A comprehensive policy&technology strategy for mitigating emissions from heavy-duty vehicles in Brazilian urban centers

Olimpio Alvares – CAF

olimpioa@uol.com.br

Workshop: STRATEGIES FOR MITIGATING AIR POLLUTION

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A comprehensive policy&technology strategy for mitigating emissions from heavy-duty vehicles in Brazilian urban centers

Topics

- Air quality situation in Latin American urban centers

- Air quality and morbi-mortality rates

- Air quality standards in Latin American countries – mind the (huge) gap from WHO 2005 recommendation for air quality levels

- Particulate matter urban levels - the case of São Paulo

- Key new-vehicles emissions technology

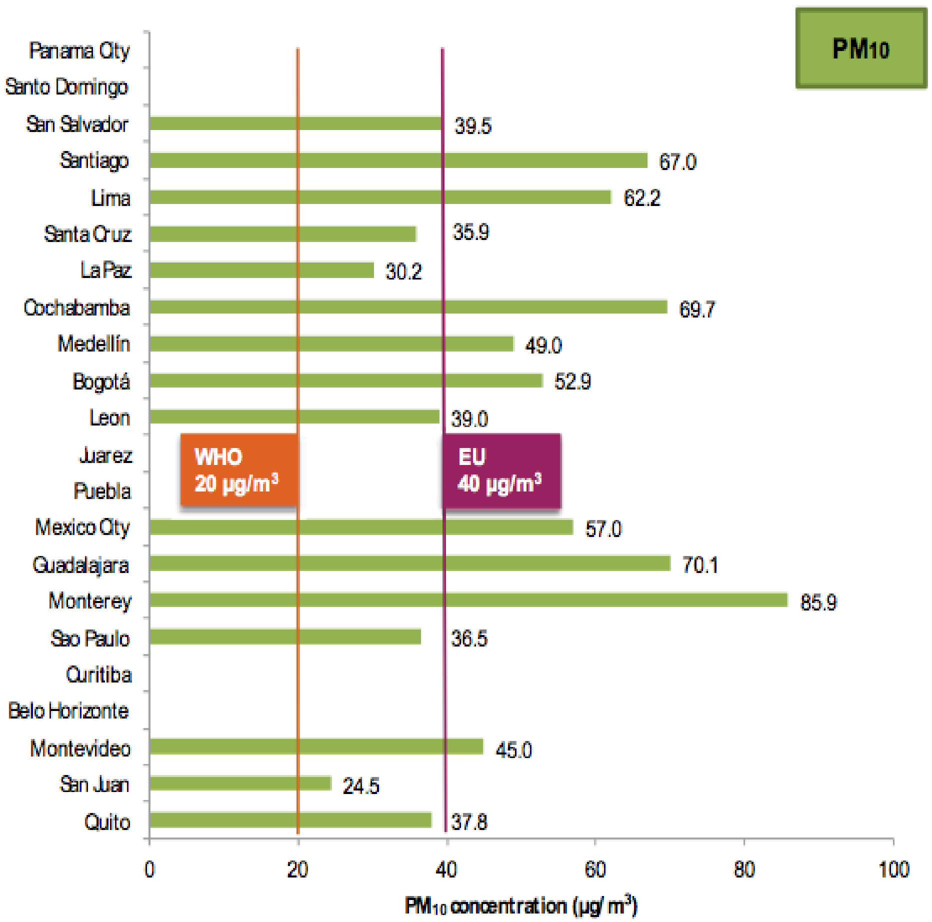
- In-use vehicle emissions control effectiveness

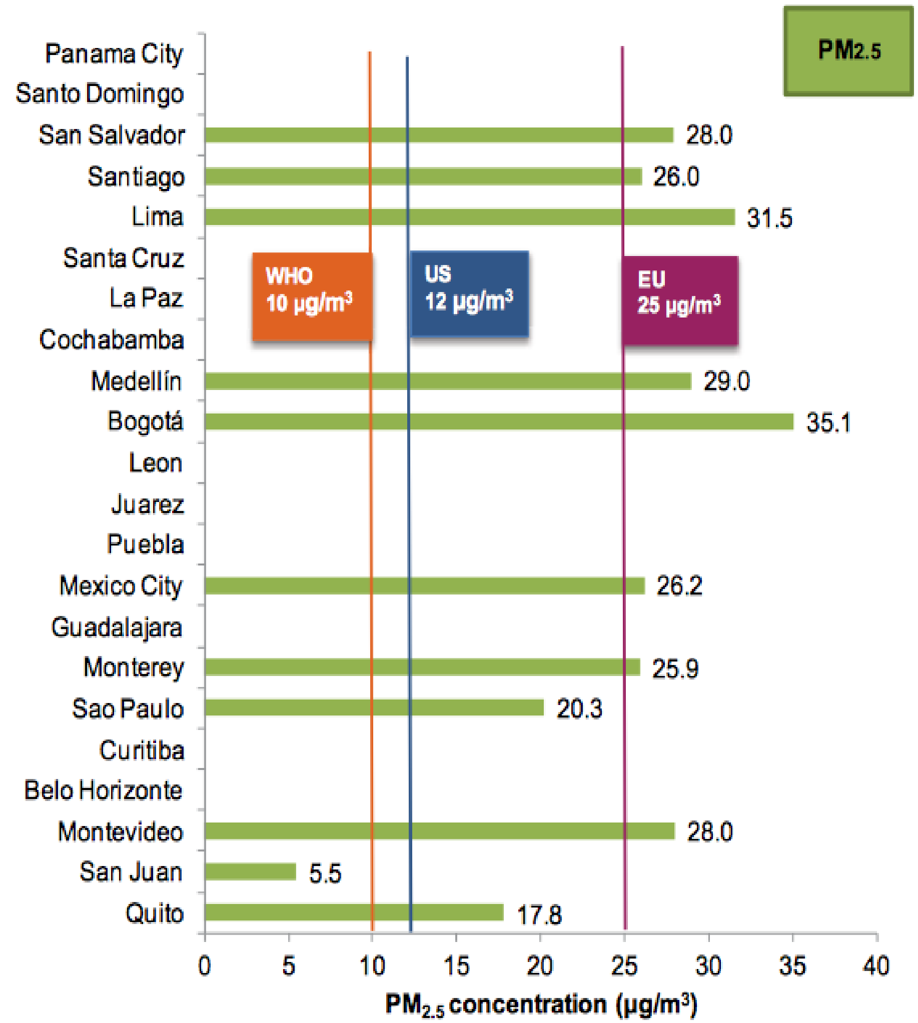
- Retrofit programs - diesel particulate filters

- Urban bus environmental upgrade - Country INDCs

Air quality situation in Latin American urban centers

Particulate matter annual average concentrations

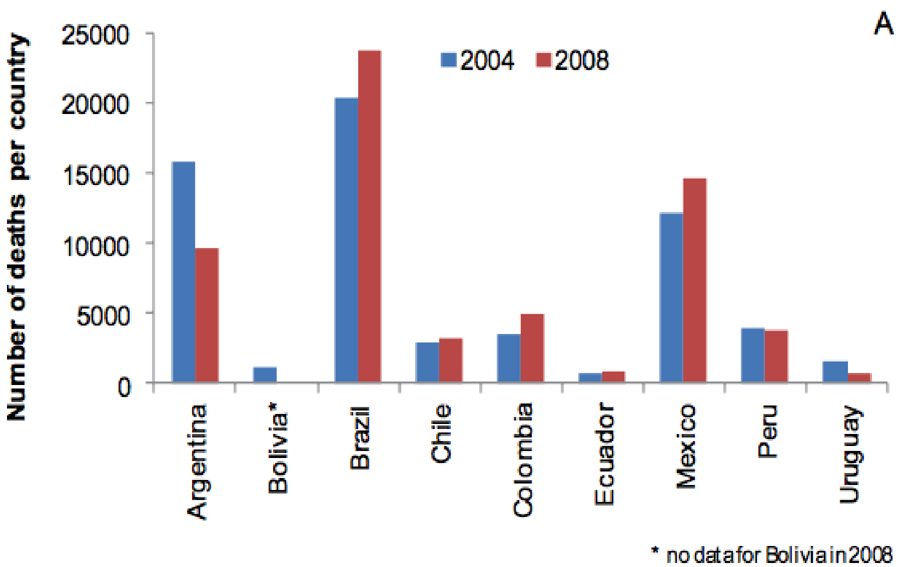


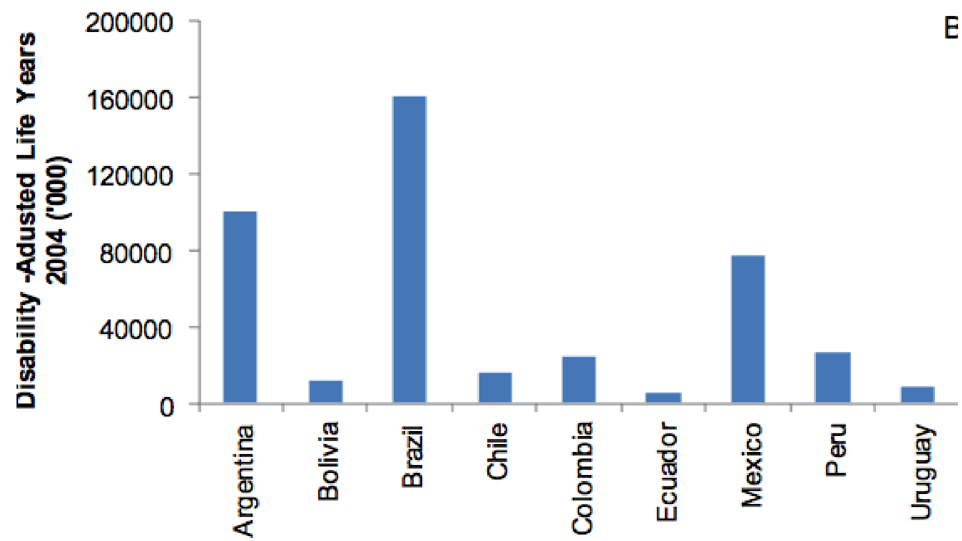


NB: There is no USEPA Annual Standard for PM_{10}

Source: Air Quality in Latin America: An Overview - Clean Air Institute - 2012

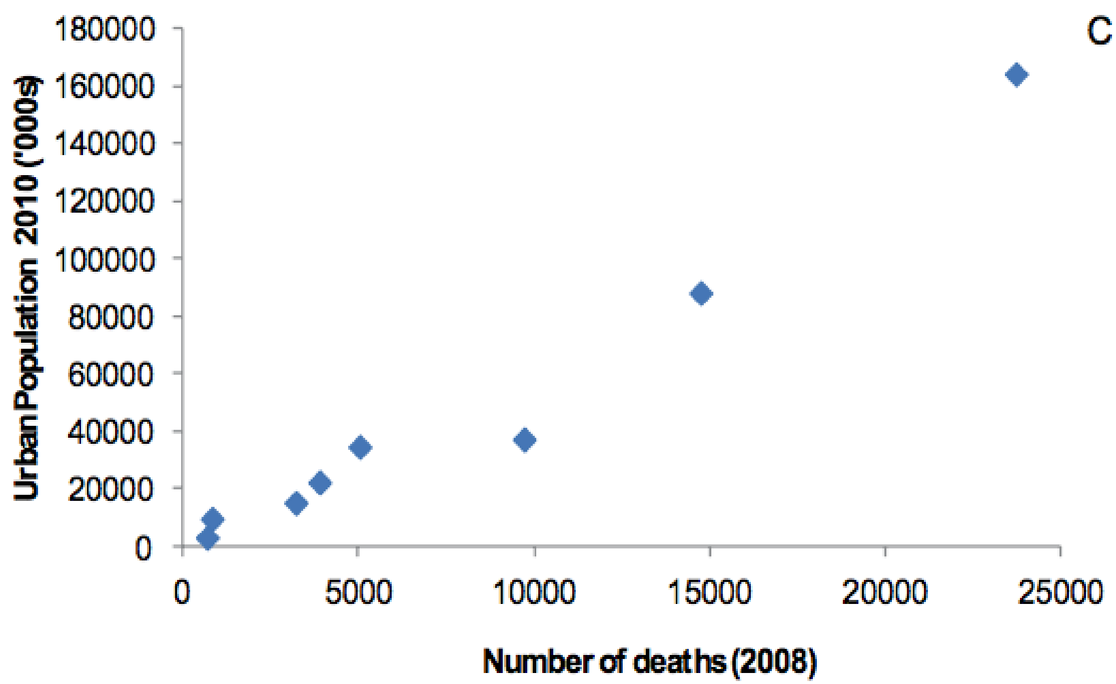
Air quality and morbi-mortality rates





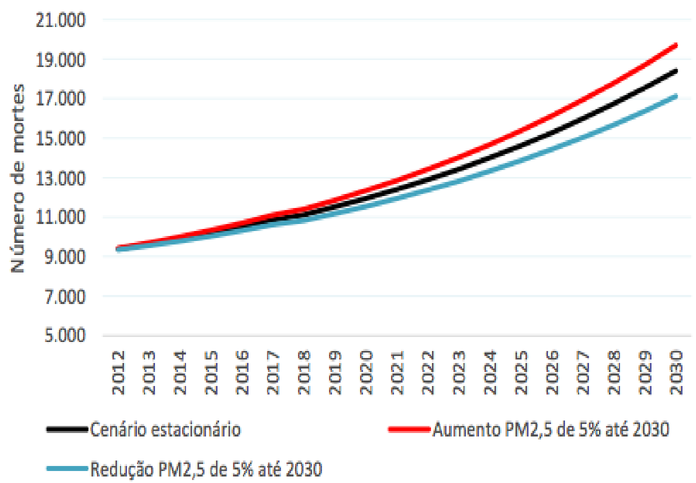
Source: Air Quality in Latin America: An Overview - Clean Air Institute - 2012

"In the region at least 100 million people were already estimated to be exposed to air pollution above World Health Organization (WHO) recommended levels as of 2005 (Cifuentes et al., 2005). This issue will only intensify as the urbanization rate in the region continues with predicted urbanization rates of almost 90% by 2030"



Air quality and morbi-mortality rates

Figura 2 Projeções de mortes atribuíveis ao material particulado $MP_{2,5}$ – São Paulo, 2012 a 2030.



Fonte: SIM e SIH/Datasus e Projeções Demográficas do IBGE (Revisão 2013).

Tabela 4 Total de mortes, internações e gastos com internações entre 2012 a 2030 – São Paulo

Indicadores	Cenário estacionário	Aumento $MP_{2,5}$ em 5% até 2030	Redução $MP_{2,5}$ em 5% até 2030
1) Mortalidade			
Geral	246.375	256.515	236.198
Neoplasias	28.248	29.347	27.139
Cardiovasculares	128.520	133.560	123.442
Respiratório crianças	596	615	577
Respiratório idoso	88.647	92.400	84.866
2) Internações			
Neoplasias	28.534	29.538	27.514
Cardiovasculares	342.347	355.559	329.025
Respiratório idoso	416.590	432.289	400.677
Respiratório crianças	130.364	134.748	125.940
Soma internações	917.835	952.134	883.156
3) Gasto com Internações (R$ de 2011)			
Neoplasias	29.256.276	30.282.829	28.212.245
Cardiovasculares	1.059.331.412	1.100.078.936	1.018.243.996
Respiratório idoso	409.010.535	424.410.176	393.400.681
Respiratório crianças	126.583.685	130.840.589	122.287.311
Soma gastos	1.624.181.908	1.685.612.530	1.562.144.233

Fonte: SIM, SIH/SUS, IBGE (2013).

MP related deaths - State of São Paulo - stationary PM atmospheric concentrations scenario - 2012-2030 (18 years):

- 236.198 total deaths - 13.122 deaths/year

- Public hospital network costs: US$ 500 million (not included death social costs)

http://www.saudeesustentabilidade.org.br/site/wp-content/uploads/2014/08/Saude-e-Sustentabilidade_-Projecao-20151.pdf

Air quality standards in Latin American countries - the (huge) gap from WHO 2005 recommendation for air quality levels

Figure A4. Annual PM_{10} Standards in Latin American countries

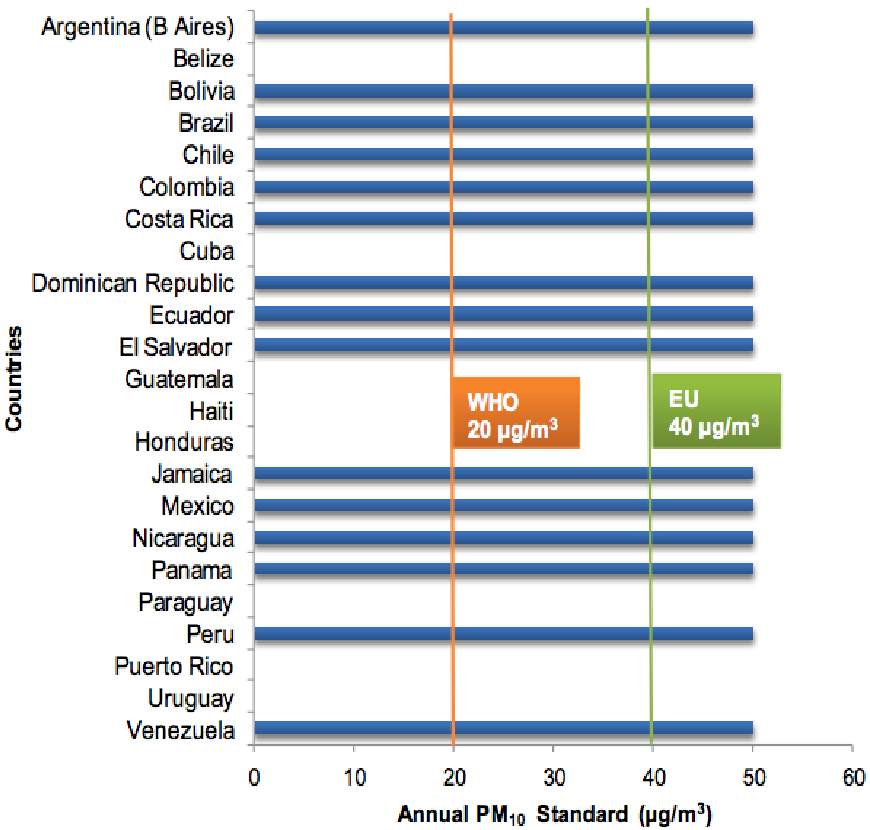
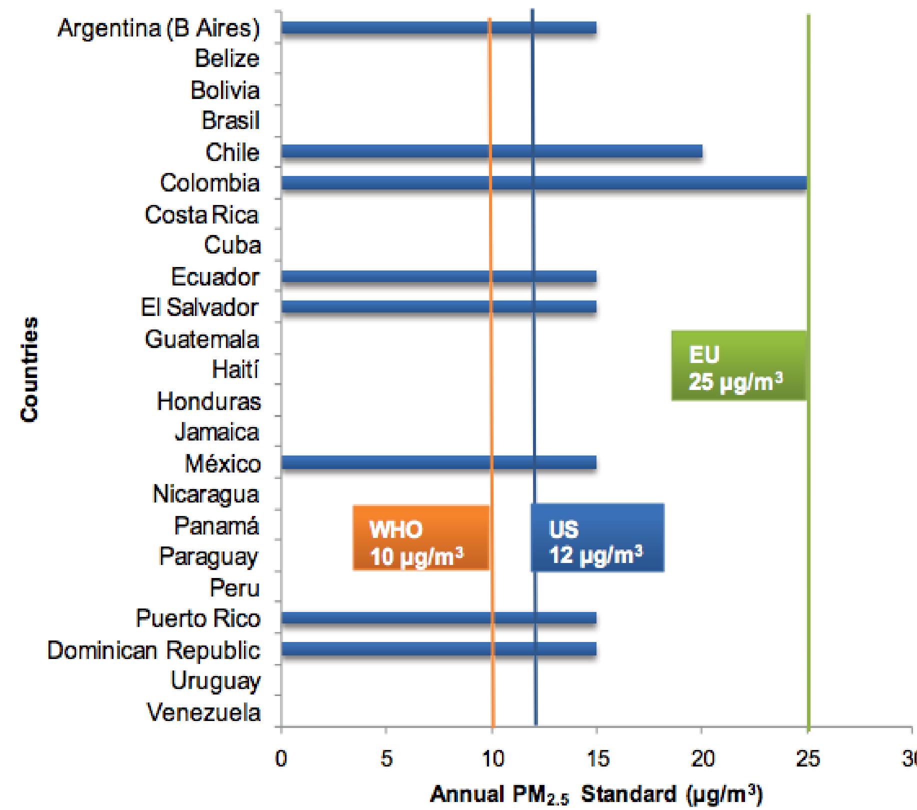


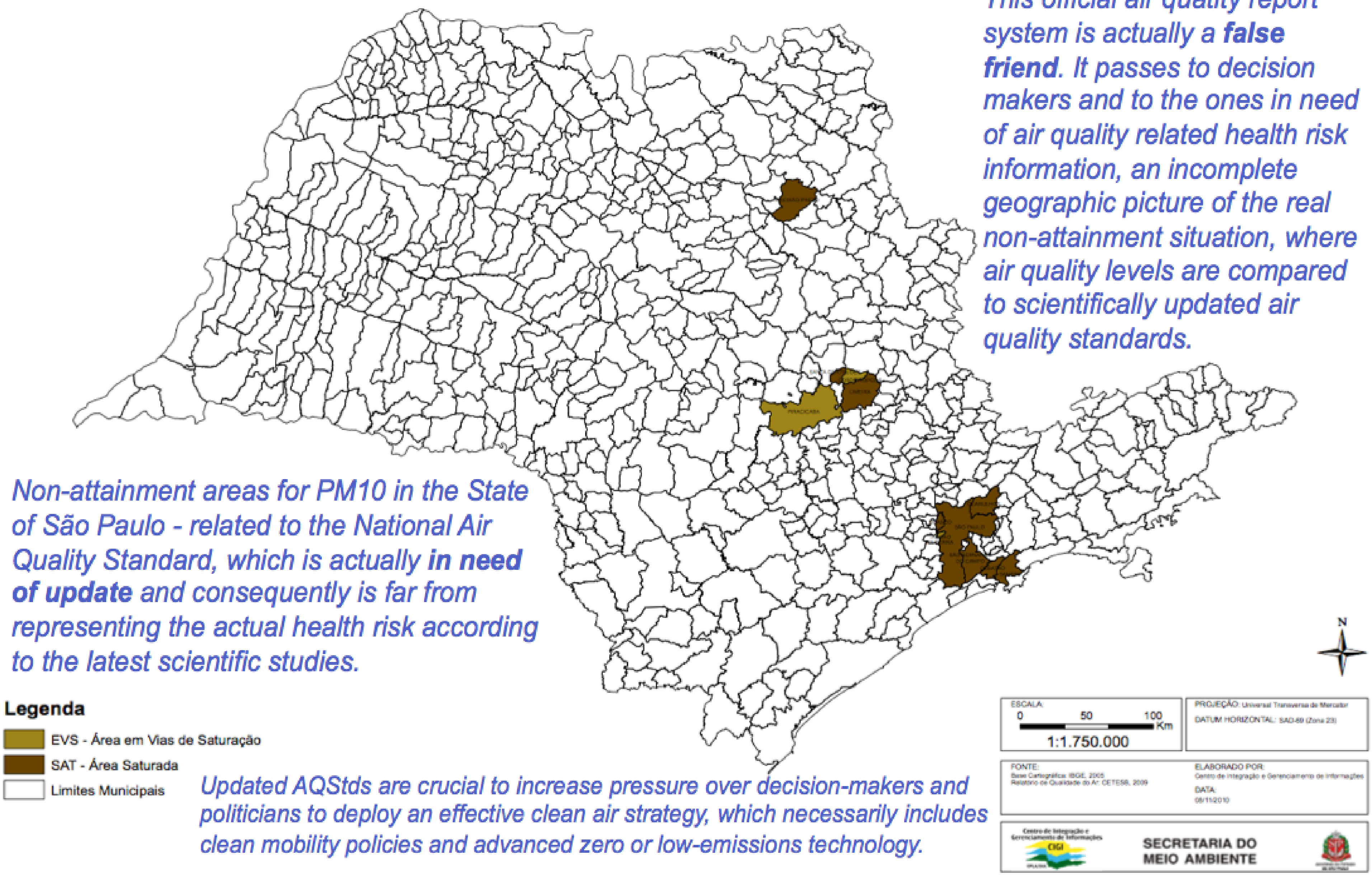
Figure A2. Annual $PM_{2.5}$ Standards in Latin American countries



Source: Air Quality in Latin America: An Overview - Clean Air Institute - 2012

Air quality standards in Latin American countries – mind the gap from WHO recommendation for air quality levels

This official air quatity report system is actually a ***false friend***. *It passes to decision makers and to the ones in need of air quality related health risk information, an incomplete geographic picture of the real non-attainment situation, where air quality levels are compared to scientifically updated air quality standards.*



Non-attainment areas for PM10 in the State of São Paulo - related to the National Air Quality Standard, which is actually ***in need of update*** *and consequently is far from representing the actual health risk according to the latest scientific studies.*

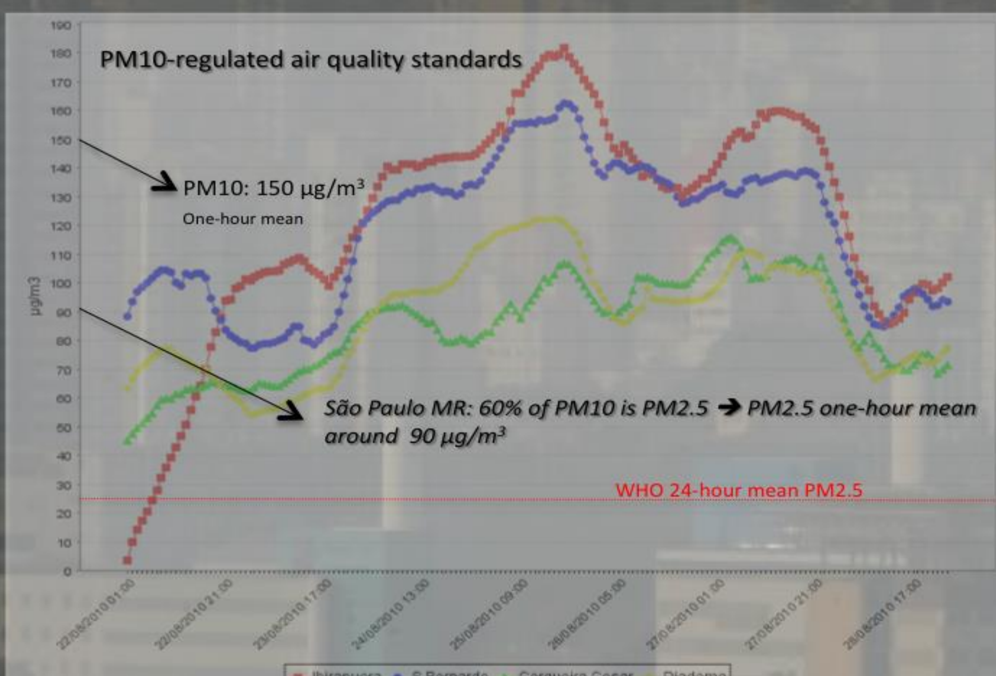
Updated AQStds are crucial to increase pressure over decision-makers and politicians to deploy an effective clean air strategy, which necessarily includes clean mobility policies and advanced zero or low-emissions technology.

Particulate matter urban levels - the case of São Paulo

São Paulo MR – August 22-28, 2010

Press communication (August 26): .... during these periods of low humidity levels and high pollutant concentrations *(long sequence of days with air quality standards and attention level violations for PM10* ***and O_3****)*, it is common to occur respiratory complications, nose bleeding, skin drying and eye irritation..... Despite of the physical uncomfortable effects, **air quality situation is normal during this period of the year - thus, under control**. ......There is no need to take drastic measures to avoid imminent risks to public health. Voluntary restriction of the use of individual transport is recommended.....

.... What about the long term risks? Is there a need for drastic control measures?

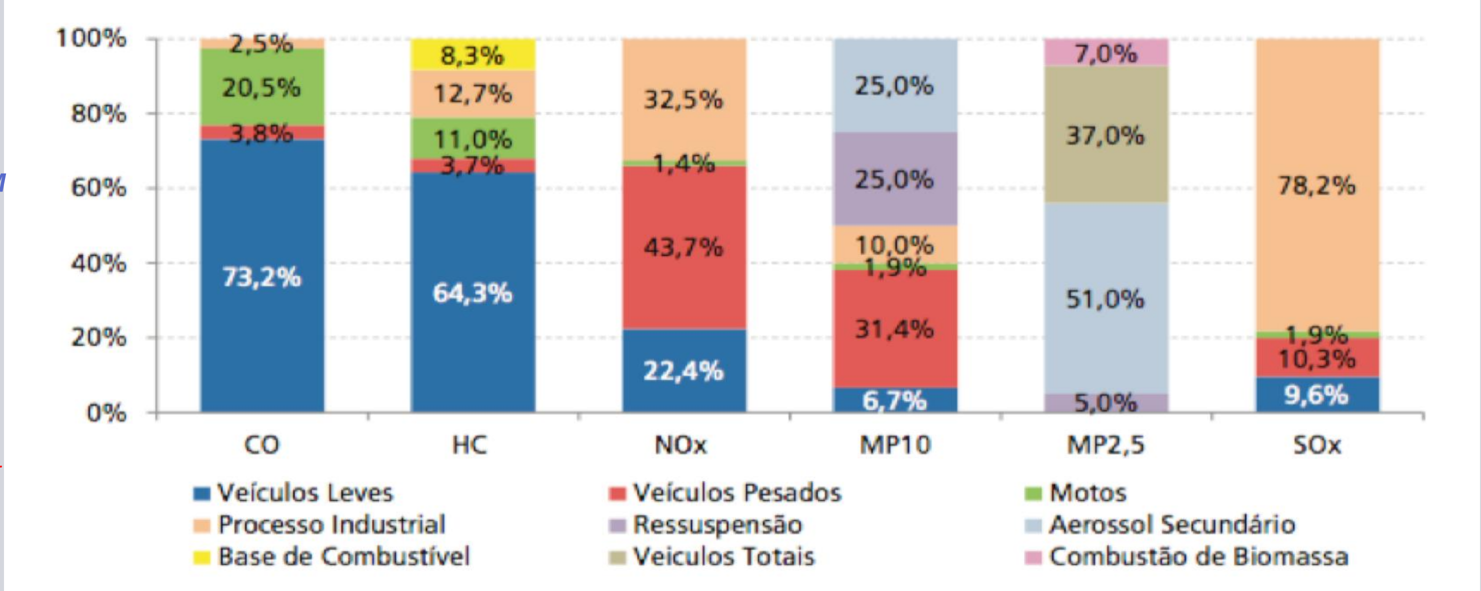


Particulate matter urban levels - the case of São Paulo

Total São Paulo Metro Area PM emissions – all sources

- Diesel vehicles: 31,4% MP10
*- All vehicles: 37% MP2.5**
(Diesel vehicles: aprox. 35%)

** These numbers refer to an inventory estimation based on theoretical emission factors – not real-world measurements*

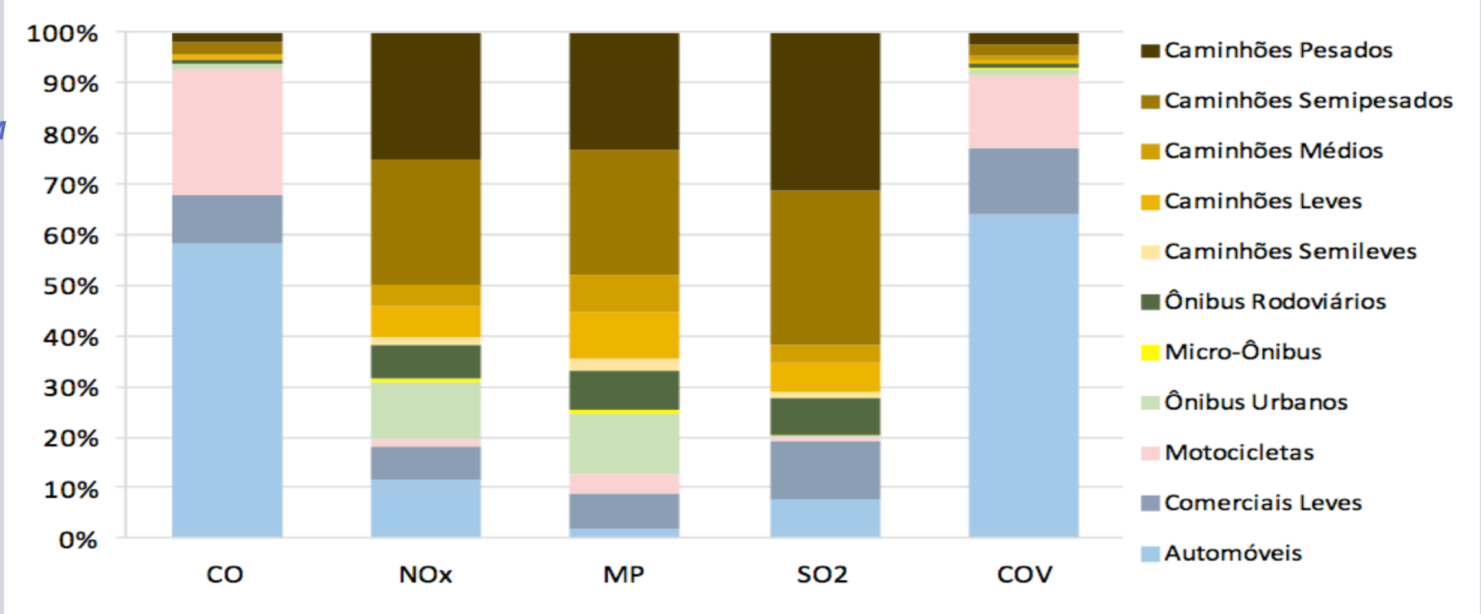


Fonte: Relatório de Qualidade do Ar do Estado de São Paulo - Cetesb - 2015

Total São Paulo Metro Area PM emissions – only vehicles

- Diesel vehicles: 97%
*- Urban buses: 13%***
- All trucks: 62%

***Bus emissions concentrated in densely populated areas – more human exposure to harmful carcinogenic emissions*



Fonte: Relatório de Emissões Veiculares do Estado de São Paulo - Cetesb - 2015

Particulate matter urban levels - the case of São Paulo

Real World – PM 2.5 measurements in São Paulo and Rio de Janeiro

- Aprox. 60% vehicles - average contribution in São Paulo

- Aprox. 62,5% (for PM1) in Rio de Janeiro

- PM problem high levels not limited to São Paulo – measured levels found by same scientists, higher than in São Paulo

*- **Source:** Projeto Fontes – IF-USP – Prof. Paulo Artaxo*

Compilação geral do impacto veicular

Filtros

Contribuição veicular:
Ibirapuera: 59% PM2.5
FSP: 55% do PM2.5
IFUSP: 63% do PM2.5

Tempo-real

FSP – SP – **Veículos: 61.5%**
Leves : 20% PM1
Pesados: 36% PM1
Secundários: 25.4% PM1

Taquara – RJ – **Veículos: 63%**
Leves: 24% PM1
Pesados: 34% PM1
Secundários: 30.6% PM1

Média contribuição veicular:

$PM_{2.5}$: (60 ± 5)%

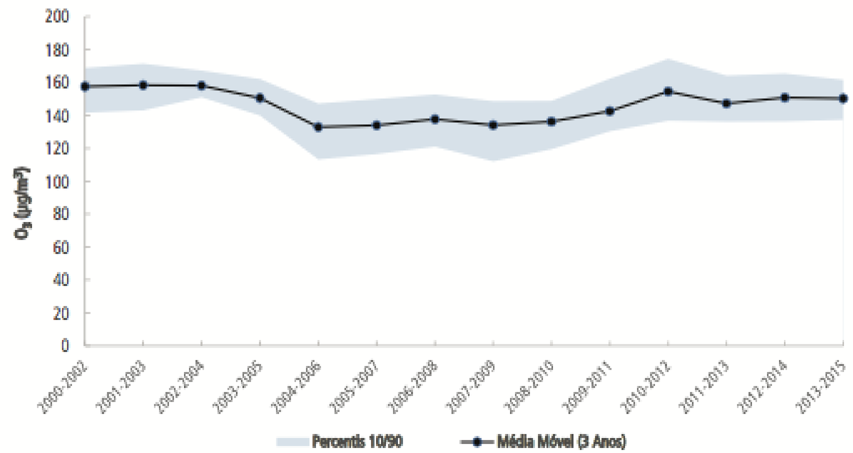
PM_1: FSP: 62%, Taquara: 63%

Solo: IBI 15%, FSP 14%, IFUSP 7%. Média: **12%** do PM2.5
Sulfato: IBI: 17%, FSP: 23%, IFUSP: 7%. Média: **16%** do PM2.5
Industria, marinho e SOA somam em média **13%** do PM2.5

Aerossol em São Paulo é muito bem misturado, com composição e variabilidade similares entre as estações amostradoras, apesar de desenhado para medir impactos diferentes

Ozone levels - the case of São Paulo – and LA cities

Gráfico 34 – O_3 – Evolução das médias móveis do 4º maior valor diário (máxima de 8 horas) – RMSP



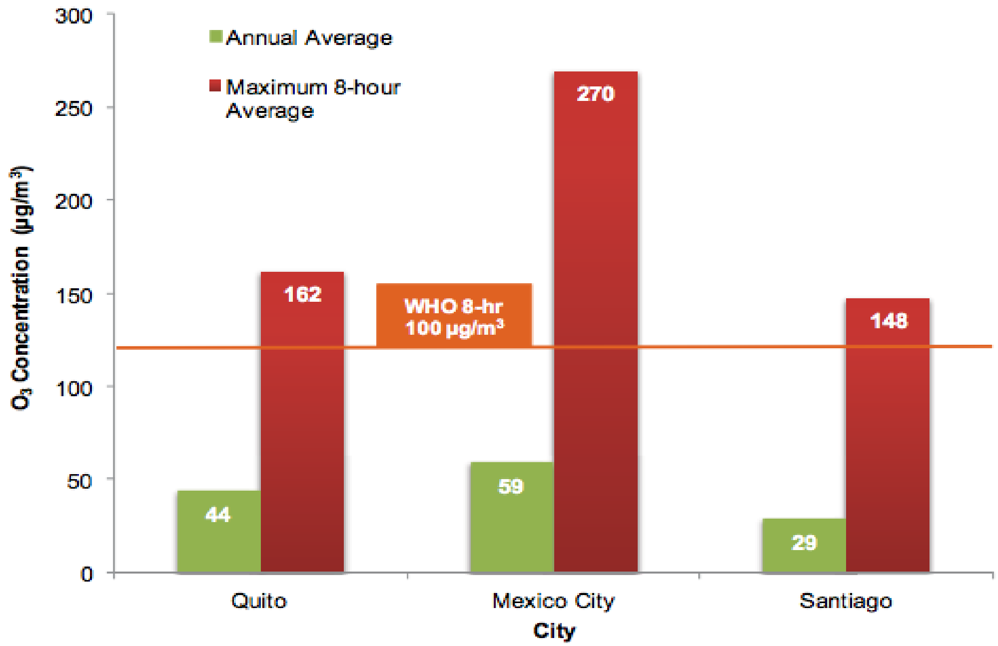
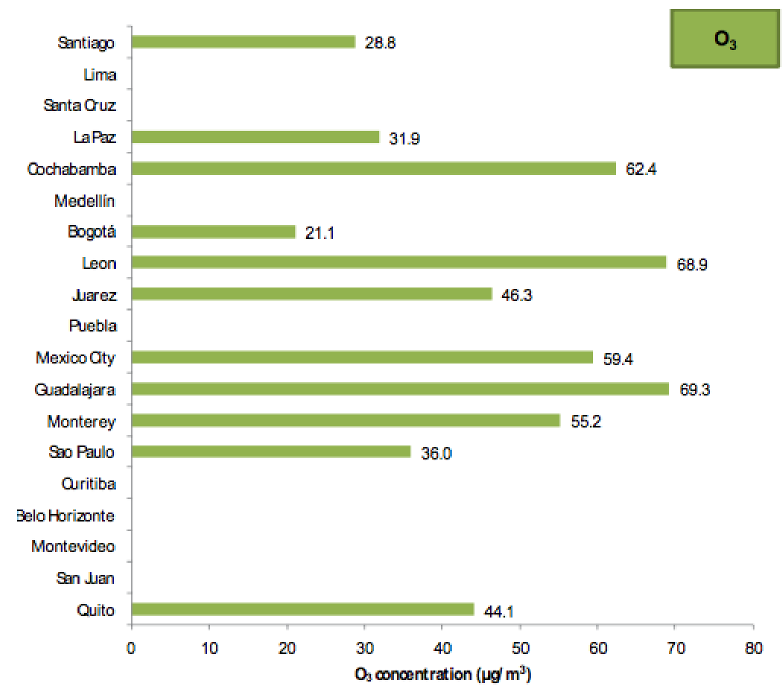


Figure 5. Annual average concentrations for O_3 – 2011.



Source: Air Quality in Latin America: An Overview - Clean Air Institute - 2012

- ***O3 max 8h levels much higher than WHO std in São Paulo***

- *Ozone leves in Quito and Santiago are also high and in Mexico City, far above the WHO max 8h level*

- *Annual mean concentrations in **many other LA cities** are much higher than in São Paulo; according to the Clean Air Institute it is an indicator of **likelihood of max 8h std violations** (although reliable systematic max 8h levels info is not available)*

* *The std for O3 (140ug/m3) in SP is distant from WHO (100 ug/m3) – **false perception of risk potential***

- ***There is no local available info on O3 health effects in SP**, and this does not help to raise authorities and public concern about this problem (PM is the center of attention)*

Key new-vehicles emissions technology

http://www.theicct.org/sites/default/files/publications/Brazil%20P-7%20Briefing%20Paper%20Final_revised.pdf

- "DEFICIENCIES IN THE BRAZILIAN PROCONVE P-7 (Euro5) AND THE CASE FOR P-8 (Euro6) STANDARDS" – ***International Council on Clean Transportation*** *(ICCT conducted the field research that triggered the VW – and other manufacturers - emissions cheating scandal)*

- Euro 5 regulation and implementation in Brazil with ***serious flaws, regarding NOx on-road compliance****; widespread use of ilegal urea presence emulator; inadequate urea sensor OBD arrangement; this reflects in* ***national consumption of Arla-32 (Urea) much lower than forecasts****.* ***Much higher real-world NOX emissions (O3 precursor)*** *than intended.*

- ***Certification emission tests procedures with loopholes fail to identify high on-road emissions*** *– this is consistetly confirmed by means of on-board emission tests using portable emission measurement systems (PEMS).*

- ***Better advance in LA cities directly into Euro 6 requirements where 10, 15 or 50 ppm sulfur content diesel is available****. Euro 6 technology available since 2010 in USA, 2012 in EU,* ***now in Santiago new urban buses****; More stringent emission limits (figure 3); particulate matter filter; efficient urea control OBD system; much more* ***stringent certification procedures including particle number measurement and on-board emission measurements and in-use conformity of all commercialized models****.*

- ***Cost-benefit analysis of Euro 6*** *implementation indicates that economic benefits, specifically savings associated with a reduction in health impacts, outweigh costs by a* ***ratio of 11:1*** *(Miller & Façanha, 2015).*

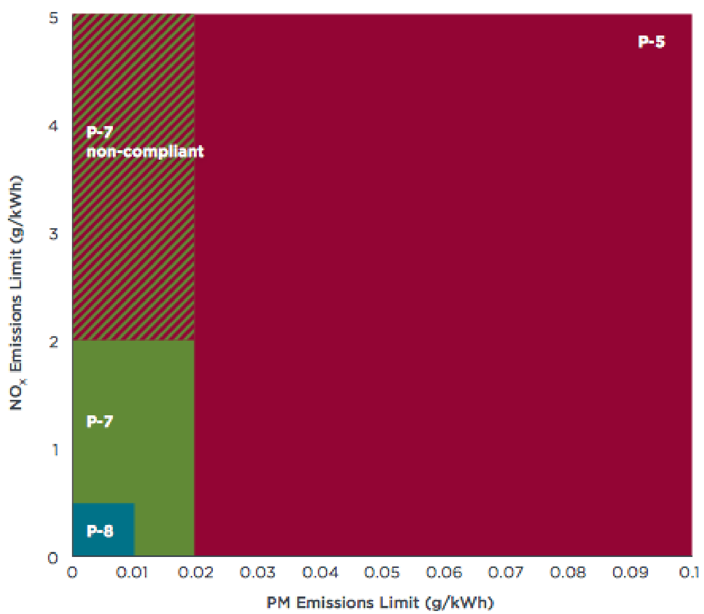


Figure 3. Change in emission limits by PROCONVE phase

- P8 = Euro 6
- P7 = Euro 5
- P5 = Euro 3
- P6 or Euro 4 skipped in Brazil in 2009 – "Proconve Diesel Crash" - S50 diesel not commercially available

In-use vehicle emissions control effectiveness

- *Private operated centralized vehicle inspection programs (I/M programs); **priority to diesel vehicles**; regional coverage; external audits linked to clearly defined contract penalties are essential and necessary*

- *Legal mechanisms guarantee authorities complliance with their implementation attribution within the deadline (**in Brazil, authorities do not obey the inspection program law because they don`t like it – there is no punishment**)*

- ***Add on-road control** (visual and/or opacity-meter instrumented) with **expensive charges** to non-compliance; incentives to non-conformity problem solving in certain time frame*

- *Control annual licensing evasion (**30% of Brazilian four-wheeled fleet illegal – 50% of motorcycles**)*

- *Regular repair shop training activities*

- ***Weakness: no clear community vision of I/M program social, environment & climate potential benefits;** poor public communication, if not nonexistent – current view: **"one more government tax to drag out money from citizens"***

Retrofit programs - diesel particulate filters

*- High emitting older diesel trucks and buses **operate for 20, 30 years**, but there is a successful **cost-effective, efficient and durable technology** to make them drastically less polluting*

*- **Particulate matter filters can be retrofited**, thus, great amounts of harmful toxic and carcinogenic particles - **which also contribute to warm the planet** (**BC - Black carbon** is considered the second most important climate forcing agent after CO_2 fossil emissions) - may be avoided. **Filters may also reduce fuel consumption and depending on each case, they may pay back in a couple of years – this is key and crucial***

*- **Many countries around the world are deploying retrofit strategies to control emissions of older diesel vehicles**; Santiago(3,2 thousand), Bogota and Medellin (no precise info available), Mexico (new program aiming urban buses and trucks), Switzerland (all vehicles and construction machines), Beijin (urban buses), USA (school buses), Germany (all fleets) etc*

*- **Adequate technical support is required** to help select the best effective types of filters to the right vehicle models in order to achieve good results (cycle average temperature, regeneration parameters, filter capacity, geometrics, performance testing, emissions and consumption measurements, cleaning procedures, vehicle maintenance, fuel quality etc); **pilot programs to test a few samples must be developed** before implementation of broader programs*

*- **All filter models must be officially certifiied** according to clear regulation requirements, with regard to emission reduction efficiency in each application **considering the real-world conditions**, as well as to its **efficiency durability***

***- Detailed financial aspects of retrofit programs are scarce in the bibliography**; this is crucial to facilitate environment agents to convince decision-makers to deploy retrofit strategies*

*- Retrofited diesel vehicles may be **eligible to operate in environmentally sensitive areas**, "hoy no circula" schemes exemption and to enter **Low Emission Zones; retrofited diesel vehicles are usually much more silent***

- Retrofit filters may also be used in stationary engines, construction machines, electric generators etc

Urban bus environmental upgrade - Country INDCs

*"**LAW No. 14.933**, **2009**, establishes the Policy for Climate Change in the Municipality of São Paulo.*

***Article 50**. Municipal public transport plans, systems, contracts and authorizations must consider a progressive reduction in the use of fossil fuels, with a progressive reduction target of at least 10% (10%) every year, starting from 2009 and, in 2018, the use of **renewable non-fossil fuel for all buses in the Municipal Transportation System of the Municipality**.*

***First Paragraph**. The goal and priority foreseen in this article apply in the hypotheses of acquisition and leasing of vehicles used in the transportation and services of the Municipal Government, as well as in the expansion and renewal of its fleet, with the exception of cases of technical impossibility."*

*- This law triggered **widespread discussion** in the municipal, regional and national level involving Government, NGOs, Midia, University, the Public Prosecutor Office, public finance authorities, vehicle manufacturers, alternative energy and fuel producers*

- Pilot projects were developed and mature alternative technologies were successfuly tested: trolebus, battery electric, hybrids, biofuels (biodiesel), natural gas and biogas

*- Convergence with the idea of the **Clean Bus Declaration –** during COP-21 in 2015 in Paris, mayors of C40 Sustainable Cities commited to shift to alternative energies and technologies*

*- Convergence with the **need to structure the main mitigation components of the Brazilian INDC** (GHG & Black Carbon)*

*- In 2012, national **governments poured USD 544 billion into fossil-fuel subsidies** (World Bank – Climate Essentials). Increasing project finance perspectives under the UNFCCC umbrella with the proliferation of **available rich Climate Funds** willing to support incremental costs, incremental investments (in the case of Urban Buses – upfront investment cost, **if necessary**) and barriers removal processes, once there is a local organized institutional framework to support a sound finance project for fleet environmental upgrade renewal.*

Gracias

Clean Bus Fleet Emissions Calculator

Associação Nacional de Transporte Público – ANTP

http://www.antp.org.br/simulador-de-emissoes-de-onibus-urbanos/apresentacao.html

Apoio Volvo do Brasil

Cálculo das Emissões da Frota Atual(Diesel) e Alternativa

E (poluente X) = (km anual) x (Qd.Veic) x FE(poluente X)

A estimativa de redução das emissões é feita a partir da caracterização dos veículos a diesel atuais a serem substituídos (ou modificados por troca de combustível), agrupados por tipo (micro; standard; padron; articulado; biarticulado) e pelas respectivas tecnologias de motorização correspondentes à idade dos veículos (Euro 2, Euro 3 ou Euro 5), o que permite o acesso aos respectivos Fatores de Emissão (g/km) para cada tipo de poluente.

Cálculo das Emissões da Frota Atual(Diesel) e Alternativa

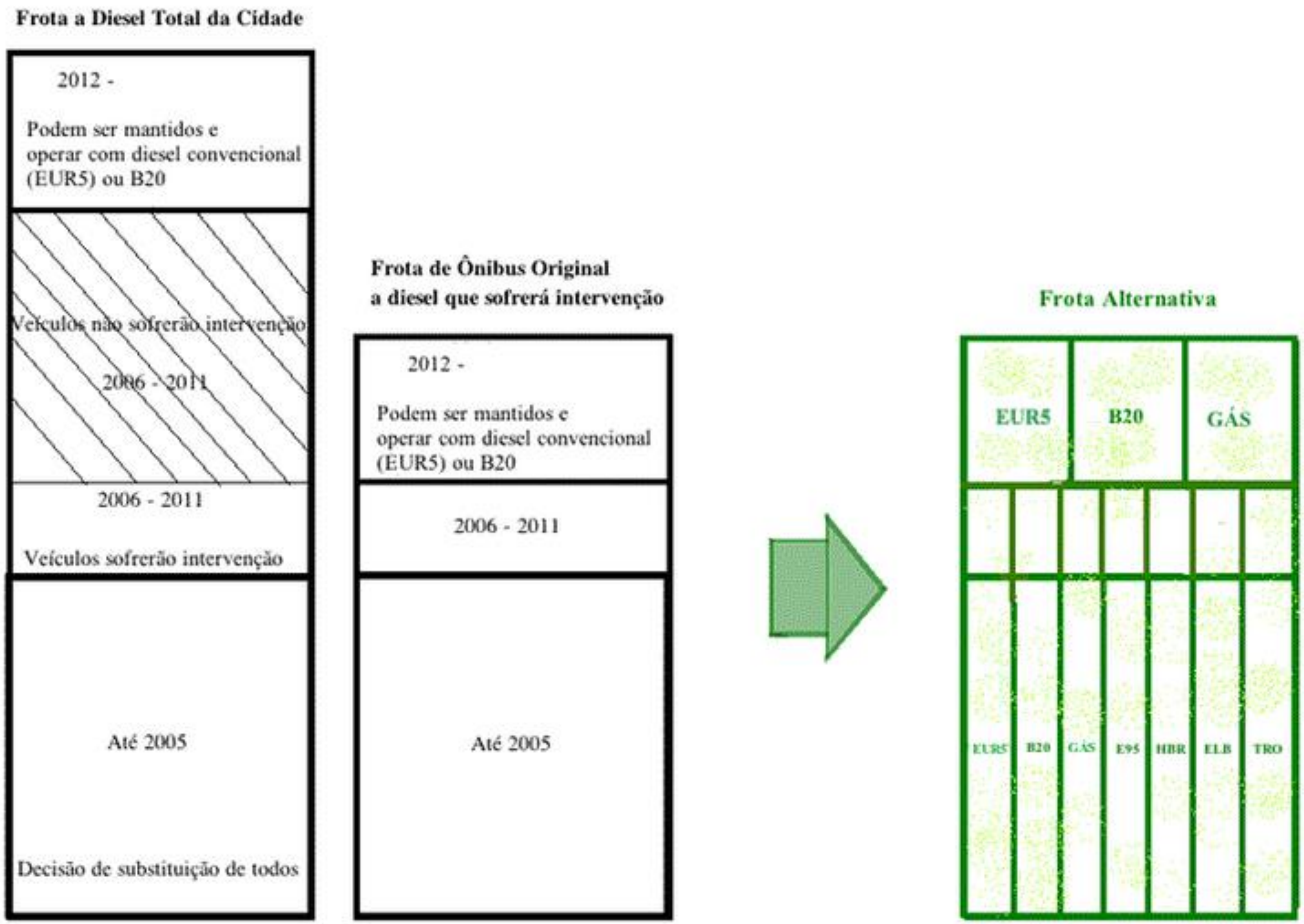
E (poluente X) = (km anual) x (Qd.Veic) x FE(poluente X)

De modo análogo, são calculadas as emissões da frota substituta (mais limpa), definida pelo usuário no próprio Simulador, a partir das alternativas energéticas economicamente viáveis disponíveis no mercado local.

As alternativas mais limpas: Diesel Euro 5 (Proconve 7); mistura de biodiesel (B20); Gás Natural ou Biometano (GÁS); etanol com 5% de aditivo detonante (E95); híbridos (HBR); ônibus elétricos a bateria (ELB) e; Trolebus (TRO).

Em seguida, é estimado o impacto positivo dessa **Intervenção Ambiental**, por meio do cálculo das respectivas reduções das emissões de cada um dos poluentes tóxicos (monóxido de carbono - CO, hidrocarbonetos - HC, óxidos de nitrogênio - NOx e material particulado - MP) e do CO_2, principal GEE responsável pelo aquecimento do planeta.

Esquema da Intervenção Ambiental – substituição por tecnologias mais limpas



Fatores de Emissão de ônibus a Diesel - CETESB 2014

FE Mini/Micro (g/km)						
Ano	Fase Proconve	CO	HC	NOx	MP	CO2
		(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Até 2005	P4 (Euro 2)	1,41	0,38	9	0,166	790
2006 a 2011	P5 (Euro 3)	1,18	0,13	4,88	0,09	790
2012 -	P7 (Euro 5)	0,13	0,03	1,22	0,01	790
FE Midi/Básico (g/km)						
Ano	Fase Proconve	CO	HC	NOx	MP	CO2
		(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Até 2005	P4 (Euro 2)	1,41	0,38	9	0,166	1168
2006 a 2011	P5 (Euro 3)	1,68	0,21	8,48	0,15	1168
2012 -	P7 (Euro 5)	0,54	0,0147	2,69	0,0209	1168
FE Padron (g/km)						
Ano	Fase Proconve	CO	HC	NOx	MP	CO2
		(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Até 2005	P4 (Euro 2)	1,41	0,38	9	0,166	1643
2006 a 2011	P5 (Euro 3)	1,68	0,21	8,48	0,15	1643
2012 -	P7 (Euro 5)	0,54	0,0147	2,69	0,0209	1643
FE Articulado (g/km)						
Ano	Fase Proconve	CO	HC	NOx	MP	CO2
		(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Até 2005	P4 (Euro 2)	1,41	0,38	9	0,166	2072
2006 a 2011	P5 (Euro 3)	1,68	0,21	8,48	0,15	2072
2012 -	P7 (Euro 5)	0,54	0,0147	2,69	0,0209	2072
FE Biarticulado (g/km)						
Ano	Fase Proconve	CO	HC	NOx	MP	CO2
		(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Até 2005	P4 (Euro 2)	1,41	0,38	9	0,166	2312
2006 a 2011	P5 (Euro 3)	1,68	0,21	8,48	0,15	2312
2012 -	P7 (Euro 5)	0,54	0,0147	2,69	0,0209	2312

Fatores de emissão da Cetesb para ônibus urbanos a diesel - Relatório de Emissões Veiculares- 2014

FATORES DE EMISSÃO DAS ALTERNATIVAS MAIS LIMPAS - ÔNIBUS NOVOS EURO 5 / P7

Fatores de Emissão de ônibus P7 (Euro 5) com mistura Diesel-20% Biodiesel (B20)					
Tipo	FE_CO	FE_HC	FE_NOx	FE_MP	FE_CO2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Micro	0,12	0,030	1,22	0,008	665
Básico	0,50	0,015	2,69	0,017	984
Padron	0,50	0,015	2,69	0,017	1384
Articulado	0,50	0,015	2,69	0,017	1745
Biarticulado	0,50	0,015	2,69	0,017	1947
Fatores de Emissão de ônibus P7 (Euro 5) com Diesel convencional (EUR5)					
Tipo	FE_CO	FE_HC	FE_NOx	FE_MP	FE_CO2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Micro	0,13	0,03	1,22	0,01	790
Básico	0,54	0,0147	2,69	0,0209	1168
Padron	0,54	0,0147	2,69	0,0209	1643
Articulado	0,54	0,0147	2,69	0,0209	2072
Biarticulado	0,54	0,0147	2,69	0,0209	2312
Fatores de Emissão de ônibus a GNV ou Biometano (GÁS)					
Tipo	FE_CO	FE_HC	FE_NOx	FE_MP	FE_CO2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Micro	nd	nd	nd	nd	nd
Básico	0,01	0,0128	2,69	0,0105	1154
Padron	0,01	0,0128	2,69	0,0105	1624
Articulado	nd	nd	nd	nd	nd
Biarticulado	nd	nd	nd	nd	nd
Fatores de Emissão de ônibus P7 híbrido (HBR)					
Tipo	FE_CO	FE_HC	FE_NOx	FE_MP	FE_CO2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Micro	0,13	0,03	0,61	0,005	470
Básico	0,54	0,015	1,345	0,01045	695
Padron	0,54	0,015	1,345	0,01045	978
Articulado	0,54	0,015	1,345	0,01045	1233
Biarticulado	0,54	0,015	1,35	0,0105	1376
Fatores de Emissão de ônibus etanol aditivado - ciclo Diesel (E95)					
Tipo	FE_CO	FE_HC	FE_NOx	FE_MP	FE_CO2
	(g/km)	(g/km)	(g/km)	(g/km)	(g/km)
Micro	nd	nd	nd	nd	nd
Básico	0,04	0,002	2,29	0,01045	0
Padron	0,04	0,002	2,29	0,01045	0
Articulado	nd	nd	nd	nd	nd
Biarticulado	nd	nd	nd	nd	nd

1- Para os veículos E95, GÁS, B20 e híbridos, os fatores de emissão foram definidos conforme valores e proporções sugeridas no relatório "Alternativas tecnológicas para ônibus no Rio de Janeiro" da COPPE de 2012, que foram extensamente investigados pela Coppe junto aos fabricantes de veículos e de novas tecnologias e combustíveis.

Simulador

Passo 1 - Informe sua frota diesel que sofrerá a intervenção ambiental

Escolha a Cidade: DF ▾ BRASÍLIA ▾

* Somente municípios com população acima de 60 mil habitantes conforme Sistema de Informação da ANTP

QTD ônibus só Diesel	Mini/Micro	Básico/Midi	Padron	Articulado	Bi-articulado	TOTAL
Até 2005	18	866	90	15	2	991
2006 a 2011	316	1118	359	129	17	1939
2012 ou mais novo	31	172	59	22	3	287
	365	2156	508	166	22	3217
KM/Ano	70000	70000	70000	70000	70000	

Passo 2 - Decida como fará a intervenção ambiental na frota alvo para cada subgrupo de veículos a diesel originais a ser modificado

*** Atenção!** Para quantidades de ônibus muito pequenas, ao preencher os percentuais desejados de veículos com energias alternativas, observe atentamente as quantidades para evitar incoerências. Exemplo: se existirem apenas 3 ônibus Básicos a diesel (2006 a 2011), percentuais escolhidos para a substituição por alternativas como, por exemplo, 45% B20, 45% GÁS e 10% HBR, resultariam, obviamente, na ausência de correspondência com a realidade. Uma boa correspondência seria 33% B20 (1 ônibus), 33% GÁS (1 ônibus) e 34% HBR (1 ônibus), totalizando os 3 ônibus.

EUR5 Diesel Euro 5	**B20** Biodiesel 20%	**GÁS** Gás Natural ou Biometano	**TRO** Trólebus
E95 Etanol aditivado	**HBR** Híbrido	**ELB** Elétrico Bateria	

Mini/Micro

Ônibus novo alternativo

Diesel Originais	Qtd	EUR5	B20	GÁS	E95	HBR	ELB	TRO	TOTAL %
Até 2005	18	20%	30%	%	%	20%	30%	%	100
2006 a 2011	316	15%	45%	%	%	20%	20%	%	100
2012 ou mais novo	31	10%	50%	%	%	15%	25%	%	100

Básico/Midi

Ônibus novo alternativo

Diesel Originais	Qtd	EUR5	B20	GÁS	E95	HBR	ELB	TRO	TOTAL %
Até 2005	866	25%	35%	10%	%	10%	20%	%	100
2006 a 2011	1118	27%	13%	60%	%	%	%	%	100
2012 ou mais novo	172	%	%	100%	%	%	%	%	100

Padron

Ônibus novo alternativo

Diesel Originais	Qtd	EUR5	B20	GÁS	E95	HBR	ELB	TRO	TOTAL %
Até 2005	90	%	%	%	%	%	%	%	
2006 a 2011	359	%	%	%	%	%	%	%	
2012 ou mais novo	59	%	%	%	%	%	%	%	

Articulado

Ônibus novo alternativo

Diesel Originais	Qtd	EUR5	B20	GÁS	E95	HBR	ELB	TRO	TOTAL %
Até 2005	15	25%	25%	%	%	50%	%	%	100
2006 a 2011	129	30%	30%	%	%	%	40%	%	100
2012 ou mais novo	22	20%	20%	%	%	20%	20%	%	80

Biarticulado

Ônibus novo alternativo

Diesel Originais	Qtd	EUR5	B20	GÁS	E95	HBR	ELB	TRO	TOTAL %
Até 2005	2	%	%	%	%	%	%	%	
2006 a 2011	17	%	%	%	%	%	%	%	
2012 ou mais novo	3	%	%	%	%	%	100%	%	100

Passo 3 - Resultado

Simular

Mini/Micro	CO	HC	NOx	MP	CO2
Diesel (t/ano)	28.16	3.42	121.93	2.22	20184.50
Alternativas energéticas (t/ano)	2.50	0.61	21.56	0.15	12619.71
Redução (t/ano)	25.66	2.81	100.37	2.07	7564.79
Redução (%)	91.1%	82.3%	82.3%	93.1%	37.5%

Básico/Midi	CO	HC	NOx	MP	CO2
Diesel (t/ano)	223.45	39.65	1241.61	22.05	176274.56
Alternativas energéticas (t/ano)	73.12	2.08	364.37	1.62	126503.15
Redução (t/ano)	150.33	37.57	877.24	20.44	49771.41
Redução (%)	67.3%	94.7%	70.7%	92.7%	28.2%

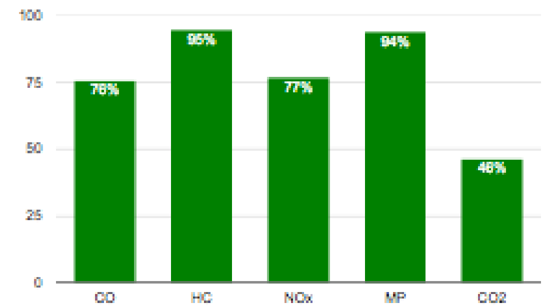
Padron	CO	HC	NOx	MP	CO2
Diesel (t/ano)	53.33	7.73	280.91	4.90	58425.08
Alternativas energéticas (t/ano)	0.00	0.00	0.00	0.00	0.00
Redução (t/ano)	53.33	7.73	280.91	4.90	58425.08
Redução (%)	100.0%	100.0%	100.0%	100.0%	100.0%

Articulado	CO	HC	NOx	MP	CO2
Diesel (t/ano)	17.48	2.32	90.17	1.56	24076.64
Alternativas energéticas (t/ano)	3.81	0.11	18.69	0.13	12829.07
Redução (t/ano)	13.68	2.21	71.48	1.43	11247.57
Redução (%)	78.2%	95.2%	79.3%	91.5%	46.7%

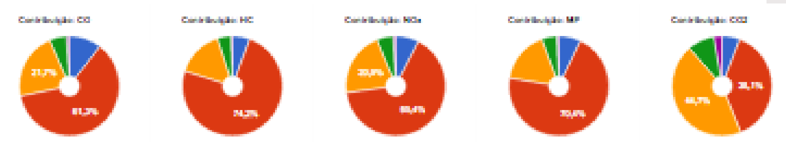
Biarticulado	CO	HC	NOx	MP	CO2
Diesel (t/ano)	2.31	0.31	11.92	0.21	3560.48
Alternativas energéticas (t/ano)	0.00	0.00	0.00	0.00	0.00
Redução (t/ano)	2.31	0.31	11.92	0.21	3560.48
Redução (%)	100.0%	100.0%	100.0%	100.0%	100.0%

EMISSÕES E REDUÇÕES DA FROTA TOTAL POR POLUENTE	CO	HC	NOx	MP	CO2
Diesel (t/ano)	324.74	53.42	1746.54	30.94	282521.26
Alternativas energéticas (t/ano)	79.43	2.80	404.62	1.90	151951.94
Redução (t/ano)	245.31	50.62	1341.92	29.04	130569.32
Redução (%)	75.5%	94.8%	76.8%	93.8%	46.2%

REDUÇÕES DE EMISSÕES DEVIDO À SUBSTITUIÇÃO DOS ÔNIBUS A DIESEL POR ALTERNATIVAS MAIS LIMPAS



CONTRIBUIÇÃO DE CADA TIPO DE VEÍCULO SUBSTITUÍDO NA REDUÇÃO TOTAL DAS EMISSÕES



	CO	HC	NOx	MP	CO2
Mini/Micro	10.5%	5.6%	7.5%	7.1%	5.8%
Básico/Midi	61.3%	74.2%	65.4%	70.4%	38.1%
Padron	21.7%	15.3%	20.9%	16.9%	44.7%
Articulado	5.6%	4.4%	5.3%	4.9%	8.6%
Biarticulado	0.9%	0.6%	0.9%	0.7%	2.7%
TOTAL	100%	100%	100%	100%	100%