

36. Energy cons by age

Overview

Target

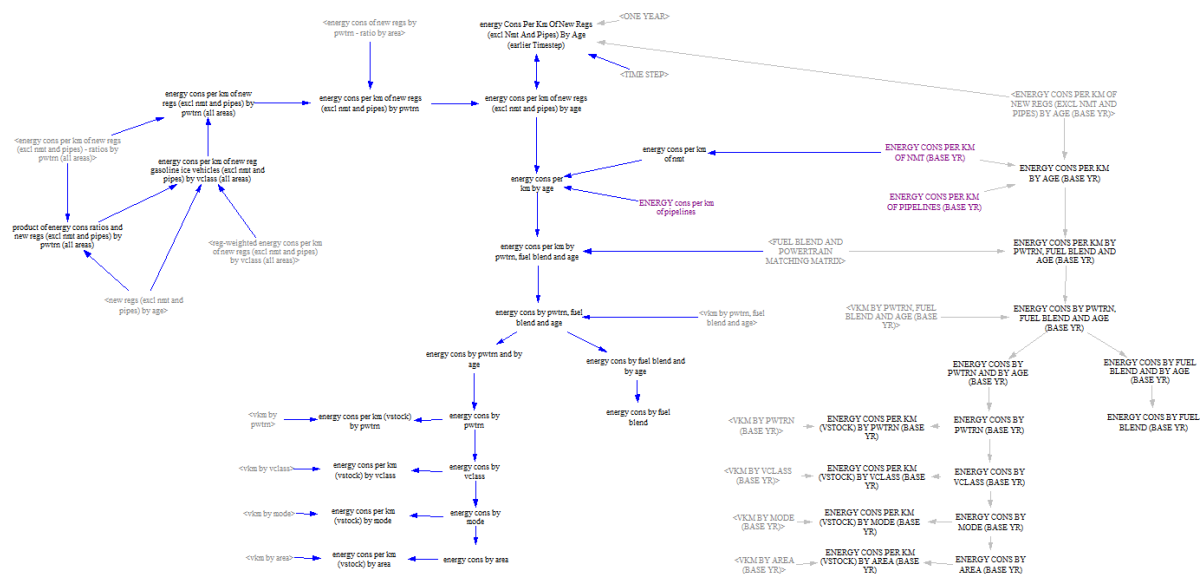
This view is aimed to calculate the energy consumption at different levels of disaggregation.

Structure

Figure 36.1 shows the Vensim sketch of the view. The calculation flow starts on the top left part and ends in the two sets of variables located at the bottom of the view. The set on the left concerns the energy consumption over time, while the set on the right refers to base year data.

The top left section of the view calculates the energy consumption per km of newly registered vehicles (excluding non-motorized transport and pipelines) by powertrain in each time step of calculation. This is linked with the top section of the view (central part), evaluating the energy consumption per km in each age subscript over time (this includes the reallocation over time of the energy consumption per km along the age subscript). The product of the energy consumption per km and the vehicle activity allows the calculation of the total energy consumption (centre-right and bottom-right of the view).

Figure 36.1 Vensim sketch



Detailed description of the view

Inputs

The top left section of this view focuses on the estimation of the energy consumption per km of newly registered vehicles in each time step of calculation. This section uses variables calculated in the "energy cons (new reg) (region)" view: "REG-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY VCLASS (ALL AREAS)", containing information on the registration-weighted energy consumption of newly registered vehicles, and "ENERGY CONS PER KM OF NEW

REGS (EXCL NMT AND PIPES) - RATIOS BY PWTRN (ALL AREAS)", containing information on the energy consumption ratios distinguishing the GASOLINE PI ICE technology and all other powertrains.

These inputs are combined with information on the new vehicle registrations ("NEW REGS (EXCL NMT AND PIPES) BY AGE", taken in age ZERO) to calculate the energy consumption per km of newly registered gasoline ICE vehicles (stored in the "ENERGY CONS PER KM OF NEW REG GASOLINE ICE VEHICLES (EXCL NMT AND PIPES) BY VCLASS (ALL AREAS)" variable) (Figure 36.2).

This calculation is based on the equation of the registration-weighted energy consumption per km of newly registered vehicles (age ZERO) by vehicle class:

$$EC \text{ per km } (NR) \text{ (all areas)} = \frac{\sum_{pwtrns} (EC \text{ per km } (NR) \text{ (all areas)}_{pwtrn i} \times NR \text{ (all areas)}_{pwtrn i})}{\sum_{pwtrns} (NR \text{ (all areas)}_{pwtrn i})}$$

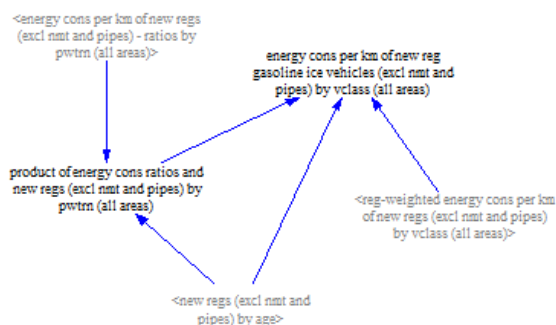
The same equation can be re-written taking into account the energy consumption ratios distinguishing the GASOLINE PI ICE technology and all other powertrains:

$$EC \text{ per km } (NR) \text{ (all areas)} = \frac{EC \text{ per km } (NR, \text{ GASOLINE PI ICE}) \text{ (all areas)}}{\sum_{pwtrns} (NR \text{ (all areas)}_{pwtrn i})} \times \sum_{pwtrns} (EC \text{ Ratio } (all \text{ areas})_{pwtrn i} \times NR \text{ (all areas)}_{pwtrn i})$$

This form of equation allows isolating the energy consumption per km of newly registered gasoline-powered PI ICE vehicles:

$$EC \text{ per km } (NR, \text{ GASOLINE PI ICE}) \text{ (all areas)} = \frac{EC \text{ per km } (NR) \text{ (all areas)}_{vehicle \text{ class}} \times \sum_{pwtrns} (NR \text{ (all areas)}_{pwtrn i})}{\sum_{pwtrns} (EC \text{ Ratio } (all \text{ areas})_{pwtrn i} \times NR \text{ (all areas)}_{pwtrn i})}$$

Figure 36.2 Energy consumption per km of newly registered gasoline ICE vehicles



The energy consumption per km of newly registered gasoline-powered PI ICE vehicles just calculated is an aggregate for all areas.

The same value needs to be obtained when weighting the energy consumption of newly registered GASOLINE PI ICE vehicles across the different areas by vkm¹. This means that the following equation needs to be always satisfied:

$$EC \text{ per km (NR, GASOLINE PI ICE) (all areas) } = \frac{\sum_{areas} (EC \text{ per km (NR, GASOLINE PI ICE)}_{area\ i} \times vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i})}{\sum_{areas} vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i}}$$

If $EC \text{ per km (NR, GASOLINE PI ICE)}_{area\ i}$ is expressed as the product of the energy consumption per km of newly registered gasoline-powered PI ICE vehicles weighted by vkm across all areas, ($EC \text{ per km (NR, GASOLINE PI ICE)}^{**}$) and ratio by area of the energy consumption per km for the GASOLINE PI ICE technology ($EC \text{ Ratio (NR, GASOLINE PI ICE)}_{area\ i}$), i.e. the parameter calculated in the view "energy cons (new reg) (area)" representing the ratio by area and over time of the energy consumption per km of newly registered vehicles, for the GASOLINE PI ICE powertrain technology, in this case), the previous equation becomes:

$$EC \text{ per km (NR, GASOLINE PI ICE) (all areas) } = \frac{EC \text{ per km (NR, GASOLINE PI ICE)}^{**}}{\sum_{area\ i} vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i}} \times \sum_{area\ i} (EC \text{ Ratio (NR, GASOLINE PI ICE)}_{area\ i} \times vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i})$$

This form of equation allows isolating the energy consumption per km of newly registered gasoline-powered PI ICE vehicles weighted by vkm across all areas (part of "VKM-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY PWTRN (ALL AREAS)", in Vensim):

$$EC \text{ per km (NR, GASOLINE PI ICE)}^{**} = EC \text{ per km (NR, GASOLINE PI ICE) (all areas) } \times \frac{\sum_{area\ i} vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i}}{\sum_{area\ i} (EC \text{ Ratio (NR, GASOLINE PI ICE)}_{area\ i} \times vkm \text{ (NR, GASOLINE PI ICE)}_{area\ i})}$$

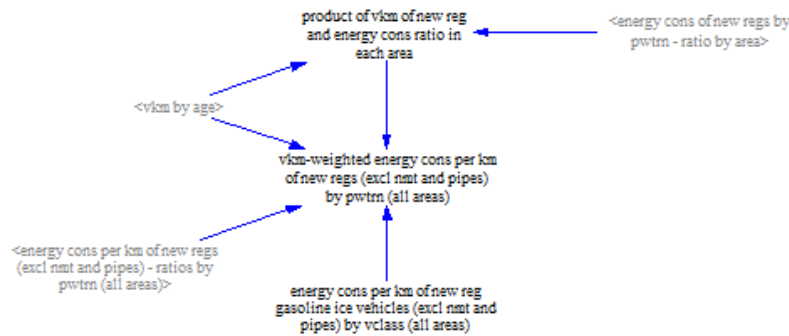
The energy consumption per km of newly registered vehicles weighted by vkm across all areas and expressed by powertrain ("VKM-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY PWTRN (ALL AREAS)" in Vensim) is then calculated as the product of $EC \text{ per km (NR, GASOLINE PI ICE)}^{**}$ and the energy consumption per km ratio by powertrain technology:

$$EC \text{ per km (NR) (all areas)}_{pwtrn\ i}^{**} = EC \text{ per km (NR, GASOLINE PI ICE)}^{**} \times EC \text{ Ratio (all areas)}_{pwtrn\ i}$$

These calculations are performed in Vensim in the steps shown in Figure 36.3

¹ Since the energy consumption results from the product of energy consumption per km of each vehicle and vkm, the weighted averages involving energy consumption must be always weighted by vkm. The only exceptions are the cases where the data come from user inputs explicitly requested to be entered registrations-weighted. This is the case of user inputs. The reason for such practice is that statistics on the energy consumption are generally associating energy consumption per km (resulting from test) to the tested vehicles, without taking into account the distribution of their average annual travel.

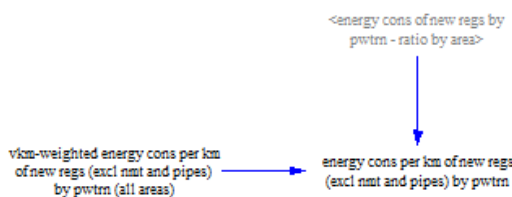
Figure 36.3 Energy consumption per km of newly registered vehicles weighted by vkm across all areas and expressed by powertrain



The last step performed in the top left area of this view consists in the multiplication of the energy consumption per km of newly registered vehicles weighted by vkm across all areas (and expressed by powertrain) by the ratios by area calculated in the view "energy cons (new reg) (area)" for each powertrain. This product allows calculating the variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY PWTRN", containing the energy consumption per km of newly registered vehicles over time by service, mode, area, vehicle class and powertrain:

$$EC (NR, pwtrn i)_{area i} = EC \text{ per km } (NR) (all \ areas)_{pwtrn i}^{**} \times EC \text{ Ratio } (NR, pwtrn i)_{area i}$$

Figure 36.4 Energy consumption per km of newly registered vehicles over time by service, mode, area, vehicle class and powertrain

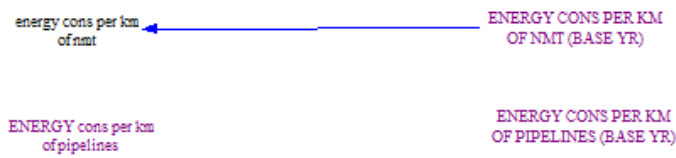


This variable provides the energy consumption per km of new registrations (age ZERO) over time to the model. At the base year, the energy consumption per km of the different age vehicles is also stored in the variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE (BASE YR)", coming from the view "energy cons (historical)".

Other inputs used in this view are the "FUEL BLEND AND POWERTRAIN MATCHING MATRIX" (an hard-coded matrix allowing the coupling between fuel blends and related powertrain technologies), as well as several variables concerning different vkm aggregations. These variables come from the transport activity module (namely the view "activity, loads and stock aggregates") and are used here to aggregate the energy consumption at different levels.

The only user input used in this view is (Figure 36.5) the energy consumption per km for non-motorised transport and pipelines. While the energy consumption per km of non-motorised transport is in principle set to zero, in the case of pipelines the user can enter the values on energy consumption over time ("User inputs (over time)" sheet of the ForFITS Excel file) by area and by class of pipelines (e.g. to reflect different values of energy consumption per km for different fluids transported by pipeline networks).

Figure 36.5 Inputs on the energy consumed per km in non-motorized transport modes and pipelines



Outputs

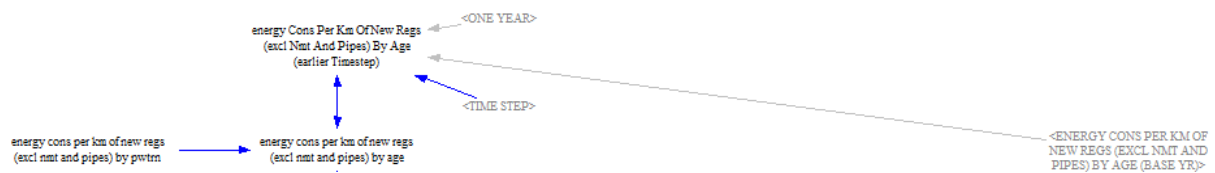
The variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE" is in charge of reallocating over time the energy consumption per km along the age subscribers. The variable provides the consumption of the vehicles depending on their age since when they were first registered.

In other words, "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE" is aging the energy consumption per km across the age subscript according to the evolution of the time variable in the model. For instance, the value of energy consumption per km at the age subscript V contains the consumption of those vehicle registered five years old in each time step considered.

The initial value of the variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE" (i.e. the value at the base year) is directly obtained from the variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE (BASE YR)". The latter gathers information on the energy consumption per km by age concerning the historical sales. In the following time steps, the variable gets its most recent (age ZERO) value from the left side (i.e. from the variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY PWTRN"). The values in all other subscripts are reallocated according to the evolution of the time, interpolating linearly between available information in case of time steps lower than 1.

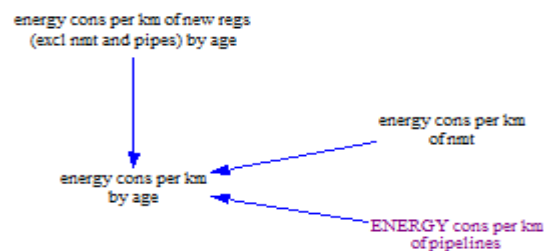
The Vensim sketch of the calculations described earlier in this section are shown in Figure 36.6

Figure 36.6 Reallocation over time of the energy consumption per km along the age subscribers



As mentioned in the inputs section of this view, the energy consumption per km in case of non-motorised transport and pipelines is directly entered by the user (Figure 36.7).

Figure 36.7 Energy consumption per km in case of non-motorised transport and pipelines



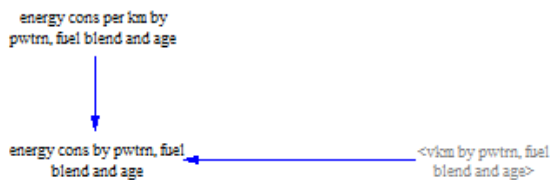
The variable "ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY AGE" contains the energy consumption per km by service, mode, area, vehicle class, powertrain and age. When combined with the information of the fuel blend and powertrain matching matrix, the variable allows the calculation of information also disaggregated by fuel blend (Figure 36.8).

Figure 36.8 Energy consumption per km by powertrain, fuel blend and age



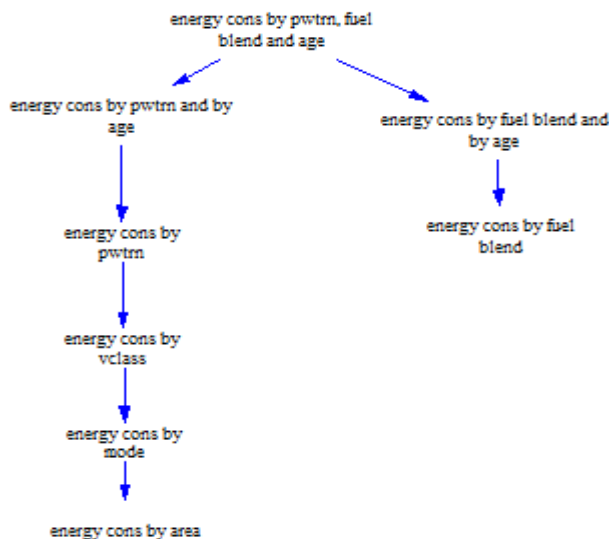
The energy consumption (litres/year) over time is calculated multiplying the energy consumption per km (litres/vehicle*km) by the transport activity (vehicle*km/year) (Figure 36.9).

Figure 36.9 Energy consumption by powertrain, fuel blend and age



This important output is aggregated (through sums) at different levels at the bottom of the view (Figure 36.10).

Figure 36.10 Energy consumption: aggregates



The right column of Figure 36.10 contains aggregates obtained summing up across the energy consumption across powertrains and age:

$$EC \text{ (litres) by fuel blend and by age} = \sum_{\text{powertrains}} EC \text{ (litres)}_{\text{powertrain } i}$$

$$EC \text{ (litres) by fuel blend} = \sum_{\text{ages}} EC \text{ (litres)}_{\text{age } i}$$

The left column of Figure 36.10 contains aggregates by age, powertrain, vehicle class, mode and area:

$$EC \text{ (litres) by age} = \sum_{\text{fuel blends}} EC \text{ (litres)}_{\text{fuel blend } i}$$

$$EC \text{ (litres) by powertrain} = \sum_{\text{ages}} EC \text{ (litres)}_{\text{age } i}$$

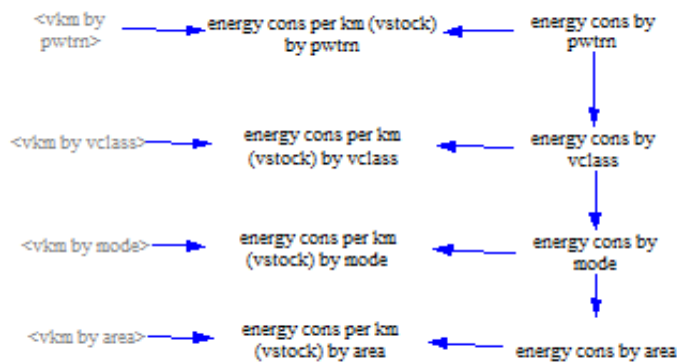
$$EC \text{ (litres) by vehicle class} = \sum_{\text{powertrains}} EC \text{ (litres)}_{\text{powertrain } i}$$

$$EC \text{ (litres) by mode} = \sum_{\text{vehicle classes}} EC \text{ (litres)}_{\text{vehicle class } i}$$

$$EC \text{ (litres) by area} = \sum_{\text{modes}} EC \text{ (litres)}_{\text{mode } i}$$

Since the vehicle stock is made up by vehicles of different ages, these variables are used along with the transport activity to know the corresponding aggregates of the energy consumption per km in the vehicle stock (Energy consumption per km = Energy consumption / vkm). This is shown in Figure 36.11.

Figure 36.11 Energy consumption per km: aggregates



The same procedures and calculations are reproduced for the base year variables on the right side of the view (Figure 36.12).

Figure 36.12 Base year calculations

