Low-carbon liquid fuels :
What impact on Urban Air Quality?

ReFuels Week – June 14, 2021

By Philippe Dégeilh, IFPEN, R&I Project leader

AGENDA

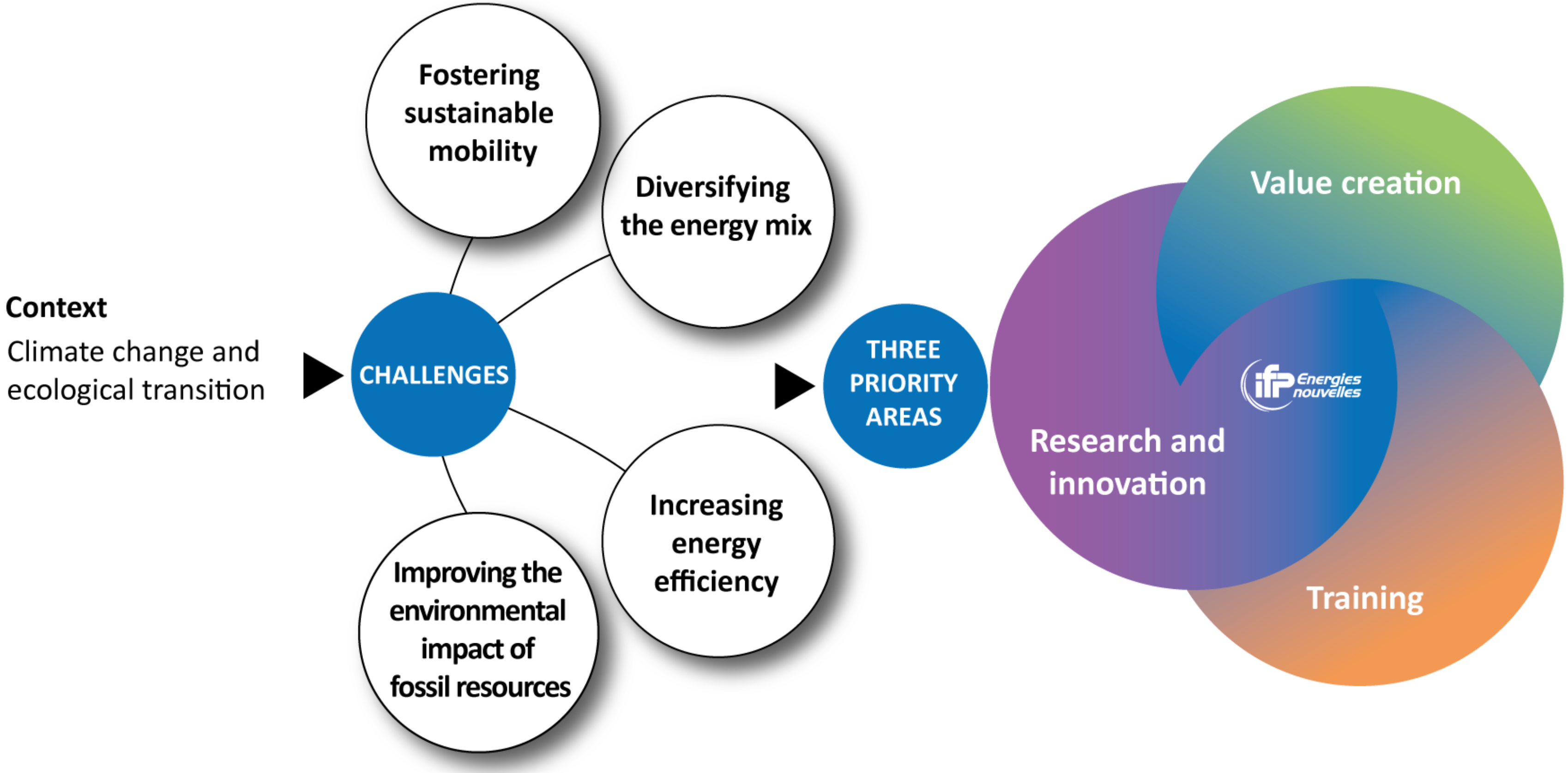
- Introduction – IFPEN
- Ongoing study on PHEV
  - Vehicles, fuels and test matrix
  - Synthesis of fuel impacts

IFPEN at a glance

An international scope in the fields of energy, transport and the environment

1,635 people

1,190 engineers and technicians dedicated to research



IFPEN ACTIVITIES IN THE FIELD

Sustainable mobility | Climate, environment and circular economy | Renewable energies

Producing 2G biofuels:
BIOTFUEL® PROJECT

Thermochemical conversion to **biodiesel** and **biokerosene**

Construction of **2** pilot units in **2016** with a view to marketing of the process in **2021** by Axens

Partners: IFPEN, Axens, CEA, Avril, ThyssenKrupp Industrial Solutions, Total

AMI Biojet 2020 application

Assessing real driving emissions :
REAL-e smart sensor

Real e

Real-e **connected suitcase**, an **exhaust gas analyser** (CO, CO_2, NOx, PN, NH_3, etc.),
for straightforward and fast **evaluation** of **vehicle emissions in real use**

Partnership with the SME Capelec

Connected mobility:
GECO AIR APPLICATION

1st free **eco-driving** application for smartphones evaluating pollutant and CO_2 emissions related to individual mobility

Combines information technologies with IFPEN's expertise in the field of powertrain and pollutant modeling

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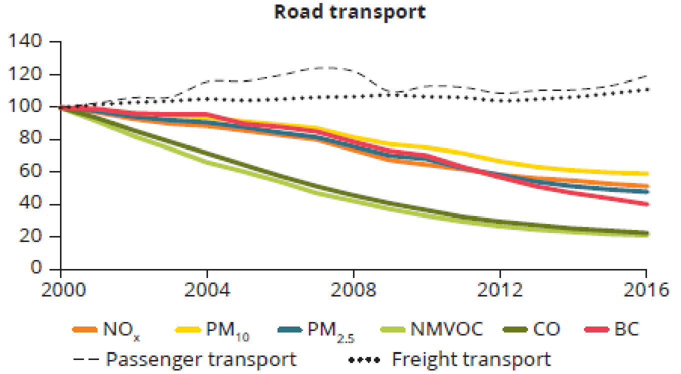
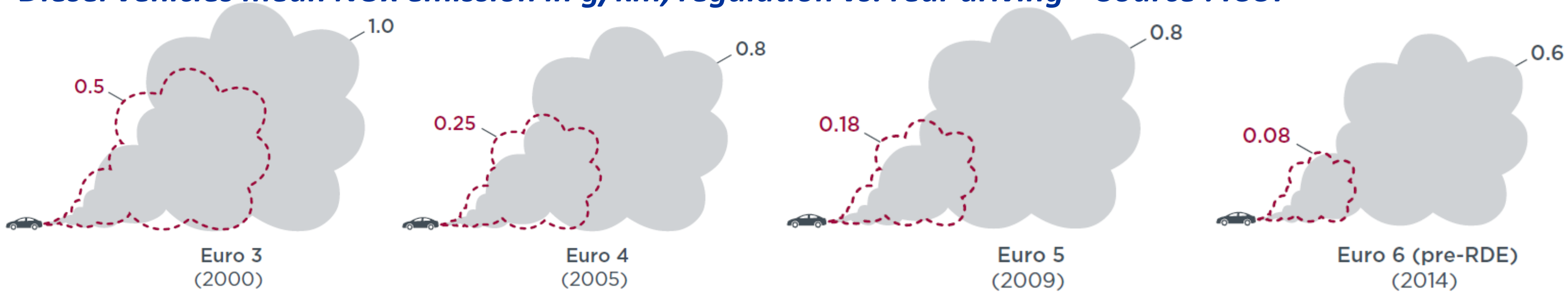
General context on pollutant emissions

European regulation for NOx and PM since 1993

EU-28 emissions from road transport, 2000-2016 (% of 2000 levels) – Source : EEA



Diesel vehicles mean NOx emission in g/km, regulation vs. real-driving – Source : ICCT



- **Successive regulations aim to reduce the impact on air quality of road transport**
- **However, a gap remained between regulations and actual emissions on the streets up to Euro 6d**

- **Recent data and studies show that the introduction of RDE (2019) has led to a significant reduction in emissions in real use**
- **Exceptions persist, and Euro 7 will aim for even more ambitious objectives (levels, conditions and list of pollutants)**

Is this panorama strongly impacted by the introduction of non-fossil fuels for the decarbonation of transport ?

Study "EVALUATION OF PLUG-IN HYBRID VEHICLES IN REAL-LIFE CONDITIONS"

2021, IFPEN for CONCAWE

Concawe
Environmental Science for European Refining

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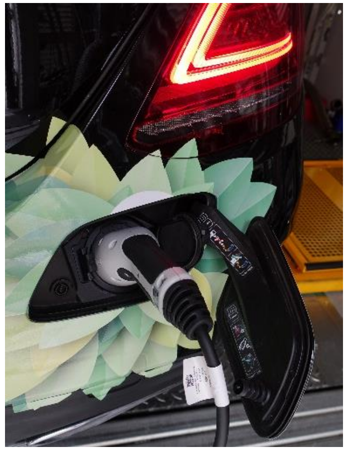
FUELS AND VEHICLES SPECS

SUSTAINABLE MOBILITY



<table>
<tr><th colspan="4">Mercedes C300 EQ Power</th></tr>
<tr><td colspan="4">Battery: 13.5 kWh 365V
Electric motor: 90 kW</td></tr>
<tr><td colspan="2">Gasoline (C300 e)
Regulation : €6d-temp
Test mass : 1885 kg
WLTP CO2 : CS 146 g/km – Weighted 31 g/km
WLTP autonomy (EAR) : 56km
2.0L 4cyl 155 kW turbo Direct injection
9-speed automatic transmission
AFTS : 2*TWC + GPF
Mileage: 4.000 km</td><td colspan="2">Diesel (C300 de)
Regulation : €6d-temp
Test mass : 1970 kg
WLTP CO2 : CS 140 g/km – Weighted 30,5 g/km
WLTP autonomy (EAR) : 57km
2.0L 4cyl 143 kW turbo Direct injection
9-speed automatic transmission
AFTS : DOC SCRF-SCR
Mileage: 14.000 km</td></tr>
<tr><th>Standard fuel</th><th>Renewable fuel</th><th>Standard fuel</th><th>Renewable fuel</th></tr>
<tr><td>E10</td><td>E20 renewable</td><td>B7</td><td>HVO</td></tr>
<tr><td>Certification gasoline with 10% ethanol</td><td>100% renewable gasoline including 20% ethanol
EN228 compliant (except oxygenate content)</td><td>Certification diesel with 7% bio-diesel</td><td>100% renewable parafinic fuel</td></tr>
</table>

- **Latest available technologies: PHEV hybrid architecture, thermal engine and after-treatment**
- **Have demonstrated very low pollutant emission levels with standard fuels on a wide range of conditions, well below the Euro 6 limits (*2020 study*)**
- **Is this status impacted using fuels from renewable sources?**

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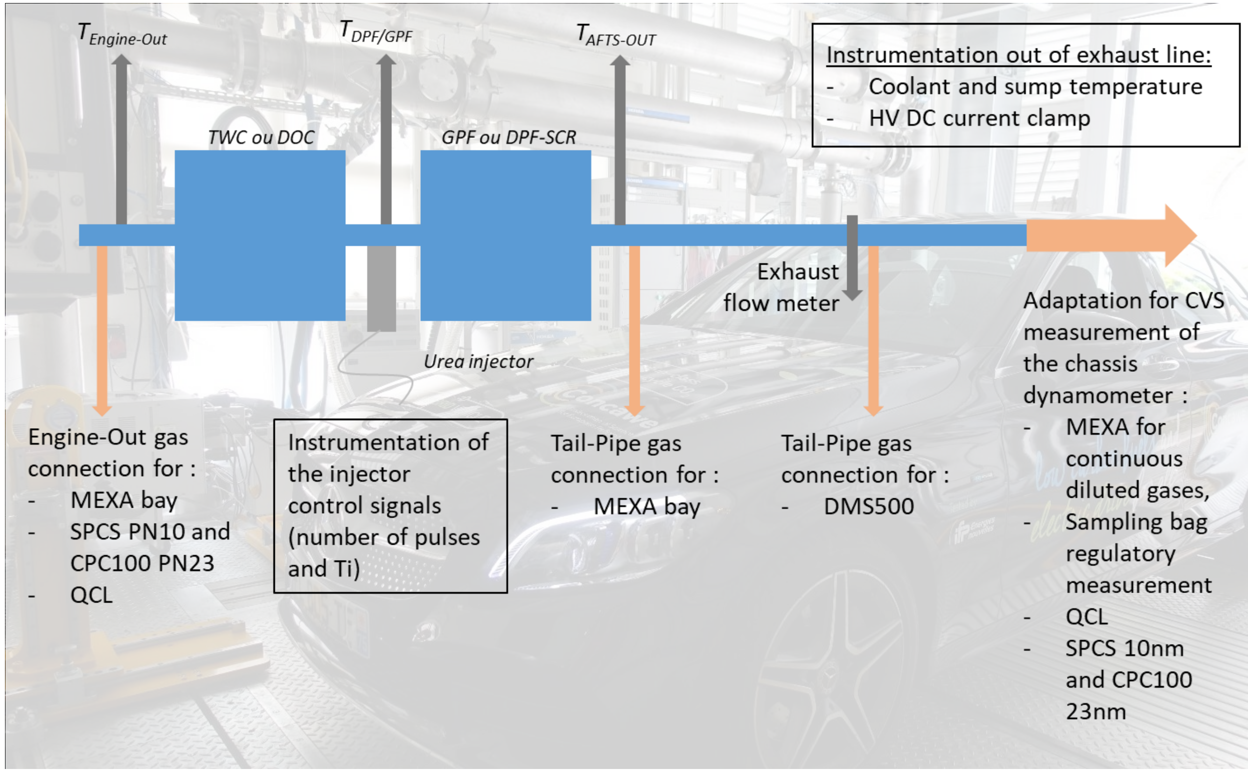
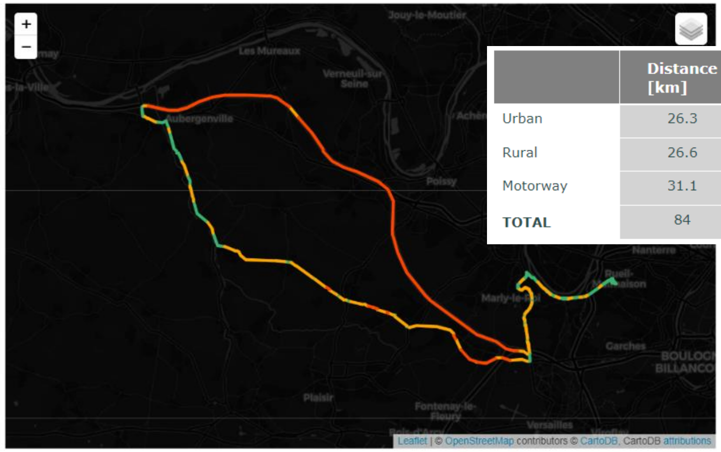
EXPERIMENTAL SETUP AND TESTS





	Distance [km]	Duration [s]	Distance share [%]	Mean speed [km/h]	Vmax [km/h]
Urban	26.3	3949	31.3	24	60
Rural	26.6	1341	31.7	71.5	90
Motorway	31.1	996	37	112.3	141.3
TOTAL	84	6285	100	48.1	141.3

SUSTAINABLE MOBILITY

- *In-deep intrumentation*
  - *Vehicle emissions:*
    - *Regulated and non-regulated pollutants*
    - *Engine-out and tail-pipe*
    - *PN focus : SPN10/23 EO+TP + DMS500*
  - *Vehicle operation:*
    - *Battery power*
    - *Urea system*
    - *AFTS temperature*
    - *OBD*
- *Realistic test conditions*
  - *RDE tests on roller test bench*
  - *Speed and slope recorded from real RDE tests operated on open road with these vehicles*
  - *At least 3 repetitions of each test*
  - *Both full and empty modes tested*

COMPARISON STANDARD & SPECIFIC FUELS - SYNTHESIS

SUSTAINABLE MOBILITY

Impact from standard to renewable fuels		NOx	CO	THC	SPN10	FC (vol.)	CO_2 TtW
Gasoline (E10 to E20)	Engine Out	→	→	↑	→	-	-
	Tail Pipe	→	→	 ↑ From 8% to 12% of standards level	→	↑ (~4%)	→
Diesel (B7 to HVO)	Engine Out	→	↓	→	→	-	-
	Tail Pipe	→	 ↓ From 1.4% to <1% of standards level	→	→	↑ (7% CS)	↓ (-4% CS)

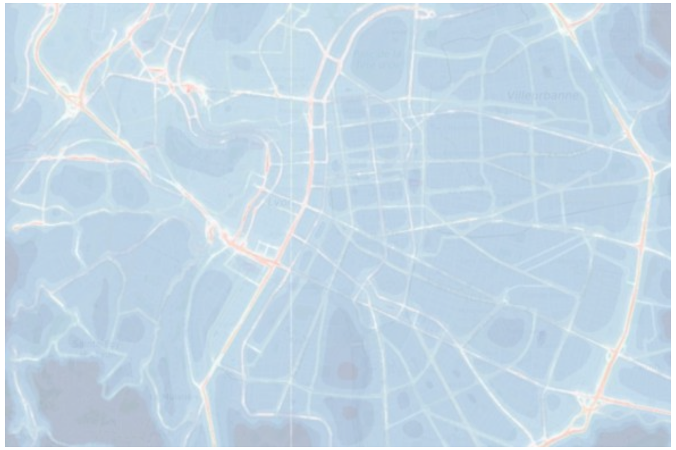
*This summary table gives the <u>trend induced by the switch to a renewable fuel</u>. The absolute levels measured are and remain **less than half that of the current Euro 6d certification levels for each local pollutant considered**.*

- **Main impacts of renewable fuels are on**
  - **<u>Volumetric fuel consumption</u> (consequence of energy density)**
  - **<u>TtW CO2 emissions</u> (consequence of chemical composition)**
- **The established impacts on local pollutants (gaseous and particulate) are low, both engine out and tail pipe.**
- **The emissions levels of these two Euro 6d vehicles therefore remain low with the use of fuels from renewable sources.**

CONCLUSION & PERSPECTIVES

- Within the current study:
  - For the latest generation light vehicles tested, the impacts on local pollutants of switching to low-carbon fuels appear to be low.
  - These experimental results will feed into a broader analysis of the performance of PHEVs and compare them to other levels of electrification, from conventional vehicles to fully electric vehicles.

- More generally about air quality:
  - Use of new communication and information technologies (NTIC, including massive GNSS data and floating vehicle data) for a detailed and localized understanding of real uses and emission impacts
  - Optimize the use of technologies to deal with both global and local issues :
    - For PHEV, geofencing "forced" ZEV mode in low emission zones



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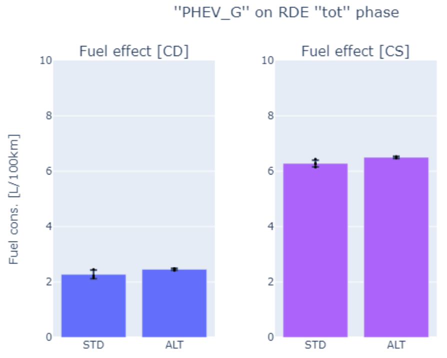
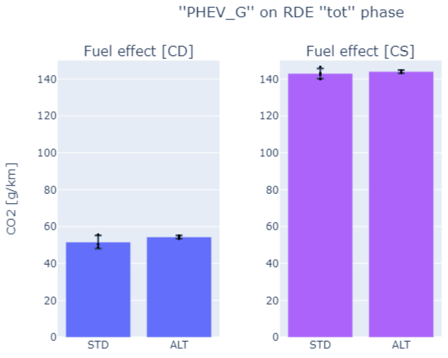
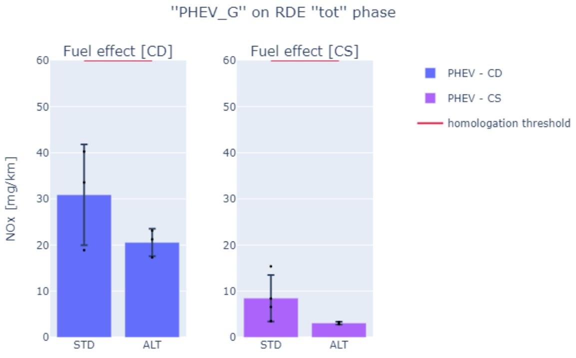
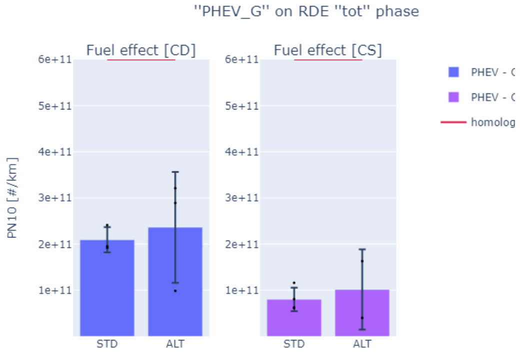
STANDARD VS. SPECIFIC FUELS – GASOLINE (TP)

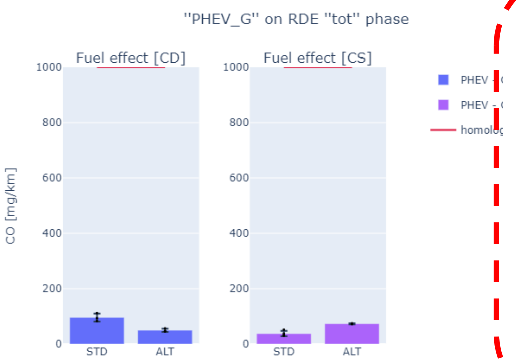
SUSTAINABLE MOBILITY

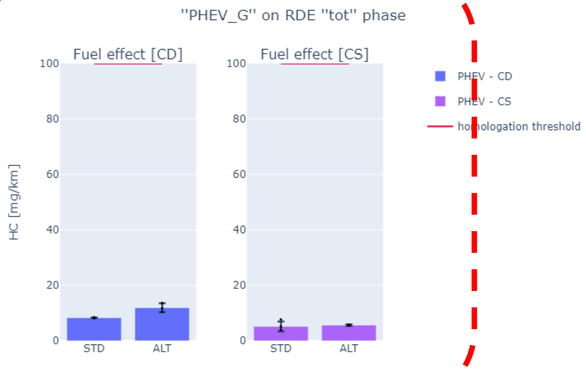










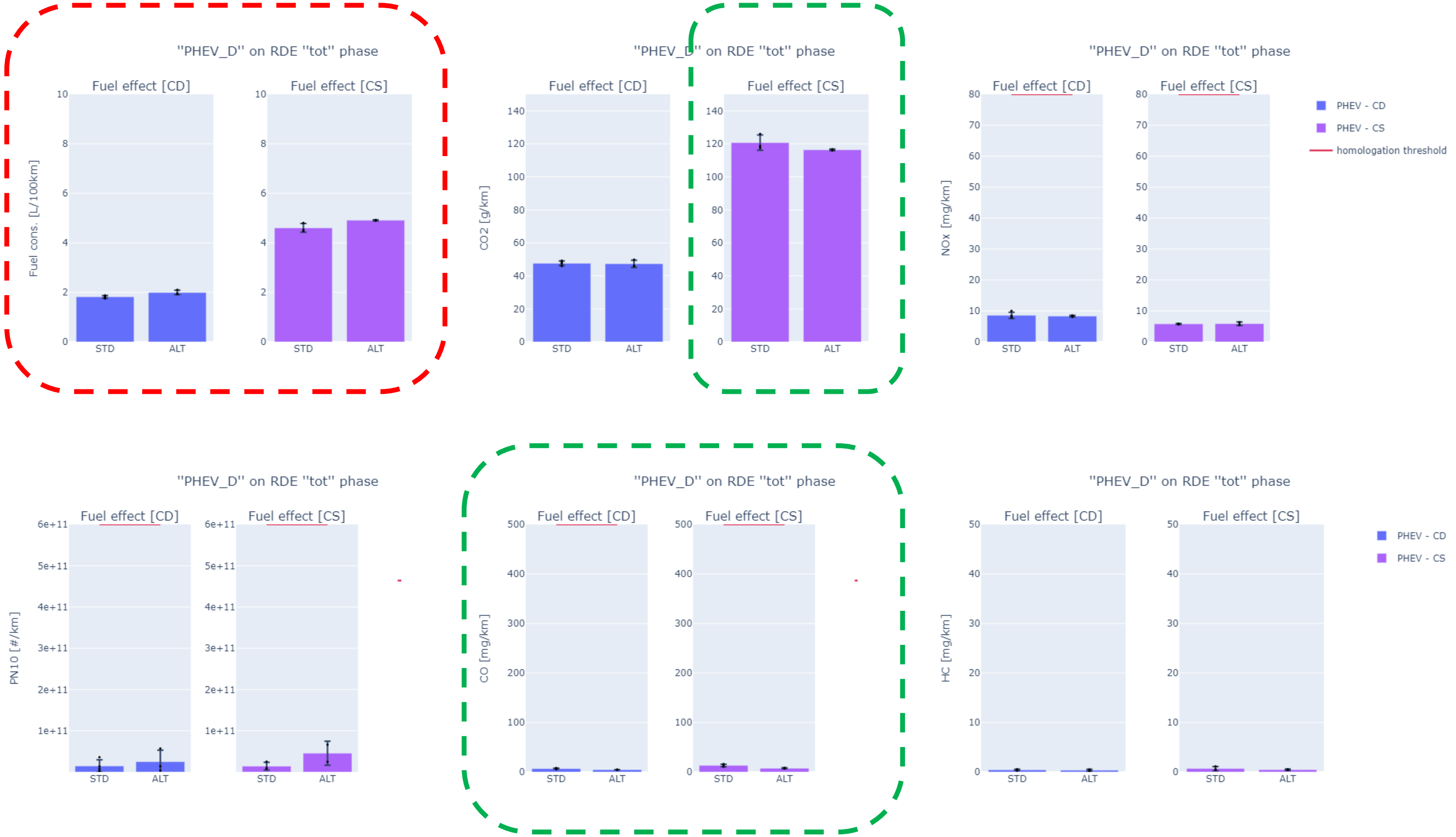


- **SIGNIFICATIVE IMPACTS :**
  - **Fuel consumption**
    - **CD: +0.2 L/100km (8%)**
    - **CS: +0.2 L/100km (4%)**
  - **CO**
    - **the impact depends on the conditions, on levels that are always very low compared to the regulatory threshold**

STD = Standard E10 fuel

ALT = Alternative E20 fuel

STANDARD VS. SPECIFIC FUELS – DIESEL (TP)



- **SIGNIFICATIVE IMPACTS :**
  - **Fuel consumption**
    - **CD: +0.2 L/100km (10%)**
    - **CS: +0.3 L/100km (7%)**
  - **CO_2 TtW**
    - **CS: -4.4 g/km (-4%)**
  - **CO**
    - **CD: -2.3 mg/km (-33%)**
    - **CS:-5.5 mg/km (-42%)**

STD = Standard B7 fuel
ALT = Alternative HVO fuel

