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**Regarding 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Proposed Rule**
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I would like to thank the EPA officials and staff and this hearing's organizers for the opportunity to speak today. I would also like to start by stating my general support for the EPA's *Proposed Rulemaking for the 2017-2025 Light-Duty Vehicle Greenhouse Gas Emission Standards*, and applaud the in-depth research and analysis that has gone into this process. I hope my comments today will demonstrate that the EPA should continue advancing its research by extending the scope of analysis from the tailpipe to the full life cycle or 'upstream' impacts of materials and vehicle technologies.

Previous life cycle assessments, or LCAs, of standard passenger vehicles have estimated that use-phase emissions constitute 85 to 95% of life cycle greenhouse gas (GHG) emissions (1-3). So, standards that address fossil fuel consumption through the regulation of vehicle fuel economy (or $CO_2$ from the tailpipe) have functioned to limit or reduce life cycle emissions, and will likely continue to do so in the near term (4).

However, two trends suggest that a tailpipe-only standard could miss important tradeoffs in technology and design decisions in the future. The first trend is that many technologies that reduce GHG emissions during operation result in greater emissions during production. This has been shown for some advanced materials used in mass reduction and for electric powertrains. The second trend is that as we reduce GHG emissions during vehicle use, the relative importance of production emissions increases. These trends were highlighted in the NHTSA's draft Environmental Impact Statement and in a recent California Air Resources Board Report (4, 5).

EPA's GHG emissions standard and NHTSA's CAFE standard are performance-based, allowing for flexibility in how vehicle producers achieve compliance; they may select from an enormous range of technologies and innovations, each of which have unique upstream emissions. This means that among future vehicles there might be significant differences in upstream emissions. And, if upstream emissions are significant enough, there is a potential for vehicles with lower tailpipe emissions but higher life cycle emissions to be favored.

We undertook research to address these issues. The research was funded by the AISI and WorldAutoSteel organizations, with additional support from the UC Davis Institute of Transportation Studies. A summary of our research and findings is currently undergoing peer review at a scholarly journal.[1]

Using a case study approach, we undertook a streamlined LCA for a future vehicle and tested whether a tailpipe-only standard could result in the preference for vehicles with lower use-phase emissions but

[1] Until a peer-reviewed journal article is published, a report summarizing the research and findings is available at http://pubs.its.ucdavis.edu/publication_detail.php?id=1526. This report will be removed when the article is published.

higher life cycle emissions. We used a vehicle design developed in Lotus Engineering's 2010 report, a model year 2020 Toyota Venza (6). Lotus redesigned the current Toyota Venza for improved fuel economy while meeting pre-defined cost constraints and targets for equivalent performance. They did this through light-weighting and powertrain actions such as hybridization. The "high development vehicle" described in Lotus's report was the basis of our modeling.

To perform the LCA, we connected the bill-of-materials generated by computer aided engineering software to life cycle inventory datasets. Life cycle inventories characterize the upstream emissions associated with material production and forming processes. The datasets were taken from Roland Geyer's UCSB Advanced Powertrain Model and commercial life cycle inventory databases (7, 8).

Using this approach, we found the use-phase was responsible for 71% to 76% of life cycle GHG emissions for the 2020 Venza, findings that align well with previous studies (9, 10).[2]

We also performed a variation on the analysis where we altered Lotus's "high development" vehicle by replacing the light-weight body structure with one that was 100 kg heavier. This heavier body structure eliminated carbon-intensive light-weight materials, such as magnesium and aluminum. These materials were replaced with mild and advanced high strength steel.[3] The change in vehicle weight led to a decrease in fuel economy of 3 mpg (1.3 L/km), which in turn increased $CO_2$ emissions during operation. Despite these increased emissions during vehicle use, the new design reduced total life cycle emissions by a significant amount, approximately 10 to 20 grams of $CO_2$-equivalent per mile, depending on vehicle service life.[4]

To put this in perspective, the difference in emissions between the two designs is greater than any of the off-cycle credit provisions, and similar in magnitude to many of the air-conditioning credits that the EPA has already considered in its rulemaking.

Our research process also demonstrated that by using a detailed bill-of-materials generated in computer aided engineering software we could produce a streamlined LCA quite efficiently. Since computer aided engineering tools are widespread in the automotive industry, conducting LCAs may be less burdensome than anticipated.

To summarize, our analysis suggests that there is a potential for a tailpipe-only $CO_2$ standard to favor vehicles with higher life cycle emissions over those with lower life cycle emissions; shifting GHG emissions from the tailpipe to production sites. For the case study we conducted, the difference on a grams-per-mile basis exceeded or was on par with off-cycle and air conditioning credit provisions that the EPA has already considered in its rulemaking. Continued research and tracking of upstream emissions for future vehicles may help manage the risk of selecting vehicle designs and technologies where upstream emissions overwhelm use-phase savings. In addition, including upstream emissions may provide vehicle producers with an additional degree of flexibility to achieve $CO_2$ reduction targets.

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[2] Total life cycle emissions were 297-278 $gCO_2e$ per mile, based on vehicle lifetimes of 11-16 years.
[3] The new body structure was taken directly from the "low-development" vehicle defined in Lotus Engineering's report.
[4] The difference in life cycle emissions was 1900 to 2500 kg $CO_2e$ for vehicle lifetimes between 16 and 11 years.

**References**


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