Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 143 (2017) 47–52

Energy Procedia

www.elsevier.com/locate/procedia

World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference, WES-CUE 2017, 19–21 July 2017, Singapore

Autonomous Vehicles and Energy Impacts: A Scenario Analysis

Catherine Ross[a]*, Subhrajit Guhathakurta[b]

[a]*Catherine Ross, Center for Quality Growth and Regional Development, Georgia Institute of Technology, 760 Spring Street NW, Atlanta, GA 30308, USA*

[b]*Subhrajit Guhathakurta, Center for GIS, Georgia Institute of Technology, 760 Spring Street NW, Atlanta, GA 30308, USA*

Abstract

Autonomous vehicles will have tremendous impact on our cities and regions. This rapidly emerging technology will affect the transport system in its entirety including changes in energy consumption; increased safety, climate change impacts, efficiency of transport operations and the platooning of trucks carrying freight. Primary questions remain. What are reasonable expectations of the impact of autonomous and connected vehicles on travel demand, energy consumption, and emissions? Can vehicle to vehicle communication have a significant impact on congestion and vehicle movements that will result in smoother traffic flow and accompanying reductions in energy and emissions? What policies and regulations guiding the operation of autonomous and connected vehicles will be enacted and to what extent will autonomous vehicles penetrate the market over what time period? This article attempts to identify and quantify the impact of autonomous vehicles on energy through development of scenarios that gauge the potential range and contribution of this emerging technology. The scenarios reflect an assessment of the state of practice and current research conducted in both the public and the private sector. Three scenarios are examined in details including energy impacts based on partial or full automation and personal versus a shared vehicle future for autonomous vehicles. There are numerous possible scenarios that may unfold but each will have to be responsive to our multimodal transport system with an objective to optimize modal, technological, financial and energy resources now and in the future.

Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.

Keywords: Autonomous vehicles; connected vehicles; energy impacts; scenario analysis; vehicle automation; fuel consumption

* Corresponding author. Tel.: +1-404-385-5130; fax: +1-404-385-5127.
E-mail address: catherine.ross@design.gatech.edu

Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.
10.1016/j.egypro.2017.12.646

1. Introduction

The connection between autonomous vehicle technologies and estimated changes in energy consumption is receiving a great deal of attention. We examine this connection further through development of different energy demand scenarios. The scenarios reflect an assessment of the state of practice and research conducted in both the public and the private sector. The literature evidences large uncertainties, based on three different paths for future vehicle use, with potentially extreme ranges of energy use as a result of both vehicle automation technology and personal versus shared autonomous vehicle use. With this lens, the estimates developed by Auld, Karbowskia, & Sokolova (2017), Fagnant (2014), Greenblatt & Saxena (2015), Stephens et al. (2016), Wadud, MacKenzie, & Leiby (2016) are applied to present-day transport energy consumption levels to demonstrate the variability in different energy futures. By connecting existing estimates with three scenarios that will be introduced below, this research provides implications for future transportation policy in managing uncertainties with regard to energy consumption. The connection between transportation and energy is increasingly important to examine as the United States (U.S.) moves efforts of reducing greenhouse gas emissions from a strong regulatory emphasis towards one based on local and state control, technological innovation and flexible pathways. As the U.S. transportation sector overwhelms other large sectors of the economy in becoming the largest source of greenhouse gas emissions (GHGs) (US EPA, 2014), efforts towards managing energy use change will need to grow in attention and use.

2. Scenario Analysis

The energy impacts of autonomous vehicles may vary significantly along two pathways: (1) the extent to which the partial or full automation of the autonomous vehicle technology is implemented; and (2) whether there is a significant portion of shared autonomous vehicles vs. personal autonomous vehicles. Therefore, we analysed three different scenarios based on different assumptions about the two pathways, which are presented in Fig.1. We analysed each of the three scenarios separately based on literature that connects autonomous vehicle impacts with energy use change. A "partial automation with shared vehicles dominating" scenario was not developed due to lack of data but future research might examine this scenario more closely.

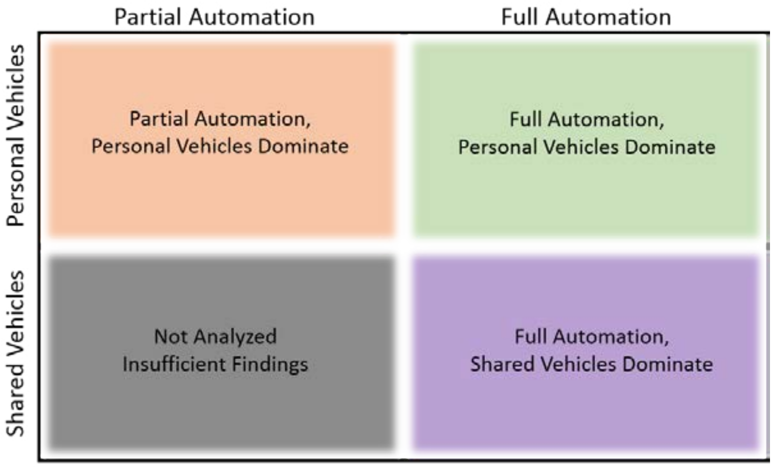

Fig. 1. Three Scenarios

In comparing full versus partial automation at the vehicle level, the 6-level standards introduced by SAE International (SAE, 2016) defines full versus partial automation levels. Partial automation is defined by levels 1, 2, and 3. Full automation levels are used to classify highly autonomous vehicles (HAVs) and have levels 4 and 5. Some of the literature also uses market penetration to characterize the level of automation at the system level. For the scenario analysis, we employ some of the early intermediate stages as partially automated. For example, when approximately ten percent of all cars are fully automated it would be considered partial automation versus 90 percent of all cars being fully automated which we consider as full automation for our estimation purposes.