21. Travel per vehicle

Overview

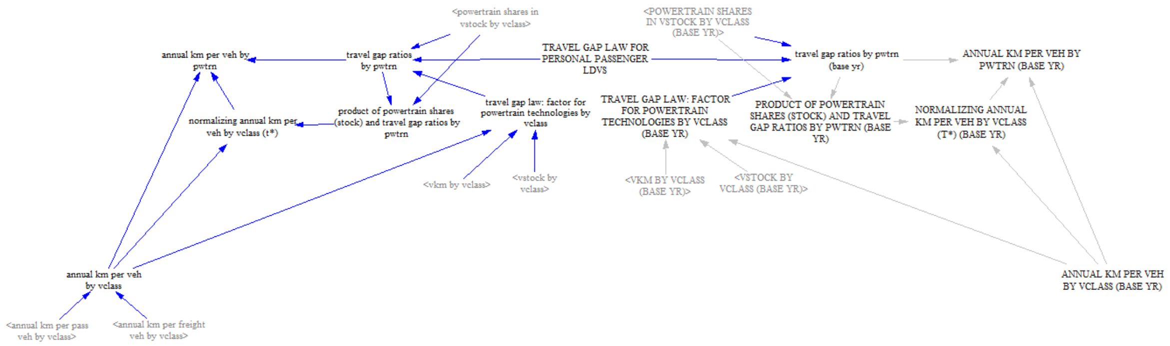
Target

The target of this view is to disaggregate the annual travel per vehicle by vehicle class across the different powertrains.

Structure

Figure 21.1 shows the Vensim sketch of the view. The calculations are divided in two main groups: base year (right side) and over time (left side). The variables for these two groups are displayed symmetrically.

Figure 21.1 Vensim sketch of the view

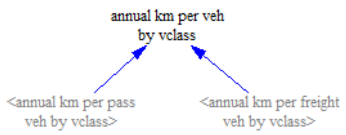


Detailed description of the view

Inputs

The variables "ANNUAL KM PER PASS VEH BY VCLASS" and "ANNUAL KM PER FREIGHT VEH BY VCLASS" (bottom left), containing data on annual km per vehicle over time for passenger and freight transport vehicles, come respectively from the views "travel per vehicle (passenger)" and "travel per vehicle (freight)". As first step, these variables are gathered in one single parameter (Figure 21.2).

Figure 21.2 Annual km per vehicle over time



At the base year, the annual km per vehicle ("ANNUAL KM PER PASS BY VCLASS (BASE YR)", bottom right of the sketch) corresponds to the user inputs ("User inputs (BASE Y)" sheet fo the ForFITS Excel file).This input contains these data disaggregated by area, service, mode and vehicle class.

Other inputs at vehicle class level that are necessary to convert the annual travel per vehicle by vehicle class into annual travel by powertrain refer to vehicle stock, vkm and powertrain shares:

- "VKM BY VCLASS", "VKM BY VCLASS (BASE YR)", "POWERTRAIN SHARES IN VSTOCK BY VCLASS" and "POWERTRAIN SHARES IN VSTOCK BY VCLASS (BASE YR)"

  All these variables come from the transport activity module and are calculated in the view "activity, loads and stock aggregates".

- "VSTOCK BY VCLASS" and "VSTOCK BY VCLASS (BASE YR)"

  The first parameter is calculated in the view "vehicles by age". The second is a user input ("User Inputs (BASE Y)" sheet of the ForFITS Excel file).

Outputs

Parameters in the left side of the Vensim sketch

The variable "ANNUAL KM PER VEH BY VCLASS" represents the vehicle travel for all the technologies used in each vehicle class. This value is the result of the average of the annual travel per vehicle of each powertrain, weighted by the number of vehicles belonging to each technology in the vehicle stock (equation below).

$$Annual\ km\ by\ vclass = \frac{\sum_{powertrains} Annual\ km\ per\ veh_{powertrain\ i} \times vehicle\ stock_{powertrain\ i}}{\sum_{powertrain} vehicle\ stock_{powertrain\ i}}$$

Taking into account that

$$\sum_{powertrain} vehicle\ stock_{powertrain\ i} = vehicle\ stock\ by\ vclass$$

and that

$$\frac{vehicle\ stock_{powertrain\ i}}{vehicle\ stock\ by\ vclass} = Share\ in\ vehicle\ stock_{\ powertrain\ i}$$

it is possible to calculate the following:

$$Annual\ km\ by\ vclass =$$
$$= \sum_{powertrains} Annual\ km\ per\ veh_{powertrain\ i} \times Share\ in\ vehicle\ stock_{\ powertrain\ i}$$

Assuming that the annual travel per vehicle of each technology is the result of the product between a common value (t*, i.e. a value of annual travel per vehicle that allows "normalizing" the travel per vehicle by powertrain to match the average by vehicle class) and a factor by powertrain, the equation can be expressed as follows:

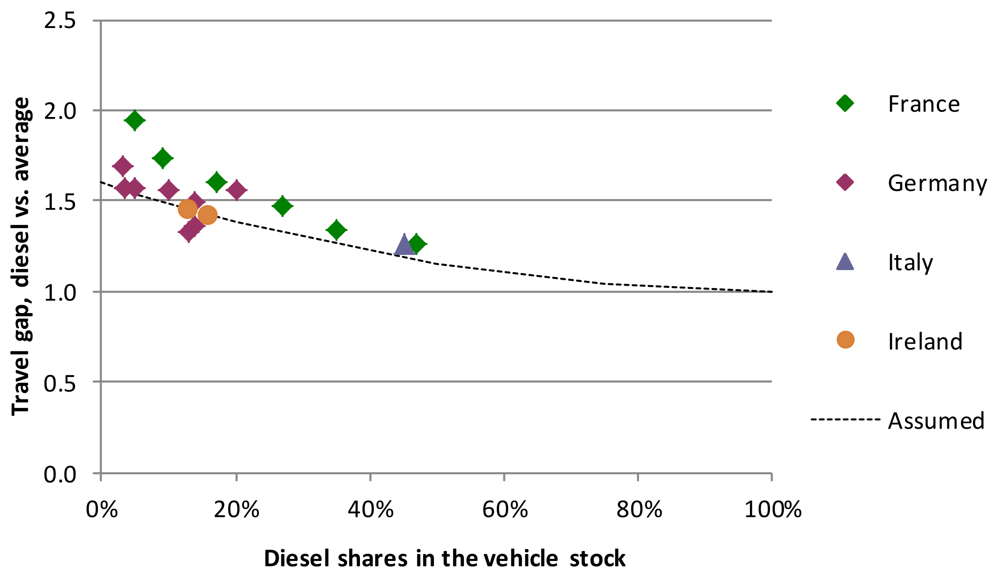
$$Annual\ km\ by\ vclass = t^{*} \times \sum_{powertrains} Factor_{powertrain\ i} \times Share\ in\ vehicle\ stock_{\ powertrain\ i}$$

Factors defining the distribution of the annual travel per vehicle across powertrains

Technologies representing an alternative to the conventional spark-ignition powertrain, fuelled with a gasoline-based blend, are assumed to be characterized by a larger average annual travel. This is consistent with the idea that alternative technologies are more costly than conventional gasoline-powered spark-ignition powertrain, but also offer fuel savings in comparison to it. This is due to the fact that the driving cost savings due to fuel savings are more relevant for vehicles that travel more. The choice of purchase of alternative technologies is therefore better justified if the average travel of vehicles is larger than in the case of the reference technology.

The average annual travel for personal passenger LDVs is assumed to follow the pattern (quadratic polynomial curve) illustrated in Figure 21.3, where historical data from a selection of countries are also shown (this assumption is introduced in the variable "TRAVEL GAP LAW FOR PERSONAL PASSENGER LDVS"). The travel gap is close to 1.6 for low shares of vehicles powered with alternative technologies, while the travel gap narrows to zero when they represent the great majority.

Figure 21.3 Travel gaps, diesel and gasoline personal passenger vehicles (1990-2010)



Sources: various datasets and publications, including Bodek and Heywood, 2008; Eurostat, 2011; Howley et al., 2007; and Caputo et al., 2008

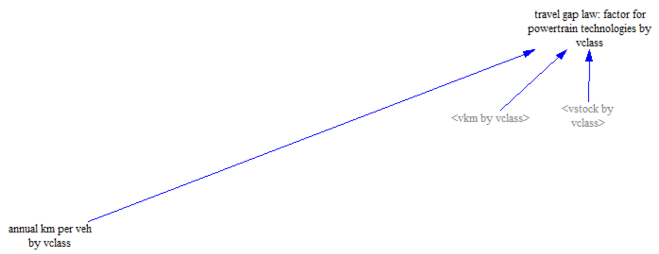
The law is corrected, for other modes and services, applying a factor equal to the ratio between the average travel of passenger LDVs and the average travel of the mode and service considered (see the following equations and Figure 21.4).

$$Annual\ travel\ of\ personal\ passenger\ LDVS = \frac{\sum_{VEHICLE\ CLASS\ A}^{VEHICLE\ CLASS\ D} vkm_{vehicle\ class\ i}}{\sum_{VEHICLE\ CLASS\ A}^{VEHICLE\ CLASS\ D} vehicle\ stock_{vehicle\ class\ i}}$$

$$Coefficient\ by\ vehicle\ class = \frac{Annual\ travel\ of\ personal\ passenger\ LDVS}{Annual\ travel\ per\ vehicle\ by\ vehicle\ class}$$

$$Travel\ gap\ law\ by\ vehicle\ class =$$
$$= 1 + (Travel\ gap\ low\ for\ personal\ passenger\ LDVS - 1) \times Coefficient\ by\ vehicle\ class$$

Figure 21.4 Correction of the travel gap law for vehicles other than personal passenger vehicles

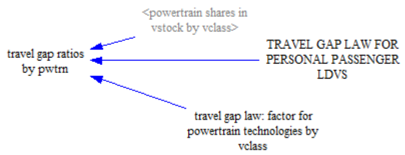


For modes and services where the average travel is lower than on passenger LDVs, the factor applied is equal to 1.

This correction aims to take into account the difficulties encountered, in modes characterized by high average travel, to further increase the vehicle usage. This is especially relevant for large road freight vehicles, where constraints like the load/unload time, speed limits and resting times for drivers are limiting the possibility to increment the average use of trucks. Similar considerations can be extended to public transport vehicles, such as taxis and buses. For modes characterized by lower average travel values than those characterizing personal passenger LDVs (this is typically the case of two wheelers), the choice of a factor 1 is due to limited available information and the assumption that the user behaviour would not differ much from what has been observed for car users.

Once set the appropriate travel gap law has been set, the travel gap that is coupled with the actual technology shares can be calculated (Figure 21.5).

Figure 21.5 Evaluation of the active travel gap from the corrected travel gap law and the actual technology shares



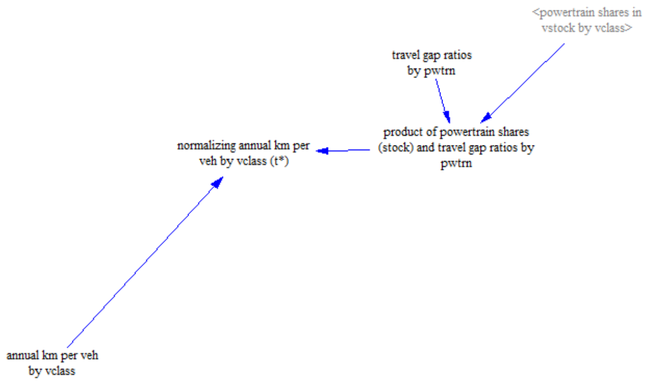
Calculation of the annual travel per vehicle by powertrain

Replacing the factors by powertrain, evaluated as described earlier, in the equation of the annual travel per vehicle by vehicle class as an average across the powertrains, the representative travel value t* (i.e. the "NORMALIZING ANNUAL KM PER VEH BY VCLASS (T*)") can be isolated (see equations below and Figure 21.6).

$$Annual\ km\ by\ vclass = t^* \times \sum_{powertrains} Factor_{powertrain\ i} \times Share\ in\ vehicle\ stock_{\ powertrain\ i}$$

$$t^* = \frac{Annual\ km\ by\ vclass}{\sum_{powertrains} Factor_{powertrain\ i} \times Share\ in\ vehicle\ stock_{\ powertrain\ i}}$$

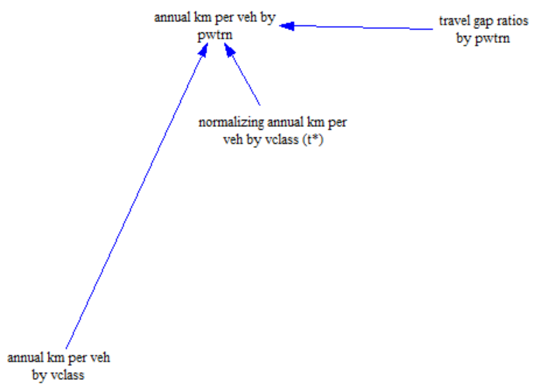
Figure 21.6 **Evaluation of the normalizing annual km per vehicle by vehicle class (t*)**



Knowing t* and the factors by powertrain allows to calculate the annual travel per vehicle by powertrain, as shown in the equation below and in Figure 21.7

$$annual\ travel\ per\ vehicle\ by\ powertrain = t^* \times Factor_{powertrain\ i}$$

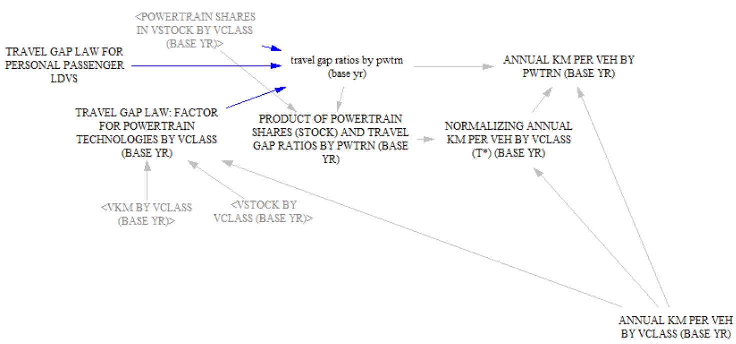
Figure 21.7 **Calculation of the annual travel per vehicle by powertrain**



Parameters in the right side of the Vensim sketch

The right half of the Vensim sketch (**Error! Not a valid bookmark self-reference.**) reproduces the same structure (and the same calculations) seen for the left side.

Figure 21.8 **Right side of the Vensim sketch**



The only difference is that this side contains calculations for the base year variables, while data on the left are evaluated for parameters evolving over time.

References

Bodek. K. and Heywood, J. (2008), *Europe's Evolving Passenger Vehicle Fleet: Fuel Use and GHG Emissions Scenarios through 2035*, Laboratory for Energy and Environment, Massachusetts Institute of Technology, http://web.mit.edu/sloan-auto-lab/research/beforeh2/files/Europe's%20Evolving%20Passenger%20Vehicle%20Fleet.pdf

Caputo, A., Contaldi, M. and Pignatelli, R. (2008), *Annuario dei Dati Ambientali 2008 – Trasporti*, Istituto Superiore per la Protezione e la Ricerca Ambientale, Dipartimento Stato dell'Ambiente e Metrologia Ambientale Servizio progetto speciale Annuario e Statistiche ambientali, http://annuario.apat.it/capitoli/Ver_6/versione_integrale/03%20Trasporti.pdf

Eurostat (2011), *Lorries, by load capacity (number)*, data extracted in October 2011, http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

Howley, M., O' Leary, F. and O' Gallachóir, B. (2007), *Energy in Transport*, Sustainable Energy Ireland, http://www.seai.ie/Publications/Statistics_Publications/EPSSU_Publications/Energy_in_Transport/EPSSU_Transport_Rpr_Fnl_Dec07.pdf