PURDUE UNIVERSITY | Environmental and Ecological Engineering

EEE Research Seminar

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Thomas Maani
Ph.D. Candidate
Environmental and
Ecological Engineering
Purdue University

Kendrick Hardaway
Ph.D. Candidate
Environmental and
Ecological Engineering
Purdue University

Impact of On-Road U.S. Vehicle Electrification and Lightweighting on Critical Materials Demands

The electrification of the future transport sector plays a crucial role in mitigating direct greenhouse gas emissions and reducing reliance on fossil fuels. Modern clean energy technologies, such as electric vehicles (EVs), comprise advanced electronics and various components that rely on critical materials for their proper functionality. However, the widespread adoption of these technologies might face constraints due to the limited availability of critical metals in the future. This study aims to assess the implications of vehicle electrification and lightweighting on the demand for critical materials in both Light Duty Vehicles (LDVs) and Medium-Heavy Duty Vehicles (MHDVs). Our estimates consider market penetration scenarios of 100% ICEV, 100% BEV, and 50%/50% ICEV/BEV for annual vehicle sales.

Bio

Thomas Maani is a PhD Candidate working under the supervision of Professor Sutherland in Environmental and Ecological Engineering. He uses material flow analysis (MFA), life cycle assessment (LCA), and technoeconomic analysis (TEA) to investigate the consequences of circularizing critical materials in electric vehicles. He is also a visiting scholar at Argonne National Laboratory where he is involved in a project whose goal is to expand their GREET model.

Silent Emissions: The Cyber-Infrastructure Environmental Impacts of Autonomous Vehicles

Autonomous vehicles (AVs) are presented in research literature as a technology that could reduce greenhouse gas emissions through efficiency gains. However, there is a critical aspect where AVs demand more energy than traditional vehicles: AV data management. This aspect, encompassing both in-vehicle and cyber infrastructure energy requirements, has been neglected in many AV environmental impact studies. To address this gap, we calculated the energy requirements and greenhouse gas emissions associated with AV data management, including previously neglected cyber infrastructure components such as data storage and security. With a mathematical model, we tested various scenarios within a United States-based AV fleet, consisting of 15 key variables like computational efficiency, vehicle models (e.g., Waymo, Tesla), sensor capabilities, data transfer, storage, and cybersecurity. Our findings reveal that neglecting the supporting data management system underestimates the environmental impact of AV data management by at least 82%, possibly even more. In the context of a renewable energy transition, a 40% market penetration of fully autonomous vehicles in the United States could demand up to 11% of the nation's current solar capacity for data management alone, highlighting the potential for AV adoption to intensify the already significant need for solar capacity installation. Thus, our results emphasize the significance of including the essential cyber infrastructure for AV data management in environmental assessments.

Bio

Kendrick Hardaway is part of the Interdisciplinary Ecological Sciences and Engineering Program at Purdue University. He holds a bachelor's degree in biological engineering from the University of Arkansas, and he is a candidate for a master's in industrial engineering and a doctorate in environmental engineering at Purdue. In his research, he models interactions between social, ecological, and technical systems to quantify the ecological impacts of emerging technologies and to build resilient infrastructure systems.