

# Fuel Economy Policies Implementation Tool (FEPIT)

## *User Guide*



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## Structure of the user guide

This report is made of two main parts.

In the first part, the structure of FEPIT is presented and the policy measures covered are introduced. The second part outlines how to simulate step by step a policy scenario with the tool.

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The chapters of this report cover the following topics:

- Purpose of FEPIT.
- Policy measures covered by FEPIT.
- Structure of FEPIT, giving details on the inputs required by the users.
- How to simulate a policy scenario and read results using the tool.

## Purpose of FEPIT

The purpose of FEPIT is to provide a simple tool for estimating the impact of some policy measures on the average fuel economy of newly registered cars. This tool is expected to support decisions to implement policy schemes aimed at getting the Global Fuel Economy Initiative (GFEI) target of 4.2 lge/100 km in the year 2030.

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FEPIT is conceived as a light application running in a widespread software environment (MS EXCEL) with limited data need to provide results and with a simple and user-friendly interface. The input data provided by the user allows to define a customised application of the tool to specific conditions (the car market of a given country or region).

FEPIT estimations are based on the input data provided by the user and on several elasticity parameters based on literature data. Such elasticity parameters have been estimated to provide realistic responses in different conditions. However it should be considered that, given its deliberately simple structure, the purpose of FEPIT is not to replace an in-depth study on the impact of a given policy in a given context. FEPIT results should be considered as estimations of the magnitude of the impact of the policy measures rather than exact forecasts.

In particular it should be considered that the availability of observed data on the penetration of electric vehicles within the new registrations is very limited. The studies used to estimate and validate elasticities do not explicitly address the uptake of electric cars. Therefore, even if FEPIT provides estimates of the share electric cars in new registrations, this data is comparatively less founded on literature than other calculations made in FEPIT.

At the same time, the policies addressed in FEPIT are mainly conceived as short-medium term policies because on the longer term many exogenous conditions can change (e.g. technology, prices). FEPIT assumes the initial conditions and provide changes with respect to such conditions. If such conditions are significantly modified the validity of the FEPIT projections is weakened.

In brief, the role of FEPIT is to help assessing the impact of policies on average fuel economy, it should not be considered as a tool for estimating long term structural modification of the fleet such as e.g. the market share of electric cars.

## The policy measures covered by FEPIT

FEPIT can be used to assess the impact of four different policy measures:

- Fuel economy target
- CO<sub>2</sub>-Based Vehicle registration tax/feebate scheme
- CO<sub>2</sub>-Based Vehicle circulation tax/feebate scheme
- Fuel taxation

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These four measures cover the major policy instruments available to influence the average fuel economy of newly registered cars. They include economic measures as well as regulatory measures like the fuel economy target.

One policy measure not explicitly considered in FEPIT is ecolabelling (i.e. a system to make explicit and easily comparable the environmental performance – fuel economy, CO<sub>2</sub> emission level – of any car model). FEPIT does not cover ecolabelling as such since this measure is considered a prerequisite for the application of all other policies. If a fuel economy target is set, ecolabelling helps car manufacturers to promote the efficiency improvement of their products. If registration or circulation taxes are based on CO<sub>2</sub> emission levels, a sort of ecolabelling will be required to inform customers about the tax level they are going to pay if purchasing that model of car. Finally, if fuel taxation is modified ecolabelling provides information allowing evaluating changes in fuel expenditure.

### Fuel economy target

A fuel economy target identifies the maximum level of average fuel consumption (or CO<sub>2</sub> emissions) computed as corporate sales weighted average on the composition of the new registrations. The target is set for future time horizon and needs to be achieved by manufacturers through technical development or changes in the models mix.

The Global Fuel Economy Initiative (GFEI) has set a target of 4.2 lge<sup>1</sup>/100 km for new vehicle tested fuel economy in the year 2030. Given that the average fuel economy in 2013 was 7.1 lge/100 km, this target corresponds to an average improvement rate of 3.1% per year. As different countries start from very different starting points, reaching the GFEI target can require either more or less ambitious improvement rates. By default, FEPIT allows to consider the following improvement rates:

- allowing to match the GFEI global target fuel economy of 2030
- corresponding to the GFEI average global improvement rate
- calculated as an average of GFEI global target and GFEI average global improvement rate
- other values entered directly by users.

### CO<sub>2</sub>-Based Vehicle registration tax/feebate scheme

The registration tax is intended as a fee paid only once when the vehicle enters a market for the first time (either as new vehicle or second hand import).

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<sup>1</sup> Lge means “liters of gasoline equivalent”

This policy consists of setting the level of the registration tax according to the CO<sub>2</sub> emission level or the specific fuel consumption of the vehicle. In general, the higher the emission level, the higher the tax.

The world “feebate” extends the idea described above for registration tax, allowing the fee faced by car purchasers to be negative (rebate). Typically, this is the case for vehicles having emission and/or fuel consumption levels below certain thresholds.

Various rules can be used to set the value of the registration tax/feebate. Taxes and rebates are more effective when they are set up as continuous functions of parameters such as the emission and/or fuel economy of vehicles. Alternately, feebates can be characterized differently for specific subsets of vehicles (“bins”) defined according to fuel consumption or CO<sub>2</sub> emission thresholds. For simplicity, FEPIT uses an approach based on discrete values: in FEPIT, new registrations are split in five different segments based on fuel consumption (lge/100 km). A different tax value is defined for each segment. The FEPIT results could reflect two alternative interpretations. First: all cars in each segment pay the same tax (enjoy the same rebate: this corresponds to the “bin” approach mentioned earlier). Second: taxes are further differentiated within the segments (still based on fuel consumption), and the values of the tax taken into account by FEPIT are the average values within each segment: in this case, FEPIT mimics what happens with the use of continuous functions, represented by specific points.

The consideration of technology policies specifically targeting HEV, PHEV and EVs is available for simulation within the registration tax policy. Namely, incentives for purchasing alternative vehicles could be implemented as rebates: nevertheless, it should be taken into account that estimates of the share electric cars in new registrations are comparatively less founded on literature than other calculations made in FEPIT.

## CO<sub>2</sub>-Based Vehicle circulation tax/feebate scheme

The circulation tax is a fee paid generally on a yearly basis by each registered vehicle irrespective whether the vehicle is actually used or not.

This policy consists of setting the level of the circulation tax according to the CO<sub>2</sub> emission level or the unitary fuel consumption of the vehicle. In general, the higher the emission level, the higher the tax. As in the case of registration taxes and feebates, below a certain threshold the circulation tax can be negative, i.e. car purchasers enjoy a rebate. Circulation taxes/feebates are due each year and may be conceived in an evolutionary manner, starting from a certain value and evolving in a way that is not necessarily constant over the vehicle life. Rebates, in the case of circulation taxes/feebates, are much less frequent than in the case of registration taxes/feebates, and rather unlikely when taking into account the average value of the circulation taxes/feebates over the vehicle life.

As in the case of registration taxes, various rules can also be used to set the value of the circulation tax/rebate across the vehicle market. For simplicity, new registrations are split in FEPIT in five different segments based on fuel consumption characteristics (lge/100 km). A different circulation tax value is defined for each of these segments, and this is assumed to remain the same across the whole vehicle life. As in the case of registration taxes/feebates, FEPIT results could reflect two alternative interpretations. First: all cars in each segment pay the same tax (enjoy the same rebate). Second: taxes are further differentiated within the segments (still based on fuel consumption according to some continuous function: linear, logarithmic, etc.) and the taxes considered in FEPIT are the average values of the taxes applied to vehicles within each segment ad over the vehicle lifetime.

As said for the registration tax, in the real world a scheme based on a continuous function is preferable, but FEPIT needs to work with the simplification of discrete values for keeping the estimation task within a manageable size.

## Fuel taxation

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Fuel taxes are duties paid on the quantity of fuel purchased. Two types of taxes are generally levied on fuels: excises and value added taxes. Taxes (usually excises) can vary according to fuel type.

The policy consists of modifying the average level of fuel taxation considering all taxes (so it can be a modification of the excises or a modification of the value added tax or both). Given the purpose of FEPIT (to evaluate policies promoting energy efficient cars), the adjustment of the taxation is expected to be upwards. Nevertheless, FEPIT accepts also (limited) reductions of fuel taxation.

FEPIT does not deal with fuel tax differentiation (i.e. between gasoline and diesel). A policy based on differentiation is relevant for FEPIT only if such a differentiation results in a variation of the average fuel tax level.

It is important to recall that, as fuel economy polices result in lower fuel consumption per km, they can be inducing increases in the amounts of km driven by each vehicle (rebound effect). Adapting fuel taxation to maintain constant the level of total costs of driving is a good practice to avoid rebound effects.

## Structure of FEPIT

FEPIT consists of an Excel file including six worksheets. The first three worksheets includes all relevant information, inputs and outputs for the user to make simulations with FEPIT, while the remaining worksheets are used for internal calculations only.

The first three worksheet are organised in various sections, each dedicated to a group of variables. In each section there are editable cells (shaded in light blue) where an input from the user is expected.

Where an input is required, a brief text is provided in a grey shaded box to explain the meaning of the input (for additional details the user is referred to the Quick user guide worksheet or to this document).

Automatic controls are embedded in the Excel file , so that an error message pops-up if invalid values are coded in the editable cells (e.g. negative market shares, negative fuel consumption).

A check message is shown bottom right the editable cells in most of the cases where an input is required. Error messages are also displayed in case of missing inputs. The message "input OK" is displayed when inputs correspond to expected formats. Note that, when FEPIT is opened for the first time, all input cells are empty and the error messages are displayed.

The remaining worksheets are used for internal calculations: they are visible for explanatory purposes but shouldn't be modified by the user.

The following sections contain explanations of the contents of each worksheet.

## Baseline input worksheet

The “Baseline input” worksheet is the place where the user is asked to provide a description of the initial conditions.

### *Base year*

This is the year the initial data refers to. Usually the latest year in which data are available.

### *New cars registrations*

The composition of newly registered cars is entered in this section, both for the base year and for a representative past year (these two values are used by the model for the determination of the baseline trend).

There are three data groups in this section.

The first group is the set of **fuel consumption thresholds** that the tool will use to identify different segments of registered cars.

The second group is the **composition of the newly registered cars** according to the segments defined above **in the base year**.

The third group is the **composition of the newly registered cars** according to the segments defined above **in the past year** that the user is asked to specify.

The past year data is used by FEPIT to estimate an endogenous baseline trend for the registration mix. The input of market shares in a past year is recommended but it is not strictly required. If this input is not provided, the baseline trend is evaluated considering constant market shares or under the assumption of an exogenous pre-defined trend (depending on the selection made by the user, see section 0).

### *New cars fuel economy*

The average fuel economy of each segment of newly registered cars, for the base year and for a past year, needs to be entered in this section.

This section contains two groups of data.

The first group of data requires inputs on the **average fuel economy of the newly registered cars in the base year**. The fuel economy is expressed in terms of lge/100km and is an average across all vehicles in that fuel economy segment irrespective of the fuel type (see section 5 for the conversion of non-gasoline fuel consumption in the required unit).

The second group is about inputs on the **average fuel economy of the newly registered cars in a representative past year**. This past year maybe or maybe not the same past year defined for providing the composition of the newly registered cars (see 4.1.3 above).

The information on the past year is used by FEPIT to estimate an endogenous baseline trend for the fuel economy in each segment. This input is recommended but it is not strictly required. If this input is not provided, the baseline is calculated assuming a constant fuel economy or under the assumption of an exogenous pre-defined improvement trend (depending on the selection made by the user, see section 0).

## Vehicle taxation

This section includes inputs on the level of vehicle taxations (registration tax/feebate and circulation tax/feebate)<sup>2</sup> **in the base year**.

The first group of data concerns the **level of registration tax for each car segment** defined earlier. This is only the registration tax, net of any value added tax.

The second group of data concerns the **level of circulation tax for each car segment** defined earlier.

Important: it is likely that, in the current situation, registration taxes/feebates and/or circulation taxes/feebates are not designed on the vehicle segments defined earlier. For instance, base year taxation structures can depend on parameters such as engine capacity, engine power, or vehicle price. If this is the case, the representation of the base year taxation structure may require elaborations aimed at estimating representative values for each demand segment (see section 0 for more details).

One of the two taxes/feebates sets (registration and circulation) or both can also be null. This is accepted by the model.

## Fuel price

This is the last section of the Baseline input worksheet and is the place where information of fuel price and fuel composition of the new cars registrations in the base year is reported. There are three elements in this section.

The first element is **average fuel price at the pump (pump price)**. Average is meant across different fuels (i.e. gasoline and diesel, while other fuels are neglected here for simplicity). Ideally it should be a weighted average where weights are the fuel consumption shares of each fuel consumed by all the newly registered vehicles under consideration (i.e. newly registered light duty vehicles). The pump price is the price paid by motorists at fuelling stations including all taxes (or subsidies).

The second element is the **average share of fuel taxes on pump price**. Again, this should ideally be a weighted average. All taxes should be considered here: excises as well as value added tax. In case of fuel subsidies, the value should be set to zero.

The third element is the **split of newly registered cars between gasoline and diesel**. This information is used by the tool to broadly estimate the CO<sub>2</sub> emissions level corresponding to the average fuel economy of the newly registered cars. Only the share between gasoline and diesel is required here, other fuels have been neglected here for simplicity, as they usually represent only a minor part of the registrations and so do not affect significantly the estimation of the CO<sub>2</sub> emissions level.

## Projection input and results worksheet

The “Projection input and results” worksheet is the place where the user is asked to choose the assumptions for the simulation of the policy scenarios and where it is possible to see the results of the calculations.

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<sup>2</sup> For the definition of registration tax and circulation tax see section 3.

This worksheet is split into two main parts: the left side, where the policy inputs are defined,; and the right side, where the results are displayed. The contents of these two parts are described in the next sections of this user guide.

### **Projection year**

This is the year for which the results are evaluated and displayed. FEPIT works by simulating the impact of the policy in terms of changes to the baseline conditions at the base year. For comparison purposes, results at the projection year related to the baseline trend (changing over time the baseline conditions according to user selection) are also shown. The user is required to choose a specific projection year (it cannot be more than 20 years later than the base year).

Please note that the policies addressed in FEPIT are mainly conceived as short-medium term policies because on the longer term many exogenous conditions can change (e.g. technology, prices). FEPIT assumes the initial conditions and provide changes with respect to such conditions. If such conditions are significantly modified the validity of the FEPIT projections is weakened.

### **User input for policy scenarios: average fuel economy target**

In this section the user can provide the input to define the setting of an average **fuel economy target**.

This section captures inputs needed to define a average **fuel economy regulatory target**.

A checkbox located in the grey shaded box reporting the title of the policy allows activating the policy itself. **When the checkbox is flagged the policy is activated**. If the check box is not checked, any input provided for this policy is not considered in the calculations.

The input required is **the regulatory target**. Four alternatives are provided with a drop-down menu.

- GFEI global target on average fuel economy. If this alternative is chosen, FEPIT uses as a reference the GFEI target on average fuel consumption of 4.2 lge/100 km in the year 2030. The target on average fuel economy is translated in an average improvement rate per year depending on the baseline conditions at the base year.
- GFEI average global improvement rate. If this alternative is chosen, FEPIT uses as a reference the GFEI target in terms of required annual improvement rate by -3.1%, estimated given the average global fuel economy at 2014.
- Average between GFEI global target on average fuel economy and global improvement rate. If this alternative is chosen, FEPIT uses as a reference the average value between the GFEI target as annual improvement rate by -3.1% and the average improvement rate per year corresponding to the GFEI target on average fuel consumption of 4.2 lge/100 km in the year 2030 (depending on the baseline conditions at the base year). For countries with lower specific fuel consumption than the global average of 2013 (7.1 lge/100 km) in the base year, the target specific fuel consumption will be lower than the GFEI target. In the opposite case, the calculated target will be higher than the GFEI target.
- User defined target. If this alternative is chosen, FEPIT uses as a reference an annual improvement rate defined by the user with the slider below the drop-down menu. The range of the improvement rate is between 0% and -7%. The value set using the slider is considered in the calculations only when the option “user defined target” is selected in the target option drop-down menu (when this option is not selected the check message shown bottom right the slider will display the message “Value not in use”).

The average improvement rate per year corresponding to the selection is shown at the bottom of the drop-down menu.

### ***User input for policy scenarios: CO<sub>2</sub>-Based Vehicle registration tax/feebate scheme***

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In this section the user can provide inputs allowing to define the application of a CO<sub>2</sub>-Based Vehicle **registration** tax/feebate scheme.

A checkbox located in the grey shaded box reporting the title of the policy allows activating the policy itself. **When the checkbox is flagged the policy is activated.** If the check box is not checked, any input provided for this policy is not considered in the calculations.

The input consists of the **level of registration tax/feebate for each car segment** defined in the baseline input worksheet (see 0).

### ***User input for policy scenarios: CO<sub>2</sub>-Based Vehicle circulation tax/feebate scheme***

In this section the user can provide inputs defining the application of a CO<sub>2</sub>-Based Vehicle **circulation** tax/feebate scheme.

A checkbox located in the grey shaded box reporting the title of the policy allows activating the policy itself. **When the checkbox is flagged the policy is activated.** If the check box is not checked, any input provided for this policy is not considered in the calculations.

The input consists of the **level of circulation tax/feebate for each car segment** defined in the baseline input worksheet (see 0).

### ***User input for policy scenarios: fuel taxation***

In this section the user can provide inputs on the application of a change of **fuel taxation**.

A checkbox located in the grey shaded box reporting the title of the policy allows activating the policy itself. **When the checkbox is flagged the policy is activated.** If the check box is not checked, any input provided for this policy is not considered in the calculations.

The input consists of the **average fuel price increment** with respect to the value defined in the baseline input worksheet (see 0). This only refers to fossil fuels.

The fuel price in the baseline and the fuel price resulting from the percentage increase chosen are shown below the input.

### ***New cars registration trend***

In this section the user can choose the assumptions to create the baseline, available for comparison with the policy impacts. Two elements are defined:

The first element is the **new registrations base trend**. A drop-down menu is available to choose among four alternatives:

- Endogenous changing composition according to past trend. If this alternative is chosen, FEPIT uses the fleet composition in the base year and in the past year (see section 4.1.3) to estimate the past trend. This trend is then applied up to the projection year. This alternative is not available if the user did not code a composition for a past year (an error message will be displayed).

- Constant base year composition. If this alternative is chosen, FEPIT assumes that the composition of cars registrations in the projection year is the same as in the base year.
- Exogenous changing composition: faster development. If this alternative is chosen FEPIT applies an exogenous trend to estimate the composition of cars registrations in the projection year. This exogenous trend is pre-determined in the tool (based on exogenous assumptions) and involves a relatively fast modification of the composition towards a better fuel economy.
- Exogenous changing composition: slower development. If this alternative is chosen FEPIT applies an alternative exogenous trend to estimate the composition of cars registrations in the projection year. Also this alternative exogenous trend is pre-determined in the tool (based on exogenous assumptions) and involves a slower modification of the composition towards a better fuel economy.

The second element is the **new registrations fuel consumption base trend**. A drop-down menu is available to choose among four alternatives:

- Endogenous changing fuel consumption according to past trend. If this alternative is chosen, FEPIT uses the average fuel consumption by vehicle segment in the base year and in the past year (see section 4.1.3) to estimate the past trend. This trend is then applied up to the projection year. This alternative is not available if the user did not code average fuel consumption for a past year (an error message will be displayed).
- Constant base year fuel consumption. If this alternative is chosen FEPIT assumes that the average fuel consumption by vehicle segment in the projection year is the same as in the base year.
- Exogenous changing fuel consumption: faster development. If this alternative is chosen FEPIT applies an exogenous trend to estimate the average fuel consumption by segment in the projection year. This exogenous trend is pre-determined and involves a relatively fast reduction of average fuel consumption by segment.
- Exogenous changing composition: slower development. If this alternative is chosen FEPIT applies an alternative exogenous trend to estimate the average fuel consumption by segment in the projection year. Also this alternative exogenous trend is pre-determined and involves a slower reduction of average fuel consumption by segment.

The two trends are estimated independently<sup>3</sup> and combined as follows: the final output in terms of average fuel economy of the baseline trend is the weighted average resulting from the average fuel economy by segment at the projection year and the market shares at the projection year.

## Results

The results of the calculations are shown on the right side of the worksheet, both tabular and graphical form. Three main output are displayed:

- **Average fuel economy of new registrations**. Four values are provided: the base year, the baseline value at the projection year, the target value<sup>4</sup> (i.e. the average fuel economy expected as result of the application of the target without any other policy) at the projection year and

<sup>3</sup> In case the endogenous option is used in both trends, the estimation is done independently using data points provided by the user with reference to each specific variable: data points for market shares are used to estimate the trend of market shares and those of the average fuel economy for the related trend. The estimation is made with a linear interpolation between the two data points available for each variable (base year and past year) and applied up to the projection year. The interpolation is made independently for each segment.

<sup>4</sup> If a target is not selected this value is not shown

the policy value (i.e. the average fuel economy expected as result of the application of all activated policies).

- **Average CO<sub>2</sub> emissions per km.** Again four values are provided: each one is the estimation of the emissions corresponding to the average fuel economy in the different scenarios. The share of gasoline and diesel defined by the user in the baseline input (see section 0) is used to estimate the CO<sub>2</sub> emissions.
- **New registrations composition.** The chart shows the registrations mix in the base year, in the baseline trend and in the policy scenario. The target scenario is not considered here because FEPIT does not simulate how the target is reached.

## Quick user guide worksheet

The ‘Quick user guide’ worksheet includes quick indications on the content of the tool.

Information is provided with reference to

- The content of FEPIT
- The scope of FEPIT in terms of policy simulation
- The simulation of a scenario with FEPIT
- Contact information

The content is a summary of the information reported in this user guide, which is always the reference for more details.

## Baseline scenario calculations worksheet

The ‘Baseline scenario calculations’ worksheet is the place where the baseline trend is estimated in terms of new registration composition and average fuel economy of each segment of newly registered cars.

The baseline trend (changing over time the baseline conditions) is available for comparison with the policy outputs and depends on user selections made in the “Projection input and results” worksheet (see section 0) in terms of:

- New registrations composition base trend,
- New registrations fuel consumption base trend

## Policy scenario calculations worksheet

The ‘Policy scenario calculations’ worksheet is the place where the impacts of the policy measures are estimated in terms of average fuel economy of new registrations and new registration composition.

On top of the worksheet the estimation of the impacts is summarised, while scrolling down the calculations for each measure is estimated separately step-by-step.

## Conversion factors – parameters worksheet

The ‘conversion factors – parameters’ worksheet includes all relevant conversion factors / parameters used in the tool, accompanied by a short description and the references used for their definition.

For more information on the calculation process, please make reference to the methodological report (Deliverable 3: Methodology for developing the upgraded FEPIT).

## How to simulate a policy scenario with FEPIT

Start the FEPIT tool by double-clicking on the FEPIT.xls file.

When Excel opens the macros are not activated. You should activate macros in order to use FEPIT.

The tool will open on the quick user guide, which provides basic instructions for using the tool.

To set up and simulate a policy scenario both the baseline inputs (historical and future trend) and the policy inputs are required. These two sets of inputs are contained in two separate worksheets that can be opened by clicking on the tabs or by clicking on the buttons at the top of the screen.

Where an input is expected from the user, editable cells (shaded in light blue) are available in the tool.

Automatic controls are embedded in the Excel file, so that an error message pops-up if invalid values are coded in the editable cells (e.g. negative market shares, negative fuel consumption).

A check message is shown bottom right the editable cells in most of the cases where an input is required. Error messages are also displayed in case of missing inputs. The message “input OK” is displayed when inputs correspond to expected formats. Note that, when FEPIT is opened for the first time, all input cells are empty and the error messages are displayed.

Please note that all monetary value have to be set in US Dollar currency at the base year.

### Setup baseline input

The first step to use the tool is the setup of the input related to the historical baseline. Some information is usually directly available, while other requires off-line data elaborations and/or assumptions (as reported in the examples below).

User inputs related with the historical baseline have to be set in the “Baseline input” worksheet. The process is the following:

- 1) Set the **Base year** (ideally the current situation, the latest year for which data is available, e.g. 2015).
- 2) Set the **fuel consumption thresholds** (in lge/100 km)<sup>5</sup> used to define the segments characterizing the registration mix of vehicles.

---

<sup>5</sup> Litres of gasoline equivalent per 100 kilometre

Fuel consumption thresholds

	( lge/100km )
ICE <	4.6
ICE 4.6-	5.0
ICE 5-	6.2
ICE 6.2-	7.8
ICE >	7.8

The values have to be positive (zero is not accepted) and might be integer or decimal. For the estimation, detailed data from national registers including information on fuel economy (or CO<sub>2</sub> emissions by km) are needed. Take into account the following criteria to set the classes:

- current mix is reasonably balanced (i.e. all classes have non-zero values and with a reasonable distribution),
- future mix can also be represented significantly (e.g., a relative low consumption category can be needed even if now only represents a few cars),
- thresholds are useful to discriminate current and future tax level (if current taxes are differentiated according to criteria other than fuel consumption, the classes should be able to reproduce the current differentiation in a reasonable fashion)

See Box 1 below for an example.

- 3) Provide the New registrations composition for the base year i.e. the share of cars registered in each segment defined above and the share of hybrid (electric and plug-in) and battery electric cars. The sum of the shares has to be 100% and this is controlled by the tool as the share of the latest class (cells shaded in darker blue) is not editable and computed automatically. In case the values coded in the editable cells exceed 100% an error message will be issued. Null values are acceptable only for the share of hybrid (electric and plug-in) and battery electric cars; otherwise an error message is displayed.

Composition for Base year (2015)

Battery electric	0.0%
Hybrid Plug-in electric	0.0%
Hybrid electric	1.0%
ICE <4.6 lge/100km	17.4%
ICE 4.6-5 lge/100km	10.2%
ICE 5-6.2 lge/100km	45.4%
ICE 6.2-7.8 lge/100km	19.1%
ICE >7.8 lge/100km	6.9%

For the estimation, data from national registers including information on fuel economy (or CO<sub>2</sub> emissions by km), are needed (see also the steps in Box 1 below).

If data on the **New registrations composition for a past year** is available, define which is this past year in the editable cell and provide the share of cars registered in each segment. This input is recommended but it is not strictly required. The past year is to be earlier than the base year. Again, the sum of the shares has to be 100% and this is controlled by the tool as the share of the latest class (cells shaded in darker blue) is not editable and computed automatically. In case the

values coded in the editable cells exceed 100% an error message will be issued. Null values are acceptable for any segment.

If data for several historical years are available, the past year used to enter data in FEPIT should be ideally made avoiding situations where registrations were affected by extraordinary events (e.g. crises, fuel price spikes, etc.). The past year data is used by FEPIT to estimate an endogenous baseline trend for the registration mix. If this input is not provided, the user can simulate policies only using a constant or an exogenous baseline trend (see paragraph 0).

Past year 2010

Composition for Past year (2010)

Battery electric	0.0%
Hybrid Plug-in electric	0.0%
Hybrid electric	0.0%
ICE <4.6 lge/100km	8.0%
ICE 4.6-5 lge/100km	10.0%
ICE 5-6.2 lge/100km	49.0%
ICE 6.2-7.8 lge/100km	23.0%
ICE >7.8 lge/100km	10.0%

Provide the **average fuel economy of new vehicles** in each segment in the base year expressed in terms of lge/100 km. This is an average across all vehicles in that fuel economy segment irrespective of the fuel type. The values have to be positive (zeros are not accepted).

<u>Fuel consumption by segment for Base year (2015)</u>	( lge/100km )
Battery electric	1.5
Hybrid Plug-in electric	3.0
Hybrid electric	4.5
ICE <4.6 lge/100km	4.5
ICE 4.6-5 lge/100km	4.8
ICE 5-6.2 lge/100km	5.7
ICE 6.2-7.8 lge/100km	6.6
ICE >7.8 lge/100km	8.7

For the estimation, data from national registers including information on fuel economy (or CO<sub>2</sub> emissions by km) are needed (see also the steps in the box below). The following values can be used for the conversion of non-gasoline fuel consumption or CO<sub>2</sub> emissions per km in the required unit (lge/100 km):

**Table 1: Multiplier conversion factors to fuel economy (in lge/100km)**

Fuel	Conversion l/100km to lge/100km	Conversion g CO <sub>2</sub> /km to lge/100km
Gasoline	1	0.0431
Diesel	1.077	0.0403
Biodiesel (B20, with conventional biodiesel)	1.057	0.0397
Compressed Natural Gas (CNG)	0.250	0.0532
Ethanol (E85)	0.686	0.0429
LPG (60% Propane, 40% butane)	0.787	0.0473
Hydrogen (35 MPa)	0.081	Not applicable
Ethanol	0.631	0.0428
Conventional biodiesel (FAME)	0.976	0.0396
Hydrotreated biodiesel	1.027	0.0403

Source: IEA Mobility Model.

- 5) If data on the **average fuel economy of new vehicles in a past year** are available define which is this past year in the editable cell and provide the average fuel economy data in each segment. This input is recommended but it is not strictly required. The past year is to be earlier than the base year.

*Past year*

*Fuel consumption by segment for Past year (2012)* ( lge/100km )

Battery electric	1.5
Hybrid Plug-in electric	3.0
Hybrid electric	4.5
ICE <4.6 lge/100km	4.55
ICE 4.6-5 lge/100km	4.9
ICE 5-6.2 lge/100km	5.8
ICE 6.2-7.8 lge/100km	6.8
ICE >7.8 lge/100km	8.9

The past year selected for fuel economy might be different from the past year selected for new registrations composition. The past year data is used by FEPIT to estimate an endogenous baseline trend for the fuel economy in each segment. If this input is not provided the user can simulate policies only using a constant or an exogenous baseline trend (see paragraph 0).

**Box 1: estimating new registration composition and fuel economy by segment**

For the estimation, data from national registers including information on fuel economy (or CO<sub>2</sub> emissions by km) are needed. Usually registers include a record for each vehicle where various details are reported such as fuel type, engine capacity, CO<sub>2</sub> emissions per km and many others.

The first step is to aggregate the data to count the number of newly registered cars with a certain combination of features in that year, e.g.:

Fuel	CO <sub>2</sub> emissions per km (g/km)	Engine cubic capacity (cm <sup>3</sup> )	Registrations (#)
Petrol	149	1364	2,530
Petrol	149	1591	2,130
Diesel	150	1968	2,216
E85	159	1598	3
NG-biomethane	157	1984	19
Petrol	151	1600	446
...			

Since segments according to fuel economy classes are required, the second step is to convert CO<sub>2</sub> emissions per km into fuel consumption (in lge/100km). This can be done by applying the conversion factors by fuel type reported in the third column of

Table 1 (in case data was available in terms of fuel consumption by fuel (e.g. l/km) the conversion factors in second column of

Table 1 could be applied). The result of the conversion could look like:

Fuel	Fuel economy per km (lge/100km)	Engine capacity (cm <sup>3</sup> )	Registrations (#)
Petrol	6.35	1364	2,530
Petrol	6.35	1591	2,130
Diesel	5.57	1968	2,216
E85	7.89	1598	3
NG-biomethane	5.71	1984	19
Petrol	6.44	1600	446
...			

Once the data are elaborated with explicit information on the fuel consumption in lge/100km, details related to fuel type are not needed anymore (except for Battery electric, Hybrid Plug-in electric, Hybrid electric which should be kept separated if they need to be the subject of specific taxation regimes/technology policy structures).

As third step, an analysis of the data should be performed to identify the thresholds defining the vehicle segments in the tool. As mentioned above, the following criteria should be taken into account:

- current mix is reasonably balanced (i.e. all conventional vehicles classes have non-zero values - and with a reasonable distribution),
- future mix can also be represented significantly (so a relative low consumption category can be needed even if now only represents a few cars),
- thresholds are useful to discriminate current and future tax level (if currently taxes are differentiated according to a certain criteria the classes should be able to reproduce the current differentiation in a reasonable fashion).

Different thresholds can be tested in order to evaluate the best option with reference to the actual and future composition of new registrations. As an example, the following three tests might be performed with different thresholds (for this purpose the shares are estimated not considering the electric and hybrid vehicles):

Test A	Shares	Test B	Shares	Test C
ICE <5 lge/100km	14.8%	ICE <4 lge/100km	0.2%	ICE <5.5 lge/100km
ICE 5-6 lge/100km	36.8%	ICE 4-6 lge/100km	51.4%	ICE 5.5-7 lge/100km
ICE 6-7 lge/100km	31.2%	ICE 6-8 lge/100km	42.4%	ICE 7-9 lge/100km
ICE 7-8 lge/100km	11.3%	ICE 8-10 lge/100km	5.4%	ICE 9-11 lge/100km
ICE >8 lge/100km	6.0%	ICE >10 lge/100km	0.7%	ICE >11 lge/100km

In test B and C the upper class (most consuming cars) includes only a very small share of vehicles. This is not very useful, as it is reasonable to assume that in the future the share of this vehicles should be further reduced. Test B shows also a small value for the lower class (less consuming cars). This could be acceptable to represent future mixes in a significant way, since some migration to less consuming tasks is expected. Test A is the more balanced with respect to the current composition, but once other criteria on future mix and tax level are taken into account, it seems recommendable to use lower thresholds (e.g. 4 lge/100 km as minimum value and 7 lge/100 km as maximum value).

Once the thresholds are set, the final shares should be recalculated to take into account also the amount of new registration of Battery electric, Hybrid Plug-in electric, Hybrid electric vehicles:

Composition at the base year	Shares
Battery electric	0.0%
Hybrid Plug-in electric	0.0%
Hybrid electric	1.0%
ICE <4 lge/100km	0.2%
ICE 4-5 lge/100km	14.2%
ICE 5-6 lge/100km	36.5%
ICE 6-7 lge/100km	30.9%
ICE >7 lge/100km	17.2%

Then, the disaggregated data with explicit information on the fuel consumption in lge/100km have to be elaborated in order to estimate the average fuel economy by segment. For each segment, the number of registered cars with a specific fuel economy are counted, e.g.:

Segment	Fuel economy	Registrations (#)
ICE 5-6 lge/100km	5.2	258
ICE 5-6 lge/100km	5.4	614
ICE 5-6 lge/100km	5.6	785
ICE 5-6 lge/100km	5.7	65
ICE 5-6 lge/100km	5.9	3

Then the average fuel economy of the segment is the average of the values weighted by the number registrations:

$$\text{Average} = (5.2 \times 258 + 5.4 \times 614 + 5.6 \times 785 + 5.7 \times 65 + 5.9 \times 3) / (258 + 614 + 785 + 65 + 3) = 5.5$$

If data are available, the same process should be repeated for a past year.

- 6) Provide the **level of registration tax in the base year for each car segment** (in USD). This is only the registration tax, net of any value added tax. Taxes should be coded as positive values, rebates should be coded as negative values, for instance:

<i>Tax level by segment for Base year (2015)</i>	<i>( USD )</i>
Battery electric	-1,500
Hybrid Plug-in electric	-1,500
Hybrid electric	-1,500
ICE <4.6 lge/100km	550
ICE 4.6-5 lge/100km	650
ICE 5-6.2 lge/100km	800
ICE 6.2-7.8 lge/100km	1,250
ICE >7.8 lge/100km	1,550

Important: it is likely that, in the current situation, registration taxes/feebates are not designed on the vehicle segments defined earlier. For instance, base year taxation structures can depend on parameters such as engine capacity, engine power, or vehicle price. If this is the case, the representation of the base year taxation structure may require elaborations aimed at estimating representative values for each demand segment (see Box 2 for an example).

In the base year the circulation tax might also be null: this is accepted by the model:

- 7) Provide the **level of circulation tax in the base year for each car segment** (in USD per year). The same considerations made on registration tax apply here.

<i>Tax level by segment for Base year (2015)</i>	<i>( USD / year )</i>
Battery electric	0.00
Hybrid Plug-in electric	0.00
Hybrid electric	0.00
ICE <4.6 lge/100km	196.0
ICE 4.6-5 lge/100km	203.0
ICE 5-6.2 lge/100km	207.2
ICE 6.2-7.8 lge/100km	245.0
ICE >7.8 lge/100km	319.2

#### Box 2: example of estimating registration and/or circulation tax by segment

Assume that the tax is not based on fuel economy but on engine capacity. In order to estimate the tax for the segments based fuel economy, the detailed data on car registrations can be used. For each car, the engine capacity and the fuel economy are known. Then, for all cars belonging to a certain segment the value of the tax can be computed given the cubic capacity and a dataset like the following can be built:

Fuel	Segment	Engine capacity (cm3)	Tax value
Petrol	ICE 5-6 lge/100km	1164	1,800
Petrol	ICE 5-6 lge/100km	1291	2,000
Diesel	ICE 5-6 lge/100km	1268	2,000

E85	ICE 5-6 lge/100km	1198	1,900
NG-biomethane	ICE 5-6 lge/100km	984	1,600
Petrol	ICE 5-6 lge/100km	1300	2,100
...	...	...	...

Then the tax level for each segment can be computed just as the sales weighted average of cars belonging to that segment.

- 8) Report the average fuel pump price (in USD /l)

( USD/litre )

Average pump price

The average has to be estimated across gasoline and diesel fuels<sup>6</sup>. Ideally it should be a weighted average where weights are the share of each fuel in the market.

- 9) Report the **average share of fuel taxes on pump price**. This is the percentage of all taxes (excises as well as value added tax, etc.) on pump price.

Fuel taxes (% of pump price)

Ideally this value should be a weighted average estimated across gasoline and diesel fuels, using the same weights considered under point 9. In case of fuel subsidies, the value should be set to zero.

**Box 3: example of estimation of average fuel prices and taxes**

In order to estimate the average fuel price and level of taxes, data on pump price, taxation and fuel consumption by fuel are needed. The weights are the shares of gasoline and diesel fuel in the market, estimated on available data on fuel consumption. As an example, the following data might be available:

Fuel	Fuel pump price by fuel (USD/l)	Share of fuel taxes on pump price (%)	Market shares by fuel (%)
Gasoline	1.91	63%	20
Diesel	1.78	53%	80

\*in litre gasoline equivalent

Then the average fuel pump price is the average of the values weighted by market shares by fuel:

$$\text{Average fuel price} = (1.91 \times 20\% + 1.78 \times 80\%) = 1.80$$

The same can be applied to estimate the average share of taxes, resulting in 55%.

- 10) Provide the **split of newly registered cars between gasoline and diesel**. Only the share between gasoline and diesel is required here (other fuels have been neglected here for simplicity, as they usually represent only a minor part of the registrations and so do not

<sup>6</sup> Other fuels have been neglected here for simplicity, as they usually represent only a minor part of the registrations and so do not affect significantly the estimation of the CO2 emissions level

affect significantly the estimation of the CO<sub>2</sub> emissions level). The sum of the shares has to be 100% and this is controlled by the tool as the share of the latest class (cells shaded in darker blue) is not editable and computed automatically.

Once that all inputs available for historical baseline are implemented, please verify that the check message shown bottom right the editable cells is displaying the message “input OK”. In case an input is missing or invalid values are set an error message is displayed and the tool will not work properly.

## Setup of policy inputs

The second step to use the tool is the setup of the policy input in the “Projection input and results” worksheet.

First of all set the **Projection year**. This is the year for which the results are calculated and displayed. It cannot be more than 20 years after than the base year.

Projection year	<input type="text" value="2020"/>	Projection year is the future horizon year for which the forecasts is requested.
	Input check: <b>Input OK</b>	

On the left of the “Projection input and results” worksheet, in the middle section, four policy options are available for the simulation with the FEPIT tool.

The policies can be implemented and analysed independently (one by one) or in combination (all measures could be applied at the same time). The following paragraphs report the inputs required activating each policy.

### Average fuel economy target

Tick the checkbox in the grey shaded box reporting the title of the policy activating it. **When the checkbox is flagged the policy is activated** otherwise any input provided for this policy is not considered in the calculations.

Then select a target option in the drop-down menu among the four alternatives available (see section 0).

If the option “User defined target” is chosen, set the improvement rate by means of the slider below the drop down menu.

**Measure 1**

Average fuel economy target

Measure activation

**Target options**

GFEL global target fuel economy

Average global improvement rate implemented -2.5%

Select one of the target options. In case the 'user defined' selection is made, please specify the value of the average global improvement rate with the slider below

'User defined target' option: -5%

average global improvement rate  yearly % average improvement rate

Input check: Value not in use

### CO<sub>2</sub>-Based Vehicle registration tax/feebate scheme

Tick the checkbox in the grey shaded box reporting the title of the policy activating it. **When the checkbox is flagged the policy is activated** otherwise any input provided for this policy is not considered in the calculations.

Then code for each segment the value of the registration tax (USD) in the editable cells. Taxes should be coded as positive values, rebates should be coded as negative values. The tax might also be null for some segment.

**Measure 2**

CO<sub>2</sub>-Based Vehicle REGISTRATION tax/feebate scheme

Measure activation

Average acquisition tax/rebate

Tax level by segment	(\$)	
Battery electric	0.00	Taxes should be coded as <u>positive</u> values. Rebates should be coded as <u>negative</u> values.
Hybrid Plug-in electric	0.00	
Hybrid electric	0.00	
ICE <4 lge/100km	100.00	
ICE 4-5 lge/100km	200.00	
ICE 5-6 lge/100km	400.00	
ICE 6-8 lge/100km	800.00	
ICE >8 lge/100km	1000.00	

Input check: Input OK

Note that if in the base year a registration tax exists, different values are expected in the policy case. **If the values of the tax are the same as in the base year FEPIT will not detect any policy change** and so there will be no effect on the fleet composition and on the average fuel economy.

Also, if in the base year non-zero values for the registration tax have been provided in the 'baseline input' worksheet and **you do not want to simulate any policy change the checkbox should not be flagged**. If the checkbox is flagged and the input policy tax values are zero FEPIT will read this as a change (as a sort of rebate, from non-zero to zero values) and will compute the impact on the registration composition accordingly.

### CO<sub>2</sub>-Based Vehicle circulation tax/feebate scheme

Tick the checkbox in the grey shaded box reporting the title of the policy activating it. **When the checkbox is flagged the policy is activated** otherwise any input provided for this policy is not considered in the calculations.

Then code for each segment the value of the registration tax (USD) in the editable cells. Taxes should be coded as positive values, rebates should be coded as negative values. The tax might also be null for some segment.

Measure 3		Measure activation
CO2-Based Vehicle CIRCULATION tax/feebate scheme		<input checked="" type="checkbox"/>
Average ownership tax/rebate		
<i>Tax level by segment</i>	(\$/year)	
Battery electric	0.00	Taxes should be coded as <u>positive</u> values. Rebates should be coded as <u>negative</u> values.
Hybrid Plug-in electric	0.00	
Hybrid electric	0.00	
ICE <4 lge/100km	40.00	
ICE 4-5 lge/100km	60.00	
ICE 5-6 lge/100km	100.00	
ICE 6-8 lge/100km	180.00	
ICE >8 lge/100km	300.00	
Input check:		Input OK

The same warnings mentioned above for the registration tax apply here: **if the values of the tax are the same as in the base year, FEPIT will not detect any policy change and if you don't want to simulate any policy change do not flag the checkbox.**

### Fuel taxation

Tick the checkbox in the grey shaded box reporting the title of the policy activating it. **When the checkbox is flagged the policy is activated** otherwise any input provided for this policy is not considered in the calculations.

Measure 4		Measure activation
Fuel taxation		<input checked="" type="checkbox"/>
Fuel price		
<i>Average fuel price increment (fossil fuels)</i>	20%	% average Increase to the base year value
Input check:		Input OK
<i>Projection Average pump price in \$/l (2020)</i>	2.400	
<i>Base year Average pump price in \$/l (2014)</i>	2.000	

Then set the **percentage average increase of the fuel tax** (with respect to the value defined in the 'baseline input' worksheet) in the editable cell. In case the user aims at simulating the phase out of fuel subsidies at the base year, translate the removal of subsidies into a direct increase of the pump price, to be implemented in the same editable cell.

The price of the fuel at the pump in the base year and the fuel price resulting from the percentage increase chosen are shown below the editable cell to clarify what a certain percentage increase of fuel tax means (e.g. starting from an average pump price of 2USD/l with 50% of taxes and applying a 30% increase of fuel taxation the resulting pump price is 2.3 USD/l).

### Setup projection values for comparison

The last input is the definition of the baseline trend (changing over time the baseline conditions), available for comparison with the policy outputs.

- 1) Choose the **New registrations composition base trend** in the drop-down menu among the four alternatives (see section 0)

- 2) Choose the **New registrations fuel consumption base trend** in the drop-down menu among the four alternatives (see section 0)

NEW CARS REGISTRATIONS TREND	
<b>New registrations base trend</b>	
endogenous changing compositon of new registrations according to past trend	Input check: <b>Input OK</b>
<b>New registrations fuel consumption base trend</b>	
endogenous changing fuel consumption of new registrations according to past trend	Input check: <b>Input OK</b>

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