ARTICLE INFO

Article ID: 14-12-01-0006

doi:10.4271/14-12-01-0006

A Data-Driven Greenhouse Gas Emission Rate Analysis for Vehicle Comparisons

Tristan Burton,[1] Scott Powers,[2] Cooper Burns,[1] Graham Conway,[3] Felix Leach,[4] and Kelly Senecal[1]

[1]*Convergent Science, Inc, USA*
[2]*Los Angeles Dodgers, USA*
[3]*Southwest Research Institute, USA*
[4]*University of Oxford, UK*

Abstract

The technology focus in the automotive sector has moved toward battery electric vehicles (BEVs) over the last few years. This shift has been ascribed to the importance of reducing greenhouse gas (GHG) emissions from transportation to mitigate the effects of climate change. In Europe, countries are proposing future bans on vehicles with internal combustion engines (ICEs), and individual United States (U.S.) states have followed suit. An important component of these complex decisions is the electricity generation GHG emission rates both for current electric grids and future electric grids. In this work we use 2019 U.S. electricity grid data to calculate the geographically and temporally resolved marginal emission rates that capture the real-world carbon emissions associated with present-day utilization of the U.S. grid for electric vehicle (EV) charging or any other electricity need. These rates are shown to be relatively independent of marginal demand at the highest marginal demand levels, indicating that they will be relatively insensitive to the addition of renewable electricity generation capacity up to the point at which curtailment occurs regularly unless the most carbon-intensive electricity sources are preferentially deactivated. We propose a simplified methodology for comparing emissions from BEVs and hybrid electric vehicles (HEVs) based on the marginal emission rates and other publicly available data and apply it to comparative case studies of BEVs and HEVs. We find that currently there is no evidence to support the idea that BEVs lead to a uniform reduction in vehicle emission rates in comparison to HEVs and in many scenarios have higher GHG emissions. This suggests that a mix of powertrain technologies is the best path toward reducing transportation sector emissions until the U.S. grid can provide electricity for the all-electric fleet infrastructure and vehicle operations with a carbon intensity that produces a net environmental benefit.

History

Received: 14 Sep 2021
Revised: 14 Feb 2022
Accepted: 29 Mar 2022
e-Available: 13 Apr 2022

Keywords

Battery electric vehicle, Hybrid electric vehicle, Life-cycle analysis, Electricity grid, Greenhouse gases, Marginal emission rate

Citation

Burton, T., Powers, S., Burns, C., Conway, G. et al., "A Data-Driven Greenhouse Gas Emission Rate Analysis for Vehicle Comparisons," *SAE Int. J. Elect. Veh.* 12(1):2023, doi:10.4271/14-12-01-0006.

ISSN: 2691-3747
e-ISSN: 2691-3755