The energy, environmental, and sustainability consequences of connected and automated vehicles: an overview

Sophie Jones

EDITORIAL NOTE

CAVs (Connected and Automated Vehicles) are poised to alter transportation and mobility by taking over the roles of driver and service provider from humans. While the fundamental motive for vehicle automation is to increase road safety and convenience, it also presents a significant opportunity to improve vehicle energy efficiency and cut emissions in the transportation sector. However, improvements in vehicle efficiency and functionality do not always equate to net favorable environmental results. At four levels of increasing complexity, we look at how CAV technology interacts with the environment: vehicle, transportation system, urban system, and society. The transportation system based on fossil fuels has a significant impact on human interactions with the environment. In 2010, transportation produced about 7 gigatons of carbon dioxide equivalent Greenhouse Gas (GHG) emissions globally, accounting for 23% of total global energy-related GHG emissions. Transportation GHG emissions are expanding at a greater rate than any other sector's emissions (i.e., power, industry, agriculture, residential, or commercial). With rising incomes and expanding infrastructure around the world, transportation demand is likely to skyrocket in the coming years. By 2050, annual emissions from the transportation industry are predicted to treble. When compared to other modes of transportation such as aviation, rail, and marine, road-based travel is responsible for the biggest percentage of CO2 emissions, GHG emissions, and energy use in the transportation sector. Strategic development and deployment of innovative technology to mitigate the environmental implications of road-based travel can thus go a long way toward relieving the environmental impacts of this mode of transportation. Vehicle connectivity and automation are two distinct technologies that can coexist yet have strong complementary characteristics. The ability of a vehicle to communicate data with other vehicles and infrastructure is referred to as connectivity. Vehicle-To-Vehicle (V2V), Vehicle-To-Infrastructure (V2I), and other cooperative communications networks can help achieve this capacity. Vehicle communication is a critical component of automated driving. Vehicle automation refers to any situation in which a computer takes over control of a vehicle capability that would normally be overseen by a human driver. Cruise control, adaptive cruise control, active lane-keep assist, and automatic emergency braking are all examples of automation found in today's vehicles. A fully automated vehicle can guide itself to its destination without the need for human intervention by perceiving and interacting with the driving environment. The terms "autonomous" and "automated" are frequently used interchangeably in the literature, although they should be distinguished. The former (a subset of the latter) refers to a vehicle that can navigate without direct input from a human driver, and self-driving is achievable with minimal or no communication with other vehicles or infrastructure, whilst the later refers to a broader category of vehicle automation. CAV technology's main goal is to improve transportation safety and provide better mobility services. However, vehicle connectivity and automation will inevitably and drastically alter the transportation sector's environmental footprint. A growing amount of research has looked into the potential environmental impacts of CAVs, and has identified significant ambiguity, owing in part to a scarcity of real-world data on CAV operations. CAV technology has the potential to support either significant transportation decarbonization or significant increases in transportation-sector emissions. The net environmental implications of CAV technology are determined by international, federal, state, and municipal legislation and judgments. With the automated road transportation transition still in its early stages, there is a chance to get ahead of the curve to ensure that CAV technology evolves sustainably. To properly design, plan, and create a CAV system that provides both improved mobility service and better environmental results, a forward-looking mindset is required.

Editorial Board office, Journal of Environmental Geology, Singapore

Correspondence: Sophie J, Editorial office, Journal of Environmental Geology, Singapore, E-mail: enviongeol@journalres.com

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