Autonomous Vehicles Have a Range of Possible Energy Impacts

Introduction

Self-driving or “autonomous” vehicles (AVs) have leapt from science fiction into the forefront of transportation technology news. The technology is likely still years away from widespread commercial adoption, but the recent progress makes it worth considering the potential national impacts of widespread implementation. This poster makes an initial assessment of the energy impacts of AV adoption on a per-vehicle basis and on total personal vehicle fuel use. While AVs offer numerous potential advantages in energy use, there are significant factors that could decrease or even eliminate the energy benefits under some circumstances. This analysis attempts to describe, quantify, and combine many of the possible effects. The nature and magnitude of these effects remain highly uncertain. This set of effects is very unlikely to be exhaustive, but this analysis approach can serve as a base for future estimates.

Method

Individual and combined impacts are assessed based on the “Kaya Identity,” modified for this analysis in two key ways:

1. Populations of AVs and CVs are separated for clarity.
2. This analysis uses liquid fuel demand as the output rather than CO2 to isolate this issue from the CO2 intensity of electricity or other fuels.

\[
\text{Fuel Demand} = \# \text{Vehicles} \times \frac{\% \text{AVs} \times \text{AV Energy}}{\text{AV Liquid Energy}} + \frac{\% \text{CVs} \times \text{CV Energy}}{\text{CV Liquid Energy}} + (1-\% \text {AVs}) \times \frac{\text{Energy}}{\text{Liquid Energy}}
\]

The top term represents fuel use by AVs and the bottom term by CVs. We refer to factors affecting VMT/vehicles as “use intensity” (UI); factors affecting Energy/VMT as “energy intensity” (EI); and factors affecting Liquids/Energy (e.g. electric vehicles use no liquid fuels) as “fuel intensity” (FI).

Private Ownership (Low Number of AVs)

These effects do not require strong system effects and could manifest themselves with low penetration cases where most AVs are owned by individuals. Here we assume 10% penetration.

Shared Ownership (High Number of AVs)

In this scenario, AV use is widespread enough to make private ownership less necessary, with users instead summoning a shared use vehicle for their immediate need. Widespread adoption without vehicle sharing is also possible, but is not considered here. The effects below become possible as penetrations increase so the majority of vehicles on the road are automated. Here we assume 90% penetration.

Shared Vehicles with Electric Vehicles

Shared AVs may be more amenable to electrification since a vehicle can be dispatched to meet a user’s specific need, only serving trips within range.

Other Potential Impacts

AVs would have many potential effects not covered here. Some include:

- Embodied energy benefits: Even at the peak, only 12% of vehicles are on the road (Burns 2012), so in a shared use model there could be many fewer total vehicles, leading to lower manufacturing energy use.
- Economic benefits: with vehicle capital cost spread over many users in shared vehicle scenarios, transportation costs could be lower (Burns 2012)
- Social benefit of transportation access: addition of travelers increases energy use but provides valuable transportation service
- Land use benefit: with fewer, smaller vehicles on the road, cities could repurpose land from parking and potentially in transportation corridors
- Safety benefits: these would include less loss of life and injury as well as fewer vehicle replacements
- Interaction with mass transit: AVs could solve the “first and last mile” problem and lower labor costs for transit, but could also make transit less competitive

Conclusion

AVs have the potential to make impacts on transportation energy use by individuals. Most possible effects on energy intensity are likely to lead to fuel savings, but many effects on use intensity could counteract this or even lead to increases in fuel use, depending on the specific scenario. Our estimates of possible impacts range from nearly 90% fuel savings (if only energy benefits occur) to more than 250% increase in energy use (if only energy-increases are considered). This emphasizes the importance of considering energy impacts in AV deployment strategy.

References and Assumptions


1. National Renewable Energy Laboratory 2. University of Maryland, College Park

The information contained in this poster is subject to a government license.

Workshop on Vehicle Automation | Stanford, CA | July 16, 2013