)), but for the most part, little technical scrutiny.

On a total energy consumed based on “well-to-wheel basis” ([Brinkman et al., 2005](#)), the benefits of electric vehicles are questionable ([Gonder and Simpson, 2006](#)), ([Li* et al., 2011](#)). [Kreith et al. \(2002\)](#) conducted well to wheels efficiency analysis of natural gas as a fuel

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under various scenarios, including conventionally burning natural gas in both spark ignition and diesel engines, hybrid vehicles and using natural gas to generate electricity, which was used to charge a grid connected plug-in vehicle. The hybrid vehicles performed the best. Direct combustion of natural gas in both spark ignition and diesel engines outperformed using the fuel to generate electricity, which in turn charged an all-electric vehicle in well-to-wheel efficiency. The [National Academies Report \(2010\)](#), on the other hand, concluded that there would be significant benefits to PHEVs, including reduced emissions in population centers, although they conclude that there are large differences depending on electric grid assumptions. [Hawkins et al. \(2012\)](#) concluded a reduction in greenhouse gas emissions when comparing PHEVs with gasoline or diesel engines, but determined that

these benefits are offset by detrimental effects on the environment based on toxicity in the supply chain.

The US Department of Energy created a separate rule to calculate fuel efficiency for use in the corporate average fuel economy (CAFE) standards. Unlike the EPA window stickers, the DOE rule accounts for some of the well-to-wheel energy conversions, but it applies a factor of 6.67 (1/0.15), which was originally developed in 1987 to encourage alternately fueled vehicles ([10CFR474](#)). The result of this rule is to incentivize electric vehicles beyond what can be justified based on an analysis of actual performance.

This paper develops a simple model to compare the energy consumption and emissions for PHEVs and fossil fuel powered vehicles. For comparative purposes, the electric and gasoline

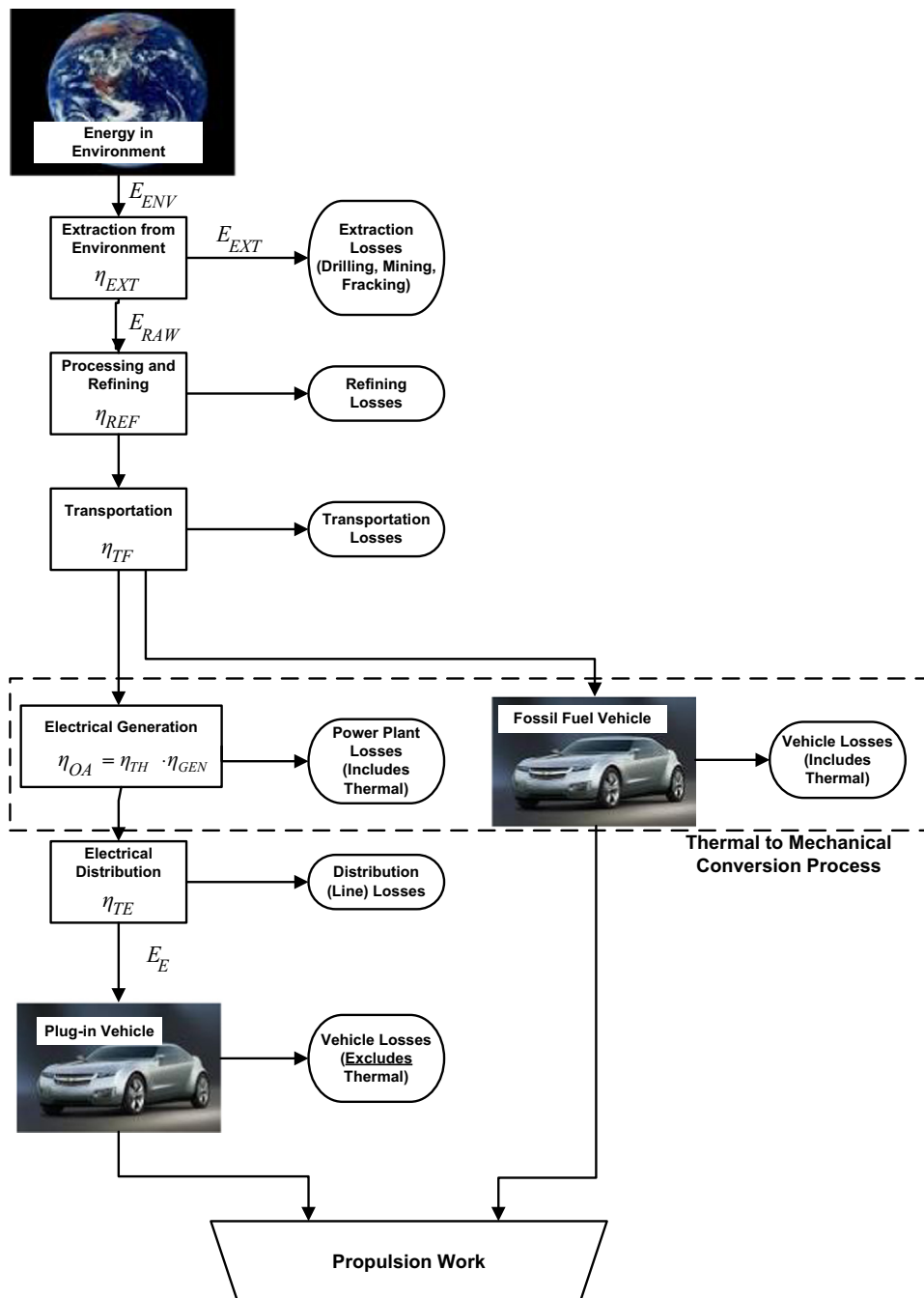


Fig. 1. Vehicle energy lifecycle: The figure shows both plug in and conventionally powered vehicles and the energy losses through the lifecycle. The thermal to mechanical conversion process, shown in the dashed box, is the limiting conversion in both cases.

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