UNITED NATIONS
ECONOMIC COMMISSION
FOR EUROPE

# ForFITS

## Explanation of the Vensim model

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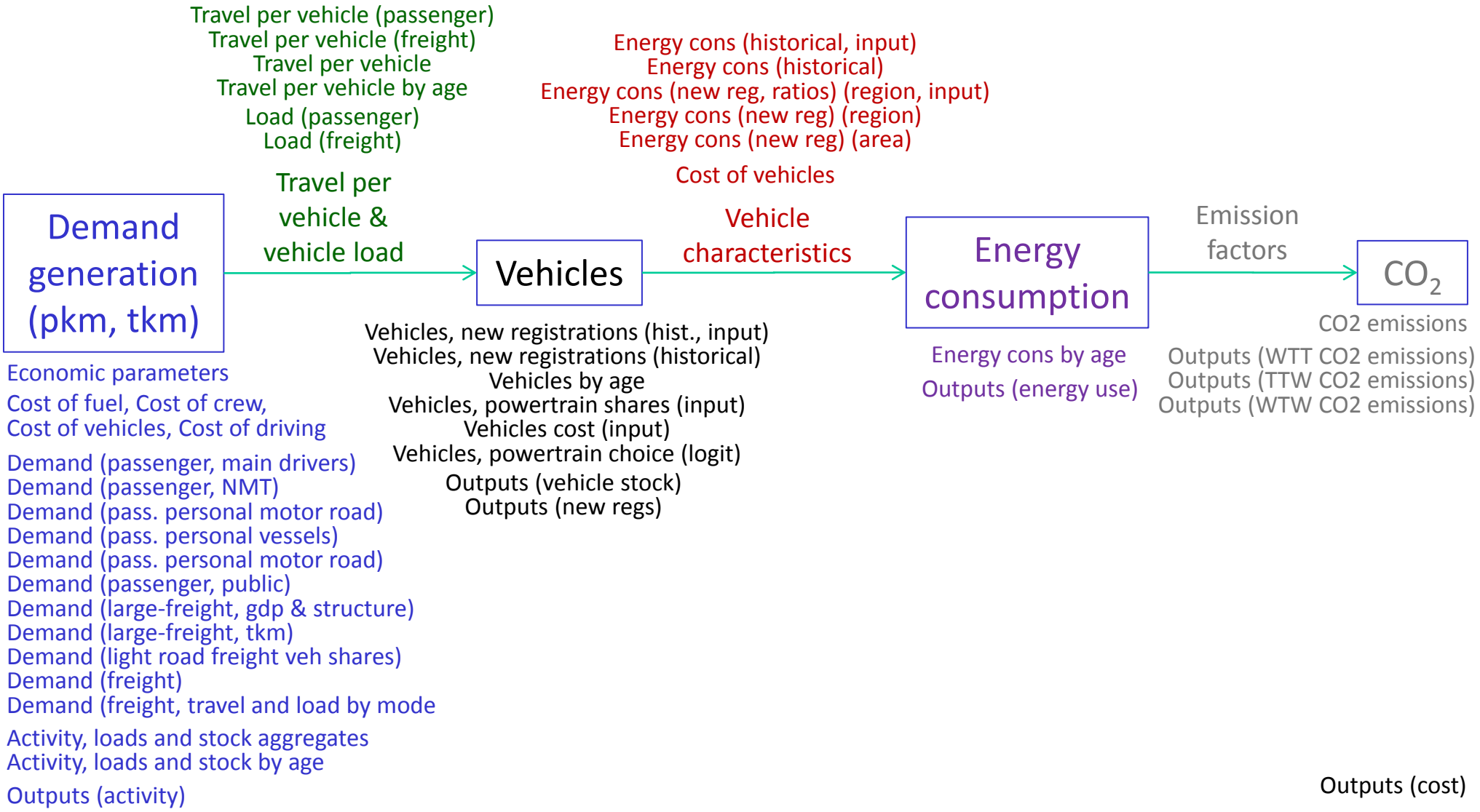
# ForFITS structure and model "views"



# Levels

- Area
- Service
- Mode
- Vehicle class
- Powertrain
- Age

# Economic parameters

## Target

Socio-economic data from the inputs excel file

## Inputs

- GDP
- Population
- Time span

## Outputs

- GDP per capita

  main driver to determine passenger transport demand

# Demand passenger (main drivers) (1/2)

## Target

S-Curves link the passenger demand with the GDP per capita taking into account several factors, such as the passenger transport characteristic index, the cost of driving and the environmental culture

## Inputs for the calibration of the initial S-Curve

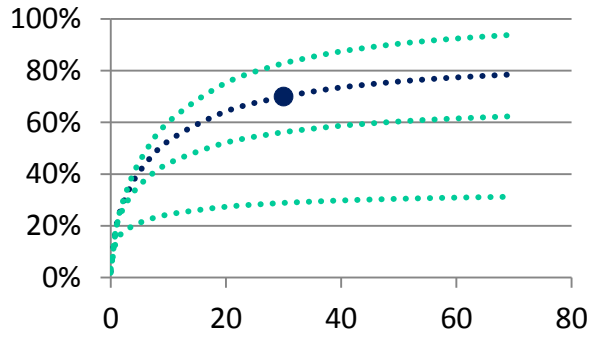
Parameters characterizing the passenger transport demand as function of the GDP/capita

- Ownership of personal passenger road vehicles
- Ownership of personal passenger LDVS
- Share of pkm on personal vehicles in total pkm of public transport and personal passenger vehicles
- Share of air transport in total pkm (personal passenger vehicles, air and public transport)
- People per active bike
- Ownership of personal passenger vessels

**Reference value → Base year**

S-CURVE FAMILY

THREE PATTERNS LOW, AVERAGE, HIGH



# Demand passenger (main drivers) (2/2)

## Factors affecting the shape of the initial S-Curve

- Passenger transport characteristic index
  - 0 Focus on personal vehicles, low density of population, significant presence of urban sprawl, horizontal urban development
  - 1 Very high density of population, very strong focus on public transport, geographical and other constraints leading to the vertical development of the urban area
- Environmental culture

  Takes into account behavioural aspect
  - 0 Little relevance of environmentally conscious behaviour
  - 1 Higher relevance of environmentally friendly transport options
- Cost of driving (and moving goods)

# Demand passenger (NMT)

## Target

Projecting transport demand for NON-MOTORISED TRANSPORT (NMT)

## Inputs

- S-Curve on people per active bike
- GDP per capita
- Population

→ Target number of bikes

- Share of people walking → Target number of walkers
- Annual travel per vehicle → Target vkm
- Load per vehicle → Target pkm

## Outputs

# Demand (pass. personal motor road)

## Target

Projecting vehicle stock, vkm and pkm for passenger personal motorized road transport (cars, two and three wheelers)

## Inputs

- S-Curve on ownership of personal passenger road vehicles
- S-Curve on ownership of personal passenger LDVS
- GDP per capita
- Population
- Exogenous vehicle shares
- Annual travel per vehicle
- Load per vehicle

## Outputs

Target vehicle stock for LDVS (cars)

Target vehicle stock for total personal passenger road vehicles

Target vehicle stock by vehicle class for TWO WHEELERS, THREE WHEELERS and LDVS

Target vkm

Target pkm

# Demand (pass. personal vessels)

## Target

Projecting vehicle stock, vkm and pkm for transport taking place on boats

## Inputs

- S-Curve on ownership of personal passenger vessels
- GDP per capita
- Population
- Exogenous vehicle shares
- Annual travel per vehicle
- Load per vehicle

## Outputs

Target number of boats

Target vehicle stock by vehicle class

Target vkm

Target pkm

# Demand (passenger, public)

## Target

Projecting pkm, vkm and vehicle stock for public passenger transport

## Inputs

- Share of pkm on personal vehicles in total pkm of public transport and personal passenger vehicles
- GDP per capita
- Target pkm on personal passenger vehicles
- Exogenous pkm shares
- Cost elasticities
- Load per vehicle
- Annual travel per vehicle

## Outputs

GDP/capita-driven pkm on public passenger transport vehicles

GDP/capita-driven pkm on public transport vehicles by class

Target pkm

Target vkm

Target vehicle stock

# Demand (passenger, air)

## Target

Projecting pkm, vkm and vehicle stock for passenger air transport

## Inputs

- Share of air transport in total pkm (personal passenger vehices, air and public transport)
- GDP per capita
- Target pkm on personal passenger vehicles
- Target pkm on public transport vehicles
- Exogenous pkm shares
- Cost elasticities
- Load per vehicle
- Annual travel per vehicle

## Outputs

GDP/capita-driven pkm on passenger air transport vehicles

GDP/capita-driven pkm on passenger air transport vehicles by class

Target pkm

Target vkm

Target vehicle stock

# Demand (large-freight, GDP & structure)

## Target

Projecting freight activity in large-freight modes as function of the GDP and the structure of the freight transport system

## Inputs

- Freight activity at the base year
- GDP

→ Evolution of the tonnes lifted over time

- Shares of tonnes lifted by good type
- Shares of tonnes lifted by haul distance
- Shares of tonnes lifted by transport zone

→ Disaggregation depending on the structural characteristics of the freight transport system

- Haul length by haul distance

→ Freight activity (tkm) over time

- Hauls per vehicle ratios
- Load factor ratios
- Vehicle capacity ratios
- Target vehicle shares

→ GDP & structure-driven tkm by vehicle class

## Outputs

# Demand (large-freight, tkm)

## Target

Projecting freight activity in large-freight modes taking into account the effects of costs

## Inputs

- GDP & structure–driven tkm by vehicle class
- Cost elasticities

## Outputs

Target tkm

# Demand (light road freight veh shares)

## Target

Projecting the share of light vehicles in total road freight

## Inputs

- S-curves family of light vehicles share in total road freight expressed as a function of the GDP per capita
- Reference value (base year)
- GDP per capita

## Outputs

Target light vehicles share

# Demand (freight)

## Target

Projecting tkm, vkm and vehicle stock by vehicle class for all freight modes

## Inputs

- Target tkm for large-freight
- Annual travel per vehicle
- Load per vehicle

→ Target tkm, target vkm and target vehicle stock for large-freight modes by vehicle class

- Number of road vehicles belonging to large-freight modes
- Light vehicles share in total road freight

→ Target vehicle stock for light-freight by vehicle class

- Annual travel per vehicle → Target vkm for light-freight by vehicle class
- Load per vehicle → Target tkm for light-freight by vehicle class

## Outputs

# Vehicles, new registrations (hist., input)

## Target

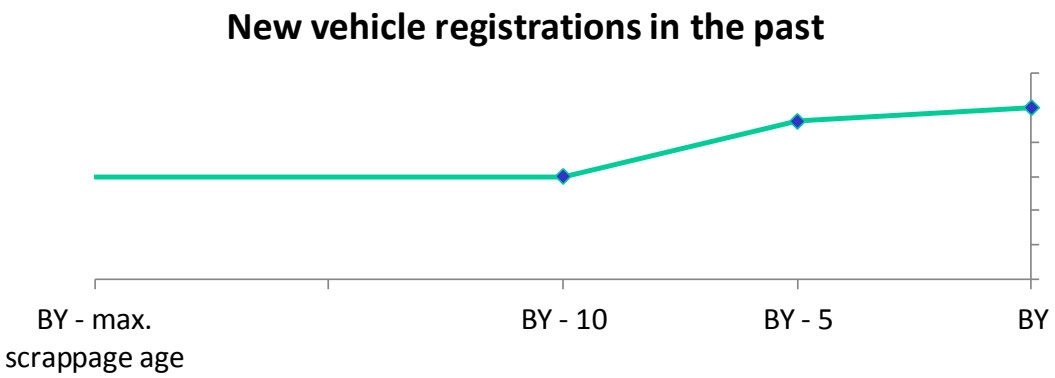
Vehicles by powertrain registered within the ten years prior to the base year

## Inputs

- User inputs on vehicle registrations at the base year as well as in the past (5 and 10 years before the base year)

## Outputs

New vehicle registrations by powertrain and by age at the base year



# Vehicles, new registrations (historical)

## Target

Calibration of the vehicle survival curves

## Inputs

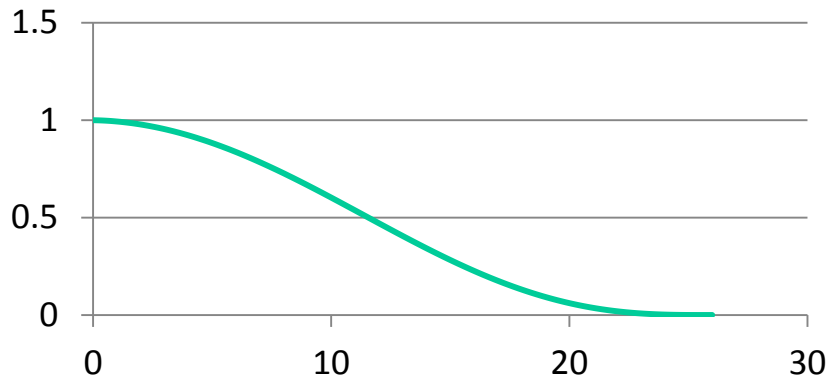
- Vehicles sold within the ten years prior to the base year
- New registrations assumed to be constant before the ten years period prior to the base year
- Vehicle stock at the base year

## Outputs

Survival curve

Maximum scrappage age by vehicle class

Average vehicle life by vehicle class



# Vehicles by age

## Target

Projection of the new vehicle registrations and the vehicle stock by age

## Inputs

- Target vehicle stock from the transport demand generation module
- Number of vehicles in the stock
- Vehicle scrappage curves
- Aging system

## Outputs

New vehicle registrations over time

Vehicle stock by age over time

# Vehicles, powertrain shares (input)

## Target

Powertrain shares or powertrain availability to distribute the new vehicle registrations across the different technologies

## Inputs

- If the powertrain choice is treated exogenously, user inputs on technology shares
- If the powertrain choice is treated endogenously, user inputs on technology availability

## Outputs

- Powertrain shares to allocate the new vehicle registrations over time across the different technologies
- Powertrain availability affecting the endogenous calculations that lead to the technology shares (logit model)

# Vehicle cost (input)

## Target

Information on the vehicle cost over time depending on the technology

## Inputs

- User inputs on technologies cost at the short and long term

## Outputs

Cost per vehicle by powertrain with respect to the new vehicle registrations over time

# Vehicles, powertrain choice (logit)

## Target

Calculation of the technology shares in the new vehicle registrations in the case that powertrain selection is treated endogenously

## Inputs

- Vehicle cost
- Estimated cost due to fuel consumption within the vehicle life

→ Total cost by powertrain

- Annual travel per vehicle by age

→ Total cost per km by powertrain

- Discount rate effect by age

→ Total discounted cost per km by powertrain

- Logit function taking into account the savings of purchasing one technology compared to the another

→ Powertrain shares

## Outputs

# Travel per vehicle (passenger)

## Target

Travel per vehicle by vehicle class over time for passenger vehicles

| Inputs | Outputs |
| --- | --- |
| ▪ User inputs on travel per vehicle at the base year<br>▪ Cost elasticities<br>▪ GDP per capita elasticity (very small)<br>▪ Passenger transport characteristic index elasticity | Travel per vehicle by vehicle class for personal passenger vehicles |
| ▪ User inputs on travel per vehicle at the base year<br>▪ Vkm variations<br>▪ Minimum and maximum factors that limit the fraction of the vkm variations absorbed by the travel component | Travel per vehicle by vehicle class for public and air passenger transport. Currently the factors are set in a way that the annual travel per vehicle remains always constant at the base year value |

# Travel per vehicle (freight)

## Target

Travel per vehicle by vehicle class over time for freight vehicles

## Inputs

- User inputs on travel per vehicle at the base year
- Cost elasticities
- GDP elasticity

- User inputs on travel per vehicle at the base year
- Vkm variations
- Minimum and maximum factors that limit the fraction of the vkm variations absorbed by the travel component

## Outputs

Travel per vehicle by vehicle class for light freight vehicles

Travel per vehicle by vehicle class for large freight vehicles. Currently the factors are set in a way that the annual travel per vehicle remains always constant at the base year value

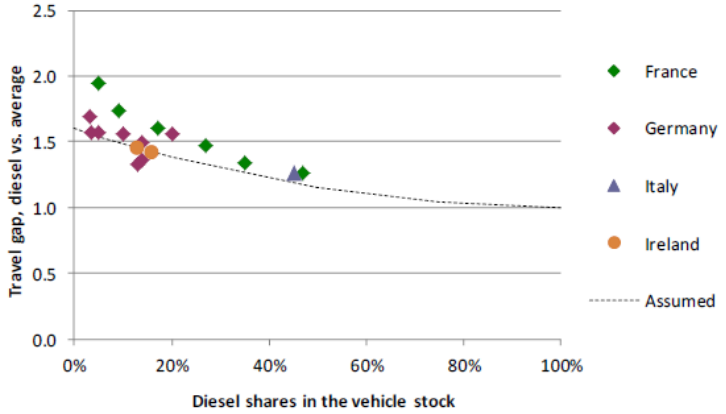
# Travel per vehicle

## Target

Travel per vehicle by powertrain over time

## Inputs

- Travel per vehicle by vehicle class
- Travel gap law for LDVS




- Powertrain shares in the vehicle fleet
- Factors correcting the travel gap law taking into account the different travel order of magnitude between the modes

## Outputs

Travel per vehicle by powertrain for LDVS

Travel per vehicle by powertrain for all the modes

# Travel per vehicle by age

## Target

Travel per vehicle by age over time

## Inputs

- Travel per vehicle by powertrain
- Vehicle shares by age in the fleet
- Annual travel per vehicle assumed as a linear function of the vehicle age

  The annual travel per vehicle at the maximum scrappage age is estimated to be half of the travel taking place in the first year of life of the vehicle

## Outputs

Travel per vehicle by age

# Cost of fuel

## Target

Cost of fuel per vkm at different levels of detail

## Inputs

- User inputs on cost of fuel per unit energy by fuel blend
- Fuel blend and powertrain matching matrix
- Energy consumption per km by powertrain

## Outputs

Cost of fuel per vkm by powertrain

- Vkm at different levels of detail → Aggregates on cost of fuel per vkm for the different modes and sub-modes

# Cost of vehicles

## Target

Cost of vehicles per vkm at different levels of detail

## Inputs

- Cost of the vehicles in the stock by age (for simplicity and to limit input requirements, this assumes that all the vehicles, independently of the age, cost the same as those registered at the base year)
- Vehicle shares in the fleet
- Average vehicle life
- Annual travel per vehicle

## Outputs

Aggregates on cost per vehicle

→ Aggregates on annual cost per vehicle

→ Aggregates on cost per vkm for the different modes and sub-modes

# Cost of crew

## Target

Cost of crew per vkm at different levels of detail

## Inputs

- User inputs on annual crew cost per vehicle
- Aggregates on annual travel per vehicle

## Outputs

Aggregates on cost of crew per vkm for the different modes and sub-modes

# Cost of driving

## Target

Total cost of driving per vkm at different levels of detail

## Inputs

- Cost of fuel per vkm
- Cost of vehicles per vkm
- Cost of crew per vkm
- User inputs on road pricing per vkm
- Aggregates on load per vehicle

## Outputs

Total cost of driving per vkm for the different modes and sub-modes

Total cost of driving per pkm/tkm for the different modes and sub-modes

# Load (passenger)

## Target

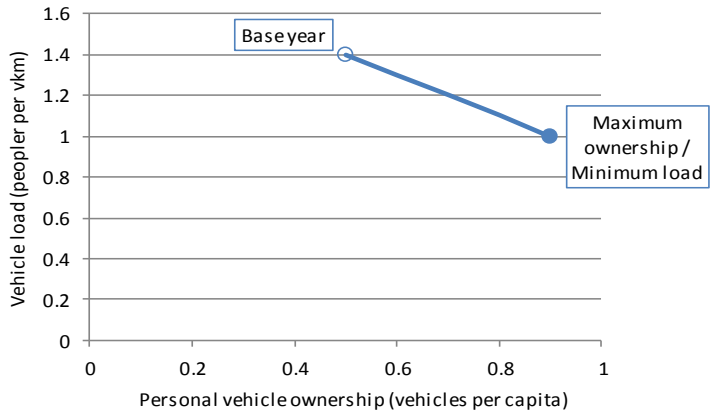
Load per vehicle by vehicle class over time for passenger vehicles

## Inputs

- User inputs on load per vehicle at the base year
- Load per vehicle as linear function of the personal vehicle ownership

## Outputs

Load per vehicle by vehicle class for personal passenger vehicles




- User inputs on load per vehicle at the base year
- Pkm variations
- Minimum and maximum factors that limit the fraction of the pkm variations absorbed by the load component

Load per vehicle by vehicle class for public and air passenger transport. Currently the factors are set in a way that the load per vehicle remains always constant at the base year value

# Load (freight)

## Target

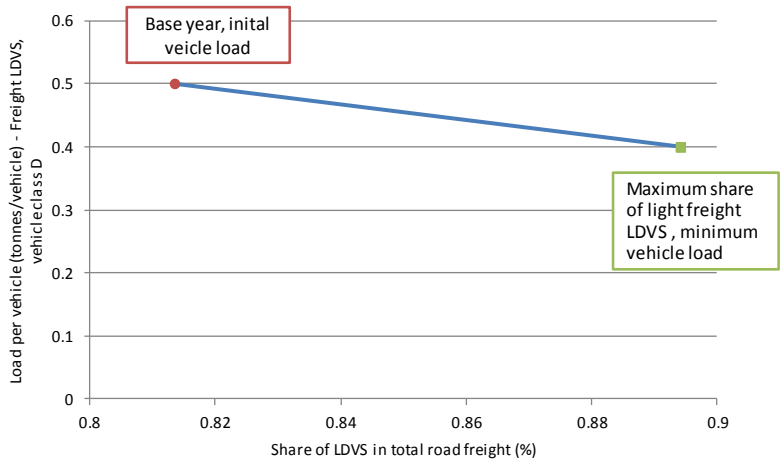
Load per vehicle by vehicle class over time for freight vehicles

## Inputs

- User inputs on load per vehicle at the base year
- Load per vehicle as linear function of the vehicle shares in total road freight

## Outputs

Load per vehicle by vehicle class for light freight vehicles




- User inputs on load per vehicle at the base year
- Change of tkm cost
- Elasticities of load per vehicle with respect to the cost of tkm

Load per vehicle by vehicle class for large freight vehicles

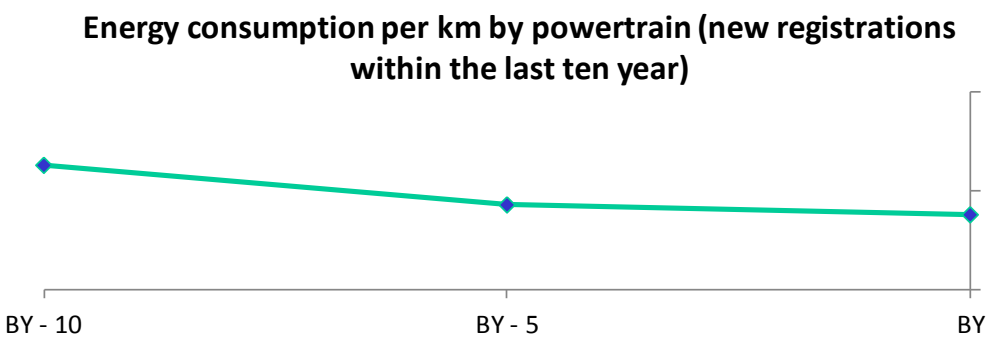
# Energy cons (historical, input)

## Target

Energy consumption of those vehicles registered within the ten years prior to the base year

## Inputs

- User inputs on registrations-weighted energy consumption per km of vehicles registered at the base year as well as in the past (5 and 10 years before the base year)
- Technology ratios with respect to GASOLINE PI ICE




## Outputs

- Registrations-weighted energy consumption per km by vehicle class and by age of those vehicles registered within the ten years prior to the base year
- Registrations-weighted energy consumption per km by powertrain and by age of those vehicles registered within the ten years prior to the base year

# Energy cons (historical)

## Target

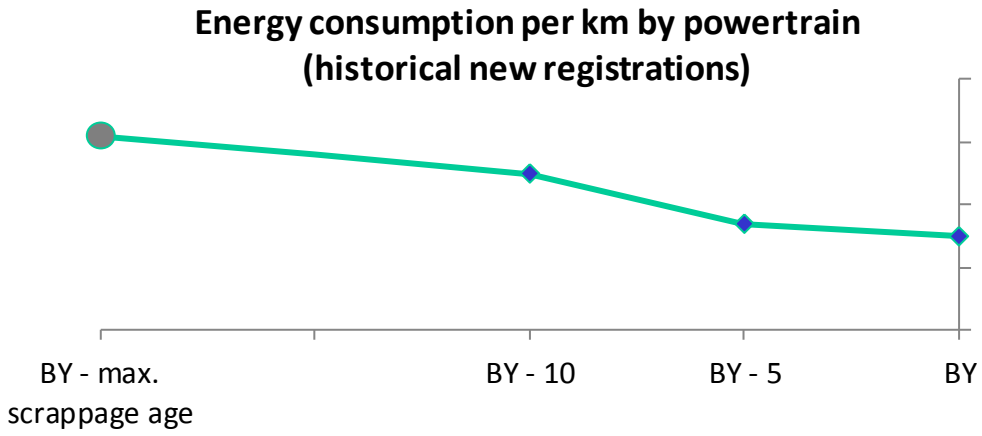
Energy consumption per km of those vehicles in the stock at the base year

## Inputs

- Energy consumption per km by powertrain of vehicles registered within the last ten years prior to the base year
- Energy consumption per km oh those vehicles registered before the period of ten years prior to the base year assumed to be linear
- User inputs on energy consumption per km by powertrain in the vehicle stock at the base year

## Outputs

Energy consumption per km by age of those vehicles that constitute the fleet at the base year



# Energy cons (new reg) (region)

## Target

Energy consumption per km of new vehicles registered over time

## Inputs

- User inputs on the evolution of GASOLINE PI ICE fuel consumption
- Powertrain ratios with respect to GASOLINE PI ICE
- Index of performance

## Outputs

Reference value for the energy consumption per km of new registrations by powertrain

Energy consumption per km of new registrations by powertrain

# Energy cons by age

**Target**

Energy consumption by age and aggregated at different levels

**Inputs**

- Energy consumption per km by age of those vehicles that constitute the stock at the base year
- Energy consumption per km of new vehicles registered over time
- Aging system

**Outputs**

Energy consumption per km by age

↓

Energy consumption by age

↓

- Vkm by age

→ Aggregates on energy consumption

↓

- Aggregates on vkm

→ Aggregates on energy consumption per km in the vehicle stock

# $CO_2$ emissions

## Target

$CO_2$ emissions by age and aggregated at different levels

## Inputs

- Energy consumption of vehicles by age
- User inputs on WTT/TTW/WTW $CO_2$ emission factors

## Outputs

WTT/TTW/WTW $CO_2$ emissions by age

Aggregates on WTT/TTW/WTW $CO_2$ emissions

Aggregates on WTT/TTW/WTW $CO_2$ emissions per km in the vehicle stock

- Aggregates on vkm

# Outputs views

## Target

Showing the results disaggregated and stacked in different ways

## Outputs views

- Vehicle stock (vehicles)
- Transport activity (tkm, pkm) and vehicle activity (vkm)
- Energy use (toe)
- Costs (USD)
- WTT $CO_2$ emissions (kg $CO_2$)
- TTW $CO_2$ emissions (kg $CO_2$)
- WTW $CO_2$ emissions (kg $CO_2$)
- New registrations (vehicles)