Life-cycle Based Regulatory Reform: Implementation Pathways, Policy Mechanisms, and Implications for the Light Duty Vehicle Sector

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Goal: Evaluate design options for life-cycle based regulation of climate emissions in the US light duty vehicle sector.

Background

Life-cycle analyses (LCAs) of passenger vehicles have shown that operation of vehicles dominate life cycle energy use and greenhouse gas (GHG) emissions. New vehicle powertrains, materials, and fuel pathways are becoming widespread; these changes are changing the contribution of different life cycle stages to life cycle emissions.

Examples Include:

- Upstream inputs and changes to land use can overwhelm emission reduction potential from biofuels[1]
- Vehicle light weighting with GHG intensive advanced materials can result in negligible emissions benefits [2]
- Emissions reductions from electric vehicles (EVs) are highly dependent on the source of electricity generation and operating climate[3,4]

Methods

Critical review of regulation, peer-reviewed literature, and government reports, including:

- Vehicle emissions policies
- Life-cycle based product policies
- Vehicle life cycle studies
- Regulatory credit systems

Expert solicitation and informal interviews:

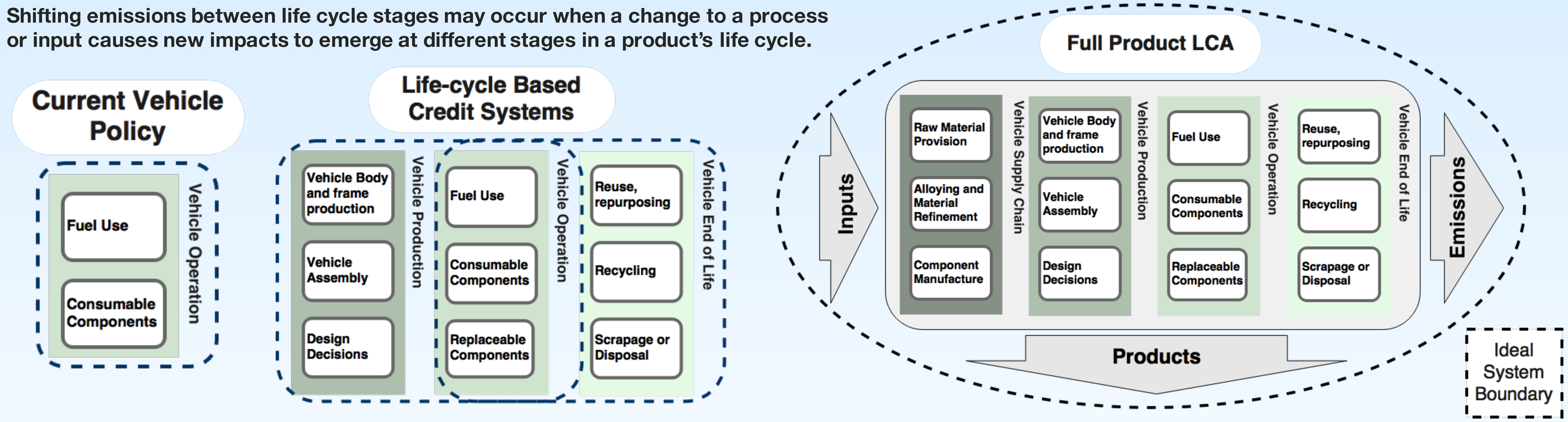
- Regulators
- Vehicle industry associations

This work extends the author's quantitative research in vehicle LCA, and considers potential policy implications / opportunities.

Tail-pipe Only Standards

	Benchmarking and Comparison	Credit Systems and Add-on Policies	Full Product LCA
Policy Objective	• Identify key drivers of product emissions • Integrate LC in policy development • Voluntary or mandated participation	• Provide credit for emissions reductions made in LC stages outside of existing tail pipe policy • Focus on production process, and can include various levels of LC integration/tool use • Achieves reductions in a single LC stage	• Performance based standard including full vehicle life cycle • Can restrict market entry based on LC standard
Policy Mechanisms	• Correction Factors • Disclosure or Reporting Standards • Industry group partnership • Labeling • Volume mandates	• Trade-able emissions credits • Production improvement credits • Technology specific credits • User-behavior credits • Reporting/disclosure credits • Fuel pathway credits	• Progressive performance standards • Compliance reporting • Direct incentives (best in class) • Product Category Rules • Trade-able compliance credits
Policy Implications	• Weakest level of LC integration • Could improve available information, build capacity for future LC based policies • Does not provide strong motivation for improvements	• Treats LC stages separately; can result in unintended leakage and/or double counting • Methodological issues conflating impacts occurring at different time scales and in different impact categories • Not assured emissions reductions on LC basis • Credit design can result in high transaction costs, price volatility, and low volume	• Strongest level of LC integration • Requires extensive measurement and verification • Can ensure emissions reductions measures accomplish emissions reductions over LC

Shifting emissions between life cycle stages may occur when a change to a process or input causes new impacts to emerge at different stages in a product's life cycle.



Conclusions

- **Consideration of the entire lifecycle of both vehicle systems and transportation fuel pathways is critical to achieving emissions reductions from continued technological development.**
- **To be implementable and enforceable, policies need to consider emissions in a systemic and systematic way.**
- **Policies designed to drive the deployment of new vehicle technologies, need to better integrate the science of life cycle analysis.**

Selected References:

1 Kendall, Alissa, Brenda Chang, and Benjamin Sharpe. *Environmental science & technology* 43.18 (2009): 7142-7147.

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3 Archsmith, J., Kendall, A., & Rapson, D. (2015). *Research in Transportation Economics*, *52*, 72-90.

4 Ambrose, H. & Kendall, A. (Under review). Lithium traction battery chemistry and performance: life cycle greenhouse gas emissions implications for electric vehicles. *Transportation Research Part D: Transport and the Environment*

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