## Fuel consumption

On road degradation factor:

LEAP uses 0.8 (<https://www.energycommunity.org/Help/Demand/Fuel_Economy_Correction_Factor.htm>)

USA uses <https://fueleconomy.gov/feg/factors.shtml>

Important of on-road factor:

<https://www.todayonline.com/lifestyle/cars/attrage-ous-fuel-economy>

### Private car

See R script. We have to consider specific models. Most of them are not justified, because of lack of data (such as CNG, BEV, PHEV, HEV-D)

For BEV: <https://www.businesstimes.com.sg/hub/bt-motoring/electric-car-population-surges-380-in-2017>

## Taxi

We assumed same fuel consumption between private car and taxi. Proof?

## Public bus

We base the public bus fuel consumption from a study by (Zhang et al., 2014) in the city of Bejiing. Justify to use Beijing for a proxy to Singapore: Population (21.5 million Beijing, 5 million in Singaproe). Density (1300 pop/km2 Beijing, 7804 pop/km2). Road conditions? Traffic?

As Singapore is significantly warmer than Beijing (Values) we assume that there is a higher use of air-conditioning in Singapore (assumed at maximum capacity). So +22.8% for ICEB-D, +9% for CNGB, +48.2% for HEB-D.

1.15 L gasoline / L Diesel

23.7 MJ/L of CNG

|  |  |  |  |
| --- | --- | --- | --- |
| Technology | Fuel | Value (L/100km) |  |
| ICEB-D | Diesel | 32.6\*1.228=40 | (Zhang et al., 2014) |
| ICEB-G | Gasoline | 40\*1.15=45.8 |  |
| HEB-D | Diesel | 24.3\*1.482=36 | (Zhang et al., 2014) |
| HEB-G | Gasoline | 36\*1.15=41.4 |  |
| CNGB | CNG | 16.1[MJ/km]\*1.09\*100/23.7[MJ/L]=74.1 | (Zhang et al., 2014) |
| EB | Electricity | 172 | Literature review laura |

ICEB-D is consistent with prior studies in Singapore, with a value of 42.3 L/100km for ICEB-D (Wei & Cheah, 2015). This is however almost half of the values of 72.1 L/100km reported by Alternative Fuels Data Center of the U.S. Department of Energy provides data on average fuel economy of different vehicle categories (U.S. Department of Energy, 2019). Why?

We assume that technology called CNG and Petrol-CNG are assumed to be CNG bus in LTA.

We assume that private bus and school bus have the same fuel consumption. Back up for this assumption?

## Motorcycle

Manufacturer fuel economy by model year motorcycle: <https://www.totalmotorcycle.com/MotorcycleFuelEconomyGuide/index?d=1>

From (Koossalapeerom et al., 2019)

|  |  |  |  |
| --- | --- | --- | --- |
| Technology | Fuel | Value | Source |
| ICEM-G | Gasoline | 2.43 (l/100km) | (Koossalapeerom et al., 2019) |
| EM | Electricity | 2.8 (kWh/100km) | (Koossalapeerom et al., 2019) |

## MRT and LRT

Same electrical consumption by veh.km: 7220 kWh/100km

We assume that all transport-related electricial consumption of EMA.gov is associated with LRT and MRT. Can we check that? Contact someone? We further assumed similar electrical consumption by MRT and LRT vehicle km travelled.

Compare electrical consumption of such systems with literature. Better to do by pkt?

In they use a value of

|  |  |  |
| --- | --- | --- |
| Reference | Fuel consumption kWh/vkt | Note |
| Own calculations | 72.2 |  |
| (Chester & Horvath, 2010) | 170 | Based on the German ICE high speed rail and similar to |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

# Fleet module

## Taxi

We assumed similar survival rates between Taxi and private cars. Proof? Contact someone? Lynette? How to better assume survival of taxi? Idea of lifetime?

# Transport Activity

## Ownership

Car ownership model developed in 1990 (Phang & Chin, 1990)

Mode choice model between cars and bus (Phang & Chin, 1990)

Discussion on travel with activite nobility in Singapore (Rojas López & Wong, 2017). Pros and cons.

## Prospective transport activity

We assume School bus and Private bus to keep constant PKT from 2018 onwards. Reasons: Stable PKT in the past, and population of potential users is not changing (population of youth will not change significantly up to 2030). When we do the linear regression of youth population and school bus PKT, we obtain a negative coefficient (with 0.99 R2) because the youth population is decreasing but school bus are increasing. Meaning that they are driven by public policies rather than population demand.

## Scenario analysis:

Three layers of scenarios (or pathways)

1. Total demand of passive mode of transport up to 2030
2. Model share of passive mode of transport up to 2030
3. Technology market share of passive mode of transport up to 2030

1)

From 2005 to 2018, there is a linear relationship between total PKT by passive mode of transport and population.

BAU: continuing linear relationship from 2019 onward.

2)

Constant case -> Modal share constant (for variables not school bus and private bus), with increasing annual mileage for cars (because of COE). We calculate the increasing mileage for cars assuming a constant stock of vehicles fixed at 2018 level.

LTA Master Plan -> If transport would follow the LTA master Plan, public transit would increase in model split from 2019 to 2030 following trends from 2012 to 2018. The rest of the modes would decrease proportionally to match the total PKT demand.

For public transit, the master plan of Singapore is to achieve “75% of all journeys during peak hours made on public transport”. Currently, 71% of all journeys during peak hours are made through Walk Cycle Ride (Land Transport Master Plan 2040)

Look at page 11 of mater plan: Active mobility represented 2.2 out of 14.7 million journeyrs in 2012

High Uber case ->

3)

For technology, the trends show high hybridixation in 2016 and 2017. This was due to the Revised Carbon Emission-Based Vehicle Scheme (CEVS) which offered high rebates (up to $30,000) to hybrid vehicles (<https://www.onemotoring.com.sg/content/onemotoring/home/buying/upfront-vehicle-costs/emissions-charges.html#CEVS_At_a_glance>). However, also offered rebates to diesel. New system now, lower rebates, therefore no increasing trends in hybrid.

* Why did they change the emission scheme?
* How much more hybrid can be deployed with a high rebate?

# GHG emissions

No car production in Singapore (<https://www.straitstimes.com/business/companies-markets/why-dyson-picked-singapore-to-build-its-electric-cars>)

# Sensitivity analysis

To build:

* Load factor assumptions
* Fuel consumption for bus, hybrid, EV,
* Projection of population scenario

# NEXT STEPS to improve

* Implement vehicle and bus manufacturing emissions (for GHG).
* Survival rates for Taxi
* Load factors for Taxi
* Fuel consumption for private and school buses
* Look at consumer voice model in Singapore. Worth it?
* Regression in vkt per private car? Maybe gasoline prices, or total car population (COE), are main drivers
* In the LTA master plan, also active mobility. Can we calculate changes in trends in active mobility? Maybe we could reduce the total PKT.
* Emission factor of PM by HEV-G is similar to ICEV-G now. REFINE.

Ideas:

-Using a LCI adjusted inventory, we should add manufacturing emissions of vehicles. Use EXIOBASE

# NEXT STEPS to do

* Air pollutant emission factors for electricity production
* Develop scenario for electricity GHG emission factors (from electricity mixes).
* Carbon budget for Singapore passenger transport
* Optimization procedure to achieve target with either modal share or technological deployment

Comments in private hire cars:

<https://www.torque.com.sg/news/petrol-consumption-singapore-hit-record-high-despite-shrinking-car-population/>

<https://www.straitstimes.com/singapore/transport/spore-petrol-usage-set-to-hit-record-despite-fewer-vehicles>

IDEA graphs

Ternary plots represent different zones for 3 variables. In these graphs, the sum of the three variables represent 100%. We could build a ternary variable, representing each axis the % of the mitgitation gap flled by one variable, and outlining different zones of air pollution.

People to contact:

NUS

<https://www.eng.nus.edu.sg/cee/research/research-centre/centre-for-transportation-research/>

Hua Wang: <https://www.researchgate.net/profile/Hua_Wang22>

Expert in EV modelling, autonomous vehicles

<https://www.sciencedirect.com/science/article/pii/S1361920919300707>

<https://onlinelibrary.wiley.com/doi/abs/10.1111/mice.12461>

<https://www.sciencedirect.com/science/article/abs/pii/S0965856419304069>

<https://www.eng.nus.edu.sg/cee/staff/lee-der-horng/>

<https://www.tum-create.edu.sg/about/about-tum-create>

NTU

<http://research.ntu.edu.sg/expertise/academicprofile/pages/StaffProfile.aspx?ST_EMAILID=CYDWONG>

<http://www.cee.ntu.edu.sg/aboutus/FacultyDir/Pages/zwwang.aspx>

<http://www.cee.ntu.edu.sg/aboutus/FacultyDir/Pages/zhuFeng.aspx>