THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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Subject: Comments on the implementation of a heavy-duty CO_2 engine standard in Brazil

SUMMARY

There are a number of benefits of instituting a separate engine standard in conjunction with a full vehicle standard. These benefits outweigh the potential disadvantages and include:

1. Establishing a link between NO_x and CO_2 emissions, therefore ensuring that future NO_x emissions targets under the P-8 standards are met without compromising the fuel consumption and CO_2 emissions of future engines.

2. Engine efficiency improvements translate into CO_2 benefits across a wide range of vehicle duty cycles and payloads. In contrast to aerodynamic and rolling resistance improvements, engine standards directly address the source of CO_2 emissions.

3. Acknowledging the diversity of applications in the HDV sector, a separate engine standard enables the exemption from whole vehicle standards of certain vehicle classes with special applications without foregoing measurable CO_2 emissions improvements.

4. Engine CO_2 standards do not require a new test protocol to be developed as the CO_2 is measured during the existing engine certification test.

5. Engine standards set out direct, multiyear targets for engine efficiency improvements, creating a secure environment for substantial, sustained, long-term investment in engine efficiency technology R&D.

These points are elaborated in greater detail in the paragraphs below.

BENEFITS OF AN ENGINE CO_2 STANDARD

1. Establish a link between NO_x and CO_2 emissions

In the world of engine calibration, there is a well-known trade-off between fuel consumption and NO_x emissions. NO_x emissions can be reduced through in-cylinder measures such as increased exhaust gas recirculation or by delaying the injection time of the fuel. Both strategies inevitably result in higher fuel consumption. With the future introduction of P-8 standards and the respective low real-world NO_x emissions that will be achieved, it is of particular importance to ensure that the lower NO_x emission limits do not result in increased fuel consumption and CO_2 emissions. Regulating CO_2 and NO_x emissions over the same test cycle will create a link between these two emissions and make it less likely that CO_2 emissions increase as an unintended consequence of tighter NO_x limits. This can be better exemplified by the engine maps presented in Figure 1.

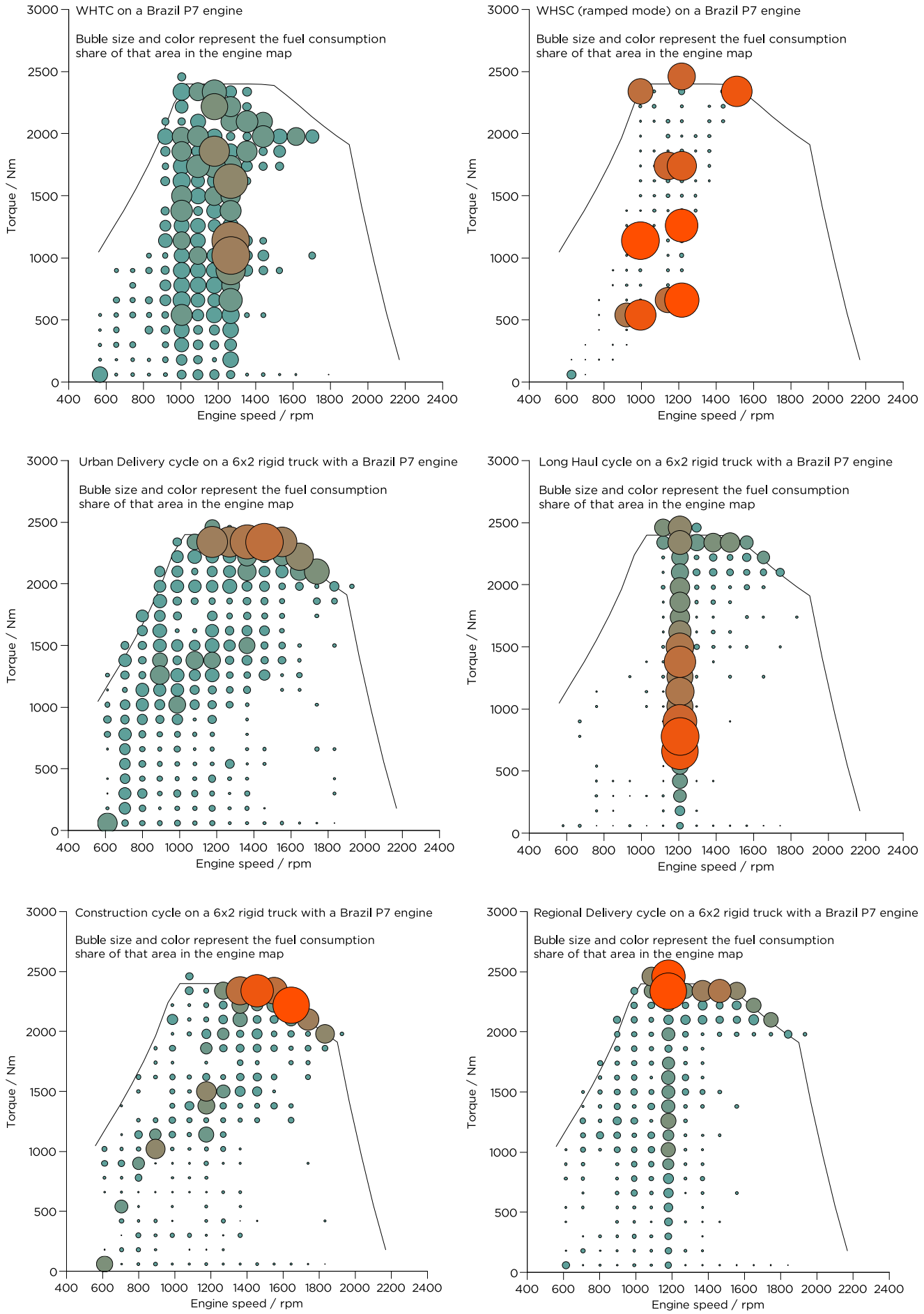

Figure 1. Location of engine operation points for the 2 engine cycles (WHTC, WHSC) and 4 different vehicle driving missions.

Figure 1 (top) shows the location of the engine operating points on the map of a P-7 compliant engine over the World Harmonized Transient and Stationary engine certification cycles (WHTC and WHSC). The bottom 4 diagrams in Figure 1 show the location of the engine operating points when a 6x2 heavy (pesado) rigid truck, equipped with the same P-7 engine, is operated in 4 different applications: urban delivery, regional delivery, long haul and construction.

It can be seen in the Figure 1 that the location of the engine operation points is significantly different when comparing the engine certification cycles (Figure 1 top) and the vehicle applications (Figure 1 bottom). **As a result, an engine might be simultaneously tuned for low NO_x/high CO_2 emissions during engine certification and to high NO_x/ low CO_2 emissions over full vehicle certification or in-use operation. Regulating CO_2 and NO_x over the same cycle under the framework of an engine standard, would promote the introduction of engine technologies that reduce the fuel consumption across the complete engine map, and prevent the optimization of certain engine regions for low NO_x/high CO_2 and vice versa.**

2. Engine efficiency improvements translate to CO_2 benefits across a wider range of vehicle duty cycles and payloads.

There are a number of engine efficiency improvements that are promoted through the adoption of an engine standard. In contrast to the localized optimization of engine efficiency (see point 1 above), the engine technologies incentivized by an engine standard result in benefits across the complete range of operation on the engine map. These technologies include:

- Piston and piston rings with reduced friction
- Low viscosity lubricants
- Reduced EGR backpressure
- Reduced aftertreatment backpressure
- Increased turbocharging efficiency
- Higher compression ratio
- Higher injection pressure
- Engine downsizing and downspeeding
- Reduced power consumption of engine accessories
- Waste heat recovery
- Model-based engine control

In contrast to aerodynamic and rolling resistance improvements, the engine efficiency improvements translate to CO_2 benefits across a wider range of vehicle duty cycles and payloads. During the development of the US HDV GHG standards, EPA developed engine maps[1] that include the influence of the aforementioned engine technologies. Similarly, West Virginia University (WVU)[2], starting from a baseline engine, developed engine maps that reflect

[1] EPA, and DOT. "Final Rule: Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles–Phase 2. Regulatory Impact Analysis." Environmental Protection Agency and Department of Transportation, August 2016.

[2] Thiruvengadam, Arvind, Saroj Pradhan, Pragalath Thiruvengadam, Marc Besch, Daniel Carder, and Oscar Delgado. "Heavy-Duty Vehicle Diesel Engine Efficiency Evaluation and Energy Audit," October 2014.

the improvements that can be achieved with the engine technologies listed above. The engine maps developed by EPA and WVU were used to quantify the improvement in fuel consumption originating only from engine improvements across specific vehicle applications. The driving profiles used in this analysis were developed by the European Commission based on proposals by the European Automobile Manufacturers Association (ACEA), and reflect a wide range of applications. The results are shown in Figure 2.

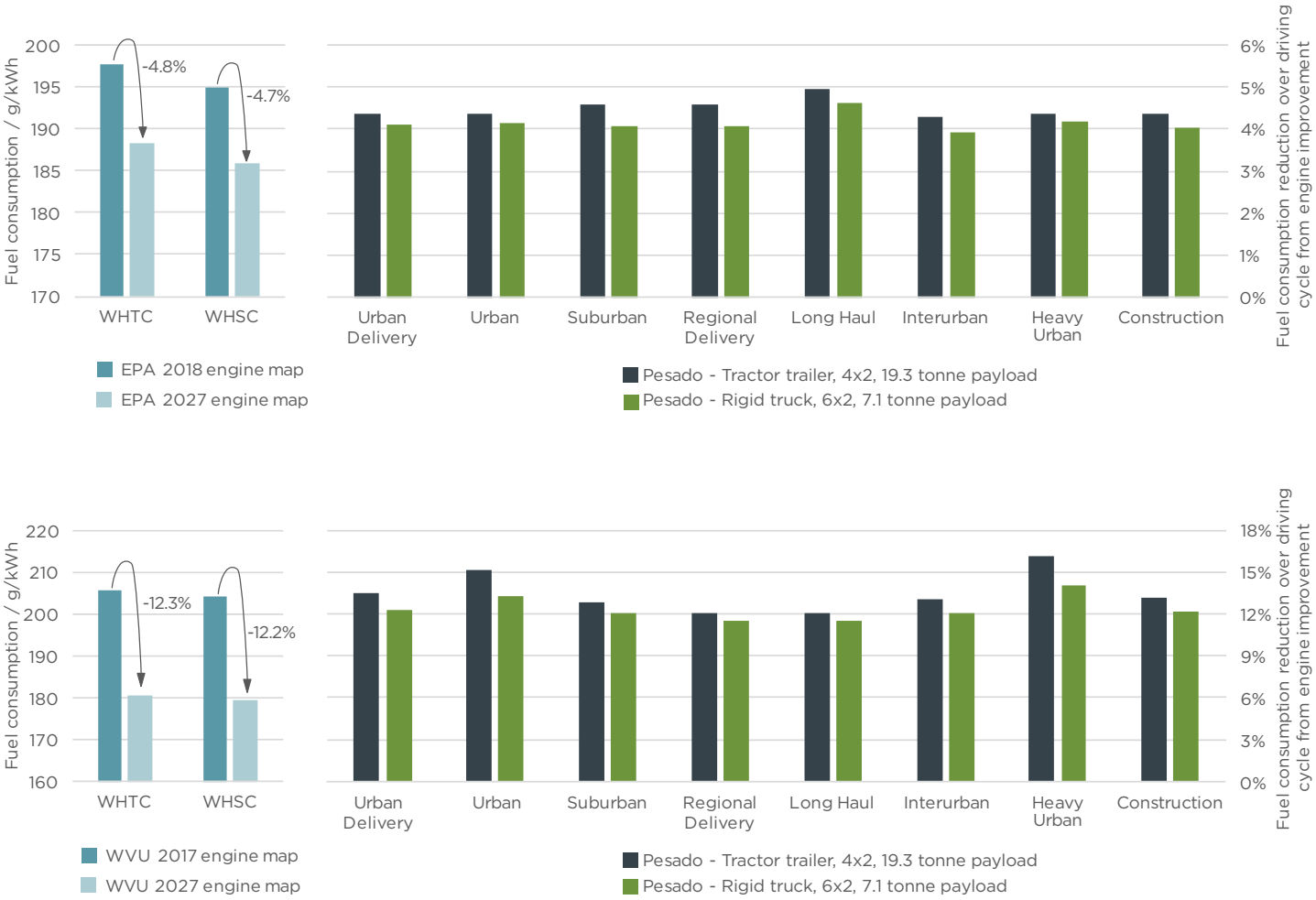

Figure 2. Fuel consumption reduction from engine improvement alone across diverse vehicle applications.

As can be seen in Figure 2, the improvement in engine efficiency results in a similar fuel consumption reduction across a wide range of vehicle duty cycles and payloads. In the case of the EPA engine the reduction achieved in the engine certification cycles is approximately 4.7%. The reduction in fuel consumption across the vehicle applications considered is between 4 and 5%. Similarly, the reduction achieved in the engine certification cycles for the WVU engine maps is approximately 12.2%. The reduction in fuel consumption across the vehicle applications considered is between 12 and 15%.

The use of engine technologies incentivized by an engine standard translate well across a wide range of applications. Conversely, in the absence of an engine standard, the optimization of small engine regions towards specific applications can worsen the consumption when the vehicle application is changed, for example, across a combined trip with urban, regional, and long-haul driving.

3. A separate engine standard enables the exemption from whole vehicle standards of certain vehicle classes with special applications without foregoing measurable CO_2 emissions improvements.

The vehicle categories “Pesado - cavalo mecanico” and “Semi Pesado – rigido” represented in 2015 approximately 70% of the HDV sales. Therefore, it is reasonable to concentrate the efforts into regulating those two categories under a combination of a whole vehicle and a separate engine CO_2 standard. Under this scenario, 30% of the HDV would not be impacted by a whole vehicle standard. Regardless of the regulatory design, inevitably, there will be a number of vehicles that will be excluded from the whole vehicle regulation due to the diversity of special applications or low sales volumes. A separate engine standard will ensure that some reductions are achieved from these segments not covered by the whole vehicle standard. In the heavy-duty market, a single engine model may be utilized in a range of vehicle types.

A separate engine standard allows for benefits to be realized across all segments of the HD fleet, since an engine could be certified individually and then be sold into many different vehicle platforms.

4. Utilize existing regulatory framework.

The engine standard would utilize the existing HD engine certification framework that has been in place under the P-7 regulation, and that can be updated under the P-8 standards. As a result, a separate engine standard would not require additional engine tests than those mandated by the pollutant emissions standards. Utilizing the existing conformity of production (CoP) framework for engine type approval would also aid with ensuring regulatory compliance.

In summary, engine standards do not result in additional test burden, and utilize existing test procedures which industry is very familiar with.

5. Ensure long term investment in engine R&D.

Brazil can benefit from the economies of scale promoted by the HD engine CO_2 standards in the US and Canada, and CO_2 standards in China and Japan. Japan’s standard, although officially a vehicle level standard is designed to mainly promote improvements in the engine and powertrain since aerodynamic and rolling resistance improvements are not credited in their existing standard. Developing more efficient diesel engines requires up front capital investment in R&D by component suppliers and engine manufacturers. The introduction of an engine CO_2 standard mandating improvements in engine efficiency will give manufacturers the certainty to make these investments. By aligning with the US standards, manufacturers can take advantage of work that that is already being planned to meet the US standards. This would create a level playing field for Brazilian manufacturers in the global markets.

Developing more efficient diesel engines requires up front capital investment in R&D by engine manufacturers. A regulation with periodic mandated improvements in engine efficiency gives manufacturers the certainty to make these investments, and increases the competitiveness of the Brazilian HD engine industry.