

Guangzhou Green Trucks Pilot Project:

Background Analysis Report

for the World Bank

“Truck GHG Emission Reduction Pilot Project”

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Clean Air Initiative for
Asian Cities (CAI-Asia) Center



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About CAI-Asia

The Clean Air Initiative for Asian Cities (CAI-Asia) promotes better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse gas emissions from transport, energy and other sectors. CAI-Asia was established in 2001 by the Asian Development Bank, the World Bank and USAID, and is part of a global initiative that includes CAI-LAC (Latin American Cities) and CAI-SSA (Sub-Saharan Africa).

Since 2007, this multi-stakeholder initiative is a registered UN Type II Partnership with over 170 organizational members, eight Country Networks (China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Vietnam) and the CAI-Asia Center as its secretariat. Individuals can join CAI-Asia by registering at the Clean Air Portal: www.cleanairinitiative.org. Its flagship event, the Better Air Quality conference, brings together over 700 air quality stakeholders.

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1. Introduction

1.1 Objectives, Scope and Outputs

The World Bank (WB) initiated a pilot project – dubbed “Guangzhou Green Trucks Pilot Project” in support of Guangzhou’s efforts to improve air quality in preparation for the 2010 Asian Games. The goal of this project was to develop a “proof of concept” for a truck program in Guangdong Province, and possibly China, that aims to:

- Enhance the fuel economy of the truck fleet
- Reduce black carbon and other air pollutants from trucks
- Consequently obtain GHG emission savings.

The project was implemented by the Clean Air Initiative for Asian Cities Center (CAI-Asia Center), in cooperation with Cascade Sierra Solutions, US EPA and World Bank, and with support from Guangzhou Environmental Protection Bureau (GEPB), Guangzhou Transport Committee (GTC), and Guangzhou Project Management Office (PMO) for the World Bank.

The pilot project aims to contribute to addressing three problems related to trucks in Guangzhou and the wider Guangdong province simultaneously: (a) fuel costs and security; (b) air pollution and associated health impacts, and (c) greenhouse gas emissions and climate change.

The **scope** of the pilot was limited to Guangdong Province, focusing on diesel trucks accessing or passing through the city of Guangzhou and surrounding cities, like Shenzhen. Aside from GHG emissions, the scope includes black carbon and other air pollutants from trucks because of their potential interacting effects and contribution to climate change, and because air pollution is an important local concern.

The pilot project consisted of the following components, each with its own output:

1. Background analysis
2. Survey of Guangzhou truck sector
3. Driver training course for fuel efficiency of trucks
4. Technology pilot

This document is the Background Analysis Report.

1.2 Problems addressed through the Pilot Project

The pilot project aims to contribute to addressing three problems related to trucks in Guangzhou and the wider Guangdong province simultaneously: (a) fuel costs and security; (b) air pollution and associated health impacts, and (c) greenhouse gas emissions and climate change.

First, there is a problem of **fuel costs and security**. The 10 million trucks on Chinese roads, more than a quarter of all vehicles in China, are a major reason China accounts for half the world's annual increase in oil. Total energy used for passenger and freight in China accounted for 5.34% of the total worldwide in 2005 and

will account for 9.9% in 2035 according to IEA estimates.¹ With international crude prices fluctuating from USD120 to USD140 a barrel in 2008 before dropping to \$40 a barrel in late 2008, economists still expect that fuel prices will be higher in the future.² China's subsidies on diesel for socio-economic reasons has resulted in a surge in diesel truck sales (in 2008 this was nearly twice as many as in the US), and subsequently diesel supplies cannot keep up with demand for diesel at service stations, causing rationing and shortages.³ Improvements in the fuel economy of trucks will gain the support from truck owners and drivers, because it reduces their fuel bill, as well as Chinese authorities because it reduces the amount of diesel subsidies and the dependency on fossil fuels. At the same time, this will make an important contribution to reducing GHG emissions.

Second, there is the growing problem of **climate change**. Greenhouse gas (GHG) emissions are rapidly rising in Asia, especially in cities. The Kyoto Protocol covers six main greenhouse gases.⁴ Air pollution⁵ and greenhouse gas emissions have similar causes (mostly energy-related), and there is increasing evidence that their effects are interacting. The strongest evidence points to black carbon, the carbonaceous component of soot (particulate matter) that is produced mostly by burning of biomass, diesel and coal. In addition to its contribution to air pollution, black carbon and is a dominant absorber of solar energy. Recent scientific studies suggest that black carbon is the second largest contributor to global warming following CO₂⁶. From a climate change perspective it thus makes sense to address black carbon emissions through the reduction of soot and particular matter.

Finally, there is the problem of **air pollution**, which at the city level, is considered a bigger problem than climate change in Asia and a main focus of the Guangzhou authorities in preparation for the Asian Games 2010. Air pollution has replaced cigarette smoking as the first cause of lung cancer in Guangzhou. In the recent decade the number of lung cancer cases has doubled.⁷ In Hong Kong, approximately 1,600 people died each year as a result of air pollution, mostly from heart attacks, stroke, pneumonia and other lung diseases.⁸ While the pilot specifically aims to reduce GHG emissions, by emphasizing the “co-benefits” from GHG reductions in the form of reduced black carbon and other air pollutants, it is more likely that local authorities in the Guangdong province, most importantly Environmental Protection Bureaus, will support this pilot. Moreover, Guangzhou will be hosting the Asian Games in 2010. Air quality plans are being developed in preparation for this event, and the Guangzhou Environmental Protection Bureau will be looking for concrete measures to reduce air pollution during and beyond these events. Health Impacts of diesel trucks have been identified through a number of studies and summarized in Box 1.

¹ International Energy Agency (IEA), Sustainable Mobility Project, www.iea.org

² <http://www.baq2008.org/preevent-fuels>

³ http://www.lifeofguangzhou.com/node_10/node_37/node_85/2008/09/28/122258050352278.shtml

⁴ Carbon dioxide (CO₂), methane (CH₄), Nitrous oxide (N₂O), Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF₆)

⁵ Nitrogen oxides (NO_x), Sulphur oxides (SO_x), Carbon monoxide (CO), particulate matter (PM), Volatile organic compounds (VOCs)

⁶ Ramanathan et al (2007) <http://www.agu.org/pubs/crossref/2007/2006JD008124.shtml>; and Rep. Henry A. Waxman, Chairman, Committee on Oversight and Government Reform, in a hearing on hearing on black carbon and global warming (18 Oct 2007) <http://oversight.house.gov/story.asp?id=1550>;

⁷ http://www.lifeofguangzhou.com/node_10/node_37/node_85/2008/09/28/122258050352278.shtml

⁸ http://www.redorbit.com/news/science/533045/pollution_costs_hong_kong_1600_lives_2bn_dollars_annually/index.html

Box 1: Health impacts of diesel emissions

The results of studies investigating exposure to diesel emissions from older and more current engines indicate effects on the respiratory, reproductive, and cardiovascular systems. Extrapolation of these findings to people exposed to much lower concentrations of diesel emission components than those used in experimental studies or in epidemiologic studies of occupationally exposed workers can be challenging.

Despite these challenges, many agencies have determined that diesel emissions are of sufficient concern to merit action to reduce emissions. New diesel engines with control systems meeting 2007 emission standards for heavy-duty on highway vehicles are now on the market. Emissions from four such engines will be characterized in detail in the Advanced Collaborative Emissions Study (ACES), which is a joint effort of the Coordinating Research Council and the Health Effects Institute (HEI); chronic and acute health endpoints will be assessed for one of the engines. Although durable older engines with higher emissions will continue to be used, these new engines, and those designed to meet the more stringent 2010 standards, will gradually become more common, with substantial replacement expected by 2030.

Source: *HEI Air Toxics Review Panel. 2007. Mobile-Source Air Toxics: A Critical Review of the Literature on Exposure and Health Effects. HEI Special Report 16. Health Effects Institute, Boston, Mass.*
(www.healtheffects.org)

2. Situational Analysis of Diesel Trucks in Guangzhou

This chapter analyses the situation of diesel trucks in Guangzhou and in the broader context of Guangdong province and the China where relevant and where data is available. The analysis covers truck numbers and operation, and characteristics of the freight truck industry.

2.1 Truck Numbers and Freight

2.1.1 Truck Numbers

Figure 1 shows that the total number of diesel motor vehicles in the China is expected to grow from around 10 million in 2005 to almost 60 million in 2035. Trucks, buses and vans (light and heavy commercial vehicles) will continue to be the dominant diesel vehicles. With Guangdong province as a main economic center, this growth is likely to apply to Guangzhou and the Guangdong province also.

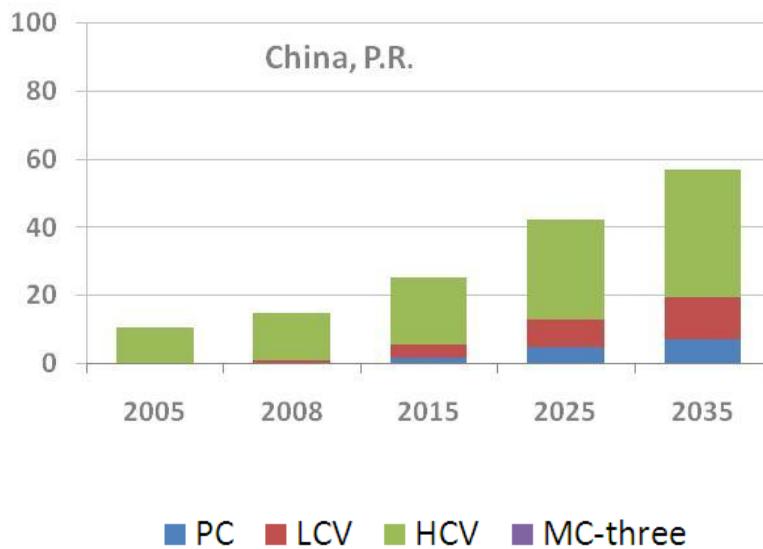


Figure 1: Expected Growth in Diesel Motor Vehicles in China 2005 – 2035 (in millions)

Source: 2006. ADB, CAI-Asia, Segment Y Ltd. Notes: PC = personal cars; LCV = light commercial vehicles; HCV = heavy commercial vehicles; MC-three = 2 and 3 wheelers

Figure 2 shows the total number of trucks registered in Guangdong province and Guangzhou from 2000 to 2007. The number of trucks registered in Guangzhou in 2007 was approximately 185,300, which is only 15% of the total 1.23 million trucks registered in the entire Guangdong Province.

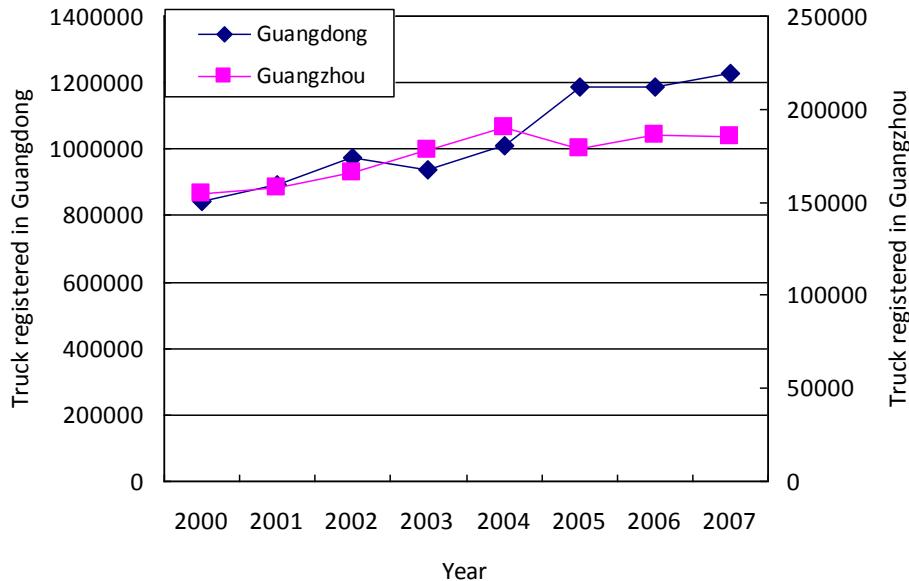


Figure 2: Trucks registered in Guangdong (left axis) and Guangzhou (right axis)

Source: Guangdong Statistics Yearbook 2001-2008

Table 1 shows the ratio of registered trucks in Guangzhou to trucks registered elsewhere for eight logistics parks surveyed in Guangzhou. The number of heavy/medium duty trucks registered outside Guangzhou outnumber the trucks registered in Guangzhou by 2.6 : 1, to 36.7 : 1. For light duty trucks the ratio is about the same, and for mini duty trucks the ratio is reversed. At two cargo centers surveyed in Guangzhou, more than 95% heavy duty trucks were registered outside Guangdong Province. This shows that trucks registered outside Guangzhou contribute significantly to the freight transportation.

Table 1: Ratio of trucks registered outside and inside Guangzhou in 8 logistics parks

Logistics park	Loading capacity category		
	>5 ton	1.5 – 5 ton	<1.5 ton
#1	17.2	0.9	0.3
#2	2.6	0.4	0.1
#3	18.8	1.2	0.3
#4	10.9	1.2	0.2
#5	6.1	1	0.5
#6	3.1	1.2	0.4
#7	15.3	2	0.3
#8	36.7	1	0

Source: MVA, Interim report of research on Guangzhou urban traffic improvement strategy (GUTS4), 2008

Table 2 shows the number of trucks and motor vehicles registered in Guangzhou from 2002 until 2007. By the end of 2007, the motor vehicle population of Guangzhou was 1.05 million and the truck population was 185,300. The total truck population in Guangzhou has increased by approximately 20,000 (12%) since 2002. The proportion of trucks of the total vehicle population has declined from 34% in 2002 to 18% because of the sharp increase in the number of motorbikes and cars. What is noticeable is that In Guangzhou, 77% of

registered trucks are light duty trucks. Figure 3 shows the number of diesel vehicles registered in Guangzhou annually between 1994 and 2004 and shows a sharp increase in especially the registration of light duty diesel vehicles.

Data on the age of trucks and whether trucks are Euro I or Euro II was not available and should be collected as part of a survey of truck drivers and companies.

Table 2: Trucks registered in Guangzhou

Year	Truck Population (thousands)					Total motor vehicle population (thousands)
	Total	HDT	MDT	LDT	Mini-DT	
2002	165.5	10.3	37.6	114.6	3.1	487.6
2003	178.1	10.5	39.9	123.9	3.8	572.0
2004	190.5	13.3	39.5	133.3	4.5	682.4
2005	178.5	10.8	33.5	130.4	3.9	761.5
2006	186.3	11.2	34.0	138.4	2.7	889.1
2007	185.3	11.3	31.2	141.0	1.8	1041.9

Source: Guangzhou Statistics Yearbook 2003 – 2008

Notes: Trucks are classified by the total weight, or gross vehicle weight (GVW), when loaded, including weight of the vehicle, fuel, passengers and cargo. HDT = heavy duty trucks, GVW≥12 tons; MDT = medium duty trucks, 4.5 tons ≤GVW<12 tons; LDT = light duty trucks, 1.8 tons <GVW<4.5 tons; Mini-DT = mini duty trucks, GVW≤1.8 tons.

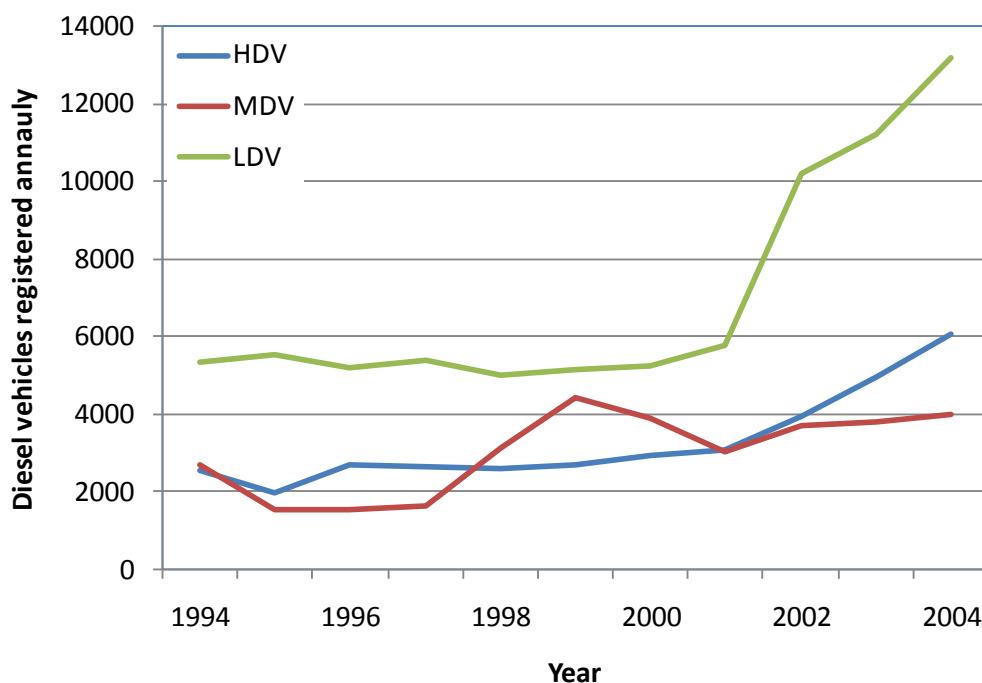


Figure 3: Diesel vehicles registered annually in Guangzhou 1994-2004

Source: Tsinghua University, Development of Motor Vehicle Pollution Control Plan for Guangzhou, research document, 2005. Notes: HDV = heavy duty vehicles; MDV = medium duty vehicles; LDV = light duty vehicles.

2.1.2 Truck freight

Figure 4 shows that the vast majority of freight in China was transported by highways in 2006 (72%) and has remained relatively stable since 1980. The railway share has decreased from 20% to 14% over the same period, although railways may increase its share in the future again.

The governor of Guangdong Province announced major transport plans for the province. Main features are:⁹

- Budgeted 80 billion yuan (\$11.7 billion) for the initial phase of an intercity light rail project linking Guangzhou with Dongguan, Shenzhen and Zhuhai, the other major cities within the delta.
- 350 billion yuan to build a rail network stretching 1,900 km in the Pearl River Delta region by 2050. The total length of track lines will be 1,100 km by 2012.
- Guangzhou-Zhuhai intercity light rail project and Guangzhou-Foshan metro project, with a total cost of 27 billion yuan, are due for completion in 2010
- the Guangzhou-Dongguan-Shenzhen, Dongguan-Huizhou, Guangzhou-Huadu-Qingyuan, and Zhongshan-Nansha-Humen projects, costing 70 billion yuan, will open in 2015
- Budgeted 220 billion yuan for the construction of expressways network in the province. By 2012, the region will have 3,000 km of expressways.

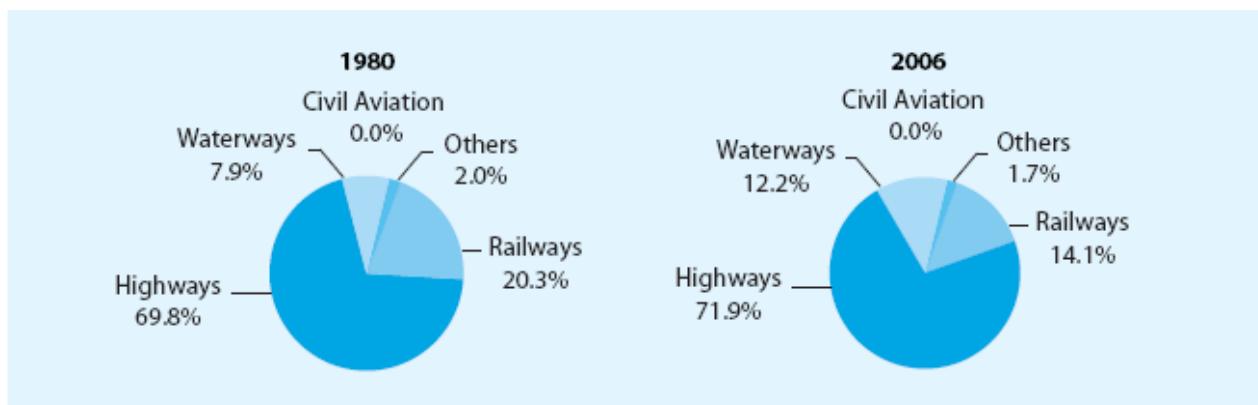


Figure 4: Freight Transport Mode Share in 1980 and 2006 in China (tons)

Source: ADB. 2008. Promoting Environmentally Sustainable Transport in PRC

Figure 5 shows that road freight volumes have increased from approximately 60 million ton km in 2002 to over 100 million ton km in 2007 – a 67% increase.

⁹ http://www.chinadaily.com.cn/regional/2009-01/09/content_7381827.htm

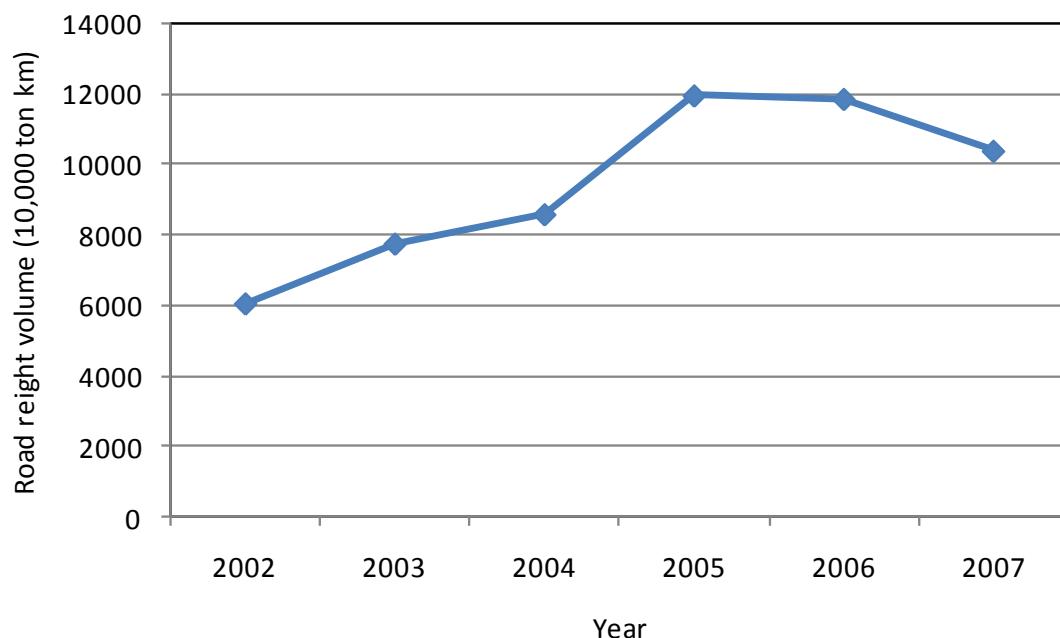


Figure 5: Road freight transport volume in Guangzhou

Source: Guangzhou Statistics Yearbook, 2003-2008. Notes: freight volume is expressed in ton km which is the number of tons carried multiplied by the distance travelled.

Table 3 shows the economic use of freight trucks in Guangzhou from 2002 to 2007. Total freight transported by trucks registered in Guangzhou grew from 1.47 million tons in 2002 to 2.16 million tons in 2007 – a 47% increase. As truck numbers in Guangzhou only increased by 12%, this suggests that trucks registered outside Guangzhou have contributed to the growth in the volume of freight transported but it can also indicate higher loads. Current statistics cannot show a further breakdown of “other” economic use although this is the largest category. Statistics for Guangdong province are not available.

It is noted that at least one-third of the freight in weight transported by trucks represent non-perishable goods. More analysis is needed to determine the characteristics of the remaining two-thirds. When freight is perishable the load needs to get to its destination fast, which limits the ability for redesigning routes and freight logistics.

Table 3: Economic use of freight transport by trucks in Guangzhou (in 10,000 tons)

Year	2002	2003	2004	2005	2006	2007
Petroleum, NG and their products	3.33	6.84	6.93	6.80	4.00	5.9
Iron and steel	1.93	2.39	3.11	14.37	17.00	19.2
Mineral construction materials	0.14	0.30	0.55	0.30	0.28	0.28
Cement	0.58	1.40	1.42	3.98	7.00	7.23
Timber	0.08	0.33	0.39	0.52	0.32	0.28
Machinery	19.9	27.7	20.23	34.76	42.00	35.2
Chemical materials and products	1.11	1.43	2.27	6.99	1.00	1.58
Non-ferrous metals	--	0.75	0.28	0.35	0.21	0.17

Year	2002	2003	2004	2005	2006	2007
Light industrial and medical products	10.07	32.97	34.30	3.78	2.00	0.11
Daily necessities	--	32.97	25.49	1.63	1.50	7.25
Others	109.55	161.93	228.57	154.20	144.05	139.25
TOTAL	146.69	269.01	323.54	227.68	219.36	216.45

Data on overloading of freight trucks, which is a big issue in China and percentages of empty trucks on the road was not available and should be collected as part of a survey of truck drivers and companies.

2.2 Fuels

2.2.1 Fuel Use and Efficiency

Vehicle fuel in Guangzhou consists of gasoline, diesel and LPG. In 2007, vehicles in Guangzhou consumed 1.45 million tons of gasoline and 2.23 million tons of diesel. LPG is mostly consumed by buses and taxis. Diesel is the “dirtiest” fuel from an air pollution perspective and Figure 6 shows that diesel consumption in Guangzhou is 50% higher than gasoline sales. Based on expected growth in diesel vehicles in China until 2035 (see Figure 1) it is expected that fuel consumption will also increase significantly.

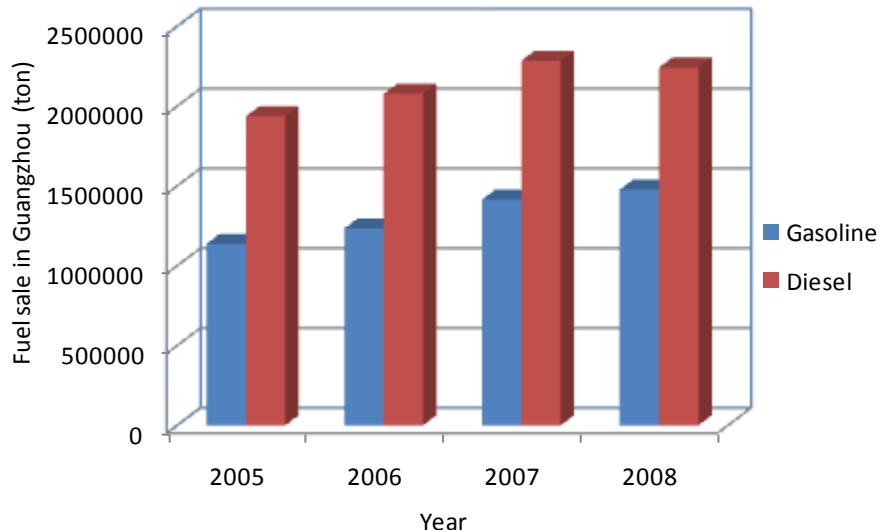


Figure 6: Diesel and gasoline sales in Guangzhou

Source: Wholesale statistics from local petrochemical companies (PetroChina, Sinopec)

Note: Data for 2008 were extrapolated from sale statistics from January to October 2008.

Data on the fuel efficiency of trucks in China should be collected as part of a survey of truck drivers and companies. A subsequent comparison with the potential efficiency of state-of-the-art trucks would demonstrate the potential of fuel efficiency for trucks in China.

2.2.2 Fuel Costs

Figure 4 shows that prices of gasoline and diesel almost doubled between 2004 and August 2008, and that fuel subsidies increased similarly. China spent 1.79 billion USD on gasoline and diesel fuel subsidies in 2008. However, Table 5 shows that in Guangdong Province fuel prices at the pump kept relatively stable since 2007, largely due to fuel subsidies, and this thus suggests that the rising fuel costs internationally during 2008 did not provide an incentive for improved fuel efficiency for trucks operating in Guangdong Province. Shortages in diesel supplies at service stations, causing rationing and shortages, may provide a greater incentive for fuel efficiency measures.¹⁰

Table 4: Fuel Prices and Subsidies in China

Type	Fuel Prices USD (\$)/L						Government Subsidy (Actual Amount in USD)		
	2004	2006	2007	2008-January	2008-July	2008-November	2006	2007	2008 (P)
Gasoline	0.48	0.69	0.78	0.67	0.91	0.99	0.71 Billion	0.9% of GDP	1.79 Billion
Diesel	0.43	0.61	0.77	0.7	0.81	1.01			

Source: GTZ and others, compiled by CAI-Asia Center 2008

Table 5. Recent official #0 diesel price change in Guangdong (RMB per liter)

Date of adoption	Lower limit	Upper limit	Medium price	Level
2009-1-15	3.91	4.81	4.36	Euro II
	4.09	5.01	4.55	Euro III
2008-12-19	4.04	4.94	4.49	Euro II
	4.22	5.14	4.68	Euro III
2008-06-20	5.13	6.03	5.58	Euro II
	5.31	6.23	5.77	Euro III
2007-11-01	4.35	5.11	4.73	Euro II
	4.5	5.28	4.89	Euro III

Source: Several announcements of Guangdong Price Control Bureau (GDPCB)

The price of Euro II and Euro III diesel is different.

2.2.3 Fuel Quality

Table 6 shows that diesel specifications for sulphur levels in Guangzhou are stricter than the national standards and comparable for other main fuel parameters. Guangzhou adopted Euro III standards for both gasoline and diesel per 1 May 2008. Sulfur levels in gasoline are 150 parts per million (ppm) and in diesel are 350 ppm. The “Vehicle Exhaust Pollution Control Plan of Guangdong Province” (2008) proposes to introduce

¹⁰ http://www.lifeofguangzhou.com/node_10/node_37/node_85/2008/09/28/122258050352278.shtml

Euro IV standards for diesel in the Pearl River Delta starting 1 October 2009 and in the whole province by 2012.¹¹ Fuel quality is important because it influences the feasibility of diesel particulate filters, which require a 50 ppm sulphur level in fuels to be effective.

In December 2007, there were 492 fuel stations in Guangzhou, which included 292 Sinopec, 38 PetroChina and 95 BP stations. Guangzhou will have 680 fuel stations at the time of the Asian Games in 2010.

Table 6. Vehicle #0 diesel specification in China, Guangdong and Guangzhou

Parameter	China ^a	Guangdong ^b	Guangzhou ^c
Sulfur (maximum, %m/m)	2000 (official) 500 (voluntary)		350
Cetane (minimum)	49		51
Density (kg/m ³ , 20°C)	820China860		820China845
T95 (°C)	365		365

Source:

a: *Automobile diesel fuels*. National standard of China. GB/T 19147-2003. 2003. It is noted that the official requirement is 2000 ppm for sulphur and that 500 ppm is a voluntary target.

b: For cities that adopted the Euro III standard, diesel specification will be the same as Guangzhou. Other cities will be the same as China.

c: *Diesel fuels for motor vehicle use*. Local standard of Guangdong. DB 44/346-2006. 2006. These values only apply to Euro III diesel fuel

2.3 Trucking industry in Guangzhou and wider Guangdong Province

2.3.1 Ownership Structure of Trucks

There are four types of contractors in Guangzhou: (a) large state-owned enterprises; (b) private enterprises; (c) self-employed truck drivers cooperating with enterprises; and (d) self-employed truck drivers. Type a means the enterprise is owned by government, while type b enterprise belongs to private owner; type c enterprise only takes care of the license management for private truck drivers but not the business, and type d truck owner is usually the driver. Based on the discussion with officials from the Guangzhou Transport Committee (GTC), there are 90,283 freight transportation companies 152,284 trucks in 2009. The average size of contractors is quite small in Guangzhou.

Among those there are 2,817 enterprises registered at municipal level, with 8716 trucks in total. The rest 87,398 companies are registered at district level, having a total of 126,656 trucks. The number of foreign ventures is 23 with a total of 1130 trucks. Data on the number of each of the four types of contractors and the number of trucks owned by each were not available and could be collected as part of a survey of truck drivers and companies during the pilot implementation phase.

2.3.2 Operational Costs of Trucks

¹¹ http://www.gddepb.gov.cn/zwxx/zfwj/szflw/200811/t20081127_57493.html

The operational cost of trucks consists of fuel cost, road maintenance fee, road transport management fee, road passenger and freight transport surcharges, road tolls, driver's salary, insurance. As the new fuel taxation reform adopted since the beginning of 2009, road maintenance fee, and road transport management fee has been canceled. Seventy cents (RMB) have been added to the diesel excise tax.¹²

As we investigated a private truck fleet manager with 15 years experience, he provided a specific case to explain the cost structure. The most popular destination of his fleet is Changsha in Hunan Province. The distance between Guangzhou and Changsha is 670 km. The information in Table 7 is based on a typical four axis truck that usually takes six round-trips a month. The monthly average cost of the truck increased by ¥903 or 3.6% after the reform. And the share of fuel cost in total cost has been increased from 46.0% to 51.7%.

Diesel costs represent the largest share of operational costs of trucks in China as illustrated in Figure 7. One interviewed fleet manager reported as much as 52%. Another big company with mostly heavy-duty trucks reported a ratio of around 40%. More detailed figures should be collected as part of a survey of truck drivers and companies during the pilot implementation phase.

Table 7. Monthly Truck Operational Cost Structure for an Interviewed Private Trucks Fleet Manager

	Before the reform	After the reform
Fuel cost	¥25,143 / month, i.e. ¥4,190.5 (850L #0 diesel) / trip X 6 trips / month	28,713 / month, i.e. ¥4,785.5 (850L #0 diesel)/trip X 6 trips/month
Road maintenance fee	¥2,350 / month	0
Road transport management fee	¥317/ month	0
Road tolls	¥19,800 / month, i.e. ¥3,300 / trip X 6 trips /month	
Salary	¥6,000 / month, i.e. ¥3,000 (all included)/driver X 2 drivers / truck	
Insurance	¥12,000 / year (¥1,000 / month)	
Others (not determined)	Inspection and maintenance, parking, depreciation	

Note: monthly operational cost of trucks for a round trip between Guangzhou and Changsha (Hunan Province)

Note: To make a comparison on the cost structure before and after the fuel taxation reform, we assumed that the basic fuel price is kept at the same level (¥4.93 / liter). Only the diesel excise tax has been considered to be increased by seventy cents per liter. So we can evaluate the impact of the reform on truck cost instead of confusing with the recent frequent fuel price fluctuation.

2.3.3 Trucking routes

Guangzhou has traffic restriction rules for trucks traveling in Guangzhou. It depends on the traveling area, time of a day, truck size and whether the truck is registered in Guangzhou or not. Generally, trucks are restricted from urban Guangzhou between 7 am and 8 pm. Restrictions for trucks larger than 5 tons and those registered outside Guangzhou are stricter. The figure in Annex B shows the detailed traffic restriction rules by area, time and truck size in Guangzhou.

¹² NO. 37 [2008] of the State Council of China, Notice of the State Council on implementing the price and tax reform of refined oil

Studies have been conducted on the movement of trucks within Guangzhou¹³. However, to date no studies were found on the movement of trucks between Guangzhou and other places within the Guangdong Province and between Guangzhou and places outside the Guangdong Province. This could be included in the survey of truck drivers and companies that is to be conducted during the pilot implementation phase.

A survey of 182 randomly selected private-owner truck drivers in Nanjing found the following:¹⁴

- For 91% of the respondents, their travel distances are less than 200km per day.
- For 65% of the respondents, the rate of empty load is more than 30%.
- For 77% of the respondents, the load factor is lower than 60%. The lower utilization rate of the truck load will increase the fuel consumption and green-house gas emission.
- For 27% of the respondents, the stop number for one trip is larger than five times.
- For 69% of the respondents, the time for load/unload is more than twenty minutes.
- For 67% of the respondents, the average vehicle speed is lower than 60km/ h.

¹³ Determined as part of the Guangzhou Urban Transport Study (GUTS by MVA for the World Bank

¹⁴ Zhang Y et al. (2008). A survey for Private-owner Truck Drivers about Trip Behavior and Environmental Awareness: a case of Nanjing in China

3. Institutional and Policy Context

3.1 Relevant Government Agencies

The Chinese government functions at three levels: national, provincial and city levels. There are 27 ministries which are part of State Council, the highest executive authority in China.

The Ministry of Transport (MOT) is responsible for formulating development plans and strategies, regulations on transportation management, roads construction and management for the whole transport sector including roads, waterway, and ports. The Department of Transport and Transport Bureaus/Committees assume similar sectoral development and management responsibilities at the provincial and local levels respectively, and report directly to the provincial or city government. They help implement national policies and programs issued by the central government and MOT.

The Ministry of Environmental Protection (MEP) is responsible for setting up environmental requirements and for enforcement of environmental policies, regulations, and standards. Environmental bureaus at provincial and city levels are, under the direct leadership of provincial and city governments, responsible for implementing and ensuring the enforcement of the national requirements on environment protection. They may formulate stricter local environment requirements at the national level, such as environment quality standards and environment emission standards.

Table 8 lists the relevant government agencies for the pilot project at the national, Guangdong Province and Guangzhou levels.

Table 8: Government Agencies Relevant for the Trucks Pilot Project in China

	Transport	Environment	Other
National	<ul style="list-style-type: none"> • Ministry of Transport (formerly Ministry of Communications), in particular the Department of Roads with <ul style="list-style-type: none"> ◦ Division of Vehicle Management ◦ Division of Road Transportation Management ◦ Division of Transport Administrative Management 	<ul style="list-style-type: none"> • Ministry of Environment (formerly State Environment Protection Administration) <ul style="list-style-type: none"> ◦ Pollution Prevention and Control Division (PPCD) ◦ Science and Technology Department (STD) 	<ul style="list-style-type: none"> • Traffic Management Department of Ministry of Public Security • State Administration of Quality and Technical Supervision: Set up and supervise the enforcement of the products and technology standards, including vehicle safety and technology standards. • State Price Bureau in the National Development and Reform Commission (NDRC): Set up fees/price for different sectors including transport. • Ministry of Finance: set up all tax rates including fuel tax • State Administration of Customs: Set up import/export regulations.
Provincial	<ul style="list-style-type: none"> • Guangdong Department of Transport (formerly 	<ul style="list-style-type: none"> • Guangdong Environmental Protection 	<ul style="list-style-type: none"> • All the above at Guangdong Provincial level

	Transport	Environment	Other
	Department of Communications)	Bureau (possibly to be changed to Department of Environment in 2009)	
Local	• Guangzhou Transport Committee ¹⁵	• Guangzhou Environmental Protection Bureau	• All above at Guangzhou municipal level

Annex B provides a brief description of each of these agencies. The following government agencies in Guangzhou that will be directly involved in the pilot project and their main roles relevant to the pilot project are:

- Guangzhou Transport Committee (GTC), and its most relevant roles are management of truck terminals, inspection and maintenance through I&M Centers, and training; setting of transport fees together with Guangzhou Municipal Price Bureau and fuel taxes together with the municipal bureau of Finance and Taxation, manage transport projects, including international cooperation projects; liaise with truck companies and associations registered in Guangzhou.
- Guangzhou Environment Protection Bureau (GEPB) and its most relevant roles are developing local regulations relating to transport-related emission monitoring and reduction; developing air quality measures in preparation for the Asian Games.
- Guangzhou Traffic Management Bureau (GTMB) under the Public Security Bureau of Guangzhou Municipal Government, assumes overall responsibility on road safety.. Vehicles, including trucks, have to be registered at the Vehicle Management Division of GTMB. Vehicle Owners shall apply for record change if: there is changed to the color, engine, purpose of use (commercial vs. non-commercial use). Trucks need to do safety technology tests once a year if the truck operates less than 10 years; once every six month if more than 10 years
- Administration of Quality and Technical Supervision of Guangzhou Municipality (GQTS) assumes responsibility of product quality and technical supervision; and drafts the municipal rules and regulations on standardization, measurement, quality inspection and safety supervision; directing and supervising the administrative enforcement within the system in various sectors including transport.
- Finance Bureau of Guangzhou Municipality and Price Bureau under Guangzhou Development and Reform Commission shall also be involved during exploration of financial mechanism options for creating incentives and instruments for fuel economy and emission reduction.

Annex B also includes a table listing other organizations that could be relevant for the pilot project, but more likely for the longer-term program. These include associations and partnerships, development agencies and foundations, NGOs, academic and research institutes, cities and the private sector. Which organizations are most relevant and what their role could be in a longer-term program will be further explored as part of the pilot implementation phase.

¹⁵ Since the establishment of Ministry of Transport in 2007, urban transport responsibilities have shifted from Bureau of Construction to the Transport Committee at city level..

3.2 Relevant Plans and Policies

In China, key plans and laws are developed at the national level, and subsequently applied at the provincial and local levels through provincial and local plans and policies. Annex C provides an overview of plans and policies. The most relevant ones are:

- Transport: 11th Five-year Plan of the Transport Sector (2006-2010) and various regulations on road transportation, including road freight transport
- Energy: Energy Conservation Law; Fuel efficiency standards for commercial freight vehicles
- Environment: Environmental Protection Law; Air Pollution Prevention and Control Law; emission standards and policies relevant to diesel vehicles
- Implementation Guidelines of PRC Law on Road Traffic Safety, effective 1 May 2004

As part of the further design of a longer-term program following the pilot implementation, existing taxes, subsidies and other economic instruments relevant to the truck industry in China should be considered. This should be discussed with the Ministry of Transport, which is focused on improving the freight sector, amongst others through promoting freight trucks types that are more environment-friendly and energy efficient. Economic instruments could play an important role in this.

4. Fuel Economy and Emission Reduction Strategies and Technologies

4.1 Available Strategies and Technologies

Internationally available control technologies and strategies can be clustered in the following groups, based on the US Smartway Program that is described in Annex D along with selected other US programs:

- **Vehicle activity and driving pattern improvement** - Fuel consumption is strongly connected with vehicle driving pattern in real-world operation.
 - **Driver training.** Drivers can be trained to follow fuel-saving driving habits or keep their highway speed a more efficient range.
 - **Reducing speed** on highways to a speed where fuel consumption is most efficient
 - **Reducing overloading** can also reduce the fuel consumption.
 - **Improved freight logistics.** The total activity can also be reduced by better logistics management like increasing returning load and reducing empty trip. Vehicle activity is linearly correlated with total fuel consumption.
- **Enhanced Maintenance** - Truck condition can affect not only their operation performance, but also their fuel economy and emission. A routine Inspection/Maintenance (I/M) is far from enough to ensure good truck condition. Special training and improved fleet management can help contractors improve the condition of their trucks. Engine rebuilding can be regarded as the strongest enhanced maintenance strategy.
- **Vehicle body improvement** - Several strategies based on vehicle body improvement can be applied to reduce diesel consumption by reducing the drags.
 - **Truck weight reduction** is a common strategy to improve the fuel economy of a truck.
 - **Improved aerodynamics** reduces drag and thus fuel consumption.
 - **Reducing rolling resistance** through tire system modifications can also reduce the fuel consumption: single wide-based tires, low rolling resistance tires or automatic tire Inflation or tire pressure monitoring systems.
- **Reduced idling.** Several technological options can assist drivers in reducing truck idling, including auxiliary power units (APUs), automatic engine idle systems, and truck stop electrification.
- **Fuel, oil and lubricant improvement**
 - **Low-sulfur diesel** can reduce the emission of in-use trucks immediately. It's also a precondition for a successful emission retrofit program.
 - **Low viscosity lubricant** can also help improve fuel economy.
 - **Oil by-pass filtration system** improves oil life performance and indirectly contributes to fuel efficiency due to reduced engine wear.
- **Emission Retrofit** - In-use diesel retrofit with emission control devices including EGR (Exhaust Gas Recirculation), DPF (Diesel Particulate Filter) and DOC (Diesel Oxidation Catalyst) systems have been widely applied in U.S. and Europe. The selection for target trucks and technology verification is crucial for a successful retrofit. Both USEPA and California Air Research Board (CARB) have well developed verification process and certified retrofit technology list.

- Fleet and Engine Modernization** - Fleet modernization can introduce much cleaner engines into the fleet which has much lower PM and NO_x emission than old one. Engine replacement is also a type of fleet modernization strategy.

A detailed description of available control strategies is provided in Annex E.

Table 9 summarizes the results of a study in the US that determined the savings potential of installing technology packages on trucks. Long-range trucks have the greatest potential for fuel economy improvement and GHG emissions savings through technology applications.

Table 9: Savings Potential of Installing Full Technology Packages on Trucks¹

Type	Characteristics	Fuel and GHG Savings Potential ²		Remarks
		Fuel Economy Improvement	Annual GHG Savings (tons CO ₂ -eq) ³	
Tractor-trailers	Long-range tractor trailers	<ul style="list-style-type: none"> Primary trip length is greater than 200 miles Long-range trucks can top 130,000 miles annually and burn a gallon of diesel fuel every 6 to 6.5 miles⁴ 	12.8%	23 <ul style="list-style-type: none"> High annual mileage and low miles/gallon mean that even small improvements in fuel efficiency can add up big in annual savings
	Medium-range tractor-trailers	<ul style="list-style-type: none"> Primary trip length is between 100 and 200 miles Can average as much as 80,000 miles per year and operate over a mix of highways and sub-urban routes 	11.3%	15 <ul style="list-style-type: none"> Tractor-trailers in such regional distribution service can realize cost and pollution savings from efficiency improvements
	Short-range tractor-trailers	<ul style="list-style-type: none"> Primary trip lengths of less than 100 miles Can travel more than 50,000 miles in a mix of highway, sub-urban and urban driving 	10.1%	8.3 <ul style="list-style-type: none">
Non-tractor-trailers	Straight-box truck	<ul style="list-style-type: none"> Vary in application from urban delivery to regional distribution and come in variety of sizes and carrying capacities 	8.1%	1 <ul style="list-style-type: none"> Improved logistics may have relatively large impact on fuel use

Notes:

- Anair, Don. 2008. Delivering the Green: Reducing Trucks' Climate Impacts While Saving at the Pump
- Savings accrued from implementing a full technology package on new trucks including: trailer side skirts, trailer front fairing, low-rolling-resistance tires, full aerodynamic tractor package for new trucks only, trailer rear fairing, aluminum wheels.
- Annual GHG savings are computed as the average over: 9 years for long-range tractor-trailers, 14 years for medium-range tractor trailers, 20 years for short-range tractor-trailers and 20 years for short-range tractor-trailers and straight trucks.
- U.S. Census Bureau. 2002. Vehicle Inventory and Use Survey.

4.2 Selection Criteria

The selection criteria for recommended control technologies and strategies for Guangzhou consist of: good savings potential for contractors, high GHGs and regulatory pollutant reduction potential, acceptable cost and technology availability in China.

- **Investment and operational costs** include the economic input not only from the contractors but also from other related institutions. The cost-effectiveness is crucial for the selection of available control strategies/technologies.
- **Cost savings.** The most important concern of fleet contractors is the economic output. The economic effect of a strategy/technology will determine their willingness to take action if there no pressure from the government. Fuel saving, higher logistics efficiency, less maintenance cost all contributes to economic incentive.
- **GHGs reduction and reduction of air pollutant emissions controlled by legislation** is the target for the success of this program. Their reduction potential of individual strategy/technology is a very important selection criterion.
- **Technical requirements** for installing and operating technologies.
- **The availability and proven effective application** of the strategies/technologies, preferably in China, is important for the success of this program. Their current availability and their availability in the recent future determine whether we can adopt them now or put them in the conditional list.
- **Difficulty of implementation and/or enforcement** if there are legal restrictions that make it not possible to apply the technology or if a strategy or technology a mandated by law but is difficult to enforce.

A survey of 182 randomly selected private-owner truck drivers in Nanjing found the following:¹⁶

- Private-owner truck drivers agreed that the most important strategies to reduce truck emissions are "To improve the fuel economy by promoting the market of "new energy" vehicles.", "To change the "aggressive" driving habits and carry out eco-driving", "Heavy-duty vehicles should be widely used for transportation sectors by incentives and "It is crucial for drivers to schedule their vehicle route by choosing urban logistic centers".
- A multipronged technique consisting of improving the vehicle technology, system efficiency, driving behavior and improving the environmental awareness have significant potential to reduce the emissions.

4.3 Strategies and Technologies proposed for Pilot Project

Based on the above criteria and a site visit to Guangzhou together with two US truck experts, the following strategies and technologies were proposed for consideration in the pilot project:

- Driver training to improve fuel economy and reduce emissions
- Technologies:
 - Truck weight reduction: aluminum wheels

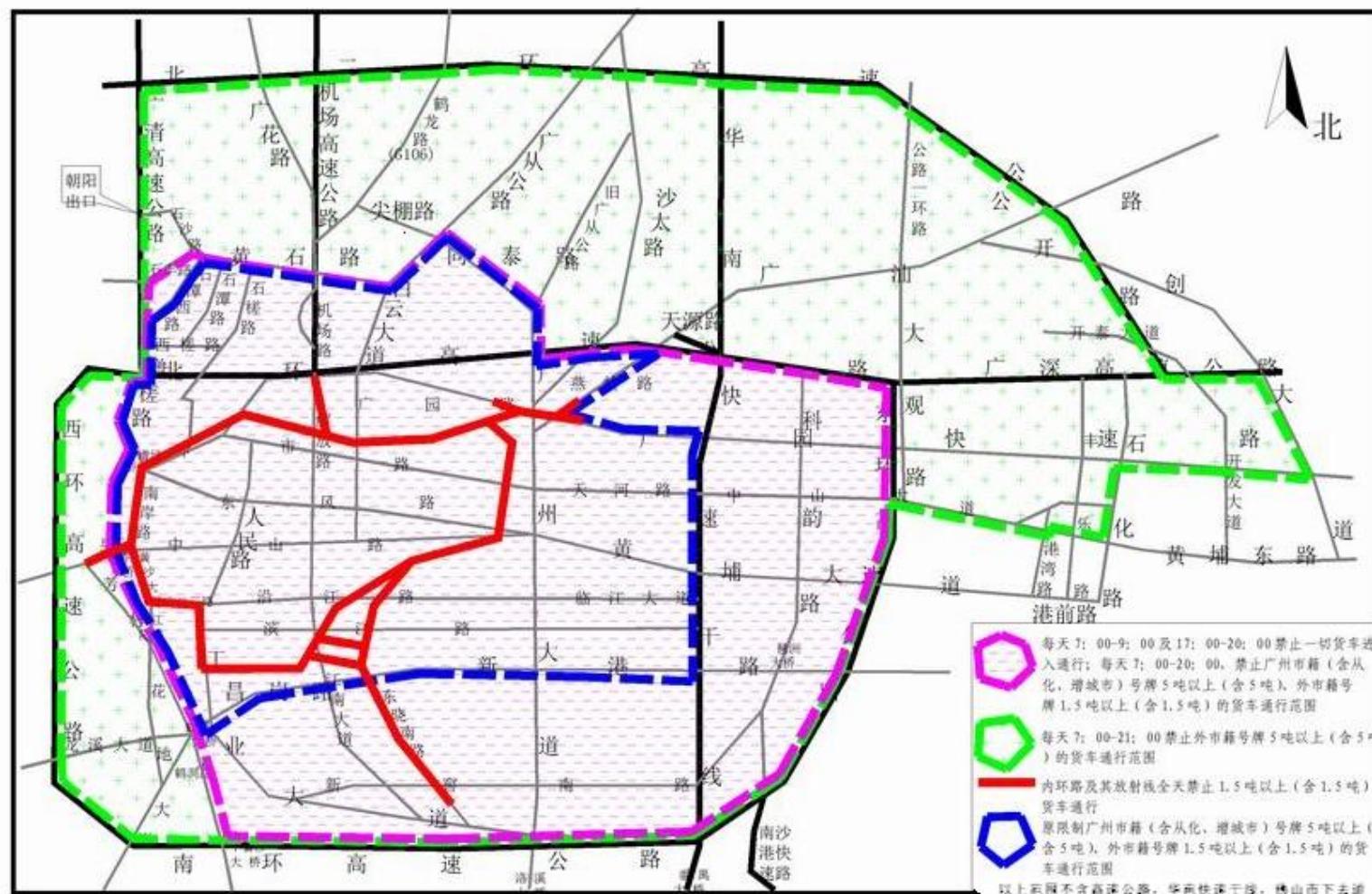
¹⁶ Zhang Y et al. 2008. A survey for Private-owner Truck Drivers about Trip Behavior and Environmental Awareness: a case of Nanjing in China. Since the number of people surveyed was limited, there is a need to expand the scope of survey and analysis in future

- Reducing tire rolling resistance: dual low rolling resistance tires & tire pressure monitoring system
- Improved aerodynamics to reduce drag above 75 km/hr: nosecone, cab fairing, skirt

ANNEXES

Annex A – Traffic Restriction Rules for Trucks in Guangzhou

- Purple line: Restricted area for any truck (7:00-9:00 and 17:00-20:00), Guangzhou truck larger than 5 tons (7:00-20:00), trucks larger than 1.5 ton registered outside Guangzhou (7:00-20:00)
- Green line: Restricted area for trucks larger than 5 ton registered outside Guangzhou (7:00-21:00)
- Red line: trucks larger than 1.5 ton were restricted from the Inner at any time



Annex B – Relevant Government Agencies and Other Organizations

Government Agencies relevant to the Trucks Pilot Project and their Mandates

Agency	Mandates
National	
Ministry of Transport	<ul style="list-style-type: none"> • Make development strategy, policies and regulations and monitor the implementation of them • Adjust and control transport of national crucial materials, and urgent passengers / freight transport • Organize the implementation of national crucial road and water transport engineering • Guide reform and keep normal order of transport industry, • Make technical standards and criterion, and organize key development of science, technology and education. • Manage ports, guarantee safety of water transport
• Comprehensive Planning Department, MOT	<ul style="list-style-type: none"> • Key divisions include: Comprehensive Planning Division; Roads Planning Divisions; Investment Division; and Statistical Division. • Formulate Development Plans for Road & Waterways; • Formulate sectoral industrial and infrastructure financing policies; • Fundraising preparation and post evaluation; • Provide guidance to provincial / local agencies on sectoral statistics, projection, and information • Issues the “Vehicle and Vessel Catalogue of Energy Saving Product and Technology”, which could include future recommended equipment and technologies under the trucks pilot project or longer-term program
• Department of Roads (DoR), MOT	<ul style="list-style-type: none"> • Formulate sectoral policies, regulations and technical standards on road construction and transportation • Regulate and manage fees from road use, road maintenance, administration, toll gates; management activities on road transportation, vehicle repair market, Driving schools and training • Proposing transportation pricing • License Permit for Class 2 Truck Fleet Enterprises
• Division of Vehicle Management, DoR, MOT	<ul style="list-style-type: none"> • Formulate and supervise enforcement of Policies, Regulations and technical standards on Vehicle management, use and maintenance, upgrade and scrap age. • Formulate policy measures concerning vehicle development and type structure adjustment • Formulate vehicle development plan and technical policies. • Conduct sectoral administration on vehicle inspection and maintenance market • Management on Training and driving school • Guide on R&D of vehicle facilities • Guide on introduction to new technology, new process and new material • Guide on energy saving and environment protection of vehicles.
• Division of Road Transportation Management, DoR, MOT	<ul style="list-style-type: none"> • Overall management on qualification review of road freight enterprises; • Approval and coordinate inter-province transportation • Guide constructions and management of cargo stations and approval on Class I terminal construction • Contact point and guidance for social organizations in road transportation
• Division of Transportation Administrative Management, DoR,	<ul style="list-style-type: none"> • Organize the formulation of road transportation policies, regulation, and standards • Guide the enforcement of the transportation regulations, administrative reform and capacity building. • Statistics and digitizing road transport activities.

Agency	Mandates
MOT	<ul style="list-style-type: none"> • International Cooperation on road transportation technology
Ministry for Environmental Protection (MEP)	<ul style="list-style-type: none"> • Prevent and control environmental pollution • Protect nature and ecology • Supervise nuclear safety • Safeguard public health and environmental safety, and • Promote the harmony between man and nature
Ministry of Public Security	<ul style="list-style-type: none"> • Road safety and traffic management
State Administration of Quality and Technical Supervision	<ul style="list-style-type: none"> • Establish and supervise the enforcement of the products and technology standards, including vehicle safety and technology standards.
National Development and Reform Commission	<ul style="list-style-type: none"> • Determine fees/price for different sectors including transport.
Ministry of Finance	<ul style="list-style-type: none"> • Determine tax rates including fuel tax
State Administration of Customs	<ul style="list-style-type: none"> • Establish import/export regulations. • The Customs only established offices in only a few cities including Guangzhou.
Guangdong Province	
Guangdong Provincial Department of Transport (DoT),	<ul style="list-style-type: none"> • Formulate and enforce local regulatory requirements, technology upgrade plans for priority projects in Guangzhou transport sector; • Organize and coordinate the planning and construction of roads, terminals and stations. (as well as ports, waterways) • Set up, together with price bureau, various fee rates in transport sector. • Overall Management on Guangdong Provincial roads transportation, transportation service, terminals, inspection and maintenance, training and driving school • Organize and coordinate international cooperation in Guangzhou transport sector
Guangdong Provincial EPB	<ul style="list-style-type: none"> • Set up and enforce Environment Requirements for Guangdong.
Department of Public Security	<ul style="list-style-type: none"> • Traffic Management Department of the Ministry of Public Security is responsible for road safety and traffic management cross cities within the province.
Guangdong Provincial Administration of Quality and Technical Supervision	<ul style="list-style-type: none"> • Supervise the enforcement of national standards of products and technologies • Establish and supervise the enforcement of the provincial products and technology standards, including vehicle safety and technology standards, which are more stricter than national ones if any
Guangdong Provincial Development and Reform Commission	<ul style="list-style-type: none"> • The Price Bureau in the Guangdong Provincial Development and Reform Commission: Set up fees/price for different sectors including transport which are appropriate for Guangdong province
Guangdong Provincial Department of Finance	<ul style="list-style-type: none"> • Establish all tax rates including fuel tax
State Administration of Customs in Guangzhou	<ul style="list-style-type: none"> • Establish import/export regulations.
Guangzhou	
Guangzhou Transport Committee (GTC)	<ul style="list-style-type: none"> • Implement policies regulatory requirements for transport sector; • Formulate and enforce local regulatory requirements, technology upgrade plans for priority projects in Guangzhou transport sector; • Organize and coordinate the planning and construction of roads, terminals and stations. (as well as ports, waterways) • Set up, together with price bureau, various fee rates in transport sector.

Agency	Mandates
	<ul style="list-style-type: none"> Overall Management on Guangzhou urban public transport, roads transportation, transportation service, terminals, inspection and maintenance, training and driving school Organize and coordinate international cooperation in Guangzhou transport sector
Guangzhou Municipal EPB	<ul style="list-style-type: none"> Executing the State, provincial and municipal laws, policies, regulations and standards for environmental protection; formulating and implementing municipal rules, regulations and standards for environmental protection. Set up and enforce environment requirements in Guangzhou including air quality management for different function zones. Be Responsible for managing the environment monitoring network , including supervisory monitoring on the pollution sources Organize the formulate the Catalogue of New Vehicle Types which meet the Vehicle Emission Standards Organize annual check for all vehicles, random on-road vehicles emission checks (delegated or jointly implement with Traffic Management Bureau, and random vehicle emission check for large fleets or logistics centers/terminals (jointly implement with GTC), Coordinate the development of cleaner energy vehicles
Guangzhou Municipal Traffic Management Bureau (GTMB) under Guangzhou Public Security Bureau,	<ul style="list-style-type: none"> Managing road and traffic safety, maintaining traffic order; handling traffic accidents and administering vehicles and drivers. Managing vehicle registration, regular safety checks, and on-road compliance of traffic rules
Administration of Quality and Technology Supervision of Guangzhou Municipality(GQTS)	<ul style="list-style-type: none"> Publicizing, implementing and enforcing the relevant guidelines and policies, laws, rules and regulations formulated by the State on quality and technical supervision; drafting the municipal rules and regulations on standardization, measurement, quality inspection and safety supervision; directing and supervising the administrative enforcement within the system, Certifying the institutions/organizations qualified for vehicle safety and technology checks and supervise the enforcement of the standards Formulating and implementing the development program for quality and technique supervision; coordinating the quality and technical inspection work with the other industries; supervising and directing the quality and technical supervision work; In the transport sector, GQTS is responsible to supervise and ensure that the I&M and annual check on vehicles (i.e. Trucks) follow the requirements sets for the specific type of the vehicles.
Finance Bureau of Guangzhou Municipality	<ul style="list-style-type: none"> Establish all tax rates including local fuel tax in Guangzhou
Guangzhou municipal Development and Reform Commission	<ul style="list-style-type: none"> The Price Bureau in the Guangzhou Municipal Development and Reform Commission: Set up fees/price for different sectors including transport which are appropriate for Guangdong province

Other Organizations Relevant to the Trucks Pilot Project

Organization type	Description
Associations and partnerships	<ul style="list-style-type: none"> Asian Environmental Compliance and Enforcement Network (AECEN) Air & Waste Management Association (A&WMA)

Organization type	Description
	<ul style="list-style-type: none"> • International Transport Forum, Partnership for Clean Fuels and Vehicles (PCFV) • Regional Forum on Environment and Health
Development and international agencies and foundations	<ul style="list-style-type: none"> • Multilateral development agencies: World Bank, Asian Development Bank (ADB), International Energy Agency (IEA), United Nations Environment Programme (UNEP), United National Center for Regional Development (UNCRD), US Environment Protection Agency (US-EPA), US Agency for International Development (USAID) • Bilateral development agencies: German Technical Agency for International Cooperation (GTZ), Institute for Atmospheric Pollution of the Italian National Research Council (CNR), Norwegian Agency for Development Cooperation (NORAD), Swedish International Development Cooperation Agency (Sida), • Foundations: Energy Foundation, FIA Foundation, Hewlett Foundation
NGOs, academic and research institutes	<ul style="list-style-type: none"> • NGOs: Cascade Sierra Solutions (see annex D), All China Environment Federation (ACEF), Civic Exchange in Hong Kong, • Academic/research institutes: Asian Institute for Technology (AIT), Chinese Academy for Environmental Sciences, Health Effects Institute (HEI), Hong Kong Polytechnic University, Institute for Transportation and Development Policy (ITDP), Tsinghua University, Tongji University, World Conservation Union (IUCN), World Resources Institute Center for Sustainable Transport - EMBARQ (EMBARQ-WRI)
Cities	<ul style="list-style-type: none"> • CAI-Asia works with a network of 13 Chinese cities: Changsha, Chengdu, Chongqing, Guangzhou, Guiyang, Hangzhou, Harbin, Luoyang, Qingdao, Tianjin, Urumqi, Suzhou and Lanzhou.
Private sector	<ul style="list-style-type: none"> • Truck companies • Financial companies • Suppliers of fuel, trucks, equipment, technologies

Annex C – Most Relevant Plans and Policies

Plans, policies and laws/regulations relevant to a Guangzhou trucks pilot project

Policy / legislation	Level	Description	Relevance to the Project
TRANSPORT			
The 11th Five Year Plan of transport sector	National	<ul style="list-style-type: none"> Aims to establish a highway transportation network. Trucks are projected to reach 7 million in 2010 with the shares of heavy-duty trucks, special vehicles, and vans trucks reach 30%, 30% and 20% respectively. (http://www.moc.gov.cn/2006/06tongjisj/06jiaotonggh/shiyiwuguihuajd/guihuajd/200611/t20061107_115042.html) 	
Regulation of the People's Republic of China on Road Transport	National	<ul style="list-style-type: none"> Defines principles and management methodologies on road transport in China 	Core regulation for Guangzhou freight transport
Management Regulation on Road Transportation of Guangzhou province (2002 amendment)	Provincial	<ul style="list-style-type: none"> Defines road transport management in Guangzhou including freight transport, passengers transport, transfer, load and unload, service and maintenance of motor bikes. 	Local and direct management regulation to the freight transport in Guangzhou trucks.
Regulations of Road Administrative Control	National	<ul style="list-style-type: none"> Defines the principle of road administrative control and the duties of road administrative control organizations 	main law for road management
State Council Circular: Decision on the Revision to Protocol of Road Management, 1 January 2009	National	<ul style="list-style-type: none"> Road Construction can be financed through: national and local investments through designated investing organizations, co-financing with international organizations, funding from society, loans, and Vehicle Procurement Tax; Charges can be introduced at main ports, bridges, Tunnels and toll gates of major roads, for the purpose of repaying loans. Approval is required from the Provincial level government. Charge rates need to be agreed by finance and pricing agencies; Roads are classified as national, provincial and local roads. Provincial DOC is responsible for the construction, maintenance and management of the first two types of roads, while the local BOC takes care of the local roads. 	Mandates of BOC/DOC on road transport; How to link the mandates on road construction and toll gate fees with incentives to reduce truck emission?
Decision on Revision to	National	<ul style="list-style-type: none"> Defines that DOC/BOC takes responsibilities for truck fleets and stations business permit and management; 	Very important document: identifies

Policy / legislation	Level	Description	Relevance to the Project
Management Regulation on Road Freight Transportation and Stations by Minister of Communications, July 2008		<ul style="list-style-type: none"> • Regulates approval procedures; • Defines the responsibilities of the business enterprises on transport or Stations; • Specifies the technical standards applied to trucks 	full range of stakeholders: BOC/DOC, Business Owners of Truck Stations, Owners of Truck Fleet, Management fees, set of rules of transportation behavior-overloading, poor maintenance;
ENERGY			
Implementation Methods of Energy Conservation Law in Land and Water Transportation Sector, issued by Minister of Communications	National	<ul style="list-style-type: none"> • Defines the energy saving responsibility of the Ministry of Communications (transport), the Provincial Department of Communications (transport), and the Municipal Bureau of Communications (transport); Administrative Management Framework for Energy Saving in transport sector; Responsible to publish recommended technology for transport vehicles. etc. 	Energy conservation is a key mandate of the Bureau of Communications. Shall have incentives to explore energy saving technologies and strategies
Fuel Efficiency Standards for Commercial Freight Vehicle, Issued by MOC in June 2008	National	<ul style="list-style-type: none"> • Stipulates standards for fuel efficiency 	The standard effects cost of truck freight transport, especially trucks using diesel.
Trial Management Provisions on Qualifications of Freight Transportation Enterprises by Ministry of Communications, 2001,	National	<ul style="list-style-type: none"> • Defines five formal classifications of freight transportation enterprises, main differences are the level of approval and scope of work; Annual Review Requirements; MOC, DOC and BOC are the main approval and administration Agency the Enterprises will report to 	The profile of fleets by classifications will affect the stability of economic outputs of the truck industry? Selection of fleet for pilot studies.
ENVIRONMENT			
Law of People's Republic of China on Environmental Protection	National	<ul style="list-style-type: none"> • Main/general law of environmental protection in China. Defines environmental protection and improvement, and stimulates management methodology for environment protection and monitoring, as well as legal responsibilities. 	One of the guild laws for vehicles management

Policy / legislation	Level	Description	Relevance to the Project
Law of People's Republic of China on Air Pollution Prevention and Control	National	<ul style="list-style-type: none"> Defines air quality and air pollution, including management of vehicles 	One of the guild laws for vehicles management
Limits and measurement methods for exhaust pollutants from compression ignition and gas fuelled positive ignition engines of vehicles(III, IV, V) (GB 17691-2005)	National	<ul style="list-style-type: none"> Light-duty gasoline vehicles and M-types light diesel vehicles need to accord with Grade III Emission standard from Jul 1st 2008, New gasoline vehicles of 1st type need to add OBD system from July 1st 2008; M-type light diesel vehicles need to accord with Grade III Standard in main cities; Vehicle producers have to ensure environmental protection production conformability 	The regulation shows the emission standard required by country for trucks
Management methods of vehicles emission monitoring	National	<ul style="list-style-type: none"> Early policy and measures for vehicle emission control and management, show manage measures for new cars, in-use cars, engines and so on. 	Early policy for vehicles in China, updated by the Air Pollution Prevention and Control Law
Technology and policy on prevention and control for diesel vehicles	National	<ul style="list-style-type: none"> Technology and policy for diesel vehicles, car-use diesel productions and diesel fuel to reduce pollution and control emissions 	This is specific technology and policy for diesel vehicles
Technology and policy on prevention and control for vehicles	National	<ul style="list-style-type: none"> Technology and policy for vehicles(incl. diesel vehicles), motorbikes and car-use engine production to reduce pollution and control emissions 	This policy gives technology and policy for vehicles including diesel and gasoline
Method for Estimation of Air Pollution from Vehicular Emission in Urban Area	National	<ul style="list-style-type: none"> Stipulates the method for estimating air pollution from vehicular emission in urban area as industrial standard 	Relevant in determining the pollution load from trucks and its influence on health

ADB Study: Green Transport, Resource Optimization in the Road Sector in PRC

In this in-depth study financed by the Asian Development Bank (ADB) and implemented by the Ministry of Transport (MOT) of the People's Republic of China, many aspects of 'green transport' are discussed (green transport - a transport system that leaves a smaller physical footprint, uses less energy and produces less CO₂ and other harmful pollutants). The freight sector has been analyzed in detail with some good conclusions. <http://www.adb.org/Documents/Reports/Consultant/39150-PRC/39150-01-PRC-TACR.pdf>

Policies Relevant to Freight Sector mentioned in ADB Study

Chinese legislation and regulations of relevance to GHG emissions	Effectiveness level	Year of release*	Year of implement
PRC's Laws related to Climate Change			
Environmental Impact Assessment Law of PRC	Law	28-Oct-02	1-Sep-03
Environment Protection Law of PRC	Law		
Energy Conservation Law of PRC	Law	28-Oct-07	1-Apr-08
PRC's Transport Legislations related to emission and energy consumption			
Road Transport Regulation of PRC	Regulation	30-Apr-04	1-Jul-04
"Management of Toll Roads"	Regulation	13-Sep-04	1-Nov-04
Provisions for the Administration on Training of Motor Vehicle Drivers	Act	12-Jan-06	1-Apr-06
Policy on Automobile Manufacturing Industry	Policy	16-Jun-05	1-Jun-94
The Suggestion on Application of Smooth Traffic Project to PRC's Urban Road and Transport Management (MoPS & MoCon)	N/A	N/A	N/A
The Regulation on Publication of Energy-Saving Products among Fields of Automobiles and Ships	Regulation	20-Mar-92	1-Jun-92
Popularization and Application of Energy-Saving Products (Technologies) used by Automobiles and Ships	Act	14-Aug-95	15-Oct-95
Detailed Rules among the Transport Industry on the Implementation of the Energy Conservation Law	Act	16-Jun-00	16-Jun-00
PRC's Transport Policy Measures related to emissions and energy consumption			
"fee-to-tax" (fuel tax in PRC)	-	-	-
Congestion toll	-	-	-
Parking pricing	-	-	-

Policy recommendations and implementation responsibility from ADB Study

Recommendation	Responsible Agency
Improve Data Base and Use of IT	
Develop Vehicle Data Base	MOT and All PCDs
Develop Improved method of allocating vehicle	

registration and maintenance fees.	
Set up IC card based management information network systems across both passenger and freight to improve efficiency, with guidelines	MOT and all PCDs
Network Efficiency	
The development of a National Highway Network Management system.	MOT, State Council
Designation of restricted heavy duty truck network	MOT, MSS
Efficiency in Road Transport Vehicles and Fleets	
Remove the impediments to the use of swap trailer transport, including the road maintenance fee charged and insurance policy on each of the trailers, the annual vehicle inspection requirements and the administration procedures	MOT, and All PCDs
Efficiency in Terminal Development and Operations	
Strengthening monitoring on freight forwarder and terminal operation	MOT,
Offer opportunity to private sector in terminal investment	MOT all PCDs Municipalities
Develop Human Capacity to Improve Operating Efficiency	
Publish best practice or guidelines for managers, drivers, mechanics and quality control supervisors to ensure highly efficient operations.	MOT and PCDs

Annex D – Descriptions of Existing Trucks Programs

This annex describes selected US programs only. A more in-depth review is needed to cover the broader range of programs that may exist around the world that are relevant to trucks.

1. Cascade Sierra Solutions (CSS)

Description: A non-profit organization dedicated to saving fuel and reducing emissions from heavy-duty vehicles. CSS operates in the States of Washington, Oregon and California with a primary focus on the Interstate 5 corridor.

Objectives:

CSS aims to achieve the following through truck retrofit and replacement:

1. Improve Fuel Economy
2. Reduce Air Pollution
3. Slow Climate Change
4. Improve Health
5. Promote Trucker Prosperity

Components/ Services:

CSS has outreach centers for truckers which are located at major truck stops and ports. CSS outreach centers provide a non-regulatory, non-profit environment where owner-operators or large fleets can visit a one-stop shop for accurate information on laws affecting their businesses, technology available to meet their needs and low-interest financing to make that technology affordable. Because of the non-profit mission and the bulk discounts CSS negotiate, they can offer SmartWay upgrades and financing at significantly below-market rates. Each outreach center provides the following detailed services:

1. Regulatory advice- CSS presents regulatory information such as rules on idling, emissions and air quality from national, state and local authorities
2. Equipment selection – CSS showcases brands and equipment models that address the USEPA's Smartway Strategies and CSS stakeholder goals. All upgrades and replacement trucks are scientifically verified by our technical advisory team
3. Financing – CSS matches customers with financial assistance to purchase and install energy-efficient or to replace old dirty trucks with clean new ones. Financing may include leases, lease guarantees, grants, tax credits and manufacturer rebates.
4. Installation Contracting and Coordination – CSS coordinates equipment installation with qualified vendors and installers for leased equipment. CSS matches customers with financing option specific to their areas of operations.
5. Monitoring, Testing, Certification and Reporting – CSS will verify use and operation after the sale to ensure program objective s and grant requirements are met.

Organizations Involved:

The CSS Fleet Member Program is designed to monitor, gather and direct funding and information opportunities from regulatory and port authorities and rapidly publish this information to its members. The participants and their responsibilities are:

- Agency/authority – develop rules, review and advise on CSS Fleet Program; prescribe data requirements for programs, grants, incentives; publish program announcements; review and endorse CSS program policies and procedures for consistency and harmony with governing rules/policies
- CSS – set-up of membership program; set-up and on-going management of fleet employer and member accounts
- Fleet employer- Review and accept program participation terms and conditions; review Agency/Authority relationships and uses of the database; set up administrative procedures to protect local files of confidential owner-operator information; present CSS Fleet Member Program to owner-operators to offer participation membership; for participating members, gather the initial data requirements onto a CD Rom and collect the membership fee; monitor notices of grants, loans, incentives, technology announcements, regulatory alerts to fleet members; assist the owner-operator through the process
- Owner-operator member- Together with Fleet Employer, review and approve the terms/conditions of program participation; assemble the truck and operator data, maintain the data on the CSS website to insure accuracy and completeness; receive alerts and notices of opportunities and incentives, regulatory alerts, and technology offerings; receive decision on applications, taking action according to the guidance provided by the agency/authority; if the Owner-Operator does not have a fleet employer, the Fleet Employer and Owner-Operator responsibilities above belong to the Owner-Operator,
- State government agencies such as the Oregon Department of Energy and the Oregon Department of Transportation are involved in financing, particularly in the “Everybody Wins Lease Program” which is a special lease-to-own truck program.CSS is also working with a lot of manufacturers.

Solutions:

Listed below are some of the basic solutions that are highlighted by CSS in saving fuel and emissions from trucks, which are also described in the “Guide to Saving Fuel and Reducing Emissions”

(<https://secure.cascadesierrasolutions.org/downloads/documents/CSS-Guide-Fall08-Web.pdf>):

- Idle reduction
- Improved aerodynamics
- Improved freight logistics
- Automatic tire inflation systems
- Single wide-base tires
- Driver training
- Low-viscosity lubricants
- Reducing highway speed
- Weight reduction
- Fleet modernization

Organizations Involved:

Partnership organizations:

U.S. Environmental Protection Agency

NativeEnergy (<http://www.csrwire.com/News/13885.html>)

Partnership manufacturers: (in figure)



Reference

CSS Website: <https://secure.cascadesierrasolutions.org/index.php>

2. U.S. Environmental Protection Agency Smartway

Description: In 2004, EPA launched SmartWaySM — an innovative brand that represents environmentally cleaner, more fuel efficient transportation options.

In its simplest form, the SmartWay brand identifies products and services that reduce transportation-related emissions. However, the impact of the brand is much greater as the SmartWay brand signifies a partnership among government, business and consumers to protect our environment, reduce fuel consumption, and improve our air quality for future generations.

Objectives: All of EPA SmartWay transportation programs aim to result in significant, measurable air quality and/or greenhouse gas improvements while maintaining or improving current levels of other emissions and/or pollutants.

Components/ Services:

1. Smartway Vehicles - USEPA has developed a Green Vehicle Guide as a resource for the public in selecting next cars, SUVs or light trucks. The Green Vehicle Guide provides air pollution scores and greenhouse gas scores for all vehicles.
2. Smartway transport partnership - The SmartWay Transport Partnership helps progressive companies and organizations recognize that they can improve their bottom line and the environment at the same time. Companies that provide or hire freight delivery and logistics services can become SmartWay Transport partners by committing to improve the environmental performance of their freight delivery operations.
3. Innovative Financing – i.e. The SmartWay Clean Diesel Finance Program uses cooperative agreements to establish innovative finance programs for buyers of eligible diesel vehicles and equipment. Innovative finance projects include those where the loan recipient receives a unique

financial incentive (i.e., greater than regular market rates or conditions) for the purchase of eligible vehicles or equipment. SmartWay also provides information on financial institutions that provide loans for purchase of new or pre-owned trucks through their finance center website.

4. Smartway Tractors and Trailers – They provide information on equipment manufacturers of tractors and trailers.
5. Smartway Grow and Go- They give information on cleaner fuel options such as ethanol, biodiesel, nat gas and propane Smartway Tractors and Trailers
6. Idling Reduction – Smartway also provide information on idling reduction technologies (see below)
7. Upgrade Kits - Upgrade Kits that include an idling reduction device, emissions control device, tractor and/or trailer aerodynamics, automatic tire inflation, and low rolling resistance duals or single wide tires may improve fuel economy up to 15 percent, reduce oxides of nitrogen (NOx) up to 15 percent, and reduce particulate matter (PM) up to 90 percent. Upgrade Kits purchased by trucking companies can be customized to the specific needs of the company.
8. Research and Training - SmartWay's team of researchers collaborate with industry leaders to provide fleet managers and truck owners with the tools and information they need to make smart purchasing decisions and reduce their environmental impact while saving money in the process.

Organizations Involved:

The Smartway Partners would include logistics, truck and rail carriers, shippers, dealers/service centers in EPA's 10 regions.

Technologies/Solutions:

- *Innovative Carrier Technologies*
 - Idle Reduction
 - Improved Aerodynamics
 - Improved Freight Logistics
 - Automatic Tire Inflation Systems
 - Wide Tire Base
 - Driver Training
 - Low-Viscosity Lubricants
 - Weight Reduction
 - Intermodal Shipping
 - Hybrid Powertrain technology
- *Idling Reduction Technologies (Mobile)*
 - Automatic shut-down/ start-up systems
 - Battery powered technologies
 - Fuel-operated heaters
 - Auxiliary power units
- *Idling Reduction Technologies (Stationary)*
 - Electrified parking spaces
- *Upgrade kits*
 - Idle Reduction Device - Bunk Heater
 - Idle Reduction Device - Auxiliary Power Unit or Generator Set
 - Aluminum Wheels for Single Wide Tires

- Trailer Aerodynamics
- Emission control device

Cost-benefit analysis:

A truck retrofitted with a complete kit of our EPA SmartWay™ technology can save up to 25% of the fuel it consumes, about 5,000 gallons/year for a long-haul truck traveling 120,000 miles/year. A fully-upgraded long-haul truck will save the same amount of fuel per year as 15 Toyota Priuses. (source: Toyota Prius saves 337 gallons/year <http://www.google.org/recharge/dashboard/calculator>)

A new truck can get up to 40% better fuel efficiency than the old truck it replaces. CSS is developing truck replacement programs in the West Coast Ports and along the I-5 corridor. All new trucks feature diesel particulate filters which remove 85% of diesel particulate matter emissions.

By saving 1 billion gallons of fuel, we will also save 110 million metric tons of CO₂, 110,000 metric tons NO_x and 5,000 metric tons PM10. (source: Calculation factors from California Air Resources Board's Carl Moyer Program http://www.arb.ca.gov/msprog/moyer/guidelines/2005_Carl_Moyer_Guidelines_Part4.pdf)

The trucking industry is an important strategic area to focus our efforts on—it generates 6% of US global warming pollution and consumes over 10% of our oil.(source: Union of Concerned Scientists http://www.ucsusa.org/clean_vehicles/big_rig_cleanup/rolling-smokestacks-cleaning-up-americas-trucks-and-buses.html)

Diesel particulate matter is more carcinogenic than all other outdoor pollutants combined. It causes 410,000 asthma attacks, 27,000 non-fatal heart attacks and 21,000 premature deaths in the United States every year, killing more Americans annually than terrorism, war, aids, drunk driving or firearm homicide.⁴ One ton of PM2.5 creates \$109,000 in health care costs. (source: Calculation factors from California Air Resources Board's Carl Moyer Program http://www.arb.ca.gov/msprog/moyer/guidelines/2005_Carl_Moyer_Guidelines_Part4.pdf)

Every year, the health and environmental impacts of diesel particulate matter cost Oregonians \$2 billion.(source: Oregon Department of Environmental Quality http://www.lungoregon.org/advocacy/pdf_docs/Clean_Diesel_DEQ.pdf)

Technology	Cost	Benefits (Monthly Fuel Savings)	EW lease payment	Net Monthly Savings
Idle Reduction Device – Bunk Heater	\$1500	\$215	\$30	\$185
Idle Reduction Device – Auxiliary Power Unit	\$8500	\$330	\$170	\$160
Aluminum Wheels & Single Wide Tires	\$5600	\$153	\$110	\$43
Trailer Aerodynamics	\$2400	\$420	\$60	\$360
Exhaust After treatment Device – (DOC) Diesel Oxidation Catalyst	\$1200	\$0 (20-50% PM emission reduction)	\$30	-
Exhaust After treatment Device – Diesel Particulate Matter (PM) Filter	\$6000	\$0 (90% PM emission reduction)	\$120	-

A specific estimate of savings depends upon a number of factors such as truck and engine characteristics, routes driven, fuel costs, service and miles driven. A Smartway Technology Package Savings Calculator that considers a number of these factors, can be found at www.epa.gov/smartway/calculator/loancalc.htm. Truck owners can use this calculator to begin to analyze costs of the various technologies and see resulting fuel savings.

Reference

USEPA Smartway Website: <http://www.epa.gov/smartway/index.htm>

CSS Website: <https://secure.cascadesierrasolutions.org/index.php>

3. U.S. Environmental Protection Agency: Beijing Diesel Retrofit Pilot Program

Description: This project is a cooperative program promoted by the Beijing Environmental Protection Bureau (BEPB) and the USA Environmental Protection Agency (US EPA). The US EPA is providing technical and financial support. The US EPA assigned to Southwest Research Institute (SwRI) the task of managing a pilot project to demonstrate the effectiveness of retrofit technologies. The retrofit technologies consisted of exhaust system retrofit hardware that had been either US EPA verified and/or California Air Resources Board (CARB) certified at the time of project initiation. Another important element in the project was to demonstrate the impact of using low sulfur (less than 50 ppm) diesel fuel on the performance of the retrofit systems.

The project began in November of 2005 and the technical activities ended December of 2007. The fleet of buses involved in the project included a total of 25 buses initially. The fleet included 6 EURO I and 19

EURO II buses. The initial plan called for the EURO I buses to be equipped with diesel oxidation catalysts (DOC) as well as flow through diesel particulate filters (FT-DPF). The EURO II buses were to be equipped with the same two technologies as with the EURO I buses, plus a third technology relying on wallflow diesel particulate filtration (WF-DPF). The three retrofit technologies represented three levels of particulate matter (PM) reduction responsible for 20-40, 40-60, and over 85 percent PM reduction by weight.

Objective:

1. To demonstrate the in-use effectiveness of US EPA-or CARB-verified retrofit devices and low sulfur-as well as ultra low sulfur-diesel fuel on Beijing urban transit buses;
2. To develop quantitative information on costs and real-world emissions reduction of retrofit technologies in Beijing as an example for dissemination to other Chinese cities and Chinese Partnership stakeholders;
3. To build technical and policy capacity in China to implement such a program by working in close collaboration with Chinese partners during this project.

Components/ Services:

1. The following is an abbreviated list of the project tasks and responsibilities:
2. Identification and characterization of the fleet for the project.
3. Select appropriate vehicles within the fleet and retrofit technologies for the project.
4. Procure appropriate low sulfur diesel fuel for the duration of the project.
5. Develop emissions testing protocols and calculate baseline emissions.
6. Procure and install retrofit technologies.
7. Measure emissions reductions from retrofit technologies and analyze emissions data.
8. Provide training for Chinese staff, including SEPA, Beijing EPB, the fleet company, and other stakeholders.
9. Monitor vehicle performance, maintenance and refueling.
10. Develop public outreach materials.
11. Document the costs of the project.
12. Develop policy options for Beijing for reducing diesel emissions from heavy-duty diesel vehicles.
13. Develop a case study report in Chinese and English for the project.
14. Facilitate and serve as secretariat for the Technical Advisory Group.
15. Facilitate continued collaboration between SEPA and Beijing EPB.

Organizations Involved:

This project involves a very special cooperation primarily among BEPB, the US EPA, the Beijing Public Transportation Holding company (BPTH/BBS), SwRI, and SINOPEC. BEPB has enlisted the Beijing Automotive Research Institute (BARI) to coordinate tasks on their behalf. The BBS is providing the buses for the retrofit, a dedicated depot facility, and garage access for enabling installations and maintenance.

Technologies/Solutions:

Three exhaust treatment technologies will be used:

- Diesel oxidation catalysts (DOC) that can reduce particulates by as much as 30%;

- Partial-flow diesel particulate filters (DPF) that can reduce particulates approximately 50%;
- Wall-flow catalytic filters that can reduce particulates by more than 90% when used with low-sulfur diesel fuel.

These retrofit systems will be installed on transit buses owned by the Beijing BaFangDa Services Company (BBS) under the operation of the Beijing Public Transportation Holding Company (BPTH). The BPTH operates a total of about 19,000 buses of which over 5,000 buses are equipped with diesel engines. The buses involved in the retrofit program will be operated in the city of Beijing on pre-selected in-service operating route. The retrofit systems selected for this project must be verified either under US EPA's Voluntary Retrofit Program or the California Air Resources Board's (CARB) retrofit program.

The retrofitted buses will be assigned to operate on one of two different fuels, provided by SINOPEC, to demonstrate the importance of low sulfur diesel fuel. The first fuel will be Beijing's standard No. 2 diesel fuel having a nominal fuel sulfur content of 350 ppm, by weight, and the second fuel is also No.2 low-sulfur diesel that is specially refined for minimum sulfur content.

The retrofit system suppliers will provide installation services and training for the bus company technicians in how to install and properly maintain the equipment and to provide ongoing services as needed, including monitoring of the systems' performance and collecting data necessary to assure the safe and effective operation.

Reference

<https://vault.swri.org/retrofit/>

Beijing Diesel Retrofit Pilot Program Draft Final Report

(Submitted to: US EPA Mr. John Guy Compliance and Innovative Strategies Division

Washington, DC 20460

Issued by: Southwest Research Institute® (SwRI) ®

March 31, 2008)

4. Northwest Ports Clean Air Strategy

Description: This is a strategy (herein referred to as the "Strategy") to reduce maritime and port-related emissions that affect air quality and climate change in the Pacific Northwest via a collaborative approach led by the Ports of Seattle and Tacoma in Washington State and Vancouver in British Columbia.

The Northwest Ports Clean Air Strategy marks the first such international cooperative effort in the port community. It builds on early environmental efforts at each port, and establishes short- and long-term performance measures for reducing emissions from cargo-handling equipment, rail, harbor craft, ocean-going vessels and trucks.

Objective:

1. Reduce maritime and port-related air quality impacts on human health, the environment, and the economy;
2. Reduce contribution to climate change through co-benefits associated with reducing air quality impacts; and
3. Help the Georgia Basin – Puget Sound airshed continue to meet air quality standards and objectives.

Components/ Services:

Short-term (by 2010) actions for all sectors focus primarily on:

- Switching to use of electricity and cleaner fuels and increasing fuel efficiency,
- Retrofitting⁴ existing engines,
- Ensuring best available engine technologies for new equipment purchased in this time frame,
- Initiating demonstration projects to evaluate promising emissions reduction technologies, and;
- Continued operational efficiency improvements during port development.

The short-term actions are intended to achieve real reductions quickly, while the long-term actions will take more time to develop. Although the focus of this Strategy is on actions between now and 2015, the Ports recognize the need to review and adjust the Strategy up to 2015 and beyond in light of new standards, technology, and air emissions data. A major review and update process is planned for five-year intervals through 2015. The suggested activities outlined are potential options for achieving these standards, and would augment those currently underway. A sixth category, Administration, is also included to highlight some of the various administrative actions the Ports are taking to reduce their own diesel and other emissions.

Technologies/Solutions:

Each of the ports, along with their customers and tenants, continues to work collaboratively with air and environmental regulatory agencies to reduce emissions through such initiatives as:

Cargo-handling equipment: Using ultra-low sulfur diesel, biodiesel and other cleaner-burning fuels in cargo-handling equipment

Ships: Using low-sulfur distillate fuels at berth. Adding “green design” environmental features to ships, including diesel-electric motors that save up to 30 percent in fuel and significantly reduce emissions.

Trucks: Setting targets to turn over older, less-efficient truck engines.

Rail: Installing anti-idling devices on rail-switching engines, as well as partnering on other innovative technological advances

Reference

<http://www.portoftacoma.com/Page.aspx?nid=226>

Annex E – Descriptions of Strategies, Equipment and Technologies

This annex provides more detailed description of control strategies, equipment and technologies.^{17,18}

1. Vehicle activity and driving pattern improvement

a. Driver Training

Even highly experienced truck drivers can boost their skills and enhance driving performance through driver training programs. Training that targets fuel efficiency can help drivers recognize and change driving habits that waste fuel. For example, driving 65 mph instead of 55 mph can use up to 20% more fuel. Idling an engine burns almost one gallon of fuel per hour. Driving with the engine rpm too high can waste several gallons of fuel each hour. Other common habits that reduce fuel economy are frequent or improper shifting, too-rapid acceleration, too-frequent stops and starts from failing to anticipate traffic flow, and taking circuitous routes. A few simple changes in driving techniques can produce sizable fuel savings of 5 percent or more. A Canadian study estimates that many fleets could achieve a 10 percent fuel economy improvement through driver training and monitoring. For a typical combination truck, a 10 percent saving is the equivalent of nearly \$2,500. A study for the European Commission estimates that an annual one-day driver training course will improve truck fuel efficiency by five percent. Two trucking fleets in Canada documented the impact of driver training and found fuel efficiency improvements of 18 percent and 20 percent.

Well-trained drivers can reduce fuel consumption by applying a number of simple techniques. These include: use cruise control where appropriate; coast whenever possible; block-shift (go from, for example, 2nd gear to 5th gear); brake and accelerate smoothly and gradually; progressive shift (upshift at the lowest rpm possible); limit unnecessary truck idling; start out in a gear that doesn't require using the throttle when releasing the clutch; limit unnecessary shifting; drive at the lowest engine speed possible; reduce parasitic energy losses by limiting the use of accessories.

Employers, vocational schools, and for-profit training organizations can teach drivers these fuel-saving techniques. Many trucking companies also monitor driver performance and may provide incentives to drivers who reduce fuel consumption. Electronic engine monitors can be used to review drivers' operating patterns and benchmark individual performance over time.

b. Reducing Highway Speed

In the U.S., A typical combination truck spends 65 percent or more of its operating time at highway speeds. Line-haul trucks spend even more time on highways. The impact of speed on fuel economy depends upon many factors including vehicle aerodynamics, engine speed and operating conditions. As a general rule of thumb, increasing speed by one mile per hour reduces fuel economy by about 0.1 miles per gallon. For a truck with poor aerodynamics, the fuel penalty may be nearly twice as great. Higher speed also leads to higher maintenance costs by increasing wear on the engine, tires and brakes.

¹⁷ <http://www.epa.gov/midwestcleandiesel/technology/index.html>

¹⁸ <https://secure.cascadesierrasolutions.org/>

Speed management is an easy and effective way to save fuel, reduce emissions, and prevent excess wear. A trucking firm or driver can adopt a speed policy at little or no cost. The most successful speed management policies combine technology (e.g., speed settings on electronic engine controls) with driver training and incentive programs to encourage drivers to maintain speed limits.

A line-haul truck with 90 percent highway miles that reduces its top speed from 70 to 65 miles per hour could cut its annual fuel bill nearly \$1,500 while eliminating almost 10 metric tons of carbon dioxide. Reducing speed can also cut truck maintenance costs and reduce the frequency of maintenance work. The time between engine overhauls, for example, is directly related to fuel use. Holding maximum speeds at 60 rather than 70 miles per hour reduces engine wear and extends time between engine rebuilds, saving hundreds of dollars per truck each year while keeping revenue-earning equipment on the road.

Reducing highway speed does increase travel time. Assuming ideal conditions, a trucker driving 60 miles per hour instead of 65 miles per hour could spend about eight percent longer on the road. If a trucking company pays its drivers by the mile or by the load rather than by the hour, reducing speed should not increase labor costs. It could reduce the productivity of trucking operations since slower trucks may carry fewer loads. However, the benefits of lower fuel and maintenance costs combined with less frequent out-of-service work and driver safety considerations may well outweigh any costs associated with increased delivery time.

c. Reduced Overloading

See 1.4.

d. Improved Freight Logistics

Inefficiencies in freight operations can cause trucks to travel empty, use longer or more congested routes, and idle unnecessarily. These inefficiencies increase fuel consumption and fuel costs, and cause trucking companies to miss opportunities to generate revenue. When motor carriers cannot arrange for a return shipment, the empty truck move (called a deadhead) doesn't generate revenue but accumulates costs in labor, equipment wear and fuel. Inefficient truck routing and loading and unloading practices also contribute to excessive fuel use and greenhouse gas emissions.

Improved freight logistics can minimize inefficient freight operations, saving fuel and increasing revenue for trucking companies. Improved logistics include load matching, more efficient routes and delivery schedules, and improved shipping and receiving practices.

- Motor carriers can use a variety of load matching strategies to reduce empty mileage. Routes can be arranged so trucks haul successive loads in a triangular pattern. Trucking companies in different areas may coordinate on loads and back hauls. Trucking companies can use freight brokers that match empty carriers with shippers. Drivers may check the electronic monitors (called load boards) available at some truck plazas, for information on loads that shippers have available to carry. The Internet, with its potential for widespread, real time information exchange, offers load matching opportunities via a number of trucking-oriented web sites. Another option is to use an electronic data interchange system to communicate logistics information among dispatchers, drivers, and customers.
- Computerized routing and scheduling software that is based on optimization models can often provide more efficient routing solutions than dispatchers can achieve on their own. This software allows routes to

be constructed taking into account numerous dynamic factors that include driver hours-of-service rules, pick up and delivery schedules, vehicle size constraints, vehicle-product compatibility, equipment availability, vehicle-loading dock compatibility, route restrictions, and empty mileage. Large fleets with 200 or more trucks generally get the most benefit from sophisticated routing and scheduling software. Smaller fleets can use less costly software products to manage their routing and scheduling operations.

- Increased flexibility at loading docks can contribute to fuel efficiency and cost reduction. Innovations like 24/7 shipping-and-receiving allow trucks to travel at off-peak times and avoid traffic congestion. With more flexibility to deliver and pick up loads, trucking companies can decrease idling, minimize the time spent loading and unloading, and use their hours and equipment to haul freight and generate revenue.

Improved logistics can increase the return load and reduce the miles that a truck drives empty. Eliminating 15 percent of a line-haul truck's empty miles could save \$3,000 in fuel and reduce 24 metric tons of carbon dioxide annually.

Improving freight logistics demands good management within the company and the coordination between different fleets. Some cases have proved their effectiveness in China. It also needs good technical support to ensure a high-efficient logistics management system.

There are some freight logistics improvement practices in other areas in China.

- Develop logistics park/center for intermodal transport (A case in Zhejiang province, China:
<http://www.logink.org/zjhy/web/qy/xxjs.jsp?uid=10000025>)
- To establish logistics platform (Chongqing case—Road freight transport information exchange system: <http://www.cq56.net/>)

2. Enhanced Maintenance

Current annual inspection is not strict enough to promote good maintenance in Guangzhou. The proper maintenance of trucks can improve their fuel economy and decrease their emission by more than 10%. Based on the current survey, the maintenance status was poor for most small freight transportation companies. Even some big companies cannot ensure timely and correct maintenance strategies which may improve the fuel economy. Enhanced maintenance demands advanced technical guidance and efficient management scheme within the fleet.

3. Vehicle Body Improvements

a. Truck Weight Reduction

Truck fuel consumption increases with the weight of the vehicle. Many truck components are typically made of heavier material, such as steel. Heavier trucks require more fuel to accelerate and to climb hills, and may reduce the amount of cargo that can be carried.

Every 10 percent drop in truck weight reduces fuel use between 5 and 10 percent. Generally, an empty truck makes up about one-third of the total weight of the truck. Using aluminum, metal alloys, metal matrix

composites, and other lightweight components where appropriate can reduce empty truck weight (known as “tare weight”), improve fuel efficiency, and reduce greenhouse gas emissions. Weight-saving options include:

- Aluminum alloy wheels, axle hubs, clutch housings, and cab frame can trim hundreds of pounds from a truck tractor. Downsizing to a smaller engine can also provide significant weight savings.
- Thousands of pounds can be reduced from a truck trailer using aluminum roof posts, floor joists, upright posts, and hubs and wheels.

Lighter-weight alternative materials can cost more. According to truck retailers, lighter-weight truck tractors cost about \$2,000 more than comparable standard models. Trailer manufacturers report a similar cost premium. Therefore, use of lighter-weight truck options is more common in freight applications that are weight-sensitive, like heavy-goods and refrigerated foods. However, virtually any truck fleet could employ weight saving strategies.

Reducing 3,000 pounds from a line-haul truck by using lighter-weight components could improve fuel economy by three percent and save up to 500 gallons of fuel annually and eliminate up to five metric tons of carbon dioxide.

b. Improved Aerodynamics

Aerodynamic drag (wind resistance) accounts for most truck energy losses at highway speeds. Reducing drag can improve fuel efficiency. The longer the drive and the higher the speed, the greater the potential efficiency benefits. Manufacturers made significant progress in reducing the drag coefficient (a measure of wind resistance) of a typical freight truck from about 0.8 to about 0.65 – an improvement of nearly 20 percent. Additional efforts to improve aerodynamics could result in a further 20 percent reduction in the drag coefficient. This could have a significant impact on fuel economy. For example, cutting drag by 25 percent could raise fuel economy up to 15 percent at highway speed.

Improving the aerodynamics of a typical line-haul truck by 15 percent could cut annual fuel use more than 2,000 gallons, save over \$6,000 in fuel costs, and eliminate 20 metric tons of carbon dioxide. The following strategies can be applied to improve the aerodynamics of a truck.

- Truck tractor aerodynamics can be improved by roof fairings (an integrated air deflector mounted on the top of the cab), cab extenders (known as gap seals, which reduce the gap between the tractor and the trailer), side fairings, and a front bumper air dam (to reduce air flow beneath the truck). Truck manufacturers offer aerodynamic models that include a streamlined front profile, sloped hood, and a full package of add-on devices. These tractor models can improve fuel economy by up to 15 percent, when compared to similar models without aerodynamic devices. For a typical combination truck, improving aerodynamics by 15 percent would cut annual fuel use by up to 2,430 gallons and save up to \$3,644 in fuel costs.
- Trailer aerodynamics can be improved minimizing the gap between the tractor and the trailer, to reduce air turbulence. Specifying wheelbase and fifth-wheel settings that position the trailer as close to the rear of the tractor as possible can reduce tractor-trailer gap. Reducing trailer gap from 45 to 25 inches could improve fuel economy as much as 2 percent. Another innovative trailer option is to use side skirts. These panels hang down from the bottom of a trailer to enclose the open space between the rear wheels of the tractor and the rear wheels of the trailer. According to the manufacturers, trailer side skirts can improve fuel economy by up to 5 percent. Cargo “profile” is also

important. On flatbed trailers, reduce drag by arranging cargo as low and smooth as possible. Secure loose tarpaulins and close the curtains on empty curtain-sided trailers to improve fuel economy by up to 2.5 percent and 4.5 percent, respectively. Single-unit trucks can be improved with air deflector bubbles or by purchasing new streamlined models.

- Many new single-unit truck models incorporate a sloped hood and a more streamlined front profile as a standard feature in order to reduce drag. Rounded air deflector bubbles can be added to single-unit trucks with van-style bodies to reduce drag; manufacturers claim fuel economy benefits of 5 to 10 percent. This would yield annual fuel savings of 82 to 165 gallons, saving \$124 to \$247 in fuel costs. Single unit trucks with higher annual mileage could realize even larger benefits.

Improving the aerodynamics of trucks demands high technical support to ensure a success. The emission reduction effectiveness can be remarkable. Truck owner can also benefit significantly from the fuel saving. It will be highly recommended if the technology is available in China.

c. Automatic Tire Inflation Systems

When not properly inflated, tires flex more under load, producing heat and increasing rolling resistance, which wastes fuel. Truck tires inflated ten pounds per square inch (psi) below recommended air pressure levels can reduce truck fuel economy from 0.5 percent to one percent. Heat and stress from improper inflation soften and deflect tire components, causing faster and more uneven wear, which shortens the life of the tire. Under inflated tires have more frequent punctures, increasing the risk of tire failures that could lead to costly road service and loss of revenue.

Even a good tire maintenance program may fall short of its aims. In part, this is because trailer tires have more impact on truck fuel economy than tractor tires, yet trailers are interchangeable and thus harder to monitor. Since the bulk of the load is carried in the trailer, a 10-psi under inflation in a trailer tire may have nearly twice the impact on truck fuel economy as the same amount of under inflation in a drive tire. Despite the importance of keeping trailer tires properly inflated, a fleet may not be able to inspect its trailers regularly. A trailer may be gone from the service yard for extended periods of time while on the road, at a customer's facility or at drop-off location waiting for a back haul. A fleet may not even own the trailers it hauls, but pick them up from a shipper or third party. These circumstances can place much of the responsibility for checking tire pressure onto drivers. However, an industry survey in the U.S. indicates only eight percent of truck drivers check tire pressure with a tire gauge before each trip.

Automatic tire inflation (ATI) systems can monitor and continually adjust the level of pressurized air in tires, maintaining proper tire inflation automatically, even while the truck is moving. One ATI system uses the vehicle's own air-brake compressor to supply air to all the tires. Another system uses self-contained compressors mounted on each hub that are powered by the rolling motion of the wheels. Once an ATI system is installed, it should not require any special attention from the driver.

Retrofitting a line-haul truck with an automatic tire inflation system could save 100 gallons of fuel annually and reduce tire wear and maintenance, while eliminating one metric ton of carbon dioxide.

d. Single Wide-base Tires

Besides ATI system, using single wide-base tires is also a promising fuel efficiency improvement strategy. A single wide-base tire and wheel is lighter than two standard tires and wheels. Total weight savings for a typical combination truck using single wide-base tires on its drive and trailer axles ranges from 800 to 1,000 pounds. The weight savings would reduce fuel consumption, or increase cargo capacity for truck trucks that are weight-limited. Wide-base tires have lower rolling resistance and aerodynamic drag, and generate slightly less pass-by noise than do dual tires.

Wide-base tires can improve the stability of tank trailers by allowing the tank to be mounted lower. In a test of 15 fleets driving 57 million miles using its latest wide-base tire models, one manufacturer reported that the tires wear at a rate comparable to conventional tires. Wide-base tires also can be retreaded.

Several factors associated with wide-base tires have limited their use to date. Some of the factors result from fleets' unfamiliarity with this technology, and its lack of availability. Wide-base tires are not as yet widely stocked by repair facilities, so drivers might not easily find replacements while on the road. Fleets may need to alter retread methods, and monitor air pressure more closely. The shift in wheel bearing load position could stress and prematurely shorten the life of certain wheel ends. Since the tires are not paired, some drivers question whether they would be immobilized if a wide-base tire failed. Tire makers respond to this concern by noting that since most combination trucks have tandem axles, they could still operate if a wide-base tire fails.

Specifying single wide-base tires on a new combination truck could save \$1,000 immediately and reap annual fuel savings of two percent or more while cutting carbon dioxide by more than four metric tons.

In a recent report the Department of Energy's Oak Ridge National Laboratory confirms that wide single tires are more fuel efficient than duals on heavy trucks. More than 700,000 real-world miles were driven by six instrumented tractors and 10 trailers over the course of the four-year test. Primary data collected during the tests includes instantaneous fuel consumption, speed, acceleration, gear, location, time of day and grade. Half of the tractors were outfitted with Michelin X One wide single tires, and half with standard dual tires. Half of the trailers were outfitted with Michelin X One wide single tires, two with standard dual tires, and three with dual retread tires. Oak Ridge researchers found significant fuel efficiency improvement over dual tires when wide singles were in use - 6 percent overall and 10 percent with fully-loaded tractor-trailers.

e. Low rolling resistance tires

If single-wide based tires are not an option, for example due to regulatory barriers (e.g. this is the case in China), then an alternative is to replace existing tires with low rolling resistance tires. The number of tires stays the same, but fuel consumption is reduced due to reduced tire resistance on the road.

4. Idle Reduction

Many long-haul truck drivers idle their engines during rest periods to:

- provide heat or air conditioning for the sleeper compartment
- keep the engine warm during cold weather
- generate electrical power for appliances

Several technological options can assist drivers in reducing truck idling.

- Auxiliary power units (APUs) are mounted externally on the truck cab. An APU typically consists of a small combustion engine and generator combination that can provide power to the truck when the main engine is shut off. Electricity from an APU can be used to power heating, air conditioning, and electrical accessories for the cab and sleeper.
- Automatic engine idle systems start and stop the truck engine automatically to maintain a specified cab temperature, or to maintain minimum battery charge. Drivers typically activate the system in the evening and program a desired temperature range.
- Truck stop electrification allows trucks to use electrical power from an external source. At properly equipped truck stops, drivers can shut the main truck engine off and plug into an electrical outlet that provides power for heaters, air conditioners, marker lights, and other accessories. Trucks need to be equipped with the required internal wiring, inverter system, and HVAC system to take advantage of truck stop electrification.
- Advanced truck stop electrification also provides electricity from an external source, but doesn't require the truck to be equipped with special systems. Truck parking bays are installed with equipment that provides the cab with electrical power, and heating, cooling, and other amenities like telecommunication hook ups, through an external console that fits into the truck's window frame. The truck-side console has temperature controls, an air supply and return pipe, a credit card reader, keypad, and AC outlet.

An idling truck burns nearly one gallon of diesel fuel per hour. Based on the survey in the U.S., Trucks idle an average of 1,900 hours per year. Reducing unnecessary idling could save nearly \$4,750 in fuel costs, cut air pollutants, and cut 19 metric tons of carbon dioxide annually. In China, especially in Guangzhou, the status of idling of trucks needs to be further investigated. The effectiveness of idle reduction strategies can be defined with the survey finding.

5. Fuel and Lubricant Improvement

a. Ultra-low sulfur diesel (ULSD)

ULSD with sulfur lower than 50ppm or even 10ppm for on-road trucks can reduce the emission of all in-use trucks with or without other emission-control devices. Their effect on regulatory pollutants and after treatment devices is well known. The low sulfur strategy should be adopted by the government and all truck fleets can benefit.

b. Low-Viscosity Lubricants

Lubricants can reduce friction and wear of critical vehicle systems including the engine, transmission and drive train. Conventional mineral oil lubricants may have too high viscosity to effectively slip between and lubricate the moving parts of these systems, particularly in newer truck components that are designed with close tolerances and tight fits.

Low-viscosity lubricants are less resistant to flow than conventional lubricants, a property that helps reduce friction and energy losses. Depending upon the application, low-viscosity lubricants may also contain additives designed to withstand the extreme pressure (EP) that could occur as the lubricant flows between tight-fitting parts. Low-viscosity lubricants may be made from synthetic or mineral oil blends with low

viscosity and EP additives. Manufacturers generally offer low-viscosity blends as “fuel economy” lubricants, since the fuel-saving potential of these products is significant.

When used in a typical combination truck, synthetic engine and drive train lubricants can improve fuel economy by three percent, saving nearly 500 gallons of fuel and cutting five metric tons of carbon dioxide annually. Synthetic and semi-synthetic lubricants typically cost more than conventional mineral oil lubricants. Truck service stations suggest that semi-synthetic oils cost about 50 percent more than conventional mineral oils. However, for most trucks, the fuel cost savings generally outweigh the higher lubricant cost.

c. Oil By-pass Filtration System

Increased engine wear contributes to power loss which translates directly to increased fuel consumption. Oil bypass filtration technology applies bypass oil filters designed to remove solid, liquid, and gaseous contaminants from engine oil. The change interval of engine oil will be extended, so the cost of engine oil and related maintenance can be reduced by more than 80%. The damage of contaminants in engine oil will be reduced, which can improve the engine fuel efficiency.

6. Emission Retrofit

a. Emission Retrofit with DPFs

Diesel particulate filters (DPFs) can remove particulate matter from the diesel exhaust through physical filtration. They also have some passive or positive clean strategies to remove the carbon and organic particles captured which is also called regeneration. Emission retrofit with DPFs has been widely applied on diesel trucks around the world. Both USEPA and CARB have special verification processes for diesel retrofit technology. Currently all CARB Level 3 certified products adopt DPF technology. The particulate reduction effectiveness can be more than 85% as certified. DPFs can also reduce emissions of hydrocarbons and carbon monoxide by 60 to 90 percent. DPFs must be used with ultra-low sulfur diesel fuel (ULSD – 15 ppm sulfur). Use of regular diesel fuel in a DPF equipped bus could eventually clog the filter. This could lead to exhaust back-pressure increases and engine damage.

USEPA verifies individual DPFs based on information supplied by the DPF manufacturer. Since USEPA generally receives results of testing conducted on a limited number of diesel engine models, a conservative approach is taken to establish the verified levels of reduction. In most cases the actual reductions are higher than the verified values. The list of DPFs and other technologies that USEPA has verified can be found at www.epa.gov/otaq/retrofit/retroverifiedlist.htm.

b. Emission Retrofit with DOCs

Diesel oxidation catalyst (DOCs) is another diesel retrofit choice. DOCs can remove the organic carbon component of particulate emissions. Diesel sulfur will affect its effectiveness because diesel sulfur may hurt the catalyst. Another reason is that DOCs may oxidize sulfur into sulfate-based particulate emission. USEPA and CARB also have special verification process for DOCs technology. The particulate reduction effectiveness can be 25% as certified by USEPA and CARB. DOCs also reduce emissions of hydrocarbons by 50

percent and carbon monoxide by 40 percent. DOCs can be used with regular diesel fuel, but the effectiveness of a DOC may be increased with the use of ultra low sulfur diesel (ULSD – 15 ppm sulfur).

USEPA has a special verification process to evaluate the emission reduction performance of retrofit technologies such as DOCs, including their durability, and identifies engine operating criteria and conditions that must exist for these technologies to achieve those reductions. The list of DOCs and other technologies that USEPA has verified can be found at www.epa.gov/otaq/retrofit/retroverifiedlist.htm.

7. Fleet and Engine Modernization

a. Fleet Modernization

The latest emission standard adopted in Guangzhou was Euro III. Figure 1 illustrates the NO_x and PM emission reduction ratio of Euro 1 China Euro 4 as compared with Euro 0. The data was achieved from the Emission Inventory Guidebook published by European Environment Agency in 2007. The framework of vehicle emission standard is similar to the system of European Union. Purchasing a new Euro III truck can reduce diesel particulate emissions by 82% and Oxides of Nitrogen (NO_x) by 64% as compared with old Euro 0 trucks. The PM emission of an old truck can be more than 30 times higher than a Euro 4 truck.

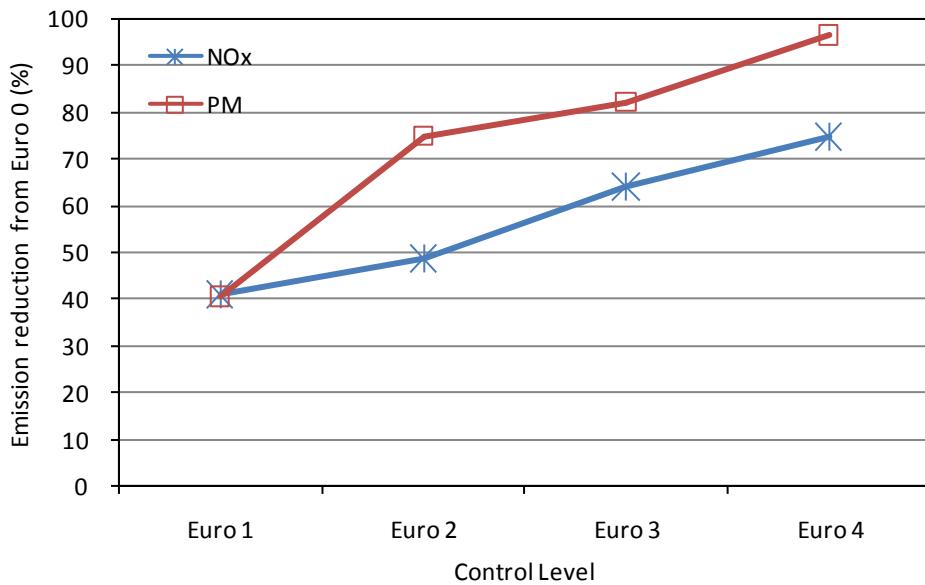


Figure A: Emission reduction compared with Euro 0 (%)

Hybrid electric technology combines a conventional propulsion system with a rechargeable energy storage system to achieve better fuel economy. Many hybrid system reduce idle emissions by shutting down the conventional engine at idle and restarting it when needed. Hybrid diesel-electric system can save fuel consumption by up to 60% and reduce diesel engine idle by up to 87%. The maintenance cost, vehicle GHG emission and engine noise will be also reduced. The system can also be designed to provide energy for use during engine-off worksite operations. As an additional benefit, should the hybrid electric system go off-line, conventional engine operation continues. Some hybrid electric system maintains conventional drive train architecture while adding the ability to augment engine torque with electrical torque.

b. Engine Replacement

Besides truck modernization, replacing old engines is also an available control strategy. The effectiveness of engine modernization is similar to purchasing new trucks. Replacing an old engine with one certified for Euro 3 can reduce the PM and NOX emission by more than 60%. The replacement engine may not necessarily be a conventional, newer and cleaner diesel engine, but could be an electric or hybrid engine. But the quality control of engine replacement is very important to ensure good performance of new engines on old trucks.