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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BRIEFING

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Effect of P-8 standards on bus system costs in Brazil

The adoption of Euro VI-equivalent tailpipe emissions standards in Brazil—currently being considered for implementation in 2019—would likely lead to lower bus system costs in the country; this is because the fuel-efficiency benefits more than offset the costs of more advanced emission controls needed to meet the more stringent standards. These benefits are in addition to a 90% reduction in harmful local air pollutants, better air quality, and the prevention of 74,000 premature deaths nationwide.

REGULATORY BACKGROUND

Brazil has controlled harmful pollutant emissions from heavy-duty vehicles (HDVs), including trucks and buses, through a series of progressively more stringent vehicle emissions standards put in place since 1994 that apply to new vehicles sold nationwide. These so-called PROCONVE (Programa de Controle da Poluição do Ar por Veículos Automotores) standards have followed the European precedent for emission limits and certification requirements. The most recent standard in Brazil, P-7, was introduced in 2012 and is equivalent to Euro V standards.

But Brazil has yet to adopt the most recent Euro standards. The Euro VI standards, which took effect in the European Union (EU) in 2013, have achieved a 90% reduction in fine particle ($PM_{2.5}$) and nitrogen oxide (NO_X) emissions compared to Euro V. Euro VI standards and their equivalent in other markets are the current best practice for controlling local air pollution from trucks and buses. Such standards have now been adopted or proposed in most major vehicle markets, including the United States, Canada,

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Japan, the EU, South Korea, Turkey, Mexico, China, and India (Figure 1). Additionally, Latin American cities such as Santiago[1] and Cartagena have shifted their bus purchases to Euro VI. Yet Euro VI buses are not entirely foreign to Brazil: Scania already produces Euro VI engines and trucks in Brazil for export to Europe, Asia, and Latin America.[2]

The benefits and costs of implementing P-8 standards—equivalent to Euro VI—in Brazil starting in 2018 were examined in a detailed assessment in 2016.[3] The analysis was conservative and excluded the fuel savings from better fuel efficiency. Still, the analysis found that the health benefits of reduced tailpipe $PM_{2.5}$ emissions alone outweigh the costs of complying with the standards by a factor of 11:1, resulting in savings of USD 67 billion over 30 years and preventing 74,000 premature deaths nationwide over this period. For comparison, 5,800 tailpipe $PM_{2.5}$-related premature deaths and 80,000 years of life are lost each year in Brazil under the current P-7 standards.

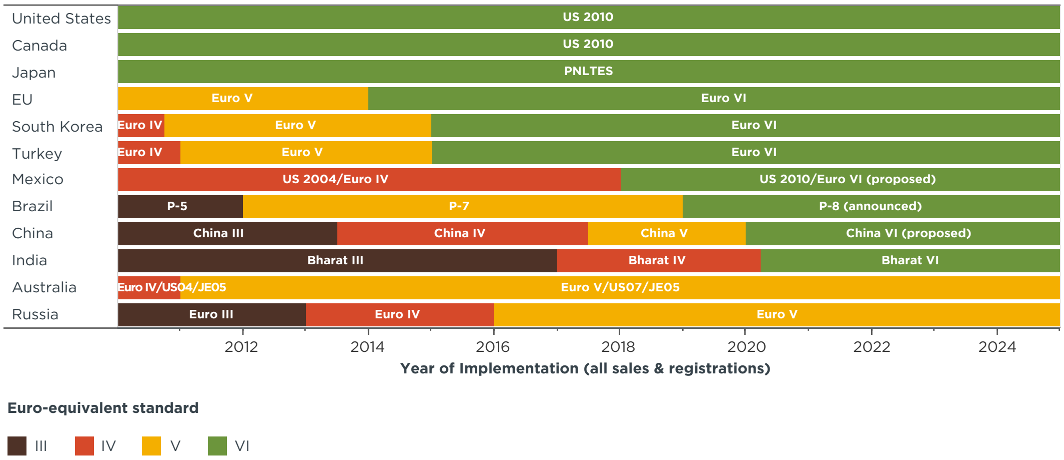

Figure 1. Timeline for implementation of nationwide emission standards for diesel heavy-duty vehicles.

Although the benefits to society of P-8 standards far outweigh their costs, gains and losses are not necessarily equally distributed. In particular, for regulations that could affect the cost of buses, it is important to evaluate the potential impacts on public transit users. Bus fares are a perennial source of contention, in Brazil as elsewhere, even when changes are proposed to achieve some larger policy goal. In 2016, attempts to close budget shortfalls by increasing public bus fares were met with protests in São Paulo and Rio de Janeiro, and even larger demonstrations against rising fares took place in those cities in 2013.[4]

1 United Nations Environment Program, "Chile: Santiago adopts Euro VI bus standard," Climate and Clean Air Coalition (2017). http://ccacoalition.org/en/resources/santiago-adopts-euro-vi-buses-case-study

2 Rodrigo Caetano, "Scania antecipa produção de motores Euro 6 no Brasil" (BiodieselBR.com). https://www.biodieselbr.com/noticias/qualidade/motor/scania-antecipa-producao-motores-euro-6-brasil-231115.htm#

3 Joshua Miller and Cristiano Façanha, *Cost-benefit analysis of Brazil's heavy-duty emission standards (P-8)* (ICCT: Washington DC, 2016). http://www.theicct.org/cost-benefit-analysis-brazil-HDV-emission-standards-p-8

4 Simon Romero, "Brazil: Protest Over Higher Bus Fares Erupt in 3 Cities," The New York Times, Jan. 8, 2016, https://www.nytimes.com/2016/01/09/world/americas/brazil-protest-over-higher-bus-fares-erupt-in-3-cities.html

BUS SYSTEM COST COMPONENTS

Fixed costs, including personnel and administration expenses, account for 50% of bus transportation system costs in São Paulo. Variable costs of operation are 25% of system costs and are dominated by the cost of diesel fuel. Vehicle depreciation, infrastructure, and other operational costs make up the remainder (Figure 2).

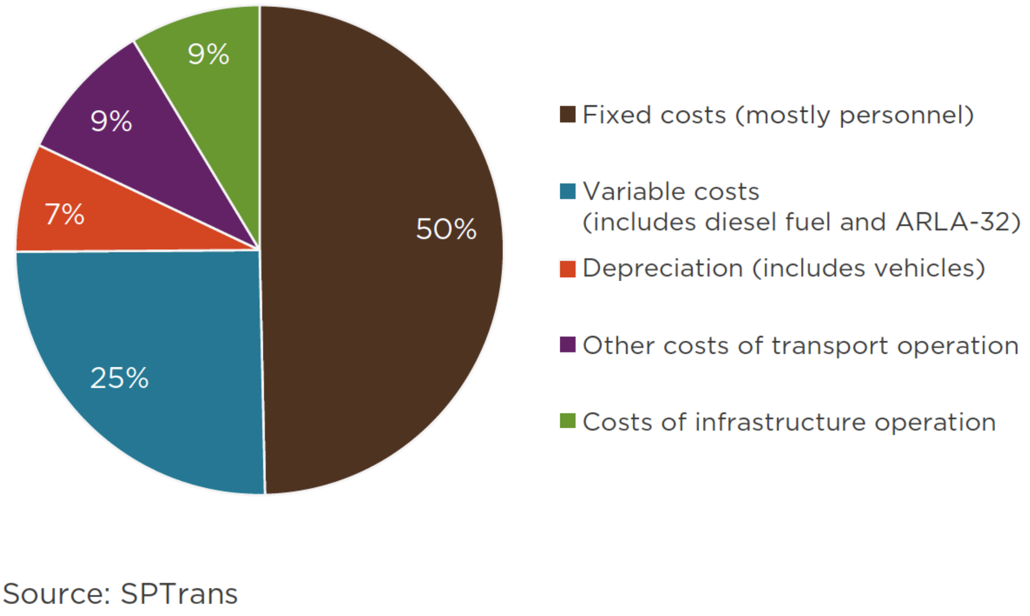

Figure 2. Costs of bus transportation system in São Paulo.

P-8 standards could affect several of these cost components: bus purchase price, which reflects the cost of vehicle technology; vehicle maintenance; and the costs of diesel fuel and ARLA-32.[5]

PURCHASE PRICE AND DEPRECIATION

Vehicle purchase price depends on a variety of factors, such as manufacturer pricing strategies and model availability; the change in purchase price following an improvement in vehicle emission controls can be approximated by multiplying the incremental cost of vehicle technology, also known as the direct manufacturing cost, by a factor that accounts for manufacturer markup. The estimated direct incremental cost of technology needed to meet Euro VI standards is $2,280 (2015 USD) for a diesel vehicle with a 12-liter engine.[6] For a bus in São Paulo with a 6.9-liter diesel engine, the cost would be lower: approximately $1,538 (considering direct costs) to $1,969 (accounting for manufacturer markup).[7] This is equivalent to 1.2% to 1.5% of the purchase price of a Padron LE bus.

5 Automotive Liquid Reducing Agent (ARLA-32) is a fluid used in diesel exhaust aftertreatment systems to reduce NOx emissions. ARLA-32 is already used in Brazil for Euro V buses.

6 Francisco Posada, Sarah Chambliss, Kate Blumberg, *Costs of emission reduction technologies for heavy-duty diesel vehicles* (ICCT: Washington DC, 2016). http://www.theicct.org/costs-emission-reduction-tech-hdvs

7 Assuming retail price equivalent factor of 1.28 for heavy engine manufacturers. See Table 2-117, U.S. Environmental Protection Agency, "Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles - Phase 2," Regulatory Impact Analysis EPA-420-R-16-900 (2016). https://nepis.epa.gov/Exe/ZyPDF.cgi/P100P7NS.PDF?Dockey=P100P7NS.PDF

SPTrans compensates service operators for the depreciation of their vehicles based on assumed vehicle purchase price and mileage accumulation over a 10-year service lifetime. Assuming vehicle depreciation schedules are updated to reflect the cost of Euro VI technology, this could amount to approximately a 0.1% increase in total bus system costs.

MAINTENANCE

The diesel particulate filter (DPF) on a Euro VI bus requires periodic cleaning. Recommended service intervals vary, depending on filter type and other factors, ranging between 75,000 km and 500,000 km. Assuming an annual service interval that reflects harsh operating conditions, long periods at idle, and mostly urban driving, DPF maintenance could add $0.55 (less than R$2) to the cost of service per thousand vehicle kilometers.[8] Considering the total cost of bus service in São Paulo, this additional maintenance would be effectively zero—significantly less than one tenth of 1%.

DIESEL FUEL AND ARLA-32

The transition from Euro V to Euro VI standards involves the addition of better exhaust aftertreatment and engine controls that dramatically cut NO_x and PM emissions. These controls typically include a DPF and a selective catalytic reduction (SCR) system with higher NO_x conversion efficiency. Although the addition of these technologies alone would slightly decrease fuel efficiency, in practice, manufacturers of Euro VI vehicles have simultaneously made efficiency improvements to engines, transmissions, and auxiliary equipment that outweigh the fuel efficiency decreases associated with the improved emissions controls.[9] The net effect of these offsetting improvements has been that Euro VI buses consume approximately 5% less diesel fuel than do equivalent Euro V buses.[10] These fuel savings are partially consumed by a 1 to 2 percentage-point increase in ARLA-32 per liter of diesel consumed.[11] Assuming an ARLA-32 price equivalent to 80% of the price of diesel and an initial ARLA-32 consumption of 4% of diesel use,[12] net costs of diesel fuel and ARLA-32 in Euro VI buses would fall by 3.5% to 4.3%. Since diesel fuel and ARLA-32 account for about 17% of total bus system costs in São Paulo, the net savings of Euro VI buses could amount to a 0.6% to 0.7% reduction in total costs.

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8 Assuming an exchange rate of R$ 3.23 to 1 USD. See: Joshua Miller and Cristiano Façanha, *Cost-benefit analysis of Brazil's heavy-duty emission standards (P-8)* (ICCT: Washington DC, 2016). http://www.theicct.org/cost-benefit-analysis-brazil-HDV-emission-standards-p-8

9 In fact, the addition of higher conversion efficiency SCR gives manufacturers the opportunity to operate their engines at a higher efficiency, because the higher engine-out NO_x emissions are subsequently controlled by the improved SCR system.

10 VTT Technical Research Centre of Finland Ltd, "Technology options for clean and efficient commercial vehicles and buses," Regional Workshop for Emission Standards Update for Heavy-Duty Vehicles in Latin America (2016).

11 Meinrad Signer, Euro VI (msco GmbH). http://www.theicct.org/sites/default/files/2016_09%20Mexico%20Euro%20VI%20SIGNER.pdf

12 Joshua Miller, Katherine Blumberg, Ben Sharpe , *Cost-benefit analysis of Mexico's heavy-duty emission standards (NOM 044)* (ICCT: Washington DC, 2014). http://www.theicct.org/cost-benefit-analysis-mexicos-heavy-duty-emission-standards-nom-044

NET EFFECT OF P-8 STANDARDS ON BUS SYSTEM COSTS

As the foregoing summary shows, the potential effects of P-8 standards on the overall cost of operating bus systems in São Paulo are very small. As shown in Figure 3, each of the three factors considered would individually have less than a 1% effect on bus system costs—and the net effect is likely to be a reduction in total bus system costs. The outsized influence of fuel-efficiency benefits reflects the fact that the average bus operating in São Paulo consumes the equivalent of 26% of its purchase price in diesel fuel each year.[13] The fuel savings associated with more efficient Euro VI buses will fully offset the average initial technology cost within 2 years of operation.[14]

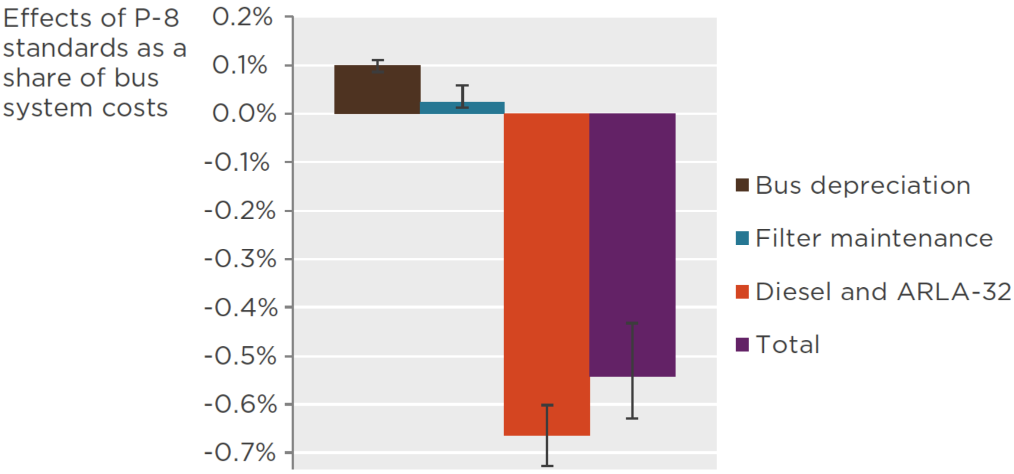

Figure 3. Effects of P-8 standards on bus system costs in São Paulo.

MAXIMIZING THE BENEFITS OF P-8 FOR BUS RIDERS

The cost savings that would likely result from implementing P-8 standards in Brazil could be applied to lower fares for P-8 bus riders and/or reduce the amount of government funds spent on subsidizing bus operators. Given the potential of fuel-efficiency improvements to reduce the cost of bus service, complementary policies should be considered that promote the deployment of the most efficient Euro VI technology options.[15] For example, in addition to adopting improved emission-control standards, introducing nationwide fuel-consumption standards for HDVs in Brazil (as already implemented in the United States, China, Japan, and Canada,[16] and under development in India[17]) could increase fuel savings and further reduce the cost of bus service. At the local level, cities could reinstitute maximum and average age limits for contracted buses at the same time P-8 standards take effect for new buses. Doing so would combine the emissions and fuel-saving benefits of P-8 buses with more intensive fleet renewal as service operators upgrade their fleets to comply with age limits.

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13 Fleet average based on the number of buses, purchase price, and diesel fuel consumption by size category.

14 Based on average annual fuel and ARLA-32 net savings of 980–1,180 USD and an average incremental technology cost of 1,969 USD.

15 The ICCT is exploring options for P-8 compliant alternative engine technologies and fuels in a concurrent analysis.

16 Drew Kodjak, *Policies to reduce fuel consumption, air pollution, and carbon emissions from vehicles in G20 nations*, (ICCT: Washington DC, 2015). http://www.theicct.org/policies-reduce-fuel-consumption-air-pollution-and-carbon-emissions-vehicles-g20-nations

17 Ben Sharpe and Oscar Delgado, *Engines and tires as technology areas for efficiency improvements for trucks and buses in India*, (ICCT: Washington DC, 2016). http://www.theicct.org/engine-and-tire-tech-hdvs-india-201602