Fuel Economy policies and how to quantify their impacts?

Kiev, 13th of October 2017
GFEI workshop
François Cuenot, GFEI consultant
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- What is Fuel Economy?
- Fuel Economy policy options
  - Fiscal
  - Non-Fiscal
- Fuel Economy policy framework
  - Baseline
  - Objective setting
  - Monitor / track progress
- Modeling expected impacts: FEPIT
  - Purpose, data needs
  - Methodological approach
What is fuel economy?

- Vehicles use energy, and fuel economy measures energy per unit of vehicle travel. It is the RATE of energy use.
  - Litres per 100km (Europe)
  - Km per litre (Japan)
  - Miles per gallon (United States)

- Fuel economy, fuel efficiency, fuel intensity are all fairly interchangeable terms. But fuel economy always refers to fuel use relative to distance travelled.
What is fuel economy? (2)

- Important relationship: there is about 2.4 kg of CO$_2$ emitted per litre of gasoline burned, 2.6 for diesel.
  - The only way to cut CO$_2$ emissions is to burn less fuel (you can’t capture it at the tailpipe).
  - For gasoline vehicles, 8 L/100 km = 189 g/km CO$_2$ emissions, 7 L/100 km = 165 L/100km, etc. It’s a fixed relationship.

- If you reduce improve vehicle fuel economy, you:
  - Save fuel
  - Reduce costs
  - Cut CO$_2$ emissions
  - Don’t help air quality very much (though complex and important topic)
Types of Air Pollutants

Air pollutants affecting air quality
- NOx
- Non-methane hydrocarbons
- particulates
- carbon monoxide
- Toxic emissions (e.g. benzene)
- Heavy metals

Air pollutants affecting the climate
- Methane
- Black carbon
- \( \text{N}_2\text{O} \)

Fuel quality / tailpipe controls

Fuel economy improvement
Gasoline and Diesel fuel CO$_2$ emissions v. fuel economy
What is fuel economy? (3)

- Fuel economy improvement can be achieved through:
  - Technical changes to vehicles
  - Changing the types of vehicles bought
  - Improving vehicle maintenance
  - Changing the way vehicles are driven (ecodriving)
  - Reducing traffic congestion

- Fuel economy improvement to vehicles should be part of a broader strategy:
  - Traffic management
  - City and regional planning
  - Promotion of public transit
  - Etc.
How to improve vehicle fuel economy?

- The average 2010 car, at 15-20% efficiency, has many efficiency losses – and many efficiency opportunities

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Efficiency Loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>70-75%</td>
</tr>
<tr>
<td>Accessories</td>
<td>1-3%</td>
</tr>
<tr>
<td>Idling</td>
<td>1-3%</td>
</tr>
<tr>
<td>Transmission</td>
<td>5-6%</td>
</tr>
<tr>
<td>Aerodynamic drag</td>
<td>3-5%</td>
</tr>
<tr>
<td>Rolling resistance</td>
<td>3-5%</td>
</tr>
<tr>
<td>Braking</td>
<td>3-8%</td>
</tr>
<tr>
<td>Inertial acceleration</td>
<td>3-9%</td>
</tr>
<tr>
<td>Road</td>
<td>~15%</td>
</tr>
</tbody>
</table>

- CO₂ emissions: 100%

- Fuel efficiency: 100%

- Advanced lightweight materials
- Optimized vehicle design
- Improved aerodynamics
- Low rolling resistance tires
- Low drag brakes
- 6-8 speed transmission
- Dual-clutch transmission
- Integrated starter “Stop-start”
- Electric power steering
- Efficient air conditioning
- Lean-burn
- Direct injection
- Turbocharging
- Cooled exhaust gas recirculation
- Low friction lubrication
- Cylinder deactivation
- Variable valve timing
- Idling
- Transmission
- Braking
- Inertial acceleration
- Aerodynamic drag
- Rolling resistance

Fuel economy policies – 4 keys

- Fuel economy labeling
  - Widely based on tested fuel economy
  - Need to make available to consumers before purchase (internet, car window stickers)

- Fuel pricing
  - Taxation system should at least internalize externalities
  - CO2 tax will help differentiate fuels as well as encourage fuel economy
Fuel economy policies – 4 keys

- **Fuel Economy Standards**
  - Typically corporate average standards
  - Typically either vehicle mass or size based
  - Could be applied to 2\textsuperscript{nd} hand vehicles

- **Vehicle purchase taxes**
  - Sales tax, registration tax, import duties
  - Can be differentiated by fuel economy or CO2 emissions
  - Germany also differentiates by pollutant emissions levels
Fuel Economy Labels – “No Brainer”

- Informative, transparent, independent
- Need for representativeness
- Different metrics:
  - Absolute: Tested fuel economy
  - Relative: by segment/vehicle mass
- Classification
  - No Classification/comparison
  - Scaled results
    - Versus all other vehicles
    - Versus best in class
No scale

- Hard to know if good or not
Color scale

- Lettered, numbered or starred
Label of the future?
Fuel Pricing
Fuel tax as a key enabler

- Fuel tax policies around the world diverse and fast changing
- Fuel subsidies have been phased-out in many countries
  - Lower oil prices making the changes transparent to the end consumer
- Gasoline/Diesel tax difference tends to narrow in many countries, especially in Europe
GIZ international fuel price survey
Fuel Economy Standards
Passenger Car CO₂ Standards
Globally

Solid lines: historical performance
Dashed lines: enacted targets
Dotted lines: proposed targets or targets under study

US 2025: 103
Canada 2025: 103
Mexico 2016: 153
EU 2021: 95
Japan 2020: 105
China 2020: 117
S. Korea 2015: 153
India 2021: 113
Brazil 2017: 146

[1] China’s target reflects gasoline vehicles only. The target may be higher after new energy vehicles are considered.
[2] US standards GHG standards set by EPA, which is slightly different from fuel economy standards due to low-GWP refrigerant credits.
[3] Gasoline in Brazil contains 22% of ethanol (E22), all data in the chart have been converted to gasoline (E00) equivalent.
Key elements to consider when introducing fuel economy standards

1. Regulated metric

2. Form of target curve + underlying attribute

3. Target timeframe/limit value
## 1. Regulated metric

<table>
<thead>
<tr>
<th>Country or Region</th>
<th>Target Year</th>
<th>Regulated metric</th>
<th>Unadjusted Fleet Target/Measure</th>
<th>Form of target curve</th>
<th>Test Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>2015</td>
<td>CO₂</td>
<td>130 gCO₂/km, 95 gCO₂/km</td>
<td>Weight-based</td>
<td>NEDC</td>
</tr>
<tr>
<td></td>
<td>2021</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>2015</td>
<td>Fuel consumption</td>
<td>6.9 L/100km, 5 L/100km</td>
<td>Weight-class based</td>
<td>NEDC</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.S.</td>
<td>2016</td>
<td>Fuel economy/ GHG</td>
<td>36.2 mpg or 225 gCO₂/mi, 56.2 mpg or 143 gCO₂/mi</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>2016</td>
<td>GHG</td>
<td>217 gCO₂/mi, N/A</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>2015</td>
<td>Fuel economy</td>
<td>16.8 km/L, 20.3 km/L</td>
<td>Weight-class based</td>
<td>JC08</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>2017</td>
<td>Fuel consumption</td>
<td>1.82 MJ/km</td>
<td>Weight-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>2017</td>
<td>CO₂</td>
<td>130 g/km, 113 g/km</td>
<td>Weight-based</td>
<td>NEDC for low-powered vehicle</td>
</tr>
<tr>
<td></td>
<td>2022</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>2015</td>
<td>Fuel economy/GHG</td>
<td>17 km/L or 140 gCO₂/km, 24 km/L or 97 gCO₂/km</td>
<td>Weight-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>2016</td>
<td>Fuel economy/GHG</td>
<td>39.3 mpg or 140 g/km</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>2020</td>
<td>Fuel economy</td>
<td>17 km/L</td>
<td>Footprint-based</td>
<td>U.S. combined</td>
</tr>
</tbody>
</table>
US fuel economy standard curves
European Standards

CO₂ Emissions of Selected Vehicle Models by Technology (2013)
China standard curves

Fuel consumption (NEDC l/100km)

CURB WEIGHT (KG)

Phase 1 Max (2005)
Phase 2 Max (2008)
Phase 3 CAFC (2015)/Phase 4 Max
Phase 4 CAFC proposed (2020)

Ph. 1 Reg  Ph. 1 Spec.  Ph. 2 RegL  Ph. 2 Spec.  Ph. 3 Reg
Ph. 3 Spec.  Ph. 4 Reg  Ph. 4 Minivan  Ph. 4 3-Row

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# Fiscal Measures

<table>
<thead>
<tr>
<th>Fiscal policy type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel taxes, CO2 taxes</td>
<td>Set by fuel type; paid upon refueling</td>
</tr>
<tr>
<td>VMT taxes</td>
<td>Typically paid at annual registration; could be CO2-adjusted</td>
</tr>
<tr>
<td>Road pricing</td>
<td>Paid by km of driving or when passing a cordon line</td>
</tr>
<tr>
<td>Vehicle purchase taxes/feebates</td>
<td>Paid at time of purchase; can be differentiated by fuel economy or CO2</td>
</tr>
</tbody>
</table>
Role of fiscal policies in promoting fuel efficiency

- Encourage manufacturers to adopt technologies to improve fuel efficiency and reduce emissions
- Send consumers appropriate price signals to purchase fuel-efficient and low carbon vehicles
- Support fuel efficiency and emission regulatory targets
  - Regulatory standards set the minimum requirement and need to be strengthened overtime
  - Fiscal policies provide continuous incentive to improve
  - Easy to establish, does not require detailed knowledge of vehicles and technology costs, only needs to establish “rate, or value of fuel or GHG savings”, “revenue target”, and “test method and enforcement”
What is a Feebate?

Feebate = Fee + Rebate

- Market-based policy that shifts consumer purchases (and potentially manufacturer production) by encouraging GHG reductions by placing a fee on higher-emitting vehicles and providing a rebate to lower-emitting vehicles.

- Based on fuel economy or CO2 differential between vehicles.

- Could also take into account vehicle attributes like size or weight.
How to design a feebate system?

Slope determines marginal costs and benefits.

Pivot point can be designed to meet revenue goals.
Design Elements For Effective Incentives

- Base fiscal charges directly on vehicle fuel consumption levels, instead of vehicle physical attribute, avoid fixed charges.
  - Mandatory labeling for fuel consumption is an enabler.

- Apply the incentive widely across fleet, instead of limiting to a portion of the fleet.

- Provide continuous incentive on every fuel consumption or fuel consumption level.

- Targeted incentive programs should also be linked to fuel consumption.
  - A targeted incentive program refers to incentive provided to vehicles with special features (such as a certain fuel type, or vehicles equipped with certain technologies).
Important to have a continuous slope, no steps

- Toyota Yaris – 6.4 l/100km
  - Sales +49%
- Honda Fit – 6.6 l/100km
  - Sales +3%

example: Canada
Feebates around Europe – many systems

Comparison of Feebate Functions

Source: Bunch and Greene
French feebate schedule over time

- The fees have risen and the rebates declined...

![Diagram showing the fee rebate schedule over time with specific years and fee levels represented.]
The only vehicles receiving rebates have 60 g/km or below.
French feebate system led to significant drop in CO₂ emissions

- 2001–2007 avg. reduction new vehicle CO₂ = 1 g/km per year
- 2008: emissions drop 9 g/km and 2009 by 7 g/km, Ministry of Transport attributes to introduction of bonus/malus system

Source: Les véhicules particuliers en France (Ademe), March 2011
# Standards v. Feebates

<table>
<thead>
<tr>
<th>Standards</th>
<th>Feebates</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Guarantee&quot; a minimum level of fuel economy</td>
<td>Do not guarantee level</td>
</tr>
<tr>
<td>No incentive to go beyond minimum</td>
<td>On-going incentive</td>
</tr>
<tr>
<td>Must be regularly updated to maintain pressure</td>
<td>Must be regularly updated to meet revenue targets</td>
</tr>
<tr>
<td>No cap on costs</td>
<td>Provide a cap on cost</td>
</tr>
<tr>
<td>Could ban some vehicles</td>
<td>Wouldn't ban any vehicles</td>
</tr>
<tr>
<td>No clear price signals</td>
<td>Clear price signals to consumers and producers</td>
</tr>
</tbody>
</table>

*Source: Bunch and Greene*
The FEPIT tool
Purpose of FEPIT

- Simple tool to estimate the impact of selected policy measures on the average fuel economy of newly registered cars in a given year in the future
- Support for decision makers to implement policy schemes to achieve region specific fuel economy targets in the light of the GFEI target
- Light application running in MS EXCEL with limited data requirements and with a simple and user-friendly interface
- Does not replace in-depth policy study: magnitude of the impact of the policy measures rather than exact forecast
- Designed to make the most out of the baseline work
Data requirement
FE baseline & additional info

- **New registrations by fuel economy segment** for at least one past year
- **Average fuel economy by fuel economy segment** of all newly registered cars for at least one past year
- **Additional Information on:**
  - Vehicle taxation (registration and circulation tax/feebate)
  - Fuel price and fuel taxation
  - Fuel composition of newly registered cars (gasoline/diesel)
Policy measures in FEPIT

- Fuel economy regulation/standard
- CO$_2$-Based Vehicle registration tax/feebate scheme
- CO$_2$-Based Vehicle circulation tax/feebate scheme
- Fuel taxation

Eco-labelling not explicitly considered: it is assumed to be a pre-requisite for the application for all other policies
Fuel economy standard

- Maximum level of average fuel consumption (or CO2 emissions) computed as corporate sales weighted average based on the composition of the new registrations in the regulated zone
- Target set for future time horizon, to be achieved by manufacturers through technical development or changes in the models mix
- Global Fuel Economy Initiative (GFEI) target: 2.8% annual improvement rate from 2005 to 2030, leading to 50% improvement over the 25 years time interval
CO₂-Based Vehicle registration tax/feebate scheme

- Registration tax: a fee paid only once, when the vehicle enters a market for the first time (either as new vehicle or second hand import)

- Setting the level of the registration tax according to the CO₂ emission level or the specific fuel consumption of the vehicle (e.g., the higher the emission level the higher the tax)

- “Feebate”: allowing the fee to be negative (rebate, e.g. for vehicles having emission and/or fuel consumption levels below certain thresholds and/or for alternative vehicles, HEV, PHEV and EVs)
CO$_2$-Based Vehicle circulation tax/feebate scheme

- **Circulation tax**: a fee paid generally on a yearly basis by each registered vehicle irrespective whether the vehicle is actually used or not

- **Setting the level of the circulation tax according to the CO$_2$ emission level or the specific fuel consumption of the vehicle** (e.g., the higher the emission level the higher the tax)

- **“Feebate”**: allowing the fee to be negative (rebate, e.g. for vehicles having emission and/or fuel consumption levels below certain thresholds and/or for alternative vehicles, HEV, PHEV and EVs)
Fuel taxation

- Fuel taxes: paid on the quantity of fuel purchased. In general, composed of excise tax and value added taxes (excises can vary according to fuel type)
- Modifying the average level of fuel taxation considering all taxes (modification of the excises or a modification of the value added tax or both)
- The adjustment of the taxation expected to be upwards. Nevertheless, also (limited) reductions of fuel taxation accepted
- FEPIT does not deal with fuel tax differentiation (i.e. between gasoline and diesel)
The methodological approach

Impacts of the policies reported in terms of:
- Average fuel economy of new registrations (lge/100km)
- New registrations composition (share of a given segment in the total amount of newly registered vehicles)

Estimation of the impacts based on:
- policy selection and characterization by users at the projection year
- policy characterization and market environments at the base year (e.g., level of vehicle registration tax or level of fuel duties)
- set of elasticities, linking policy characteristics with changes in the output variable
The methodological approach

**Theoretical approach**

- New vehicles registrations segmented into fuel consumption classes
- Each segment represented by the related average fuel consumption
- Policies affect both
  - the new registration composition, and
  - the average fuel consumption by segment
- Context factors and interaction between policies affect the size of final impacts
Structure of FEPIT

- Excel file including six worksheets:
  - First three worksheets including all relevant information, inputs and outputs for the user
  - Remaining worksheets used for internal calculations only

- User-worksheets
  - With **editable cells** shaded in light blue for user input
  - **Automatic controls** to avoid invalid values
  - **Error messages** in case of wrong / missing inputs
  - **When FEPIT is opened for the first time, all input cells are empty and the error messages are displayed**

<table>
<thead>
<tr>
<th>Worksheet</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline input</td>
<td>User</td>
</tr>
<tr>
<td>Projection input and results</td>
<td>User</td>
</tr>
<tr>
<td>Quick user guide</td>
<td>User</td>
</tr>
<tr>
<td>Baseline scenario calculations</td>
<td>Calculation only</td>
</tr>
<tr>
<td>Policy scenario calculations</td>
<td>Calculation only</td>
</tr>
<tr>
<td>Conversion factors - parameters</td>
<td>Calculation only</td>
</tr>
</tbody>
</table>
Structure of FEPIT

Projection input and results worksheet:
- setting the assumptions for the policy scenarios
- and reading the results of the calculations
Structure of FEPIT

Projection input and results worksheet

- Fuel economy target: four alternatives provided with a drop-down menu
  
  A. **GFEI global target on average fuel economy**
     4.2 lge/100 km in the year 2030 (translated in average improvement rate per year depending on the baseline conditions at the base year)
  
  B. **GFEI average global improvement rate**
     required annual improvement rate by -2.8%
  
  C. **Average between GFEI global target on average fuel economy and global improvement rate** average between option A and B
  
  D. **User defined target** annual improvement rate (range of the improvement rate is between 0% and -7%)
Structure of FEPIT

Projection input and results worksheet

- Setting baseline trend on new registrations and average fuel consumption: four alternatives provided with a drop-down menu
  
  A. **Endogenous trend** according to past data, using data provided in the base year and in the past year to estimate the past trend, applied up to the projection year

  B. **Constant base year values**

  C. **Exogenous trend: faster development** (exogenous trend pre-determined in the tool with fast development)

  D. **Exogenous trend: slower development** (exogenous trend pre-determined in the tool with slow development)
Structure of FEPIT

Other worksheets:

**Quick user guide worksheet:** quick indications on the content of the tool

**Baseline scenario calculations worksheet:** where the baseline trend is estimated in terms of new registration composition and average fuel economy of each segment of newly registered cars
Structure of FEPIT

Other worksheets:

**Policy scenario calculations worksheet**: where the impacts of the policy measures are estimated in terms of average fuel economy of new registrations and new registration composition

**Conversion factors – parameters worksheet**: including all relevant conversion factors / parameters used in the tool, accompanied by a short description and the references used for their definition
Hints for using FEPIT

- Criteria for setting the fuel consumption thresholds
  - Analysis of detailed data from national registers, including information on fuel economy
  - current mix reasonably balanced (i.e. all classes have non-zero values and with a reasonable distribution)
  - future mix also represented significantly (e.g., a relative low consumption category can be needed)
  - thresholds useful to discriminate current and future tax level (reproducing the current differentiation in a reasonable fashion even if criteria other than fuel consumption)
Hints for using FEPIT

- Past year data on new registrations and average fuel economy
  - recommended but not strictly required
  - earlier than the base year
  - avoid situations where data affected by extraordinary events (e.g. crises, fuel price spikes, etc.)
  - used to estimate an endogenous baseline trend: if this input is not provided, only constant values or an exogenous baseline trend available
Hints for using FEPIT

- Average fuel economy of new vehicles by segment in lge/100km
  - average across all vehicles in a fuel economy segment irrespective of the fuel type (weighted by the number registrations)
  - conversion of non-gasoline fuel consumption or CO₂ emissions per km in the required unit (l/100 km to lge/100km or g CO₂ /km to lge/100km)
Hints for using FEPIT

- Registration/circulation tax in the base year by segment
  - Usually not designed on the vehicle segments defined by the user in terms of fuel economy (e.g., depending on engine capacity, engine power, vehicle price, etc.)
  - Elaborations required to estimate representative values for each demand segment, base on detailed data on car registrations (average weighted by the number registrations)
Hints for using FEPIT

- Policy registration/circulation tax in the projection year by segment
  - **Different values from the base year**: if the same, no impacts simulated (policy change not detected by FEPIT)
  - Impacts simulated with reference to **policy change from base year to projection year**
Hints for using FEPIT

- Average fuel price (at the pump) and taxes
  - average estimated across gasoline and diesel fuels only (other fuels neglected for simplicity)
  - weighted by the shares of each fuel in the market
  - taxes include excises as well as value added tax, etc. on pump price
Thank you

Time for more Q&As
Additional details on FEPIT
Structure of FEPIT

Baseline input worksheet: description of the initial conditions

- Base year

- New cars registrations
  - Fuel consumption thresholds, to define segments
  - Composition of newly registered cars by segment in the base year
  - Composition of newly registered cars by segment in the past year (optional)
Structure of FEPIT

Baseline input worksheet

- New cars registrations

<table>
<thead>
<tr>
<th>Fuel consumption thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICE &lt; 4.0</td>
</tr>
<tr>
<td>ICE 4-5.0</td>
</tr>
<tr>
<td>ICE 5-6.0</td>
</tr>
<tr>
<td>ICE 6-7.0</td>
</tr>
<tr>
<td>ICE &gt; 7.0</td>
</tr>
</tbody>
</table>

These values define the segments used by the tool to represent the registration mix of conventional Internal Combustion Engine cars.

CO2 based vehicle taxation policies are described in the tool by applying taxes differentiated according to these segments.

See the user guide for more details on the choice of the thresholds.

<table>
<thead>
<tr>
<th>New registrations composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composition for Base year (2015)</td>
</tr>
<tr>
<td>Battery electric</td>
</tr>
<tr>
<td>Hybrid Plug-in electric</td>
</tr>
<tr>
<td>Hybrid electric</td>
</tr>
<tr>
<td>ICE &lt; 4 lge/100km</td>
</tr>
<tr>
<td>ICE 4-5 lge/100km</td>
</tr>
<tr>
<td>ICE 5-6 lge/100km</td>
</tr>
<tr>
<td>ICE 6-7 lge/100km</td>
</tr>
<tr>
<td>ICE &gt;7 lge/100km</td>
</tr>
</tbody>
</table>

The composition of new registrations is defined in terms of share of cars registered in each segment (according to the classes defined above).

Hybrid (electric and plug-in) and battery electric cars are kept separated.

The sum of the shares has to be 100%.
# Structure of FEPIT

## Baseline input worksheet – fuel economy

### New Cars Fuel Economy

#### Average fuel consumption

<table>
<thead>
<tr>
<th>Fuel consumption by segment for Base year (2015)</th>
<th>(lge/100km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery electric</td>
<td>1.50</td>
</tr>
<tr>
<td>Hybrid Plug-in electric</td>
<td>3.00</td>
</tr>
<tr>
<td>Hybrid electric</td>
<td>4.50</td>
</tr>
<tr>
<td>ICE &lt; 4 lge/100km</td>
<td>3.86</td>
</tr>
<tr>
<td>ICE 4-5 lge/100km</td>
<td>4.71</td>
</tr>
<tr>
<td>ICE 5-6 lge/100km</td>
<td>5.54</td>
</tr>
<tr>
<td>ICE 6-7 lge/100km</td>
<td>6.47</td>
</tr>
<tr>
<td>ICE &gt; 7 lge/100km</td>
<td>8.35</td>
</tr>
</tbody>
</table>

The average fuel consumption has to be defined according to the new registrations classes defined above. It is expressed in terms of lge/100 km (litre-gasoline-equivalent per 100 kilometre).

#### Past year

This is a past year for which data on fuel consumption by car segment is available.

**Past year not in use**

Data related to past year is used to estimate the endogenous changing fuel consumption of new registrations according to past trend. If past year data is not available cells should be empty.

Input check: Input OK
Structure of FEPIT

Baseline input worksheet

- Vehicle taxation in the base year
  - Level of registration tax for each car segment, net of any value added tax
  - Level of circulation tax for each car segment

![Vehicle Taxation Table]

**Average REGISTRATION tax in the base year**

<table>
<thead>
<tr>
<th>Tax level by segment for Base year (2015)</th>
<th>($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery electric</td>
<td>0.00</td>
</tr>
<tr>
<td>Hybrid Plug-in electric</td>
<td>0.00</td>
</tr>
<tr>
<td>Hybrid electric</td>
<td>0.00</td>
</tr>
<tr>
<td>ICE &lt; 4 lge/100km</td>
<td>150.00</td>
</tr>
<tr>
<td>ICE 4-5 lge/100km</td>
<td>500.00</td>
</tr>
<tr>
<td>ICE 5-6 lge/100km</td>
<td>1000.00</td>
</tr>
<tr>
<td>ICE 6-7 lge/100km</td>
<td>2000.00</td>
</tr>
<tr>
<td>ICE &gt; 7 lge/100km</td>
<td>3000.00</td>
</tr>
</tbody>
</table>

The REGISTRATION tax is a tax paid only once when the vehicle is purchased and registered. It does NOT include any VAT or similar tax applied to the purchase price. The tax/rebate level has to be defined according to the registration classes defined above. Taxes should be coded as positive values, rebates should be coded as negative values. The values of the registration tax should be provided in US Dollars. If registration tax does not exist in the base year all values should be set to zero.
Structure of FEPIT

Baseline input worksheet

- Fuel price in the base year
  - Average fuel price at the pump (pump price), in $/liter
  - Average share of fuel taxes on pump price
  - Split of newly registered cars between gasoline and diesel

![Baseline input worksheet diagram](image-url)
Structure of FEPIT

Projection input and results worksheet: setting the policy scenarios and reading the results of the calculations

- Projection year
- Activating and setting policies
  - Fuel economy target
  - CO2-Based Vehicle registration tax/feebate scheme
  - CO2-Based Vehicle circulation tax/feebate scheme
  - Fuel taxation
- Setting baseline trend
- Reading results
  - new registration composition
  - average fuel consumption / CO₂ emission
Structure of FEPIT

Projection input and results worksheet

- Fuel economy target
Structure of FEPIT

Projection input and results worksheet

- CO2-Based Vehicle registration tax/feebate scheme: level of registration tax/feebate for each car segment

![Table showing tax/feebate for different vehicle segments](image)
Structure of FEPIT

Projection input and results worksheet

- CO2-Based Vehicle circulation tax/feebate scheme: level of circulation tax/feebate for each car segment

![Image of CO2-Based Vehicle circulation tax/feebate scheme](image-url)
Structure of FEPIT

Projection input and results worksheet

- **Fuel taxation**: percentage average increase of the fuel tax

![Fuel taxation worksheet]

- **Average fuel taxes increment**: 30%
- **Input check**: Input OK

  - **Projection Average pump price in S/l (2020)**: 2.300
  - **Base year Average pump price in S/l (2015)**: 2.000
Structure of FEPIT

Projection input and results worksheet

- Setting baseline trend on new registrations and average fuel consumption
Structure of FEPIT

Projection input and results worksheet

Reading results: average fuel economy

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Average fuel economy</th>
<th>% Variance from Base (2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base year (2015)</td>
<td>6.20</td>
<td></td>
</tr>
<tr>
<td>Projection year - Fuel economy Target (2030)</td>
<td>4.20</td>
<td>-32.3%</td>
</tr>
<tr>
<td>Projection year - Other fuel economy policies (2030)</td>
<td>5.59</td>
<td>-9.8%</td>
</tr>
<tr>
<td>Projection year - Combined policy scenario (2030)</td>
<td>3.74</td>
<td>-39.7%</td>
</tr>
<tr>
<td>Projection year - Baseline trend (2030)</td>
<td>5.73</td>
<td>-7.6%</td>
</tr>
</tbody>
</table>

Bar chart showing the projection results for different scenarios compared to the base year (2015) for average fuel economy.
Structure of FEPIT

Projection input and results worksheet

- **Reading results**: average CO2 emissions per km (estimated on the basis of the split of gasoline and diesel registrations provided by the user)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Average CO2 emissions per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base year (2015)</td>
<td>154.6 g CO2/km</td>
</tr>
<tr>
<td>Projection year - Fuel economy Target (2030)</td>
<td>104.7 g CO2/km</td>
</tr>
<tr>
<td>Projection year - Other Fuel economy policies (2030)</td>
<td>139.4 g CO2/km</td>
</tr>
<tr>
<td>Projection year - combined policy scenario (2030)</td>
<td>93.3 g CO2/km</td>
</tr>
<tr>
<td>Projection year - Baseline trend (2030)</td>
<td>142.9 g CO2/km</td>
</tr>
</tbody>
</table>
Structure of FEPIT

Projection input and results worksheet

- **Reading results**: New Registrations composition
The methodological approach

- Elasticity parameters estimated on the basis of literature data to provide realistic responses in different conditions
Theoretical approach

- Impact on new registrations composition by segment
  - Direct change of the natural logarithm in car registrations in a given segment in response to a 1000 Euro tax/rebate (registration share of segment s change by x%) [D’Haultfœuille et al. (2012), Klier and Linn (2012)]
  - Compensation of direct change by changes in the other segments (for instance, if the most energy intensive class loses 2% of share, this 2% is gained by less energy intensive segments, proportionally to the relative shares they had in the base year)
The theoretical approach

- Impact on the average fuel consumption by segment
  - Due to changes of the distribution of the registrations within the segments and the deployment of technical improvements
    [COWI (2002), Bunch, Greene et al. (2011)]
  - Function estimated on COWI (2002) data, generated by registration tax under a fleet neutrality assumption
The methodological approach

Theoretical approach

- **Base elasticities** drawn from studies based on the experience of vehicle taxation in Europe.
- **The effect** of vehicle taxation may potentially be quite different in other contexts.
- Taking into account context factors influencing the base elasticities: effect of the baseline fuel price:
  - Comparing the effect of feebate scheme related to registration tax in US [Bunch, Greene et al. (2011)] and France [Klier and Linn (2012)]
  - Reduction of the elasticity parameters to simulate lower responsiveness in US with respect to the EU reference case (assumed to be related to baseline fuel price differences)
The methodological approach

Theoretical approach

- **Interaction between measures:**
  - **Circulation and registration taxes:** the effect is larger when combined [COWI (2002)]
  - **Fuel consumption target and other policies:** responsiveness to other measures is reduced assuming that, as vehicle efficiency gradually improves, the incentive to choose a more fuel efficient car also gradually declines

- **Electric vehicles segments**
  - **Comparing the effect of incentives** [Mock, P. and Yang, Z. (2014)]
  - **Smoothing the elasticities**
  - Estimating shares at projection year based also on an exogenous increasing trend from 2012 onward
The methodological approach

Validation in different conditions:
- Simulating various case studies
- Revision of the elasticity parameters