34. Energy cons (new reg) (region)

Overview

Target

The purpose of this view is to calculate the energy consumption by vehicle class of new vehicle registrations over time.

For motorized road modes, rail, and vessels, this calculation takes into account of:

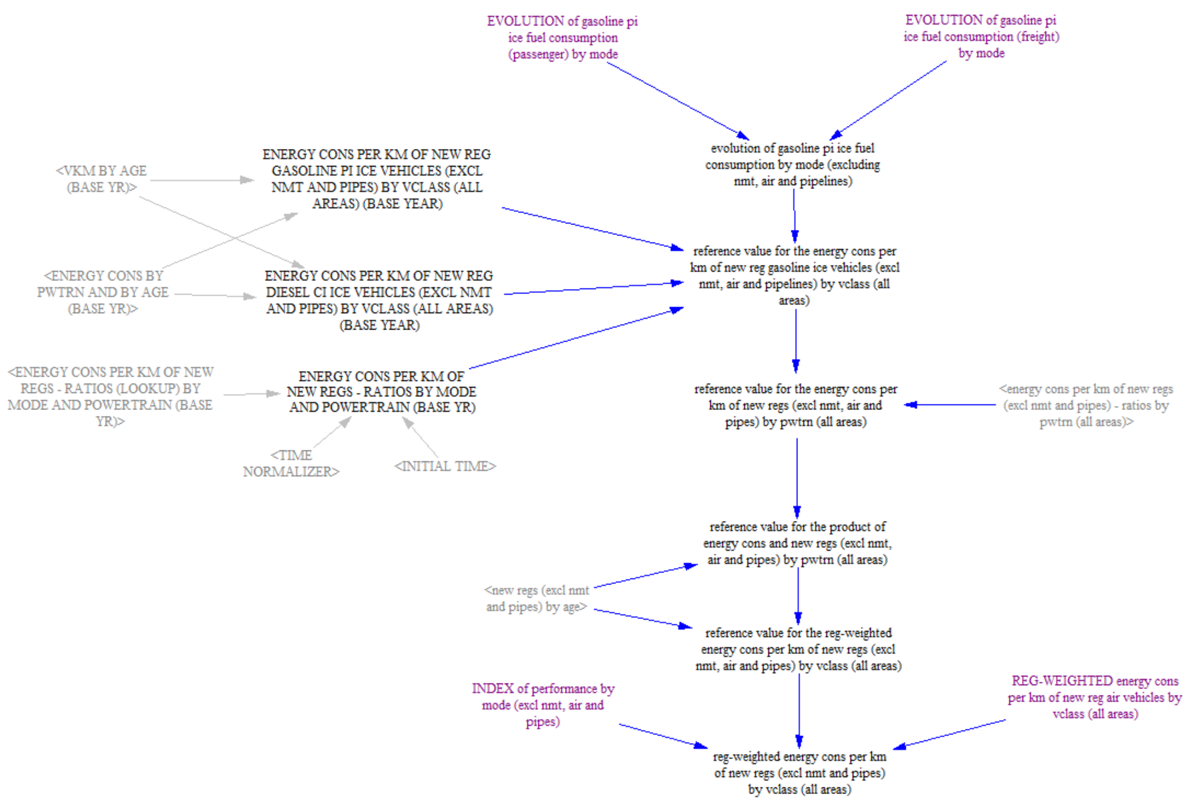
a) the set of technologies that are expected to be introduced on vehicles (technological potential, expressed in terms of the potential fuel savings delivered by each powertrain technology); and
b) the share of the available technological potential that is actually used for energy efficiency (as opposed to the share used for increased vehicle size, power and, more generally, performance).

Information for the air mode is entered directly in terms of energy consumption. Non-motorized transport and pipelines are not considered in this context.

Structure

Figure 34.1 shows the Vensim sketch of the view. The calculation flow follows the column of balck variables on the right side of the view.

Figure 34.1 Vensim sketch of the view



Detailed description of the view

Inputs

The variables "EVOLUTION OF GASOLINE PI ICE FUEL CONSUMPTION (PASSENGER) BY MODE" and "EVOLUTION OF GASOLINE PI ICE FUEL CONSUMPTION (FREIGHT) BY MODE" contain information on the potential improvement, over time, of the energy consumption per km of newly registered vehicles that are equipped with gasoline-powered positive ignition internal combustion engines (GASOLINE PI ICE technology, taken as the reference technology in this section).

The inputs entered in these variables (passenger and freight) shall illustrate, for each mode, the development over time of the energy consumption of a representative vehicle (for the mode under consideration) using GASOLINE PI ICE technology.

The information entered here shall take into account of all the improvements that are expected to be introduced in the projection period. This shall include: a) improvements expected to result in actual fuel savings per vkm; and b) improvements that are expected to be "absorbed" by increases in vehicle power, size, weight or performance. For this purpose, the latter shall be first converted in the "equivalent savings" that they would generate if they were used to save energy rather than to increase the vehicle performances.

These data are entered by the user in the form of an index in the ForFITS Excel file ("Pwtrn potential" sheet, last line of each of the (modal) tables, labelled as "FUEL CONS. INDEX, GASOLINE PI ICE").

Box 34.1 Default assumption for the expected evolution over time of energy consumption per km of newly registered gasoline-powered positive ignition internal combustion engines

The default values currently used in the model result from information on technological potentials and costs published on a wide number of different literature sources. They aim to reflect a situation reflecting the introduction of significant improvements to conventional gasoline-powered positive ignition ICEs.

In the default values currently include in the mode, the potential fuel consumption improvements for reference powertrains (GASOLINE PI ICE) by 2025 is currently close to 20-25% for light duty vehicles. The percentage falls to 10-15% for two and three wheelers, and 0-5% for heavy duty vehicles (all transport services). By 2040, the improvement is 5 to 10% larger.

The value for LDVs aims to reflect the introduction of the following technological solutions: reduced engine friction (improved lubrication), advanced starter-alternator (micro-hybrid) solutions, reduced throttling losses variable valve lift and timing, and the adoption of Atkinson/Miller thermodynamic cycles (or turbochargers).

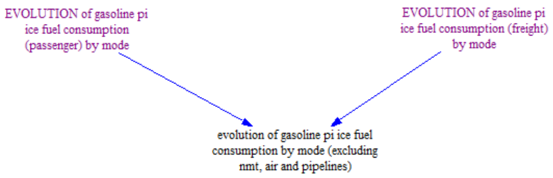
The estimate for two and three wheelers is lower than for LDVs to reflect the lower powertrain complexity, the higher importance of weight on two and three wheelers, and the lower less non-engine improvement potential available – e.g. because of weight reduction.

For heavy duty modes, the lower estimate is due to the fact that improvements are considered to be primarily due to vehicle improvements, and are not specific to powertrain improvements (with the main exception of waste heat recovery systems).

Estimations of energy efficiency improvements concerning the whole vehicle (and not just a specific powertrain technology), such as improved aerodynamics, low rolling resistance tyres, improvement of the energy efficiency of peripheral systems and vehicle weight reductions, are also provided by default. Including the vehicle improvements as part of the potential exploited by the reference powertrain also requires taking this into account when defining the energy consumption ratios for other powertrain technologies. The default values assume that the same improvement applied for the reference technology is also used on competing powertrain technologies.

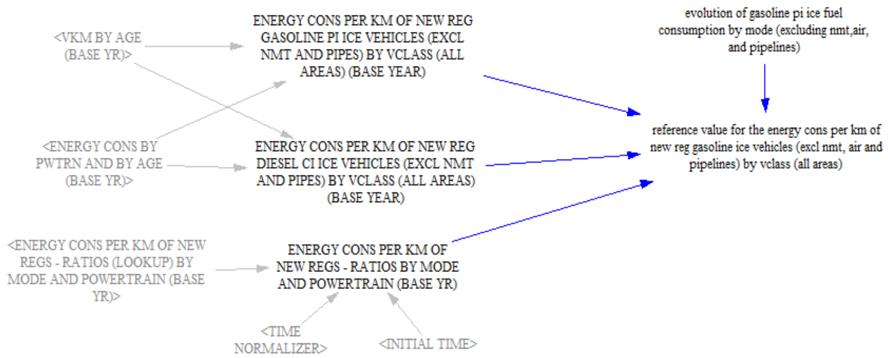
Note: the whole set of literature sources used for the techno-economic assessment justifying the existing default values includes those quoted in pp. 49-54 and 74-78 of UNECE, 2012, as well as the following sources: ABB, 2010; AEA, 2011; American Clean Skies Foundation, 2012; Bombardier, 2002-2012; CCNR, 2012; DNV, 2012; Kasseris, E. P., 2004; TOSCA, 2011a and 2011b; and US EPA, 2008.

Figure 34.2 Data on the expected evolution over time of energy consumption per km of newly registered gasoline vehicles



The purple variables (Figure 34.2) include the data on the evolution of newly registered gasoline vehicles over time introduced in the ForFITS Excel file on all the modes for a specific service. They are joined in a single variable ("EVOLUTION OF GASOLINE PI ICE FUEL CONSUMPTION BY MODE (EXCLUDING NMT, AIR AND PIPELINES)"), gathering the data by service and by mode.

Figure 34.3 Evolution of the fuel consumption of newly registered gasoline vehicles over time



The index describing the pattern of the technological potential for the GASOLINE PI ICE powertrain technology is applied to the fuel consumption of newly registered GASOLINE PI ICE vehicles at the base year (reference value, assumed equal to 1) to obtain the evolution of the fuel consumption of newly registered gasoline vehicles over time (variable "REFERENCE VALUE FOR THE ENERGY CONS PER KM OF NEW REG GASOLINE ICE VEHICLES (EXCL NMT, AIR AND PIPELINES) BY VCLASS (ALL AREAS)").

In case there are no GASOLINE PI ICE vehicles, the value of this variable is calculated taking into account the fuel consumption of newly registered DIESEL CI ICE vehicles, correcting for technology gap between GASOLINE PI ICE and DIESEL CI ICE technologies at the base year (as defined in the "ENERGY CONS PER KM OF NEW REGS - RATIOS BY MODE AND POWERTRAIN (BASE YR)" variable).

Figure 34.3 shows the variables and the logical links needed to perform the calculations just mentioned. The following section provides further details on these calculations.

Since the subscript area is not included in the whole view (in order to limit the complexity of the inputs required), the average energy consumption per km across all areas of the energy consumption per km of newly registered (age ZERO) gasoline vehicles at the base year (BY) is calculated as the ratio between the energy consumption of the GASOLINE PI ICE vehicles in all areas (variable "ENERGY CONS BY PWTRN AND BY AGE (BASE YR)", calculated in the view "energy cons by age") and the related vkm (variable "VKM BY AGE (BASE YR)", calculated in the view "activity, loads and stock by age"):

$$EC\ per\ km\ age\ ZERO\ GASOLINE\ PI\ ICE\ vehicles\ (BY) = \frac{EC[GASOLINE\ PI\ ICE, ZERO]\ (BY)}{vkm\ [GASOLINE\ PI\ ICE, ZERO](BY)}$$

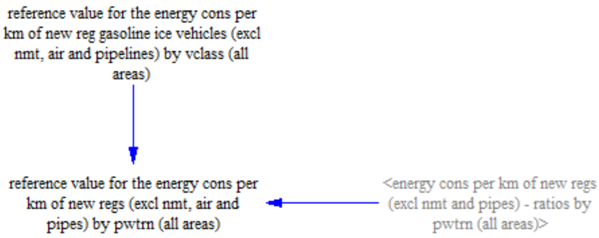
If the GASOLINE PI ICE is not an applicable technology for a specific vehicle class, then the value calculated is the energy consumption per km of age zero diesel vehicles at the base year (BY):

$$EC\ per\ km\ age\ ZERO\ DIESEL\ CI\ ICE\ vehicles\ (BY) = \frac{EC[DIESEL\ CI\ ICE, ZERO]\ (BY)}{vkm\ [DIESEL\ CI\ ICE, ZERO](BY)}$$

In this last case, the DIESEL CI ICE value is converted into GASOLINE PI ICE by means of the ratio gasoline-diesel for newly registered (age ZERO) vehicles at the base year (variable "ENERGY CONS PER KM OF NEW REGS-RATIOS (LOOKUP) BY MODE AND POWERTRAIN (BASE YR)" from the view "energy cons (historical)"):

$$EC\ per\ km\ age\ ZERO\ GASOLINE\ PI\ ICE\ vehicles\ (BY) \\ = \frac{EC\ per\ km\ age\ ZERO\ DIESEL\ CI\ ICE\ vehicles\ (BY)}{Ratios\ compared\ to\ gasoline\ [DIESEL\ CI\ ICE, ZERO](BY)}$$

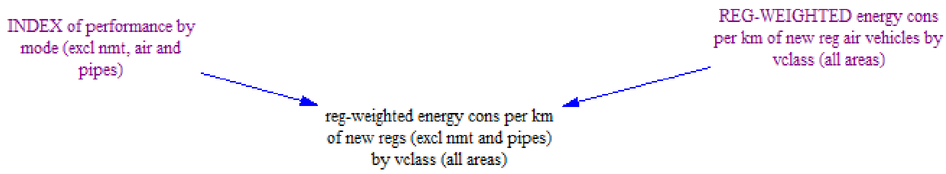
Figure 34.4 Energy consumption per km of newly registered vehicles for all technologies over time



The energy consumption per km of newly registered (age ZERO) gasoline vehicles is multiplied by the powertrain ratios coming from the view "energy cons-ratios (input, all areas)" to obtain the energy consumption per km of newly registered vehicles for all technologies over time (see Figure 34.4 and the following equation):

$$EC\ per\ km\ of\ age\ ZERO\ vehicles\ by\ powertrain\ (over\ time) = \\ = EC\ per\ km\ of\ age\ ZERO\ gasoline\ vehicles \times Ratios\ by\ powertrain$$

Figure 34.5 Inputs in the index of performance and the registration-weighted energy consumption of air transport vehicles



On the bottom left of the view (Figure 34.5), the variable "INDEX OF PERFORMANCE BY MODE (EXCL NMT, AIR AND PIPES)" contains user inputs ("User inputs (over time)" sheet of the ForFITS Excel file) defining the portion of the available technological potential that is actually used to deliver fuel savings (as opposed to the share used for performance improvements).

Box 34.2 Index of performance

The "index of performance" is an indicator of the share of the available technological potential actually used to deliver fuel savings. This parameter is aimed to enable the user to decide whether the vehicles will consume according to the expected evolution of the technologies or in a different way.

If the index of performance is 1 (i.e. 100%), the energy consumption per km of vehicles in road motorized modes, rail and vessels, will follow exactly the trend defined by the technical data on the technological potential for fuel savings.

If the index of performance is lower than 1 (e.g. for LDVS), part of the available potential (for the mode affected) is assumed to be used for performance improvements and/or increases of the average vehicle power. This means that the energy consumption per km of vehicles in road motorized modes, rail and vessels will result from its base year value, reduced over time by an amount equal to the product of the potential savings (i.e. the technological potential, expressed as a percentage of the base year consumption) and the index of performance (defined as the percentage of the technological potential actually used to deliver energy efficiency improvements).

An index of performance above 1 would represent a situation where the average size, power and performance parameters of vehicles are actually reduced. In this case, the technological potential for fuel savings is further complemented by the reduction of energy consumption derived from the lower performance requirement of vehicles. If such reduction is coupled with cost savings, this case also requires the correction of cost inputs of ForFITS.

In the case of the air mode, where the only possible powertrain is the KEROSENE TURBINE, the user introduces directly the energy consumption per km by service and by vehicle class (bottom right of the view: see Figure 34.5). This input is introduced in the "User inputs (over time)" sheet of the ForFITS Excel file by means of an index that defines the trend over time of the fuel consumption of representative air transport vehicles since the base year).

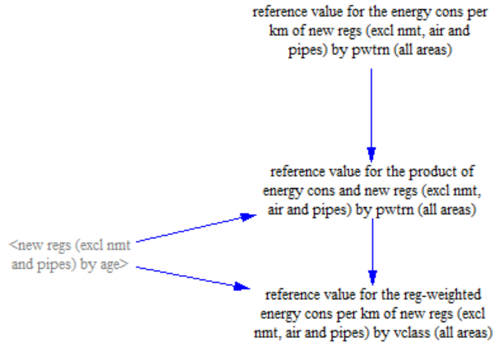
Outputs

The main output of this view is the registration-weighted energy consumption per km of newly registered vehicles (NR, in the following equations) by vehicle class over time (registration-weighted information reflects the type of data that are available from statistics on this topic). This is stored in the variable "REG-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT AND PIPES) BY VCLASS (ALL AREAS)".

For all road motorized modes, rail and vessels, the registration-weighted energy consumption per km of newly registered vehicles (resulting from the information on the technological potential) is calculated as a registration-weighted average (see Figure 34.6 and the following equation) and stored in the variable "REFERENCE VALUE FOR THE REG-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT, AIR AND PIPES) BY VCLASS (ALL AREAS)".

$$EC\ per\ km\ of\ NR\ (age\ ZERO)\ by\ vehicle\ class\ (over\ time) = \\ = \frac{\sum_{powertrains} EC\ per\ km\ of\ NR\ (age\ ZERO)_{powertrain\ i} \times NR\ (age\ ZERO)_{powertrain\ i}}{\sum_{powertrain} NR\ (age\ ZERO)_{powertrain\ i}}$$

Figure 34.6 Calculation of the registration-weighted energy consumption per km of newly registered vehicles by vehicle class for motorized road modes, rail and vessels

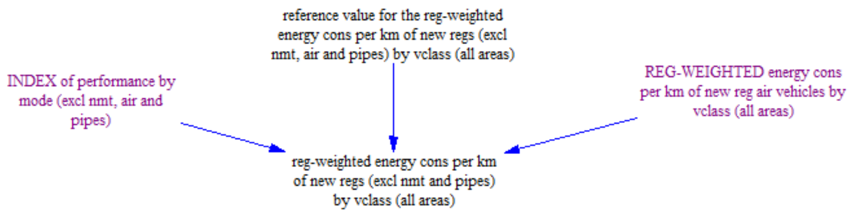


For all road motorized modes, rail and vessels, the value of "REFERENCE VALUE FOR THE REG-WEIGHTED ENERGY CONS PER KM OF NEW REGS (EXCL NMT, AIR AND PIPES) BY VCLASS (ALL AREAS)" it is modified by the index of performance (Figure 34.7, left side). This calculation (shown in the following equation) concludes the calculation flow for these modes:

$$EC\ per\ km\ of\ NR\ (age\ ZERO)\ by\ vehicle\ class\ affected\ by\ the\ performance\ (over\ time) = \\ = EC\ per\ km\ of\ NR\ (age\ ZERO)\ by\ vehicle\ class \times Index\ of\ performance$$

As mentioned earlier, the energy consumption per km of newly registered vehicles (age ZERO) over time is directly introduced by vehicle class for the air mode (Figure 34.7, right side).

Figure 34.7



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