Master Thesis Presentation

Microscopic Traffic Simulation to Investigate the Impact of Automated Vehicles on Road Traffic Emission

By Zelalem Birhanu Biramo

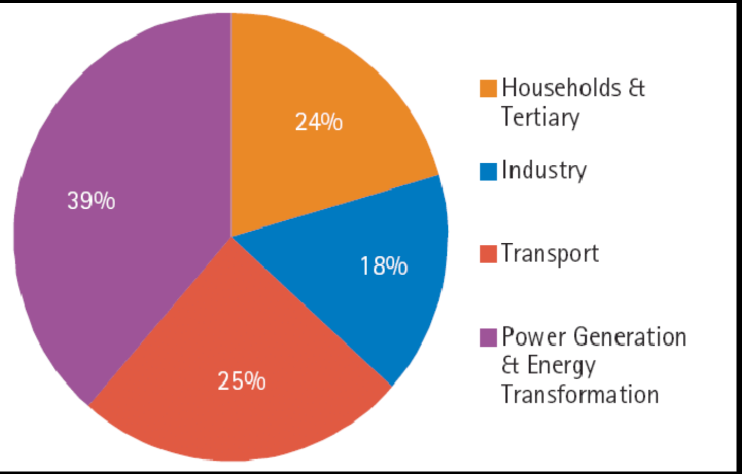
Supervisor: Tamás Tettamanti, PhD.

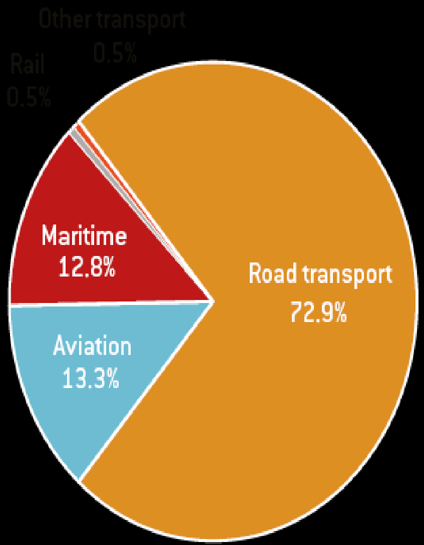
BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS

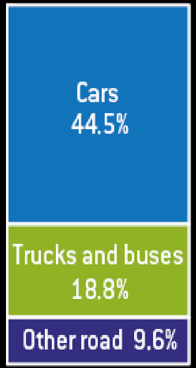
Dept. of Control for Transportation and Vehicle Systems

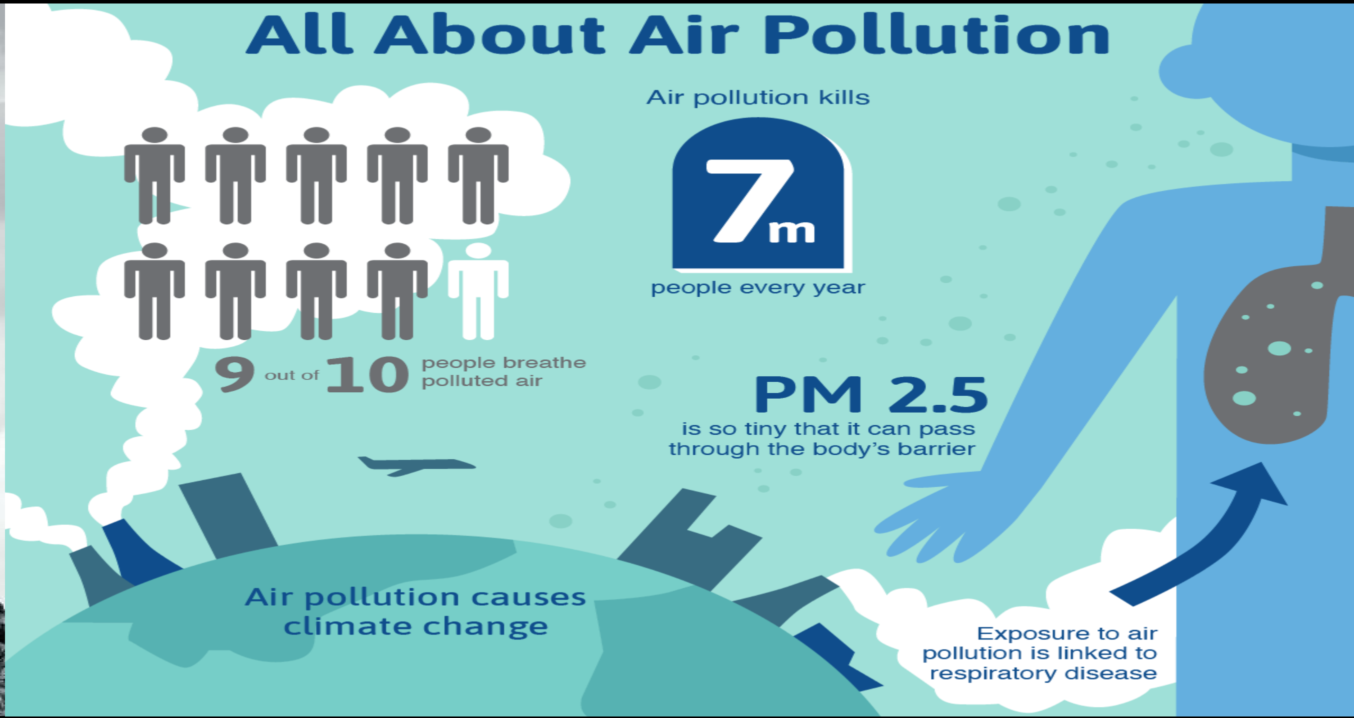
Introduction

MŰEGYETEM 1782









Introduction

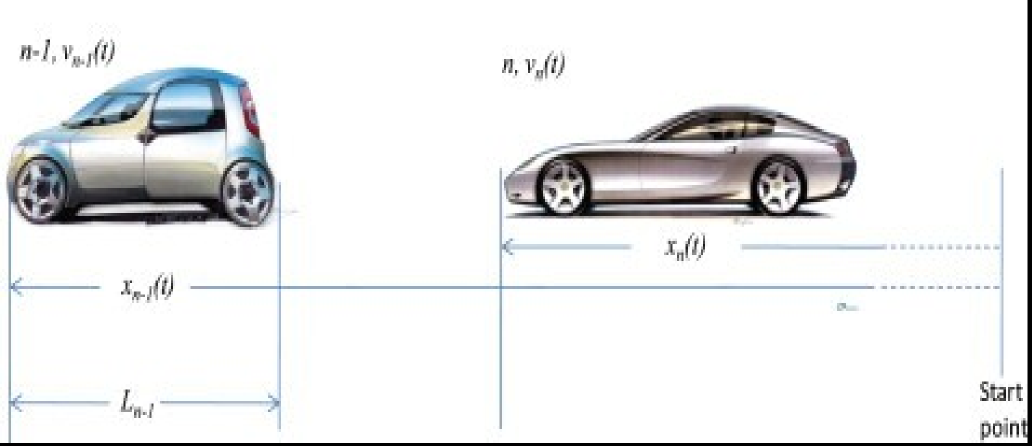
- *The aim of this study is to evaluate the efficiency and effectiveness of automated vehicles in reducing air pollution by developing models of automated vehicles with various degrees of automation and slowly introducing them into the network with various market penetration rates.*
- *The software used for modelling and analysis is Simulation of Urban Mobility(SUMO)*
- *Six emissions types are measured;- CO(Carbon monoxide), Carbon dioxide(CO2), Hydro carbon(HC), Particulate matters(PMx), Nitrogen oxides(NOx) and fuel consumption.*
- *HBEFA V3.1 is used as emission measuring model.*

Location of Study

- ZalaZone is a long-term project located at 46.88947 N and 16.83676 E in the Zala county of Zalaegerszeg town.
- It is a project aimed at speeding up the development of automated vehicles while also serving as a testing ground for traditional, semi-automated, and completely automated vehicles.

Vehicle Modelling

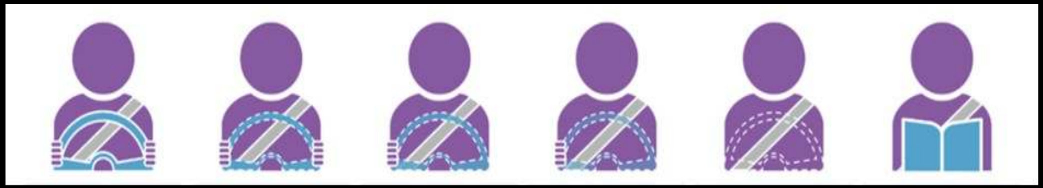
Car following



- Krauss Modified car following model is used to investigate the impact
- The Krauss modified model includes editable parameters that allow us to model automated vehicles with varying degrees of automation.
- the following maneuvering parameters were used as deciding factors:

Automation Level

Table: Car following parameters



Mingap(m)	2.5	2	1.5	1.17	0.83	0.5
Accel(m/s^2)	2.6	3.05	3.5	3.6	3.7	3.8
Decel(m/s^2)	4.5	2	4.5	4.5	4.5	4.5
Emergency decel (m/s^2)	8	8	8	8	8	8
Sigma(driver imperfection)	0.5	0.4	0.3	0.2	0	0
tau(s)	1	0.95	0.9	0.8	0.7	0.6

Lane changing model

LC2013 is used for lane changing models.

Vehicle Modelling

Traffic mix

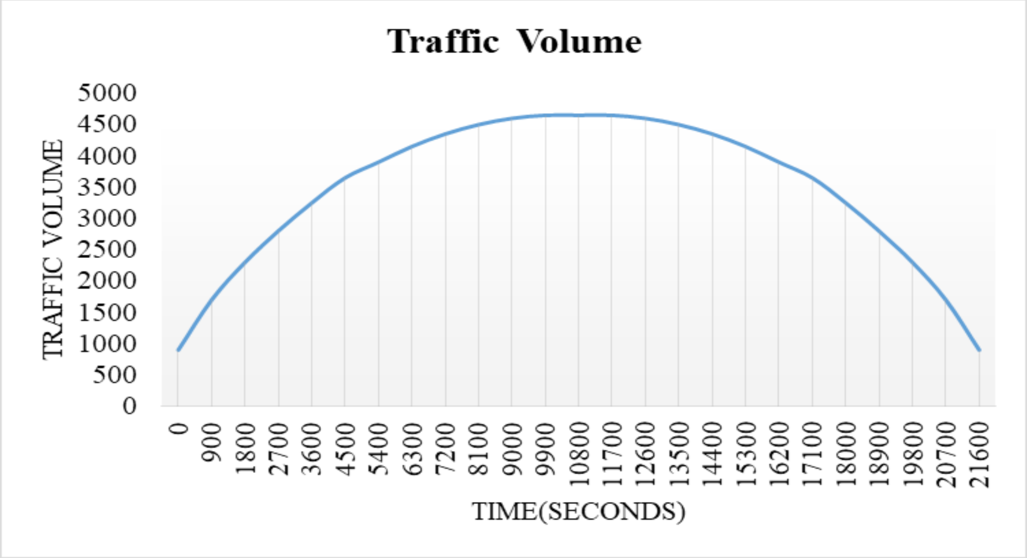
Lack of technological availability and user skepticism about the technology's safety and security will obstruct the widespread adoption of automated vehicles. This will result in the incremental penetration of automated vehicles into the market.

Table 2: Vehicles mix ratio

Scenario nr.	Scenarios	Ratio of legacy cars	Level 1	Level 2	Level 3	Level 4	Level 5
1	Base	100 %	0 %	0 %	0 %	0 %	0 %
2	25 % penetration	75 %	15 %	5 %	5 %	0 %	0 %
3	50 % penetration	50 %	25 %	10 %	10 %	5 %	0 %
4	75 % penetration	25 %	25 %	20 %	15 %	10 %	5 %
5	100 % penetration	0 %	15 %	20 %	20 %	25 %	20 %
6	Upper bound	0 %	0 %	0 %	0 %	0 %	100 %

Traffic volume

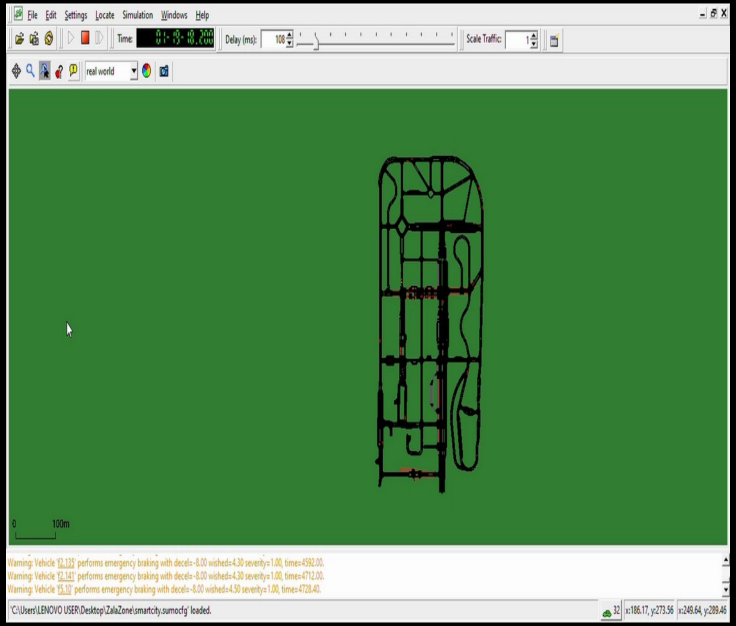
To ensure a more objective assessment, the changes in traffic flow covered a wide variety of traffic situations. Traffic demands were steadily injected into the network, progressing from free flow to congestion and then gradually decreasing to free flow.



Simulation

Network

Zalazone smart city network is used for the investigation

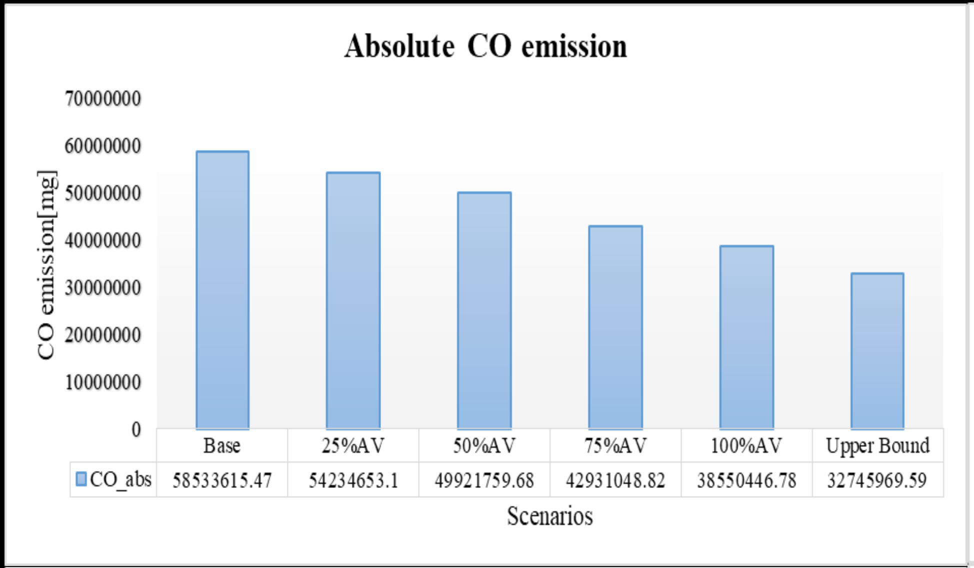


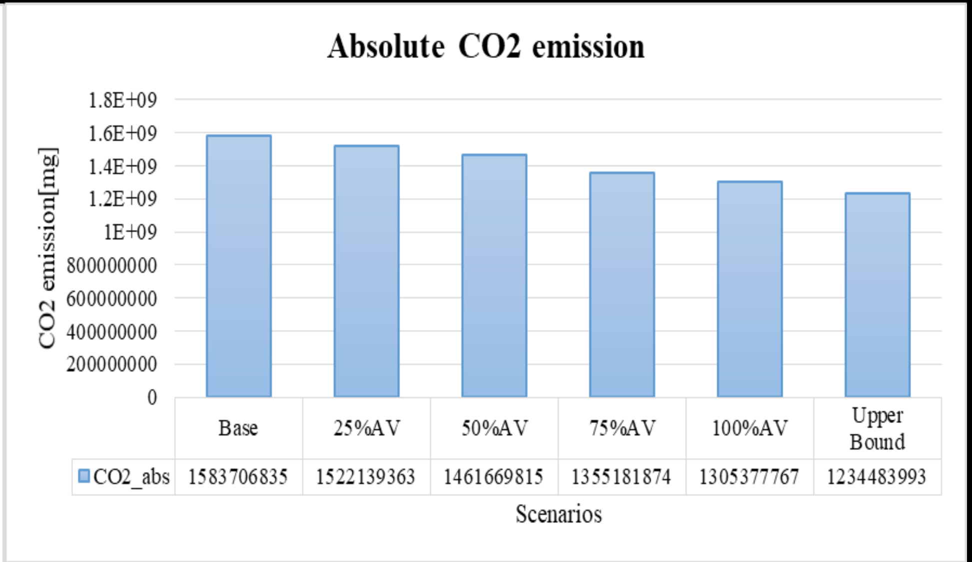
Traffic assignment

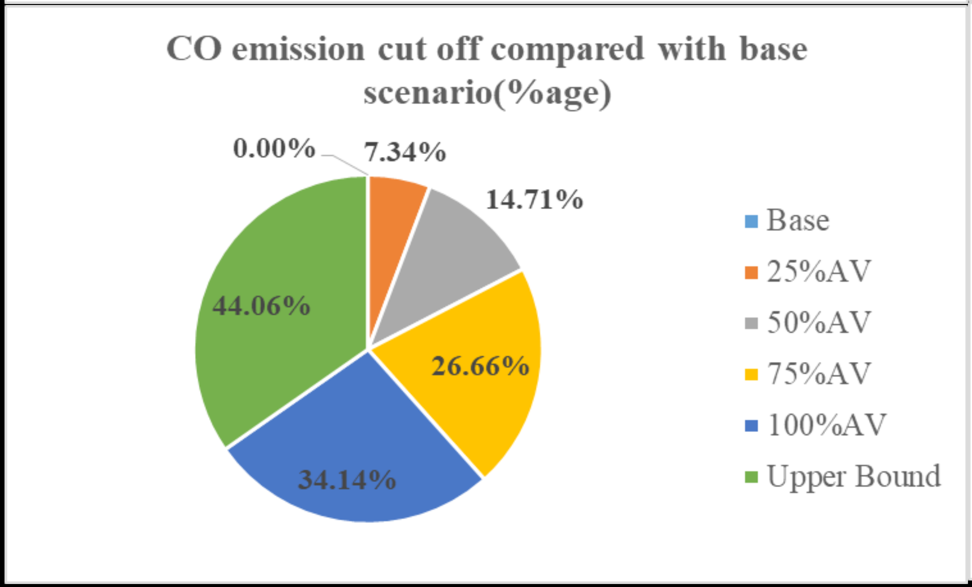
Two types of traffic assignment methods are used:

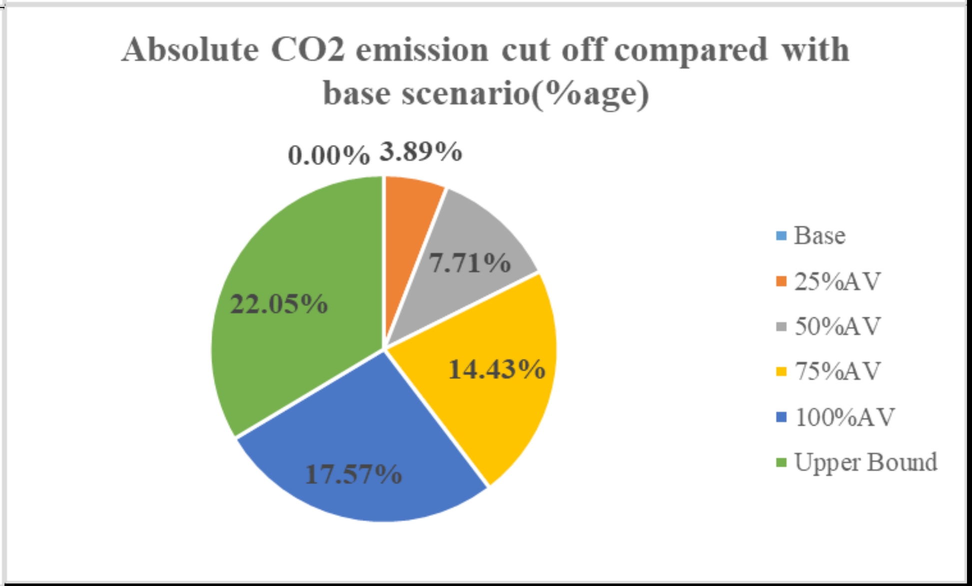
1. ***Dynamic user assignment(Iterative assignment):*** This method enables the driver to leave the current route in favor of a more feasible one for the remaining trip as a consequence of improvements in link travel times since the previous route option was taken at an earlier decision node or the origin node.
2. ***One shot traffic assignment method:*** In this situation, each vehicle computes the fastest route at the moment of departure, which prevents all vehicles from going blindly into the traffic jam. However, Once the car has departed from its origin, it is unable to alter its route at the center the network's, as the iterative user approach does.

Results and Discussion





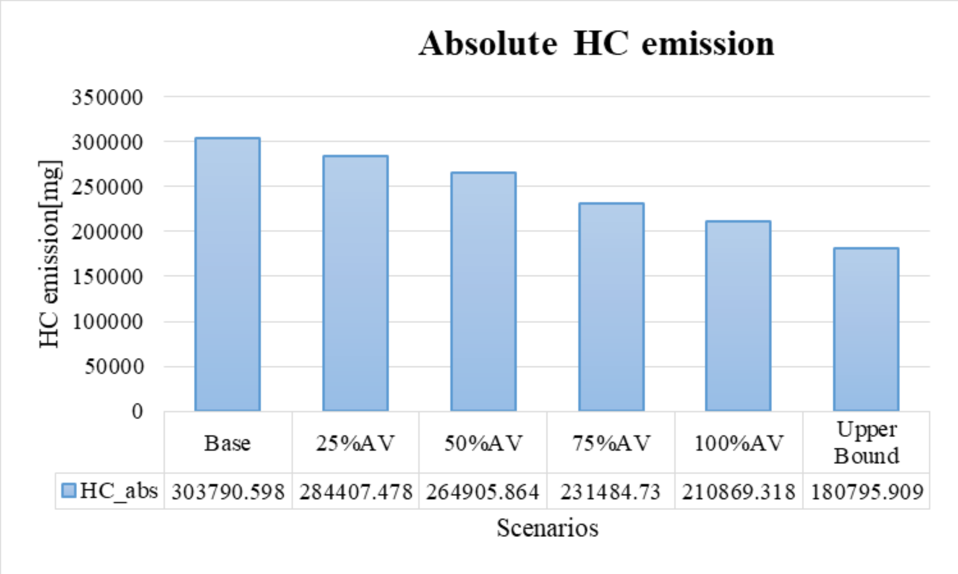


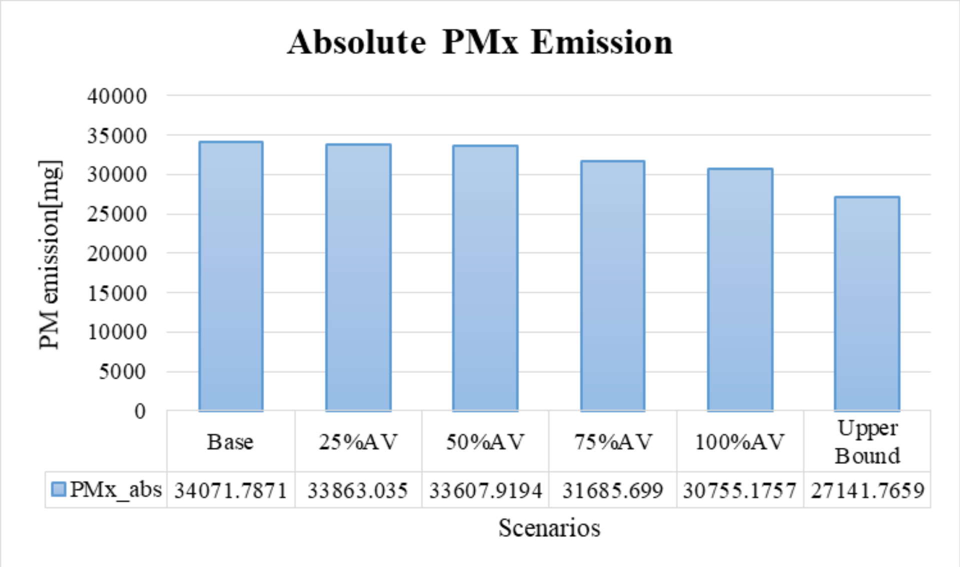


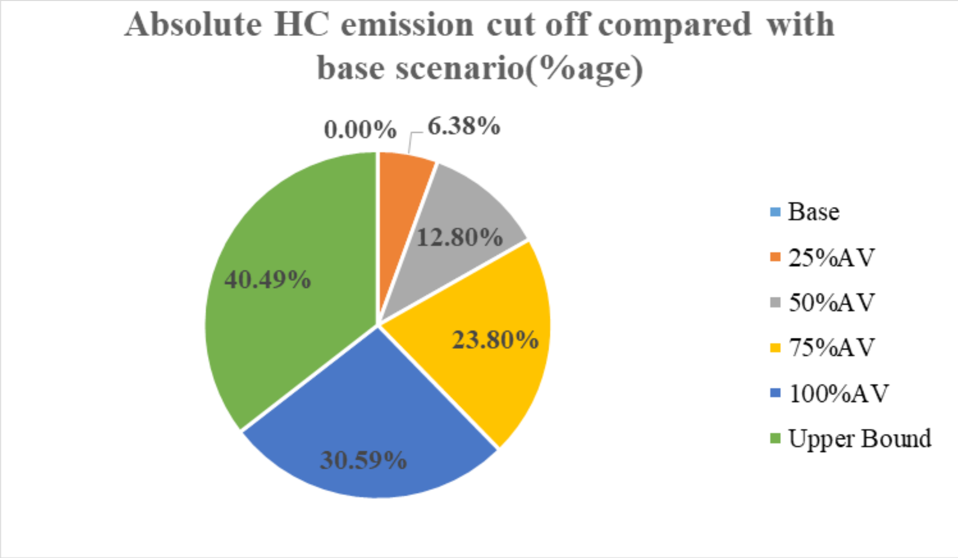
The total amount of CO emission for the whole network is 585.34 kg in the base scenario, and the emission contents steadily decreased as the market penetration rate of automated vehicles increased in both number and degree of automation.

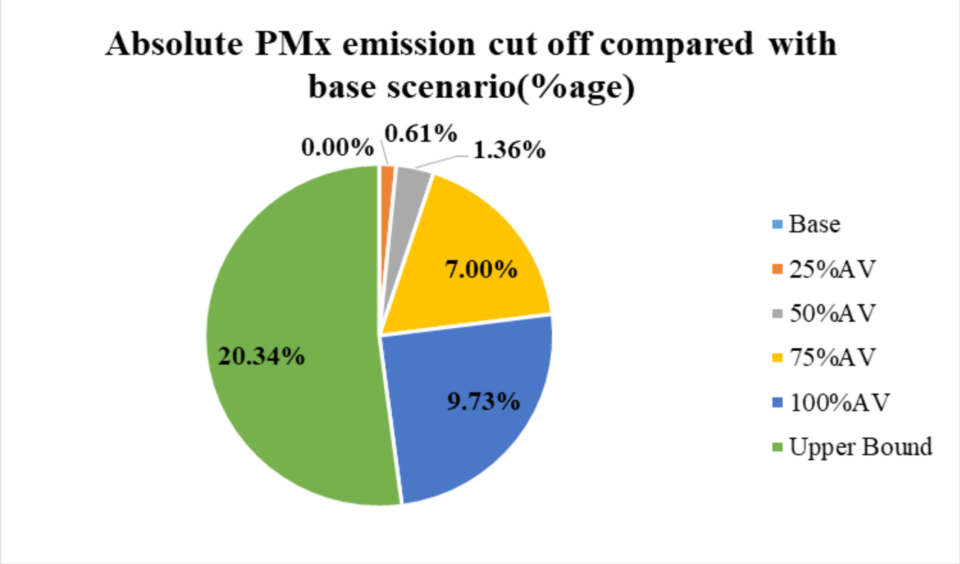
In the scenario 5, the automated vehicles were able to cut emission by 257.88 kg (44.06 %) compared to the base scenario.

Results and Discussion





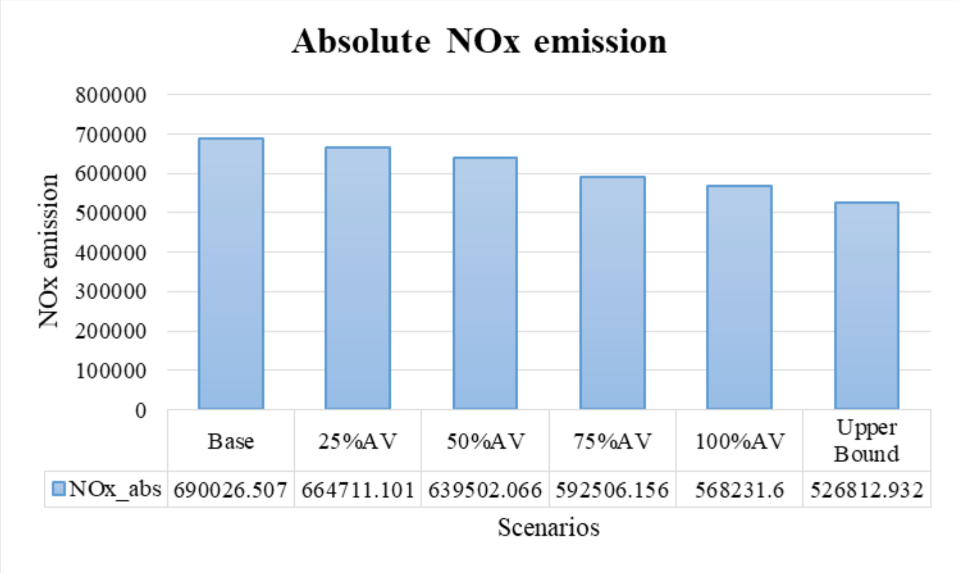


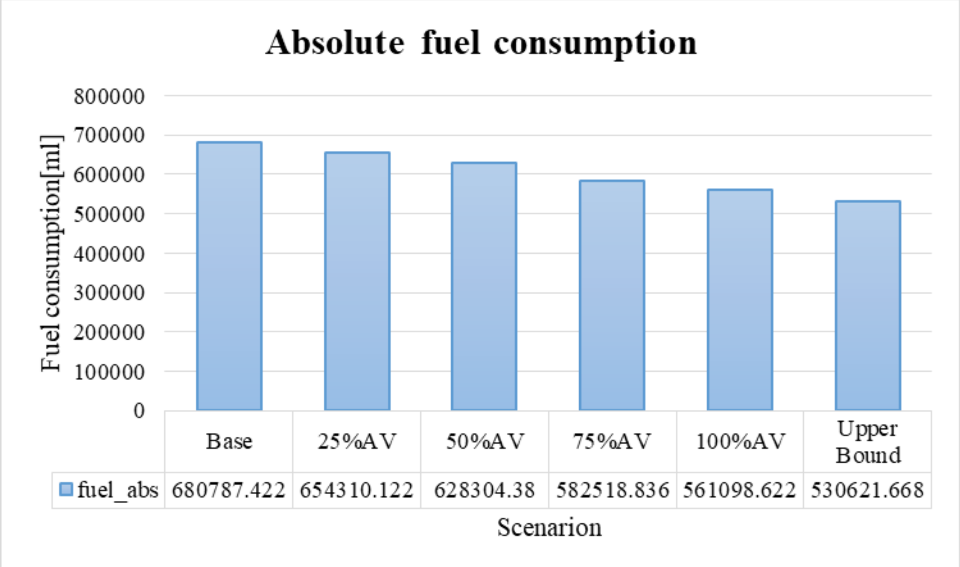


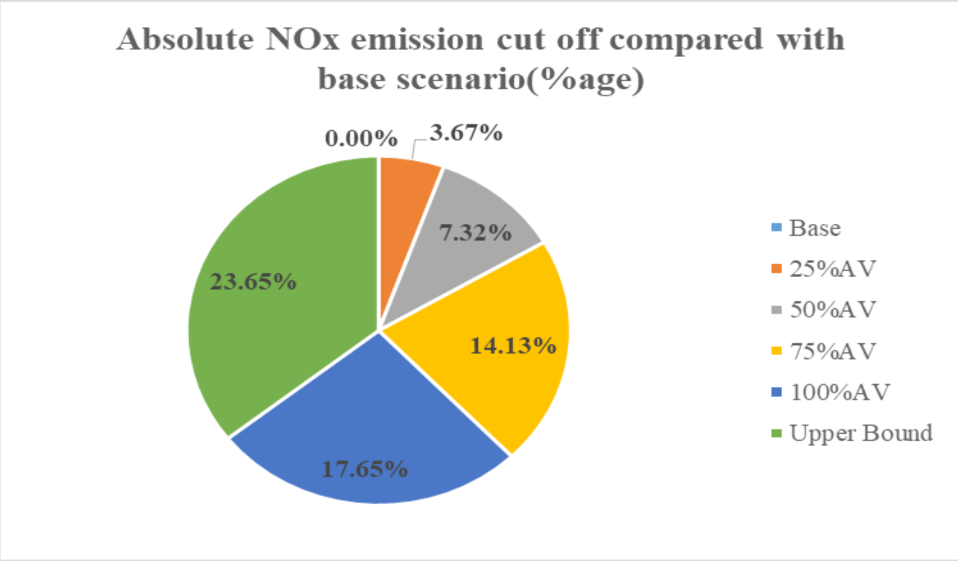
The total amount of HC emission for the whole network is 303.8 g in the base scenario, and the emission contents steadily decreased as the market penetration rate of automated vehicles increased in both number and degree of automation.

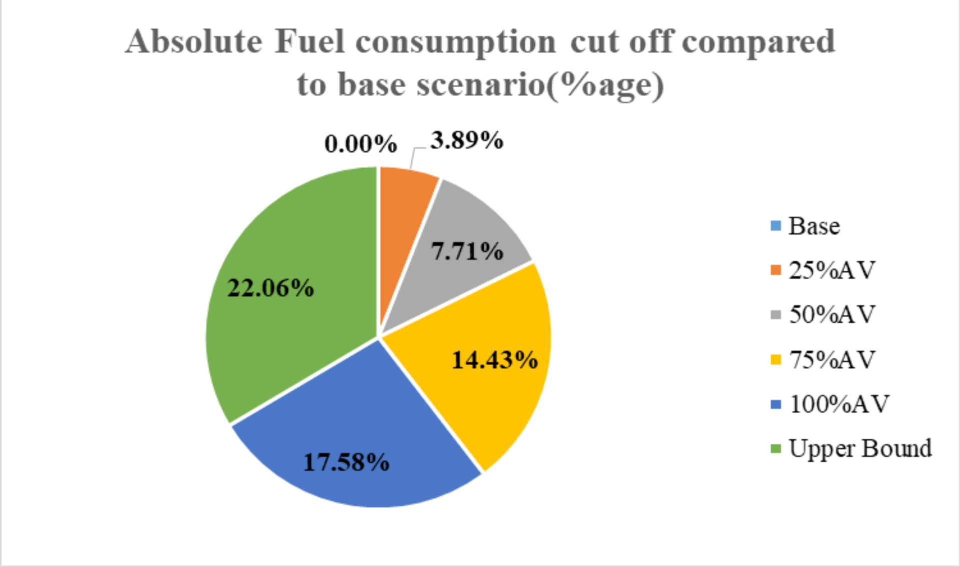
In the most optimistic scenario, the automated vehicles were able to cut HC emission by 123 g (44.06 %) compared to the base scenario.

Results and Discussion







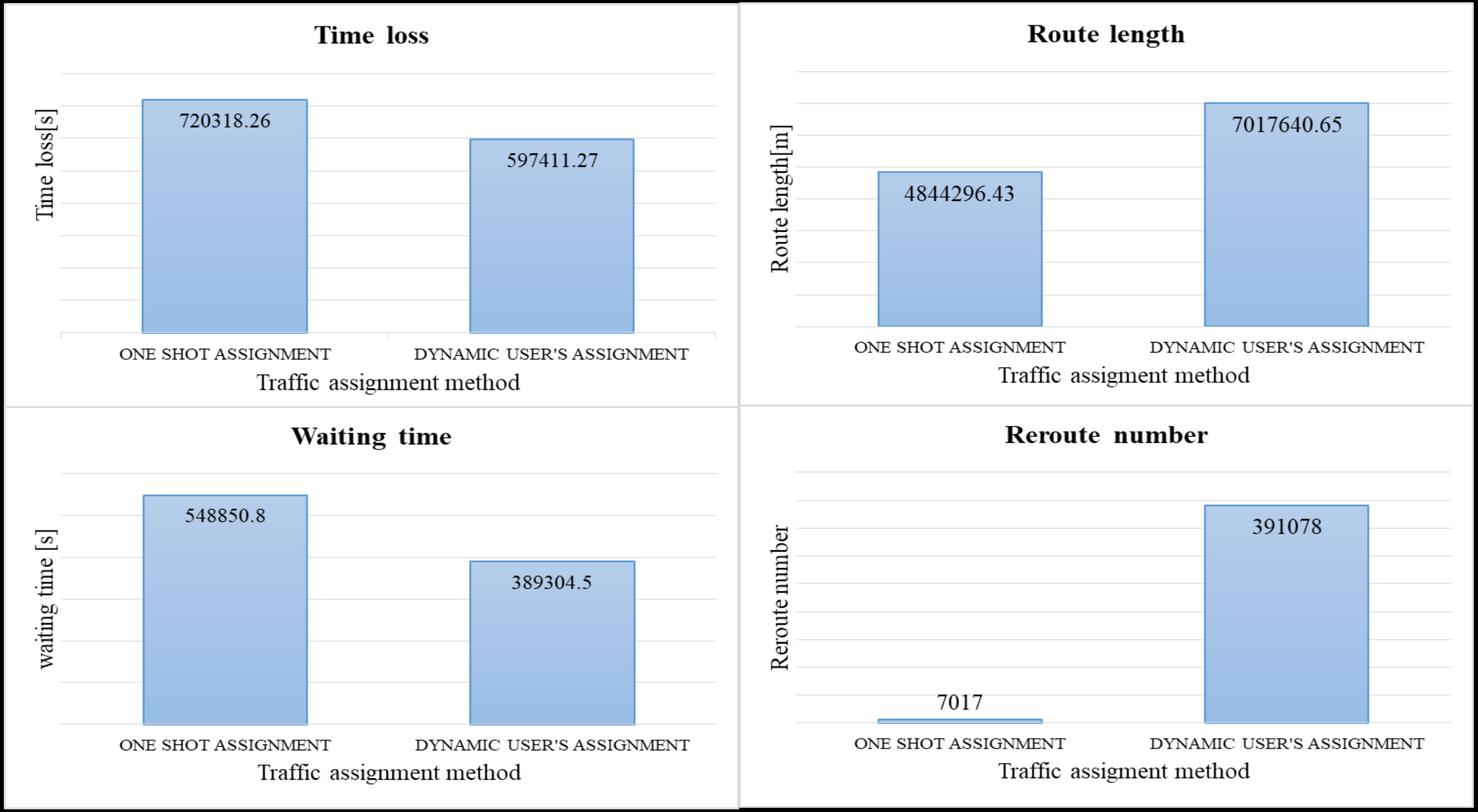


The total amount of NOx emission for the whole network is 690 g in the base scenario, and the emission contents steadily decreased as the market penetration rate of automated vehicles increased in both number and degree of automation.

In the upper bound case scenario, fuel usage was decreased to 530.6 l (down by 150.2 l or 22.06 % relative to the base scenario)

Results and Discussion

Traffic assignment methods



In 15% of level 1, 20% of level 2, 20% of level 3, 25% of level 4, and 20% of level 5;
Dynamic User's assignment outperforms the one shot traffic assignment by shortening the time loss during the travels and by lowering waiting time.

However, the DUA has relatively higher route length and reroute numbers

Conclusion

- *Simulation of Urban Mobility (SUMO) was employed for developing and simulating both conventional and automated vehicles.*
- *Krauss modified and LC2013 were used as car-following and lane changing models, respectively.*
- *HBEFA v3.1 emission model was used to measure emission.*
- *The analysis has been done by* six successive scenarios with varying volume and level of automations.
- *Automated vehicles have the potential to significantly reduce the amount of pollution emitted by vehicles.*
- On the most optimistic scenario case, automated vehicles are capable of reducing carbon monoxide (CO) emissions by 44.06 %, carbon dioxide (CO_2) emissions by 22.05 %, hydrocarbons (HC) emissions by 40.49 %, particulate matter (PMx) emissions by 20.34 %, and nitrogen oxides (NOx) emissions by 23.65 %.
- The DUA outperformed one-shot assignment by reducing vehicle time loss and waiting period by 17.06 % and 29.07 %, respectively.