Autonomous Vehicles

Re-defining the Future of Transportation and Emissions

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INTRODUCTION

Personal vehicles emit 8.11 Mt of CO_2 emissions per year in Alberta [1]. This project evaluates the possible effects autonomous vehicles (AVs) will have on those emissions. A reference scenario as well as two alternative futures are discussed: a consumer driven and an environmentally driven model. The consumer driven scenario takes a focus on convenience for consumers and personal ownership, while the environmentally driven scenario prioritizes in making choices to minimize emissions.

Autonomous vehicles are classified in five levels going from zero to four. Level four, the focus of this project, is when the vehicle is fully autonomous and only requires destination input [2]. These vehicles will be introduced beginning in 2021, as companies such as Ford look to provide them to consumers [3].

Fig. 1. The Google Level Four Autonomous Car [4]

METHODS

Both the reference and alternative scenarios draw on data created in the CanESS model [1]. The two alternative futures have been constructed using a series of change mechanisms, or levers:

- Vehicle Stock
- Trip Demand
- Load Factor
- Trip Length
- Energy Efficiency

Each of these change mechanisms as shown in the flow chart below (Fig. 2) is affected by the change of one or more variables as represented in the white boxes. The scope of this project only focuses personal transportation and their relevant market. Further omissions include disregarding diesel engine vehicles as well as emissions other than CO_2.

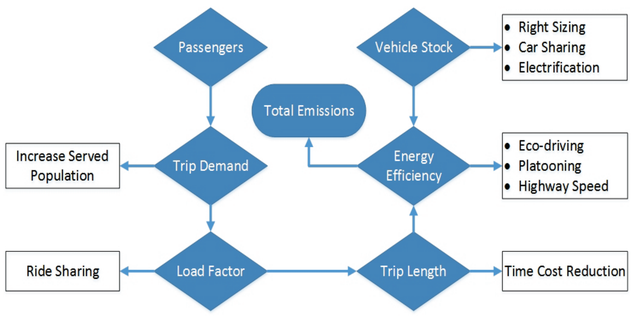
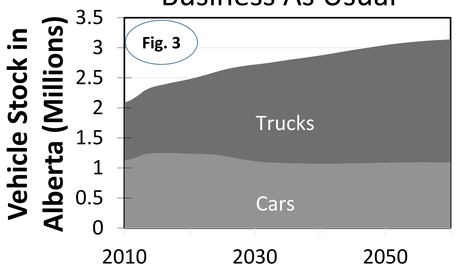


Fig. 2. Flow Chart of Change Mechanisms [1][5]

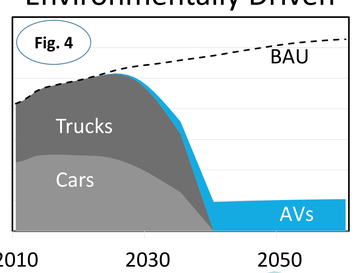
RESULTS

Business As Usual



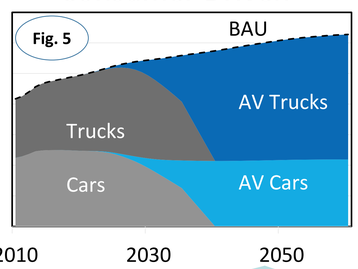
- S-curve adoption of AVs from 2021 to 2035 until 100% of new vehicles are AVs.
- Existing manual vehicles retired from use from 2035 to 2040 for safety reasons.
- 100% of vehicles are AVs from 2040 on.

Environmentally Driven

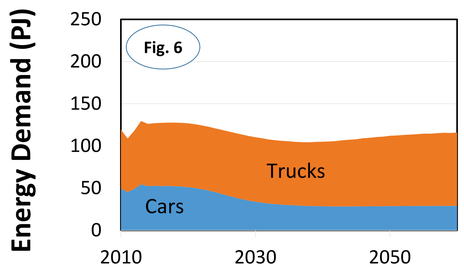


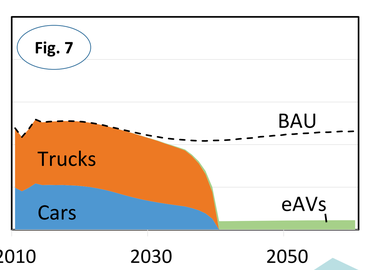
- Replacement ratio of 6:1 of existing vehicles to AVs.
- Vehicles are not replaced by type (trucks do not replace trucks).
- 3 types of AVs (electric cars, 1-person electric cars and electric trucks).

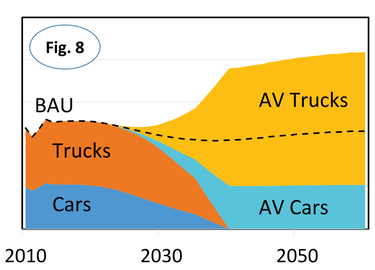
Consumer Driven



- No change to total number of vehicles.
- No change in distribution of cars and trucks from the business-as-usual scenario.







Low energy demand due to an all electric AV fleet

Consumer driven scenario will see an increase in emissions of approximately 5.8 Mt CO_2/year (72.6%) by the year 2060.

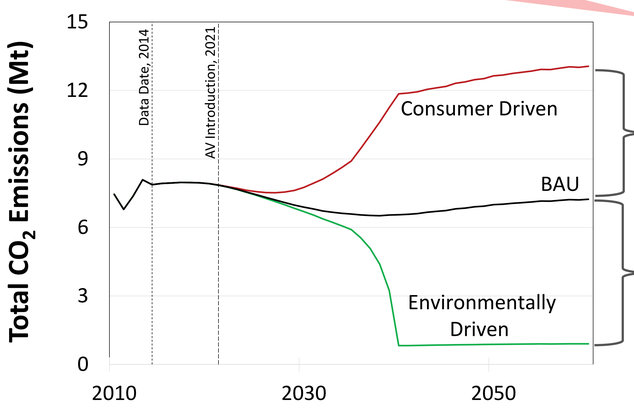
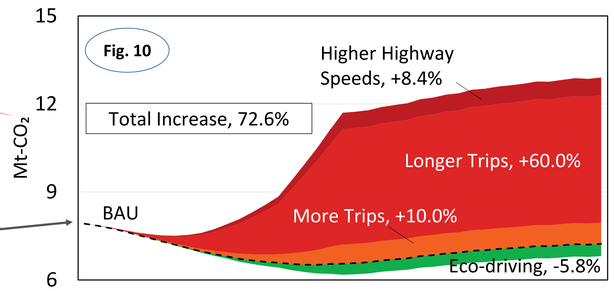
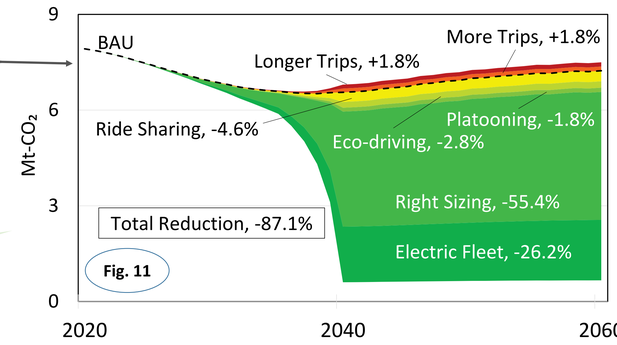


Fig. 9. Scenario Emissions





Environmentally driven scenario will see a reduction in emissions of approximately 6.3 Mt CO_2/year (87.1%) by the year 2060.

DISCUSSION

In the consumer driven scenario, the largest increase of emissions (≈ 5 Mt CO_2/year) comes from the increased travel demand due to the perceived reduction in passenger time cost as well as transportation opportunities for the demographic not capable of manual driving. In the environmentally driven scenario, the greatest reductions come from the introduction of right-sized vehicles (≈ 4 Mt CO_2/year) as well as implementing an all electric fleet (≈ 1.9 Mt CO_2/year) in addition to smaller benefits from vehicle and ride sharing. This project is primarily guided by a study conducted by Wadud et al., which provides rationale for changes in driving style, however, further change mechanisms are included, such as car and ride sharing.

CONCLUSIONS

A number of conditions shaped by policy makers will result in an increase or decrease of approximately 85% level change of emissions from the BAU scenario. Although these scenarios represent extreme cases, policies need to be established in Alberta that will encourage the environmentally driven scenario to push CO_2 emissions lower. These should include most prominently a push for right-sized vehicles, discouragement of long commutes, and the encouragement of electric engines, as these all have the largest impact. This could be accomplished through monetary credit for travelling at capacity and a road tax for vehicle travel outside of cities. As for electric motors, gasoline engines could be phased out through regulations. Simply introducing AVs with BAU vehicle trends is shown to have adverse effects on the environment.

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