# Methodology Document:

### Modelling Energy Use in Transport

### Introduction:

This methodology is designed to provide a comprehensive approach to model energy use in transport. The model considers various factors such as vehicle stocks, mileage, occupancy, and more. Depending on the type of transport, the activity can be measured in either freight tonne km or passenger km.

## Key calculations within the model

1. **Calculating Activity in Kilometers (km):**

Equation:

- stocks: The current number of vehicles.

- mileage: Distance a vehicle can travel per unit of fuel.

- occupancy\_or\_load: Depending on the mode of transport, this can represent the number of passengers or the tonnage carried by freight transport.

Note:

For freight transport: activity km represents freight tonne km.

For passenger transport: activity km represents passenger km.

1. **Estimating Energy Use:**

Equation:

- travel\_km: The total distance traveled by the vehicle.

- efficiency: Represents how efficiently the vehicle uses its energy source.

1. **Supply side fuel share:**

The supply side fuel share pertains to the blending or mixing of "mixable fuels" prior to the fuel reaching the consumer. This is particularly relevant for fuels like biofuels and e-fuels. In essence, if there’s a fuel share for fuel (e.g., biodiesel) in fuel (e.g., diesel), then vehicles that conventionally use fuel will now utilize of fuel and of fuel . This will not have an impact on efficiency.

Example:

If there's a 5% supply side fuel share for biodiesel in diesel, vehicles using diesel will effectively be running on 95% diesel and 5% biodiesel.

1. **Calculating New Stocks:**

Equation:

- vehicle sales share: Percentage of vehicles sold from the total.

- new activity km: Growth in activity km based on historical data and projections.

1. **Estimating New Activity km:**

Equation:

- activity growth: Expected growth rate of the activity km based on past trends.

1. **Calculating Stock Turnover:**

Equation:

- vehicle age average: Average age of the vehicles in the stock. - survival rate function: Function representing the likelihood of a vehicle surviving a certain number of years.

1. **Adjusting Stocks:**

Equation:

This equation updates the stocks by subtracting the number of vehicles turned over and adding new stocks.

## Model functions

After outlining the main calculations of our model, we'll now explore the functions that influence them. Think of these functions as the gears of our model, fine-tuning our results to match real-world scenarios. They cover aspects from vehicle survival rates to fuel shares, showing the complexity of transport energy dynamics. Let's dive into these functions and understand their role and design.

1. **Survival Rate Function (SRF):**

This function calculates the rate at which vehicles remain operational over time. It’s an essential component in assessing how the fleet evolves and changes due to factors such as wear and tear, accidents, and vehicle retirement.

Equation**:**

Where: - represents the function (for now an S-curve) based on the vehicle’s age.

Side note: For now, the survival rate function is based on an S-curve. This decision was taken primarily because the parameters were previously available. During the next model development cycle, we plan to adjust this to use an exponential function.

1. **Stocks Turnover:**

This function calculates the number of vehicles that are no longer operational each year and is crucial for assessing the change in total vehicle stocks. Given that total stocks are computed by considering new additions and deducting turnovers, this function directly influences the dynamics of the fleet for each drive type and vehicle type.

Equation

Where:

- represents the mean age of all vehicles considered.

- provides the proportion of vehicles of a given age that are still operational.

Consequently, the updated stocks for each vehicle type and drive type can be determined by:

1. **Vehicle Sales Share (VSS):**

This function represents the proportion of a specific type of vehicle (determined by vehicle type and drive type) sold from the total number of new vehicles.

Equation

Where:

- is the number of new vehicles of a specific vehicle type and drive type that are sold in a given year.

- is the total number of new vehicles sold across all types and drive types.

Interpretation:

The vehicle sales share for a specific type of vehicle and drive type is determined by the user. The user provides sales share targets for each vehicle type and drive type. These targets are interpolated for each year, creating a smooth transition between given target years. After interpolation, the sales share values are normalized across each transport type for each year to ensure they sum up to 1 (or 100

1. **Supply Side Fuel Share (SSFS):**

This function represents the proportion of an alternative fuel type utilized within a primary fuel category.

Equation

Where:

- is the estimated energy requirement for a primary fuel type.

- is the user-specified proportion of the alternative fuel within the primary fuel category.

Example:

If there is a 5% supply side fuel share specified for biodiesel within the diesel category, and the expected diesel use for a specific period is 1 PJ (PetaJoule), then the energy use for biodiesel would be:

So, for 1 PJ of expected diesel use, 5% (or 0.05 PJ) would be accounted for by biodiesel.

1. **New Activity:**

This function calculates new activity using the the expected growth rate of activity km. The new activity for each transport type is then distributed among new vehicle stocks using the vehicle sales share.

Equation

Where:

- is the activity for the previous year.

- is representing the growth rate.

1. **Activity Growth Rate**:

The activity growth rate is computed differently based on the transport type:

- Freight: For freight transport, the growth rate is derived from a fraction of the industry GDP growth of the respective economy, added to a constant.

- Passenger: The passenger growth rate is intricately tied to the stocks-per-capita metric. When the maximum stocks-per-capita threshold hasn’t been attained, the growth rate is determined based on past growth rates using regression analysis. Once the maximum threshold is achieved, the growth rate aligns with the population growth rate.

1. **Logarithmic Curve to Limit Max Stocks Per Capita:**

This function ensures that the stock of vehicles doesn’t grow indefinitely and will taper off as it approaches a maximum limit per capita.

Equation

Where:

- represents the current stocks per capita.

- is the maximum limit of stocks per capita.

- is a growth rate constant.

- is the stocks per capita at the midpoint of the sigmoid curve.

Interpretation:

The function provides an S-shaped curve (sigmoid function) which starts slow, increases at a faster rate in the middle, and then slows down as it approaches the maximum limit.

Side note: For now, the Max Stocks Per Capita is based on an S-curve. This decision was taken primarily because the parameters were previously available. During the next model development cycle, we plan to adjust this to use an exponential function.

## Model Inputs

**Inputs for All Years (Levers):**

1. **Mileage:** This refers to the distance that a vehicle can travel on a specified amount of fuel.

2. **Efficiency:** A measure of how effectively a vehicle utilizes its fuel for producing movement.

3. **Occupancy:** This represents the number of passengers or the load a vehicle carries relative to its capacity.

4. **Supply Side Fuel Share:** The blending ratio of 'mixable fuels' like biofuels and efuels in on the supply side, before reaching the consumer.

5. **Vehicle Sales Share:** Percentage representation of each vehicle type and drive type in total new vehicle sales.

6. **Activity Growth:** A projected increase in transportation activity, which could be in passenger-km or freight tonne-km, depending on the transport type.

7. **Survival Rate Function Inputs:** Parameters for determining how vehicles phase out over time. Generally consistent across economies with exceptions in unique cases (e.g., Singapore).

8. **Expected Vehicle Saturation Limit in Stocks per Capita:** The anticipated maximum number of vehicles relative to the population size.

**Inputs Exclusive for Base Year:**

1. **Stocks:** The starting count of vehicles in circulation.

2. **Average Vehicle Age:** The mean age of vehicles in circulation at the beginning of the model.

## Yearly Calculations

1. **Energy by Fuel:** Computation of energy consumption broken down by each fuel type based on the activity and efficiency.
2. **Activity:** The sum total of distance covered or work done by all vehicles, either in passenger-km or freight tonne-km.
3. **Stocks (Excluding Base Year):** The updated number of vehicles in circulation, factoring in new additions and those phased out.

## Model Complications and Challenges:

**1. Data Collection for Vehicle Stocks and Age:**

- Granularity Issues: While data collection is integral to model accuracy, there is often a lack of detailed data that accurately represents the transport system. This includes the specific breakdown of freight vehicles such as Light Commercial Vehicles (LCV), Heavy Trucks (HT), and Medium Trucks (MT).

- Fuel Type Ambiguity: The ratio of Internal Combustion Engine (ICE) vehicles using diesel vs. gasoline for each vehicle type is often unclear.

- Age Data Shortage: Acquiring accurate average vehicle ages is a challenge for most APEC economies. Typically, a general average is used in place of precise data.

**2. Fuel Use Estimation vs. Reality:**

- Alignment Issues: When estimating fuel use based on gathered or assumed data for stocks, mileage, and efficiency, discrepancies often arise between these estimates and actual reported energy use.

-Optimization Method: To reconcile these differences, an optimization technique has been employed. This method balances out changes in the stocks, mileage, and efficiency so that their product equates to the actual reported energy use while reducing differences where they seem obviously wrong. For example, it will only change mileage and efficiency by up to x% of the original amount, so the remaining change needs to come from stocks.

**Conclusion**:

The methodology provided outlines a systematic approach to model energy use in transport. It takes into account various key factors, ensuring a comprehensive and accurate representation of the energy dynamics in the transport sector.