The Environmental Impact of the Self-Driving Car

UNIVERSITY OF CALGARY


Scott Lalonde
Mechanical Eng.


Jeremy Mattison
Natural Sciences


Kayla Olde
Mechanical Eng.


Venice Tang
Geomatics Eng.


Joshua West
Chemical Eng.

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

Correspondence: smlalond@ucalgary.ca

INTRODUCTION

The autonomous vehicle (AV) is a driverless vehicle that fulfills the transportation capabilities of a traditional vehicle. AVs are capable of sensing their environment to navigate without human input.

Fig. 1. Google Self-Driving Vehicle [1]

The environmental footprint of AVs is not yet defined. This is because the future development of AVs depends on many different factors such as technology availability, economics, regulations and commuter attitude.

We analyzed the potential environmental impact of AVs based on varying commuter attitudes. This resulted in three different scenarios using data provided by the CanESS model [2]:

- A base case, business-as-usual scenario
- An independent, non-environmentally conscious scenario
- A collective, environmentally conscious scenario

METHODS

Assumptions for Scenarios:

- Trucks are excluded due to limited data and applicability of AV/electric vehicle technology.
- AV cars are for individual drivers (neglecting car-pooling)
- 0% - 90% exponential implementation from 2025-2060.
- Ultimate 31% driving efficiency improvement [3].

Independent Scenario

- Continued use of gas internal combustion engine.
- Driving distance inflation from human behaviour (10% increase in commute distances) [4].

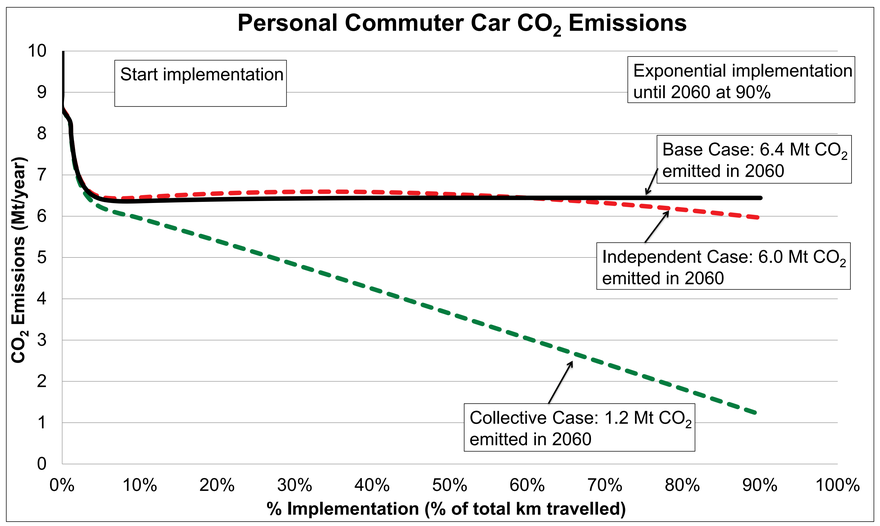
Collective Scenario

- Vehicles are shared similar to how Car2Go is implemented (11:1 car replacement ratio) [4].
- Vehicles are powered by electricity.

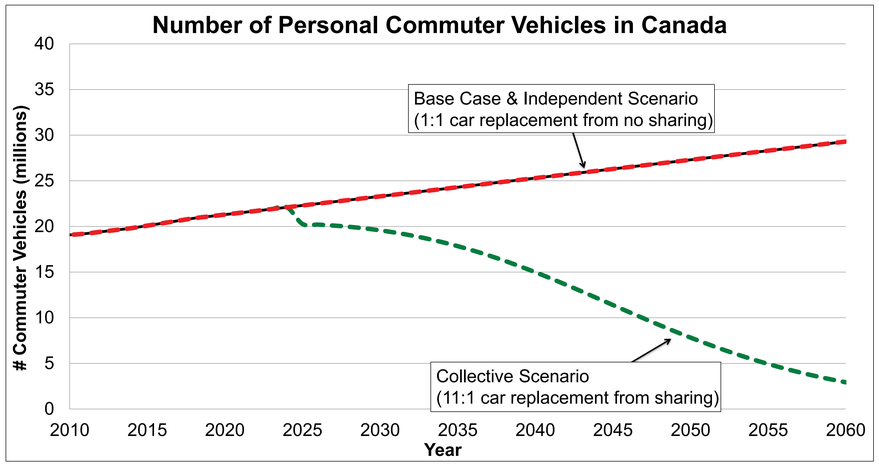
Criteria	Base Case	Independent Scenario	Collective Scenario
Principle:	Business as Usual	Personal Freedom, Environment is Low Priority	Environment is High Priority, Value in Sharing
Autonomous Vehicle Use:	None	Personally Owned, Improved Personal Productivity During Transport, Avoid Downtown Parking	Car Sharing Vehicle, Improved Personal Productivity During Transport, Avoid Car Ownership, Avoid Downtown Parking
Fuel Source:	Gasoline	Gasoline	Electric
Inter-Vehicle Communication:	No	Yes	Yes
Autonomous Vehicle Lane:	No	Yes	Yes
Fuel Efficiency Improvement:	None	31% Improvement	31% Improvement

Table 1. Future Scenarios for Integration of Autonomous Vehicles

RESULTS



- Base case shows a drop in emissions initially due to technological advances that increase fuel efficiency of gasoline vehicles. These advances eventually slow down causing emissions to plateau.
- Independent scenario shows initial increase over base case due to longer driving distances.
- Use of electric vehicles shows emissions decrease immediately.
- Improved driving efficiency does not have a significant effect until higher implementation rate is reached.



- Use of car sharing shows positive effects at low implementation rates.

DISCUSSION / CONCLUSION

In Canada, the transportation sector accounts for the greatest percentage of Greenhouse Gas Emissions [5]. As a result, AVs have the potential to substantially impact societies by decreasing commuter GHG emissions. As a result, AVs provide an attractive route to reduce Canada's environmental footprint, however it ultimately depends on government regulation; safety, and other socioeconomic issues for the development of this new emerging technology to occur.

As demonstrated in our results:

- When the collective scenario is implemented, there is a reduction in CO_2 emissions of 5.2 Mt/year compared to the base case in 2060.
- Whereas, when the Independent case is exhibited, there is a minute decrease to 0.5 Mt of CO_2 per year.
- The base case predicts 6.4 Mt of CO_2 emitted in 2060.

Although AV technology is compatible with trucks, our study excluded them from the commuter category. In reality, a significant amount of trucks are used for personal commuting. Subsequently, CO_2 emissions could be reduced further should trucks switch to this technology.

The future of AV technology is fairly new and full of uncertainties. Further research must be conducted to quantify the effects of AVs in regards to the following factors:

- Safety and control
- Convenience and multitasking (productivity)
- Cost and competition

Furthermore, we recommend:

- Scientific studies quantify the socioeconomic effects of AVs.
- Regulatory bodies to streamline emergence of autonomous vehicles. For instance, introduce pilot programs for AV sharing services and promote the growth of AVs companies using tax incentives/subsidies.

Scenario	CO_2 Emissions (Mt/year)	Benefit (+)/Detriment (-) from Source (Mt CO_2/year)	% Benefit/Detriment
Base Case	**6.4**	**-**	**-**
Collective Scenario	**1.2**	**5.2**	**100 %**
Car Sharing	-	1.7	33 %
Improved Efficiency	-	0.2	4 %
Electric Vehicle	-	3.4	64 %
Independent Scenario	**6.0**	**0.5**	**100 %**
Improved Efficiency	-	1.1	220 %
Driving Distance Inflation	-	-0.6	-120 %

Table 2. GHG Share of Model Assumptions

REFERENCES

[1] Forbes, "Google's New Self-Driving Car Has No Steering Wheel, No Brakes, And A Face Designed To Be 'Friendly'" May 2014. [Online]. Available: http://www.forbes.com/.../googles-new-self-driving-car-has-no-steering-wheel-no-brakes-and-a-face-designed-to-be-friendly/. [Accessed October 2014]

[2] whatIf? Technologies Inc., 2014. Canadian Energy Systems Simulator (CanESS) - Version 6, Reference Scenario. www.caness.ca

[3] D. a. K. K. Fagnant, "Preparing a Nation for AV," University of Texas, N.D.

[4] D. a. K. K. Fagnant, "The travel and environmental implications of shared AV, using agent-based model scenarios," 2013.

[5] Environment Canada, "Canada's Emissions Trends," Government of Canada, 2013.

ACKNOWLEDGEMENTS

We would like to thank our instructors for support and whatIf? Technologies [2] for providing the projected data.
We would also like to thank our expert advisors Nathan Armstrong and Peter Tertzakian for provided insight into this new emerging topic.

This poster produced as part of University of Calgary course Scie529 in Fall 2014. For info: dlayzell@ucalgary.ca