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中国机动车排放控制措施评估

—— 成功经验与未来展望

Overview of China's Vehicle Emission Control Program

Past Successes and Future Prospects

icct
THE INTERNATIONAL COUNCIL
ON CLEAN TRANSPORTATION

国际清洁交通委员会（ICCT）的目标是通过提高私人交通、公共交通及货运交通的环保性和能效性，从而保护和改善公众健康、环境和生活质量。委员会由来自多国的官员和专家组成，与大家共享他们在空气质量、气候变化和交通领域的丰富经验。国际清洁交通委员会通过推广最佳的实践经验和全面的解决方案，来降低车辆排放、提高能效、改善燃料品质、开发可持续替代燃料、减少在用车污染并削减来自国际运输（空运、海运）的污染排放。

The goal of the International Council on Clean Transportation (ICCT) is to dramatically improve the environmental performance and efficiency of personal, public and goods transportation in order to protect and improve public health, the environment and quality of life. The Council is made up of leading regulators and experts from around the world that participate as individuals based on their experience with air quality, climate change, and transportation issues. The ICCT promotes best practices and comprehensive solutions to improve vehicle emissions and efficiency, increase fuel quality and sustainability of alternative fuels, reduce pollution from the in-use fleet, and curtail emissions from international goods movement.

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目录

图

表

Table of Contents

Figures

Tables

1. 概述

背景

在不到一代人的时间内，中国成为了世界机动车生产和销售市场的第一大国。在许多城市，从前满街自行车的景象已被拥堵的机动车流所取代，而这其中，大部分是国产的轿车、摩托车、卡车和巴士。中国的汽车年销售量（不含摩托车和农用车）从1980年的25万辆增长至2009年的1400万辆。摩托车的销售量（包含电动自行车）也从80年代的60万辆飞速增长至2009年的5000万辆以上。

环境保护部于2008年正式成为国务院组成部委，该部及其前身[1]长期致力于减少机动车及其它空气污染。在过去的10年中，根据中国《大气污染防治法》的规定，中国已经实施了一系列逐步加严的机动车和燃料管理标准，配合相关监督及维修保养措施，划定限行区，以求改善空气质量。然而，快速增长的机动车数量带来了严峻的挑战。一辆辆汽车走下流水线，加入到城市交通，对本已不堪重负的空气造成更多污染。随着工业企业逐渐搬离各大城市，交通领域成为细微颗粒物(PM2.5)、灰霾、烟雾和其它严重空气质量问题的主要源头之一[2]。而由此引发的健康危害则包括过早死亡和提高呼吸道及心血管疾病的发病率。

出于减少石油依赖性的考虑，中国于2005年引入了轻型乘用车和摩托车燃料消耗标准，成为世界上为数不多的首批实施这类法规的国家之一。的确，在过去的15年当中，中国已经从一个石油自给自足的国家逐渐成为世界上最大的原油进口国之一。20世纪末，中国已经成为仅次于美国和日本的世界第三大原油消耗国。而促使中国原油消耗量增长的一个主要因素就是快速增长的交通流量，特别是机动车数量的增长[3]。2009年，交通领域所消耗的原油约占中国原油总消耗量的60%。

目标和方法

受中国环境保护部的委托，国际清洁交通委员会（以下简称ICCT）对中国机动车排放控制政策实施的成果与不足进行评估。此外，环保部要求ICCT对不同政策选择和实施情景进行短期和较长期（2010-2030年）的分析评估，政策涉及城市和区域空气污染以及气候影响。实施情景分析包括对实施更加严格的车辆和燃料标准、改善实施措施、加严燃料消耗量标准以及新能源车辆技术和替代燃料的影响进行分析评估。

ICCT在此报告中的评估结果既包括了各种情景下对常规排放物、温室气体排放、燃料消耗和公众健康影响的定量分析，也包括中国在这些方面的政策措施与国际先进措施的定性对比。此次，ICCT与环保部下属的政策研究机构机动车排污监控中心（以下简称VECC）紧密合作，此外还有由贺克斌教授领导的来自清华大学的研究人员，负责采集中国机动车保有量和环保部相关项目的详细信息和数据。

1 环境保护部的前身为1974年成立的国务院环境保护领导小组，之后于1978年成为城乡建设环保部的环保局，1988年成为国务院直属的国家环境保护局，1998年成为国务院直属的国家环境保护总局。在2008年，环境保护部正式成为国务院组成部委。

2 柴发合，2009，《“十二五”中的大气污染控制法规》，发表于第五届区域空气质量管理会议，中国北京，09年10月26日。郝吉明，2008，《通过排放控制保障北京奥运期间空气质量》，08年11月6日。

3 贺克斌、霍红、张强、何东全、Michael Walsh、王全录，2005年，《中国道路交通燃料消耗和CO_2排放现状、未来趋势及政策实施》能源政策33卷。

1. Executive summary

Introduction

In less than a generation, China has become the world's leading motor vehicle market in terms of both production and sales. The iconic image of bicycle-filled boulevards has been replaced in many cities by one of congested roadways where primarily domestically produced cars, motorcycles, trucks, and buses vie for space. Annual sales of on-road vehicles (excluding two-wheelers and rural vehicles) have grown from roughly 250,000 in 1980 to nearly 14 million in 2009. Annual sales of two-wheelers (including electric bikes) have grown from about 600,000 to a staggering 50 million plus.

The Ministry of Environmental Protection (MEP), which achieved cabinet-level ministry status in 2008, is on the front line of efforts to mitigate the air pollution resulting from these vehicles and other sources[1]. In the last decade, under the auspices of the China Air Pollution Prevention and Control Law, China has implemented a series of increasingly stringent vehicle and fuel standards, inspection and maintenance programs, and traffic restriction zones to improve air quality. However, the rapidly growing vehicle fleet poses a great challenge. Every vehicle rolling down the assembly line and joining traffic on those roadways adds to an already heavy burden of air pollution. With industry increasingly located away from the big cities, motorized transportation has become one of the leading contributors to fine particulate matter pollution (PM2.5), haze, smog, and other serious air quality problems[2]. The resulting public health impacts range from increased risk of premature death to rising incidence of respiratory and cardiovascular diseases.

Driven by oil independence concerns, China was among the first countries in the world to adopt its first phase of fuel consumption standard for light-duty passenger vehicles in 2005 and has also regulated motorcycle fuel consumption. Indeed over the past decade and a half, China has gone from being self sufficient in oil to becoming one of the largest importers in the world. By the end of the 20th century, China became the world's third largest oil consumer after the US and Japan. One of the major drivers of this increase in Chinese oil consumption is the rapid growth of the transportation sector in general and motor vehicles in particular[3]. About 60% of China's oil consumption in 2009 was for transportation.

Objectives and methodology

At the request of MEP, the International Council on Clean Transportation (ICCT) has undertaken an assessment of the accomplishments to date and deficiencies of China's current vehicle emission control program. Further, MEP asked the ICCT to assess the impact of various policy options and implementation scenarios in the short- and longer term (between 2010 and 2030) covering urban and regional air pollutants as well as emissions of climate forcers. The scenarios are to include the potential tightening of vehicle and fuel standards along with improvements to the compliance program, improvements in fuel consumption standards, and the impact of advanced vehicle technologies and alternative fuels.

1 The MEP, formerly known as the State Council Leadership Group of Environmental Protection, was established in 1974. The agency was elevated to become the Bureau of Environmental Protection under the Ministry of Urban and Rural Construction and Environmental Protection in 1978, then became the National Environmental Protection Agency (NEPA) in 1988, directly reporting to the State Council. In 1998, NEPA became the State Environmental Protection Administration (SEPA) directly under the State Council. And in 2008, it was formally elevated to the cabinet-level as the Ministry of Environmental Protection, as one of the ministries of the State Council.

2 Chai Fahe, 2009. Air Pollution Control Law in the 12th Five Year Plan. Presentation at the 5th Regional Air Quality Management Conference, Beijing, China. 10/26/09; Hao Jiming, 2008. Emission Control to Guarantee the Air Quality during the Olympic Games in Beijing. 11/6/08.

3 He, Huo, Zhang, He, Walsh and Wang, 2005. Oil consumption and CO_2 emissions in China's road transport, current status, future trends and policy implication. Energy Policy Vol. 33.

此次的定量分析主要以中国机动车模型（China Fleet Model, CFM）及健康影响评估方法（Health Impact Assessment, HIA）[4]为基础。CFM模型能够根据以往和今后的不同政策方案，测算中国机动车的排放和燃料消耗。该模型能够测算所有与空气质量和气候变化相关的排放污染物，如一氧化碳、氮氧化物、碳氢化合物、颗粒物、二氧化碳、一氧化二氮、甲烷和黑炭。使用者可以在该模型中设定不同的新车排放标准、燃料硫含量和车辆燃料消耗标准情景。使用者还可以在模型中调整政策的执行实施效果以及电动车的推广程度。

为了评估现有政策，ICCT进行了一项对比，即以上世纪90年代末为起点，将执行车辆和燃料标准以及相关排放控制手段与不实施任何管理办法的效果进行对比（“现行管理”对比 “无管理”）。

在对未来进行预测时，排放量与燃料消耗量的预测，都是假定实施了管理措施，即所有目前采用的管理方案措施都有效的实施，并考虑了车辆保有量的持续增长。对未来的政策方案改善进行潜在评估时，多设计了两个额外的情景（“改善方案”与“强化方案”）。我们同时评估了这两种情景稍有差异的情况下延迟实施机动车标准（推迟到2020年实施国VI标准，而不是2015年）所带来的影响。我们还特别设计了一个情景，来反映城市地区的不同政策选择（“城市改善方案”）。在开发设计这些情景时，我们咨询了来自VECC和清华大学的项目人员以及环保部的官员。排放和燃料标准、燃料消耗量标准和实施方案的情景设计反映了项目人员对今后10-20年中可能取得的进展的最佳判断。情景设计详见表1.1。

在进行定性分析之初，我们深入的研究了制定新车和燃料标准及其执行方法的最佳经验。为了达到这一目的，我们综合了美国、欧盟、日本的成熟机动车排放控制措施，并将这些与中国国情相结合。与此同时，ICCT在VECC与清华大学的协助下，了解掌握了中国现行的管理措施。我们重点研究了排放标志，这是一种为消费者提供信息和实施在用车管理的手段。ICCT还开展了燃料经济性/消耗量和温室气体方案以及替代燃料和新能源汽车方案的评估。虽然这些项目目前尚不是环保部的工作重点，但随着对交通领域气候影响的增加，环保部将越来越多的参与到这些领域当中。对于所有评估的项目，ICCT都会将中国现有措施与国际先进案例进行对比，并指明中国在未来发展中的障碍。

4 中国机动车模型及健康影响评估方法资料详见附录B。

The ICCT assessment presented in this report includes a quantitative analysis of each scenario's impact on conventional and climate forcer emissions, fuel consumption and public health as well as a qualitative comparison of China's programs to international best practices. The ICCT team worked closely with the Vehicle Emission Control Center (VECC), which is a policy research center affiliated with MEP, and a team of researchers from Tsinghua University led by Prof. He Kebin to assemble detailed information and data about China's vehicle population and MEP's programs.

The quantitative analysis is based on the China Fleet Model (CFM) and the Health Impact Assessment (HIA) tool[4]. The CFM can estimate emissions and fuel consumption from the entire Chinese vehicle fleet under a variety of past and future policy scenarios. The model estimates all the major emissions of concern for air quality and climate change such as carbon monoxide, oxides of nitrogen, total hydrocarbons, particulate matter, carbon dioxide, nitrous oxide, methane and black carbon. The model user can customize policy scenarios that cover new vehicle emission standard levels, fuel sulfur concentration and vehicle fuel consumption limits. The model user can also adjust the effectiveness of enforcement and compliance programs and the penetration of all-electric vehicles.

To assess the current program, the ICCT compared the vehicle and fuel standards implemented to date and the existing compliance efforts with the emissions which would have occurred if no program improvements had been adopted beyond those already in effect by the late 1990's ("Business as Usual" vs "No Regulation").

Looking ahead, emissions and fuel consumption estimates were made assuming that business as usual, i.e., all currently adopted program elements are fully implemented while forecasted vehicle population growth continues. To assess potential program improvements in the future, two additional scenarios were constructed ("Improved Program" and "Strong Program"). A variation on these two scenarios was analyzed to evaluate the impact of delayed implementation of vehicle standards (China VI in 2020 instead of 2015). A special scenario was also created to reflect policy options for urban areas ("Improved Urban Program"). These scenarios were developed after consulting with the project team at the VECC and Tsinghua University and stakeholders within the MEP. The emissions and fuels standards, fuel consumption requirements and compliance program elements set forth in these scenarios reflect the project team's best judgment for what can be achieved over the next one to two decades. The scenarios are further defined in Table 1.1.

The qualitative analysis begins with an in-depth review of best practices for setting new vehicle and fuel standards and enforcing compliance. To this end, mature vehicle emission control programs in the United States, the European Union, and Japan are synthesized and related to the Chinese context. In parallel, the ICCT team documented, with the help of the VECC and Tsinghua University, the implementation of the current Chinese programs. A closer look was given to emission labels, an important consumer information and in-use program enforcement tool. The ICCT also included a review of fuel economy/consumption and GHG programs as well as alternative fuel and new energy vehicle programs. Although these programs are currently not MEP's primary focus, the Ministry's involvement is expected to grow as concerns about transportation's climate impact redefine MEP's scope. For each program reviewed, the ICCT team compared China's current program to the global best practices and identified barriers to further progress in China.

4 The China Fleet Model and Health Impact Assessment tool documentations are available in Appendix B.

表 1.1: 情景设定说明

情景设定	排放标准	燃料标准	燃料消耗量标准	实施方案	电动车比例
无管理	止步于1999年标准	止步于1999年标准	无	只进行型式核准	无
现行管理	国I, II, III, (IV)	国 I, II, III	轻型车: 第I、II 、III阶段标准 (每年加严2%); 对重型车无管理要求	10% 的车辆为高排放车	无
改善方案	2015年实施国VI	2015年，低硫汽柴油 (50 PPM)	轻型车: 每年加严3%; 重型车:从2015年起，到2030年加严 20%	到2015年，仅5%的车辆为高排放车	轻型车: 2030年, 新车销售的5%为电动车
强化方案	国 V (2012) 国VI (2015)，2020年实现“超低排放”(轻型车) 及 “国 VII”(重型车)	2015年，超低硫汽柴油(10 PPM)	轻型车: 每年加严4%; 重型车:从2015年起，到2030年加严 50%	到2020年, 仅3%的车辆为高排放车	轻型车: 2030年, 新车销售的10%为电动车
城市改善方案	2012年国 IV + 柴油车颗粒物捕集器，2015年国VI	2012年，低硫汽柴油(50 PPM)	同改善方案	同改善方案	同改善方案

结论

尽管车辆保有量和使用率都有巨大增长，中国的车辆排放控制措施还是能有效的削减常规污染物排放。根据中国机动车模型（CFM），从2000年到2010年，较之无管理情景，现有管理措施累计减排4450万公吨总碳氢化合物（THC）、2.387亿公吨一氧化碳（CO）、3800万公吨氮氧化物（NOx）和700万公吨颗粒物（PM）。图1.1展示了两种情景的对比5。中国机动车模型（CFM）数据源、假设和方法论详见附录B。

5 该模型不能评估过去的燃料消耗和CO_2，因为该模型只能计算2010年之后的燃料消耗量。

Table 1.1: Scenario description

SCENARIOS	EMISSION STANDARDS	FUEL STANDARDS	FUEL CONSUMPTION STANDARDS	ENFORCEMENT AND COMPLIANCE	DEGREE OF ELECTRIFICATION
No regulation	Stop at standards adopted by 1999	Stop at standards adopted by 1999	None	Existing type approval only	None
BAU/Baseline	China I, II, III, (IV)	China I, II, III	LD: Phase I, II, and III (2% annual improvement); no HD regulation	10% of vehicle fleet are gross emitters	None
Improved program	China VI by 2015	Low-sulfur gasoline and diesel (50 PPM) by 2015	LD: 3% annual improvement; HD: 20% improvement by 2030, starting in 2015	By 2015, only 5% of vehicle fleet are gross emitters	LD: by 2030, 5% of new vehicle sales are electric vehicles
Strong program	China V (2012) and VI (2015) and “SULEV” (LD) and “China VII” (HD) by 2020	Ultra low-sulfur gasoline and diesel (10 PPM) by 2015	LD: 4% annual improvement; HD: 50% improvement by 2030, starting in 2015	By 2020, only 3% of vehicle fleet are gross emitters	LD: by 2030, 10% of new vehicle sales are electric vehicles
Improved urban program	China IV + diesel particle filter in 2012 and China VI by 2015	Low-sulfur gasoline and diesel (50 PPM) by 2012	Same as Improved program	Same as Improved program	Same as Improved program

Conclusions

Despite the massive growth in vehicle stock and activity, China's vehicle emission control program has been effective in curbing conventional pollutant emissions. According to the China Fleet Model (CFM), between 2000 and 2010, the cumulative emissions benefit of the current program over a "no program" scenario has been 44.5 million metric tons for total hydrocarbons (THC), 238.7 million metric tons for carbon monoxide (CO), 38 million metric tons for oxides of nitrogen (NO_x), and 7 million metric tons for particulate matter (PM). See Figure 1.1 for a comparison of the two scenarios[5]. For a detailed account of the China Fleet Model data sources, assumptions, and methodology, please see Appendix B.

5 The model does not provide retrospective estimates of fuel consumption and CO_2 estimates because it only include fuel consumption calculations from 2010 on.

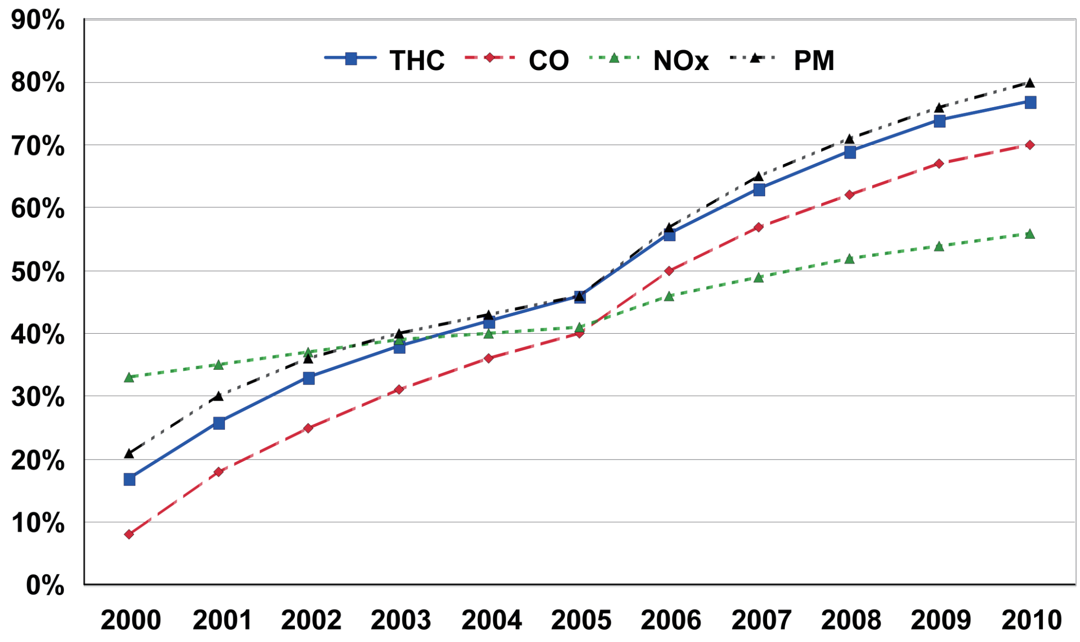


图 1.1: 现行管理与无管理相比的减排百分比

长期以来，环保部采取的各项政策为公众健康带来了很多收益。根据CFM模型的计算结果，ICCT利用健康影响评估方法，估算出了已避免的过早死亡人数和其它健康影响获益。而这一估算仅仅是包括了车辆直接排放的颗粒物和由NOx排放所形成的二次颗粒物的健康影响，尚没有将臭氧以及直接的NOx、CO、有毒物质、挥发性有机化合物（VOC_s）和其它排放物的影响考虑在内。表1.2展示了评估结果，即当前中国所实施的各项政策在过早死亡、急慢性支气管炎、哮喘、入院和工作影响天数等方面所取得的效益。关于健康影响评估的方法论，详见附录B。我们将此分析结论与其它相关研究结论进行对比，认为此分析对影响的评估结果是相对比较保守的。

表 1.2: 当前政策对避免不利健康影响的收效评估

健康影响(千人或天)	2000年	2005年	2010年
提前死亡	6.3	30	110
入院就医	0.95	4.2	15
慢性支气管炎	14	63	220
急性支气管炎	75	320	1,100
哮喘	96	420	1,400
工作影响天数	7,400	33,000	110,000

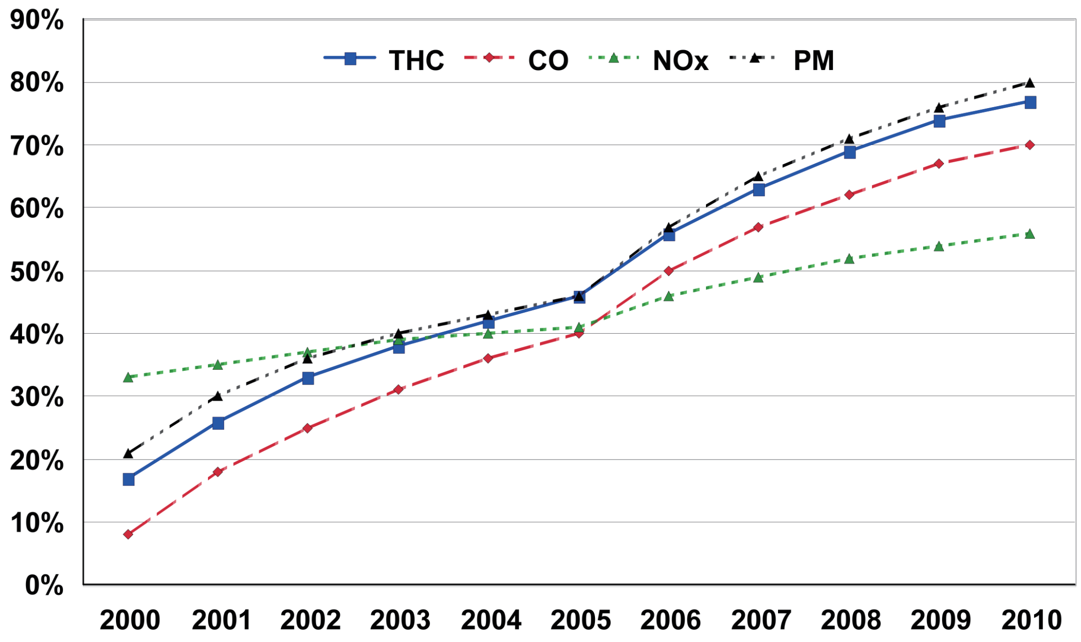


Figure 1.1: Percent emission reductions of current program versus no program

The policies carried out by MEP to date have resulted in substantial public health benefits. Using outputs from the CFM, ICCT estimated the avoided premature deaths and other health impacts in the HIA tool. These estimates only account for direct PM and secondary PM formation due to NOx emissions and do not include health impacts due to ozone formation and direct emissions of NOx, CO, toxics, volatile organic compounds (VOCs) and other species. Table 1.2 provides the estimated incidences of premature mortality, chronic and acute bronchitis, asthma attacks, hospital admissions, and restricted activity days that have been avoided in China due to the current policies that are in place. More details on the methodology for quantification of health impacts can be found in Appendix B. Comparison of ICCT's analysis with other recent studies suggests that ICCT's findings should be viewed as conservative, low-end estimates of impacts.

Table 1.2: Avoided incidences of health impacts due to the current policy package

HEALTH IMPACTS (THOUSANDS)	2000	2005	2010
Premature mortality	6.3	30	110
Hospital admissions	0.95	4.2	15
Chronic bronchitis	14	63	220
Acute bronchitis	75	320	1,100
Asthma attacks	96	420	1,400
Restricted activity days	7,400	33,000	110,000

根据保守估计，仅在中国大陆地区，健康收益的价值就十分可观。2010年，约收益1700亿人民币（250亿美元），相当于国内生产总值（GDP）的0.5%。在本研究中，对于健康影响价值的评估，主要是基于在中国进行的另外一些研究，即中国居民愿意花费多少钱来降低空气污染带来的死亡风险。关于健康影响评估的具体方法论，详见附录B。

尽管目前的政策措施已经在减排和维护健康方面取得了显著成就，但是随着汽车市场的不断扩大，仍需要不断改进和加严政策措施来减轻健康和气候影响。例如，图1.2展示了在当前政策措施下，排放的增长趋势。

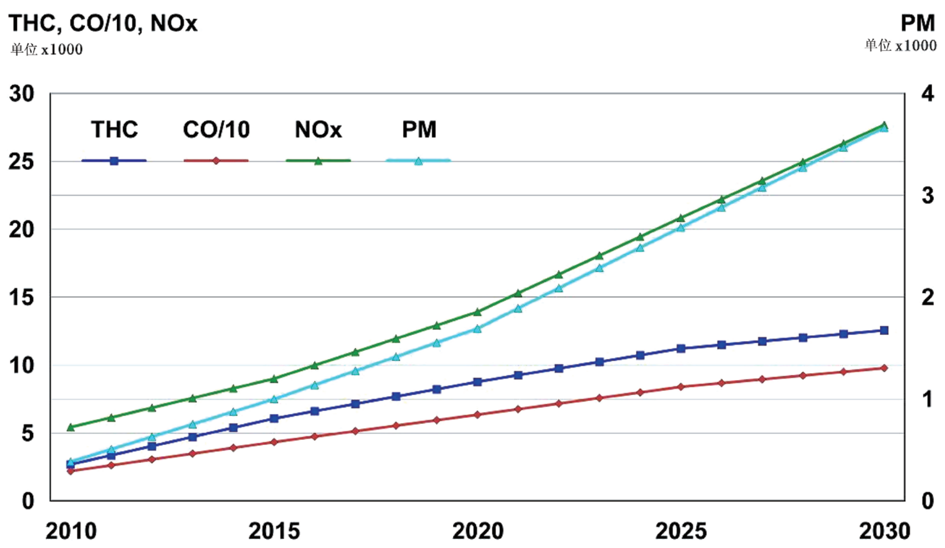


图 1.2: 现行管理情景下的排放趋势2010 – 2030年 (1000 公吨)

中国若承诺不断加严车辆和燃料标准，且配合引入国际先进的管理政策，将能够降低排放，并逐步实现国际级的排放控制措施。图1.3明确的展示了这一趋势，说明了两种不同情景（改善方案、强化方案）所带来的结果。实施时间也将对未来的减排效果有着重大影响。以2020年为结点，通过情景分析，如果到2020年才实施国VI标准，相对于2015年开始实施国VI标准，将会多排放30%-70%的颗粒物和64%-70%的氮氧化物。即使到了2030年，提前实施国VI（2015年）和延迟实施国VI（2020年）之间的减排差异依然存在。

Using conservative estimates, based on studies conducted within mainland China, the value of these avoided health impacts is significant. In 2010 it amounts to 170 billion RMB ($25 billion), the equivalent of 0.5% of the GDP. This study valued health impacts based on studies conducted in China of the willingness to pay to reduce the risk of dying from air pollution. The methodology for the valuation of health impacts is included in Appendix B.

Despite the emission reductions and concomitant health benefits achieved by the current program, continued improvements and more stringent policy measures will be required to mitigate the negative health and climate impacts of the significant projected growth trends in the vehicle market. For example, Figure 1.2 illustrates the emissions increases expected under the current program.

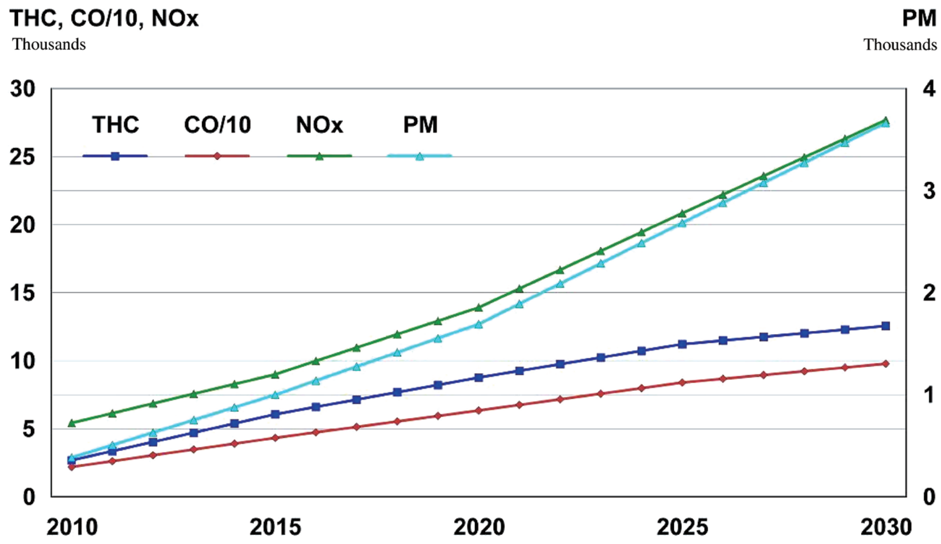


Figure 1.2: 'Business as Usual (BAU)' trends, 2010 – 2030 (thousand metric tons)

With continued commitment to further tightening vehicle and fuel standards and by introducing new policy elements that parallel international best practice, China can drive down emissions trends and move towards a world-class emission control program. This is clearly illustrated in Figure 1.3, which shows the results of the two national scenarios (Improved Program, Strong Program). Implementation timeline does have a significant impact on the potential to capture these emission reductions. In 2020, scenarios that achieve China VI by 2020 lead to 30% to 70% more PM and 64% to 70% more NOx emitted than the scenarios where China VI is reached by 2015. Even by 2030, there is still an emission reduction gap between 2020 and 2015 China VI implementation scenarios.

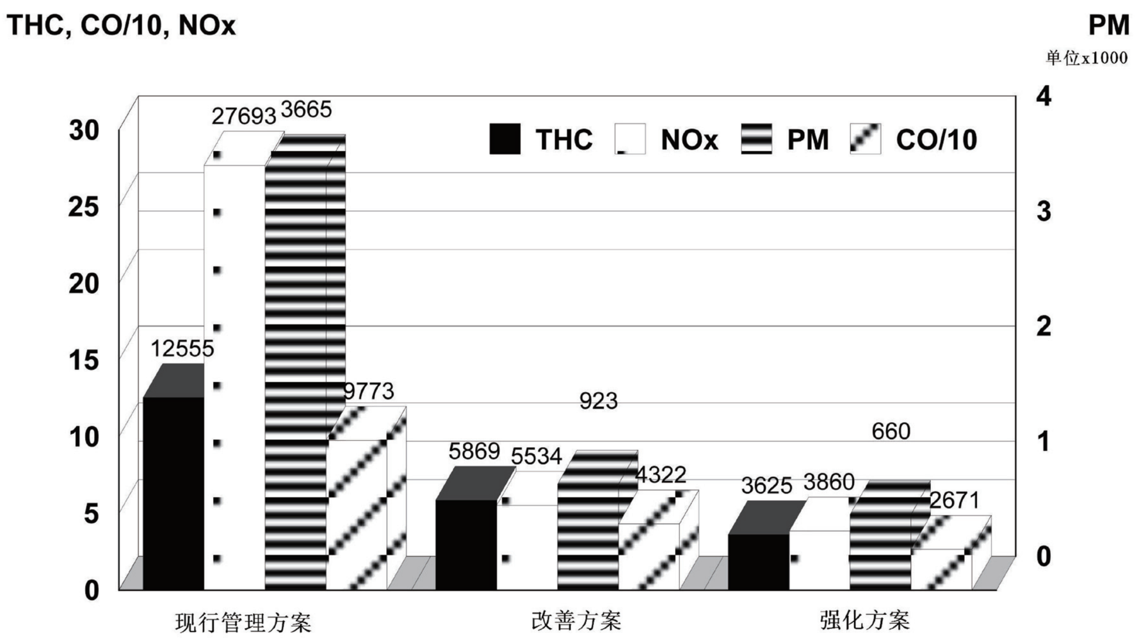


图1.3: 现行管理、改善方案和强化方案情景下2030年的排放趋势 (1000公吨)

在改善方案和强化方案情景下的显著减排还将在今后的几年中带来重大的健康收益。图1.4总结了各种情景下的健康影响评估结果，可以看出，现行管理措施在过去的10年中拯救了许多生命，而实施强化方案，在未来的20年中，还将避免3倍的人数由于污染造成过早死亡。

到2030年，实施强化方案所带来的健康收益的经济价值预计可达2.4-2.6万亿人民币（3500-3900亿美元），相当于国内生产总值的2.3%-2.6%。中国其它一些研究结果和英国以及其它地区的研究结果肯定了这样的价值评估，甚至认为减排所带来的健康收益（减少空气污染造成的过早死亡）和经济收益应比我们当前预计的更高。

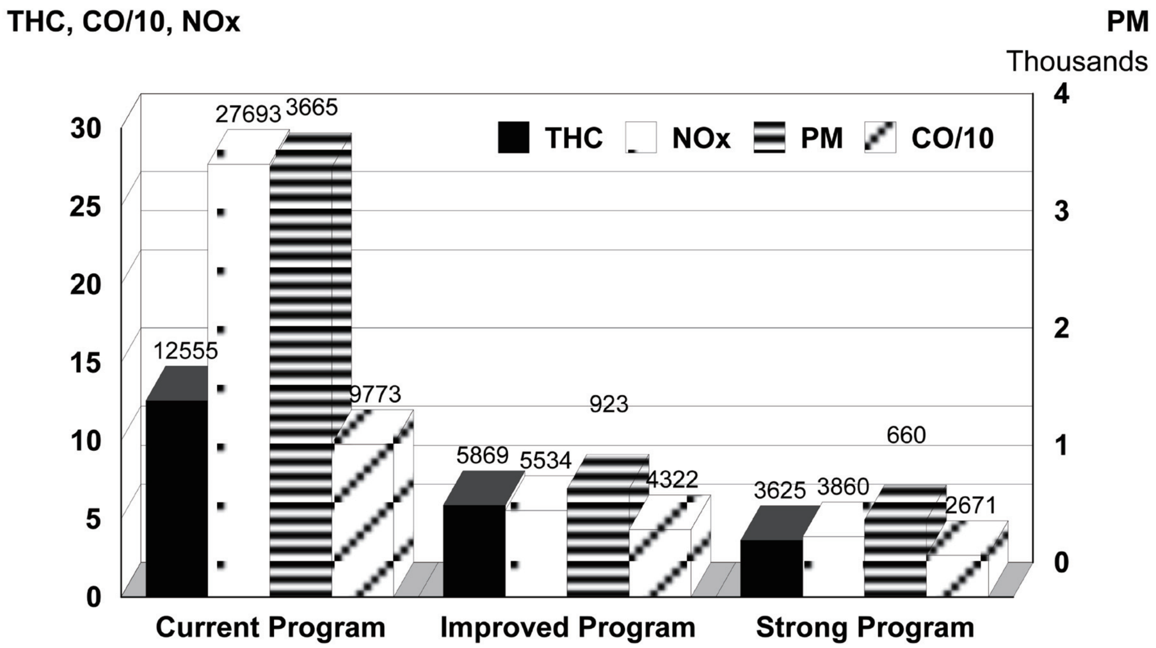


Figure 1.3: Emissions of the BAU, Improved, and Strong Programs in 2030 (thousand metric tons)

The dramatic reductions in emissions with the Improved and Strong Program scenarios would translate into important reductions in adverse health impacts in future years. Figure 1.4, which summarizes the health impact assessment results for all scenarios, shows that the current program has saved numerous lives in the past decade and that a strong emissions control program could prevent three times as many premature deaths in the coming two decades.

In 2030, the monetary benefits associated with the reduced health impacts of the Improved and Strong Programs would be expected to amount to approximately 2.4–2.6 trillion RMB ($350–390 billion), equivalent to an estimated 2.3%-2.6% percent of the GDP. Analyses conducted by other researchers in China, the United Kingdom and elsewhere confirm these findings with similar or higher expected impacts in terms of levels of premature mortality due to air pollution and total monetary benefits of reducing emissions.

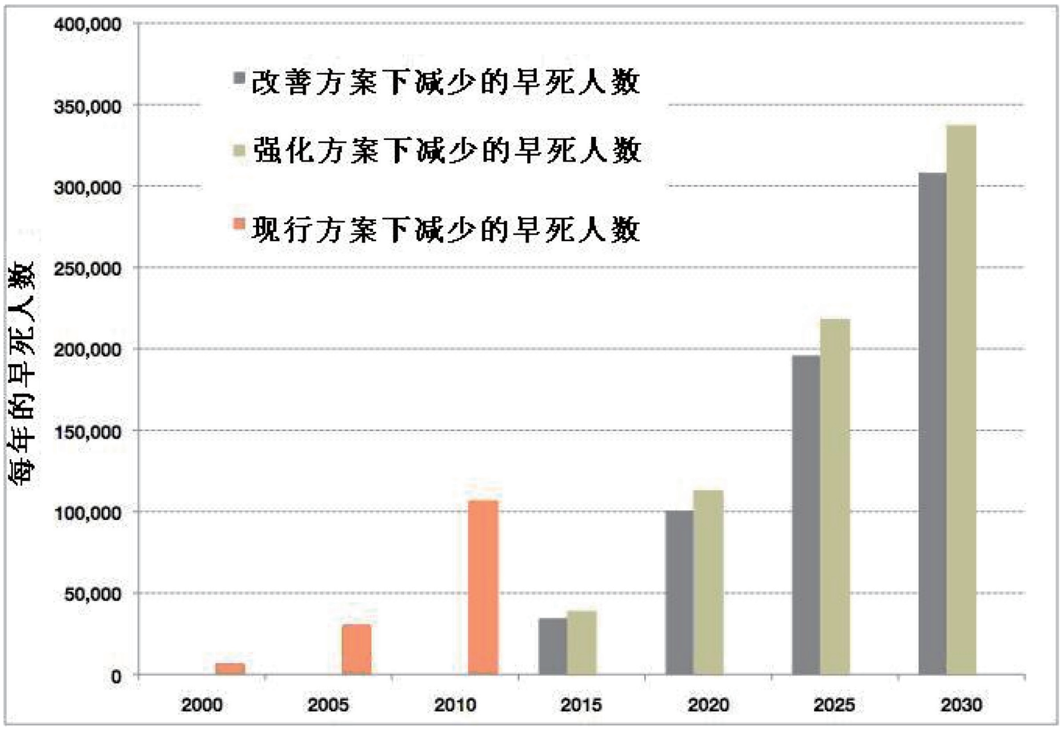


图1.4: 各种情境下提前死亡减少数量

改善燃料经济性政策将有效节省燃料并减少二氧化碳排放，同时将中国在这一政策领域推向世界领先位置（图1.5和图1.6）。到2030年，根据ICCT的估算，较之现行管理措施，实施强化方案将节省780亿加仑燃料（约18亿桶原油）。另外，还会带来相应的气候变化收益，因为颗粒物排放的减少直接减少了黑炭排放，而颗粒物中的黑炭是具有重大气候影响危害的颗粒。

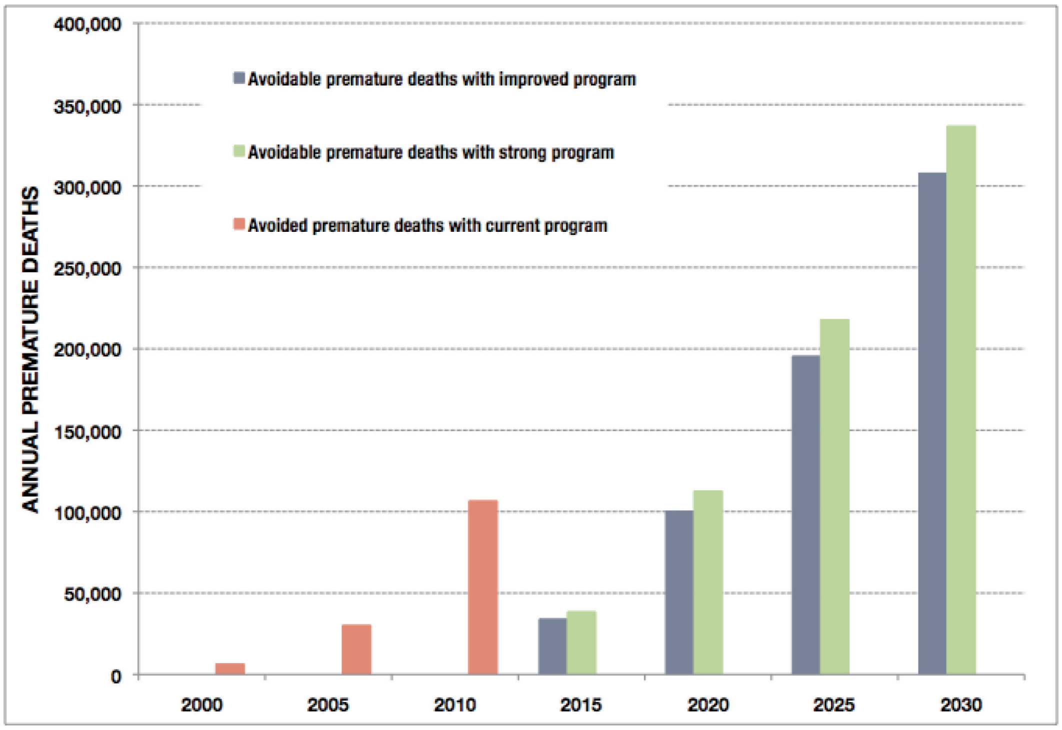


Figure 1.4: Annual premature deaths under different scenarios

Additional improvements to the fuel economy program will yield substantial fuel savings and avoided carbon dioxide (CO_2) emissions as well as cement China's position as a global leader in this policy arena (Figures 1.5 and 1.6). In 2030, ICCT estimates that the Strong Program will save roughly 78 billion gallons of fuel as compared to the baseline scenario (over 1,800 million barrels of oil). In addition, there are considerable climate co-benefits associated with decreasing particulate matter emissions due to the fact that black carbon-the highly potent climate forcing aerosol that is a subset of PM-is reduced as well.

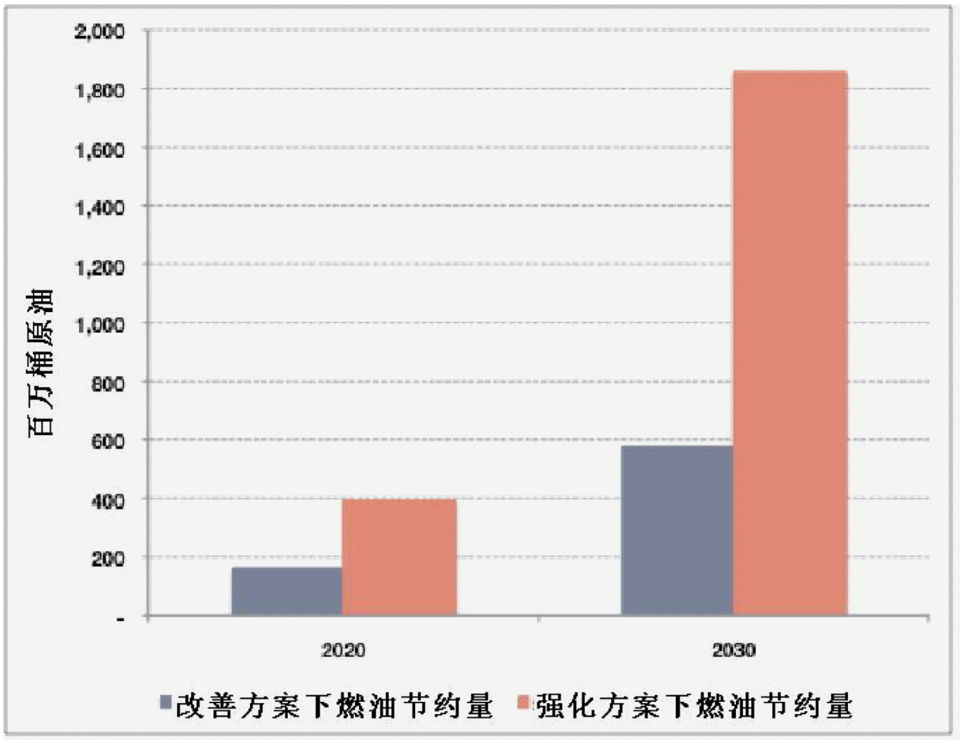


图1.5: 实施改善方案和强化方法的燃料节省预测 2020年及2030年

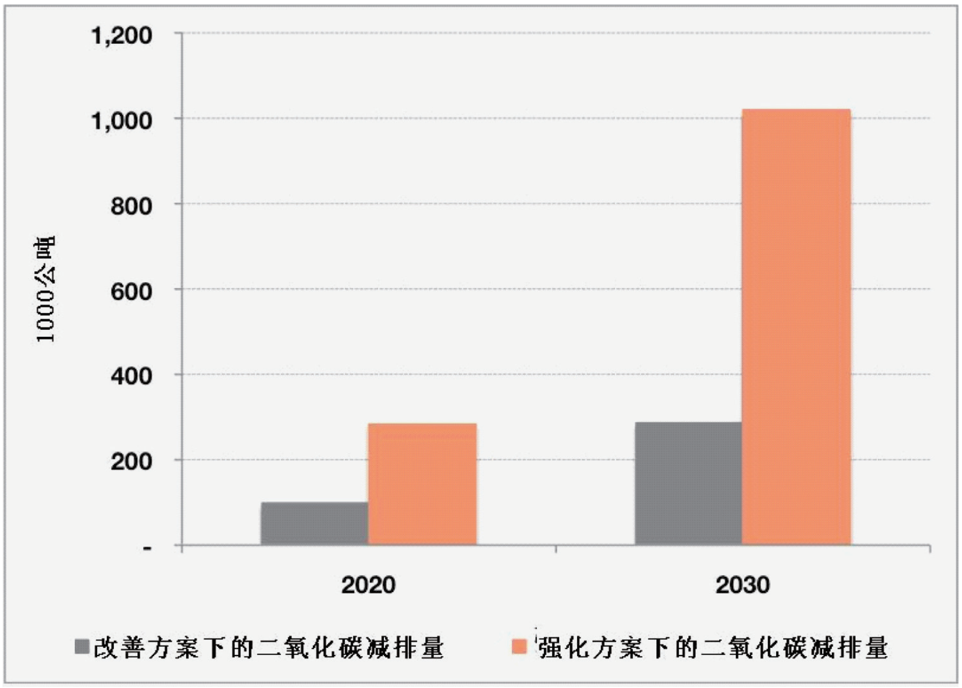


图 1.6: 实施改善方案和强化方法的二氧化碳减排预测 2020年及2030年

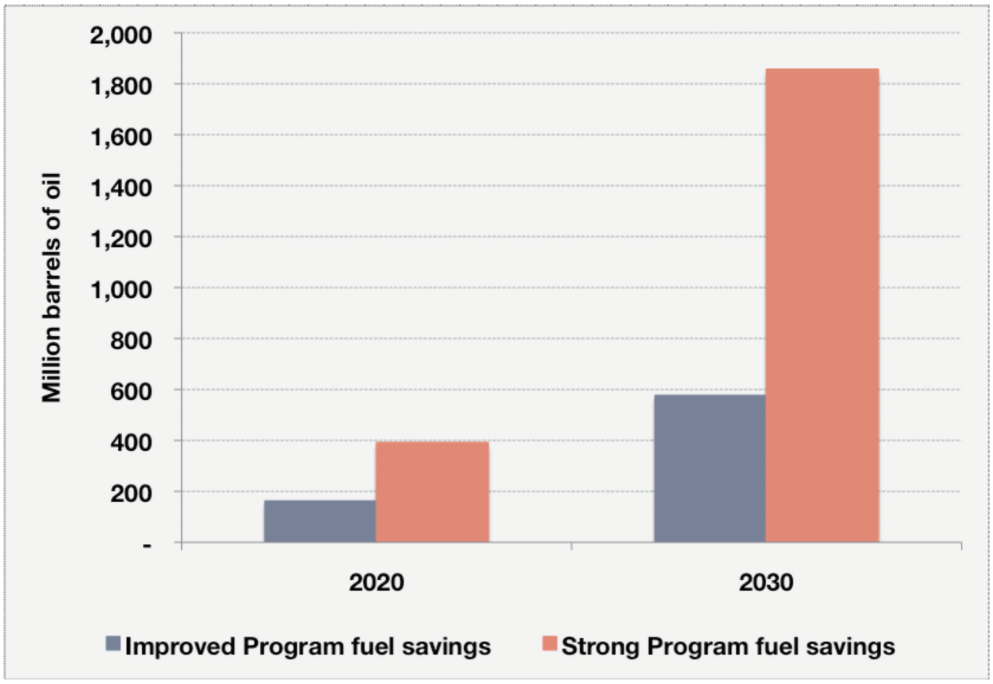


Figure 1.5: Projected fuel savings of Improved and Strong Program compared to BAU, 2020 and 2030

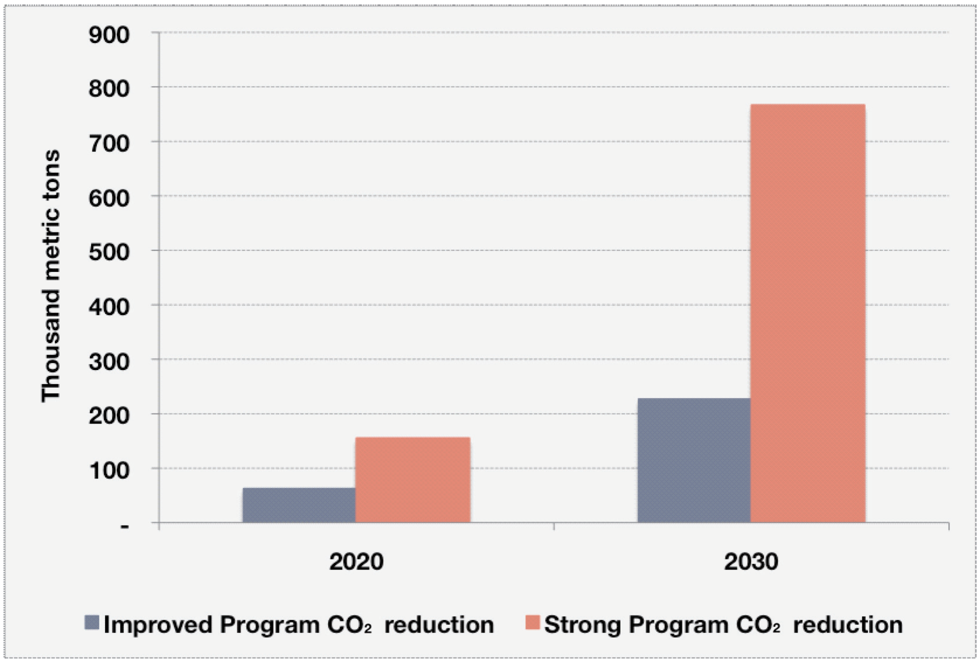


Figure 1.6: Projected CO_2 emissions reductions of Improved and Strong Program compared to BAU, 2020 and 2030

总而言之，在有限的资源下，环保部已经成功的采取了日益严格的排放标准和实施措施，已经有效削减了数百万公吨的污染物。在2010年，这些成效可避免大约17万人的死亡。如果不进行进一步管理，那么随着车辆保有量的增长，排放将会显著增加。通过两个前瞻情景预测，我们可以看到，采取适当的政策措施，在机动车不断增长的前提下，完全能够实现减排和节能双丰收。

目前，中国所面临的最大瓶颈，就是环保部在制订与排放切实相关的车用油品标准和实施车辆及油品标准方面的权限限制。这样一来，低硫燃料的推行速度必然受到影响，也就直接影响了当前标准的执行情况。此外，汽车制造企业和炼油企业对继续加严汽车排放和油品标准的反对以及财政和人员技术水平等问题，也是当前存在的障碍。

建议

我们通过定量和定性分析，为中国的清洁高效交通提出了一套近期和长期的建议。

中国为配合其在国际汽车市场的领先地位，已经在制定国际先进车辆排放控制措施方面走出了决定性的第一步。要想继续发展，需要在现有政策方案的基础上学习参考欧盟、美国和日本的成熟措施。同时，还要根据中国国情，解放思想，敢于创新政策，寻求最适合的可实践方案。在今后几年中，重点领域主要包括：

• *沿用当前的欧盟排放标准模式，继续实施更加严格的机动车排放标准，缩短与欧盟现行标准的距离。这并不是说中国一定要单纯的照搬欧盟的线路。*相反，环保部应当选择适当的、具有可行性的先进标准。目前部分有低硫燃料（使用排放控制技术的必须条件）的地区可以先“跳跃”性地实施国VI甚至更严的标准，然后再推广至全国。如果可以这样做，公众健康和环境收益都将十分显著。

• *修订《大气污染防治法》，加强环保部制订燃料标准和实施车辆及燃料标准的权威性，赋予环保部召回和处罚不达标对象的权力。*要想推进清洁燃料、有力的实施执行各项标准，就需要相应的权力。

• *提高环保部的财政预算和技术能力。已经有很多例子表明，经费和技术能力不足，会使机动车排放控制措施在其它政府机构和工业企业面前处于劣势地位。*环保部应当通过政策机制提高自身的财政收入，如征收排放费、车辆税费和其它财税手段。很多措施的出台和实施都需要联合其它部委。要想提高技术能力，可以从分批培训入手，陆续安排人员到一些经验成熟的机构进行培训，例如美国环保局，还可以从高校及研究机构补充一部分资源。

• *制订针对交通领域的温室气体排放的政策。温室气体政策可以被视为是环保部当前政策的自然延伸。*要实现常规污染物和温室气体控制的双赢，两种政策应齐头并进。在未来几年中，环保部应获得管理移动源温室气体排放的权力，并负责执行实施管理方案（包括违规罚款的权力）。

• *与相关单位合作，重新修订中国目前的轻型车燃料消耗量标准，代之以轻重型车辆的温室气体排放标准。*具体包括加严标准和优化标准设计体系两方面。将当前的根据质量或排量的分类方法改为根据尺寸（大小）分类，从而避免刺激车辆重量化或大排量化。

• *对常规污染物和温室气体减排项目进行经济激励能对相关标准起到有力配合作用。*在过去的几年中，中国已经不断的做出努力，通过车辆减税政策，鼓励购买小排量节能型汽车。若将目前按排量分级的财税政策改为按二氧化碳/温室气体排放量分级，能取得更好的效果。

以上各项评估方案的详细建议内容请参见第10章。

In summary, with limited resources, the MEP has successfully adopted increasingly stringent emission standards and implemented compliance programs that have helped eliminate millions of tons of pollution. In 2010, those efforts translated into approximately 170,000 avoided deaths. Without further regulation, however, emissions will increase dramatically, propelled by the expected vehicle population growth. The two forward-looking scenarios evaluated show that a suite of well-defined policies together can reduce emissions and fuel use as the Chinese fleet continues to grow.

Amongst the most important barriers to progress in China are the limits on MEP's authority with regards to emission-related fuel standards and vehicle and fuel standard enforcement. This has undoubtedly delayed the adoption of lower sulfur fuels and reduced the effectiveness of current standard compliance programs. Other barriers include opposition from the politically influential vehicle and fuel industries on further tighening the vehicle and fuel quality standards as well as limited financial resources and staff technical capacity.

Recommendations

The insights yielded by the quantitative and qualitative analyses lead to a set of near- and long-term recommendations for China's path towards cleaner and more efficient transportation.

China has taken the critical first steps in the development of a world-class vehicle emission control program that can match its position as a leading world vehicle market. Continuing that development will require building on the foundation established by the current program and incorporating lessons learned from mature programs in the European Union, United States, and Japan. It will also require unleashing creative and innovative policy thinking to adapt best practices to the Chinese context. Key areas of emphasis in the coming years should include:

• *Continued progress toward more stringent motor vehicles standards to close the gap with the Euro program, on which MEP currently patterns its standards. This does not mean that China should simply retrace the path followed by the EU.* On the contrary, MEP should seek to adopt the most advanced standards necessary and feasible whenever possible. There are clear opportunities to "leapfrog" to China VI and even beyond first in local jurisdictions where lower sulfur fuels (necessary for using the best available control technologies) are available and then nationally. The public health and environmental payoff of seizing those opportunities will be significant.

• *Amending the "China Air Pollution Prevention and Control Law" to enhance MEP's authority to set fuel standards for emission related parameters, enforce vehicle and fuel standards, conduct recall campaigns, and penalize noncompliance.* Any significant progress in the availability of clean fuels and the compliance and enforcement of adopted standards depends on the effectiveness of that authority.

• *Improving MEP's budget level and technical capacity.* Limits on funding and technical capacity have in several instances put the vehicle emission control program at a disadvantage with respect to other government and industry stakeholders. MEP should pursue opportunities to raise funds through creative policy mechanisms such as emission fees, vehicle taxes and fiscal policies. Many such programs would require partnerships with other ministries. Enhancing technical capacity could begin by prioritizing training needs, continuing staff training programs with mature agencies, such as the U.S. Environmental Protection Agency, and leveraging resources in China's universities and research institutes.

• *Establishing policies to address greenhouse gas (GHG) emissions from the transportation sector.* GHG policies are a natural extension of the MEP's current program. To realize the potential co-benefits, conventional pollutants and climate forcers should be addressed together. In near- to mid- term, MEP should obtain the authority to regulate GHG emissions from mobile sources and enforce these regulations (including by imposing fines for non-compliance).

• *Working with relevant agencies to realign China's current fuel consumption standards for light- and heavy-duty vehicles to GHG emissions standards.* This process should include enhancing the stringency and improving the structure of current passenger vehicle standards. Shifting from a weight-based or displacement-based to size-based (footprint) standard would remove incentives for up-weighting and gaming.

• *Fiscal incentives for both conventional pollutant and GHG/efficiency programs are an important complement to relevant regulation.* China in the past few years has made continuous efforts to reform its vehicle tax policies to encourage a market shift to smaller and thus more efficient vehicles. Replacing the current displacement-based fiscal policies with a CO_2/GHG-based scheme would better achieve this goal.

Detailed recommendations for each of the reviewed programs can be found in the relevant chapters and are summarized in Chapter 10.

2. 项目介绍与背景

受中国环境保护部的委托，ICCT从2009年7月起，开始对中国机动车排放控制措施进行综合性评估。本次评估项目——在此称为回顾分析，主要包括以下几个方面：

1) 对中国当前的机动车污染控制措施进行定量和定性评估，分析成果和不足之处。

2) 提出近期推荐方案（针对“十二五”计划）和长期推荐方案(2015 – 2030)。

3) 为今后的方案效果评估提供技术方法。

此次的项目，涵盖了包括农用车的所有道路机动车类型，同时还包括了燃料消耗量管理方案分析。ICCT的研究分析工作从四个主要任务入手，实现上述目标:

1) 总结中国现有的标准和实施措施，将其与国际先进管理经验进行比较；

2) 设计未来情景，分析引入和实施排放标准及燃料消耗量标准的效果；

3) 开发机动车模型，评估现有和今后可能的排放标准及燃料消耗量标准的影响；

4) 评估现有和今后可能的管理方法所带来的健康影响价值和经济收益。

ICCT的项目组由Fanta Kamakate和ICCT董事会会长Michal Walsh(本项目的指导顾问)二位领导，包括冯淑慧、Ben Sharpe、何卉、Kate Blumberg和孙永伶几位组员组成。内部审查委员会成员包括Alan Lloyd、Drew Kodjak、John German 和Anup Bandivadekar。ICCT董事会成员王全录参与部分替代燃料与新能源汽车章节的撰写工作。同时ICCT与机动车排污监控中心（隶属于环保部的政策研究中心）和清华大学合作这研究项目。这两个合作单位为我们提供了所需的数据和信息，这些数据和信息很有价值，能使我们更好的了解中国的国情。

2.1 历史背景和现行车辆排放控制措施的意义

在过去的30年中，中国的机动车保有量显著增长。过去10年中的飞速增长，使中国在2009年成为世界上最大的汽车生产和销售国。如图2.1所示，道路机动车的年销售量（不含两轮车辆和农用车）已经从1980年的25万辆增长至2008年的1000万辆。与此同时，两轮车辆（摩托车和电动自行车）的年销售量也从60万辆增至惊人的5000万辆以上。从2000年至今，轿车、卡车和巴士总保有量翻了两番以上，从1350万辆增长至6000万量以上。而在这10年当中，摩托车的保有量也增加了两倍，从6800万增加至2亿辆以上。

2. Project introduction and background

The International Council on Clean Transportation's (ICCT) comprehensive assessment of China's vehicle emission control program began in July of 2009 at the request of the Ministry of Environmental Protection (MEP) of China. The main objectives of this project-hereto referred to as the Retrospective Study-are as follows:

1) Assess both quantitatively and qualitatively the successes and gaps in China's current vehicle pollution control program.

2) Provide recommendations for program improvements in the near term (to inform the 12th 5-year plan) and the long term (2015 – 2030) .

3) Provide tools for continued assessment of the program's impact.

The project scope extends to all on-road vehicle types as well as rural vehicles and includes an analysis of fuel consumption regulations. The ICCT organized its activities to achieve these objectives in four major tasks:

1) Summarizing regulations adopted and implemented to date and comparing them to international best practices；

2) Establishing future scenarios for the adoption and implementation of emission and fuel consumption regulations；

3) Developing a fleet model to estimate emission and fuel consumption impacts of current and potential future regulations；

4) Assessing costs and monetizing health benefits associated with current and potential future regulations.

The ICCT project team is led by Fanta Kamakaté and Michael Walsh, chairman of the ICCT board (advisor) and includes Freda Fung, Ben Sharpe, Hui He, Kate Blumberg, and Yongling Sun. The internal review committee is comprised of Alan Lloyd, Drew Kodjak, John German, and Anup Bandivadekar. Board member Michael Wang provided input to the chapter on Alternative Fuels and New Energy Vehicles. Collaborations with the Vehicle Emission Control Center (VECC), which is a policy research center affiliated with MEP, and Tsinghua University have facilitated the availability of data and information, which has been extremely valuable in better understanding the Chinese context.

2.1 Historical context and significance of the current vehicle emission control program

The vehicle population in China has experienced significant growth over the past thirty years. The tremendous growth in the last decade has led China to become in 2009 the largest vehicle producer and consumer in the world. As shown in Figure 2.1, annual sales of on-road vehicles (excluding two-wheelers and rural vehicles) have grown from roughly 250,000 in 1980 to nearly 10 million vehicles in 2008. Over that same time period, two-wheelers (motorcycles and electric bikes) annual sales have grown from about 600,000 to a staggering 50+ million. Since 2000, the total stock of cars, trucks, and buses has more than quadrupled from 13.5 to over 60 million vehicles. Over this ten-year span, the total stock of motorcycles has roughly tripled from 68 to over 200 million.

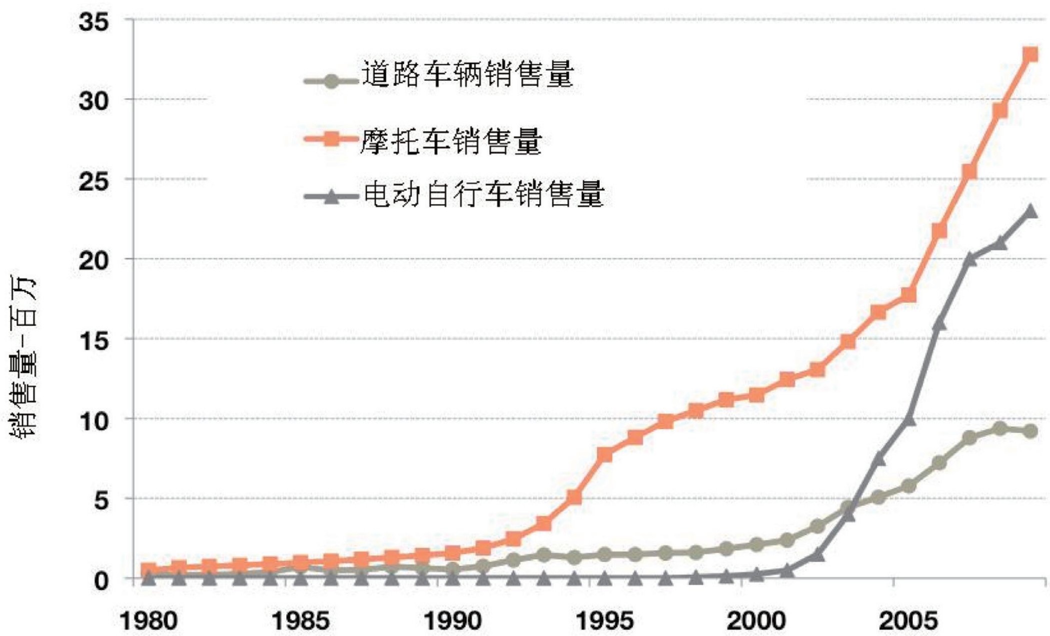


图 2.1: 1980 – 2009[6]年车辆销售量 (道路车辆包括乘用轿车、卡车和巴士)

考虑到过去10年中机动车的增长情况，控制机动车排放影响的工作就显得意义更加重大。回顾过去在改善空气质量方面所取得的成就，从上世纪80年代初开始，中国的排放控制立法取得了重大发展。图2.2展示了中国移动源排放控制的几个里程碑，包括颁布和修订《大气污染防治法》。此法为中国实施各项空气质量管理措施的基石。针对机动车排放，具有重大意义的第一步就是1999年在北京和上海开始实施国I排放标准[7]。更多车辆和燃料管理措施将会在后面的章节中予以讨论。

6 图中的数据来源于中国机动车模型(China Fleet Model, CFM)。CFM模型中所包含的历史销售量数据/评估值来源于美国阿岗实验室与霍红共同开发的一个模型。这些数据是基于1980-2008年中国汽车技术研究中心的《汽车工业年鉴》，并据此对此后几年做出情景分析。因此，图中2008年以后的销售数据可能无法准确体现真实销售量。

7 和世界上许多国家一样，中国也选择了效仿欧盟的车辆和燃料管理标准。在欧盟管理中，轻型车和重型车标准分别采用阿拉伯数字和罗马数字来编号，而在中国却没有正式区分，轻型车和重型车标准都是使用罗马数字。和欧盟模式一样，数字数值的越高表明实施的标准越严格。

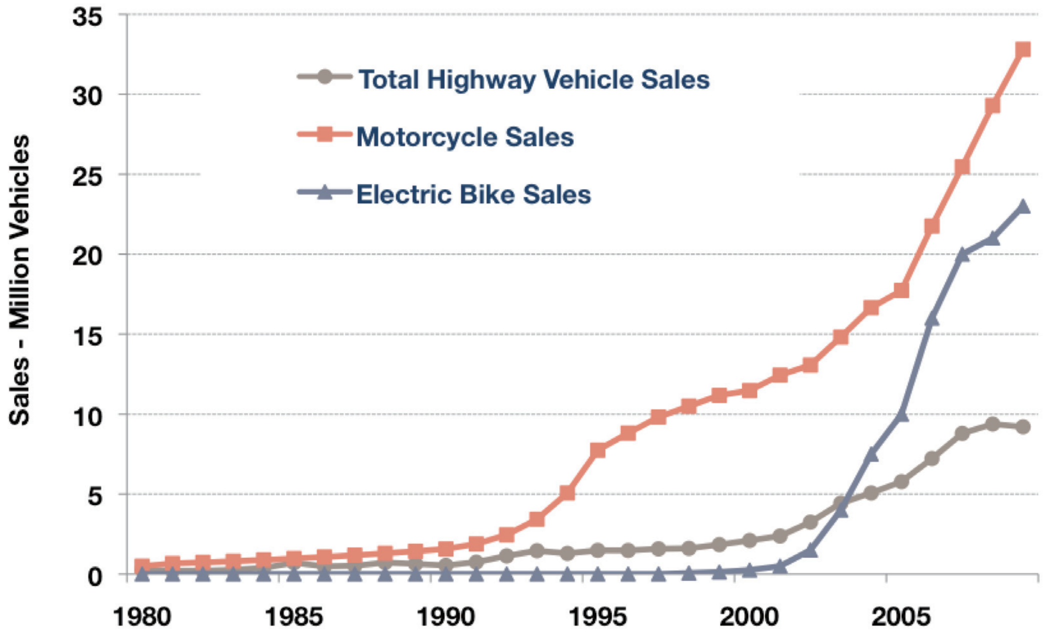


Figure 2.1: Vehicles sales from 1980 – 2009[6] (highway vehicles include passenger cars, trucks, and buses)

Given the sheer magnitude of vehicle growth over the past decade, the task of curbing the negative impacts of vehicle emissions has taken on increased significance. Looking at the history of efforts to improve air quality, emission control legislation in China has evolved greatly since its inception in the early 1980s. Figure 2.2 highlights a few select milestones in China's mobile source emission control including the establishment and revisions of the "Air Pollution Prevention and Control Law", the cornerstone of the air quality program. The first significant policies targeting vehicle emissions were phased in with the implementation of 'China I' standards[7] in Beijing and Shanghai in 1999. The various elements of the vehicle and fuel programs are discussed in more detail in later chapters.

6 Data in this figure comes from the China Fleet Model (CFM). The CFM has historical sales data/estimates from the model developed by Hong Huo and the Argonne National Laboratory. This data is based on China Automotive Technology and Research Center (CATARC) "Automotive Industry Yearbooks" for years 1980 through 2008, and then projections are used for the subsequent years. As such, data points in this figure may not accurately represent sales for years after 2008.

7 Like many countries around the world, China has chosen to mirror its vehicle and fuels programs after those set forth by the European Commission. In the Euro program, the Arabic numerals and Roman numerals denote standards for light- and heavy-duty vehicles respectively; however, in China, there is no official distinction, and Roman numerals are used to represent both light- and heavy-duty standards. As with the Euro program, increasing number values imply greater stringency of the standard.

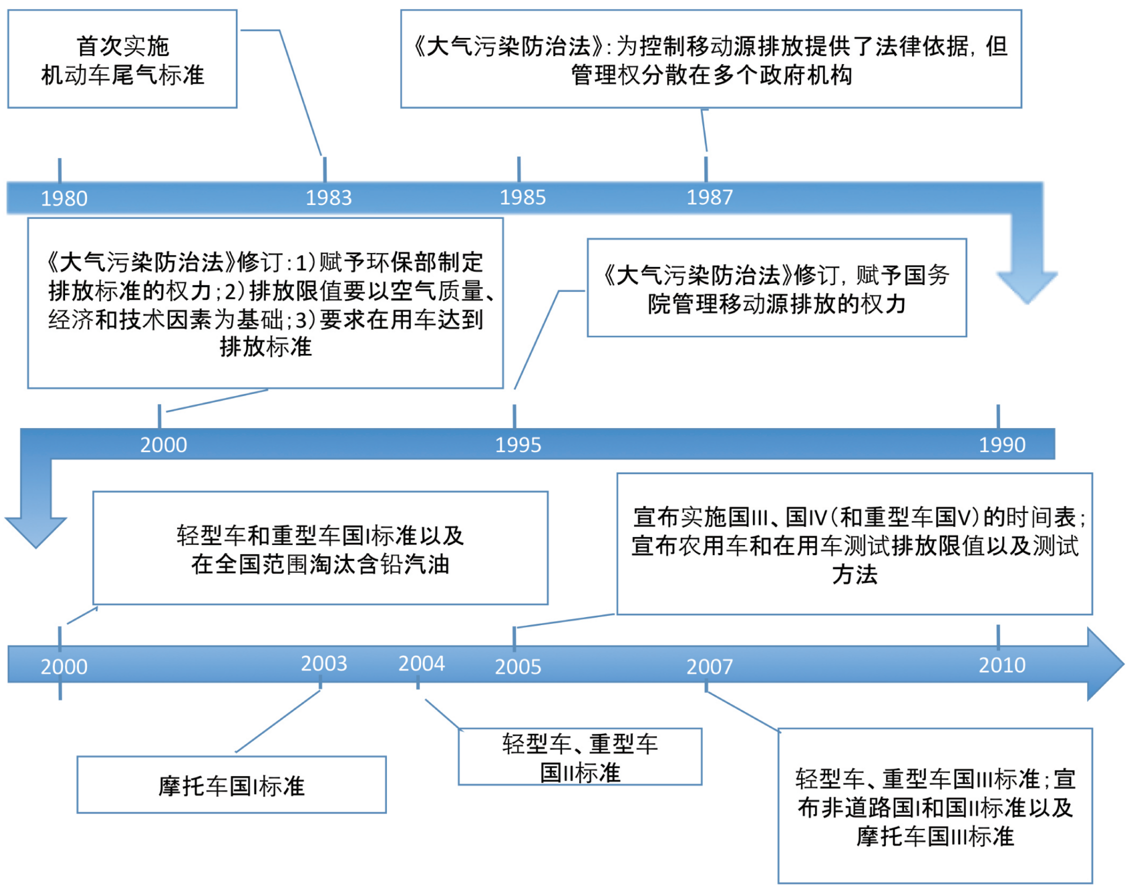


图2.2：中国机动车排放控制政策的里程碑

尽管车辆保有量和使用率都有巨大增长，中国的车辆排放控制措施还是能有效的削减常规污染物排放。根据中国机动车模型（CFM），从2000年到2010年，较之无管理情景，现有管理措施累计减排总碳氢化合物（THC）4450万公吨、一氧化碳（CO）2.387亿公吨、氮氧化物（NOx）3800万公吨和颗粒物（PM）700万公吨。中国机动车模型（CFM）数据源、假设和方法论详见附录B。

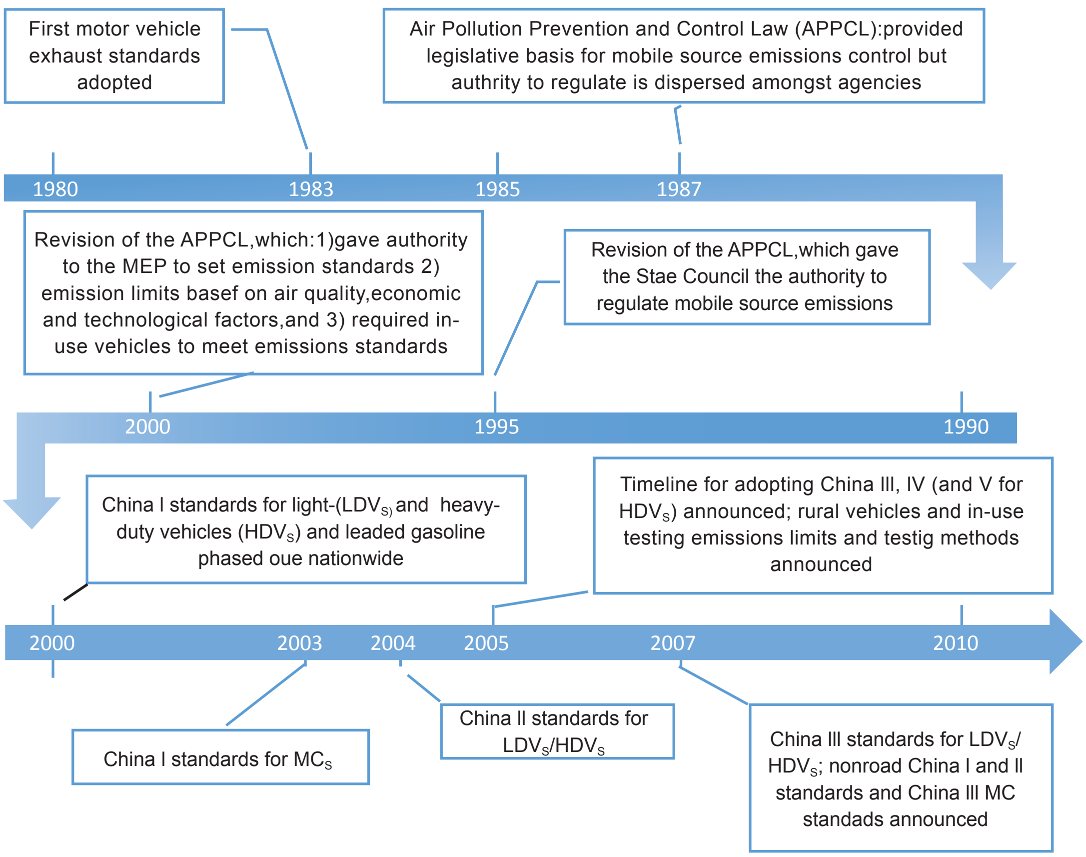


Figure 2.2: Selected milestones in China's vehicle emission control program

Despite the massive growth in vehicle stock and activity, China's vehicle emission control program has been effective in curbing criteria pollutant emissions. According to the China Fleet Model (CFM), between 2000 and 2010, the cumulative emissions benefit of the current program over a "no program" scenario has been 44.5 million metric tons for total hydrocarbons (THC), 238.7 million metric tons for carbon monoxide (CO), 38 million metric tons for oxides of nitrogen (NOx), and 7 million metric tons for particulate matter (PM). For a detailed account of the China Fleet Model data sources, assumptions, and methodology, please see Appendix B.

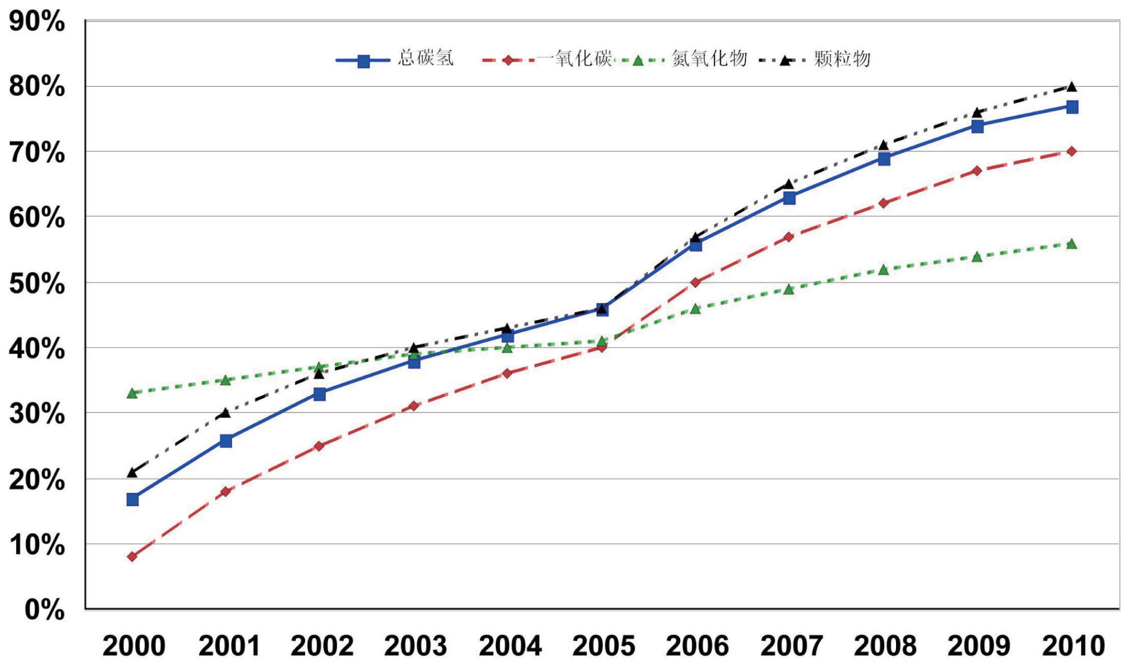


图 2.3: 相对于无管理情景实施现行管理措施的减排效果（减排百分比）

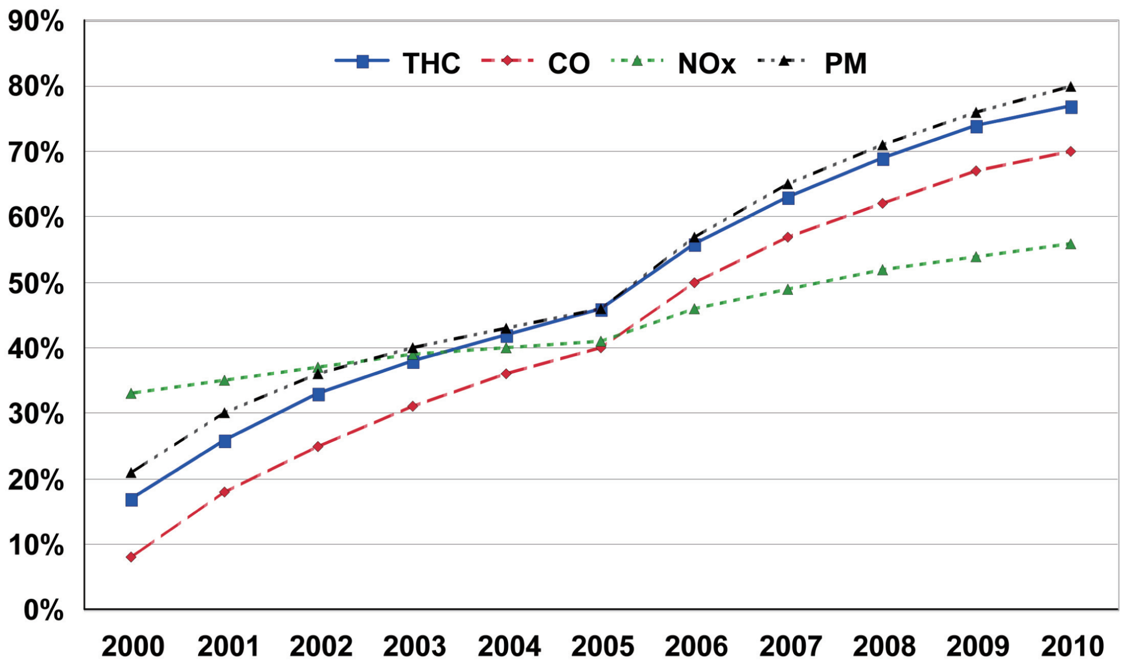


Figure 2.3: Percent emission reductions of current program versus no program

科学界一致认同，人口暴露于机动车的尾气污染物中会增加死亡率和发病率。很明显，实施各项政策至今已取得了实质性的健康收益。我们根据CFM模型的减排计算结果，估算出了现行机动车管理措施已避免的过早死亡人数和其它健康影响。而这一估算仅仅是包括了车辆直接排放的颗粒物和由NOx排放所形成的二次颗粒物的健康影响，尚没有将臭氧形成以及直接的NOx、CO、有毒物质、挥发性有机化合物（VOCs）和其它排放物的影响考虑在内。表2.1列出了评估结果，显示中国现行的各项政策在过早死亡、急慢性支气管炎、哮喘、入院就医和工作影响天数等方面所取得的效益。关于健康影响定量评估的方法论，详见附录B。

这些健康收益结论与近期由Zhang等人开展的一项关于中国空气污染健康影响的研究结论相一致，但我方更趋于保守[8]。与Zhang的研究相比，我们的结果显示2004年（Zhang的研究完成的同年）机动车排放所带来的健康影响占空气污染健康影响的十分之一。在工业化国家的主要城市，移动源污染在空气污染中的贡献率通常高达50%-80%以上[9]。并且移动源污染靠近人体呼吸高度，在中国增长速度也很快。可以估计，移动源在中国应带来比这研究计算更大比例的健康影响，并且影响力还将随着时间不断加大[10]。与其它研究相比，本文中的分析结论应该说是比较保守的，对健康影响的估计较低。

表2.1: 当前政策对避免不利健康影响的收效评估

健康影响 (千人或千天)	2000年	2005年	2010年
提前死亡	6.3	30	110
入院就医	0.95	4.2	15
慢性支气管炎	14	63	220
急性支气管炎	75	320	1,100
哮喘	96	420	1,400
工作影响天数	7,400	33,000	110,000

根据保守估计，健康收益的价值十分可观。2010年，避免健康损害的收益约价值1700亿人民币（250亿美元），相当于国内生产总值（GDP）的0.5%。在本研究中，对于健康影响价值的评估，主要是基于在中国大陆地区进行的一些关于中国对降低由空气污染带来的健康风险的付出预期的研究。关于健康影响评估的具体方法论，详见附录B。

8 Zhang, M等人著，2008年，《中国111个城市颗粒污染物的健康影响经济学评估---疾病带来的经济负担分析》（ Economic assessment of the health effects related to particulate matter pollution in 111 Chinese cities by using economic burden of disease analysis ）《环境管理期刊》（Journal of Environmental Management ）88:947-954.

9 Han, X, 和 Naeher, L.P. 2006年，《发展中国家的交通空气污染评估研究》，《国际环境》（Environment International ）32:106-120.

10 近期一项关于北京PM2.5 的研究表明机动车是城市颗粒物的主要污染源(Chan, C.T. 等人，2005年，《北京地区PM2.5、PM10，和含碳物质的垂直分布特征和来源》,《大气环境》39:5113-5124; Dan等人，2004年，《北京地区含碳物质的特征与在PM2.5中成分的来源》,《大气环境》38:3443-3452)。根据Dan等人的研究，2001-2002年期间，PM2.5的浓度在冬季上升了50%-100%，这说明尽管已经采用清洁燃料取代了煤来减少颗粒物，家庭取暖仍是一个重大的排放源。尽管如此，根据估算，如不采取额外的排放控制措施，机动车排放所带来的健康影响，在中国仍然至少要占20-30%，甚至比例更大。

Given the consensus within the scientific community that human exposure to the pollutants in vehicle exhaust can lead to increased incidence of mortality and morbidity, it is evident that the policies carried out to date have resulted in substantial public health benefits. Avoided premature deaths and other health impacts were estimated using outputs from the CFM. These estimates only account for direct PM and secondary PM formation due to NOx emissions and do not include health impacts due to ozone formation and direct emissions of NOx, CO, toxics, volatile organic compounds (VOCs) and other species. Table 2.1 provides the estimated incidences of premature mortality, chronic and acute bronchitis, asthma attacks, hospital admissions, and restricted activity days that have been avoided in China due to the current policies that are in place. More details on the methodology for quantification of health impacts can be found in Appendix B.

These benefits are in line with, but lower than, recent estimates by Zhang et al. of the total health impacts of air pollution in China[8]. Compared with Zhang's study, this analysis would imply that vehicle emissions were responsible for one-tenth of the health impacts of air pollution at 2004 pollution levels, the year in which Zhang's study was done. As mobile sources tend to be responsible for 50 to more than 80 percent of air pollution in major cities in industrialized countries[9], are in close proximity to people breathing, and are a rapidly growing source in China, it would be expected that mobile sources are responsible for a larger portion of the health impacts and are growing over time[10]. Comparison of this analysis with other recent studies suggests that these findings should be viewed as conservative, low-end estimates of impacts.

Table 2.1: Avoided incidences of health impacts due to the current policy package

HEALTH IMPACTS (THOUSANDS)	2000	2005	2010
Premature mortality	6.3	30	110
Hospital admissions	0.95	4.2	15
Chronic bronchitis	14	63	220
Acute bronchitis	75	320	1,100
Asthma attacks	96	420	1,400
Restricted activity days	7,400	33,000	110,000

Using conservative estimates to value health impacts, the total economic impact is significant. The avoided health impacts in 2010 are valued at a total of 170 billion RMB ($25 billion), the equivalent of 0.5% of the GDP. This study valued health impacts based on studies conducted in mainland China of the willingness to pay to reduce the risk of dying from air pollution. The methodology for the valuation of health impacts is included in Appendix B.

8 Zhang, M, et al. 2008. Economic assessment of the health effects related to particulate matter pollution in 111 Chinese cities by using economic burden of disease analysis. Journal of Environmental Management 88:947-954.

9 Han, X, and Naeher, L.P. 2006. A review of traffic-related air pollution assessment studies in the developing world. Environment International 32:106-120.

10 Recent studies of $PM_2.5$ sources in Beijing found vehicles to be one of the major sources of particles in the city (Chan, C.T. et al. 2005, Characteristics of vertical profiles and sources of $PM_2.5$, PM_{10}, and carbonaceous species in Beijing. Atmospheric Environment 39:5113-5124; Dan et al. 2004. The characteristics of carbonaceous species and their sources in $PM_2.5$ in Beijing. Atmospheric Environment 38:3443-3452.). In the 2001-2002 study by Dan et al., however, $PM_2.5$ concentrations rose by 50 to 100 percent in winter months, suggesting that home heating has been a significant source of emissions, although this source is declining as other, cleaner fuels are replacing coal. Nonetheless, it would be expected that vehicle emissions be responsible for at least 20 to 30 percent or more of health impacts in China with the share growing substantially if additional emission controls are not put in place.

2.2 展望未来

尽管目前的政策措施已经在减排和维护健康方面取得了显著成就，但是随着汽车市场的不断扩大，仍需要不断加严政策措施来减轻汽车排放对健康和气候的影响。图2.4展示了从现在到2030年的车辆销售量预测，图2.5则展示了同期道路车辆的增长情况。图2.6和2.7展示了在现行管理情景下，如果不采取更加严格的管理措施，在模型中模拟出的污染物排放和燃料消耗量结果。

2.2 A look to the future

Despite the emission reductions and concomitant health benefits achieved by the current program, continued policy measures will be required to mitigate the negative health and climate impacts of the significant projected growth trends in the vehicle market. Figure 2.4 provides the projected vehicle sales from today to 2030, and Figure 2.5 shows an estimate of total highway vehicle population growth over the same time period. Figure 2.6 and 2.7 show the model results for criteria pollutant emissions and fuel consumption, assuming no further action is taken to tighten regulations beyond their current, or business-as-usual (BAU), state.

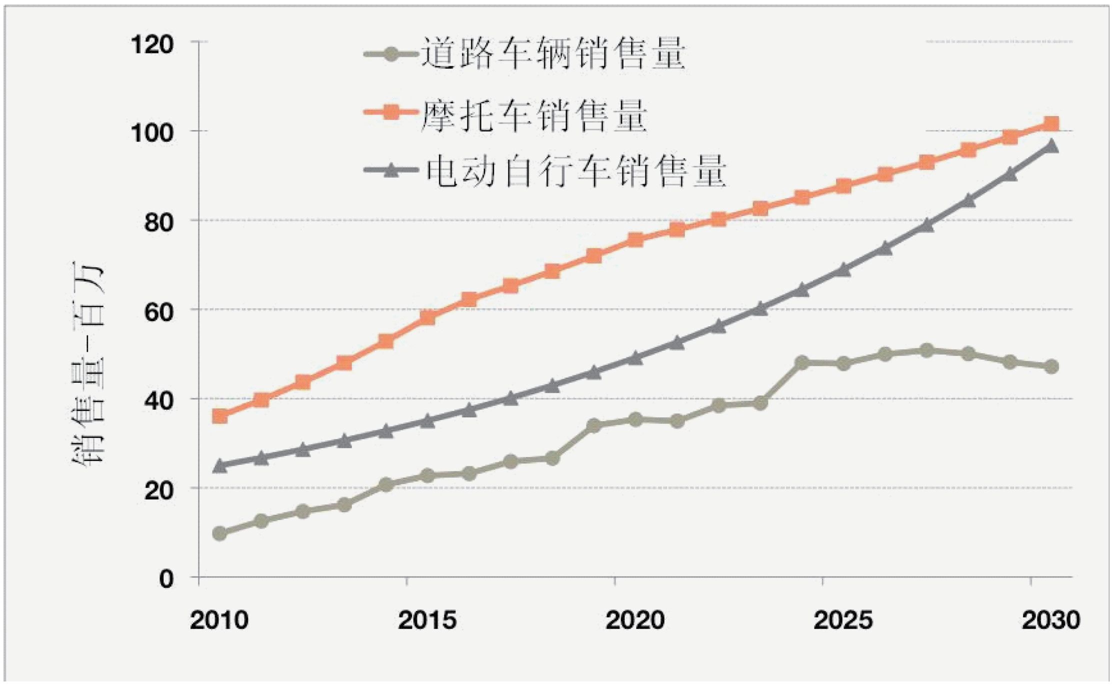


图2.4: 2010 – 2030年[11]机动车销售量模拟

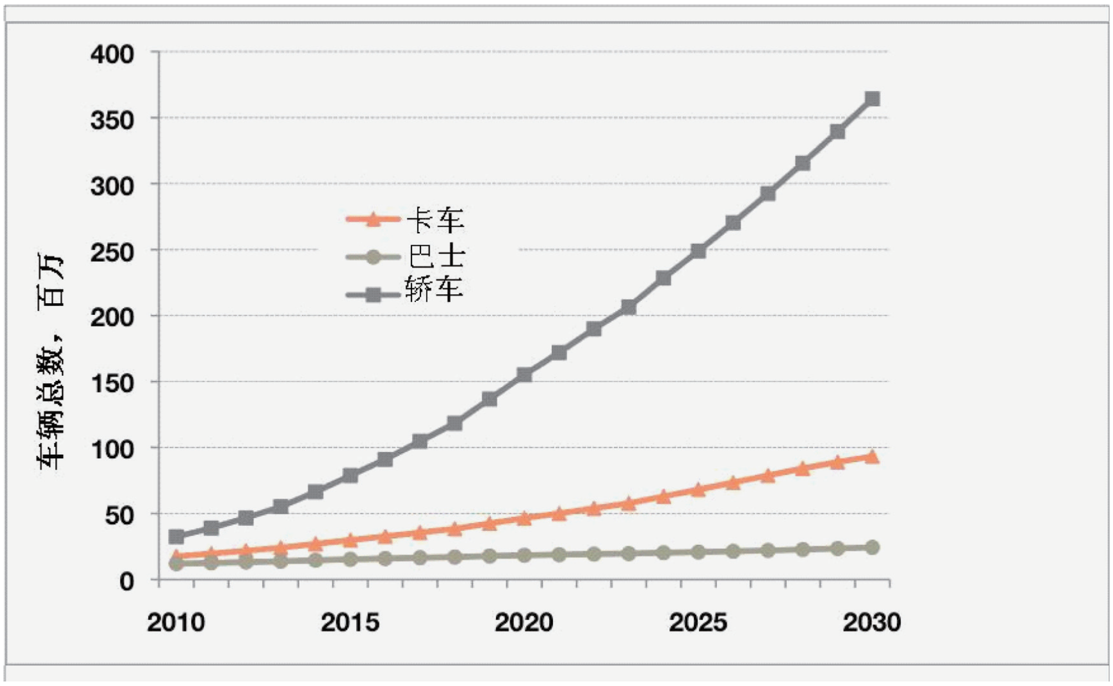


图 2.5: 2010 – 2030年道路机动车保有量模拟

11 道路机动车销售量模拟基于霍红及阿贡实验室共同开发的一款模型。摩托车和电动自行车的销售量预测基于项目人员的最佳判断。模型方法论详情，请参见附录B。

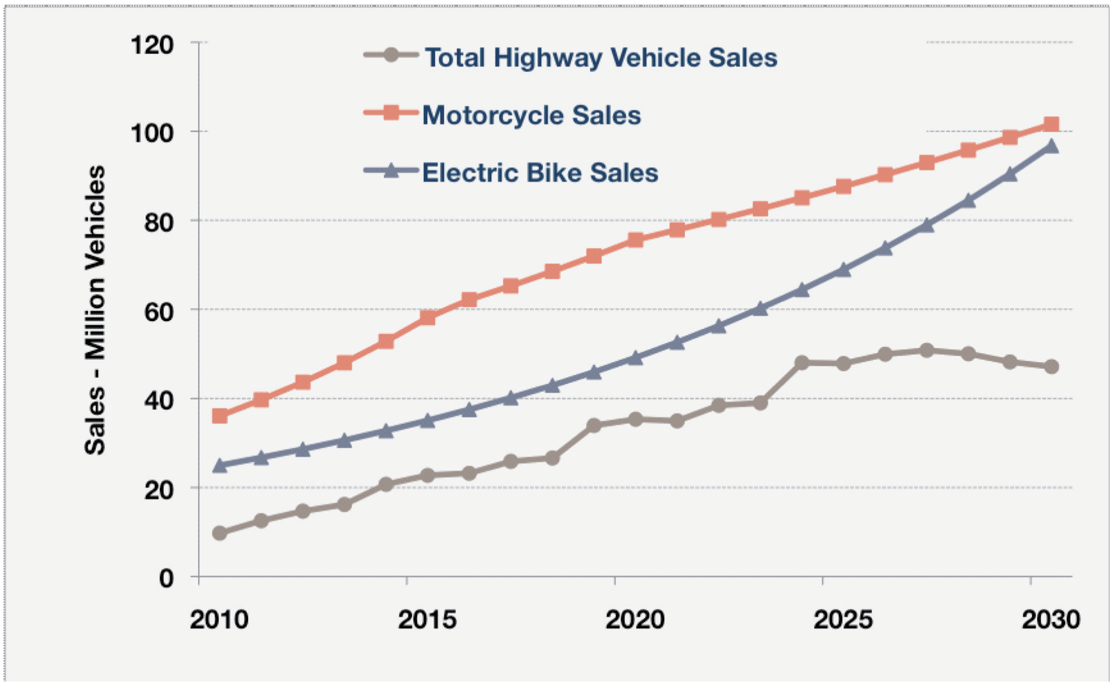


Figure 2.4: Modeled vehicles sales from 2010 – 2030[11]

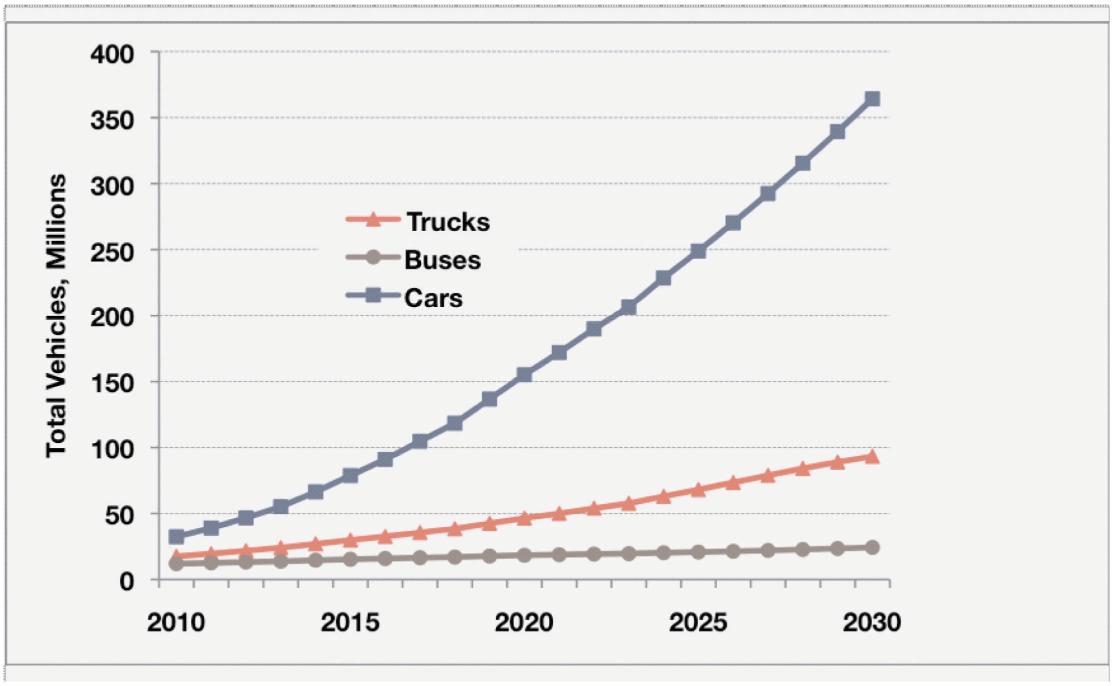


Figure 2.5: Modeled highway vehicle stock from 2010 – 2030

11 For highway vehicles, projections of vehicle sales are based on the model developed by Hong Huo and the Argonne National Laboratory. Forecasts for motorcycle and electric bike sales are based on the team's best judgment. More details about modeling methodologies are discussed in Appendix B.

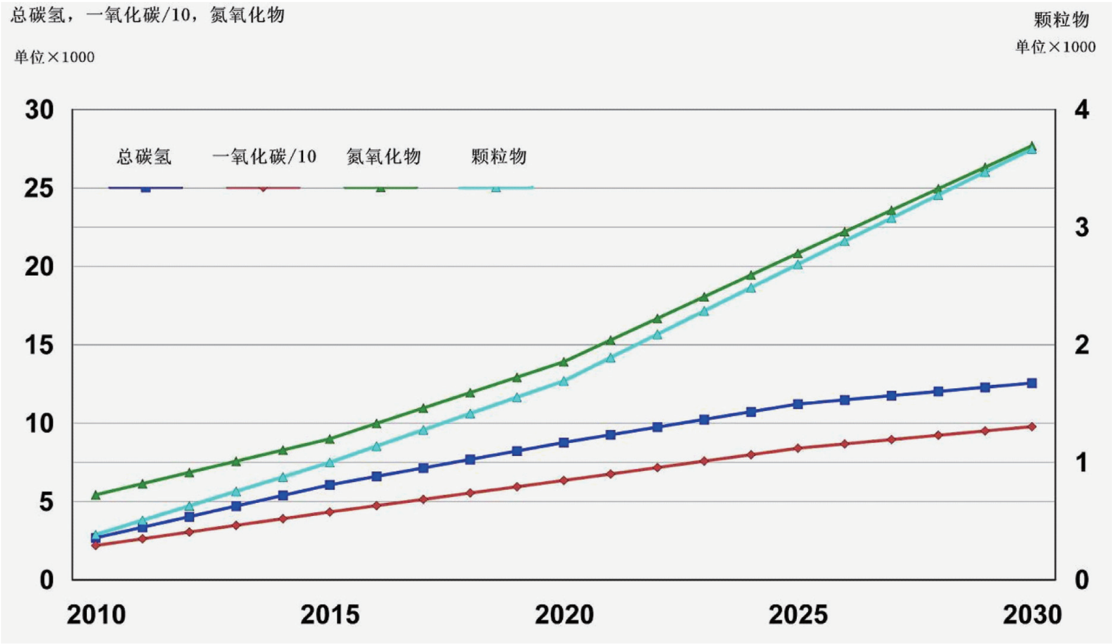


图2.6: 现行管理情景下的排放趋势2010 – 2030年(1000 公吨)

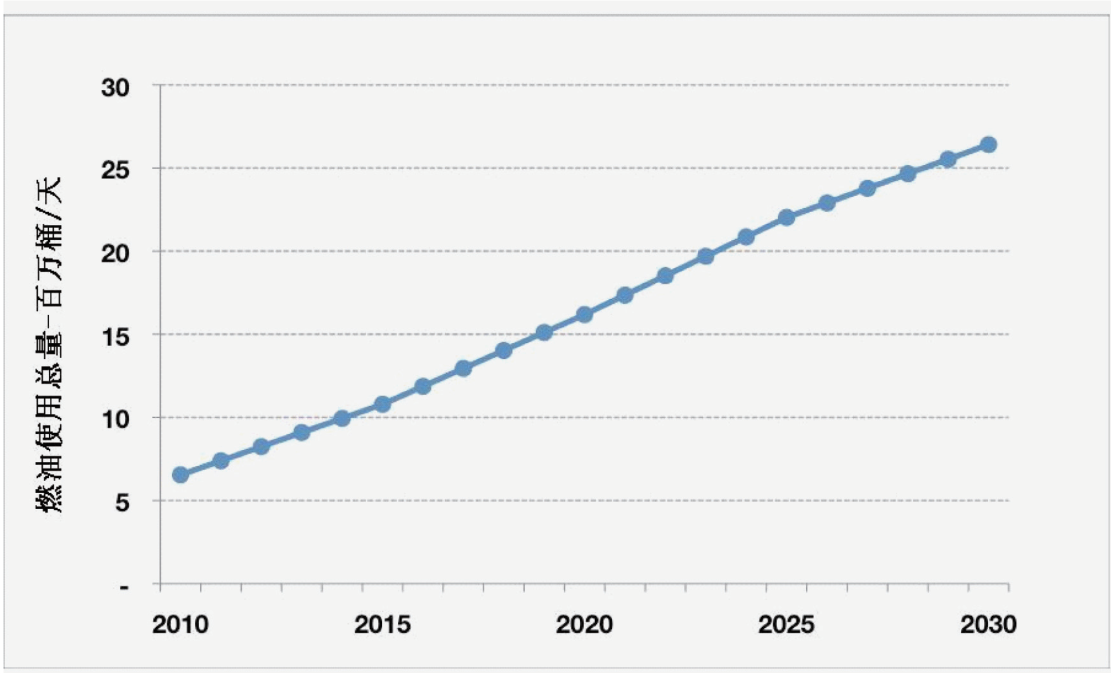


图2.7: 现行管理情景[12]下的燃料消耗量趋势2010 – 2030年

12 现行管理情景假设在第三期乘用车燃料消耗量标准后不实施任何燃料经济性政策。

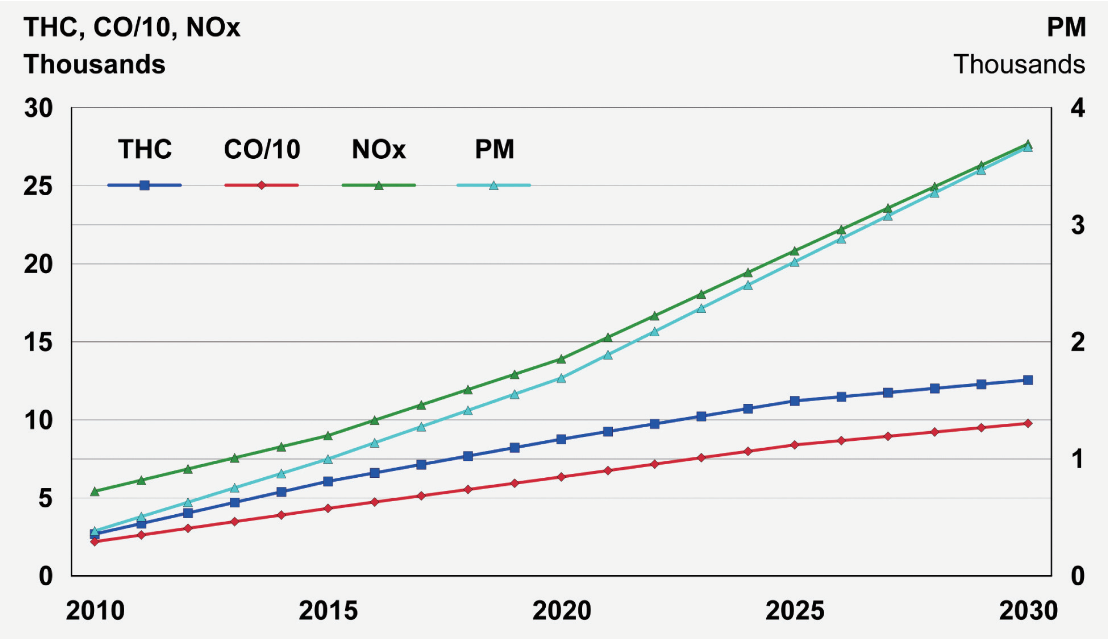


Figure 2.6: 'Business as Usual (BAU)' trends, 2010 – 2030 (thousands of metric tons)

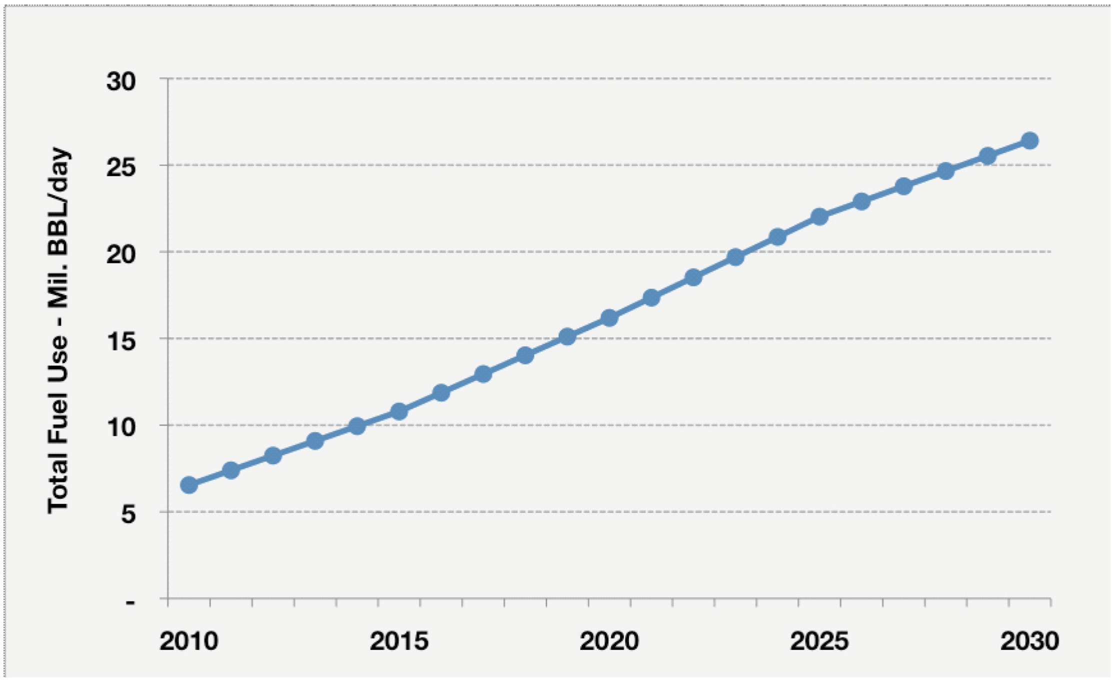


Figure 2.7: 'Business as Usual[12] (BAU)' trends for fuel consumption, 2010 – 2030

12 With continued commitment to ratcheting down vehicle and fuel standards and by introducing new policy elements that parallel international best practice, China can drive down emissions trends and move towards a world-class control program.

中国若能不断加严车辆和燃料标准，且配合引入国际先进的管理政策，将能够降低排放，并逐步实现世界一流的排放控制方案。为了模拟中国现有措施的改进路线，我们设计了三种情景方案：改善方案、强化方案和城市改善方案。改善方案假设在未来的若干年中（2010-2025年）实施更加严格的标准并配合优化的实施方案。强化方案则为今后设计了比改善方案步伐更快、力度更强的短期和长期标准和实施方案。最后的一个情景方案是城市改善方案，强化了改善方案中对重型车部分的要求，增加了有超低硫柴油燃料供应的城市地区的颗粒物减排收益。在咨询了VECC、清华大学以及环保部官员的意见后，目前，这些情景中所设置的目标（情景描述详见表2.2）能够反映出项目人员对到2030年可能取得的成就的最佳判断。情景分析包括以下几个方面：

1) 排放标准: 逐步实施到国VI及后续标准的时间表；

2) 油品标准: 在全国范围内实现超低硫汽柴油的时间表；

3) 燃料经济性[13](FE): 乘用车：现行管理措施情景包括了第I、 II和III阶段标准，从2005年持续实施至2015年。在模拟现行乘用车措施的实施效果时，每年车队燃料经济性改善率以从2002年到2015年第三阶段标准完全实施期间的年改善率，即2%来计算。中重型车及轻型或微型卡车：现行方案情景假定了燃料经济性逐年提高1%；

4)标准实施和执法方案：由于缺乏特定数据来量化实施和执法方案的效果，这些政策因素被模拟为高排放车辆所占百分比的减少[14]；

5)电动化程度：电能是此次唯一纳入情景中的替代能源。根据ICCT的判断，在本研究项目所考虑的时间范围中，电动重型车的使用可能十分微小，因此电动化情景中不包含重型车；

各种模拟情景的进一步描述详见下方表2.2。

13 在改善方案和强化方案情景中，一个重要的假设就是增加混合动力车的使用能够改善燃料经济性。但是，混合动力车并没有从燃料经济性或市场占有率角度进行特别模拟。

14 在模型中，高排放车辆的排放水平相当于无发动机排放控制装置或后处理装置的车辆的排放水平。

To model how China might strengthen its current program of today, three scenarios were developed: an Improved Program, a Strong Program, and an Improved Urban Program. The Improved Program assumes the adoption of more stringent standards and other program improvements in the near-and mid-term (2010-2025). The Strong Program includes more accelerated near- and long-term improvements as compared to the Improved Program. The final scenario, the Improved Urban Program is an enhancement of the heavy-duty vehicle portion of the Improved Program providing additional PM reduction benefits in urban areas that have early access to ultra low sulfur diesel. After consulting with the project team at the VECC and Tsinghua University and stakeholders within the MEP, the goals set forth in these scenarios (see Table 2.2 for scenario descriptions) reflect the project team's best judgment for what can be achieved by 2030. The analysis included the following dimensions:

1) Emission standards: the timeline for moving to China VI standards and beyond

2) Fuel standards: the timeline for providing ultra low sulfur gasoline and diesel nationwide

3) Fuel economy[13] (FE): for light-duty vehicles, the BAU scenario includes Phases I, II, and III which extend from 2005 to 2015. The effect of the current program was modeled as an annual FE improvement of 2% based on estimates of sales-weighted FE in 2002 and the Phase III target for 2015. For medium and heavy-duty vehicles as well as light and mini trucks, the BAU annual improvement was assumed to be 1%.

4) Compliance and enforcement: due to lack of China-specific data quantifying the efficacy of compliance and enforcement programs, these policy components were modeled as having the cumulative effect of driving down the percentage of gross emitters[14].

5) Degree of electrification: electricity was the only alternative fuel for which a penetration scenario was developed. Heavy-duty vehicles are not included in the electrification scenarios based on the ICCT's judgment that electric vehicles would have very minimal adoption in on-road heavy-duty applications in the study timeframe.

Each modeled scenario is further described below in Table 2.2.

13 An important assumption in the Improved and Strong scenarios is that increased adoption of hybrid-electric vehicles will lead to improvements in FE. However, hybrid vehicles are not specifically modeled in terms of their FE performance or market penetration.

14 In the model, gross emitting vehicles have emissions equivalent to vehicles with no engine or aftertreatment emission control features.

表2.2: 情景设定说明下图总结了模拟结果，阐释了先进车辆排放控制方案所带来的收益

情景设定	排放标准	燃料标准	燃料消耗量标准	实施情况	电动车比例
无管理	止步于1999年标准	止步于1999年标准	无	只进行型式核准	无
现行管理	国I, II, III, (IV)	国 I, II, III	轻型车: 第I、II、III阶段标准 (每年加严2%); 对重型车无管理要求	10% 的车辆为高排放车	无
改善方案	2015年实施国VI	2015年，低硫汽柴油 (50 PPM)	轻型车: 每年加严3%; 重型车:从2015年起，到2030年共加严 20%	到2015年，仅5%的车辆为高排放车	轻型车: 2030年, 新车销售的5%为电动车
强化方案	国 V (2012) 国VI (2015)，2020年实现“超低排放”(轻型车) 及 “国 VII” (重型车)	2015年，超低硫汽柴油(10 PPM)	轻型车: 每年加严4%; 重型车:从2015年起，到2030年共加严 50%	到2020年, 仅3%的车辆为高排放车	轻型车: 2030年, 新车销售的10%为电动车
城市改善方案	2012年国 IV + 柴油车颗粒物捕集器，2015年国VI	2012年，低硫汽柴油(50 PPM)	同改善方案	同改善方案	同改善方案

下图总结了模拟结果，阐释了先进车辆排放控制方案所带来的收益。

Table 2.2: Scenario descriptions

SCENARIOS	EMISSION STANDARDS	FUEL STANDARDS	FUEL CONSUMPTION STANDARDS	ENFORCEMENT AND COMPLIANCE	DEGREE OF ELECTRIFICATION
No regulation	Stop at standards adopted by 1999	Stop at standards adopted by 1999	None	Existing type approval only	None
BAU/Baseline	China I, II, III, (IV)	China I, II, III	LD: Phase I, II, and III (2% annual improvement); no HD regulation	10% of vehicle fleet are gross emitters	None
Improved Program	China VI by 2015	Low-sulfur gasoline and diesel (50 PPM) by 2015	LD: 3% annual improvement; HD: 20% improvement by 2030, starting in 2015	By 2015, only 5% of vehicle fleet are gross emitters	LD: by 2030, 5% of new vehicle sales are electric vehicles
Strong Program	China V (2012) and VI (2015) and "SULEV" (LD) and "China VII" (HD) by 2020	Ultra low-sulfur gasoline and diesel (10 PPM) by 2015	LD: 4% annual improvement; HD: 50% improvement by 2030, starting in 2015	By 2020, only 3% of vehicle fleet are gross emitters	LD: by 2030, 10% of new vehicle sales are electric vehicles
Improved Urban Program	China IV + diesel particle filter in 2012 and China VI by 2015	Low-sulfur gasoline and diesel (50 PPM) by 2012	Same as Improved Program	Same as Improved Program	Same as Improved Program

The following figures summarize the modeling results and illustrate the significant benefits of a progressive vehicle emission control program.

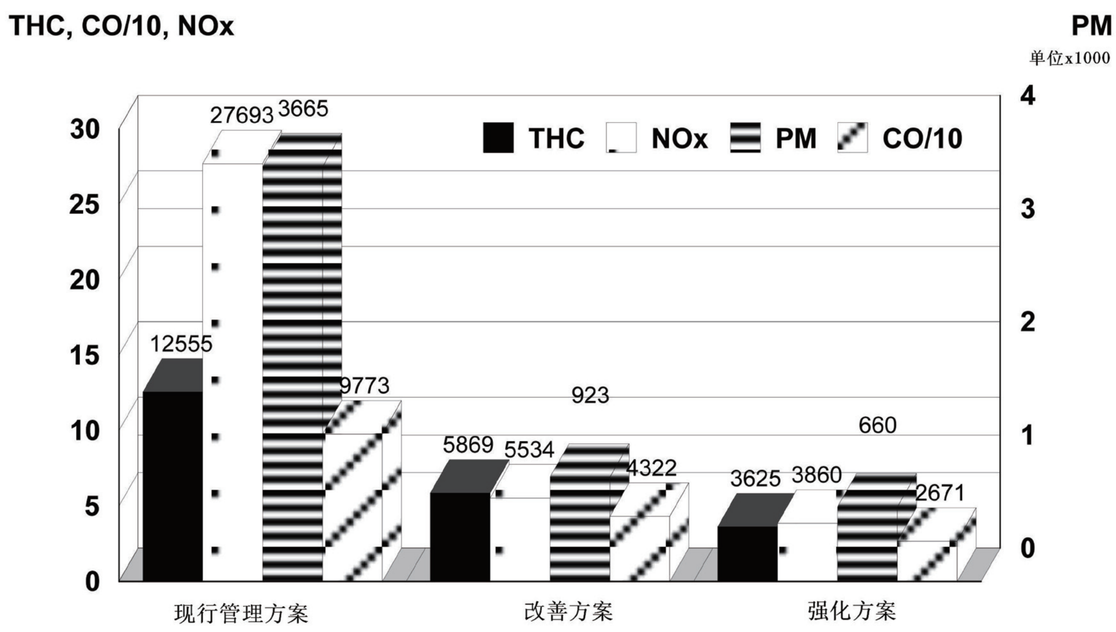


图 2.8: 现行管理、改善方案和强化方案情景下2030年的排放情况 (1000公吨)

改善方案和强化方案带来的大幅减排在未来将带来重大的健康收益。表2.3展示了到2015年、2020年、2025年和2030年各个情景下健康风险发生率降低情况的评估结果。

表 2.3: 强化和改善方案下可避免健康影响的效益评估

健康影响 (千人或千天)	2015年		2020年		2025年		2030年	
	改善	强化	改善	强化	改善	强化	改善	强化
提前死亡	34	38	100	110	200	220	310	340
入院就医	4.4	5	13	14	24	27	35	41
慢性支气管炎	67	76	180	210	330	370	480	530
急性支气管炎	310	350	820	920	1,400	1,600	2,000	2,200
哮喘	410	470	850	960	1,500	1,700	2,200	2,400
工作影响天数	32000	36,000	84000	94,000	150,000	160,000	200,000	220,000

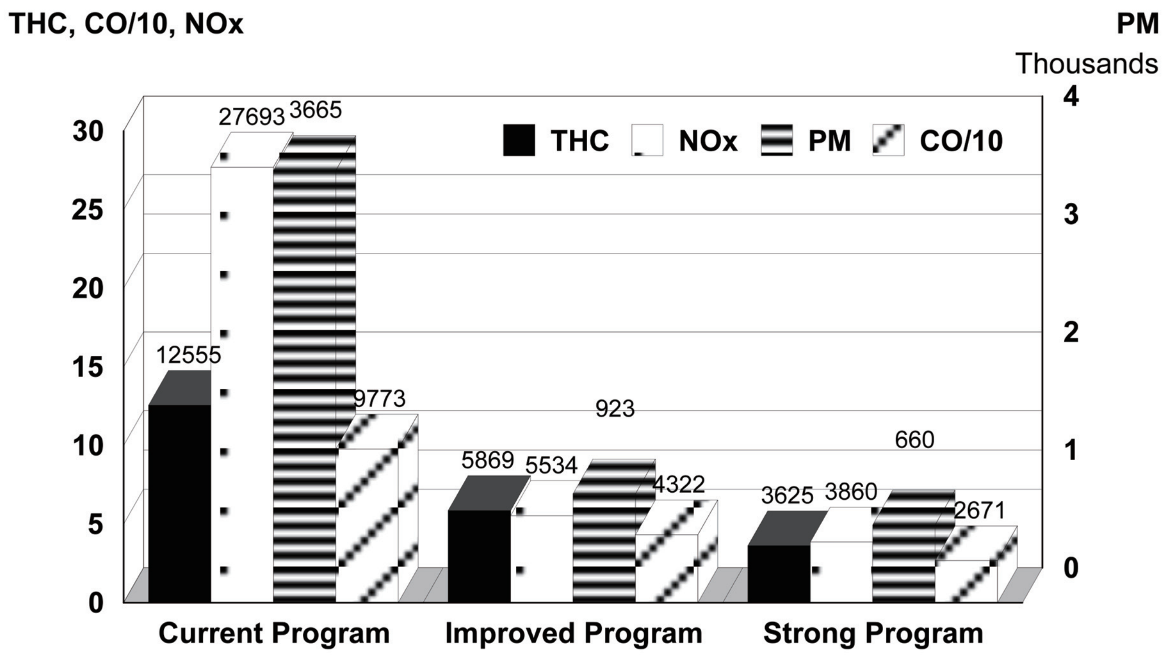


Figure 2.8: Emissions of the BAU, Improved, and Strong Programs in 2030 (thousand metric tons)

The dramatic reductions in emissions with the Improved and Strong Programs would translate into important reductions in adverse health impacts in future years. Table 2.3 provides the estimated incidences of adverse health impacts that could be avoided in each scenario in the years 2015, 2020, 2025, and 2030.

Table 2.3: Avoided incidences of health impacts due Strong and Improved Programs

HEALTH IMPACTS (THOUSANDS)	2015		2020		2025		2030	
	IMPROVED	STRONG	IMPROVED	STRONG	IMPROVED	STRONG	IMPROVED	STRONG
Premature mortality	34	38	100	110	200	220	310	340
Hospital admissions	4.4	5	13	14	24	27	35	41
Chronic bronchitis	67	76	180	210	330	370	480	530
Acute bronchitis	310	350	820	920	1,400	1,600	2,000	2,200
Asthma attacks	410	470	850	960	1,500	1,700	2,200	2,400
Restricted activity days	32000	36,000	84000	94,000	150,000	160,000	200,000	220,000

从图2.9中可以看到，在过去的10年中，现行管理措施已经拯救了许多生命，而实施强化方案，在未来的若干年中，可避免由于污染而过早死亡的人数将会比现行管理方案高2倍。

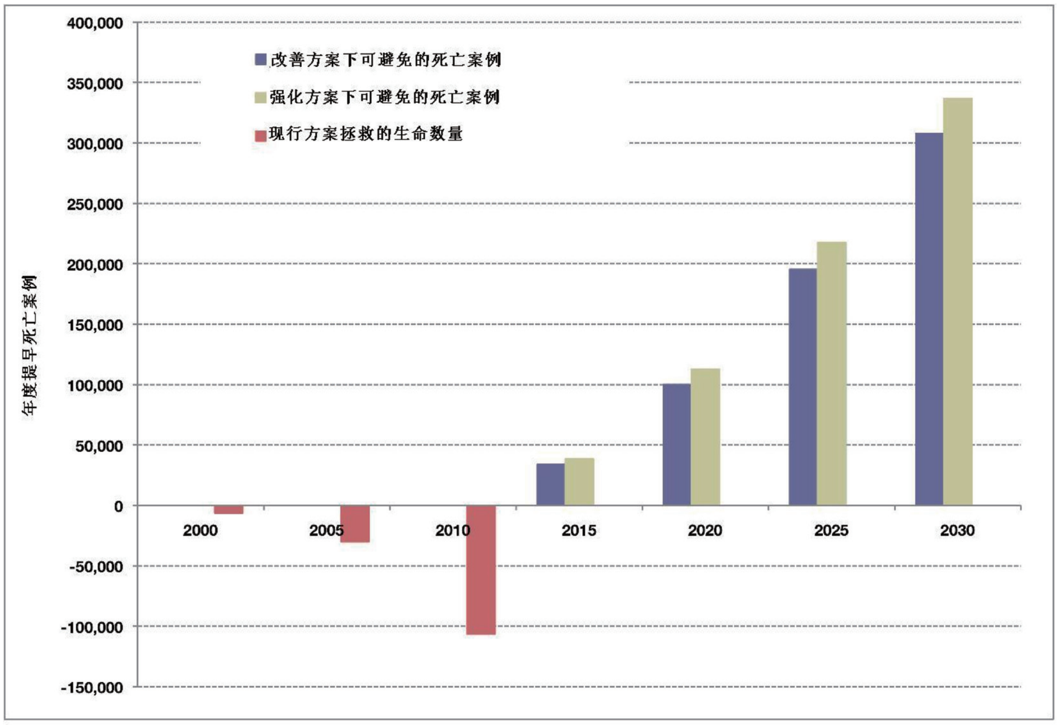


图 2.9: 各种情景下提前死亡案例的数量

到2030年，实施改善方案和强化方案的预期健康收益的经济价值可达2.4-2.6万亿人民币（3500-3900亿美元），相当于国内生产总值（GDP）的2.3-2.6%。健康影响价值评估方法论详见附录B。中国其它研究学者进行的分析和英国以及其它地区的研究结果都肯定了这样的价值评估，甚至认为在减少提前死亡方面，减排所带来的健康收益和经济收益应比我们当前预计的更高[15]。

仅仅考虑北京、上海和天津三个城市，在2015年，实施城市改善方案能够额外拯救1900人的生命。尽管减排量很小，但是由于大城市内人口暴露于污染物中的比率高，因此对死亡率的影响较大。

15 如之前所述，在最近由Zhang等人进行的两项研究中，从2000年到2005年，各种污染源造成的空气污染所造成的提前死亡率比ICCT的研究结果高10倍，自然其估计的健康收益经济影响的价值也要高得多。英国政府近日公布了欧盟环境总署的研究结论，即该国每年过早死亡个例高达5万人，占死亡总数的10%（英国国会下议院，环境审核委员会，空气质量，2009年10月第五次会议报告，2010年3月22日）。根据这一分析，由机动车污染造成的死亡百分比约在0.2%和3%这一最高的估计范围内（2030年排放水平，无额外控制措施）。还有其它许多研究都指出了机动车空气污染会对死亡率和经济都造成更大影响，而这些研究结果还被认为是比较保守的。

As can be seen in Figure 2.9, the current program has saved numerous lives in the past decade but a strong emissions control program could prevent three times as many premature deaths in the coming years.

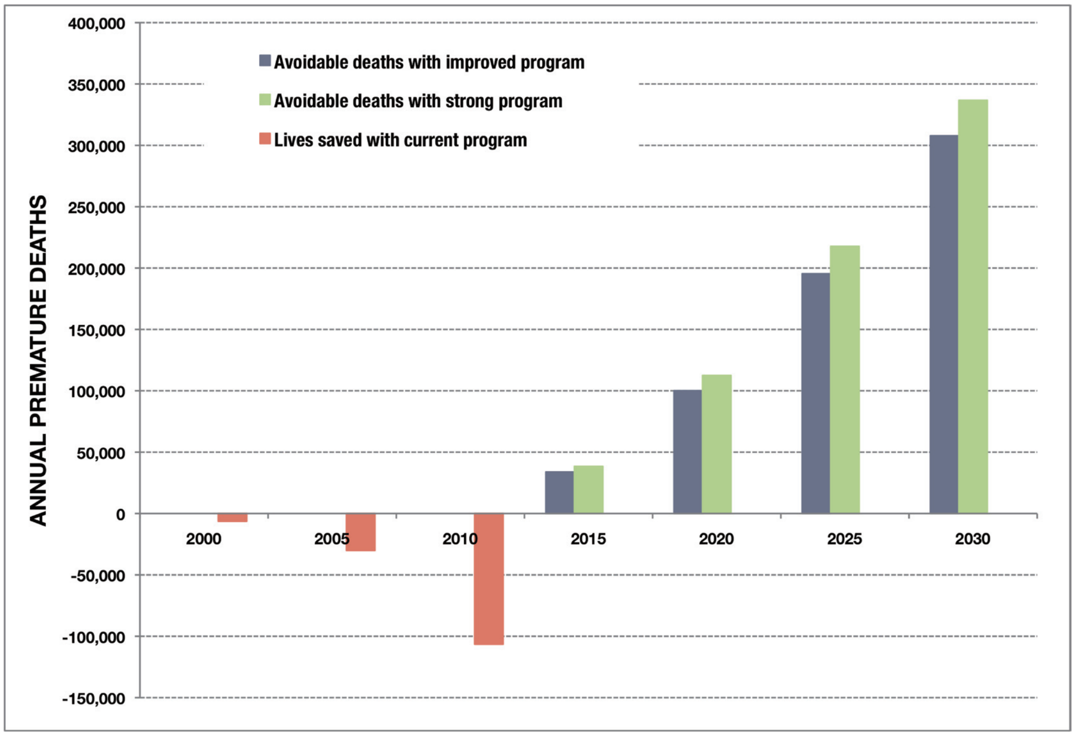


Figure 2.9: Annual premature deaths under different scenarios

In 2030, the monetary benefits associated with the reduced health impacts of the Improved Program and Strong Program scenarios would be expected to have health benefits of approximately 2.4–2.6 trillion RMB ($350–390 billion), equivalent to an estimated 2.3-2.6 percent of the GDP. The complete methodology for valuation of health impacts is included in Appendix B. Analyses conducted by other researchers in China, the United Kingdom and elsewhere confirm these findings with similar or higher expected impacts in terms of levels of premature mortality due to air pollution and total monetary benefits of reducing emissions[15].

Considering the impacts in just the three cities of Beijing, Shanghai, and Tianjin, the Improved Urban Program would save an additional 1,900 lives in the year 2015. While the emissions reduction is very small, it has a larger impact on mortality because of the higher exposure rate in these large cities.

15 As previously reported, two recent studies by Zhang et al. found premature mortality rates in the years 2000 through 2005 associated with air pollution from all sources to be up to 10 times higher than the ICCT findings, with the value of the impacts also an order of magnitude higher. The UK government recently publicized findings by the European Environment Agency that premature deaths in that country could be as high as 50,000 per year, or 10 percent of all deaths (House of Commons, Environmental Audit Committee, Air Quality. Fifth Report of Session 2009-10. March 22, 2010). In this analysis, the percentage of deaths due to air pollution from vehicles varied between 0.2 percent and three percent at the extreme (2030 emissions with no additional controls in place). Many other studies have also reported much higher impacts of air pollution from vehicles both in terms of mortality rates and economic impacts, suggesting that these study results should be considered conservative.

改善燃料经济性政策将有效节省燃料并减少二氧化碳排放，同时将中国在这一政策领域的地位推向世界领先位置（图2.10和图2.11）。到2030年，根据估算，较之现行管理措施，实施强化方案将节省780亿加仑燃料。另外，颗粒物的减少还会带来附加的气候变化收益，因为颗粒物排放的减少直接减少了具有重大气候影响危害的黑炭的排放（图2.12）。

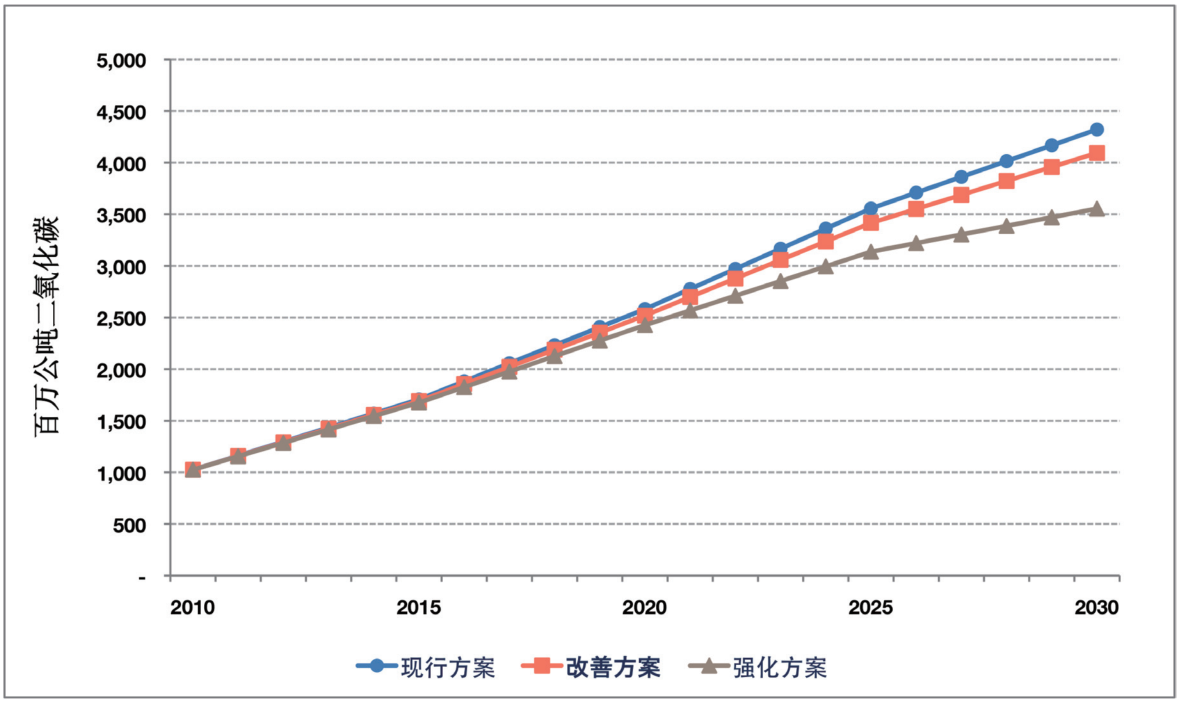


图2.10: 现行方案、改善方案和强化方案情景下的CO_2 排放趋势2010 – 2030年

Additional improvements to the fuel economy program will yield substantial fuel savings and avoided carbon dioxide (CO_2) emissions as well as cement China's position as a global leader in this policy arena (Figures 2.10 and 2.11). In 2030, it is estimated that the Strong Program will save roughly 78 billion gallons of fuel as compared to the baseline scenario. In addition, there are considerable climate co-benefits associated with decreasing particulate matter emissions due to the fact that black carbon—the highly potent climate forcing aerosol that is a subset of PM-is reduced as well (Figure 2.12).

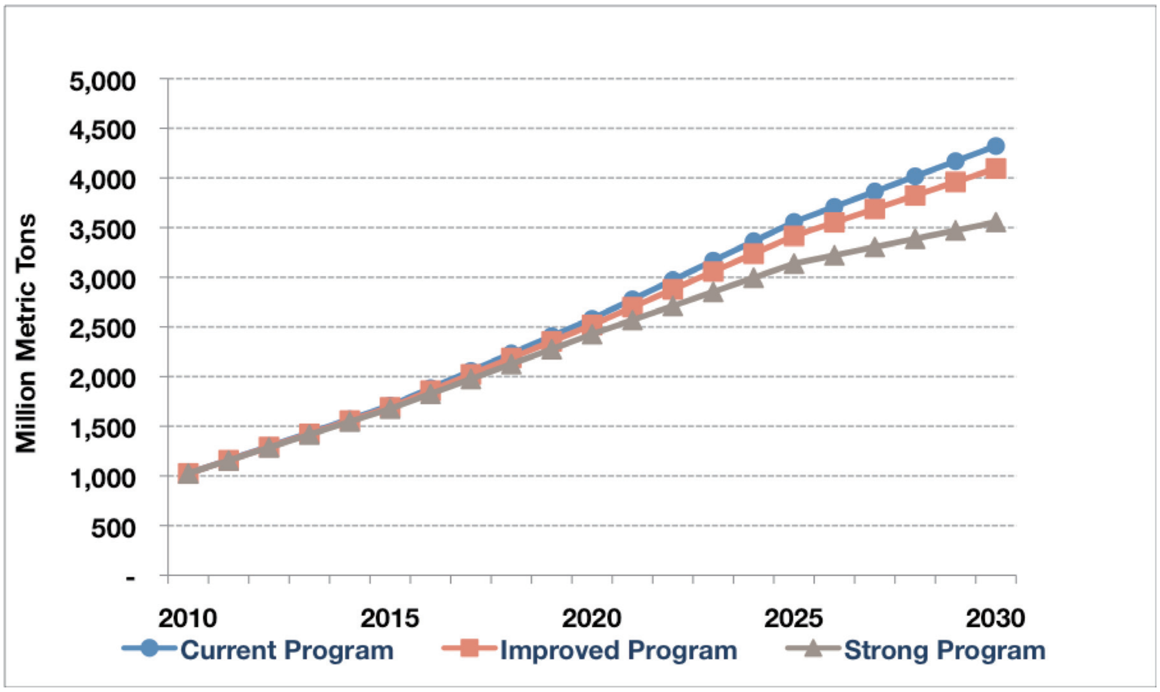


Figure 2.10: CO_2 emission trends for BAU, Improved and Strong Programs, 2010 – 2030

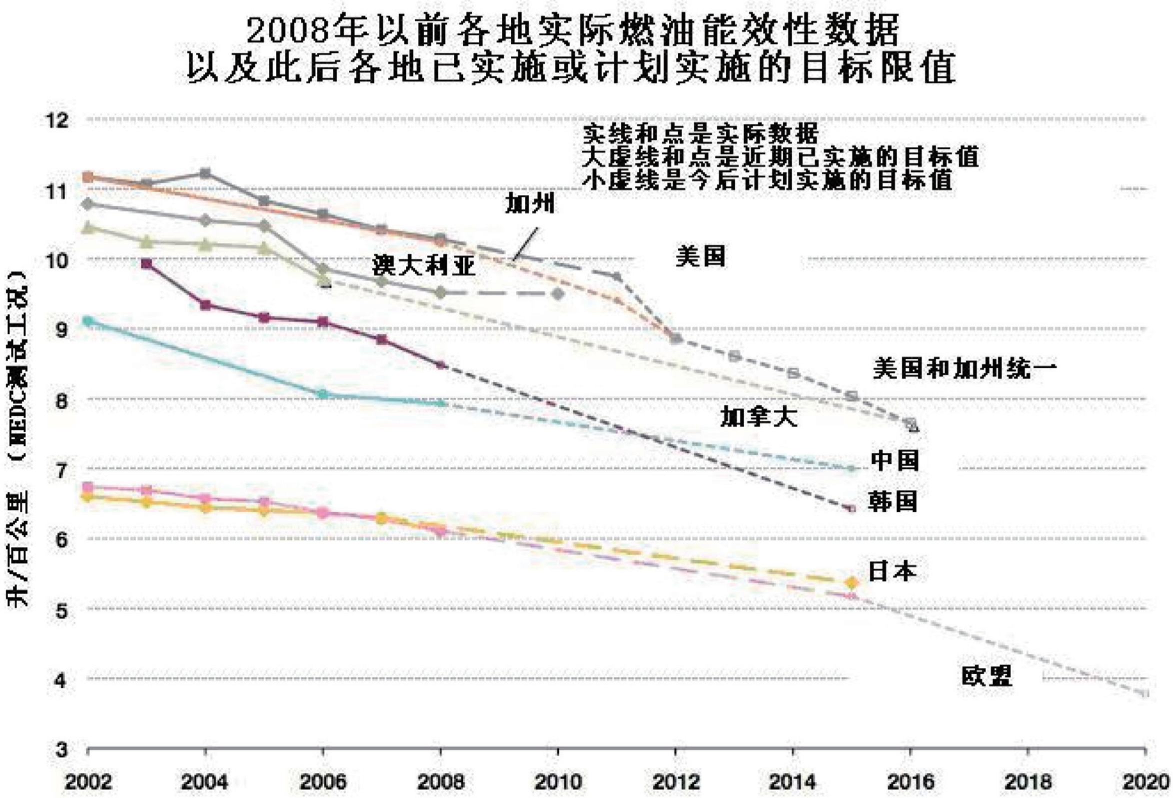


图 2.11: 部分国家/地区燃料经济性水平和法定目标值的发展趋势2002 – 2030年

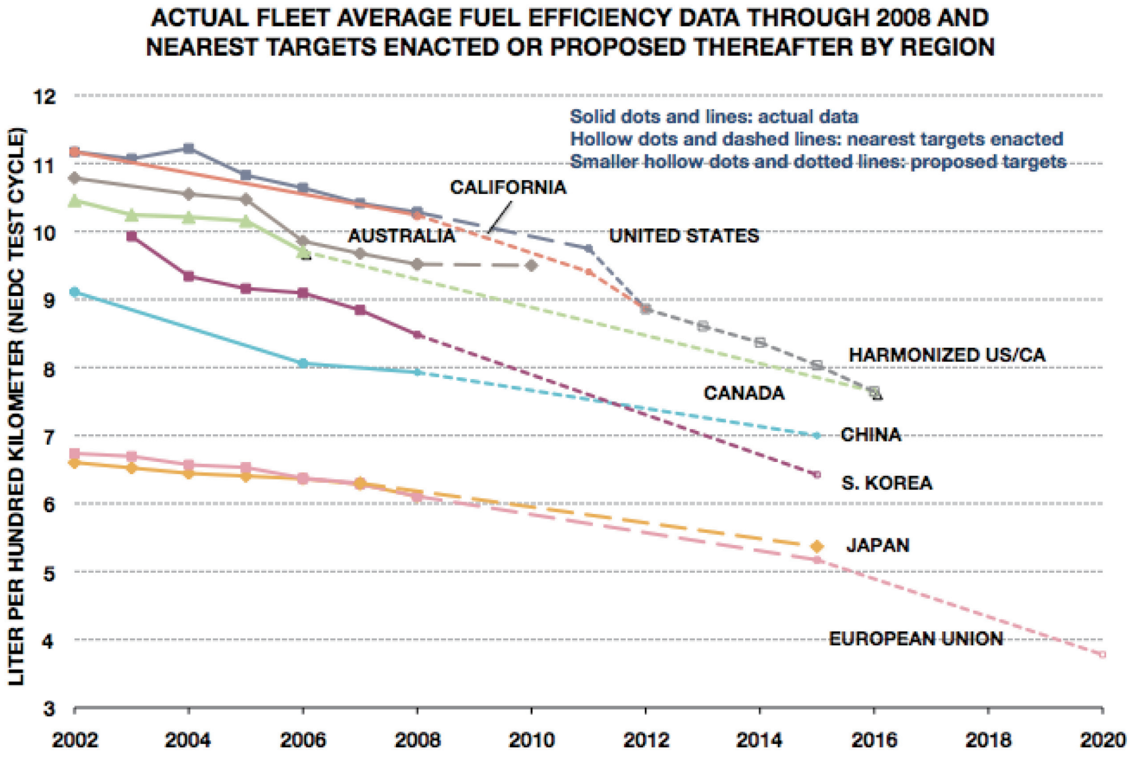


Figure 2.11: Fuel economy trends of select countries/regions, 2002 – 2030

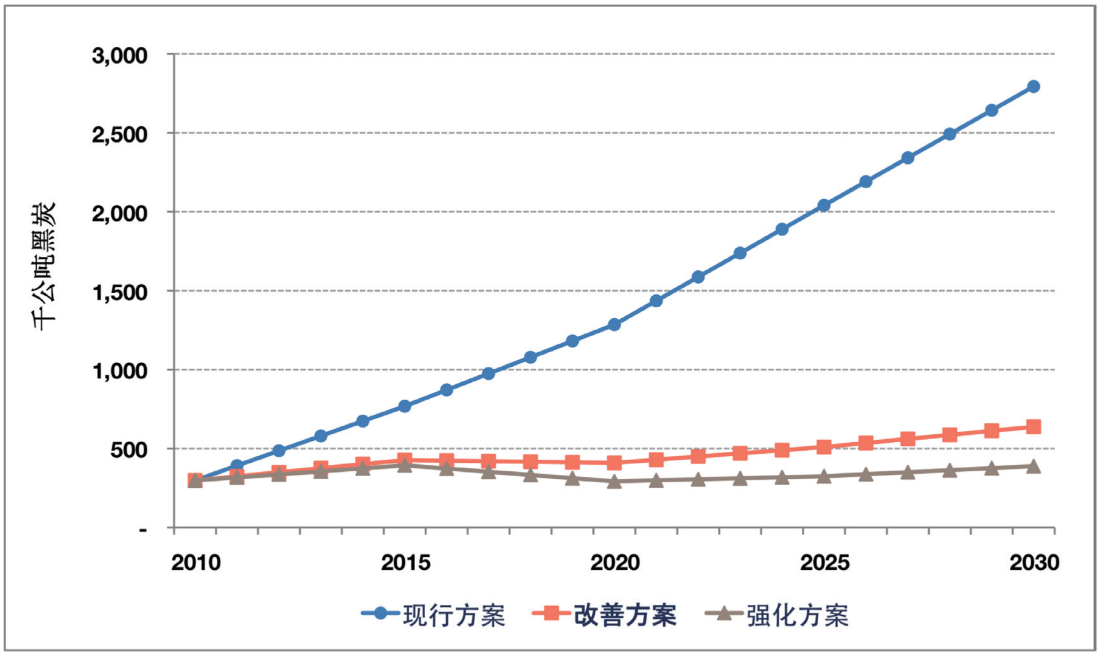


图 2.12: 现行方案、改善方案和强化方案情景下的黑炭排放趋势2010 – 2030年

在接下来的七章中，我们将从多方面分析现行的车辆污染控制方案，并与国际最佳经验进行比较。通过比较能够帮助我们提出推荐意见，改进现行方案，在未来的10年中，挽救中国更多人的生命。

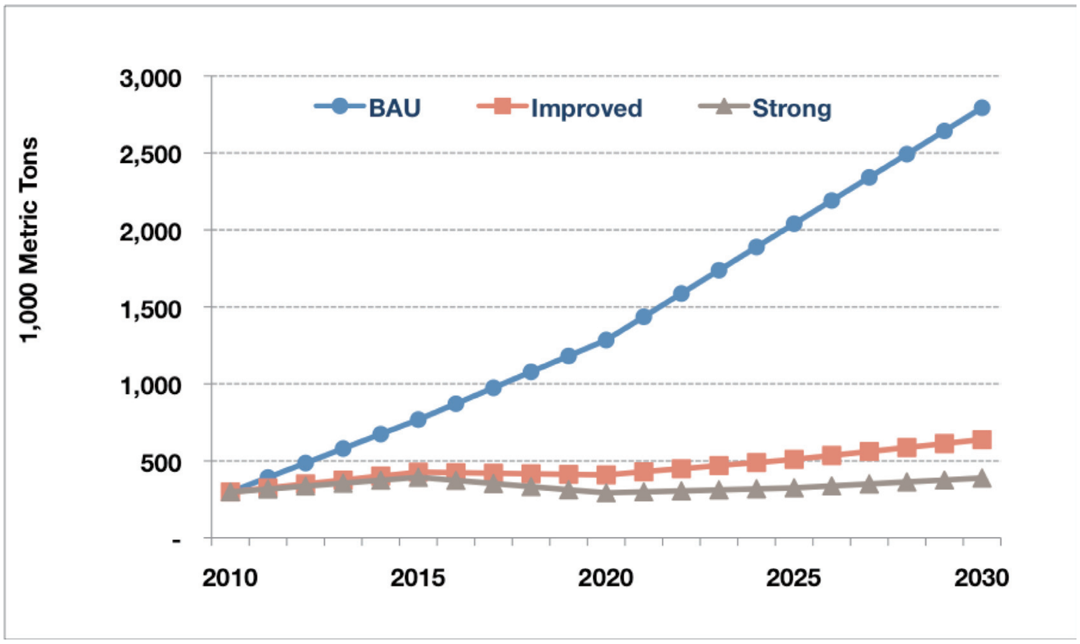


Figure 2.12: Black carbon trends for BAU, Improved and Strong Programs, 2010 – 2030

The next seven chapters will review each component of the current vehicle pollution control program and compare them to international best practices. The comparison will help identify recommendations that will assist in enhancing the current program and saving lives in China over the next decade.

3. 新车和发动机排放标准

排放标准规定了新车/发动机在预先设定好的测试工况下所排放或蒸发的污染物数量，是所有机动车排放控制措施中的重要组成环节。车辆标准与油品品质密切相关，特别是限制硫含量，是使先进排放控制技术得以应用并使其减排结果最优化的必要前提。油品标准将在第四章专门进行讨论。标准实施和执法是保障排放控制措施成功有效的重要因素，它能够保障车辆在整个使用寿命周期满足相关标准的要求。这些具体措施将在第五章和第六章进行分析。

我们在前面提到过，中国从上世纪90年代末开始循着“欧洲”路线对主要车型实施排放控制标准，北京、上海等主要城市更是带头加快标准推进的步伐。尽管中国与欧盟之间的差距正在逐步拉近，但假设中国按计划从2011年起在全国范围实施国IV标准（详见图3.1和3.2），仍然比当前最新的欧盟标准落后4-5年。如情景模拟结果所示（图2.8-2.12），早日缩小差距并采纳严格的标准，从而迫使车辆采用现有的最佳排放控制技术，将带来重大的环境和公共健康收益。

与美国、加州和日本的成熟措施相仿，欧盟排放标准限值的设定也是基于特定时期最佳技术所能实现的减排效果。另外，还会考虑成本效益和安全等因素。例如，美国《清洁空气法》第202节明确规定，要保护公众健康和财产，环保局所采纳的标准要能够反映出“在合理考虑相关技术的成本、能源和安全因素后，利用标准实施时的适当技术，所能实现的最大幅度的减排”。

不过，标准只是限制了污染物的排放率，却无法限制污染物排放总量。要想实现机动车污染物总量控制，还需要控制车辆总数和使用率。这方面的政策大多是基础设施和道路使用规划，而且通常应用于特定区域。这些政策包括道路收费、提供公共交通、发展非机动交通基础设施。这些措施针对的不是车辆生产企业，而是车主。尽管详尽讨论这些政策超出了本报告的相关范围，但重要的是，这些政策确实是减少机动车污染综合管理方案中的必要环节。

以下各部分按车辆类型排序“轻型车(LDVs)、重型车/发动机(HDVs)、两轮及三轮车（摩托车）、非道路机械和农用车。将总结和讨论各个车型对应标准的实施时间表以及部分标准所涉及的主要城市。同时，我们还将总结满足中国未来标准所必需的技术。在本章的结尾，将会讨论实施过程中的障碍，并为改善实施方案提出建议。

3. New vehicle and engine emission standards

Emission standards, limits on the amount of pollutant released by or evaporated from new vehicles/engines over a pre-defined test cycle, are a crucial element of all vehicle emission control programs. Vehicle standards go hand in hand with fuel quality requirements—specifically, sulfur limits— that enable advanced emission control technologies to be used and optimized. Fuel standards are discussed in Chapter 4. Compliance/enforcement measures are crucial elements of a successful emission control program as they ensure standards are met over the vehicles' useful lives. These activities are further described in Chapters 5 and 6.

As discussed in the previous section, China has since the late 1990's ratcheted down the emission limits for its major vehicle categories following the ‘Euro' path, with major cities such as Beijing and Shanghai leading the way with accelerated adoption of standards. Although the time gap between standards in the European Union (EU) and China has been closing, there still remains a four to five year lag in adopting the newest standards, assuming China IV is implemented in all new models according to schedule in 2011 (see Figures 3.1 and 3.2). As illustrated by the modeling results (Figures 2.8 through 2.12), closing this gap and moving to standards that force the use of the best available control technologies as quickly as possible would yield significant environmental and public health benefits.

The emission standards limit values in the EU as well as in other mature programs such as the United States, California, and Japan are set primarily based on the reductions achievable by the best available technologies in the period considered. Other aspects such as cost effectiveness and safety are also taken into consideration. For example, Section 202 of the US Clean Air Act (CAA) clearly states that to protect public health and welfare, the Administrator should adopt “Standards which reflect the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the model year to which such standards apply, giving appropriate consideration to cost, energy, and safety factors associated with the application of such technology.”

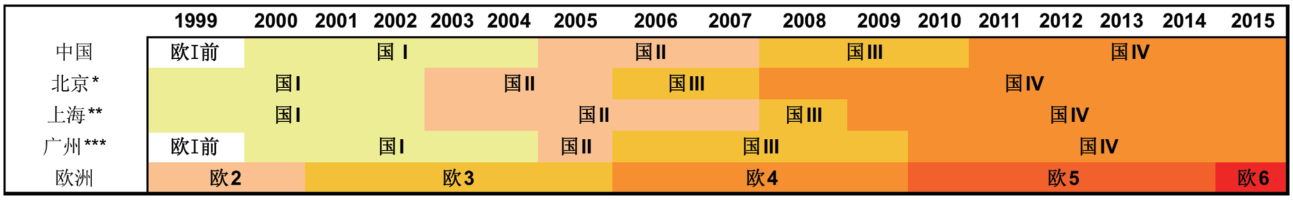
However, standards only limit the rate at which pollutants are emitted and not the total amount of pollutants released in the atmosphere. Controlling the total amount of vehicle pollution entails also addressing the number of vehicles in the fleet and how much they are used. These policies are traditionally in the realm of infrastructure and land use planning and often implemented at a local or regional level. They range from road pricing schemes to providing public transportation to developing infrastructure for non-motorized transportation. The focus of these measures is not the vehicle manufacturer but the vehicle owner. Although a detailed discussion of these policies is beyond the scope of this report, it is important to note that they are an essential component of a comprehensive approach towards reducing vehicle pollution.

The following sections are organized by vehicle type: light-duty vehicles (LDVs), heavy-duty vehicles/engines (HDVs), two- and three-wheelers (motorcycles), non-road equipment and rural vehicles. For each vehicle type, the standards adoption timeline in China and, if relevant, the major cities, is presented and discussed. Also included are summaries of the technologies required to meet future standards in China. The chapter ends with a discussion of barriers to progress and specific recommendations for program improvements.

3.1 轻型车

此类车型包括乘用轿车、面包车和轻型载货卡车。管理要求控制的排放物包括碳氢化合物(HC)、一氧化碳(CO)、氮氧化物(NOx)和颗粒物(PM)，采用的测试工况是在欧洲NEDC测试工况基础上进行了一些修改。各种污染物标准限值表详见附录C [16] 。

欧盟从1992年开始实施欧1/I标准，如图3.1所示，在过去的10年中，在标准实施方面，中国（不包括主要城市）与欧盟之间的时间差距已经从8年缩短至5年左右。附录D中的表D-1归纳了实施欧4、5和6标准所必需的技术手段。至于柴油车，要满足欧5和欧6标准的颗粒物限值，要求使用柴油车颗粒物捕集器(DPF)，并且要使用硫含量50ppm以下乃至推荐使用10ppm的燃料才能实现更好的减排效果 [17]。



* 北京在2005年12月30日实施国III标准，但对OBD的要求到2006年12月1日才执行。

**上海从2009年11月开始实施国IV标准。

***珠三角从2010年6月1日开始实施国IV标准。

图 3.1: 中国和欧盟轻型车标准实施时间表[18]

欧盟标准体系与美国不同，对柴油车和汽油车的要求不一样，对柴油车的NOx要求比较宽松，甚至在尚未实施的欧6标准中依然如此（详见附录C）。相反，美国的管理方案则对所有燃料类型的车辆实行同样的标准，而且几个柴油车型已能够通过认证。这就表明，在设置标准时并不需要权衡改善空气质量与燃料经济性之间的矛盾。香港设计了一个特殊的体系来确保不会产生这种矛盾。在香港特别行政区允许销售经过美国、欧盟和日本最新标准认证的汽油车，但柴油车必须通过美国Tier2 Bin5标准认证[19]。尽管目前中国大陆的轻型柴油车很少，但是一旦柴油车数量显著增长，香港对柴油车标准制定的经验可作为有用的参考。

16 新欧洲行驶工况(NEDC)结合了ECE-15工况中的城市行驶工况和EUDC（补充城市行驶工况）。

17 在国III实施初期，中国没有同时要求认证国III的车辆要安装车载诊断系统（OBD）。国III须带OBD的要求在国III实施1年后（2008年7月）才对小轻型客车（坐位不超过6个，重量不超过2,500公斤）生效。 其他轻型车安装OBD的要求到国III实施3年后才实行（2010年7月）。因为没有OBD的监察，很难保证不带OBD 的国III车在正常寿命期内或耐久性要求的5年 / 80000公里内可以保持排放达到国III标准。

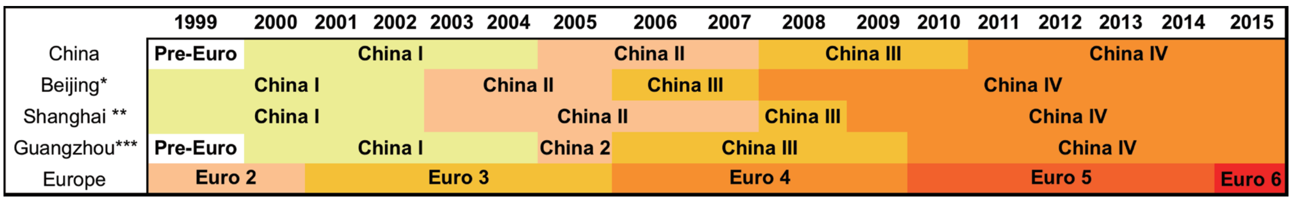
18 此处的实施时间是停止对达到前一阶段新车的生产、销售和上牌的日期，即停止实施前一阶段标准的型式核准。

19 与 Vanessa Au 的会谈(香港环保署), 2010年3月29日。

3.1 Light-duty vehicles

This category includes passenger cars, vans and light cargo trucks. Regulated emissions include hydrocarbon (HC), carbon monoxide (CO), oxides of nitrogen (NOx), and particulate matter (PM) and are tested using a modified version of the European NEDC test cycle [16]. Tables with limits by standard level for all regulated pollutants are provided in Appendix C.

With the EU having introduced Euro 1/I in 1992, Figure 3.1 shows that over the past ten years the adoption time lag between China (not including major cities) and the EU has decreased from eight years to just over five years. Table D-1 in Appendix D summarizes the technology requirements to meet Euro 4, 5, and 6 standards. For diesel vehicles, meeting Euro 5 and 6 with its particle number limits requires diesel particle filter (DPF) technology and lower sulfur fuels—below 50-ppm but 10-ppm is recommended for better emission reduction performance [17].



* China III was adopted in Beijing on Dec 30, 2005 but without OBD requirements; OBD are required since Dec 1, 2006.

**China IV standards were implemented in Shanghai in November 2009.

*** China IV standards took effect in Pearl River Delta starting on June 1, 2010.

Figure 3.1: Light-duty vehicle standard adoption timeline in China and EU [18]

The Euro standards, unlike the US program, have different requirements for diesel and gasoline vehicles, with a less stringent NOx requirement for diesel vehicles—even in the upcoming Euro 6 standards (see Appendix C). In contrast, the US program has set the same standards for all fuel types and it is expected that several diesel vehicles will be certified. This shows that a tradeoff between air quality benefits and fuel efficiency is not necessary in setting standards. Hong Kong has developed a unique system to ensure this tradeoff does not occur. The Special Administrative Region allows the sale of gasoline vehicles certified to the latest US, EU, and Japanese standards but only allows diesel vehicles certified to US Tier 2 Bin 5 standards [19]. Although the fraction of light-duty diesel vehicles remains small in mainland China, Hong Kong's example may be useful were the diesel fleet increase significantly.

16 The New European Driving Cycle (NEDC) is a combination of the ECE 15-cycle urban driving cycle and the EUDC (Extra Urban Driving Cycle).

17 When China III standards were first implemented, vehicles certifying for China III were not required to have OBD system. The OBD requirement for China III vehicles took effect one year after China III standards were implemented in 2007, but only apply to small passenger vehicles with no more than 6 seats and weigh no more than 2500kg. For other light-duty vehicles, the OBD requirements were enforced 3 years after China III was adopted (in 2010). Because there is no OBD system to monitor emissions level, it is difficult to guarantee emissions from China III vehicles without OBDs could meet the standards throughout the vehicle's lifetime and within the required durability period (5 years/80,000km).

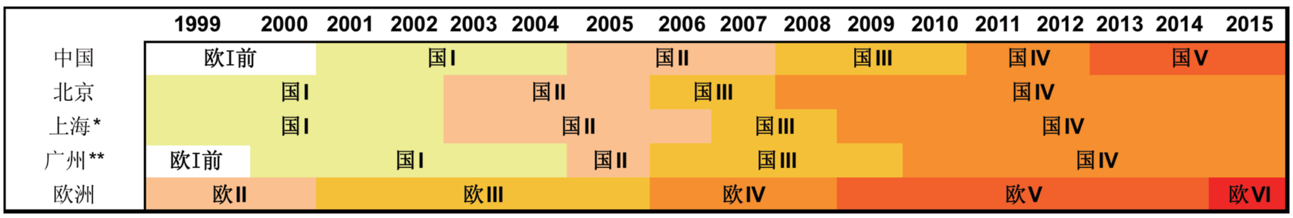
18 Adoption timeline is the date by which vehicles meeting previous level of standards are prohibited from production, sales and registration. This is the date by which the MEP will stop type approval for vehicle models meeting the previous emissions standards.

19 Communication with Vanessa Au (HKEPD), March 29, 2010

3.2 重型车

此类车型包括货运卡车和拖拉机、巴士和特种车，如垃圾车和水泥搅拌车。管理涉及的污染物种类与轻型车相同，但重型车与轻型车的标准不同。轻型车在测量污染物时直接使用底盘测功机（单位以克/英里计算）；而重型车分两步进行测量。第一步，将发动机（包括排放控制系统）放在测功机上进行测试，然后再参考整车对排放的影响加入计算整车排放[20]。发动机排放限值以克/千瓦-小时为单位，具体数据详见附录C。

图3.2展示了2000年到2010年之间的重型车实施时间表。如果中国到2011年1月和2013年1月能够分别对所有车型实施国IV和国V标准，中国与欧盟之间的差距将从8年缩小至4年。



*上海从2009年11月对城市公交车、环卫车和市政建设车开始实施国IV标准。

**珠三角从2010年6月开始实施国IV标准。

图3.2: 中国和欧盟重型柴油车标准实施时间表[21]

附录D表D-3中概括了迈进到欧IV、V和VI的技术路线，指出了发动机修改要求和后处理技术选择。就重型车而言，欧VI的颗粒物限值要求使用颗粒物捕集装置（DPF）和低硫燃料。和轻型车情况类似，燃料的硫含量接近零(< 10-ppm)能够保证DPF的最佳工作状态。虽然使用50ppm的燃料DPF也可以工作，但是颗粒物排放会有所上升。为了尽快获取严格实施国IV→V→VI路线所带来的环境和健康收益，可以效仿欧洲部分国家，通过道路税收（德国）或设定低排放区等鼓励机制提早引入DPF。在已经或即将具备低硫燃料的城市地区，这是一个具有可行性的战略。要想尽快获得收益，还可以在实施国IV→V→VI时，提前引入要求使用DPF的标准限值（例如，在国V标准中采用国VI的颗粒物限值）。这些要求可以主要针对只在低硫柴油区行驶的车辆类型实施。例如，在智利首都圣地亚哥要求所有新巴士必须满足规定的颗粒物标准，这就要求欧III车辆必须安装经过加州空气资源局（CARB）或欧洲减排技术认证协会（VERT）认证的DPF。

在欧洲，要满足欧IV和欧V的氮氧化物限值要求使用选择催化还原技术（SCR）或废气再循环技术（EGR）。欧VI则要求同时使用上述两种技术。SCR具有燃料经济性优势，但是要使用尿素作为反应物来保障氮氧化物减排。建立充足的尿素供应基础设施，从而使卡车司机能方便地获得尿素是使用SCR的关键。要考虑的另外一个关键问题就是SCR系统需要配备故障保险装置来保障尿素的使用和补充。事实上，如果没有尿素，欧IV或欧V车辆排放的氮氧化物会比欧III车还高。装有SCR系统的车辆可以通过多种方式来告知司机，如尿素罐余量指示灯，尿素传感器（确保罐里装的是尿素而非其它物质）或在尿素罐空了的情况下，限制车辆的使用性能（例如：大幅度减速或无法启动发动机）。

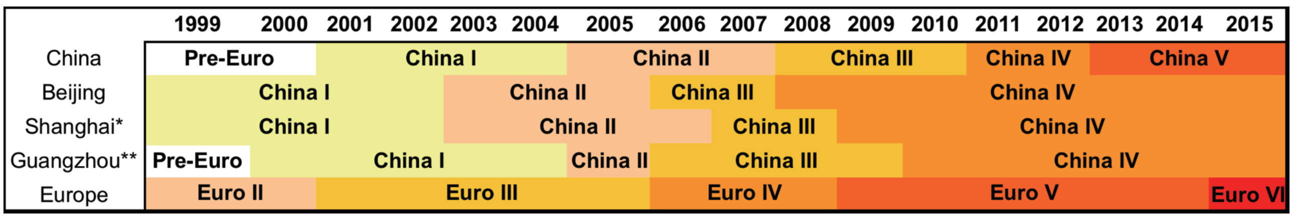
20 参考影响要求使用其它的测试数据和工程评价方法来评估车辆的其它组件对发动机排放的影响。

21 此处的实施时间是停止对达到前一阶段新车的生产、售卖和上牌的日期，即停止实施前一阶段标准的型式核准。

3.2 Heavy-duty vehicles

This vehicle grouping includes cargo trucks and tractors, buses and on-road vocational vehicles such as refuse haulers and cement mixers. Regulated criteria pollutants are identical to that of light-duty vehicles. Unlike the light-duty vehicles standards, which are measured directly using a chassis dynamometer (and have units of grams/mile) heavy-duty vehicle emissions are certified in two phases. First the engine (including the emission control system) is tested on an engine dynamometer, then the vehicle impacts are incorporated by reference [20]. The engine limits are set in grams/kilowatt-hour and are summarized in Appendix C.

Looking at adoption timelines for heavy-duty vehicles, Figure 3.2 shows that between 2000 and 2010, if China IV and V are implemented for all models in January 2011 and January 2013 respectively as scheduled, the time lag behind the EU will have decreased from eight to four years.



* Shanghai required all city buses, sanitation trucks and construction trucks to meet China IV standards starting from Nov, 2010.

**China IV standards took effect in Pearl River Delta starting on June, 2010.

Figure 3.2: Heavy-duty diesel vehicle standard adoption timeline in China and EU [21]

A technology pathway overview is provided in Table D-3 of Appendix D and outlines various engine modification and aftertreatment options for moving to Euro IV, V, and VI. For heavy-duty vehicles, Euro VI PM limits will require the use of DPFs and low sulfur fuel. As in the light-duty case, near-zero (< 10-ppm) sulfur levels will enable DPFs to perform at their maximum potential although fuels with 50-ppm will allow the DPF to function, albeit with somewhat higher PM emission levels. To accelerate the environmental and health benefits beyond what can be achieved by strictly following the China IV→V→VI pathway, DPFs can be introduced early through incentives as was done in some European countries through road tax pricing schemes (i.e. Germany) or the establishment of Low Emission Zones. This is a viable strategy in urban areas where lower sulfur fuels are already, or soon to be, available. Accelerated benefits could also be achieved through adopting standard limits that require DPFs ahead of the China IV →V→VI schedule (e.g. China VI PM limits adopted with China V). Such requirements could focus on the vehicles types likely to remain within the lower sulfur diesel zone. For example, the Santiago Metropolitan Region in Chile requires all new buses to meet a PM standard that requires Euro III vehicles to be outfitted with DPFs verified by the California Air Resources Board (CARB) or the European VERT (Verminderung der Emissionen von Realmaschinen im Tunnelbau) program.

As seen in Europe, meeting the NOx limits for Euro IV and V will require the use of Selective Catalytic Reduction (SCR) or Exhaust Gas Recirculation (EGR). Euro VI is likely to require the use of both options. SCR provides fuel efficiency advantages but requires the use of urea as a reagent to ensure NOx emissions are reduced. Development of an adequate urea infrastructure is a critical step for enabling SCR technology so that urea is widely available to truck operators. Another key consideration is that SCR systems need to be coupled with failsafe measures to make sure urea is used and the tank is replenished. Indeed, without urea, NOx emission from a Euro IV or V vehicle can surpass Euro III levels. Options for driver inducements range from warning lights for tank levels, urea quality sensors to make sure the urea tank is filled with urea and not other substances, and limiting the performance of the vehicle if the vehicle is operated when the tank is empty (e.g. drastically reduced speeds or inability to start the engine).

20 Incorporating by reference requires using other test data and engineering judgment to establish how the remainder of the vehicle's components would impact engine emissions.

21 Adoption timeline for first registration of all new and existing models, which is the date by which vehicles meeting previous level of standards are prohibited from production, sales and registration. This date is typically a year after standards were adopted for new model type approval.

此外，最近的研究引出了一个问题，即在市区行驶工况下，欧V标准到底能带来多少氮氧化物减排。在低负载条件下，测量欧V车使用中的氮氧化物排放，结果比标准限值要高出三倍[22]。欧V排放控制系统的设计是在运行负荷和温度都相对较高的欧洲测试工况下才能发挥最优效果，从而满足标准限值要求。因此，欧V车辆在高负荷和高速工况下控制排放的表现较好。然而，现在看来，在测试工况不覆盖的负荷水平下，包括城市交通拥堵时的低负荷状态，排放控制系统（SCR甚至可能包括EGR）却无法正常发挥作用甚至被完全停用。已知很多SCR系统在尾气温度低的时候会停止尿素喷射来尽可能减少氨逃逸[23]。 也有发现有些发动机设计，为了保障燃料经济性，在低负载状态下将EGR关闭。有证据显示，欧IV车辆的运行性能也会随不同负载条件发生变化[24]。

目前，我们希望欧VI在测试程序上的变化能要求排放控制覆盖更大的工作范围。欧VI测试程序采用全球统一测试工况，其它变化包括添加了冷启动测试和在用车测试要求。这样一来，分子筛SCR催化器可能将取代价格低廉且耐硫性较好的钒基SCR催化器，因为分子筛催化器在低温时表现较好。也有一些方法可以减轻欧V车辆存在的上述问题，不过目前世界上还没有先例。其中一个方法就是将现有的欧V测试程序替换为欧VI测试程序（冷启动，全球统一测试工况和在用车测试要求）。在尚未实施欧V的国家，另外一个方法就是直接从欧IV跳至欧VI。

要构建世界级的管理方案，除了排放限值、油品品质和测试工况外，还要有其它一些条件。在2007年的一本报告《减少重型车辆和发动机尾气及蒸发排放的管理措施范例》中，ICCT描述了构建重型车世界级先进管理方案的一些要素：

o 生产企业的责任

o 设置NTE区域排放上限，控制在用车非法规循环工况下的排放

o 车载排放诊断系统(OBD)

关于生产企业的责任、NTE上限和OBD的更多内容将在车辆达标管理一章予以介绍。

22 Ligterink, N., de Lange, R., Vermeulen, R.,和Dekker, H.，2009年.《欧V卡车的道路NOx排放》，TNO科学与工业

23 排放未反应的氨称为氨逃逸。

24 Rexeis, M. 2009年.《重型车真实排放情况调查》格拉茨科技大学。

Additionally, recent research has called into question the extent to which Euro V standards translate to NOx reductions under urban driving conditions. In-use emission measurements of NOx emissions from Euro V vehicles at low loads found levels three times higher than the standard limit [22]. The Euro V emission control system is optimized to meet the standard limit over the relatively high load and high temperature European test cycle. As a consequence, Euro V vehicles are performing well at the high loads typical in highway driving. However, it appears that at loads that are not covered by the test cycle, including the low loads seen in congested urban traffic, the emission control system (SCR and potentially EGR) either underperforms or is deactivated completely. Many SCR systems are known to stop urea dosing at low exhaust temperatures to minimize ammonia slip [23]. EGR can be deactivated at low loads to ensure better fuel consumption. There is evidence that these performance variations at different loads apply to Euro IV as well [24].

It is currently expected that the changes in the test procedures for Euro VI would require emission control over a larger range of operating conditions. The test procedure for Euro VI is the World Harmonized Test Cycle, and other changes include the addition of a cold start testing component and in-use testing requirements. This may lead, for example, to zeolyte SCR catalysts replacing the current low cost and less sulfur sensitive Vanadium-based SCR catalyst because zeolyte catalysts perform better at low temperatures. There are some options to mitigate some of the aforementioned issues with Euro V vehicles, but there is currently no precedent anywhere in the world for such measures. One option is replacing the current Euro V test procedure to adopt features of the Euro VI test procedure (cold start, World Harmonized Test Cycle and in-use testing requirements). Another option for countries that have not implemented Euro V is to leapfrog directly from Euro IV to Euro VI.

In addition to emission limits, fuel quality, and test cycle, several other components are required to create a world-class program. In its 2007 report, A Model Regulatory Program for "Reducing Exhaust and Evaporative Emissions from Heavy-duty Vehicles and Engines", the ICCT describes the components of a world-class program for HDVs:

- o Manufacturer responsibility
- o Not to exceed (NTE) limits to control off-cycle in-use emissions
- o On-board emission diagnostics (OBD)

More details about manufacturer responsibility, NTE limits, and OBD are included in the Vehicle Compliance Section.

22 Ligterink, N., de Lange, R., Vermeulen, R., and Dekker, H. 2009. On-road NOx emissions of Euro V trucks. TNO Science and Industry.

23 The release of unreacted ammonia is called ammonia slip.

24 Rexeis, M. 2009. Ascertainment of real world emissions of heavy-duty vehicles. Graz University of Technology.

3.3　两轮及三轮摩托车

中国是世界上最大的摩托车生产国，两轮和三轮摩托车的年产量超过2700万辆（不包括电动自行车或农用车，这两类车辆将在下一节进行讨论）[25]。摩托车和轻便摩托车的保有量如此之大，管理这一车辆群体自然成为排放控制措施的重要环节。这些车绝大多数是汽油车，欧盟标准（及中国标准）纳入管理范围的污染物包括碳氢化合物、一氧化碳和氮氧化物[26]。这些污染物的具体排放限值详见附录C。

尽管欧盟从1992年起开始对轻型车和重型车实施管理，到2000年才制定了第一个两轮及三轮摩托车标准（图3.3）。中国从2004年开始引入第一阶段标准并很快过度到了第二阶段，计划2010年和2011年起分别对两轮和三轮摩托车实施第三阶段标准。此外，从2009年起，在型式核准中纳入了燃料消耗量标准[27]。排放耐久性要求（欧盟管理中不做此要求）加强了第三阶段标准的严格性。另外，中国还采用类似美国的测试方法，引入了蒸发排放限值。附录D中的表D-4列出了各阶段可选择的技术路线。目前，在国内市场销售的国产摩托车中只有很少一部分采用二冲程发动机。通过大幅减少二冲程发动机摩托的使用，有效地减少了摩托车的白烟问题（二冲程发动机摩托容易导致白烟问题）。

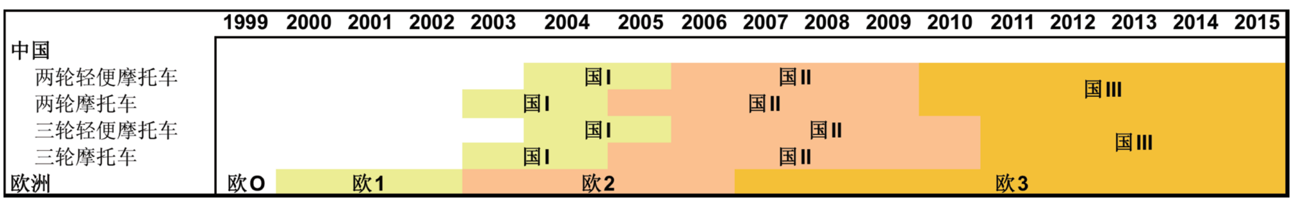


图3.3: 中国和欧盟两轮及三轮车标准实施时间表

尽管两轮及三轮车的标准在不断加严，摩托车行驶每公里排放的污染物仍然比四轮车辆高，因此为了减少空气质量影响，需要进一步加严排放限值。下一步，摩托车排放标准应与轻型车标准接轨。中国有机会成为这一领域的先驱。

电动自行车的出现带来了一个良好的前景。在过去10年中，电动自行车市场持续扩大，目前自行车和电动自行车的年销售总量超过2000万辆。其中高电能的产品甚至可以与摩托车竞争市场。电动自行车的环境影响是比较复杂的，因为它们很可能取代更低污染的自行车和公共交通的使用，并且其全生命周期排放要考虑其使用的火电发电量。

25 中国汽车技术研究中心，2009年，《中国汽车工业年鉴》。

26 汽油车发动机的颗粒物排放率要比柴油车低很多。

27 2008年7月1日起，开始进行两轮及三轮车三阶段型式核准，从2010年7月1日起停止销售和登记注册所有第二阶段的两轮摩托车和轻型摩托车；从2010年7月1日起停止销售和登记注册所有第二阶段的三轮摩托车和轻型摩托车。

3.3 Two and three-wheelers

China is the world's leading motorcycle manufacturer with an annual production volume of over 27 million two and three-wheelers (not including e-bikes or agricultural/rural vehicles, which will be discussed in the next section) [25]. With such an immense population of motorcycles and mopeds, regulating this group of vehicles is certainly an important piece of the emission control program. Gasoline is the dominant power plant for these types of vehicles, and the regulated pollutants in the Euro (and China) program are HC, CO, and NOx [26]. Limit values for these three pollutants are shown in Appendix C.

While light- and heavy-duty vehicles were brought under regulation in the EU in 1992, the first set of standards for two- and three-wheelers were enacted in 2000 (Figure 3.3). China introduced the Stage 1 standard in 2004 and quickly moved to Stage 2. Stage 3 is scheduled for implementation for all two-wheeled motorcycles in 2010 and three-wheelers in 2011, and fuel consumption standards have been adopted for type approval in 2009 [27]. Emission durability requirements—which are not part of the EU program—increase the stringency of Stage 3 regulations. In addition, China has adopted evaporative limits with test procedure comparable to those in place in the United States. Technology options for reaching all three levels are outlined in Table D-4 of Appendix D. Today very few motorcycles produced in China for the domestic market are equipped with a two-stroke engine, which has significantly reduced white smoke issues from motorcycles.

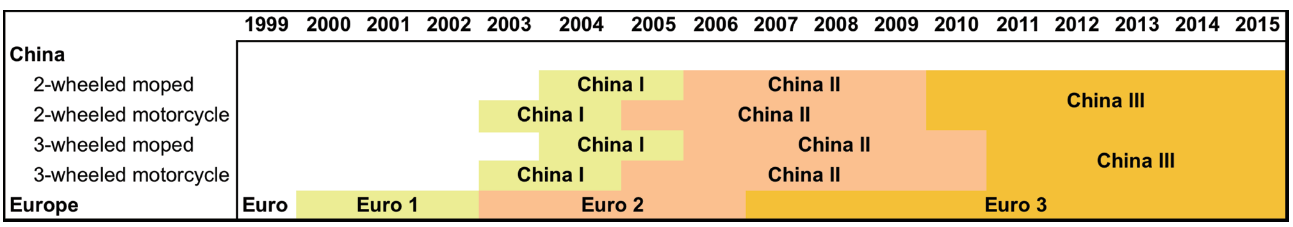


Figure 3.3: Two- and three-wheeler standard adoption timeline in China and EU

Even as standards for two and three-wheelers continue to tighten, motorcycles remain more polluting than four-wheel vehicles on a per kilometer basis, and further reduction in emission limits will be required to mitigate their air quality impact. The next level of motorcycle emission should be designed to match LDV standards. China has an opportunity to become the leader in this arena.

A potentially positive trend is the strong emergence of electric two-wheelers. Over the past 10 years, the e-bike market has grown substantially, and now annual sales of bicycle and scooter style e-bikes exceed 20 million. Higher power products may compete with motorcycles. E-bikes' net environmental impact is mixed as they often substitute bicycles and public transit trips, and lifecycle emissions depend on coal-heavy electricity production.

25 Chinese Automotive Technology and Research Center. 2009. "China Automotive Industry Yearbook".

26 Gasoline vehicles typically have much lower engine-out emission rates of particulate matter than their diesel counterparts.

27 Stage 3 standards became effective for type approval for both two- and three-wheeled motorcycles in July 1, 2008. The production, sale and registration of Stage 2 2-wheeled motorcycles and moped are prohibited starting from July 1, 2010, and production, sale and registration of Stage 2 3-wheeled motorcycles and mopeds would be prohibited starting from July 1, 2011.

3.4　非道路机械设备和农用车

非道路机械设备种类繁多，在上世纪90年代之前，在世界范围内大多没有针对这些机械设备的排放管理法规。非道路机械设备主要包括建筑、农业、矿业和仓储用设备。同时还包括一些私人消费产品，如私人船只、草坪花园设备。随着对非道路机械车排放贡献率的逐步了解和其它车辆已经在多年的管理过程中相对实现清洁化，非道路领域排放管理的重要性显得愈发突出。中国目前依然是采用欧盟标准，实施二阶段标准，如图3.4所示，比欧盟实施等效标准的时间要落后8年，是中、欧差距最大的移动源领域。

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
中国									一阶段		二阶段						
欧洲	一阶段		二阶段					三阶段					四阶段			五阶段	

图3.4: 中国与欧盟非道路标准实施时间表

农用车是中国的特有群体，在这方面没有可借鉴的国际经验。随着中国的繁荣发展，农用车将会逐渐被主流车型取代，如轻型卡车和拖拉机。实施财政鼓励能加速这类车的更新淘汰，作为经济刺激系列方案之一，在2009年曾经实施过相关鼓励政策。另外，可能有必要帮助农用车生产企业转型生产更加先进的非道路和道路车辆。

3.5　中国实施过程中的障碍

要实施更加严格的排放标准，采用可利用的最佳先进控制技术，面临的最大障碍主要有以下三方面:

1)　低硫燃料的不确定性。现有燃料的硫含量是推进排放标准的最大障碍之一，特别是对柴油车。目前可利用的最佳排放控制技术，包括三元催化器、柴油车颗粒物捕集器（DPFs）和分子筛选择催化还原（SCR）催化器都不耐硫。要满足轻型车国V标准和重型车国VI标准需要使用DPF，这就要求燃料的硫含量水平要不大于50ppm（10ppm为最佳，可进一步减少颗粒物排放）。

2)　国内外生产企业的技术能力差距。这个问题导致了生产过程及产品现代化进程缓慢，特别是在轻型卡车、重型车和非道路领域。例如，国内生产企业不具备柴油发动机电控喷油系统技术，就给按期实施国IV标准带来障碍。采用电控发动机不仅能够达到更严格的排放标准，还能显著提高燃料经济性。技术水平的差距还会严重影响国产发动机和卡车向管理严格的地区出口的前景。

3)　对以国产企业主导的农用车和非道路机械设备缺乏管理。相比其它移动源，这类车辆和设备在标准引入方面落后很多，而且大部分都未进行登记注册。

3.6　建议

在车辆数量持续快速增长的情况下，为了有效降低排放，在管理规定中须提出要求在全国范围内使用低硫燃料，这对保护公众健康至关重要。与此同时，为推进维护健康的排放标准，可继续按实施时间表推进国IV，这样做即使在当前燃料条件下，依然可以获得一些收益。

3.4 Non-road equipment and rural vehicles

Non-road equipment is extremely diverse and, until the 1990s, was a largely under-regulated mobile source category throughout the world. The non-road category consists primarily of equipment used in construction, agriculture, mining, and warehousing. Also included are consumer products such as personal watercraft and lawn and garden equipment. The significance of emissions control for the non-road sector has grown overtime as their contribution to the overall inventory is better understood and as other sectors have been comparatively cleaner after years of regulation. As with other mobile source categories, China's program is patterned after the Euro standards. Stage 2 is currently in force and was implemented eight years after its Euro equivalent, the largest gap of all mobile source categories as shown in Figure 3.4.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China									Stage 1		Stage 2						
Europe	Stage I		Stage II					Stage III					Stage IV			Stage V	

Figure 3.4: Non-road standard adoption timeline in China and EU

Rural vehicles are unique to China, and, as such, there is no international experience to draw on per se. With rising prosperity in China, it is expected that rural vehicles will be replaced over time with more mainstream vehicle types such as light trucks and tractors. Measures such as financial incentives for accelerated retirement and replacement could hasten this transition and were implemented for one year in 2009 as part of the economic stimulus package. It may also be necessary to assist rural vehicle manufacturers as they transition to production of more modern types of non-road and on-road vehicles.

3.5 Barriers to progress in China

The three most significant barriers to moving to more stringent emission standards that take advantage of the best available control technologies are:

1) Uncertainty about lower sulfur fuel availability. The sulfur content in current fuel is one of the greatest barriers to further progress on emission standards, especially for diesel vehicles. The best available emission control technologies, including three-way catalysts, diesel particle filters (DPFs) and zeolyte SCR catalysts are sensitive to sulfur. DPFs, which are required for meeting the future China V for light-duty vehicles and China VI for heavy-duty vehicles, require fuels with a sulfur level of 50-ppm or less (10-ppm is preferable for further reduction of PM emissions).

2) Significant differences in the level of technical expertise and access to advanced technologies between domestic and foreign manufacturers. This results in a much slower modernization of manufacturing processes and products, especially in the light-duty truck, heavy-duty and non-road sectors. For example, the lack of domestic manufacturers of electronically controlled fuel injection systems in diesel engines has been identified as a barrier to the on-schedule implementation of China IV. The shift to electronically controlled engines would not only enable meeting more stringent emissions standards, it would also results in a significant gain in fuel efficiency. The current technology gap also seriously limits the export potential of Chinese engines and trucks to markets with tight regulations.

3) Under-regulation of vehicle types such as rural and non-road vehicles, whose production is dominated by domestic manufacturers. These vehicle categories have the largest gap in standard adoption of all mobile sources and the majority of these vehicles are not registered.

3.6 Recommendations

In order to enable dramatically lower emissions, regulations requiring nationwide use of lower sulfur fuels are critical for the protection of public health, especially as vehicle numbers continue to quickly rise. In the meantime, some progress in adopting health-protective emission standards can be made by maintaining the schedule for China IV standards, which can still provide some benefits with current fuels.

第二章中的情景分析结果明确表明如不进一步加严车辆标准，主要污染物排放量和其带来的健康影响都会大幅提高。要让车辆采用当前最佳的控制技术，需要在短期内实施欧6/VI车辆标准。与之等效的国VI和轻型柴油车国V标准将最起码需要硫含量不大于50ppm的燃料，最好是使用10ppm的燃料。

图3.5和图3.6中展示了尽早实施国VI的优势，其中共有四种实施路线，表3.1中总结了这四种路线的实施时间表。除了改善方案和强化方案两种情景，即到2015年达到国VI，我们还添加了另外两种情景—2020年跳跃实施方案和2020年分步实施方案。这两个新情景体现了较缓和的实施步调，即在2020年之前不实施国VI。这两种2020年情景是为了说明延迟实施国VI的影响。结果表明，即使再过10年，依然无法消除延迟5年实施国VI所造成的减排差距。

表3.1: 国VI标准实施路线

情景	国 IV	国 V	国VI
改善方案	2011年	-	2015年
强化方案	2011年	2012年	2015年
2020年跳跃实施方案	2011年	-	2020年
2020年分步实施方案	2011年	2015年	2020年

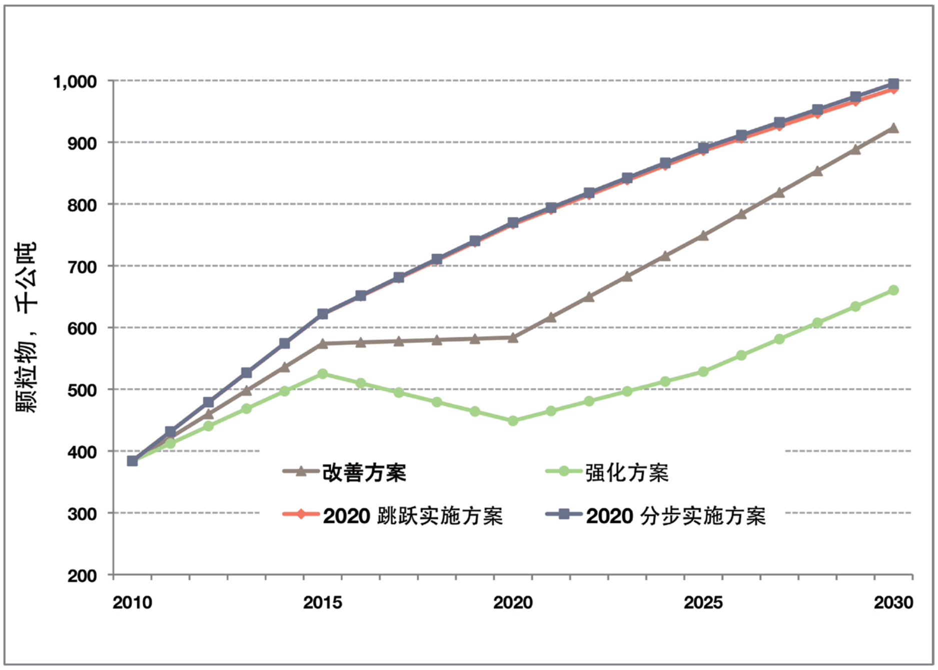


图3.5: 不同国VI实施路线下颗粒物（PM）的排放趋势

The results of the scenario analysis presented in Chapter 2 clearly show that without further tightening of vehicle standards, emissions of all the major pollutants and their associated health impacts will increase dramatically. Introducing today's best available control technologies into the fleet will require implementing Euro 6/VI level vehicle standards in the near term. The equivalent China VI and China V for light-duty diesels standards will require at least 50-ppm fuels, preferably 10-ppm fuels.

The benefits of swift China VI adoption are illustrated in Figures 3.5 and 3.6, which show four distinct pathways for implementation, whose timelines are summarized in Table 3.1. In addition to the Improved and Strong scenarios, which reach China VI by 2015, two additional scenarios—2020 Leapfrog and 2020 Step-by-step—represent much less aggressive adoption timelines in which China VI is not implemented until 2020. The two 2020 scenarios are meant to illustrate the effect of delayed implementation of China VI. The results show that even after 10 years, the gap in emission reduction caused by the five-year delay in China VI adoption is not closed.

Table 3.1: Pathways to China VI standards

SCENARIO	CHINA IV	CHINA V	CHINA VI
Improved	2011	-	2015
Strong	2011	2012	2015
2020 Leapfrog	2011	-	2020
2020 Step-by-step	2011	2015	2020

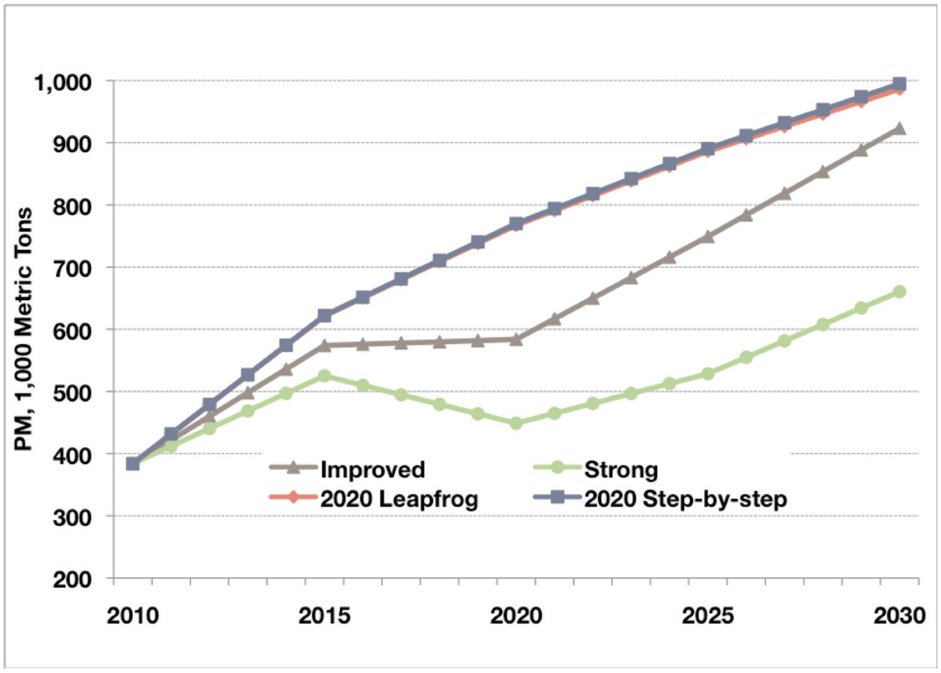


Figure 3.5: PM trends for different China VI adoption pathways

从2015年开始实施国VI标准是一个很雄伟的目标，不过从图3.5与图3.6中可以看到，较之到2020年开始实施国VI的情景，前者取得的减排效果还是非常显著的[28]。的确，在2020年跳跃实施方案和2020年分步实施方案情境中，由于重型车是颗粒物的主要贡献源（大于50%），对健康影响最大的颗粒物排放在两种情景下区别并不大。在模型中，国V重型车较之国IV，颗粒物排放没有减少，因为从国IV到国V标准，颗粒物限值并没有变化。实施国VI标准必须使用柴油车颗粒物捕集器，而这是控制颗粒物排放最有效的技术。环保部如考虑尽快过渡到国VI标准，可以先参考并利用已存在的一些有利因素，包括：

- 燃料企业正在为国内和出口市场生产低硫燃料
- 汽车企业正在加速现代化进程，着眼于欧洲和美国的出口市场
- 部分城市和地区先于全国实施清洁车辆和油品

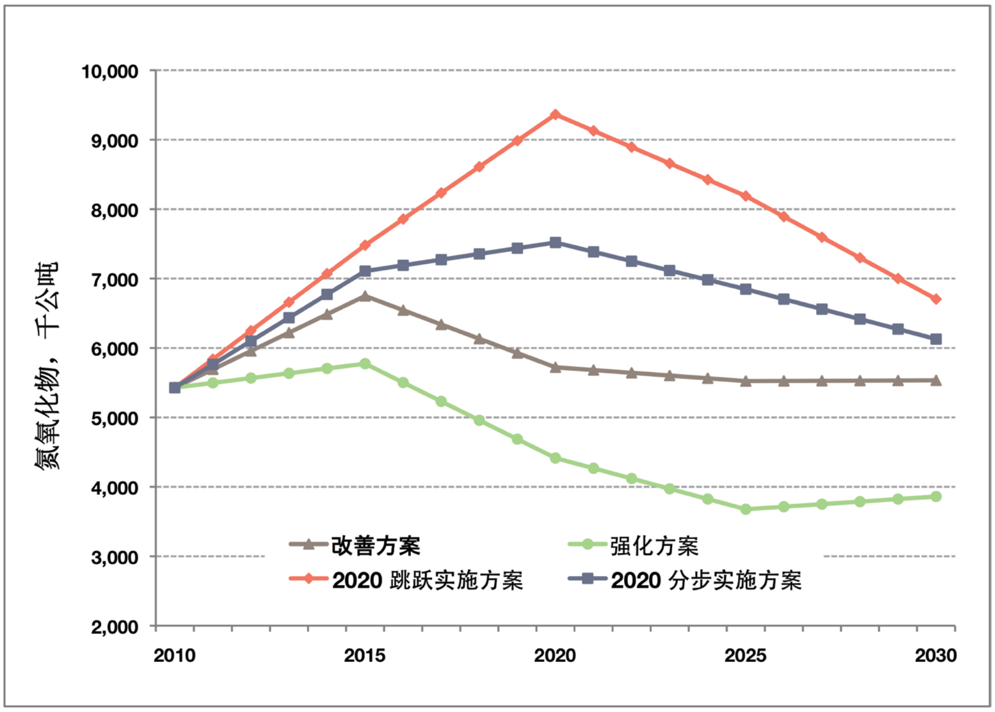


图 3.6: 不同国VI实施路线下氮氧化物（NOx）的排放趋势

28 在“国VI实施路线”分析中，影响排放趋势的主要模拟参数有两项：1）排放标准实施时间；2）高排放车辆的比例（GEs）。在模型中，尽管GEs的数量群体相对很小（在四种情景中，GEs分别占车辆构成的5%），但是随着其它车辆的清洁化和采纳新标准，GEs所占的排放量比例越来越高，因为我们已假设GEs的排放相当于没有排放控制装置的车辆的排放水平，且排放水平不变。关于GEs的假设—车辆的排放水平和比例对图3.5和3.6的中的曲线造成很大影响。CFM假设和方法论详见附录B。

Introducing China VI by 2015 is an ambitious goal, but as shown by the PM and NOx trends in the above figures, the emission reduction benefits are quite substantial as compared to the scenarios where China VI is not adopted until 2020[28]. Indeed, the trend for PM emissions—which are associated with the most serious health impacts—is nearly identical between the 2020 Leapfrog and 2020 Step-by-step scenarios due to the fact that HD vehicles are the main (> 50%) contributor to PM emissions. In the model, China V HD vehicles provide no PM reductions beyond China IV since the PM limit remains unchanged from the China IV to V standard. The introduction of China VI will force the use of diesel particulate filters, which are the most effective technology for controlling PM emissions. To move to China VI standards as quickly as possible, the MEP can leverage the following factors:

- Oil companies are currently producing lower sulfur fuels in China for domestic and export markets
- Vehicle manufacturing is rapidly modernizing with an eye to export markets in Europe and the United States
- Cities and regions have begun implementing clean vehicles and fuels ahead of the national schedule

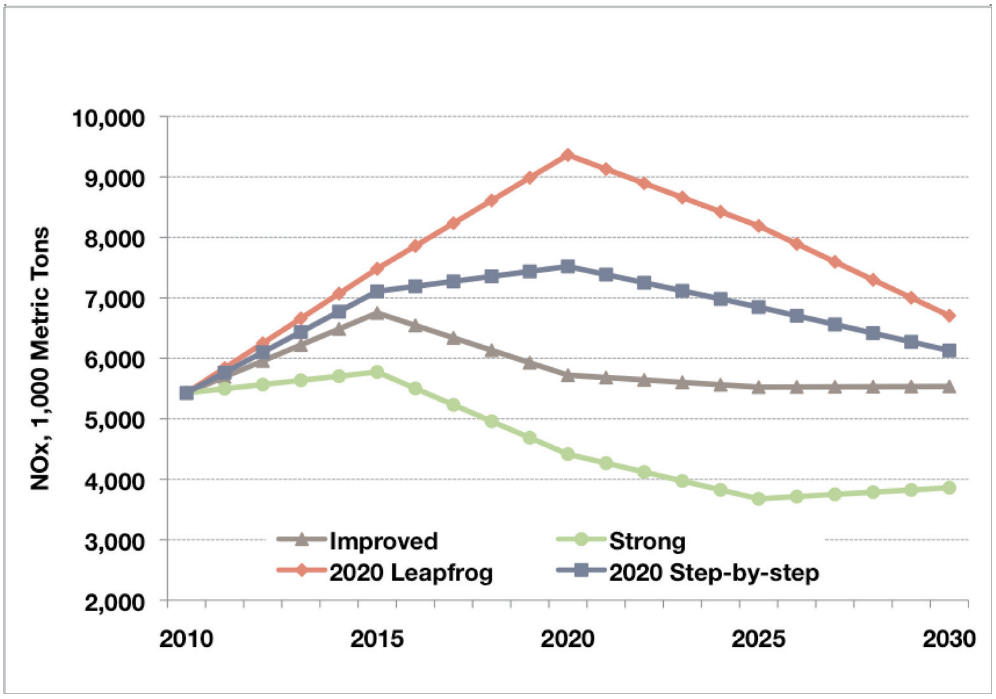


Figure 3.6: NOx trends for different China VI adoption pathways

28 In this 'Pathways to China VI' analysis, there are two main modeling parameters affecting emission trends: 1) emission standard adoption timelines and 2) the percent of the fleet that are gross emitters (GEs). In the model, GEs—though their numbers are relatively small (in each of the four scenarios, GEs are 5% of the fleet)—are responsible for a growing percentage of emissions over time because as the rest of the fleet gets cleaner as new standards are adopted, GEs are assumed to pollute at the level of a vehicle with no emission controls, which is constant over time. The assumptions about GEs—the emission levels of these vehicles as well as the percent of the fleet that are GEs—have a large impact on the shape of the curves in Figures 3.5 and 3.6. See Appendix B for a full discussion of the CFM assumptions and methodologies.

如本章所述，近期的在用车排放研究在欧洲已经产生了一些顾虑，令政策制定者担心欧V或许乃至欧IV车辆在城市实际道路运行时无法达到预期的减排目标。这些车包括巴士、垃圾车和其它走走停停的低速工况运行车辆。而造成车辆运行状态不佳的主要原因是测试工况与实际使用工况不吻合，而排放控制系统都是依据测试工况来调试成最优结果的。在进行国V过渡评估时，环保部应当考虑几种方案，包括修改测试程序，引入为欧VI设计的优化测试工况，或者干脆跳过国V，尽快实施国VI。

在中国朝着国VI标准迈进的同时，包括北京、上海和珠三角在内的已经或即将实现50ppm硫含量油品供应部分的主要城市和地区就可以要求在国IV基础上额外要求加装DPF，实现有低硫燃料保证下的最大程度的颗粒物减排，并带来最大的健康收益。为了加速这一过程，环保部应研究相应方案，来减少部分城市和地方想要超前实现国家标准的过程中遇到的阻力与负担。目前的流程要求上报国务院批准，这需要很长时间并且十分繁琐，这可能会给一些想要提前实施的地区造成阻碍。在《大气污染防治法》中应该加入这样的弹性条款，允许城市和地区提前实施严于国标的标准。美国《清洁空气法》中也有类似规定，允许各州实施比联邦标准更加严格或等效于联邦标准的加州标准。一直以来，加州标准的实施步伐都比联邦政府快。

放眼未来，今后发展中非常关键的一步就是制订严格程度等效于轻型车标准的四阶段、五阶段摩托车标准。此外，还要制订非道路机械设备和农用车标准。从整体车队而言，制订使用低碳燃料和零排放车的相应鼓励政策也是排放控制措施中的重要部分，使用替代燃料和先进车辆的机遇与挑战将在第9章中重点探讨。

As discussed in this chapter, there have been concerns raised in Europe that Euro V and perhaps Euro IV vehicles are not meeting expected emission reductions in-use in urban applications. This includes buses, refuse haulers, and other vehicles in stop-and-go or low speed duty cycles. The principal reason for underperformance is the mismatch between the test procedure cycle to which the system is optimized and the in-use duty cycle. In assessing the transition to China V, MEP should consider several options, including modifying the test procedures to include the improvements planned for Euro VI that are expected to address the current test cycle issues as well as skipping China V and implementing China VI as soon as possible.

As the country develops its pathway towards China VI standards, major cities and regions including Beijing, Shanghai and Guangzhou that already or will soon have a supply of 50-ppm sulfur fuels could require China IV enhanced with a DPF to capture the maximum health benefits from PM reduction enabled by lower sulfur fuels. In order to streamline that process, MEP should investigate options to reduce the burden on cities and regions seeking accelerated adoption of the national schedule. The current process, which requires approval from the State Council, is lengthy and complicated, possibly impeding additional regions that would benefit from pursuing this option. Flexibility within the "Air Pollution Prevention and Control Law" should be added to allow cities and regions to adopt standards early if they can prove these standards are at least as stringent as those in vigor nationwide. This would be similar to the provisions in the "United States Clean Air Act" that allow states to adopt standards developed in California as long as they are at least as stringent as the Federal standards. Historically, California has ratcheted down its standards faster than the Federal government.

Looking further into the future, a key step in the program's evolution will be developing Stage 4 and 5 standards for motorcycles that match the light-duty stringency. Further work will also be required to develop standards to improve non-road equipment and rural vehicles. For the entire fleet, policies that encourage a transition to lower carbon fuels and vehicles with zero tailpipe emissions can be an important piece of the emission control program. The opportunities and challenges presented by these alternative fuels and advanced vehicles are explored in Chapter 9.

4. 油品质量标准

关于车辆技术、油品质量和排放水平之间的关系，在美国、欧洲和日本已经开展了很广泛的研究[29]。这些研究表明，改善油品质量能够减少燃料燃烧产生的直接污染物排放，更重要的是能够令更加有效的排放后处理装置得以使用。这些结论强调了只有同步实施油品和车辆标准，并且辅以有效的实施和执法措施，才能令汽车实现最佳的排放性能。

中国从上世纪90年代末期才开始逐步加严油品标准，而其标准基本上是效仿欧盟标准。90年代末中国开始引入无铅汽油并从2000年开始在全国范围禁止销售含铅汽油。硫是除了铅以外对车辆排放影响最大的因素，而中国汽油的硫含量标准已经从1999年的1500ppm降低到目前的150ppm，柴油从高达10000ppm降低至不超过2000ppm。此外，中国还实施了硫含量限值500ppm的柴油推荐性标准，并计划从2011年7月起，强制全国实施350ppm限值。北京、上海和珠三角等主要城市、地区目前已经实施了相关标准，将汽柴油硫含量限制在50ppm，以便提前实施欧4乘用车标准和欧IV中、重型车标准。

在过去的10年中，除了一些主要城市，中国的油品标准一直落后于相应车辆排放标准的要求（详见图4.1和4.2）。 从2007年1月1日和7月1日起，全国范围停止接受对只达到国II标准的重型和轻型新车型的型式核准，即从这日期开始，所有型式核准车型均可达到国III车辆排放标准[30]。但是国III汽油标准从2010年1月1日起才实施，比轻型车国III标准的实施时间落后了两年半，而国III柴油标准更要到2011年7月1日才能在全国范围实施，这比重型车国III标准实施时间要落后四年半。油品标准的滞后（特别是柴油硫含量过高）已经成为推进车辆排放标准的主要障碍。

29 例如，美国1989年开展的汽车/燃料空气质量改善研究项目（AQIRP）包括了多家石化企业、汽车企业和4家合作机构。欧盟委员会开展了名为欧盟排放、燃料和发动机技术（EPEFE）的测试项目，也有汽车和石化行业加入。日本清洁空气项目（JCAP）由石油能源中心发起，是由经济贸易与工业部支持的，多家汽车和石化企业参与联合研究项目。

30 从2007年7月1日起停止国II标准轻型车新车型式核准，从2007年1月1日开始停止国II标准重型车的新车型式核准。

4. Fuel quality standards

Extensive studies have been carried out in the US, EU and Japan to understand the linkage between vehicle technology, fuel quality and emissions level[29]. These studies have shown that fuel improvements can reduce pollutants from fuel combustion directly, and more importantly, enable the use of more effective exhaust aftertreatment devices. These findings highlight that the best vehicle emission performance can only be achieved if fuel and vehicle standards are implemented in parallel and a compliance program is established to enforce both fuel and vehicle standards.

Primarily following the European standards, the China fuel standards have been gradually tightened since the late 1990s. Unleaded gasoline was introduced in the late 1990s and the sale of leaded gasoline was banned nationwide in 2000. The national limit on sulfur, the most important parameter affecting vehicle emissions after lead, has been lowered from 1,500-ppm in 1999 to the current level of 150-ppm for gasoline, and from up to 10,000-ppm to at most 2,000-ppm for diesel. A voluntary diesel sulfur limit of 500-ppm has been in effect and a mandatory limit of 350-ppm will take effect in July 2011. Major cities like Beijing and Shanghai have adopted fuel standards limiting sulfur content in gasoline and diesel to 50-ppm to enable early implementation of Euro 4 for passenger vehicles and Euro IV standards for medium- and heavy-duty vehicles.

Over the past decade, fuel standards in China, except for some major cities, have consistently lagged behind the fuel requirements corresponding to the vehicle emission standards (see Figures 4.1 and 4.2). China stopped type approval for China II heavy-duty diesel vehicles (HDDVs) on Jan 1, 2007 and for China II light-duty vehicles (LDVs) on Jul 1, 2007 nationwide[30], meaning that only HDDV and LDV prototypes meeting China III standards can be certified starting from these two dates. But China III gasoline standard was implemented in Jan 2010, two-and-a-half years after China III LDV standards were implemented, and China III diesel standard will not be adopted nationwide until July 2011, four -and-a-half years after the HDDV standard was tightened to China III. The lagged implementation of fuel standards (particularly the high diesel sulfur limits) has become a major roadblock to ratcheting down vehicle emission standards.

29 For example, the Auto/Oil Air Quality Improvement Research Program (AQIRP) established in the US in 1989 included major oil companies, automakers and four associate members. A test program called the European Program on Emissions, Fuels and Engine Technologies (EPEFE) was initiated by the European Commission and joined by the auto and oil industry. The Japan Clean Air Program (JCAP) was formed by the Petroleum Energy Center as a joint research program of the auto and oil industries and supported by the Ministry of Economy, Trade and Industry.

30 Starting from Jul 1, 2007, China stopped type approval for China II LDV standards, and no China II diesel HDV models could obtain type approval starting from Jan 1, 2007.

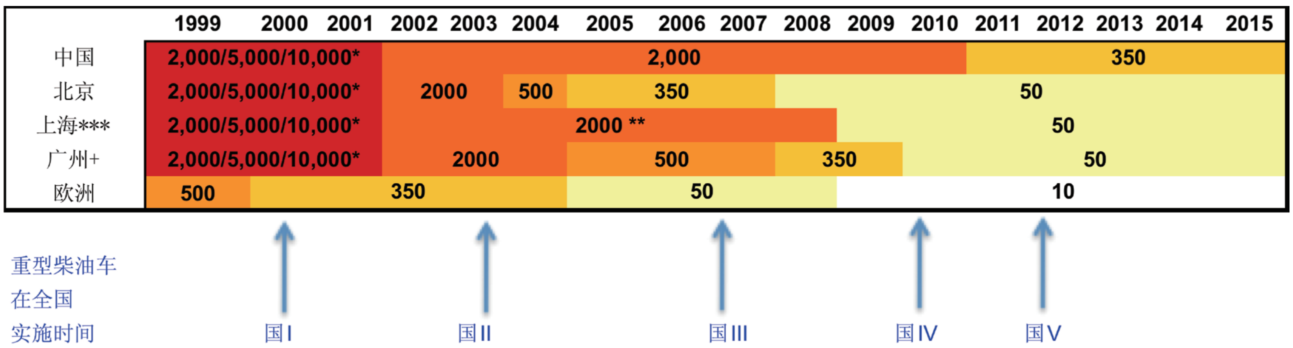


图 4.1: 柴油燃料标准实施时间表

* 超级(2,000 ppm), 优质 (5,000 ppm) 和普通(10,000 ppm)车用柴油燃料的硫含量限值。

** 推荐性国II柴油标准从2003年起实施，硫含量限值为500ppm，但不要求在全国范围内满足国II柴油标准。

*** 虽然在2009年11月上海率先实施国III柴油标准（不高于50ppm）前，没有其他的先进地方标准出台，但柴油硫含量应在2009年以前就已降到2000ppm以下了（很可能在1000ppm或以下）。

\+ 国IV柴油重型车标准在2010年6月1日在珠三角开始实施；硫含量50-ppm的柴油已在广州市供应，同时会在2010年开始在其他广东城市提供。

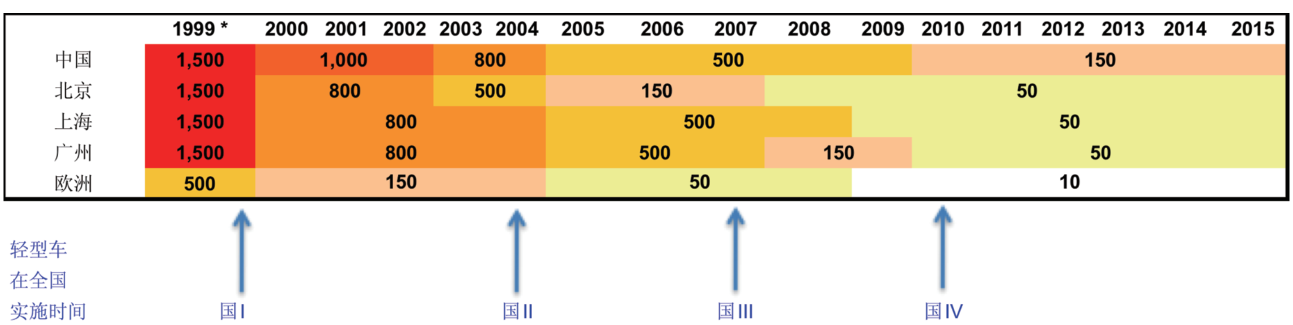


图 4.2: 汽油燃料标准实施时间表

本节将评估中国汽柴油的现行标准，讨论推进燃料标准过程中的障碍并提供逾越这些障碍的推荐方案，从而确保油品标准和车辆标准同步发展和实施。

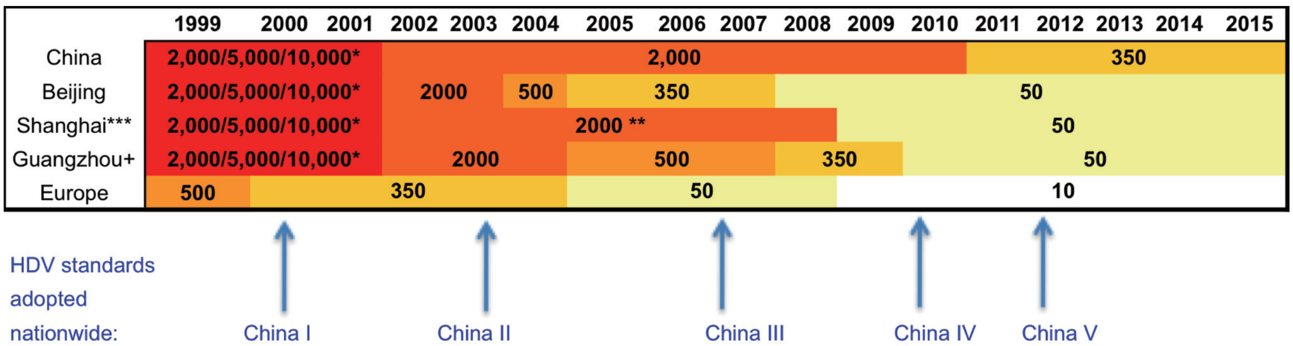


Figure 4.1: Diesel fuel standard adoption timeline

* Fuel sulfur limits for super (2,000 ppm), premium (5,000 ppm) and regular (10,000 ppm) motor diesel fuel.

** A set of voluntary China II diesel standards, with limits on sulfur at 500 ppm, was adopted in 2003, but diesel meeting China II requirements are not widely available in China.

*** No intermediate local standard was announced before the advanced implementation of China III diesel standard (50-ppm sulfur content) in Shanghai in November 2009, but diesel sulfur content should have come down to below 2000 ppm (probably around 1000 ppm or less) the few years before 2009.

+ China IV vehicle standards took effect in Pearl River Delta on Jun 1, 2010; 50 ppm diesel fuel is already available in Guangzhou and will be gradually supplied to Guangdong province in 2010.

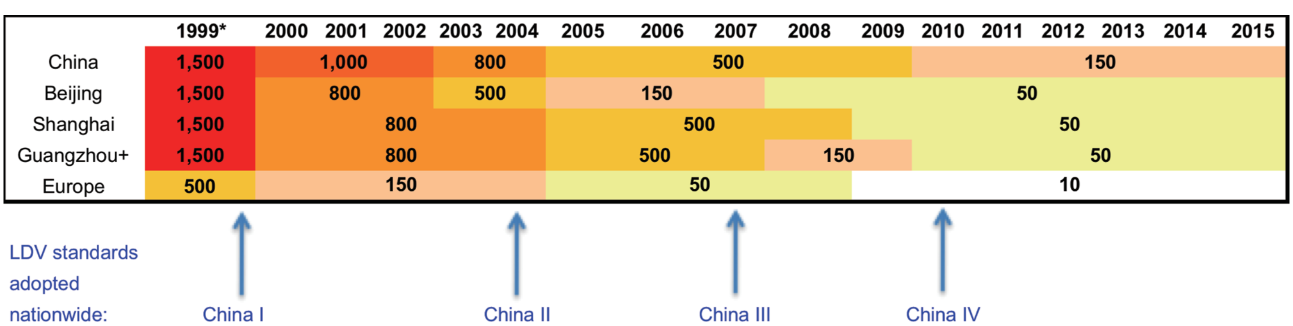


Figure 4.2: Gasoline fuel standard adoption timeline

This section reviews the current diesel and gasoline standards adopted in China, discusses the obstacles for improving the fuel standard and offers recommendations for overcoming those obstacles to ensure that fuel standards and vehicle standards are developed and adopted in tandem.

4.1 汽油燃料标准

当前的汽油指标中，与车辆排放关系最密切的几项特性是硫含量、挥发性、芳香烃、烯烃、氧含量和苯含量。附录E中的表E-1和E-2归纳了汽油品质对轻型汽油车和两轮及三轮摩托车排放的影响。

现行的汽油标准（国III标准，与欧3汽油标准类似）从2010年1月1日起在全国范围内实施。国III标准与国II标准相比，减排力度有显著的提升：硫含量限值从500ppm降低至150ppm，苯限值从2.5%降低至1%，烯烃限值从35%降低至30%。如前文所述，较之相应的车辆排放标准，国III燃料标准的实施滞后了两年半。根据计划，将从2010年7月1日起开始实施轻型汽油车国IV标准，但是国IV油品标准的实施日期还尚未提及。当然，国IV轻型车和摩托车使用国III汽油不会造成发动机或排放控制系统的长期损伤，我们利用有限的一些中国测试数据和国际上的测试结果进行了研究，发现尽管使用150ppm硫含量的汽油时，国IV轻型汽油车比国III轻型汽油车的排放要低，但国IV轻型汽油车在使用150ppm硫含量（国III）的汽油时排放出的氮氧化物、一氧化碳和碳氢化合物还是分别比使用50ppm硫含量（国IV）的汽油时要高出36%、25%和13%[31]。此处估算的收益损失还不包括现有的国IV前车辆使用低硫燃料可带来的减排量。

汽油硫含量升高会导致氮氧化物、一氧化碳和碳氢化合物排放升高，因为汽油中的硫会从以下几方面影响三元催化器：

o 燃料中的硫会降低一氧化碳、碳氢化合物和氮氧化物的转化效果（硫抑制作用），因为硫会与这些气体污染物竞争催化器的反应空间并影响催化器表面的氧含量控制。已有充分的研究表明，当燃料中的硫含量从高水平（200-600ppm）降至低水平（18-50ppm），碳氢化合物和一氧化碳排放可减少9-55%，氮氧化物排放可减少8-77%[32]。除了燃料因素，减排的幅度还取决于车辆技术和行驶工况，不过通常情况下，在改用低硫汽油后，低排放车辆在高速工况下可实现更佳的减排效果[33]。

o 虽然硫对三元催化器的影响是可逆的，但彻底逆转硫的抑制作用要求很高的催化剂温度，然而这会造成催化剂的热损伤并降低催化效果[34]。日常驾驶可以快速地逆转部分硫抑制作用，但是要想彻底消除，要求不时地进行高速和快速加速的驾驶操作以使催化器达到特定高温。因此，低负载和低速运行的车辆可能会无法彻底消除硫造成的影响。

总之，较之使用国IV规格的汽油，国IV车辆使用国III汽油会导致碳氢化合物、氮氧化物、一氧化碳、苯、二氧化硫、三氧化硫和1,3丁二烯排放的升高。这主要是因为与欧4相比，欧3汽油没有严格的限制芳香烃、烯烃、硫和蒸气压限值（中国、欧盟、美国和加州油品标准对比详见附录F）。由于油品品质改善的滞后，国IV达标车辆在认证时在使用国IV汽油的情况下能够满足国IV排放限值，但上路行驶就无法达标。因此，延迟采纳国IV汽油标准将从实质上减少实施国IV标准所带来的全面收益。

31 详见刘欢等人著，2008年，《中国燃料硫含量对车辆排放影响的分析》《FUEL》87期. 3147-3154页。

32 ACEA欧洲汽车工业协会等. 2006年.《世界燃料宪章》， 9月，第四版。

33 美国环保局，1998年，美国环保局关于汽油硫含量问题的局报，EPA 420-R-98-005。

34 美国环保局，1999年，Tier 2/硫含量管理影响分析. 附录B: 硫造成的不可逆转的排放影响。

4.1 Gasoline fuel standards

The characteristics of today's gasoline that are the most relevant to vehicle emissions are sulfur concentration, volatility, aromatics, olefins, oxygenate and benzene levels. Tables E-1 and E-2 in Appendix E summarize the impacts of various gasoline fuel qualities on emissions from light-duty gasoline vehicles and two- and three-wheeled motorcycles.

The current gasoline standards (China III, which is similar to Euro 3 gasoline standards) took effect on Jan 1, 2010 nationwide. While they are a marked improvement from the previous (China II) standards: limit on sulfur is lowered from 500 ppm to 150 ppm, benzene and olefin limits are cut down from 2.5% to 1%, and from 35% to 30% respectively, the China III fuel standards were implemented two-and-a-half years after the compatible vehicle standards became effective, as mentioned above. On July 1, 2010, China IV light-duty gasoline vehicle (LDGV) standards are scheduled to take effect, but no announcement has been made on the implementation date of China IV fuel standards. While using China III gasoline in China IV LDGVs and motorcycles would not cause long term damage to engines and emission control systems, research based on limited testing data in China and test results from around the world suggested that a China IV LDGV using 150-ppm sulfur (China III) gasoline would emit 36%, 25% and 13% more NOx, CO and HC respectively than one using 50-ppm sulfur (China IV) gasoline, even though emissions would still be less than a China III LDGV using 150-ppm sulfur gasoline[31]. The estimated lost benefits do not account for reduced emissions from using lower sulfur fuel in existing pre-China IV vehicles.

Higher sulfur gasoline leads to higher NOx, CO and HC emissions because sulfur in gasoline impacts the three-way catalytic converter (TWC) in the following ways:

o Fuel sulfur reduces conversion efficiency for CO, HC and NOx (known as sulfur inhibition) because sulfur competes with these gaseous pollutants for catalyst reaction space and interferes the management of oxygen on the catalyst surface. Extensive research has been conducted showing that emissions of HC and CO dropped by 9-55% and NOx emissions reduced by 8-77% when sulfur in fuel is reduced from high (200-600ppm) to low (18-50ppm) [32]. The level of emission reduction for going from high to low sulfur gasoline depends on vehicle technologies and driving conditions, but in general low emission vehicles and high-speed driving conditions have demonstrated greater emissions reduction when switching to lower sulfur gasoline[33].

o While sulfur's effects on three-way catalysts are reversible, high catalyst temperatures are required to completely reverse sulfur inhibition, which could thermally damage catalyst and reduce its efficiency. Normal driving will quickly reverse part of the sulfur inhibition, but complete reversibility requires extending driving with occasional high catalyst temperatures from high speed and high acceleration operation. Therefore, impacts of sulfur might never be completely reversed for vehicles that operate at low load and low speed[34].

In general, operating China IV vehicles on China III gasoline would lead to higher emissions of HC, NOx, CO, benzene, SO_2, SO_3, and 1,3 butadiene than if gasoline specified for China IV standards is used. This is a result of the less stringent limits on aromatics, olefin, sulfur and RVP for Euro 3 gasoline compared to Euro 4 (see Appendix F for comparison of China fuel standards with EU, US and California). Because of the lag in improving fuel quality, China IV-compliant vehicles can meet China IV emission limits during certification (when China IV gasoline is used), but not when operating on the road. Therefore delayed adoption of China IV gasoline will substantially reduce the full benefits that could be offered by implementing China IV standards.

31 See Liu H. et. al. 2008. Analysis of the impacts of fuel sulfur on vehicle emissions in China. Fuel. Vol. 87. pp. 3147-3154.

32 ACEA et. al. 2006. Worldwide Fuel Charter. September. Fourth Edition.

33 EPA. 1998. EPA Staff Paper on Gasoline Sulfur Issues. EPA 420-R-98-005.

34 EPA. 1999. Tier 2/Sulfur Regulatory Impact Analysis. Appendix B: Irreversibility of Sulfur's Emission Impact.

4.2 柴油燃料标准

柴油特性中对发动机排放（氮氧化物和颗粒物排放）影响最大的就是硫。在燃烧过程中，柴油中的硫会直接转化为颗粒物排放（硫酸）和二氧化硫排放，这会在空气中形成二次颗粒物并导致形成酸雨。对于没有排放控制装置的柴油车而言，含硫颗粒物的排放量直接取决于燃料的硫含量。因此，无论是满足哪种排放标准的发动机，减少燃料中的硫都能够降低柴油发动机的颗粒物排放量。

更重要的是，柴油中的硫会损坏先进的后处理装置或影响其控制颗粒物和氮氧化物排放的效果。这些技术包括柴油车颗粒物捕集器（DPFs），选择催化还原（SCR）技术中使用的一些催化剂，和稀燃氮氧化物吸附装置。我们接下来将讨论硫对于这些技术的影响。

燃料中的硫对后处理系统的影响

DPFs能实现颗粒物减排85%-95%，但是燃料中的硫会从以下几个方面影响减排效果：

- 使用高硫燃料，捕集装置会由于积累的炭烟造成过载，令背压升高而可能会导致发动机损伤，和 / 或可能造成不受控的捕集器再生，损坏捕集器。

- 在被动再生的DPFs中，尾气中的硫在通过捕集器时会被氧化为硫酸盐，大大提高了颗粒物排放量。硫氧化物还会占据催化器的反应空间，影响一氧化氮向二氧化氮的转化效率。这样会提高再生温度且降低捕集器的效率。

- 在主动再生的DPFs中，硫含量高会导致硫酸盐形成，增加颗粒物排放。硫酸盐形成还会使背压升高，迫使更频繁的进行再生，这会增加燃料消耗量，缩短保养间隔期。

燃料中的硫对两种先进的氮氧化物控制技术SCR和稀燃氮氧化物吸附装置也有影响。在一些SCR系统中，在SCR催化器之前有一个前置的氧化催化器，燃料硫含量高会限制氧化催化器的效果，造成颗粒物排放升高。硫接触到尿素SCR系统也会形成亚硫酸氢铵，会强烈刺激呼吸系统。另外，SCR系统使用分子筛催化器在城市工况下会有较好的表现（低负载，低温），但也对硫很敏感（不能在使用硫含量350ppm柴油的情况下正常运行）。高硫燃料会限制SCR系统分子筛催化器的使用效果，从而影响SCR系统在城市中应用的性能表现。

稀燃氮氧化物吸附装置是一种发展中的氮氧化物后处理技术，因为吸附装置在吸附氮氧化物时会优先吸附硫化物，这装置很容易因为燃料中的硫而导致失效。虽然这种影响是可逆的，但再生要求高温，而高温会加速催化器老化。同时再生时需要消耗燃料，也影响车辆的燃料经济性。

柴油的其它指标，包括多环芳烃、十六烷值、密度、馏程、灰分、悬浮杂质和运动粘度也都对柴油车排放有影响。上述指标及硫对轻重型发动机性能和排放的影响详见附录E的E-3和E-4表。

4.2 Diesel fuel standards

One of the most important diesel characteristics affecting engine emissions (NOx and PM emissions) is sulfur. During combustion, sulfur in the diesel fuel converts into direct particulate matter emissions (sulfuric acid) and SO_2 emissions that can lead to secondary particle formation in the atmosphere and cause acid rain formation. For a diesel vehicle with no emission control, sulfur-related PM emissions are directly related to the fuel sulfur content. Therefore, reducing sulfur in fuels can result in lower PM emissions from any diesel engine regardless of the vehicle standard the engine could reach.

Even more importantly, sulfur in diesel can damage or impede the performance of advanced aftertreatment devices effective for controlling PM and NOx emissions. These technologies include diesel particle filters (DPFs), some types of catalysts used in selective catalytic reduction (SCR) technology and lean NOx traps. The impacts of sulfur on these technologies are discussed below.

Fuel sulfur impacts on after-treatment systems

DPFs can achieve about 85%-95% reduction in PM emissions but its efficiency can be impacted by fuel sulfur in several ways:

- Operation with higher-sulfur fuels can cause the filter to be over-loaded with soot and can result in engine damage (due to increased backpressure) and/or uncontrolled filter regeneration that can damage the filter.

- In DPFs with passive regeneration, sulfur in the exhaust can be oxidized over the filter to form sulfates, dramatically increasing the PM emissions. Sulfur oxides also decrease the efficiency of the filter by competing for sites on the catalyst needed for the critical NO to NO_2 reaction. This increases the regeneration temperature and lowers the efficiency of the filter.

- In active regeneration DPFs, higher sulfur leads to sulfate formation, resulting in an increase in PM emissions. Sulfate formation can also increase backpressure, requiring more frequent regeneration, which results in increased fuel consumption and shorter maintenance intervals.

Sulfur in fuels also impacts the efficiency of two advanced NOx control technologies: SCR and lean NO_x traps. For an SCR system with an oxidation catalyst ahead of the SCR catalyst, high fuel sulfur limits the efficacy of the oxidation catalyst, resulting in an increase in PM emissions. Sulfur reaction with urea-based SCR systems can also form ammonium bi-sulfate, a severe respiratory irritant. In addition, SCR system using zeolyte catalysts that perform better in urban duty cycles (low-load, low-temperature) operations are sensitive to sulfur (cannot function well with 350-ppm sulfur). High sulfur fuel will limit the effective use of zeolyte catalysts for SCR systems, therefore impacting the performance of SCR systems for urban uses.

Lean NOx traps, a NOx after-treatment technology still under development, can easily be deactivated by fuel sulfur because the NO_x absorption sites absorb SO_x in preference to NO_x. The effects are reversible, but the high temperatures required to regenerate can contribute to catalyst aging and the fuel needed for regeneration degrades vehicle fuel efficiency.

Other diesel characteristics, including polyaromatic content, cetane number, density, distillation, ash, suspended solids content and viscosity, also affect diesel emissions. Impacts of these characteristics and sulfur on the performance and emissions of light- and heavy-duty engine are summarized in Tables E-3 and E-4 in Appendix E.

2002年，中国在全国范围实施了强制性柴油标准，硫含量限值为2000ppm，一年后，又出台了硫含量限值为500ppm的推荐性车用柴油标准。但是，根据在中国北方和其它地区进行的燃料抽样结果，全国的柴油硫含量水平参差不齐，在一些地区，仍然在销售硫含量2000ppm的柴油（详见图4.3）。如前文所述，中国将从2011年7月起在全国实施国III柴油标准（硫含量350ppm），但是实施国IV油品标准（硫含量50ppm的柴油）尚未提上日程。按计划，中国将于2011年1月开始对重型柴油车实施国IV标准，那么在实施初期，在一些地区国IV车将使用硫含量2000ppm的柴油，然后才能使用硫含量350ppm的柴油（2011年6月以后）。可满足欧IV标准的常规技术组合（尾气再循环加氧化催化器或发动机控制加SCR系统）对硫的敏感性没有前面提到的DPFs、分子筛SCR和稀燃氮氧化物吸附装置那么强，因此，在尚不具备国IV燃料（硫含量50ppm的柴油）的过渡期，国IV车辆也可以使用。不过没有配套的油品标准，就无法全面发挥国IV车辆的减排效果[35]。有研究表明，较之使用硫含量50ppm的柴油，国IV车如使用硫含量350ppm的柴油氮氧化物排放会增加19%，颗粒物排放增加75%[36]。

我们在前面提到过，部分机动车污染严重的城市已经开始使用硫含量50ppm的低硫柴油，北京和上海分别在2008和2009年提前实施国IV车辆排放标准时也强制推广了低硫柴油，广东省珠三角地区也已得到国务院批准于2010年6月1日起提前实施国IV车辆排放和油品标准。目前除北京和上海市外，其他地区供应的柴油硫含量可以很高，会损坏国IV重型柴油车的排放控制装置或增加车辆保养需求，国IV车辆标准只对市内运行的重型柴油车实施（城市公交车、环卫车和邮政车）[37]。考虑到这两个城市的柴油公交车群体庞大，提前实施国IV车辆和油品标准能够带来显著的空气质量改善。如果其它地区销售的燃料也能够达到国IV燃料标准，那么北京和上海就可以对全部重型柴油车实施国IV车辆排放标准，那么这两个城市能够获得更多的空气质量收益。

35 在制订欧4/IV标准时，欧盟标准制定者希望相应车辆装备柴油车颗粒物捕集器（DPFs）来满足颗粒物要求。因为使用DPFs要求使用低硫柴油（不超过50ppm），因此配套的欧4/IV车辆标准的柴油硫含量限值就设为了50ppm。在标准实施之后，生产企业通过改良发动机和使用相对DPFs没对硫那么敏感的后处理装置—如尾气再循环加柴油车氧化催化器（DOC）/ 分流捕集器或改良发动机加装SCR－也可以满足欧IV排放要求。因此现时达欧4/IV标准的技术可以使用硫含量大于50ppm的燃料。

36 详见刘欢等人著，2008年，《中国燃料硫含量对车辆排放影响的分析》,《FUEL》87期, 3147-3154页。

37 上海也要求建筑用卡车执行国IV标准。

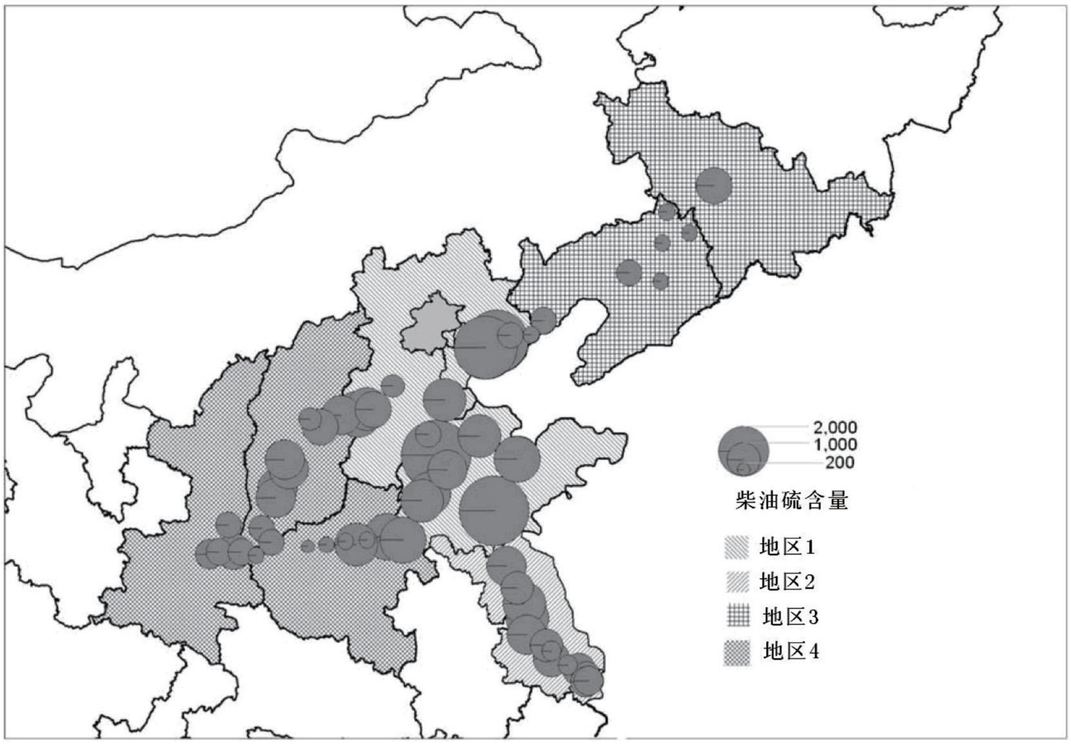
A mandatory diesel standard limiting sulfur content to 2,000 ppm (light diesel standard) was adopted nationwide in China in 2002, and a year later, a voluntary standard for automotive diesel fuel of 500-ppm sulfur was introduced. However, fuel sampling conducted in Northern China and other locations suggest that sulfur content of diesel varies considerably across the country and diesel with 2000-ppm sulfur is still being sold in some regions (see Figure 4.3). As discussed earlier, China is going to implement China III diesel standards (350-ppm sulfur) across the country in July 2011, but no timeline is set for adopting China IV fuel standards (50-ppm sulfur diesel). If China IV heavy-duty vehicle standards are to go into effect for all diesel vehicles as planned in Jan 2011, China IV vehicles will be operated using diesel with up to 2,000 ppm sulfur initially then with 350-ppm sulfur diesel (after June 2011). Common technology combinations for meeting Euro IV standards (EGR plus oxidation catalysts or engine control plus SCR systems) are not as sulfur sensitive as DPFs, SCR systems using zeolyte catalysts, and lean NOx traps mentioned above. Therefore China IV vehicles could function in the interim before China IV fuels (50-ppm sulfur diesel) are available. However, full emission reduction benefits of these vehicles would not be delivered without the matching fuel standard[35]. A study projected that a China IV-compliant vehicle using 350-ppm sulfur diesel would emit 19% more NOx and 75% more PM than if it is using 50-ppm sulfur diesel[36].

As mentioned before, some cities suffering from severe pollution from motor vehicles have already shifted to diesel with lower sulfur content: 50-ppm diesel fuels are mandated in Beijing and Shanghai when the two cities adopted China IV vehicle emission standards in 2008 and 2009 respectively and the Pearl River Delta of Guangdong province has obtained State Council approval to implement China IV vehicle and fuel standards starting from June 1, 2010. Right now in Beijing and Shanghai, China IV vehicle standards only apply to HDDVs operating within these two cities (city buses, sanitary and postal trucks) because fuel supplied outside these two cities can have much higher sulfur content that could damage emission control devices of China IV HDDVs or increase maintenance needs for those vehicles[37]. Considering the large fleet of urban diesel buses in these two cities, advanced implementation of China IV vehicle and fuel standards can bring significant air quality benefits. Beijing and Shanghai could realize more air quality benefits if fuels sold outside the cities could meet China IV standards, which allow the two cities to adopt China IV HDDV standards for all HDDVs.

35 When the Euro 4/IV standards were developed, it was expected that compliant vehicles would have to be equipped with DPFs to meet the PM requirements. Because the use of diesel particulate filters (DPFs) requires low sulfur diesel (50-ppm maximum), the diesel sulfur limit to match with Euro 4/IV vehicle standards was set at 50 ppm. After the standards were adopted, manufacturers were able to meet Euro IV requirements through engine modifications and the use of after-treatment devices that are less sulfur-sensitive than DPFs, like EGR plus diesel oxidation catalysts (DOC) or partial flow filters, or engine improvements plus SCR. As a result, the technologies for meeting Euro 4/IV standards can function using fuel with more than 50-ppm sulfur.

36 See Liu H. et. al. 2008. Analysis of the impacts of fuel sulfur on vehicle emissions in China. Fuel. Vol. 87. pp. 3147-3154

37 Shanghai also requires construction trucks to comply with China IV standards.



来源：张克松等人，2010年，《中国北方汽柴油燃料硫含量》，《能源政策》38期 6号。

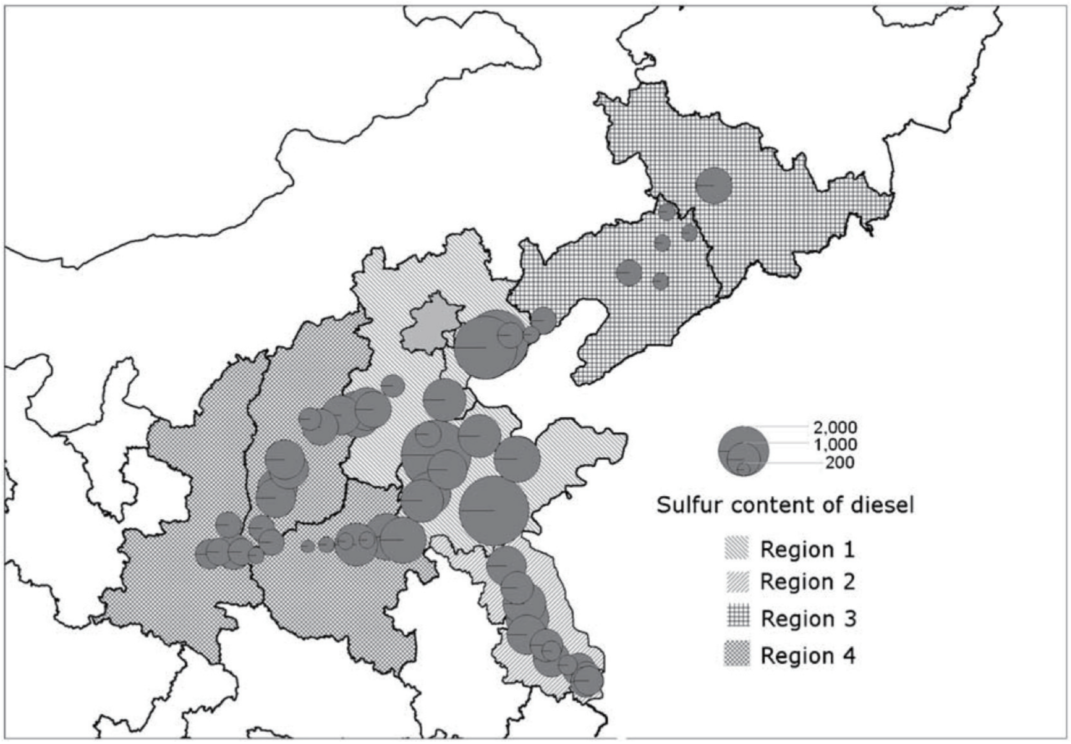
图4.3: 中国北方地区高速公路加油站柴油硫含量抽样情况

低硫燃料的滞后除了削弱大城市的机动车排放控制效果外，已经成为加严新车标准和在全国范围内控制在用车排放的主要障碍。作为最有效的新车和在用车颗粒物排放控制装置，柴油车颗粒物捕集器要求使用低硫柴油（不大于50ppm，推荐10ppm）。如果没有低硫柴油，尽管不是不可能，但要进一步加严车辆标准和强化在用车排放控制将面临重大挑战。

4.3 非道路柴油燃料标准

和车用柴油一样，非道路柴油中对排放影响最大的指标也是硫含量。在许多国家，非道路发动机和设备执行的标准相对较松，因此对非道路柴油燃料的要求也通常没有车用燃料标准那么严格。

在过去的10年中，美国、欧盟和日本已经在逐步加严非道路机车的排放标准。为了在非道路机车上使用排放控制装置，这些国家已经出台了配套的较低非道路柴油硫含量限值。目前，中国的非道路燃料硫含量标准为2000ppm，与车用柴油强制标准相同。中国的非道路燃料硫含量限值比欧盟、美国和日本的限值要高出许多。表4.1展示了美国、欧盟、日本、巴西和中国的燃料硫含量限值。



Source: Zhang, K., et al. 2010. Sulfur content of gasoline and diesel fuels in northern China. Energy Policy, vol. 38, number 6.

Figure 4.3: Sulfur content of diesel in samples from highway service stations in northern China

In addition to undercutting the efforts of big cities to control vehicle emissions, the delays in adopting requirements for lower sulfur diesel fuel have become a major roadblock for tightening new vehicle standards and for implementing measures for controlling in-use emissions nationwide. Diesel particle filters, the most effective emission control devices for controlling PM emissions from new and in-use vehicles, require the use of low sulfur diesel (50-ppm maximum, 10-ppm preferred). If lower sulfur diesel is not available, further tightening of vehicle standards and strengthening control of emissions from the existing fleet would be challenging, if not impossible.

4.3 Non-road diesel fuel standards

Like motor vehicle diesel, the most important characteristic of non-road diesel affecting emissions is sulfur content. In many countries, non-road engines and equipment are subject to less stringent emissions standards, and so non-road diesel fuels are usually subject to less strict standards than those that apply to motor fuel.

In the past decade, the US, EU and Japan have gradually tightened emissions standards for non-road engines and equipment. To enable the use of emission control devices on non-road applications, these countries have promulgated in parallel lower limits on non-road diesel sulfur. China's current sulfur standard for non-road fuel is 2,000 ppm, the same as the mandatory standard for motor vehicle diesel. The sulfur limits for non-road fuel in China is much higher than the limits adopted/to be adopted in EU, US, and Japan. Table 4.1 shows the fuel sulfur limits adopted in the US, EU, Japan, Brazil and China.

限值	美国[1]	欧盟	日本	巴西	中国
现行的硫含量限值	非道路设备[2] 15 ppm (从2010年起)	1000 ppm	10 ppm (从2008年起)	1800 ppm [3]	2000 ppm
即将执行的硫含量限值	从2012年起，非道路火车和船舶 15 ppm	2011年，10 ppm		非道路特殊标准，2014年以前: 1800ppm	

表4.1: 美国、欧盟、日本、巴西和中国的非道路燃料要求

1 – 小型炼油商和进口商可以有更长的时间来满足柴油硫含量要求，2010年之前达到500ppm，2014年之前达到15ppm。

2 – 非道路发动机和设备，包括建筑、农业、工业和机场用设备。

3 – 农村地区市售柴油硫含量限值，主要用于非道路设备。巴西将于2014年起，正式对非道路柴油实施硫含量1800ppm限值。

4.4 中国在油品标准前进道路上的障碍

政策和行政障碍

环保部不具备制订油品标准的权力： 尽管环保部是制订和实施车辆排放标准的带头机构并已经制订了油品有毒物质限值（例如：汽油的苯含量），但却没有明确的权力来规定直接影响车辆排放的油品质量参数。由于环保部不能直接控制油品质量标准的力度和实施时间，进一步加严车辆标准到国IV及更高标准就可能面临挑战，因为轻型柴油车国V和柴油车国VI标准要求的最有效的排放控制技术选择（DPFs和分子筛SCR系统）都要求限制燃料硫含量（硫含量50ppm或更低）。

制订油品标准的技术委员会受控于石化企业界代表: 油品质量标准由全国石油产品和润滑剂标准化技术委员会（又称TC280）制订和管理，该委员会归属国家标准化管理委员会管理[38]，在TC280下设有分委员会（石油燃料和润滑剂分技术委员会），专门制订油品规格。TC280的秘书处机构是石油化工科学研究院，中国最大的石油公司之一中国石化下属的研究部门。石科院负责管理TC280及其分委员会和提供工作人员，同时拟定油品规格。石油工业的代表和与之来往密切的一些专家掌控着TC280及其分委员会—在TC280的43名代表中仅有3名来自环境和汽车领域，分委员会的30名代表中也仅有3名来自环保部或汽车企业。由于环保和汽车部门代表席位太少，而石化行业的影响力很大，在进行制订新标准时很难进行平衡和顾及各方面利益的讨论。

小型炼厂的落后技术不具备升级价值： 据估计，中国约5%的燃料供应来自于技术落后的小型炼厂，且从成本效益方面不具备技术升级价值[39]。对关闭这些设备造成的失业和对炼厂所在地区的经济影响的考虑可能会进一步推迟加严燃料标准。

38 详见委员会组织机构http://www.cptcstd.org/viewOrg.aspx (中文版, 2010年3月22日)。
39 与VECC的会谈(2010年3月12日)。

LIMITS	US [1]	EU	JAPAN	BRAZIL	CHINA
Current sulfur limits	15 ppm for non-road uses[2] (starting in 2010)	1000 ppm	10 ppm (starting in 2008)	1800 ppm [3]	2000 ppm
Adopted future limits	15 ppm by 2012 for non-road, locomotive and marine applications	10 ppm by 2011		Non-road specific standards: 1800ppm by 2014	

Table 4.1: Non-road fuel requirements in the US, EU, Japan, Brazil and China

1 – Small refiners and importers are allowed more time to meet the diesel sulfur requirements, which will be 500ppm by 2010 and 15 ppm by 2014.

2 – Non-road engines and equipment include construction, agricultural, industrial and airport equipment.

3 – Sulfur limit for diesel sold at the countryside, which is mainly consumed for non-road applications; Brazil will implement an official sulfur limit of 1800 ppm for non-road diesel in 2014.

4.4 Barriers to progress in China

Policy and political barriers

MEP lacks the authority to set fuel standards: While MEP is the lead agency for developing and enforcing vehicle emission standards and has proposed limits for toxics in fuels (e.g., benzene in gasoline), it does not have the clear authority to specify fuel quality parameters even if those parameters affect vehicle emissions. With MEP having no direct control of the stringency and implementation timeline of fuel quality standards, it would be challenging to further tightening vehicle standards to or beyond China IV because the most effective options of emission control technologies for meeting China V for light-duty diesels and China VI for all diesel vehicles (DPFs and zeolyte SCR systems) are limited without low sulfur fuel (fuels with 50 ppm or less sulfur content).

The technical committee that sets fuel standards is dominated by industry representatives: The development and management of fuel quality standards is led by the National Petroleum Products and Lubricants Standardization Committee (which is called TC280), a committee managed by the Standardization Administration of China (SAC)[38], and a subcommittee under TC280 is dedicated to development of the fuel specifications. The secretariat organization of TC280, the Research Institute of Petroleum Processing (RIPP), is a research division of Sinopec, one of the largest oil companies in China. RIPP is responsible for staffing and managing TC280 and its subcommittee, as well as for drafting fuel specifications. Oil industry representatives and experts close to the industry dominate TC280 and its subcommittee—only three out of the 43 members in TC280 represent environmental and automobile interests and three out of the 30 members of the subcommittee are MEP or auto representatives. Such a small representation from the MEP and auto industry compromises the balance of the discussions on setting new standards due to the outsized influence of the oil industry's perspective.

Small refineries with dated technologies are not cost effective to upgrade: It is estimated that about 5% of fuel supply in China comes from small refineries with dated technologies that might not be cost effective to upgrade[39]. Concerns about unemployment and other economic impacts from facility closures in the regions where these small refineries are located could cause more delay in tightening fuel standards.

38 See description of the function of the committee at http://www.cptcstd.org/viewOrg.aspx (in Chinese, accessed on March 22, 2010)

39 Communications with VECC (March 12, 2010).

财政障碍

*由于对油品价格实施控制，炼厂可能无法收回投资：*中国的汽柴油零售价格一直是由中央政府制定的。缺少市场价格机制，石油企业无自主权提高产品价格，将增加的产品成本转嫁给消费者，来收回炼厂升级的投资（如炼厂加强脱硫能力）。在实施标准之前，根据美国环保局估算，满足超低硫燃料所需的年投资额（硫含量15ppm的汽柴油）约为2004年21.5亿美元（150亿人民币）和2005年24.9亿美元（175亿人民币）[40]。美国炼厂可以提高超低硫汽柴油的价格来收回脱硫设备投资[41]。比起原油价格波动带来的价格变化，这方面的价格增长幅度很小。要想引导石化行业支持制定更为严格的油品标准，环保部需要想办法解决炼厂升级财政支持的需求。

技术障碍

*技术知识和数据相对匮乏：*环保部（包括中国环境科学研究院的五位工作人员和机动车排污监控中心的的两名工作人员）只有一个很小的团队从事油品方面的研究和管理工作，在环科院有一个进行油品测试的实验室。但是，与石化行业相比，环保部的专业和技术能力还差得很远，特别是对燃料组分的排放影响的评估能力不足，而这恰恰是对标准规格提出意见的关键。另外，环保部掌握的炼厂能力数据也很有限，在考虑实施更加严格的标准时，只能依靠石化行业做出的成本和技术分析。

4.5 建议

*为应对上述障碍，ICCT为环保部提出了下列近期和中长期建议，以便加快改善油品质量，实施与车辆排放标准要求一致的油品标准。这些建议主要针对环保部需要做的事情：*1）力争获得与排放有关的燃料参数的制订权力；2）支持实施采纳逐步加严的油品标准，实现最大的健康收益；3）协助认识和解决实施更加严格的油品标准带来的经济和社会收益。

近期，环保部应力争获得制订和落实与排放有关的燃料参数的权力，从长期而言，逐步实现油品和车辆的一体化管理。

*环保部通过修订《大气污染防治法》赋予其制订和管理与车辆排放相关联的必要油品参数的权力（包括硫含量）。*从法律上赋予环保部制订和实施与排放相关的油品标准的权力是从实质上保障油品标准和车辆标准一体化发展和推进，最大幅度的控制车辆排放的关键。在美国，美国环保局和加州空气资源局（CARB）都有权规管车辆排放和影响车辆排放的燃料特性[42]。同时具有管理车辆和油品的权力使美国环保局和CARB能不断推行新的排放标准限值，并配以不断加严的燃料品质要求。欧盟由环境总署（DG ENV）负责制订与环境有关的油品标准，由工业总署负责制订车辆标准。尽管油品和车辆标准的制订权分属于两个部门，他们却是合作拟定新车和油品标准的。

*扩大环保部在制订油品质量标准过程中的影响作用：*保证油品标准制订过程中能充分考虑环境的重要性，增加环保部和汽车企业代表在TC280和分委员会中的席位数，保障油品标准审议过程中能全面考虑空气质量需求和推进先进的排放控制技术。如果大气法能赋予环保部管理与排放相关的油品参数的权力，那么环保部可能能在这些委员会里获得更多代表席位。无论最终能否获得管理燃料相关参数的权力，环保部都应当力争加强在TC280及其技术分委员会中的影响力。

40 美国环保局，2000年，《管理影响分析：重型发动机/车辆标准和高速柴油燃料硫含量要求》EPA420-R-00-026, 第 IV章, IV-63–IV-64页。

41 华盛顿州立大学能源拓展项目 超低硫柴油案例分析http://www.energy.wsu.edu/documents/renewables/Fuels.pdf (2010年4月29日查阅), 及美国环保局车辆改造和清洁燃料，网址. http://www.epa.gov/ne/eco/diesel/retrofits.html (2010年4月29日查阅)。

42 加州是美国唯一可以单独设定车辆和油品标准的州，在必要的情况下，可以设置比联邦标准更为严格的标准来“满足特定环境”。《清洁空气法》允许其它各州采用加州标准。

Financial barriers

Refineries may not recoup capital investment due to fuel price control: Retail prices of gasoline and diesel have always been set by the central government in China. Without a market pricing mechanism, it is difficult for the oil industry to recoup capital investments on refinery upgrades (such as adding desulfurization capacity at refineries) by passing on the higher production costs to consumers. Prior to its implementation, US EPA estimated the annual capital investment cost for meeting the ultra low sulfur fuel requirements (15-ppm sulfur gasoline and diesel) would be USD 2.15 billion (15 billion RMB) in 2004 and USD 2.49 billion (17.5 billion RMB) in 2005[40]. US refineries were able to raise prices of ultra low sulfur gasoline and diesel to recover investments for the desulfurization units[41]. The incremental price was small compared to the variation in fuel price due to fluctuations in oil prices. To solicit industry's support for setting more stringent fuel standards, MEP needs to explore ways to provide financial support for refinery upgrades.

Technical barriers

Limited technical expertise and data compared to the industry: There is a small team at MEP (including five staff in CRAES and two staff in VECC) working on fuels-related research and regulatory work and a laboratory in CRAES that performs fuel testing. But compared to the oil industry, MEP has far less expertise and technical capability, particularly on evaluating the emission implication of various fuel compositions, which is essential for recommending standard specifications. In addition, MEP has limited access data on refinery capacity and can only rely on the industry's analysis of the cost and technical implications when considering adopting more stringent standards.

4.5 Recommendations

To address the barriers identified above, below are the ICCT's recommendations to MEP in the near-, medium- and longer-term to accelerate improvement of fuel quality and allow the adoption of fuel standards that are consistent with vehicles standard requirements. The recommendations are aimed to address the need for MEP to 1) seek the authority to set emission-related fuel parameters, 2) support the adoption of increasingly cleaner fuel standards to maximize health benefits, and 3) help understand and address economic and social impacts associated with the adoption of tighter fuel standards.

In the near term, MEP should seek the authority to set and enforce emission-related fuel parameters, and in the longer term, pursue to the goal of having fuel and vehicles regulated as one system

Seek revisions to the Air Pollution Prevention and Control Law to grant MEP authority to set and regulate fuel parameters necessary to control vehicle emissions (including sulfur levels): Granting MEP the legal authority to set and enforce emission-related fuel standards is essential to ensure that standards for fuels and vehicle are developed and adopted as a system to achieve maximum control of vehicle emissions. In the US, both the US EPA and the California Air Resources Board (CARB) have the authority to regulate vehicle emissions and fuel characteristics that affect vehicle emissions[42]. Having the regulatory authority on both vehicle and fuel allows US EPA and CARB to continue to adopt new limits for vehicle emission standards in tandem with increasingly stringent fuel quality requirements. In the EU, the Directorate-General for the Environment (DG ENV) is responsible for setting the environment-related fuel standards and the Directorate-General of Enterprise and Industry (DG-ENTR) sets vehicle standards. While the authority for setting fuel and vehicle standards falls into two divisions, they work together on drafting new vehicle and fuel standards.

40 EPA. 2000. Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Requirements, EPA420-R-00-026, Chapter IV, pp. IV-63–IV-64.

41 See some anecdotal examples in Washington States University Energy Extension Program. Ultra Low Sulfur Diesel. http://www.energy.wsu.edu/documents/renewables/Fuels.pdf (accessed April 29, 2010), and EPA. Retrofits and Cleaner Fuels. EPA website. http://www.epa.gov/ne/eco/diesel/retrofits.html (accessed April 29, 2010).

42 California is the only state in the US that is allowed to set separate vehicle and fuel standards as long as those standards are more stringent than the federal standards and there is a need for the separate standards “to meet compelling and extraordinary conditions”. Other states are allowed to adopt California standards.

*通过与美国环保局或其它规管机构合作进行培训，逐步加强自主制定油品标准的能力：*美国环保局和加州空气资源局（CARB）在制订支持新车标准的油品标准方面都有着很长的历史。过去几年中，美国环保局已经成功地培训了环保部一些负责车辆达标管理的人员。环保部在争取管理与排放相关的油品标准的同时，应拓展与美国环保局和CARB油品工作团队之间的合作，为环保部的人员提供油品质量标准制订和实施方面的培训。

*力争修订《大气污染防治法》将油品和车辆标准视为一个整体：*已经有大量研究明确指明了特定燃料特性、车辆排放和空气质量之间的关系。随着环保部推行越来越严格的车辆排放管理方案，油品质量控制也将变得越发重要，因为燃料中的硫会影响甚至破坏许多先进的排放控制技术。在美国，《清洁空气法》从1963年起就授权通过油品管理来减少机动车排放。1970年的《清洁空气法》修订案明确声明，根据221节（C）款，如果危及公众健康或损害机动车排放控制系统，美国环保局有权控制或禁止相应燃料或燃料添加剂[43]。《清洁空气法》在1977年的修订中更进一步扩大了环保局管理油品规格的权限。从法律上明确赋予环保局管理油品规格和车辆排放的权力，这就使环保局可以有系统地制订油品和车辆标准，并要求油品管理标准先于车辆管理标准实施，从而实现最大幅度的减排。在《大气污染防治法》今后的修订中，环保部应力争在《大气法》中规定在实施排放控制管理时，将油品和车辆视为一个整体，这种规定能够成为环保部制订和实施油品及车辆管理方案的有力法律依据。

环保部应支持实施逐步加严的油品标准从而获得最大幅度的健康收益

*考虑短期内在全国范围从国III油品标准跳跃至国V油品标准（硫含量10ppm）：*国V燃料不仅能保障新车先进排放控制技术的应用，现有车辆使用了国V燃料也能降低排放。尽早将国V燃料推向市场，能够增加空气质量改善收益。从成本方面来讲，根据调查，生产50ppm和10ppm的燃料都需要高能加氢裂化装置[44]。因此，对中国炼厂来说，燃料硫含量水平从国III到国IV（硫含量50ppm）和从国III到国V（硫含量10ppm）的投资成本差异并不大（0.02美分/升，或0.14元/升）。从成本效益角度对比油品标准国III->国IV->国V过渡与国III->国V跳跃过渡，显然对中国来说采用直接跳过国IV标准的路线成本效益更高，也能获取最大程度的空气质量改善。环保部应尽量争取对直接跳跃至国V油品标准的支持。

43 最新版本的《清洁空气法》第211节（C）款声明美国环保局“可以控制或禁止生产商将油品或油品添加剂产品引入市场，提供销售或直接销售用于机动车、机动车发动机、非道路发动机或非道路车辆，如果（a）该油品或油品添加剂产品会造成或增加可能危害公众健康及财产的排放物；或（b）该油品或油品添加剂产品带来的排放物会明显损伤排放控制装置或系统。”

44 Enstrat国际咨询有限公司，2003年，《亚洲各类炼厂的柴油脱硫成本》（Cost of Diesel Fuel Desulphurization for Different Refinery Structures Typical of the Asian Refining Industry），提交给亚行的最终报告。

Expand MEP's role in setting fuel quality standards: To make sure that fuel standards are set with sufficient consideration of environmental consequences, representation of MEP and the auto industry should be expanded in TC280 and the subcommittee to ensure deliberation of fuel standards fully accounts for air quality needs and advancement of emission control technologies. If MEP were granted the authority to regulate emission-related fuel parameters, the ministry might be given more representation in those committees. But regardless of the outcome of its pursuit for regulatory authority on certain fuel parameters, MEP should seek to expand its voices in TC280 and its technical subcommittee.

Gradually build up in-house capacity for setting fuel standards through MEP training collaboration with the EPA or other regulatory agencies: EPA and California Air Resources Board (CARB) have a long history of setting fuel standards that support new vehicle standards. In the past few years, EPA has hosted successful trainings for MEP staff on vehicle compliance and enforcement. While MEP pursues the authority to regulate emission-related fuel standards, MEP should explore collaborations with the fuels team at EPA and CARB to provide training to MEP's staff on developing and implementing fuel quality standards.

Pursue modifications of the "Air Pollution Prevention and Control Law" to treat fuel and vehicle standards as one system: Extensive studies have established the relationship of selected fuel characteristics, vehicle emissions and air quality. As MEP adopts increasingly stringent vehicle emission regulation, control of fuel quality will become even more critical because the performance of many advanced emission control technologies can be impacted or even be destroyed by sulfur in fuels. In the US, the CAA authorized fuel regulation to reduce emissions from motor vehicle since 1963. The 1970 CAA amendment explicitly stated that US EPA could control or prohibit fuel or fuel additive under Section 211(c) if public health was endangered or if automotive emission control system was impaired [43]. The 1977 CAA amendments further expanded EPA's authority to regulate the content of fuels. The clear legal authority granted to EPA to regulate fuel content and vehicle emissions enables the agency to set standards for fuel and vehicles as one system and requires fuel regulation be implemented preceding vehicle regulation to maximize emissions reduction. In future revisions of the "Air Pollution Prevention and Control Law", MEP should pursue the recognition of fuels and vehicle as a system for effective emission control, such recognition can become a strong legal basis for MEP's efforts on setting and enforcing fuel and vehicle regulation.

MEP should support the adoption of increasingly cleaner fuel standards to maximize health benefits

Consider support to leapfrogging from China III fuel standards to China V standards (10-ppm sulfur content) nationwide in the near term: China V fuels would not only enable the use of advanced emission control technologies in new vehicles, they would also lower emissions when used in all the existing vehicles. Resulting air quality benefits would be enhanced if China V fuels could be brought to the market as early as possible. From a cost perspective, studies have shown that high capacity hydro-cracking units would needed to produce 50-ppm as well as 10-ppm sulfur fuels[44]. Therefore, the estimated incremental costs difference between lowering fuel sulfur limit from China III to China IV (50-ppm sulfur), and from China III to China V are actually small (0.02 cents/liter, or 0.14 fen/liter) for a typical refinery in China. Comparing the costs and benefits of going from China III->IV->V fuel standards and from China III->V, it is clear that skipping China IV standards would be a more cost effective pathway for China to maximize air quality benefits. MEP should solicit support for leapfrogging to China V fuel standards.

43 Section 211(c) of the current version of CAA states that USEPA "may…control or prohibit the manufacturer, introduction into commerce, offering for sale or sale of any fuel or fuel additive for use in a motor vehicle, motor vehicle engine, or non-road engine or non-road vehicle (a) if … any emission product of such fuel or fuel additive causes, or contributes, to air pollution which may reasonably be anticipated to endanger the public health or welfare, or (B) if emission productions of such fuel or fuel additive will impair to a significant degree the performance of any emission control device or system…".

44 Enstrat International Limited. 2003. "Cost of Diesel Fuel Desulphurization for Different Refinery Structures Typical of the Asian Refining Industry". Final Report prepared for the Asian Development Bank.

*力争统一道路与非道路柴油硫含量要求：*主要汽车市场，如美国、日本和欧洲都已经或即将对道路和非道路柴油实施统一的硫含量限值。目前，中国没有正式区分道路和非道路柴油，但是随着对道路柴油的要求更严格，可能需要制订道路和非道路两种标准。即使是实施了两种标准，今后环保部还是应该继续降低非道路燃料硫含量直至和道路油品标准接轨。对道路和非道路实施同样的低硫标准可以减轻管理部门的负担，也可以使道路车辆排放控制技术拓展用于非道路发动机。

环保部应与其他相关部委合作，协助认识和解决实施更加严格的油品标准所带来的经济和社会影响。

*环保部应与相关部委合作设法为企业提供财政支援，用于购买脱硫设备或改善燃料品质：*炼厂升级所需的投资可以通过燃料税来提供财政补贴，燃料税的形式可以是短期的专项税收，专门用于覆盖启动资金成本，也可以是设置成长期税收，对不清洁的燃料（如高硫燃料）收税高，对清洁燃料（如超低硫柴油）收税低。对不清洁的燃料提高收税还可以鼓励销售清洁燃料。中国在上世纪90年代末成功采取消费者鼓励措施帮助在全国转换实施无铅汽油。2003年亚洲发展银行进行的一项研究指出，对典型中国炼厂来说，将柴油硫含量从350ppm降低至10ppm，成本增加额为0.11人民币/升[45]。2002年的一项研究认为，对中国炼油企业而言，柴油硫含量从2000ppm降至50ppm，成本大约为0.08人民币/升[46]。鉴于近年来中国许多炼厂已经或正在投资进行现代化改造和扩大生产能力，如果能够以此为基础开展中国国情分析，更好的了解基层炼厂的最新状况，评估中国的生产能力，重新估算增加的成本和炼厂升级所需的补贴金额，将会有所帮助。

*逐步淘汰技术落后的小型炼厂：*环保部应联手相关部委，制订过渡计划，关闭无法在保证成本收益的情况下升级为生产低硫柴油或所生产的产品无法暂时用于非道路的小型炼厂。在美国，由于考虑到关闭小型炼厂带来的经济影响和潜在的能源安全风险，美国环保局允许小型炼厂推迟油品标准达标期限。至今为止，美国依然有一大批小型老旧炼厂。在标准实施和今后继续加严燃料质量要求方面，这些炼厂将不断为美国环保局带来挑战。

*发起油价控制政策改革的讨论：*中央政府控制汽柴油的零售价格一直是推动清洁燃料生产的主要障碍。环保部应以油品质量为着眼点，在各部委中发起关于油价控制政策改革的讨论。在讨论过程中应考虑如何减轻油价走高对农民和其它有关民众的影响。

45 同注44。

46 基于最高估算成本（2010年估算值）4.7美元/加仑。Yamaguchi, N., D, Fridley及K. Xiaoming，2002年《改善中国交通燃料品质：炼油领域的影响》（ Improving Transport Fuel Quality in China: Implications for the Refining Sector.）报告编号： LBNL-50681. (http://china.lbl.gov/publications/improving-transport-fuel-quality-china-implications-refining-sector（ 2010年3月23日查阅)

Strive to align onroad and non-road diesel sulfur requirements: Major vehicle markets, such as the US, Japan and Europe, have already or in the process of aligning the sulfur limits for on-road and non-road diesel. Right now there is no official differentiation between on-road and non-road diesel in China, but as onroad diesel requirements become more stringent, there might be a need for dual standards for onroad and non-road fuels. Even if a dual standard is adopted, in the near and longer term, MEP should strive to continue lowering non-road fuel sulfur content as it tightens on-road fuel standards. Having the same low sulfur standards for on-road and non-road standards will lighten the enforcement burden on the regulatory ministry, and would also enable the deployment of onroad emission control technologies on non-road engines.

MEP should work with other ministries to help understand and address economic and social impacts associated with the adoption of tighter fuel standards

MEP should work with relevant ministires to identify ways to finance industry's capacity investment on desulfurization units or other costs to improve fuel quality: Subsidies for industry to finance refinery upgrades could be raised through raising fuel taxes, either as a dedicated tax levied for a few years to cover most of the initial capital costs, or a permanent fuel tax that is set higher for less clean fuel (e.g., higher sulfur fuel) and lower for cleaner fuels (e.g., ultra low sulfur diesel). Setting higher fuel tax for dirtier fuels could also encourage sales of the lower sulfur fuel. Consumer incentives have proven to be successful in promoting early transition to cleaner fuels when China switched to unleaded gasoline in the late 1990s. A 2003 study prepared for the Asian Development Bank suggested that reducing sulfur content of diesel from 350-ppm to 10-ppm would result in an incremental cost of about 0.11 RMB/liter for a typical Chinese refinery[45]. A 2002 study suggested that the incremental costs for lowering diesel sulfur content from 2000-ppm to 50-ppm would be about 0.08 RMB/liter for Chinese refineries[46]. In light of the major investments in modernization and capacity expansion that have been made or are being made by Chinese refineries in recent years, it would be helpful to conduct an updated China-specific analysis to better characterize the latest baseline refinery configuration and determine the current Chinese refinery production capacity and capability to reassess the incremental cost and potential subsidies needed for refinery upgrades.

Phase-out small refineries with dated technologies: MEP in partnership with other relevant ministries should develop a transition plan for closing down small refineries that cannot be cost effectively upgraded to produce low-sulfur diesel or whose products cannot be temporarily diverted to non mobile source applications. In the US, because of concerns about the economic impacts of closing down small refineries and the potential risks on energy security, EPA has allowed longer lead times for small refineries to comply with the fuel standards. To-date, the US still has a large number of small, very old refineries. Those refineries would continue to present challenge to EPA on enforcement and for future tightening of fuel quality requirements.

Initiate the discussion on the reform of the fuel price control policy: The central government control of gasoline and diesel retail prices will continue to be a major barrier to promoting the production of cleaner fuels. MEP should initiate discussions of reforming fuel price control among agencies in the context of fuel quality, vehicle emissions and air quality. The discussion should consider measures for mitigating the impacts of higher fuel prices on farmers and other impacted populations.

45 Ibid.

46 Derived based on the highest cost estimate (2010 estimated cost) of 4.7 US cents per gallon. Yamaguchi, N., D, Fridley and K. Xiaoming. 2002. Improving Transport Fuel Quality in China: Implications for the Refining Sector. Report No. LBNL-50681. (http://china.lbl.gov/publications/improving-transport-fuel-quality-china-implications-refining-sector, accessed on March 23, 2010)

5. 车辆达标管理和实施方案

只有车辆在日常使用中的排放真正降下来，新车排放标准才能起到保护空气质量的作用。要全面实现新车标准的环境和健康收益承诺，必须推行有效的车辆达标管理和实施方案，从而确保新车和在用车的排放被有效控制。

本章归纳了中美两国车辆达标管理和实施方案的关键点。美国环保局（EPA）的车辆达标管理和实施方案是当今世界最全面的车辆达标管理和实施方案之一，本章将通过对比中美的现行措施，为改进中国当前的方案提出一些建议。

5.1 国际最佳实践经验：EPA的车辆达标管理和实施方案

美国的车辆实施方案是目前全世界最全面且影响最深远的车辆达标管理和实施方案。不过，在1970年《清洁空气法》刚刚通过的时候，美国的车辆达标管理和实施方案也仅仅只涵盖新车认证。多年来，管理方案不断成熟完善，从最初侧重于确保样车和新车达标发展，到现在重点强调在用车测试的方案，确保车辆在整个使用周期满足排放标准要求。

由于美国早年实施了强力有效的认证方案和选择性达标审核（Selective Enforcement Audit, SEA）方案，EPA现行的车辆达标管理工作可以把更多的资源用于在用车测试管理。上述两项方案杜绝了认证结果报告中的舞弊现象，并迫使生产企业出资大量测试其生产的新车以确保生产一致性。这就使EPA可以将更多的资源用于在用车测试，确保发动机和排放控制装置在车辆的使用周期内的耐久性并保证排放得以有效控制。近年来便携式排放测量系统（PEMS）的研发实现了在用车排放测量的突破，使在用车排放测量，特别是针对重型车和非道路机械设备排放的测量，变得可行。

下面我们将分几部分讨论轻型车、重型车、非道路机械及摩托车的达标管理和实施方案。其中一节内容专门总结检验与维护（I/M）方案和先进经验。美国管理实施方案的效果和成本也将予以介绍。

轻型车达标管理方案:

轻型车新车达标管理和实施方案包括：1）生产前认证；2）一致性测试；3）选择性达标审核（SEA）；4）由EPA执行的在用车监督检查；5）生产企业执行的在用车验证检测（in-use verification testing program, IUVP)；6）召回；7）保修和缺陷报告。各部分在车辆使用周期内如何实施，详见图5.1。

生产前认证测试:

根据《清洁空气法》206节规定，所有在美国销售的发动机及车辆都要求在进入市场前进行达标认证以得到认证证书。通过认证证明该发动机或车辆符合所有相关排放和燃料经济性要求。测试结果结合劣化系数之后与排放标准进行比较，然后判定是否通过[47]。

47 劣化系数是生产前认证、选择性达标审核和生产一致性测试中的基本组成部分，选择性达标审核和生产一致性将在本章后文中进行讨论。EPA通过耐久性验证管理来判定劣化系数。EPA要求每家生产企业设计一个耐久性实验方案，预测其生产的车辆在使用过程中的劣化情况。多数生产企业对排放控制元件采用台架加速老化程序来判定劣化系数。生产企业出资进行的在用车验证检测 (IUVP) 为劣化系数的判定提供了有价值的数据，本章稍后会具体讨论。如果在用车测试反映出更大的劣化系数，生产企业就必须修改他们的劣化系数判定程序。

5. Vehicle compliance and enforcement program

New vehicle emission standards can only serve to protect air quality if vehicular emissions are actually reduced when the vehicles are in normal use. To fully deliver the promise of environmental and health benefits from new vehicle standards, an effective vehicle compliance and enforcement program has to be in place to ensure emissions of new and in-use vehicles are effectively controlled.

This chapter summarizes the key elements of the vehicle compliance and enforcement program in the US and China. By comparing the current China program with the US EPA program, which is one of the most comprehensive vehicle enforcement programs in the world, this chapter offers some recommendations for enhancing China's current program.

5.1 International best practice overview: US EPA's vehicle compliance and enforcement program

The US vehicle compliance program is by far the most comprehensive and far-reaching compliance program in the world. But looking back to when the "Clean Air Act" was passed in 1970, the US vehicle compliance program only covered new vehicle certification. Over the years, the program has grown and evolved from one that focused mainly on ensuring prototype and new production vehicles comply with standards, to the current program that places strong emphasis on in-use testing to ensure compliance of emissions standard over the vehicle useful life.

EPA was able to shift more resources to in-use vehicle testing programs because of the strong enforcement presence established in early years through its vigorous certification program and the Selective Enforcement Audit (SEA) program. These two programs deterred fraudulent reporting of certification results and compelled manufacturers to extensively test new vehicles at their own costs to ensure production conformity. This allowed EPA to shift its resources to in-use testing to ensure engines and emission control devices are durable and emissions are effectively control over the useful life of vehicles. The development of the portable emissions measurement system (PEMS), a recent breakthrough of instrumentation for on-road/in-use emission measurement, makes in-use emission testing feasible, particularly for heavy-duty vehicles and non-road engines.

The following sections review the compliance program for light-duty vehicles, heavy-duty and non-road engines and motorcycles. A section is devoted to a summary of inspection and maintenance programs and best practices. Results and costs of the US compliance and enforcement program are also presented.

Light-duty vehicles (LDVs) compliance program:

The new vehicle compliance and enforcement program for LDVs consists of: 1) Pre-production certification, 2) Confirmatory testing, 3) Selective enforcement audit (SEA), 4) In-use surveillance performed by EPA, 5) In-use verification testing performed by manufacturer, 6) Recall, and 7) Warranties and defect reporting. How these elements are implemented over a vehicle's life is illustrated in Figure 5.1.

Pre-production certification testing:

Under CAA Section 206, all engines and vehicles sold in the US are required to be covered by a certificate of conformity before they can enter the market. The certification demonstrates that the engine or vehicle conforms with all applicable emissions and fuel economy requirements. A deterioration factor is applied to the test results before comparing to the emission standards and determining pass and fail[47].

47 The deterioration factor is an essential part of testing for pre-production certification, as well as for selective enforcement audits and conformity of production discussed in later part of this chapter. EPA has adopted a durability demonstration regulation on how to determine deterioration factors. Each manufacturer is required to design a durability process that predicts the in-use deterioration of the vehicles it produces. Most manufacturers determine deterioration factors using accelerated bench aging procedures for emission control components. The manufacturer-funded in-use testing program (In-use Verification Testing Program) discussed later in this chapter provides valuable data to validate manufacturers' procedures for determining deterioration factors. If in-use testing shows larger deterioration factors, the manufacturer must revise their procedures for determining deterioration factors.

由生产企业进行生产前认证测试，用于支持其达标认证的申请，通常在核发认证证书前进行[48]。生产企业可以组建自己的设备进行测试，也可以承包给独立的实验室。测试结果经过劣化系数调整之后，必须记录在认证申请材料中，以证明可以达标。生产企业对想要进行认证的全部“测试组别”都要进行认证测试。

“测试组别”或“发动机系族”是进行排放达标认证时的基本分类单元，是指一组设计和排放特性相似的车辆或发动机。对轻型和重型车而言，这些特性包括发动机排量、汽缸数、汽缸排列和燃烧室排列（直列或V型排列）以及适用于相同的排放标准。制造商应选择测试组别中排放和排放劣化最高的车型配置作为测试用车（即最差车型）。在美国，所选出来的车型配置被称为排放数据车[49]。

生产企业通过EPA的“VERIFY”计算机系统上传认证申请，申请在系统内会被自动核实。部分申请则需要人工审核。2007年，EPA向车辆及发动机制造商颁发了3500多份达标认证证书。

48 美国的认证测试包括以下试验程序：联邦测试程序（Federal Test Procedure, FTP）、高速公路燃料经济性试验、US06（高速/加速工况）、SC03（空调测试工况）、冷启动一氧化碳（在华氏20度条件下运行FTP工况）、蒸发排放、车载油气回收（Onboard refueling vapor recovery, ORVR）和汽车运作中的蒸发排放试验。

49 测试组别的详细定义请参见《美国联邦管理法规》40 CFR 86.1822-01 及 40 CFR 86.1827-01。

Pre-production certification testing is conducted by manufacturers to support their applications for a certificate of conformity and is usually performed before a certificate is issued[48]. A manufacturer can establish its own testing facility to conduct the test or contract the services of independent laboratories. Test results, adjusted with deterioration factors, must be recorded in the certification applications to demonstrate compliance. Manufacturers must perform certification testing for all the “test groups” that they choose to certify.

A test group or engine family is a basic classification unit used for demonstrating compliance with vehicle emissions requirements. It is a group of vehicles or engines having similar design and emission characteristics. For light- and heavy-duty vehicles, these characteristics include engine displacement, cylinder number, arrangement of cylinders and combustion chambers (in-line vs. v-shaped), and subject to the same type of emission standards. The manufacturer should select the vehicle configuration within the test group that is expected to generate the highest level of emission and emission deterioration as the test vehicle (the worst-case configuration). The selected configuration is called the emission data vehicle in the US[49].

Manufacturers submit certification applications through EPA's computer system called VERIFY, which automatically validate all applications. Manual auditing is performed for some applications. EPA issued over 3,500 certificates for conformity to vehicle and engine manufacturers in 2007.

48 Certification testing in the US comprises the following test procedures: federal test procedure (FTP), highway fuel economy test, US06 (high speed/ acceleration cycle), SC03 (air conditioning test cycle), cold CO (FTP conducted at 20 deg F), evaporative emissions, Onboard Refueling Vapor Recovery (ORVR), and running loss emissions test.

49 For more details about test group determination, see US Code of Federal Regulations 40 CFR 86.1822-01 and 40 CFR 86.1827-01.

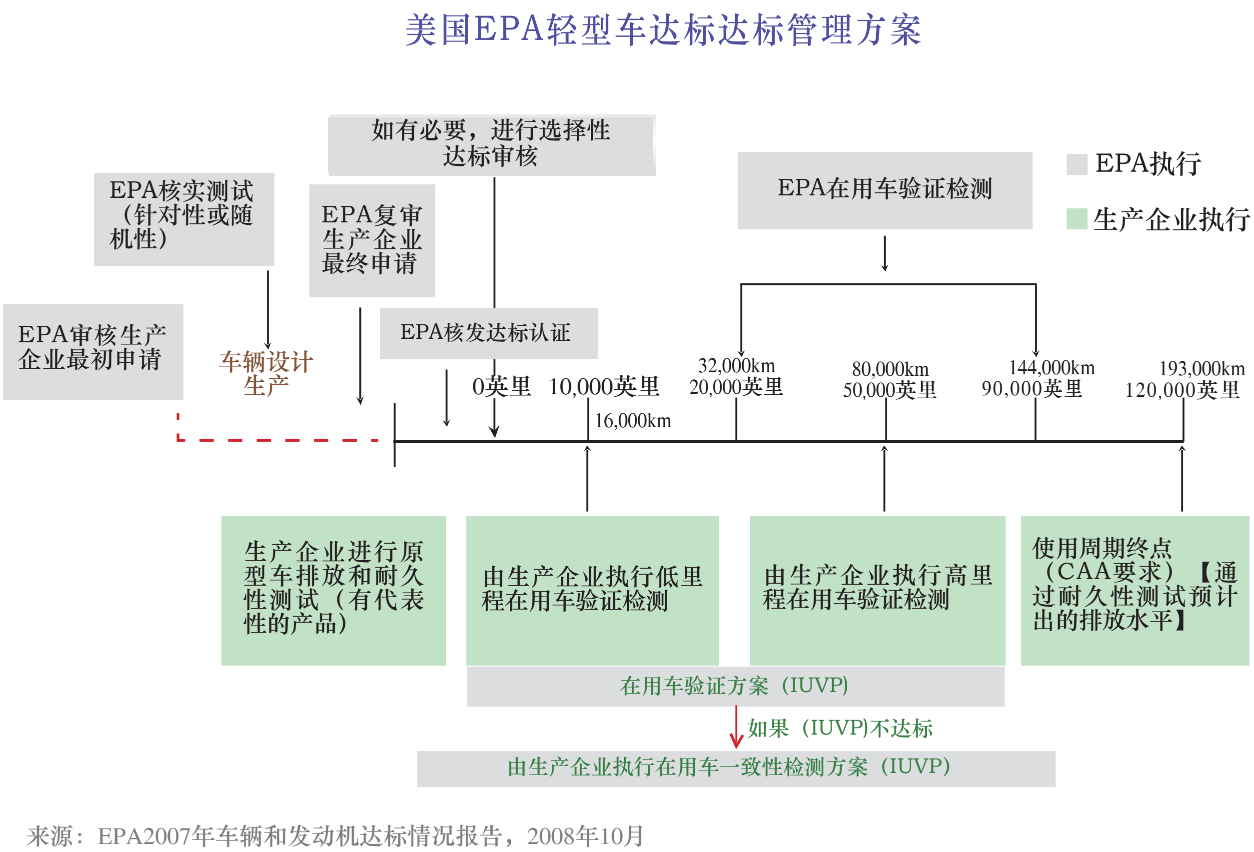


图 5.1: EPA轻型车达标管理和实施方案

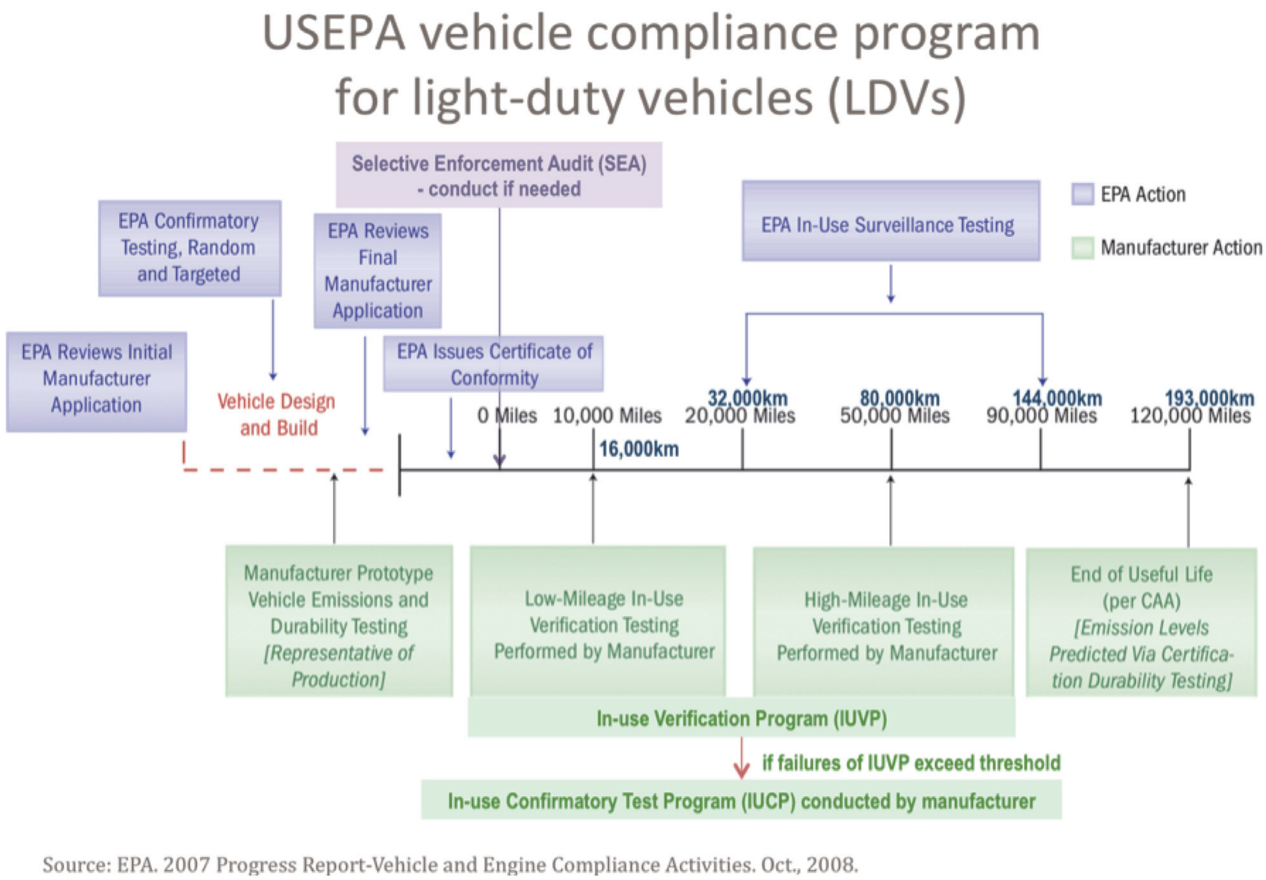


Figure 5.1: US EPA Vehicle Compliance program for light-duty vehicles

核实测试:

核实测试是EPA进行的有针对性的或随机的测试来确认认证测试中报告的排放和燃料经济性试验结果。近年来，EPA在所有测试组别中挑选了大约15%进行核实测试，其中2/3（占全部测试组别的10%）是随机挑选的，另外1/3（占全部测试组别的5%）是有针对性的进行测试。所有轻型车的核实试验都由EPA位于安娜堡（Ann Arbor）的实验室执行。

有针对性的一致性测试的主要对象是使用新技术或新设计的车型，其它的测试对象则是被认为可能存在排放问题的车型，包括在认证时排放水平非常接近标准上限（处于排放限值边缘）的车型。

制造商会被邀请观察测试的执行情况。每辆测试车有两次通过机会，如果第一次测试没有通过，将进行第二次测试。制造商可以选择在第一次测试失败后对车辆进行检查，确定车辆的问题（如是否存在错误零件或管路断开）。如果制造商能够证明测试无效，则车辆可以被重新测试。如果车辆两次测试均未通过，将不能获得认证。此时，制造商可以选择放弃认证或进行调整之后（重新标定）重新申请认证。

选择性达标审核 (SEA):

SEA开始于上世纪70年代中期，当时EPA发现一些制造商会偶尔生产出不达标的车辆类型，尽管进行认证的样车是达标的。SEA的目的就是找出制造商提供的样车不能作代表性产品的情况。

通过SEA方案，EPA可以要求制造商测试从生产线终端抽取的车辆，并由制造商支付费用，预先不予通知。SEA能在早期给EPA提供机会评估在核实认证下生产的车辆是否确实与认证样车规格一致，以及制造商是否留出充分的达标空间，确保其批量生产的发动机和排放控制设备能够在应用劣化系数后达到标准要求。

SEA的设计前提是没有必要对所有流水线上的车辆进行固定比例的测试，相比之下，把精力集中在疑问较大的车型上，也能取得同样的信息且对企业来说成本较低。在选择测试对象时，EPA会采纳多渠道的信息，包括制造商以往的达标率、达标水平、认证数据、I/M数据、技术评估和缺陷报告等。

根据EPA的要求，SEA测试可以使用制造商的实验设备按照EPA的测试要求进行，或在任何一家EPA指定的实验室进行。如果某车型没能通过SEA测试，EPA有权吊销或暂停该车型的认证资格，这将限制该车型的销售，直至制造商证明该车型能够达标。

审核失败带来的处罚对制造商来说影响非常严重，如关停不达标车型的生产线，所以许多制造商自SEA方案实施后开始定期测试他们的车辆。在本方案实施后不久，制造商测试的车辆数量已远远超过EPA审核测试的数量（超出100倍以上）。到上世纪80年代中期，不能通过审核的轻型车生产线已经非常少了，具体轻型车辆不能通过SEA的也很少见，因此EPA决定将轻型车SEA员工换去执行重型车SEA工作和在用车测试（召回）项目[50]。

EPA已经很多年没有执行轻型车SEA审核了，但是一旦发现日常生产线测试有可疑之处，如报告作假或测试程序不当等，EPA依然保留有执行SEA审核的权力。

50 与 Chuck Freed的谈话。

Confirmatory testing:

Confirmatory tests are targeted and random tests performed by EPA to validate the emission and fuel economy testing results reported in certification testing. In recent years, EPA selected about 15% of all test groups for confirmatory test; two-third of the selected test groups (10% of all test groups) are randomly selected and the remaining one-third (5% of all test groups) are targeted testing. All LDV confirmatory tests are conducted at EPA's Ann Arbor laboratory.

The majority of vehicles targeted for confirmatory test are those models that use new technology or new design. Others are targeted due to potential emission concerns, including models with certified emission levels very close to the standards (small emission margin).

Manufacturers are invited to observe how the tests are performed. Every test vehicle has two attempts to pass, if the vehicle failed the first test, the vehicle is tested a second time. The manufacturer can also choose to inspect the test vehicle after it failed the first test to determine what went wrong (e.g., if the failure is due to wrong parts, or disconnected hose). If the manufacturer can demonstrate that it was an invalid test, the vehicle can be retested. If a vehicle fails two valid tests, no certificate will be issued. The manufacturer can choose either not to pursue certification, or make changes (recalibration) and then resubmit a new application.

Selective enforcement audit (SEA):

The SEA program came about in the mid-1970s when EPA found that manufacturers were occasionally producing classes of new vehicles that did not comply with standards, even though the certified prototypes meet the standards. The SEA is aimed at identifying cases where prototype vehicles supplied by manufacturers are not representative of production.

Through the SEA program, EPA can require manufacturers to test vehicles pulled off from the end of the assembly line, at the manufacturer's expense, without prior notice. SEA offers EPA an early opportunity to assess whether the vehicles produced under the certificate of conformity are actually built adhering to the specifications of the prototype, and if manufacturers allow sufficient compliance margins such that in mass production the engine and emissions control equipment function effectively to comply with standards after deterioration factors are applied.

The SEA was designed based on the premise that testing a fixed percentage of all assembly line vehicles is not necessary; rather, a program that focuses on potentially suspect classes could achieve the same information at lower cost to the industry. To pick the target test groups for the audits, EPA uses information from many different sources, including compliance history with a manufacturer, compliance margin, certification data, I/M data, technology reviews, and defect reports.

The SEA can be performed at the manufacturer facility following EPA's requirements, or at any testing lab EPA chooses. If a model fails SEA testing, EPA has the power to revoke or suspend certification, which will restrict sales of the model, until the manufacturer can demonstrate conformity with the standards.

Because the penalties of failing the audits, like halting the assembly line of a failed vehicle class, were disruptive to the manufacturers, many manufacturers began routinely testing their vehicles. Soon after the program started, manufacturers tested far more (100 times more) vehicles than the number of vehicles audited by EPA. By mid 1980s, failed LDV audits became rare, and even failed individual vehicles in the SEA were infrequent, and EPA decided to shifted LDV SEA staff resources to heavy-duty SEA efforts and the in-use testing (recall) program[50] .

EPA has not conducted any SEA for LDVs in many years but the agency reserves the authority to conduct SEA if a problem is suspected with routine production line testing, such as reporting fraud or improper testing procedures.

50 Communications with Chuck Freed.

在用车监督检查和召回测试方案：

EPA实施的在用车监督检查和召回测试方案主要针对可能存在排放相关问题的车型（通常为测试组别）或出于其它原因抽取的车辆群体。选择车型的主要依据是：1）生产企业的缺陷报告；2）各州实施I/M的数据；3）生产企业服务记录；4）认证测试结果（EPA更多的是测试认证时存在问题的车型）；5）配备新技术或新发动机车型；6）销售量；7）在用车验证检测未通过车型；8）随机；9）其它EPA认为适当的原因。

所有被选车辆都在安娜堡实验室进行测试（除非EPA另行指定其他场地），采用与认证相同的测试程序和燃料（标准燃料）。车辆被抽到进行在用车测试时会通知生产企业，并邀请他们参观测试过程和测试前的车辆维护保养过程，这样一来，他们就可以信任测试完成的质量。

在监督检查过程中，EPA会从密西根东南部（安娜堡实验室附近）招募三至五辆车龄在两年或三年的车。项目承包人员会根据EPA选出的测试车辆组别，分别联系车主。车主会获得小额的奖金（每天约20美元）和一辆代步车（或每天50美元代替代步车）。EPA确保车辆会被合理保养和使用，如有必要会在测试前进行保养。所进行维修养护是根据测试方案要求而定。如果更换任何部件，会向参与者提供清单。

如果在监督检查测试中发现一定数量测试车辆不达标，EPA将会与生产企业进行商讨，寻求可接受的解决方案，如自愿召回、生产企业修理服务或延长保修。EPA很少会采用强制召回手段，但保留使用该手段作为最终解决方案的权力。

2007年共计测试了142辆车，代表47个测试组别。其中9辆车（代表5个测试组别）未通过在用车测试，不过只有一个测试组别反映出大范围不达标，引致EPA的进一步调查[51]。

如果监督检查结果表明某一车型可能存在多车次在使用周期内排放超标的情况，且生产企业拒绝自愿补救该问题，则测试将进入核实检查阶段。如果这一阶段的测试证实了该车型存在大量不达标的现象，将导致EPA下令召回。生产企业可以在任何时候实施自愿召回以避免上述情况发生。EPA也会同生产企业协商补救方法来避免实施下令召回。然而，根据《清洁空气法》207节（C）款之规定，如果无法达成一致的自愿解决方案，EPA有权下令召回。

核实测试的车辆选择和测试过程比监督检查测试要严格的多，因为要证明这些车辆在正常保养和使用情况下无法达标。通常，EPA会从问题车型中随机选出10辆进行测试，车主必须正常保养和使用测试车辆。EPA将评估核实测试的结果并判断不通过率是否反映出大规模的不达标现象。这主要取决于不通过车辆的数量和排放超标量。没有规定具体多少车辆不通过就要实施下令召回。通常，如果抽样中有两辆以上的车不合格，EPA就可能采取进一步行动。在EPA发布官方结论之前，生产企业有机会自愿采取相应行动[52]。

EPA从2000年开始实施新达标保障方案（CAP2000），其中将在用车核实阶段改为下面将要介绍的在用车一致性检测方案（IUCP）。

51 EPA，2008年，车辆与发动机达标行动，10月， EPA-420-R-08-011. (http://www.epa.gov/otaq/about/420r08011.pdf, 2009年11月10日查阅)。

52 与EPA交流（2010年4月8日）哈里森•丹，2006年，《美国的在用车符合性管理》发表于机动车污染控制国际研讨会，北京，中国。

In-use surveillance and recall testing program:

Performed by EPA, the in-use surveillance and recall testing program targets vehicle classes (usually test groups) that are suspected of having emission-related problems, or are simply populations that are chosen to be sampled for other reasons. Vehicle classes could be selected based on: 1) manufacturer defect reports, 2) information from state I/M programs, 3) manufacturer service bulletins, 4) certification test results (EPA more likely tests vehicle models that have had problems in certification), 5) newer technology or engine, 6) sales volume, 7) IUVP failures, 8) random, or 9) any other reason EPA deems appropriate.

All selected vehicles are tested at the Ann Arbor laboratory (unless designated by EPA), following the same test procedures and fuels (standard fuels) used in certification. Manufacturers are contacted if their vehicles are picked for in-use testing, and they are invited to watch the tests being performed and maintenance being performed on the vehicles, so they have confidence of the quality of the tests.

At the surveillance phase, EPA typically recruits three to five vehicles that are two or three years old from Southeastern Michigan (in proximity to the Ann Arbor lab). EPA's contractor contacts vehicle owners of each of the test group selected by EPA for testing. The owners are given small monetary awards (about US$20 per day) and a loaner car (or US$50 per day in lieu of a loaner car). EPA ensures that the cars have been properly maintained and used, and if needed performs required maintenance before testing. The maintenance performed depends on program requirements. Participants are given a list of any parts that are replaced.

If a number of failures were identified in the surveillance testing, EPA will discuss these with the manufacturer to find out some acceptable resolutions, such as voluntary recall, field fix, or extended warranty. EPA rarely uses forced recall and reserves to use it as a last resort.

In 2007, a total of 142 vehicles were tested, representing 47 test groups. Nine vehicles (representing five test groups) failed the in-use tests, but only one test group showed the extent of failure that resulted in further EPA investigation[51].

The testing enters the confirmatory phase if the surveillance results indicate that a substantial number of vehicles in the class may exceed emission standards within the useful life, and if the manufacturer declines to voluntarily remedy the problem at that time. This step could lead to an EPA-ordered recall if the testing confirms the likelihood of a substantial number of vehicles failing within the class. The manufacturer can voluntarily recall the vehicles at any time to avoid this process. EPA will work with manufacturers to agree on appropriate remedies to avoid an ordered recall. However, EPA has the authority under Section 207(c) of the "Clean Air" Act to order a recall if voluntary measures are not agreed upon.

Recruitment and testing in confirmatory testing are much more rigorous than in surveillance testing because vehicles must be shown to fail when properly maintained and used. Usually, ten randomly selected vehicles from within the class in question are tested, and the test vehicles must have been properly maintained and used. EPA will review the results of the confirmatory testing and make a determination whether the failure rate indicates a substantial number are failing. This will depend on the number of failures and the margins of failure. There is no set number of failures that can trigger the ordered recall process. Generally, if more than two of the vehicles in the sample fail, there is risk of further action. The manufacturer will have the opportunity to take voluntary action prior to EPA issuing an official finding[52].

In the New Compliance Assurance Program (CAP2000) adopted by EPA in 2000, the in-use conformity phase becomes the in-use confirmatory testing (IUCP) program discussed below.

51 EPA. 2008. Vehicle and Engine Compliance Activity. October. EPA-420-R-08-011. (http://www.epa.gov/otaq/about/420r08011.pdf, accessed Nov 10, 2009)

52 Communications with EPA (April 8, 2010); Harrison, Dan. 2006. In-use Vehicle Compliance Management in the United States. Presentation at Vehicle Pollution Control International Workshop. Beijing, China.

在用车验证检测方案(In-use verification testing program (IUVP)):

IUVP检测[53]由生产企业执行，设计用于测试低里程（1万英里或1.6万公里）和高里程（5万英里或8万公里）的在用车排放情况。每个测试组别抽出1-5辆车参加测试，在2007年汽车企业约进行了2000次测试。无论低里程还是高里程，如果测试抽样中有50%的测试车未能通过测试且平均排放水平超过标准限值1.3倍，生产企业就必须自动执行在用车核实检测方案（In-use confirmatory test program (IUCP)）。在IUCP方案下，车辆的选择和测试方法更为严格（同上文核实阶段的在用车测试方案），若无法通过IUCP，将导致召回。

EPA要求生产企业上报IUVP检测数据。大量的在用车数据能使EPA发现未来几年车辆技术设计中可能的问题，特别是排放控制装置在日常行驶工况下的劣化情况，并可以重点关注存在高排放隐患的车型。IUVP数据还可以用于评估和更新生产企业设定的劣化系数和测定劣化系数的过程。

召回:

《清洁空气法》授权EPA，如经认定车辆或发动机在正常保养和使用状态下仍有一部分无法达标，可以要求生产企业召回该组别的车辆或发动机并支付所有召回所需的费用。

当某一测试组别不能通过在用车监督检查测试的核实阶段 (IUCP) 时，EPA可以要求实施召回。EPA还可以根据IUCP数据，提出召回要求。生产企业通常愿意在提供数据时实施自愿召回。如果生产企业拒绝召回，EPA可以依照管理程序下令召回。

EPA还会调查与排放相关的车辆（技术或设计）缺陷，并判定生产企业是否要修复这些缺陷。通常，EPA会在采取措施前先与生产企业联系，而生产企业通常也会发布自愿召回。有时候，EPA也会实施监督检查或核实检测，收集在用车不达标证据，或者生产企业自己进行检测和调查并实施自愿召回。大多数情况下，生产企业会主动召回，不需要EPA进行干预。

有些召回行为只涉及某一车型中一小部分存在缺陷的车辆，并且车辆存在的故障很明显车主能很容易发现并自主进行维修。这种情况通常称为“车主自主行为（self-campaigning）”。如果这种缺陷已经导致了排放问题，并且这个问题还可能在排放部件保修期以外发生，生产企业可以延长保修期，书面告知车主车辆可能存在的问题并告知他们延长保修的期限和里程数。EPA将这种召回视为厂商自愿服务行为，并鼓励生产企业通过这种方式维修部分存在问题的车辆。

保修和缺陷报告:

《清洁空气法》规定生产企业须提供特定排放控制部件的保修（包括轻型车、重型车和非道路机械）。这一保修要求是要保护车主，使其不必支付由于设计缺陷、材料质量和生产做工原因造成排放超标所需的相关维修。

保修有两种形式：性能保修和设计及缺陷保修。性能保修是指对车辆进行维修或调整，保证车辆在按照生产厂商的要求正常保养和正常使用的情况下，可以在2年/2.4万英里内通过经批准的各地方规定的排放测试（类似I/M）。主要排放控制部件，如催化转化器、电控单元和车载诊断装置，保修期为8年或8万英里。设计和缺陷保修是指对排放相关部件进行维修，该部件由于原材料缺陷或生产做工问题在保修期内发生故障。

53 小型生产企业无需执行IUVP。

In-use verification testing program (IUVP):

Performed by manufacturers, the IUVP[53] is designed to test emissions of low-mileage (10,000 miles or 16,000km) and high-mileage (50,000 miles or 80,000km) in-use vehicles. One to five vehicles per test group are tested, and about 2,000 tests industry-wide were performed in 2007. If 50% of tested vehicles of the test group sample at either the low or high mileage test point fail and the average emission levels are greater than 1.3 times the standard limits, manufacturer must automatically conduct an In-use confirmatory test program (IUCP). In the IUCP, test vehicles are selected and tested in a more rigorous manner (same as the confirmatory phases of in-use testing described above) and failure of the IUCP could lead to recall.

Manufacturers are required to report all IUVP data to EPA. The large sample of in-use data allow EPA to identify potential design issues for future mode years, particularly on deterioration of emissions control devices under real life driving conditions, and focus attention to potentially high emission vehicles. The IUVP data is also used to assess and update the manufacturers deterioration factors and procedures used to determine deterioration factors.

Recalls:

The CAA authorizes EPA to require a manufacturer to recall a group of vehicles or engine at its own cost if it has been determined that a substantial number of vehicles from that group do not meet the standards even if they have been properly maintained and used.

EPA could require a recall when a test group fails the confirmatory phase of the in-use surveillance test. EPA could also require a recall based on the IUCP data. Manufacturers typically prefer to launch voluntary recall when they are presented with the data. If a manufacturer refuses to recall, EPA can follow established regulatory procedures that could result in an ordered recall.

EPA also investigates emission-related defects to determine if manufactures should remedy them. EPA usually contacts manufacturers prior to initiating action, and manufacturers generally issue voluntary recalls as a result. Sometimes EPA will conduct surveillance and/or confirmatory testing to establish evidence of failure in use, or the manufacturer may conduct its own testing and investigations that may result in voluntary recalls. Most of the time, manufacturers issue voluntary recalls without direct EPA intervention.

Some recall campaigns involve defects that occur in a small number of vehicles within a class, and the malfunction is very evident to the vehicle owner such that they seek repair. These are usually termed "self-campaigning". If these defects result in emissions failures, and can occur outside of the warranty period for the emission-related component, manufacturers can conduct a warranty extension campaign where letters are sent to owners to notify them of the potential failure and tell them that the repair will be covered for a certain time and mileage. EPA deems these recalls to be voluntary service campaigns, and encourages manufacturers to conduct these when it is not appropriate to fix vehicles that do not have the problem.

Warranty and defect reporting:

The CAA requires manufacturers to warranty certain emission control components on vehicles (including LDVs, HDVs and non-road engines). The warranties protect vehicle owners from the cost of repairs for emission-related failures resulting from defects in design, materials, and workmanship that cause the vehicle or engine to exceed emission standards.

There are two types of warranties: Performance Warranty and Design and Defect Warranty. The Performance Warranty covers any repair or adjustment which is necessary to make your vehicle pass an approved, locally-required emissions test (like an I/M) during the first 2 years/24,000 miles of vehicle use as long as the vehicle has been properly maintained according to the manufacturer's specifications and has not been misused. Specified major emission control components, like catalytic converters, electronic control units, and onboard diagnostic devices, are covered for the first 8 years or 80,000 miles. The design and defect warranty covers repair of emission related parts that become defective because of a defect in materials or workmanship during the warranty period.

53 Small volume manufacturers are exempt from conducting IUVP.

所有排放控制系统的保修期和排放相关部件的保修期为2年或2.4万英里，特定主要排放控制部件为车辆使用的最初8年或8万英里[54]。

在正常保养和使用发动机的情况下，如果同一车型年的车辆中有25辆以上都存在特定的排放部件相关的缺陷，EPA则要求生产企业追踪调查这些缺陷问题并向EPA提交缺陷报告。缺陷报告中必须估测装有缺陷零件的车辆比例并进行缺陷排放影响评估。如果对排放有明显影响，哪怕系族中仅有1%的车有同样的缺陷，EPA也可以要求进行召回。

重型车和非道路机械达标管理和实施方案

重型车和非道路机械达标管理和实施方案的关键因素包括：1）生产前认证；2）核实测试；3）选择性达标审核（SEA）；4）生产企业执行的生产线检测； 5）由EPA和生产企业执行的在用车（机）检测；6）保修和缺陷报告。各部分在车辆使用周期内如何实施，详见图5.2。

生产前认证测试：

与轻型车方案类似，EPA要求所有重型车生产企业测试新重型发动机或经过修改的重型发动机，证明发动机能够达标并将测试结果纳入向EPA提交的认证申请当中。

重型发动机认证主要基于发动机测试，而并非在底盘测功机上进行整车试验。和轻型车的原理相仿，选择发动机系族（类似于测试组别）中排放水平最高的发动机进行测试。将测试结果结合劣化系数，然后判定是否达标。车辆特性也会在认证时作为参考。

核实测试：

核实测试是由EPA在安娜堡实验室或在承包商和生产企业的实验室进行的有针对性的或随机的测试。EPA选择针对性测试用的发动机会考虑多项因素，包括：1）制造商的以往的达标率；2）发动机达标水平；3）新技术应用；4）EPA掌握的其它关于某发动机系族的信息。

没有通过核实测试的重型或非道路发动机是不能获得EPA认证证书的。如果一台发动机的排放低于标准，但在一致性认证中，该发动机的测试结果超过了最初申报的系族的平均、预存和交易（Averaging, Banking, and Trading, ABT）排放限值，那么发动机生产企业则需要根据EPA的测试结果修改原来的系族排放限值（Family Emission Limit, FEL）。

EPA从2006年起开始对非道路发动机执行核实测试，并且已经将测试范围扩展到其它非道路设备，如近期纳入的园艺设备（如剪草机）。

在经过认证的676款2007车型年的重型和陆上非道路发动机（通常称为农用或建筑机械发动机）中，EPA检测了其中的11款。2007年，EPA的重心集中在非道路发动机的核实测试上，所以在那一年中没有核实检测任何一款道路用重型发动机。

生产企业执行的生产线检测：

要求小型点燃式、大型点燃式、船舶和火车发动机生产企业定期测试刚下线的发动机，证明销售的发动机和认证测试样机一样能有效控制排放。

目前, 对非道路发动机的检测主要是由企业执行生产线检测，因为一旦发动机被安装到相应设备上，再想取下来进行检测十分困难且成本较高。至于便携式排放测量系统（PEMS）进行非道路设备在用检测，目前尚没有如重型车那样具体的PEMS检测要求。

54 更多信息详见EPA简报《1995年之后轿车和卡车的排放保修》。(http://www.epa.gov/oms/consumer/warr95fs.txt, 2010年3月26日查阅)。

The warranty period for all emission control and emission related parts is the first 2 years or 24,000 miles of vehicle use, and for specified major emission control components is the first 8 years or 80,000 miles of vehicle use[54].

EPA requires manufacturers to monitor identified defects in emission control systems of properly maintained and used engines and submit defect reports to EPA whenever there are 25 or more vehicles within the same model year are found to have a particular emission-related defects. The defect reports must estimate the proportion of vehicles that contain a defective part and estimate the impact of the defect on emissions. A recall can be initiated if as little as 1% of an engine family has the same defective part and the defect has a significant impact on emissions.

Heavy-duty and non-road engine compliance program

The key elements of the heavy-duty (HD) and non-road engine enforcement and compliance program include: 1) Pre-production certification, 2) Confirmatory testing, 3) Selective enforcement audit, 4) Manufacturer production line testing, 5) In-use testing performed by EPA and manufacturers, 6) Warranties and defect reporting. Figure 5.2 illustrates how the various elements are implemented during the vehicle's useful life.

Pre-production certification testing:

Similar to the LDV program, all HD engine manufacturers are required to test new or modified HD engine to demonstrate compliance and submit testing results as part of the certification application to EPA prior to production.

HD engine certification is based primarily on engine testing as opposed to chassis dynamometer testing of the entire vehicle. Similar to the rationale applied to LDVs, certification tests are performed on an engine that represents the highest emission level of an engine family (similar to test group). Deterioration factors are applied to the testing results before comparing test data with applicable standards and determining compliance. The vehicle characteristics are included in the certification by reference.

Confirmatory testing:

Targeted and random confirmatory tests are performed by EPA at the Ann Arbor lab or at contractor's or manufacturer laboratories. Engines are selected for targeted confirmatory tests based on various criteria including: 1) compliance history with a manufacturer; 2) compliance margin of the engine; 3) use of new technologies; 4) other information the agency might have regarding an engine family.

EPA will not issue a certificate of confirmation to any heavy-duty or non-road engine that fails the confirmatory tests. An engine with emission levels below the standard but with a confirmatory test result that is higher than the Averaging, Banking, and Trading (ABT) Family Emission Limit (FEL) originally submitted in the certification application would need to replace the original FEL with the EPA test results.

EPA started performing conformity testing for non-road engines in 2006, and has expanded the test to other non-road engine categories, like lawn and garden equipment recently.

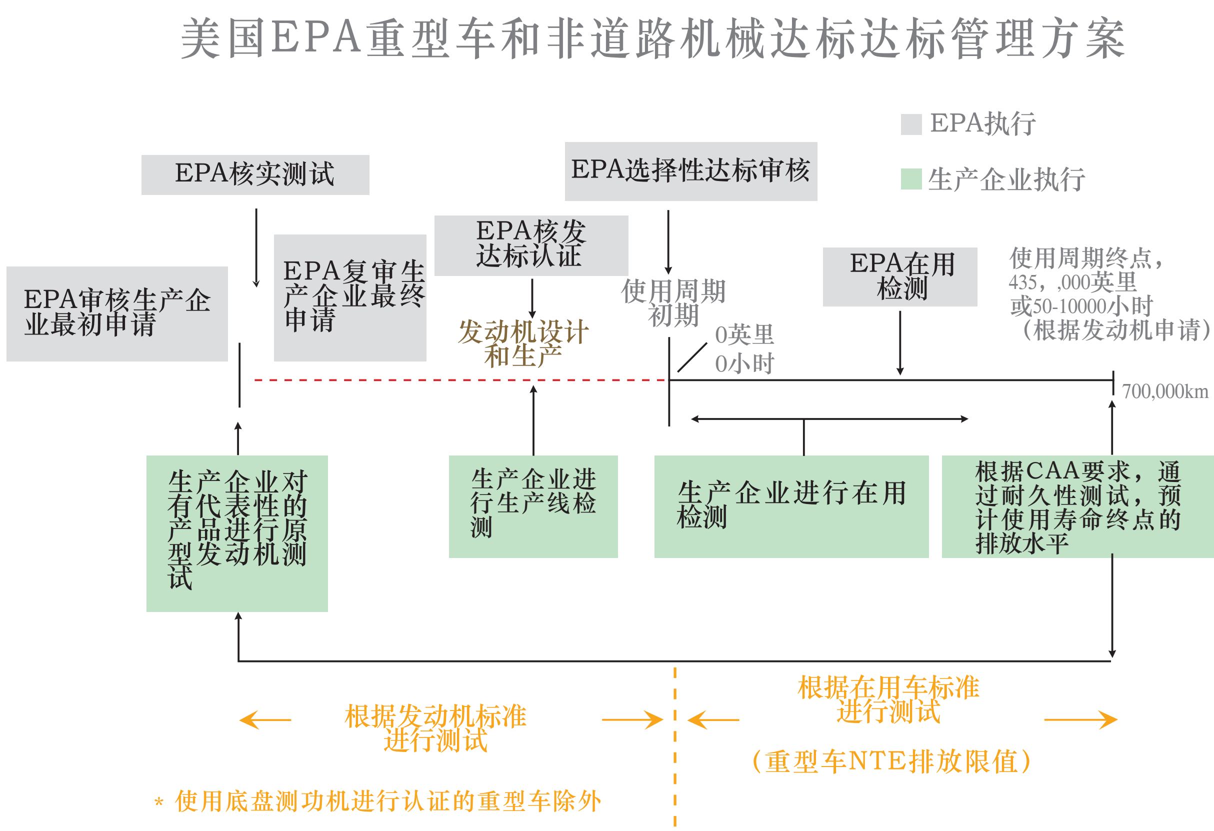
Among the 676 heavy-duty land-based non-road engines (typically called agricultural and construction engine) certified in MY2007, EPA tested 11 of them. EPA's primary focus in 2007 was on non-road engines, and it did not test any onroad heavy-duty engines that year.

Manufacturer production line testing:

Manufacturers of small spark-ignited, large spark -ignited, marine and locomotive engines are required to routinely test engines as they leave the assembly line to demonstrate that emissions from engines sold are controlled as effectively as the prototype engines tested for certification.

Manufacturer production line testing is now used primarily for non-road engines because once an engine is installed into equipment it is difficult and costly to take it out for testing. Also in-use testing requirements for non-road equipment using portable emission measurement system (PEMS) has not been as well developed as for HDVs.

54 For more information, see EPA Environmental Fact Sheet – Emissions Warranties for 1995 and newer cars and trucks. (http://www.epa.gov/oms/consumer/warr95fs.txt, accessed March 26, 2010).



来源：EPA2007年车辆和发动机达标情况报告，2008年10月

图5.2: EPA重型高速和非道路发动机达标管理和实施方案

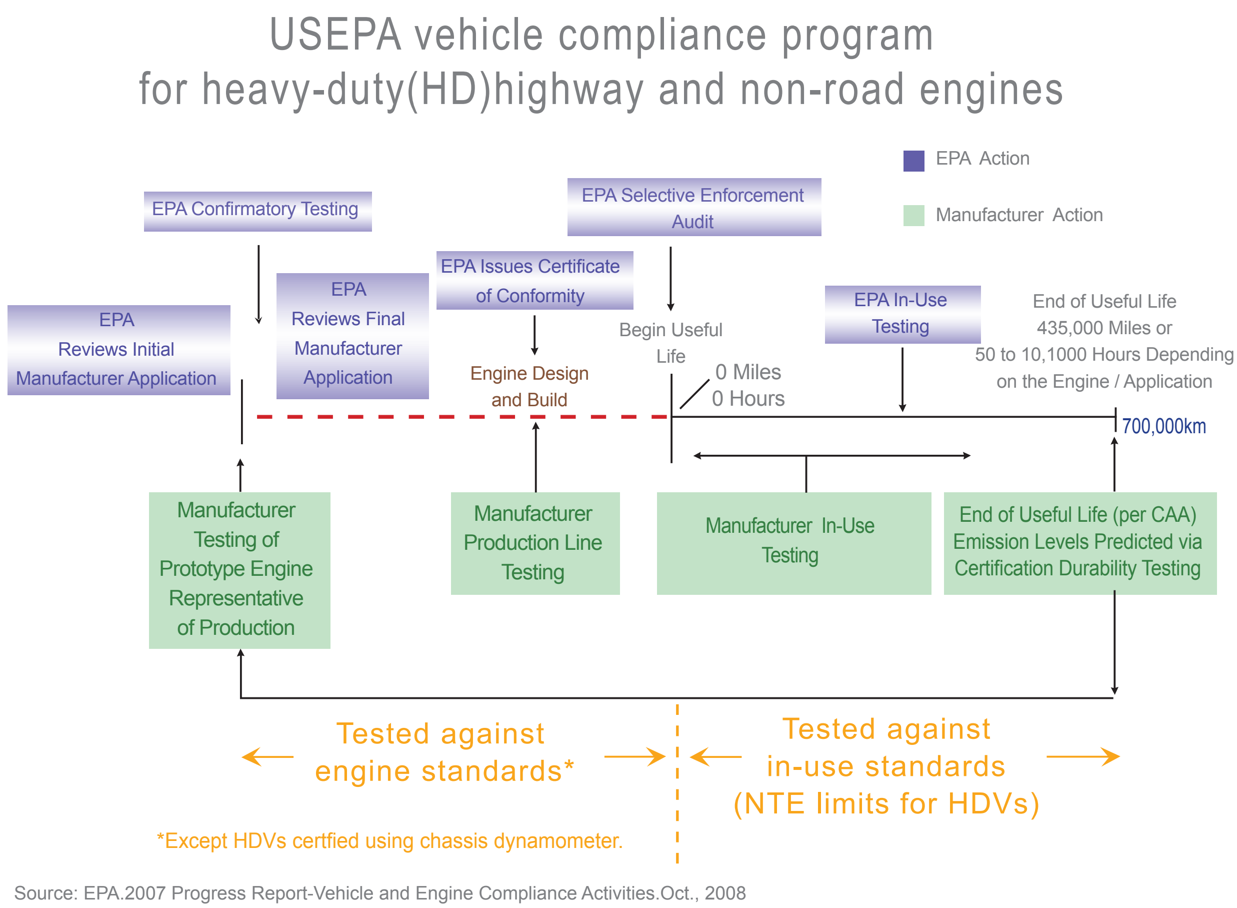


Figure 5.2: US EPA compliance program for HD highway and non-road engines

选择性达标审核 (Selective Enforcement Audit, SEA):

EPA计划对非道路机械实施SEA审核。SEA对非道路机械起到的作用比对轻型车起到的作用更大，因为非道路机械是通过发动机测试来验证是否达标的，在发动机安装到设备上之前判定其是否达标更为方便。

如果某一测试组别中有非道路发动机不能通过SEA审核，则生产企业需要找出并解决问题，直至发动机通过测试。如果整个发动机系族都不能通过，EPA有权采取进一步行动，如勒令生产企业停止生产。

由EPA和生产企业执行的在用车（发动机）检测:

传统实验室进行重型发动机和非道路发动机检测时采用的是特定的测试工况，要求将发动机从车辆或设备上拆下。因此，实施重型车和非道路在用测试既昂贵又复杂。此外，重型车和非道路机械的运行环境既多样也复杂（负载、速度），不能在有限的测试工况中充分表现出来。实验室在特定测试工况下执行的检测无法确保车辆和机械设备在实际使用中能够达到相应排放标准规定的范围。长期以来，一直需要更加有效的方法来测定重型车和非道路机械的日常使用排放（在用车/机排放）。由于便携式排放测量系统（PEMS）的开发和要求使用PEMS系统的检测规定的不可超过排放上限的出台（Not-To-Exceed (NTE) emission limit），EPA现在能够监督和验证重型车和非道路机械在日常运行中的达标情况了。

EPA与加州空气资源局（CARB）和柴油发动机生产企业共同合作，在2005年出台了重型卡车及巴士在用车检测方案。在本方案中，EPA、CARB和生产企业使用PEMS系统测量重型发动机使用过程中的排放并以是否能满足NTE标准要求来判定达标与否[55]。

EPA的在用检测都是在安娜堡（Ann Arbor）实验室和位于马里兰州阿伯丁(Aberdeen)的国防部检测实验室进行的。2007年，EPA使用PEMS系统总共测试了54辆卡车和72台非道路设备。对重型车而言，绝大部分在用测试主要由生产企业进行，这是重型车在用测试规定[56]中的一部分。 根据规定，生产企业要对其生产的发动机进行在用测试，证明其能够满足NTE限值要求，即FTP标准的1.25或1.5倍。EPA指定厂商每年测试不超过其生产发动机系族（engine family）总数的25%，但只有年产量超过1500台的发动机系族才需要测试。由于在用测试方法差异较大，EPA发起了一项综合性研发示范项目，来认定更准确的PEMS测试差额。

EPA从2005年和2006年开始推行气态污染物在用测试强制试点方案，在2007和2008年又对颗粒物推行了相同方案。从2007年开始，全面实施气态污染物在用车测试方案。

即使在在用车（机）测试中超过了NTE排放上限，也不一定就表明生产企业违反或达不到相关标准，因为EPA容许企业在达标要求上有一定的弹性。EPA会根据具体情况决定是否采取进步一措施，不过到目前为止还没有采取过有关行动。

摩托车

摩托车的达标管理和实施方案与轻型车方案非常接近。包括认证、核实测试、选择性达标审核、生产线检测、保修及缺陷报告。

检验与维修保养（I/M）管理方案

I/M方案的主要目的是找出高排放车辆并对这些车辆进行维修。在美国，《清洁空气法》要求空气质量不达标（不能满足国家环境空气质量 (NAAQS) 标准的区域）的州或地区实施I/M管理方案。臭氧问题严重的特定地区，必须实施更加严格的强化I/M方案。

各州I/M方案的执行力度各不相同。因此本文总结了优秀I/M方案的必要构成因素，而不是对美国所有的I/M制度详加介绍，具体内容详见表5.1。

55 NTE要求在发动机扭矩曲线下设置一个区域，发动机在此区域内运作时相关污染物排放量不得超过规定值。

56 详见40 CFR 第9部分及第86部分，EPA，2008年，新车的空气污染物排放控制：重型柴油发动机及车辆的在用测试。最终条款及修订内容。EPA420-F-08-011 (http://www.epa.gov/otaq/regs/hd-hwy/inuse/420f08011.htm, 2010年3月26日查阅)。

Selective Enforcement Audit (SEA):

EPA is planning to expand the use of SEA for testing non-road engines. SEA is a more useful tool for non-road engines than for LDVs because compliance with non-road new engine standards is verified by engine testing, and it's much easier to assess compliance of an engine before it is installed into equipment.

If a non-road engine of a test group failed an SEA, the manufacturer needs to identify and correct the problems until the engine can pass. If the entire engine family fails, EPA can pursue follow-up actions, such as forcing the manufacturer to stop production.

In-use testing by EPA and manufacturers:

Traditional laboratory testing for HD and non-road engines over a specific test cycle requires the engine be removed from the vehicle or equipment. This makes it prohibitively expensive and cumbersome to conduct in-use testing for HD and non-road engines. In addition, HD and non-road engines operate in a wide range of conditions (load, speed) that cannot be fully represented in limited test cycles. Laboratory testing following a specific test cycle cannot ensure that emissions from these vehicles and pieces of equipment are within the range of the applicable standards during normal operation. There has been a long-standing need for more accurate measurement of HD and non-road engine emissions under real life operation (in-use emissions). The development of the portable emissions measurement systems (PEMS) and the incorporation of testing requirement of using these systems (the Not-to-Exceed limits, NTE) make it possible for EPA to monitor and verify compliance of the HD and non-road engines during normal operation.

Collaborating with the California Air Resources Board (CARB) and diesel engine manufacturers, EPA launched the in-use testing program for HD trucks and buses in 2005. In this program, EPA, CARB and manufacturers measure in-use emissions of HD engines using PEMS, and compliance is determined against the NTE standards[55].

EPA in-use testing is conducted at the Ann Arbor lab and at the Department of Defense testing lab at Aberdeen in Maryland. In 2007, EPA tested 54 truck models and 72 non-road equipment using PEMS. For HDVs, the majority of in-use tests are conducted by manufacturers as part of the requirements of the HD in-use testing rule [56]. Manufacturers are required under the rule to conduct in-use testing to demonstrate compliance with the NTE limits, which is generally 1.25 or 1.5 times the applicable FTP standards. EPA will designate no more than 25% of a manufacturer's engine families with production volume greater than 1,500 engines for in-use testing by any given manufacturer every year. Because of the wider variations of the in-use testing measurements, EPA initiated a comprehensive research, development and demonstration program designed to identify new accuracy measurement margins for PEMS.

EPA established a mandatory pilot in-use testing program for gaseous pollutants in 2005 and 2006, and for PM pollutants on 2007 and 2008. The program became fully enforceable for gaseous pollutants starting in 2007.

Exceedences of the NTE limit during in-use testing do not necessarily represent a violation or noncompliance because of the flexibility given to manufacturers to comply with the standards. EPA will make the decision on follow-up action on a case-by-case basis, and no action has been taken to date.

Motorcycles

The compliance and enforcement program for motorcycles is very similar to the light-duty vehicle program. It includes certification, confirmatory testing, selective enforcement audits, production line testing, and warranties and defect reporting.

Inspection and Maintenance (I/M) programs

The main goal of an I/M program is to identify gross polluters—vehicles that produce excess emissions—and get those vehicles repaired. In the US, the CAA demands a state that has areas not meeting the national ambient air quality standards (NAAQS nonattainment areas) must implement a mandatory I/M program. For areas designated as serious or worse for ozone pollution have to implement a more stringent inspection program called enhanced I/M.

The stringency of the I/M programs implemented in different states varies widely. For the purpose of this study, a summary of the essential elements of a good I/M program is presented in Table 5.1, as opposed to reviewing the status of I/M programs in the US.

55 The NTE requirements establish an area or zone under the torque curve of an engine where emissions must not exceed a specified value for any of the regulated pollutants.

56 See 40 CFR Parts 9 and 86. EPA. 2008. Control of Emissions of Air Pollution from New Motor Vehicles: In-use Testing for Heavy-duty Diesel Engines and Vehicles. Final Rule, and the amendment of this rule EPA420-F-08-011 (http://www.epa.gov/otaq/regs/hd-hwy/inuse/420f08011.htm, accessed March 26, 2010).

表5.1: 优秀I/M方案的特征[57]

基本要素	最佳实践方案	优势
I/M 设计	统一实施的I/M体系，检验与维修保养分离的运行机制	-方便政府监管检测场 -大量车辆到每个检测场进行检测有可能降低测试成本
	由政府进行监管，但具体实施可以由私人企业承包	私人企业技术水平可能比政府机构更高
制度/ 行政管理设置	力争获得高级政策制订者的支持和建立足够的机构能力以便管理	获得充足的财政和资源支持，确保方案的实施不会由于贪污腐化现象和质量控制力度不足等问题而受到影响。
	建立合理的收费制度，由受影响车主支付I/M方案所需的费用（包括审核和监管费用，道边检测等）	确保有充足的资金
	在方案设计初期，要与有关部委或部门（国家级和地方级的）充分沟通	确保有关机构认可各自的职责并对方案认同及负责
	将I/M制度与登记注册数据挂钩，如无法提供检测证明，将不予登记注册	大力鼓励车主将车辆送检
	建立详细数据管理系统用于传输所有检测数据	使得监管机构可以收集数据来完善实施方案，如果检测设备能够自动将测试数据上传至数据库，能够有效防止数据篡改现象。
技术问题	实施更加严格的新车标准的同时，加严在用排放标准	不断提高I/M方案的实施效果

57 迈克尔•沃尔什(Michael Walsh)，2005年，《机动车检查与维修保养:国际经验》。

Table 5.1: Features of a good I/M program[57]

ELEMENTS	BEST PRACTICE	ADVANTAGES
I/M design	Centralized I/M system where inspection are separated from maintenance function	- Easier facility oversight by the government - Potentially lower cost per test if large number of vehicles are tested in each facility
	Government should regulate but actual enforcement could be contracted out to private companies	Private companies might have better expertise than the government
Institutional/ administrative set up	Solicit support by senior decision makers and the institutional capacity to manage and regulate the system	Adequate funding and resources would be allocated to ensure the program is not plagued by corruption and poor quality control
	Develop an adequate fee structure in which affected vehicle owners pay the full costs of the I/M programs (including costs for auditing and overseeing the program, road-side testing, etc.)	Ensure sufficient funding
	Initiate full dialogue with all appropriate ministries or departments (national and local) at the early stage of design	Assure all key stakeholders agree with their respective role and have ownership of the program
	Link I/M with registration data so that failure to present proof of inspection leads to denial of registration	Strong inducement to encourage vehicle owners sending vehicles for inspection
	Include a detailed data management system to enable transmittal of all test data	Allows oversight agencies to collect data for enhancing the enforcement program, and minimize chances of falsifying data if testing device automatically input testing data into the database
Technical issues	Tighten in-use emission standards for new vehicles in tandem with adoption of more stringent new vehicle standards	Continuous improvement of I/M program effectiveness

57 Walsh, Michael. 2005. "Motor Vehicle Inspection and Maintenance: The World Experience".

	确保根据不同车类不同的里程累积或排放控制系统耐久性，订立不同的检测周期	确保里程累积高/使用周期长的运营车，如出租车，能适时进行检测并合理维修保养
I/M的公众参与水平	使公众了解成功的I/M方案所能带来的健康收益	确保公众接受并鼓励公众参与I/M检测
	制订I/M执行标准，对执行情况不佳的站点予以处罚	保证I/M的执行质量是获得公众支持的关键
质量保障–审核	确保审核贯穿整个方案设计并纳入收费机制	树立I/M机制的威信度和实施效力
	设定合理的检测费，为私人检测机构提供足够的利润，进行必要设备的维护、置换和升级	保证测试过程的执行质量
道边检测方案	采用道边检测或遥感补充I/M方案的实施	查出利用临时检修通过I/M要求的高排放车辆
重视维修保养	保证修理行业有充足设备且知道如何正确维修车辆	实现I/M方案承诺的减排效果
	在加严I/M要求时，要给修理行业充裕的时间来作足准备，维修不达标车辆	确保车辆得到适当维修并减少排放
	建立维修行业与I/M管理方之间的沟通	解决因相关维修需求而产生的争端

在美国，I/M方案中会利用车载诊断系统（OBD）技术的州会向EPA提供OBD数据。EPA每两个月会与各州的相关人员联系，定期交换问题车辆信息。EPA会调查问题，与生产企业一起研究解决方案并告知各州如何处理实施I/M方案时查出的问题车型。

	Assure frequency of inspections varies for vehicles with differing mileage accumulation rates and with more or less durable emission control systems	Ensure that high mileage/usage commercial vehicles, like taxi cabs, are adequately inspected and properly maintained
Public participation in I/M	Raise public awareness on health benefits that can be resulted from a successful I/M program	Ensure public acceptance and encourage participation in I/M inspection
	Develop performance standards for I/M and penalize poorly performing stations	Guarantee quality of the I/M program is key to assure public support
Quality assurance – Audit	Ensure audits are fully built into the overall program design and accounted for in the fee structure	Establish credibility and effectiveness of the I/M systems
	Set test fees at a reasonable level that will allow private operators to make a sufficient profit to maintain, replace and upgrade equipment as required	Assure good quality testing is performed
Roadside Testing program	Complement I/M with roadside testing or remote sensing	Catch gross emitters that use temporary fixes to pass I/M requirements
Pay attention to maintenance	Ensure service industry have sufficient equipment and knowhow to properly repair vehicles	Realize the emission reductions promise of the I/M program
	Give sufficient lead-time to allow the service industry equip itself to repair failing vehicle when tightening I/M requirements	Ensures that failed vehicles are properly repaired and emissions are reduced
	Establish communications between the repair industry and the I/M managers	Resolve disputes over the appropriate repairs needed.

In the US, states with I/M programs that incorporate OBD technology provide OBD data to EPA. EPA holds bi-monthly stakeholder calls with the states to give both EPA and the states a regular opportunity to share information on problematic vehicles. EPA will research issues, work with manufacturers on resolution and use the calls to report back and give guidance on how states should deal with problem vehicle models identified in conducting their I/M programs.

EPA鼓励各州在I/M测试中使用OBD。OBD数据能够帮助查找出问题车型。事实证明，较新的车（1996年或之后的）上所装的OBD系统的错误代码在检测高排放车辆方面至少和I/M检测一样可靠或更好。 另外，OBD数据还能协助加快I/M检测流程，并协助找出故障从而进行维修，降低维修成本。

美国管理实施方案的效果和成本

在EPA实施其管理方案初期，核实测试和SEA成功的起到了很好的保障实施作用。不能通过实施测试和SEA的严重后果有效遏制了认证结果造假并迫使生产企业自己出钱进行大量测试来保证生产一致性。随着新车不达标现象越来越少，新车不再是EPA关心的重点，EPA就可以将更多的精力和资源转移到在用车测试方案上，从而保障车辆（及排放控制装置）在使用周期足够耐用并保持良好运行状态。

尽管车辆管理方案已经十分成熟完善，生产前认证依然会出现问题——2007年，18%的测试车辆未能通过FTP工况的核实测试。这突出了核实测试作为保证样车原型的设计可以满足标准的重要性。

实施召回的高昂成本起到了明显的威慑作用，鼓励生产企业提高车辆和排放控制装置的耐久性，确保在实际使用过程中达标。

在上世纪70年代末80年代初，刚刚开始实施召回方案时，EPA一年要召回30-40%的轿车和轻型卡车，现在EPA每年会召回5-10%的车辆[58]。

2008年，有超过100万辆新车和在用车被召回进行直接维修（约占当年1320万新车销售量的7.5%），另有210万辆车在自愿维修行动中被召回（出现问题后车主可以去维修）[59]。

从2007年起对重型车实施气态排放物在用车测试要求，颗粒物在用测试目前还处于试点阶段。EPA对要求实施后第一年内的气态排放物测试数据进行了分析，尚没有发现不达标情况[60]。

实施车辆管理方案的资源配置：

轻型车达标管理工作组有7名全职员工（FTE）和4名合约制员工。这4名合约制员工是高级环境雇员方案下的部分成员，均为退休工程师。每年，轻型车达标管理项目还要花费约100万美元，用于签订承包商，承担在用车监管、缺陷报告、自愿召回跟踪和收取认证费的工作。

58 查克•弗雷德(Chuck Freed)，2006年，《在用车排放耐久性测试--召回》，SAE-中国的口头报告。

59 2008年，导致召回的问题包括：发动机控制模块、OBD、PCV集油器和通风管道、燃料管路、车底隔热板、催化转化器、传动控制模块等。更多信息，详见EPA，2009年，《轻型车和轻型卡车2008年排放相关召回及自愿检修情况汇总》EPA420-B-09-016。

60 与EPA的谈话内容(2010年4月8日)。

EPA encourages states to adopt the use of OBD in I/M testing. The OBD data are useful for identifying problematic models. In fact, trouble codes set by the OBD system in newer (1996 or newer) vehicles have been shown to be as reliable, if not more so, than the I/M test in detecting gross emitters. Also, OBD data can help speed up I/M testing process, and can help mechanics identify problems and fix them, reducing repair costs.

Results and costs of US's enforcement program

In early years of EPA's compliance program, the conformity tests and SEA were successful in establishing strong enforcement presence. The adverse consequences of failing confirmatory tests and SEA effectively deterred fraudulent reporting of certification results and forced manufacturers to conduct large number of tests at their own costs to ensure production conformity. As new vehicle non-compliance became less of a concern, EPA was able to shift resources to in-use testing programs that ensure vehicles (and emission control devices) are designed to be durable enough to function well throughout the useful life of the vehicles.

While the vehicle compliance program is a well-developed and mature program, pre-production mistakes can still happen—18% of confirmatory tests failed over the FTP cycle in 2007. This highlights the importance of confirmatory tests to make sure prototypes are designed to meet the standards.

The high cost for initiating a recall has a significant deterrent effect, encouraging manufacturers to improve durability of vehicles and emission control devices to ensure compliance in actual use.

In the late 1970s and early 1980s, when the recall program began, EPA recalled 30-40% of cars and light trucks produced in any given year; today, EPA recalls 5% to 10% of vehicles produced in any given year[58].

In 2008, over 1 million new and in-use vehicles were recalled for immediate correction (about 7.5% of the 13.2 million new vehicles sold that year) and 2.1 million were recalled for voluntary service campaigns (owners bring in vehicles when the problem is evident) [59].

In-use testing requirements for HDVs started in 2007 for gaseous pollutants, while PM testing is still in the pilot stage. Analysis of gaseous data from the first enforceable year of manufacturer testing has not revealed any noncompliance issues[60].

Resources for running the vehicle enforcement program:

There are seven full-time-equivalent (FTE) staff and an additional four grantees on the light-duty vehicle compliance team. The four grantees are part of the senior environmental employment program and are typically retired engineers. The light-duty vehicle compliance program also spends about $1 million per year on contractor support for the in-use surveillance program, defect report and voluntary recall tracking, and certification fees.

58 Freed, C. 2006. In-use emission durability testing—recall. Presentation at SAE-China.

59 Problems leading to the recalls in 2008 included: engine control module, OBD, PCV oil trap and ventilation hose, fuel line tubes, underbody heat shield, catalytic converter, powertrain control module, etc. For more details, see EPA. 2009. 2008 Annual Summary of Emission-related Recall and Voluntary Service Campaigns Performed on Light-duty Vehicles and Light-duty Trucks. EPA420-B-09-016.

60 Communications with EPA (April 8, 2010).

5.2 中国车辆达标管理和实施方案概况

《大气污染防治法》中要求“机动车船向大气排放污染物不得超过规定的排放标准”，规定“任何单位和个人不得制造、销售或者进口污染物排放超过规定排放标准的机动车船”，而且“在用机动车不符合制造当时的在用机动车污染物排放标准的，不得上路行驶”。《大气污染防治法》还声明，“制造、销售或者进口超过污染物排放标准的机动车船的，由依法行使监督管理权的部门责令停止违法行为，没收违法所得，可以并处违法所得一倍以下的罚款；对无法达到规定的污染物排放标准的机动车船，没收销毁”。但是在本法规中却没有明确指出由哪个部门负责实施上述管理。

根据轻型车、重型车、摩托车和非道路及农用车排放标准，车辆或发动机生产企业必须将样车送至委托检测实验室进行型式核准测试（相当于美国的认证测试）。

《大气污染防治法》规定，省、自治区和直辖市级环保局有权委托经公安部门认可的车辆检测中心执行I/M检测。如果发现在未授权检测场进行检测，或发现I/M检测场有作弊行为，管理部门应制止这种违法行为，要求其立即改正并处以不超过5万元人民币的罚款。对于严重违规行为，可以取消检测机构的I/M检测资格。

《大气污染防治法》目前正处于修订阶段。环保部建议在法律中明确授权环保部负责实施新车排放标准，并有权召回不达标车辆。

中国的车辆管理方法

中国的车辆达标管理方案主要包括三部分：1）新车型式核准；2）生产一致性（conformity of production, COP）和在用性检查（in-use compliance）；3）I/M方案。环保部的管理重点主要放在新车型式核准和COP上，各省和自治区环保局负责管理各地的I/M方案。

新车型式核准

环保部在全国委托了23家实验室进行排放试验，其中18家从事轻型车、重型车及发动机、农用车和非道路机械试验，5家从事摩托车排放测试。这些实验室主要进行型式核准测试，也有一些同时进行生产一致性检测[61]。

这些实验室是经过环保部科技标准司核准的，该司每年会对实验室进行一次检查，进行实验室能力评估并决定是否延长认证有效期。在前去检查前，会提前1-2天通知实验室，由环保部官员、VECC的工作人员和其它委托实验室的专家共同实施检查。

型式核准报告要提交至VECC进行审核，不过到目前为止，提交的所有报告都是通过的，也就是说，环保部/VECC不要求实验室提供未通过认证要求的车辆或发动机的相关报告/数据。因此，环保部/VECC并没有接收认证测试失败的信息和数据。目前，型式核准报告被驳回的都是由于一些很小很表面的问题，比如生产企业提供的申请材料不正确。

61 参见VECC网站委托实验室名单 (http://www.vecc-mep.org.cn/news/newslist.jsp)。

5.2 Overview of China's vehicle compliance and enforcement programs

The "Air Pollution Prevention and Control Law" requires that emissions from all motor vehicles and vessels must not exceed the regulated limits, prohibits any entity from producing, selling and importing vehicles that do not comply with emissions standards, and it prohibits in-use vehicles that fail to meet in-use emission standards from operating on the road. The law also states that for entities producing, selling or importing nonconforming vehicles, the regulatory agency shall stop noncompliant activities, confiscate all nonconforming vehicles, and could levy a fine equivalent to the economic benefits from confiscated products; all non-conforming vehicles and vessels can be confiscated and destroyed[61]. The law, however, does not clearly specify which government agencies are responsible for enforcing these provisions.

According to the emissions standards for light- and heavy-duty vehicles, motorcycles, non-road and agricultural vehicles, engine and/ or vehicle manufacturers must submit vehicle prototypes to accredited testing laboratories for type approval testing (comparable to the certification testing in the US).

Under the "Air Pollution Prevention and Control Law", provincial- and municipality-level environmental protection authorities have the responsibility to entrust vehicle test centers that have been accredited by the Public Security Bureau to conduct inspection and maintenance (I/M) testing. If I/M tests are found to be conducted at unauthorized facilities, or if I/M facilities are found conducting fraudulent testing, the regulatory agency shall stop those illegal activities, demand remediation and levy a fine no more than 50,000 RMB. In the case of serious violation, the certificate for conducting I/M tests could be revoked.

The "Air Pollution Prevention and Control Law" is currently being revised, MEP recommends the law provide the ministry broad authority to enforce new vehicle emission standards, including the authority to recall nonconforming vehicles.

China vehicle enforcement approach

China's vehicle enforcement and compliance program consists of three main elements: 1) new vehicle type approval, 2) conformity of production (COP), and 3) I/M programs. MEP's compliance effort mainly focuses on new vehicle type approval and COP, and provincial and municipal environmental protection bureaus (EPBs) are charged with managing local I/M programs.

New vehicle type approval

MEP has entrusted 23 laboratories nationwide to conduct emissions testing of which 18 labs conduct testing for LDVs, HD vehicles and engines, agricultural vehicles and non-road engines and five labs conduct motorcycle emissions testing. These labs are mainly used for type approval testing, but some also conduct testing for conformity of production.

The labs are certified by MEP's Department of Science, Technology and Standards, which inspects the labs once a year to assess the labs' testing capabilities and decides if certification should be renewed. The labs are given one to two days of advance notice before each inspection, and the inspections are conducted by MEP staff, staff from the Vehicle Emission Control Center (VECC) and a team of experts recruited from other accredited labs.

Type approval reports are submitted to the VECC for review, but all reports submitted to date are passing reports, meaning that laboratories are not required to provide any report / data on vehicles or engines tested that do not pass the certification requirements. Therefore MEP/VECC do not receive information and data on the failed certification tests. The only rejection of type approval reports that has occurred to date are for very minor and obvious problems, such as a manufacturer not providing the correct application materials.

61 See website of VECC for list of accredited laboratories (http://www.vecc-mep.org.cn/news/newslist.jsp).

2008年，总计有10248种车型和发动机型被测试并通过型式核准检测。其中半数以上（8101种或57%）是重型发动机车型，约1/4（3474种或24%）是轻型车车型，2275种（16%）是摩托车和轻便摩托车，16种（1%）是重型发动机，另有348种（2.4%）是未指定用于轻型或重型车的发动机。每个月VECC会在自己的网站上发布通过环保部型式核准测试的车辆名单。

生产一致性

每年，环保部委托VECC组织一些随机COP检查。COP检查的结果会总结上报环保部。进行COP检测时，有时会从生产线终端选取测试车辆，有时会从市场上购买车辆进行测试。

环保部会评估VECC提交的COP报告，根据不达标车辆和企业的具体情况，设定一个期限，要求企业在规定时间内实现生产线达标并以暂停接受型式核准申请作为违规处罚。根据环保部关于加强生产一致性监督管理的公告（2005年1号函），如果某级别测试组别的发动机在整改后依然不能满足标准要求，环保部可以撤销其型式核准证书。由于《大气污染防治法》中没有明确由哪个部门征收罚款，故通常不进行罚款。

2008年，VECC对11家车辆生产企业的13个车型（包括轻型车和重型车）进行了随机COP检测。在这13款车型当中，有两款因其实际量产的部件配件与核准申请报告不符被直接判定为不达标。在接受检查的11家生产企业中，有3家的生产线检测设备质量没有达到要求。

环保部除了进行COP检查外，还要求车辆和发动机生产企业每季度向VECC提交COP保证报告。环保部要求轻型和重型车生产企业至少每发动机系族测试组别随机抽测3台样车（机），非道路和农用车企业至少随机抽测1台样车（机）。对于轻型或重型车，如果测试样车（机）的各项污染物排放全都低于标准限值，或三台样车（机）的统计量均能低于限值要求，则该发动机系族/测试组别的COP达标[62]。 对于非道路和农用车，如果第一台样车（机）合格就算通过COP检查；如第一台样车（机）不合格，企业可追加测试一定数量的样车（机），如所测样车的所有排放物的统计平均值都低于标准，则该发动机系族测试组别COP合格。

在用符合性检测和召回

目前环保局要求企业申报在用符合性计划和年报，但由于国内大部分地区还没有售卖与排放标准相配的燃料，环保局并未在全国进行在用符合性抽查，不过在北京已经有了针对乘用车的在用检测方案。2009年3月北京市环保局开始执行随机抽检，抽检累计行驶里程不超过10万公里的国III和国IV乘用车。目前已有60辆车接受了检测。另外，北京市环保局在2010年6月3日发布了要求生产企业进行在用车测试，主要针对在北京每年销售超过500辆的车型或发动机型。

北京市环保局进行的在用车检测方案暴露出了在用车存在的一些问题，例如，某些车辆只装有一个催化器来取代型式核准时指定的两个催化器。不过目前北京的在用车检测结果还在分析过程中，尚不清楚北京市环保局会采取怎样的措施来应对生产违规车型的生产企业。

62 COP测试具体要求详见车辆排放标准。 非道路和农用车是至少一台合格就算通过，轻型车和重型车都必须抽检3台，3台全部合格或统计量合格才算通过。

A total of 10,248 vehicle and engine models were tested and passed type approval testing in 2008. Over half of them (8,101 models, or 57%) are heavy-duty engines models, about one-fourth (3,474 models, or 24%) are light-duty vehicle models, 2,275 (16%) are motorcycle and moped models, 16 (1%) are heavy-duty engines, and 348 (2.4%) are engines not specified for light- or heavy-duty uses. Every month, VECC issues on its website a list of vehicles that have passed type approval testing.

Conformity of production

Every year MEP commissions VECC to conduct a number of random COP tests. Results of the COP tests are summarized in a report submitted to the MEP. Some of the COP tests are conducted by selecting and testing vehicles right off the end of the assembly line and some are performed on vehicles purchased on the market.

MEP reviews the annual COP report submitted by VECC and, based on the specific circumstances of the non-conforming vehicles and enterprises, issues a deadline for bringing the production line into compliance and temporarily suspends accepting type approval application as punishment for non-compliance. According to the MEP's notice on strengthening COP supervision (2005 Notice no.1), if an engine class/test group still cannot meet the standards after remedial actions are taken, MEP could revoke the type approval certificate. Fines are not usually issued because it is unclear from the "Air Pollution Prevention and Control Law" which ministry has the authority to impose fines.

In 2008, VECC conducted random COP testing at 11 auto manufacturers, and mass products of 13 vehicle models were inspected (including both LDV and HDV). Of the 13 models, two were directly judged as out of compliance because essential parts/accessories used in mass production were inconsistent with those reported in the certification application. Of the 11 manufacturing facilities inspected, the quality of inspection equipment of three production lines did not meet the requirements.

In addition to COP tests conducted by MEP, vehicle and engine manufacturers are required to submit COP assurance report to VECC on a quarterly basis. To demonstrate COP compliance, LDV and HDV manufacturers are required to randomly select and test at least three vehicles of each engine test family/test group, and manufacturers of non-road engines and agricultural vehicles have to randomly select and test at least one engine/vehicle. For LDVs and HDVs, an engine family/test group are COP compliant if emissions of every regulated pollutants from all samples tested are lower than the standards, or the average emission level of all pollutants of the samples tested are statistically lower than the limits. For non-road and rural vehicles, if emissions of the first sample tested are lower than the limits for all pollutants, the engine model/test group is COP compliant, otherwise, the manufacturer could chose to test more samples, and the engine model/test group passes the COP test if the average emission levels are statistically lower than the limits for all the pollutants[62].

In-use compliance testing and recall

Currently, MEP requires vehicle manufacturers to summit in-use compliance plan and annual report, but because of the lack of supply of compatible fuel, MEP has not selected and verified any of the in-use compliance plans and report. However, the city of Beijing has started an in-use testing program focused on passenger vehicles. In March 2009, the Beijing Environmental Protection Bureau (BEPB) launched a random in-use testing program for China III and IV passenger vehicles with cumulated mileage of no more than 100,000 km. So far 60 vehicles have been tested. In addition to the in-use testing conducted by BEPB, BEPB released a notice on in-use testing on June 3rd, 2010, requiring manufacturers to conduct in-use testing of any engine/vehicle model sold more than 500 units/year in Beijing.

The in-use testing program conducted by Beijing EPB has identified some problems with in-use vehicles, for example, some vehicles have only one catalyst instead of the two catalysts specified in the type approval. But the Beijing in-use testing results are still being analyzed. It is unclear what follow-up actions BEPB will undertake against manufacturers producing non-conforming models.

62 Details of the requirements for conducting COP tests are laid out in vehicle emission standards.

清华大学和其它一些科研院所也都进行了遥感和PEMS在用车排放测量研究。通过PEMS测试，显示出北京出租车在达到耐久性要求的里程之前氮氧化物排放超标，另外清华大学用PEMS在北京、深圳和西安进行了轻型和重型卡车排放测试，结果显示国III重型卡车的氮氧化物排放量明显高于国II重型卡车。PEMS研究结果总结如下。

表 5.2: 中国在用车测试结果汇总

研究机构	测试车辆	结论
中国环境科学研究院[1]	22辆国I、国II或国III北京出租车	▪ 在累计行驶里程达到6.5万公里以上时，部分车辆氮氧化物排放高 (>0.3克/公里) ▪ 在累计行驶里程28万公里上时，部分车辆碳氢化合物排放高 (>0.4克/公里) ▪ 三元催化器失效是导致排放升高的潜在原因
清华大学[2]	在北京、深圳和西安选取70辆重型卡车(国 I, II, III)和29辆轻型卡车 (国 0, 1, 2, 3)	▪ 国III重型卡车的氮氧化物排放明显高于国II重型卡车，大约处于欧I排放水平

来源：1.与中国环境科学研究院胡京南博士联系(2009)；2.与清华大学姚志良博士联系(2009).

I/M 方案

依照《大气污染防治法》，I/M方案由省级（含自治区和直辖市）环保局实施，维修保养机构则由各省的交管部门负责授权。

环保部制定了有负载和无负载I/M测试程序并规定了无负载测试的排放限值。环保部要求采用无负载测试的地方政府采用环保部定的I/M测试程序和限值；环保部推荐空气污染严重的地区采用有负载I/M测试，而地方环保部门需要根据各地的情况设定排放限值。环保部在2010年12月发布了《关于印发〈机动车环保检验机构管理规定〉的通知》，“通知”规定机动车环保检验机构每年须向市级环保局提交年度报告。然后由市级环保局向省级环保局提交环检机构日常监督管理年度报告，再由省环保局向环保部提交这些报告[63]。

《大气污染防治法》规定禁止排放不达标的车辆（新车或在用车）上路行驶。因此，许多地方政府将I/M方案与黄绿标方案相结合以便获得公众的配合——只有拥有黄绿标的车辆才能进行登记注册（标志方案将在第七章具体讨论）。环保部于2009年7月发布了《关于印发〈机动车环保检验机构管理规定〉的通知》，“通知”要求省、市环保局自2009年10月开始对所有车辆（包括农用车和摩托车）核发全国性的统一排放标志[64]。

63 参看环保部关于印发 《机动车环保检验机构管理规定》的通知，环发〔2009〕145号 (http://www.mep.gov.cn/gkml/hbb/bwj/201004/t20100407_187894.htm，2010年8月11日查看)。

64 参看环保部关于印发《机动车环保检验合格标志管理规定》的通知，环发〔2009〕87号。
（http://www.njhb.gov.cn/art/2010/1/4/art_465_16723.html，2010年8月11日查看）。

Tsinghua University and other academic institutions also have conducted remote sensing and PEMS research to measure emissions from existing vehicles. PEMS testing of Beijing taxis showed high NOx emissions before reaching durability mileage, and PEMS testing of light- and heavy-duty trucks in Beijing, Shenzhen and Xi'an showed that China III heavy-duty trucks emitting significantly more NOx than China II ones. Results of the PEMS studies are summarized below.

Table 5.2: Summary of in-use testing results in China

RESEARCH INSTITUTE	VEHICLE TESTED	FINDINGS
CRAES[1]	22 China I, II or III taxis in Beijing	Some vehicles showed high NOx emissions (>0.3g/km) with over 65,000 km mileage Some showed high HC emissions (>0.4g/km) with over 280,000km mileage Failure of three-way catalytic converters is a potential cause of high emissions
Tsinghua University[2]	70 HD trucks (China I, II, III) and 29 LD trucks (China 0, 1, 2, 3) in Beijing, Shenzhen and Xi'an	China III HD trucks emit significantly more NOx than China II HD trucks, about the same level as Euro I

Sources:

1.Communications with Hu, Jingnan at Chinese Research Academy of Environmental Science, 2009.

2.Communications with Yao Zhiliang at Tsinghua University. 2009.

I/M program

Under the "Air Pollution Prevention and Control Law", I/M programs are managed by provincial- and municipality-level environmental protection bureaus (EPBs), and maintenance and repair centers are managed by the provincial transportation management authorities.

MEP establishes test procedures for loaded and unloaded I/M tests, and specifies emission limits for unloaded tests. Local governments are required to adopt the MEP I/M test procedures and limits (if unloaded test is used); regions suffering from severe air pollution are recommended to use the loaded test for I/M testing, and the local EPBs need to set the emissions limits according to the local situation. A MEP notice released in December 2010 mandates each I/M testing facility to submit to city EPBs an annual work report with a description of the test facility and emission problems identified. City EPBs will then prepare and submit an I/M inspection and management report to provincial EPBs for transmission to MEP[63].

The "Air Pollution Prevention and Control Law" bans vehicles not meeting emission standards (new or in-use) from operating on the road. As a result, many local governments combine the I/M program with the yellow/green sticker program to get public's cooperation—vehicles can only register if there is a yellow/green emission stickers on the vehicle (more detailed discussion of the labeling program can be found in Chapter 7). MEP announced a nationwide label program in July 2009, requiring all provincial and municipal EPBs that have established emission sticker programs to verify and issue vehicle emissions stickers (including rural vehicles and motorcycles) according to a unified format and categorization specified by MEP starting from October 2009[64].

63 See MEP's notice on the regulation for managing I/M testing facilities. MEP notice [2009] No. 145. (http://www.mep.gov.cn/gkml/hbb/bwj/201004/t20100407_187894.htm, accessed Aug 10, 2010).

64 See MEP's notice on the regulation for managing vehicle environmental labels. MEP notice [2009] No. 87. (http://www.njhb.gov.cn/art/2010/1/4/art_465_16723.html, accessed Aug 10, 2010).

目前，已经有345个地方环保局推行了I/M管理方案，其中50个地区采用有负载测试（ASM或IM240）。VECC推测全国约有10-15%的车辆无法一次通过I/M检测，但目前没有具体每年有多少车参检的数据。

中国管理实施方案的效果和成本

从目前执行的小规模的在用车测试结果可以了解到有一些在路上行驶的车辆并不是按照认证规格来生产制造的（缺少催化器），这些车耐久性差（还未超出耐久性里程范围就发生排放超标现象），或污染物排放量超过预期排放量（国III卡车比国II的排放还高）。还有一些非官方的证据显示部分车辆在设计时有两个传感器，一个用于监测发动机排放，另一个用于监测后处理装置排放，而在实际生产中只装有一个传感器用于监测发动机排放。

导致上述问题的原因可能包括：低劣的车辆设计（没有在型式核准中明确指出）、企业未遵守生产一致性规定、现行达标管理方案中没有指出和修正非工况覆盖点的排放，或排放控制装置耐久性问题。要找出并控制住这些问题的源头需要进一步逐一调查，并且有些情况可能源自于多个复杂交错的原因，致无法查明问题的最终源头。无论怎样，这些结果清楚的指出环保部目前针对新车认证和COP所采取的行动还不够充分和有效，不足以保证所有生产的车辆如标准中规定的那样切实达到预期的排放要求。

实施车辆管理方案的资源配置

在环保部/VECC有15名工作人员全职或兼职负责认证（型式核准）和COP工作。

5.3　中国方案与国际最佳实践对比以及中国发展过程中的障碍

政治 / 政策问题

《清洁空气法》授权EPA管理所有向大气中排放污染物的发动机和车辆，并要求生产企业自费召回和维修即使在正常保养和使用条件下，在实际使用中不能达到标准要求的车辆和发动机。

《大气污染防治法》没有明确授予任何部委召回不达标车辆的权力。这限制了环保部实施新车认证和COP的力度（详见表5.2）。《大气法》也没有明确指出由哪个部门来对不达标车辆和行为进行罚款。另外，《大气污染防治法》允许省级和自治区环保局随机挑选车辆进行在用车测试（如进行道边测试），但却没有明确赋予环保部这项权力。由于在执行在用车测试，对生产不达标车辆的生产企业进行罚款或要求生产企业召回不达标车辆方面缺乏明确的法律授权，环保部对车辆达标管理的执法力度很弱，阻止不达标车辆生产的手段也很有限。环保部已经提出了《大气污染防治法》修订意见，要求《大气污染防治法》授于环保部实施车辆召回的权力。

技术能力和检测能力

EPA自身具有良好的技术人员和检测设备及能力来有效实施车辆排放标准：

位于安娜堡的国家车辆与燃料排放实验室成立于1971年，有约400名员工，负责执行车辆和发动机的核实检测和在用测试。环保局还利用位于马里兰州奥伯丁地区的国防部检测中心来进行重型车和非道路发动机的在用测试。

Currently 345 local EPBs have established I/M programs, 50 of them conduct loaded tests (ASM or IM240). VECC suspects that nationwide, about 10-15% of vehicles did not pass the first I/M inspection, but there is no data on how many vehicles are being tested every year.

Results and costs of China's enforcement program

Results from the small number of in-use testing conducted to date suggest that there are vehicles on the road that were not built as certified (missing catalysts), with poor durability (emissions exceeding standards before reaching durability mileage), or emit more pollutants than they are supposed to be (China III trucks emitting more than those meeting China II). There are also some anecdotal evidences suggesting that some vehicles designed to have two sensors, one for monitoring engine out emissions and another for monitoring post-treatment emissions, are produced with only one sensor installed to monitor engine out emissions.

These problems could be due to poor vehicle design (not identified during type approval), conformity of production non-compliance, off-cycle emissions that were not identified and corrected through the existing enforcement and compliance program, or durability of emissions control devices. Pinning down the source of the problem will require further case-by-case investigations, and in some cases that might not even be possible because of confounding factors. Nevertheless, these findings clearly indicates MEP's existing activities to enforce new vehicle certification and COP requirements are not sufficient nor effective in guaranteeing vehicles produced actually meet the emissions requirement they are supposed to meet.

Resources for running the vehicle enforcement program

There are 15 staff in MEP/VECC working full-time or part-time on certification (type approval) and COP.

5.3 Comparison of China's program and international best practices and barriers to progress in China

Political / policy issues

The CAA authorizes EPA to regulate all engines and vehicles that emit pollutants to the atmosphere and to require manufacturers to, at the manufacturers' cost, recall and fix any vehicle and engine not meeting the standards in actual use even though they are properly maintained and used.

The "Air Pollution Prevention and Control Law" does not explicitly confer the authority to recall vehicles that do not meet emission standards to any ministry. This limits MEP's enforcement efforts to focus on new vehicle certification and COP (see Table 5.2). The law also does not clearly specify which ministry has the authority to impose fines when noncompliant vehicles or processes are found. Further, the "Air Pollution Prevention and Control Law" allows provincial and municipal level EPBs to randomly select vehicles for in-use testing (like conducting road-side tests), but does not explicitly grant MEP such authority. Lacking clear authority to conduct in-use testing, to assess penalty on manufacturers producing non-conforming vehicles or to require manufacturers to recall non-compliant vehicles, MEP has weak enforcement power and limited means to deter production of sub-standard vehicles. MEP has recommended a revision of the "Air Pollution Prevention and Control Law" to provide MEP the authority to conduct vehicle recall.

Technical capacity and testing capability

EPA has established good in-house technical capacity and testing capability to effectively enforce vehicle emission standards:

With about 400 staff, the National Vehicle and Fuel Emission Laboratory in Ann Arbor was established in 1971 to perform conformity testing and in-use testing of vehicles and engines. The agency also uses the Department of Defense Aberdeen Test Center in Maryland to conduct in-use testing of HDVs and non-road engines.

EPA的达标与创新战略处共有7名全职员工，4名合约制员工以及一个外部委托团队来支持轻型车排放标准的实施。这还不包括负责重型车和非道路机械设备标准实施的工作人员。

环保部则恰恰相反，其自身的技术人员、检测设备和能力非常有限。目前在环保部和VECC共有15名工作人员全职和兼职负责型式核准和COP工作，负责审核车厂委托进行型式核准测试实验室所提交的检测报告和检查认证实验室，环保部/VECC缺乏有丰富检测经验的技术人员，且没有独立的检测机构（甚至没有在执行认证测试时要求使用的标准燃料）。型式核准试验缺乏有效的监管，但COP抽查时，对检测全过程采取严格的监督，数据可靠公正。技术人员和检测设备、能力的不足严重影响环保部查处认证或导致量产过程中的作弊现象。环保部 / VECC正在与厦门市政府合作建立一间独立的检测实验室，将于2010年冬季开始使用。环保部可以利用这样的独立实验室来执行核实测试或其它必要的排放测试。拥有新的检测实验室将是加强环保部检测能力的第一步。

表5.3.: 中美车辆检测和达标管理资源配置情况

国家和机构	中国环保部/VECC		美国EPA	
	员工	合约服务	员工	合约服务 (每年)
车辆检测和达标管理的资源配置情况	15名 (认证和COP)	——	7名全职员工 4名合约制员工	每年680万人民币以上

财政资源

相比以上列出的EPA的人员和实验室资源，环保部在车辆管理方面的财政资源投入也难以应对新车生产量。环保部在机动车管理方面的预算在未来几年内不会增加，这就意味着要集中力量开展回报最高的行动来加强车辆管理, 并从管理对象那里设法获得新的财政支持。

EPA's Compliance and Innovative Strategies Division has seven full-time-equivalent staff, four grantees and a team of outside contractor for the light vehicle division to enforce the vehicle emissions standards. This does not include staff responsible for heavy-duty and non-road engine and vehicle enforcement.

MEP, on the contrary, has very limited in-house technical capacity and testing capability. While there are 15 staff in MEP and VECC working part-time and full-time on type approval and COP, to verify and audit type approval testing reports supplied by laboratories contracted by the industry and inspect certified labs, MEP/VECC lacks staff with extensive expertise on testing and do not have access to independent testing facilities (not even the standard fuels needed to perform certification testing). Right now, there is not sufficient oversight on the type approval process, but when conducting random checks for COP compliance, MEP closely moinitors the entire process to ensure the data collected are fair and reliable. The limited technical capacity and testing capability severely impede MEP's efforts to identify cheating during certification or mass production. MEP/VECC is collaborating with the Xiamen city government to establish an independent testing laboratory that will open in the summer of 2010. MEP can use as an independent laboratory to conduct confirmatory tests or other tests as needed. Access to the new testing laboratory will be a first step of enhancing MEP's testing capability.

Table 5.3: Resources for conducting vehicle inspection and compliance in China and US

COUNTRY AND AGENCY	CHINA MEP/VECC		US EPA	
	STAFF	CONTRACTOR SERVICES	STAFF	CONTRACTOR SERVICES (PER YEAR)
Resources for conducting vehicle inspection and compliance	15 (certification and COP)	——	7 full-time-equivalent staff, 4 grantees	Over 6.8 million RMB per year

Financial resources

Compared to the size of enforcement staff and laboratory resources that EPA has at disposal, resources MEP spent on vehicle enforcement program are substantially smaller for an equivalent new vehicle production volume. MEP's budget for vehicle enforcement is not expected to increase in the near future, meaning that any enhancement of the program would have to focus on enforcement activities with the highest return and be associated with innovative fundraising from regulated parties.

表5.4: 中美车辆达标管理和实施方案对比

交通部门				生产前		生产中		生产后
				认证	核实测试	生产线测试	选择性达标审核/生产一致性	在用车召回
道路	轻型 (LD)	乘用车、皮卡、SUV	中国	✓			✓ 13款轻型和重型车进行测试	
			美国	✓	✓ 15%进行测试			−EPA测试150辆车，生产企业测试2000辆车
		摩托车	中国	✓			✓	
			美国	✓				
	重型 (HD)	卡车和巴士	中国	✓			✓13款轻型和重型车进行测试	
			美国	✓				− EPA测试54款车型，生产企业最多测试发动机系族的25%
非道路	花园、农用、建筑用设备、火车和船舶		中国	✓				
			美国	✓	✓ EPA 测试 15台发动机	✓ EPA测试 72 台发动机		✓

Table 5.4: Comparison of the vehicle compliance and enforcement program in China and the US

INDUSTRY SECTOR				PRE-PRODUCTION		PRODUCTION		POST-PRODUCTION
				CERTIFI-CATION	CONFIRMATORY TESTING	PRODUCTION LINE TESTING	SELECTIVE ENFORCEMENT AUDIT/CONFORMITY OF PRODUCTION	IN-USE/RECALL
On-road	Light-duty (LD)	Cars, pickup trucks & SUVs	China	✓			✓ 13 LD & HD models tested	
			US	✓	✓ 15% tested			✓EPA tested 150 vehicles; manufacturers tested 2000
		Motor-cycles	China	✓			✓	
			US	✓				
	Heavy-duty (HD)	Trucks & buses	China	✓			✓ 13 LD & HD models tested	
			US	✓				✓ EPA tested 54 models; mfrs tested up to 25% of engine families
Non-road	Garden, farm, construction equipment, locomotive and marine vessels		China	✓				
			US	✓	✓ EPA tested 15 engines	✓ EPA tested 72 engines		✓

5.4 建议

有限的在用车测试结果和一些非官方证据显示中国存在生产和使用不达标车辆的情况，并且现有的管理方案不能有效阻止不达标车辆的生产和销售。与美国的车辆达标管理方案相比，很明显中国方案在一些重点领域有待提高。扩大授权范围和额外的资金是实现这一目标的关键，应尽快予以落实。同时，环保部应评估现有方案，找出成本效益最佳的改善途径，提高自身技术能力和检测能力，配备充足的人员建立实施在用车检测方案。在用符合性和强制检测是成熟车辆管理实施方案的奠基石。实施有效的在用车检测方案（以生产企业自检为主，环保部给予支持）应当是环保部的长期目标。

环保部已经采取了一些措施来应对以上部分需求，包括与美国EPA合作开展在用车召回培训，与厦门市政府合作建立新的检测实验室。对环保部建立强效车辆管理方案的具体建议如下：

- *争取通过修订《大气污染防治法》给予环保部明确授权对生产企业进行在用车测试和对不达标行为予以处罚（包括车辆召回）：*有效的在用车管理实施方案能够从实质上确保车辆在使用寿命周期满足所有相关排放标准的要求。根据美国EPA的经验，不达标的高额处罚，无论是召回的成本或暂停未通过SEA的车型的生产和销售带来的经济损失，都是成功地实施方案的关键因素。高额的经济处罚还是推动生产企业提高产品质量、改善新车设计和不断提高车辆及排放控制装置耐久性的重要助推因素。因此，环保部应争取尽早获得授权，要求生产企业执行在用车测试并征收罚款。一旦环保部获得了车辆召回权，接下来应该重新审阅与召回有关的法律法规并作出必要修订，确保不会与环保部的新权力产生冲突。例如，环保部已经对2004年颁布的《汽车缺陷产品召回管理规定》进行修订并发表征求意见，现正在研究已收到的意见。

- *建立在用车测试和召回方案：*如果只有有限的启动资金，可以将方案的最初的重点放在分析从生产企业、研究机构和I/M实施中获得在用车数据上，通过分析这些数据来确认少数高排放车型，要求对这些车型进行在用符合性测试并要求生产企业在必要时实施召回。

- *从对车主征收的排放收费/车辆税或通过提高对车辆/发动机生产企业的认证申请收费来获得更多的资金：*如果没有额外的资金，要环保部持续改进车辆管理方案会很困难，因此增加资金储备是环保部近期的重要任务。目前，生产企业向检测实验室支付认证测试服务费用，但是环保部没有收取任何费用来支付达标管理成本（审核认证符合性报告、执行实验室检查、COP检测或在用车测试）。美国的《清洁空气法》允许EPA向生产企业收费以填补管理方案的实施开销[65]。这样做的理论依据是EPA的达标管理支出是为了保障在美国销售的车辆能够满足所有法律规定的相关要求。环保部可以考虑使用同样的理论依据征收认证费或排放费税来支付车辆管理方案的实施成本。

65 《清洁空气法》和《联邦管理条例40 》86.905-93中规定，EPA可以向生产企业合理收费，用以支付机动车和发动机达标管理方案的实施成本(详见Reitz, R. W的论述，2001年，空气污染控制法：达标与实施，环境法学会 p285)。这样EPA就可以向生产企业收取认证费，来支付实施SEA和在用车达标检测的费用，因以上两部分也属于达标管理方案范畴。

5.4 Recommendations

Results of limited in-use testing and anecdotal evidence suggest that sub-standard vehicles are produced and used in China and that the existing enforcement programs have not been sufficient in deterring production and sales of non-conforming vehicles. Compared to the US vehicle enforcement and compliance program, the China program clearly needs enhancements in several key areas. Expanded authority and additional funding will be critical to achieve this goal and should be pursued as early as possible. In the meantime, MEP should review its current programs, find cost effective ways to improve them, enhance its technical capacity and testing capability, and prepare its staff for the establishment an in-use testing program. In-use compliance and enforcement testing is the cornerstone of mature vehicle enforcement programs. Establishing an effective in-use testing program (conducted mainly by manufacturers and supported by MEP) should be the ministry's long-term goal.

MEP is already taking steps in the right direction to address some of these needs, including collaborating on training programs with US EPA on in-use recall, and working with the Xiamen city government to establish a new testing laboratory. A more detailed discussion of the overall recommendations to MEP for the establishment a strong vehicle enforcement program follows:

- *Seek modifications to the "Air Pollution Prevention and Control Law" to give MEP clear authority to require manufacturers to conduct in-use testing and impose penalties for non-compliance (including the authority to recall vehicles):* An effective in-use enforcement program is essential to ensure vehicles meet all applicable emission standards throughout their useful life. Large non-compliance penalties, either from the costs for recall or from the costs of stopping production and sale of models that fail a SEA, are a key element of a successful enforcement program, as evidenced by the US experience. Large penalties are also a key driver forcing manufacturers to improve production quality and design of new vehicles and continuously enhance durability of vehicles and emission control devices. Therefore MEP should, as early as possible, seek the authority to require manufacturers to conduct in-use testing and to impose punitive penalty. When MEP is granted the authority to recall vehicles, a follow-up step would be to review, and revise as necessary, all existing recall-related laws or regulations to ensure no conflict with MEP's new authority. For instance, MEP has just revised and released the "Defective Automotive Products Recall Management Regulation" issued in 2004 for public comments and is now reviewing all the submitted comments.

- *Establish an in-use testing and recall program:* If only limited initial funding is available, the program should focus initially on analyzing in-use data provided by manufacturers, research institutes and I/M programs to identify the small number of high polluting models for in-use compliance testing, and request manufacturers to recall if appropriate.

- *Raise funds from emissions fee/vehicle taxes on vehicle owners or increased certification application fees for vehicle/engine manufacturers:* It would be difficult for MEP to substantially upgrade its vehicle enforcement program without additional funding, so raising funds would be an important near term task. Right now, manufacturers pay a fee for certification testing to the testing labs for the services they perform, but no fee is paid to MEP to cover the cost of the compliance program (auditing compliance reports, conducting lab inspection, COP testing, or in-use testing). In the US, the "Clean Air Act grants" EPA the ability to recoup costs for its enforcement program by imposing a fee on manufacturers[65]. The rationale is that the costs of EPA's compliance efforts are incurred to ensure that vehicles sold in the US meet all the necessary requirements under the law. MEP could consider using a similar rationale to collect certification fees or set emissions fees/taxes to cover the cost of running the vehicle enforcement programs.

65 Under the CAA and the regulation 40 CFR 86.905-93, EPA can recoup the reasonable costs of running the motor vehicle and engine compliance program from manufacturers (see discussion in Reitz, R. W. 2001. "Air Pollution Control Law": Compliance and Enforcement. The Environmental Law Institute. p. 285). EPA therefore could impose a post-certification fee on manufacturers to cover the costs for conducting SEA and in-use compliance testing as they are considered part of the compliance program.

▪ *环保部要争取获得授权，让他可以要求车辆和发动机生产企业按照环保部的设定要求执行在用车测试，并将原始数据结果提供给环保部，以便数据可能用于达标管理方案当中：*充足及优质的在用车数据对环保部十分重要，可以借此发现不达标问题的源头并适当修订管理方案以应对这些挑战。中国车辆年产量超过1300万辆但环保部目前的技术能力还十分有限，因此环保部不可能自己执行在用车测试来获得大量有关数据。环保部应利用汽车企业的资源收集在用车测试数据，而环保部自身的人员资源应去执行更有针对性的在用车测试，监察汽车企业的在用车数据收集过程。环保部应通过修订《大气污染防治法》来获得授权，让其可以要求生产企业支付在用车测试费用。

环保部在寻求更多的资源来提高自身的技术水平的同时，还应开始筹备为在用车测试和召回方案培训和配备自己的团队：

▪ *通过与EPA和其它机构合作开展培训，增强内部人员的召回业务和管理水平：*由于目前还没有权限，环保部没有执行召回的经验。环保部正在与EPA合作开展关于召回管理的培训项目，将在2010年底或2011年初进行。这样的培训项目将协助环保部开始着手策划和制订适合中国特殊需求的召回方案。

随着环保部已经在着手提升自己的权威地位和增加实施在用车测试的资源，现行管理方案中存在的一些明显不足有待在近期内以较低成本妥善解决：

▪ *提高环保部的技术能力和检测能力，确保良好地执行认证测试和企业出资实施的COP检测：*一些非官方的证据表明当前的管理实施方案不能有效遏制企业生产不达标车辆。在近期，增加在改善认证实施方案和COP检测方面的资源投入可能是环保部最具有成本效益的选择。例如，在认证测试中，应要求实验单位把无论是通过、失败或测试无效的数据都报告给VECC。另外，环保部应建设自主检测能力，在厦门建立实验室就是朝正确方向迈出的第一步。这些改进对一个切实有效的方案而言是不可或缺的。提高环保部的实施力度，结合罚款权，将能阻止生产企业制造排放大幅超标的新车。提高环保部的检测能力对实施召回方案也很重要，生产企业是愿意召回或是向环保部质疑召回的要求都取决于环保部的测试质量水平。

▪ *在主要城市制订良好的I/M实施方案作为查找和消除高排放车辆的途径之一，并提供宏观层面的数据，协助环保部更有效发现高排放车型来进行在用符合性检测：*环保部可以制订一套I/M最佳实施方案，经济条件较好或机动车排放问题严重的主要城市的环保局可以通过此方案来逐步提高他们现有的I/M方案。I/M方案的效果只有在高排放车辆接受维修或置换以后才能显现出来，环保部应考虑创立一项基金来负担高排放车辆的维修或报废费用，或许可以作为目前国家报废方案的一个延展。

▪ *利用研究机构如高校和其他研究院的技术专长：*环保部应充分利用已完成的或正在进行的研究机构的研究工作来有针对性地制定工作目标，实现对管理方案的升级改善。一些研究机构，如清华大学、北京理工大学和中国环境科学研究院都使用PEMS测量过在用车排放，这些研究结果现在和今后都具有重大价值，能够协助环保部发现问题（高排放车型或高排放车辆潜在的缺陷），并引导环保部将资源投入到更有效的领域。

▪ *寻找其它方法强制生产企业遵守排放标准 (例如通过“点名曝光”活动，公开不达标车型或生产企业)：*随着中国汽车市场竞争日趋激烈，车辆生产企业，特别是乘用车企业越发意识到品牌的价值。环保部可以考虑公开查出的违反标准的生产企业或车型作为对其违规的处罚。

从长期措施而言，一旦更多的经费有所保障，环保部应当考虑下列内容：

▪ *首先增大对在用车测试的投入，覆盖大量高排放车型：*当不需要再和现在一样重点考虑新车达标问题的时候，可以将资源逐步从新车认证和COP方面转向在用符合性管理。

▪ *确定长期的资金来源，支持车辆达标管理成果：*如本章所述，过去10年中车辆保有量的急剧增长需要不断改进车辆管理实施方案来应对大量的车辆排放问题。中国机动车市场还将持续增长。寻找长期稳定的资金来源来改善和扩展排放控制工作，应对不断上升的实施管理需求，对环保部来说十分关键。

▪ *Seek authority MEP to require vehicle and engine manufacturers to carry out in-use testing of vehicles and engines using protocols established by MEP and to provide the raw data results to MEP for possible use in its compliance program:* Sufficient, good quality in-use data are essential for MEP to identify the roots of the non-compliance problems and to be capable to tailor improvements of the enforcement program to address those challenges. With China's annual vehicle production exceeding 13 million units and MEP having severely limited technical capacity, it will be impossible for MEP to conduct in-use testing to obtain sufficient representative data. MEP should leverage the industry's resources to collect in-use testing data, and use its staff resources to conduct more targeted in-use testing as well as to provide oversight to industry in-use data collection efforts. MEP should seek through the revision of the Air Pollution Prevention and Control Law the authority to require manufacturer-funded in-use testing.

While MEP pursues additional resources to enhance its own technical expertise, the ministry should start train and equip its team in preparation for setting up an in-use testing and recall program:

▪ *Increase in-house proficiency in recall program administration through MEP training collaborations with the EPA or other regulatory agencies:* Limited by the authority it currently possesses, MEP has no experience in conducting a recall program. MEP is coordinating a training program with EPA around the recall program that would be held in late 2010/early 2011. Training programs such as this one will help MEP start planning and developing a recall program that suits China's specific needs.

As progress is made to increase MEP's authority and resources to conduct in-use testing, there are significant gaps in the current program that can be remedied in the near term and cost effectively:

▪ *Increase MEP's technical capacity and testing capability to ensure certification tests and industry-funded COP testing are being done properly:* Anecdotal evidence shows that the current enforcement program has not successfully deterred production of sub-standard vehicles. In the near term, it might be most cost effective for MEP to increase resources on improving the enforcement of certification and COP testing. For instance, laboratories conducting certification testing should be required to report all certification test data to VECC – passing, failing, and voided tests. Also, MEP should establish its own testing capability and the establishment of the testing laboratory in Xiamen is a first step in the right direction. These improvements are essential for an effective program. Increasing MEP's enforcement presence, combined with MEP having the authority to impose fines, could prevent manufacturers from producing new vehicles with grossly excessive emissions. Establishing MEP's testing capacity is also essential for developing a recall program as manufacturers' acceptance of vehicle recalls – or likelihood to challenge–depends on the quality of MEP's testing.

▪ *Establish good I/M programs in major cities as a way to identify and eliminate gross emitters and provide macro level data to help MEP better target high-emission models for in-use compliance testing:* MEP could develop a set of I/M best practices that could be used to assist those major cities whose EPBs have better financial resources or major vehicle emission problems to gradually enhance their existing I/M programs. Since emissions reductions of I/M programs can only be realized if gross emitters are repaired or replaced, MEP should consider creating a fund to cover repairs or scrappage of gross emitters perhaps as an extension or variation of the existing national scrappage program.

▪ *Leverage technical expertise in existing research institutions such as universities and other research institutes:* The ministry should fully utilize research done or being conducted by research institutions to help target efforts in enhancing the compliance program. Research institutes such as Tsinghua University, Beijing Institute of Technology and CRAES have been using PEMs to examine in-use vehicle emissions, and those findings have been and will continue to be very valuable in helping MEP identify problems (models or vehicle types with excessive emissions or possible defects of high emitters), and direct its resources to areas where they could be more effective.

▪ *Pursue other measures to coerce manufacturers to comply with emissions standards (e.g., a "name and shame" campaign to publicize non-compliant models and/or manufacturers):* As the China auto market becomes increasingly competitive, vehicles manufacturers, especially those producing passenger vehicles, are increasingly aware of the brand values. MEP could consider ways to publicize manufacturers or models that are found to not be compliant with the standards, to complement non-compliance penalties.

In the longer-term, once additional funding is secured, MEP should consider the following:

▪ *Expand resources allocated to in-use testing should be expanded first to cover a larger number of high-polluting models:* When new vehicle compliance becomes less of a concern than it is today, resources could be gradually shifted away from new vehicle certification and COP to the in-use compliance program.

▪ *Identify a long-term sustained resource stream to finance vehicle compliance efforts:* The spiraling growth of vehicle population in the past decade or so demands substantial enhancements of the vehicle enforcement program to match the magnitude of the vehicular emission problems as discussed in this chapter. China's vehicle market is projected to see continued growth. It would be critical for MEP to seek long-term sustainable funding to improve and expand its emission control efforts to match the rising enforcement needs.

6. 燃料的监督检查和达标管理方案

提高油品标准能减少燃料燃烧时产生的污染物，但更重要的是，清洁燃料可以令先进的排放控制装置在车辆上得以使用。只有车辆排放与燃料标准的制定相配套，且车辆和油品同时满足标准要求，车辆才能达到最佳的排放性能。

要确保零售站点销售的燃料能满足所有规定的规格，设计并有效实施油品达标管理方案十分重要。油品达标管理方案对使用先进的排放控制技术更为关键，因为这些先进的装置会被不合格的油品破坏（例如高硫燃料）。

不过，中国地域宽广，而且燃料供应商和零售商有很大诱因将违法油品以较低的价格出售给在乎价格的消费者，在中国推行有效的油品达标管理方案具有一定的挑战。本章将评估美国和日本在推进车用燃料质量方面的经验，并将从中学习经验，为中国实施有效的燃料品质管理方案提供一些建议。

6.1 美国环保局（EPA）的油品达标管理方案概述

EPA设立了一个综合性的油品达标管理方案，包含了燃料登记注册、油品监督检查、油品质量测试和报告机制以及违规处罚措施。大多数油品监督检查项目都是由EPA出资支持的；EPA只要求石化企业出资支持一个监督检查项目，来确保新配方汽油能满足各新配方汽油控制区设定的年度平均标准要求。石化企业还出资支持另外一项审查柴油硫含量的自愿性质量保障调查来证明已有确定的防范措施保证油品达标的要求，具体细节会在本章稍后进行论述。《清洁空气法》211节规定如果燃料及燃料添加剂有可能危及公众健康或财产或损伤排放控制装置或系统，EPA有权禁止其生产和销售。《清洁空气法》1990年修订案中增加了对燃料燃烧后排放物的减排要求，并授权EPA管理非道路机械用油品。

EPA的达标管理方案将证明达标的责任主要放在炼油企业、进口商和其它燃料运输和经销商身上，通过登记注册、油品分析和报告的方式来证明油品达标。EPA通过指定中立实验室进行抽样和检测来确保企业的达标证明真实公正，由第三方对企业的报告进行审核，并有目的或随机地对炼油厂、燃料进口设施、中转油库和加油站进行检查。具体内容将在下面的章节中具体论述。

管理对象

油品达标管理的对象包括燃料输送分配系统中的所有参与者，包括炼油企业、进口商、分配商、运输商、含氧剂添加企业、零售商和大批采购的消费者（拥有分油泵的车队运营商）。

EPA的实施方法

EPA建立达标管理方案是为了确保从炼厂出厂的燃料和进口的燃料都能满足各项法定要求或规定的每加仑限值或年均限值要求。下面的表6.1中列出了对汽柴油的要求（每加仑或年均）。EPA还设置了一些附加要求来确保炼厂下游的燃料品质（每加仑为基础）。各项实施措施将在下面的章节中进行简单论述。

6. Fuel inspection and compliance programs

Fuel modifications can reduce pollutant emissions from fuel combustion and, more importantly, enable the use of advanced emission control devices. The best vehicle emission performance can only be achieved if both vehicles and fuels meet standards that are designed to complement each other in reducing vehicular emissions.

Effectively design and implement a fuel compliance program is important to ensure that fuels sold at the retail stations meet all the mandated specifications. A fuel compliance program becomes more critical with the use of advanced emission control devices that can be damaged by fuel not conforming to specifications (e.g., high sulfur fuel).

However, it has been challenging to establish an effective fuel compliance program in China, with its expansive territory and with fuel suppliers and retailers having high incentives to sell cheaper illegal fuel to their price cautious customers. This chapter reviews the experiences of US and Japan in enforcing motor fuel quality, and lessons learned from these two countries are used to inform recommendations for the establishment of an effective fuel quality enforcement program in China.

6.1 Overview of US EPA's fuel compliance program

EPA manages a comprehensive fuel compliance program that combines fuel registration, extensive fuel inspections, fuel quality testing and reporting system, and stiff noncompliance penalties. Most of the fuel inspection programs are funded by EPA; industry is required to fund one program that assures reformulated gasoline compliance for annual average standards is met separately for each reformulated gasoline control area. Another voluntary quality assurance survey program for diesel fuel sulfur compliance is also funded by industry consortium as an alternative defense that will be discussed in more detail later in this chapter. Section 211 of the Clean Air Act (CAA) gives EPA the authority to prohibit the manufacture or sales of fuel and fuel additives if they may reasonably be anticipated to endanger the public health or welfare or impairs emission control device or system. The 1990 CAA amendments added provisions to mandate that fuel combustion result in fewer emissions and expanded EPA's authority to include fuels used in non-road vehicles.

EPA's compliance program places the onus of proof largely on refiners, importers and other fuel handlers to demonstrate compliance through registration, fuel analysis and reporting. EPA assures the authenticity and probity of industry's proof of compliance by mandating independent lab sampling and testing, third party auditing of industry reports, and by conducting targeted and random audits at refineries, import facilities, truck loading terminals and retail stations. Key elements of the program are discussed in more details in the following sections.

Regulated parties

The fuel compliance program targets all parties in the distribution system, including refiners, importers, distributors, carriers, oxygenate blenders, retailers, and wholesale-purchaser-consumers (fleet operators with their own dispensing pumps).

EPA enforcement approach

EPA's compliance program was established to assure that fuel leaving the refinery gate or that is imported meets all requirements or prohibition on a per-gallon and on an annual average basis. Table 6.1 below shows the per-gallon and average fuel requirements for gasoline and diesel fuel. Additional measures are established to assure that quality of fuel is maintained downstream of the refinery on a per-gallon basis. Each of the enforcement measures is briefly discussed in the following sections.

表 6.1：汽柴油的特性要求

特性要求	新配方汽油 (RFG)[66]		其它汽油	
	每加仑	年平均	每加仑	年平均
铅	不得检出	-	不得检出	-
硫, ppm, 最大值	80	30	80	30
蒸气压 (夏季 RVP)	约7.0 psi (48 kPa)	-	7.8-9 psi (54-62 kPa)	-
芳香烃	25%	-	25%	-
苯	1.3%(体积分数)	0.95 %(体积分数)	-	-
其它重金属物质 (例如：锰)	不得检出	-	-	-
RFG和倾弃[67]	减少挥发性有机化合物（VOCs）和空气有毒物质25-30% (相比1990年的汽油质量)	减少VOCs和空气有毒物质25-30% (相比1990年的汽油质量)	-	油品清洁度不得低于1990年汽油质量
移动源空气有毒物质 (MSAT 1)		进一步减少有毒物质平均量	-	进一步减少有毒物质平均量
移动源空气有毒物（MSAT 2）	苯: 1.3 % (体积分数)	平均0.62% (体积分数)	没有上限，但在使用信用额度之前，炼厂/进口商的年平均值不得超过1.3%(体积分数)	0.62 体积.% 平均

柴油(机动车和非道路)

特性要求	每加仑
硫	15 ppm
十六烷指数 最小值	40
或芳香烃 最大值	35%

66 Reformulated gasoline (RFG)是一种配方更清洁的汽油燃料，被要求用于臭氧不达标的特定区域。

67 《清洁空气法》第211节规定了氮氧化物（NOx）限值，要求基准车辆使用非新配方汽油时NOx排放水平不得超过基准车辆使用1990年基准汽油的排放水平。实施低硫汽油（均值每加仑30ppm，上限80ppm）保障了排放满足原有的NOx标准，自此后EPA没有再执行NOx标准。从2011年起，EPA将开始淘汰有毒物质标准，代之以苯标准（年均值0.62体积百分比）。

Table 6.1: Per gallon and average standards and performance requirements for gasoline and diesel

PROPERTY OR PERFORMANCE REQUIREMENT	REFORMULATED GASOLINE (RFG)[66]		OTHER GASOLINE	
	PER GALLON	AVERAGE	PER GALLON	AVERAGE
Lead	Non-detectable	-	Non-detectable	-
Sulfur, ppm, max	80	30	80	30
Volatility (summer RVP)	Approximately 7.0 psi (48 kPa)	-	7.8-9 psi (54-62 kPa)	-
Aromatics	25%	-	25%	-
Benzene	1.3 vol.%	0.95 vol.%	-	-
Other heavy metals (e.g., manganese)	Non-detectable	-	-	-
RFG and anti-dumping[67]	Reduce VOCs and air toxics by 25-30% (compared with 1990 gasoline quality)	Reduce VOCs and air toxics by 25-30% (compared with 1990 gasoline quality)	-	Fuel not dirtier than 1990 gasoline quality
Mobile Source Air Toxics (MSAT 1)	-	Further reduces average toxics	-	Further reduces average toxics
（MSAT 2）	Benzene: 1.3 vol%	0.62 vol.% on average	No cap but refinery/ importer annual average cannot exceed 1.3 vol.% before use of credits	0.62 vol.% average

Diesel (Motor vehicle and non-road)

PROPERTY REQUIREMENT	PER GALLON
Sulfur	15 ppm
Cetane index, min	40
Or Aromatics, max	35%

66 RFG is a cleaner burning gasoline blend required in certain regions that do not meet air quality standards for ozone.

67 Sec. 211 of the "Clean Air Act" specifies a backstop limit on NOx, requiring that NOx emissions from a baseline vehicle using non-RFG shall not exceed the level from the baseline vehicle using the baseline gasoline in 1990. EPA no longer enforces the NOx standard, since compliance with the low sulfur levels in gasoline (30 ppm average and 80 ppm per-gallon cap) assures compliance with the old NOx standards. Starting 2011, EPA will begin to phase out the toxics standards as well. These will be replaced by a benzene standard (annual average of 0.62 volume percent).

油品和油品添加剂登记注册

EPA要求炼油企业和进口商在美国市场销售任何车用燃料和燃料添加剂前，须向EPA登记注册这些产品。进行登记注册要求提交燃料或燃料添加剂的化学性质描述和技术、市场和健康相关信息，如该产品的实际使用用途。EPA可能还会要求产品在延长注册有效期或新产品注册时进行健康影响测试。

EPA通过登记注册信息，使用复合模型（complex model）对燃料或添加剂的燃烧和蒸发排放进行评估[68]并找出其排放物可能带来公共健康风险的产物。如果任何燃料或燃料添加剂可能危害公众健康或损坏排放控制装置，EPA可以拒绝这些产品的注册或取消其已有的注册。

根据《清洁空气法》的要求，要在所有汽油中加入清净剂以减少发动机和油品供应系统沉积物的累积，清净剂也必须通过EPA认证。认证程序包括：

1) 和其它添加剂一样在EPA进行登记注册，登记注册中应包括添加剂的组分和最小推荐浓度。在没有告知EPA的情况下，不得降低最小推荐浓度。

2) 向EPA提交清净剂样本。

3) 提交清净剂认证函。认证函必须由认证方的法定代表人签署。

在收到认证函后，EPA会审核认证资料，分析提交的清净剂样本，或对添加剂进行验证测试，并可能在必要时取消某项认证。

另外，EPA要求清净剂生产企业将最小推荐浓度准确地告知购买其清净剂以满足EPA要求的各家炼油企业[69]。

油品测试和达标报告

EPA要求炼油企业和进口商分析生产或进口的每批次[70]燃料的油品特性指标（根据油品种类）[71]。炼油企业和进口商要保存所有测试记录并封存测试样本。油品特性要上报EPA，根据特定的达标方案[72]，按季度或按年度报告。另外，炼油企业和进口商均须向EPA提交年度报告以供存档，报告中应包括每批次的测试结果和相关特性指标，以示能够满足基于每加仑和年平均标准的要求。EPA会有选择地审核部分年度和季度报告并检查实验室记录是否与之一致。EPA还会审检实验室和审核试验方法以及质量保障程序等。

企业支付费用的独立实验室测试

除了对各批次油品进行自检，EPA还要求炼油企业和进口商雇佣独立的实验室进行新配方汽油和特定进口汽油的抽样及测试。独立实验室的测试报告要提交给EPA，以供EPA与认证管理对象提交的报告进行对比。所有的实验室报告都需要由该实验室的高级管理人员签发，一旦发现报告作假，EPA可对签署人提出刑事诉讼。

68 复合模型基于下列参数估算燃料NOx、有毒物质和挥发性有机化合物的排放量：烯烃、芳香烃、硫、苯、氧含量、馏程（E200和E300）以及雷氏蒸气压（RVP）。

69 详见《联邦管理法规》（40 CFR）86.161部分的清净剂认证方案。

70 在柴油燃料管理方案中，根据40CFR 80.502(d)的定义，一批次是保管权交给另一方的燃料的数量。一批次汽油则是指同性质的混合物。80.2 节(gg)段。

71 柴油的硫含量、芳香烃和十六烷值指数；汽油的硫含量、芳香烃、苯、铅、夏季蒸气压、馏程、烯烃；其它用来证明符合新配方汽油或传统汽油反倾弃要求的油品特性指标。

72 例如，炼油企业和进口商被要求提交所生产或进口的每批次油品的质量报告来证明产品能够到达对每加仑油品的要求。为证明符合新配方汽油和反倾弃要求，要求炼油企业和进口商每季度和每年提交报告。年度报告要求证明满足苯、挥发性有机化合物和空气有毒物质要求以及对每加仑汽油的硫含量限值和平均限值。

Fuel and fuel additive registration

Refiners and importers are required to register with EPA any motor vehicle fuel and fuel additive prior to marketing in the US. Registration requires submission of the chemical description of the fuel or fuel additive as well as technical, marketing and health-related information, such as the in-use purpose of their product. EPA might also require testing for possible health effects for a product to maintain its registration or for a new product to be registered.

EPA uses the registration information to assess the likely combustion and evaporative emissions using the complex model [68] and identify products whose emissions might pose unreasonable risks to public health. EPA can deny new registration or repeal existing registration of any fuel or fuel additive that may endanger public health or impair emission control devices.

Detergent additives, which are required under the CAA to be added to all gasoline to reduce accumulation of deposits in engines and fuel supply system, have to be certified with EPA. The certification process includes:

1) Registration with EPA like other additives, and the registration should include the additive's composition and the minimum recommended additive concentration. The recommended concentration cannot be lowered without first notifying EPA.

2) Submitting a sample of the detergent additive to EPA

3) Submitting a certification letter for the detergent additive package. The letter must be signed by a person legally authorized to represent the certifying party.

After receiving the certification letter, EPA may review the certification data, analyze the submitted detergent additive sample, or subject the additive package to confirmatory testing, and may disqualify a certification where appropriate.

In addition, the detergent additive manufacturers are required to accurately communicate the minimum recommended concentration to each fuel manufacturer who purchases the detergents for compliance with EPA's requirement[69].

Fuel testing and compliance reporting

EPA requires refiners and importers to analyze the properties of every[70] batch of fuel produced or imported for fuel properties associated with that kind of fuel[71]. Refiners and importers have to maintain all testing records and retain test samples. Fuel properties are reported to EPA on a quarterly or annual basis depending on the design of the particular compliance program [72]. In addition, annual reports are filed with EPA summarizing test results of every batch and the associated properties to show compliance with the per-gallon and average standards. EPA selectively audits the annual and quarterly reports, and lab records to check if they are internally consistent. EPA also audits the laboratories and the laboratory methods, quality assurance procedures, etc.

Industry-paid independent lab testing

In addition to conducting self-testing of every batch of fuel, EPA requires refiners and importers to hire independent labs to sample and test reformulated gasoline and certain imported gasoline. Independent lab test reports are submitted to EPA for comparison with the reports submitted by the regulated parties.

68 The complex model estimates NOx, toxics and VOC emission performance of fuels based on the following parameters: olefin, aromatics, sulfur, benzene, oxygen, distillations (E200 and E300) and RVP.

69 See 40 CFR Part 86.161 for more details about the detergent additive certification program.

70 In the diesel fuel program, by definition (40 CFR 80.502(d)), a batch is a volume of fuel whose custody has been transferred to another party. A batch of gasoline is defined as a homogeneous mixture. Section 80.2 (gg).

71 Sulfur content, aromatics and cetane number for diesel; sulfur, aromatics, benzene, lead, summer RVP distillation, olefin for gasoline, and other fuel properties that demonstrate compliance with the reformulated gasoline or conventional gasoline anti-dumping requirements.

72 For instance, refiners and importers are required to submit fuel quality report for every batch of fuel produced or imported to show that all per-gallon requirements are met. To demonstrate compliance with the RFG and anti-dumping requirements, refiners or importers are required to submit reports every quarter and annually. Annual reports are required for demonstrating compliance with the benzene, VOCs and air toxics requirements, and the average and per-gallon maximum gasoline sulfur limits.

企业支付费用对炼油企业报告和实验室记录进行独立审核

EPA同时要求炼油企业和进口商雇佣独立的注册会计师事务所或内部的注册审计师来审核所有油品测试结果、报告和炼油企业或进口商的其它信息。

推定责任和企业支付费用的市场调查

根据EPA的管理规定，如发现炼油企业、进口商、分配商、运输商、分销商、零售商或大批量购买的消费者销售或使用没有达到硫含量标准要求的车用柴油或没有达到苯、硫、挥发物、有毒物质和铅含量规定的汽油，这些机构均须承担责任。这就意味着一旦发现违规现象，不达标燃料的所有者，以及分配系统上游的所有人员机构都将被推定要为此负责，除非他们可证明已有确定的防范措施。炼油企业或零售商（其商标出现在加油站）可以实施下游质量保障方案来确保达标，并在被控诉要负上推定责任时可以作为辩护的其中一项理据[73]。这些企业还需要提供其他辩护理据，包括未能达标产品与上游生产过程及产品品质无因果关系。

为满足超低硫柴油的抽样和测试要求以作为推定责任的辩护理据，石化企业出资进行柴油油品调查。在调查中，石化企业雇佣的调查人员会利用统计学方法定期从不同地区的零售站点抽样，然后根据柴油硫含量要求对样本进行测试。

EPA审核和检查

除了审核企业提交的报告并要求企业雇佣独立的实验室进行油品测试及独立的审核机构对测试结果的真实性和公正性予以审核，EPA还会随机和有针对性地检查被怀疑生产不达标油品的炼油企业。EPA每年还会检查一小部分独立实验室，确保企业与测试实验室之间的紧密联系不会影响实验室的独立性和报告的准确性。

不达标处罚

《清洁空气法》设定了每天不超过37,500美元[74]（或256,000人民币）的民事罚款并要求企业上缴违规带来的经济收益或资金节约。实际的罚款金额由EPA在考虑经济效益、商业规模和违规程度（是否造成了明显的排放上升）后进行裁定。尽管不经常进行最高额的罚款，EPA还是会对严重违规的企业实施重罚。例如在1985年，EPA对Decker Coal公司处以266,000美元（180万人民币）的罚款，理由是该公司给37辆标明使用无铅汽油的车辆加注含铅汽油[75]。2008年EPA对售卖未通过登记注册添加剂的Biofriendly公司罚款125万美元（875万人民币）[76]。另外，EPA如果发现炼油企业、进口商和独立实验室伪造测试结果或协助作假可以对他们提出控诉 。

73 实例详见40 C.F.R. 80.613(d)。

74 根据40 CFR 19部分，由于通货膨胀，上调了《清洁空气法》规定的25,000美元的民事罚款上限。

75 美联社，1985年，油品违规罚款搜索，Spokane Chronicle。

76 EPA. 2008年，Biofriendly公司清洁空气解决方案，EPA网站tp://www.epa.gov/compliance/resources/cases/civil/caa/biofriendlycorp.html (2010年4月29日查阅)。

77 例如1998年，为炼油企业和进口商提供测试和检查服务的Saybolt公司，因向EPA提交作假的炼油企业和进口商实验室测试检查报告，共计被罚款490万美元（3300万人民币）。

All laboratories reports have to be signed by senior management of the lab, and EPA could file criminal charges against the signatory if reports are found to be falsified.

Industry-paid independent auditing of refinery reports and lab records

Refiners and importers are required to hire independent certified public accounting firms or certified internal auditor to audit all fuel test results, volume reports and other information of the refiners or importers.

Presumptive liability and industry-funded field surveys

EPA rules place liability on refiners, importers, distributors, carriers, resellers, retail and wholesale purchase-consumers if they sell or use motor vehicle diesel fuel that does not meet the sulfur standards or if they sell or use gasoline that does not comply with the benzene, sulfur, volatility, toxics and lead contamination regulations. This means that when a violation is found, the party in possession of the non-conforming fuel, as well as all parties upstream in the fuel distribution system are presumed liable unless they establish an affirmative defense. Refiners and importers whose brands appear at retail outlets may implement downstream quality assurance program to ensure compliance and to establish one element of their defense against presumptive liability [73]. Other elements must be established, including lack of causation.

As a means of meeting the sampling and testing defense element for ULSD, industry funds A fuel survey program. Under this program, industry-paid surveyors take statistically representative samples regularly from retail stations and test them against the diesel fuel sulfur requirements.

EPA field audits and inspection

Besides auditing industry's self-reports and requiring industry to arrange for independent lab testing and independent auditing to verify the authenticity and probity of test results, EPA inspects refineries both randomly and also those that are suspected of producing non-conforming fuels. It also audits a small number of independent labs every year to ensure that close ties between the testing labs are maintaining appropriate independence and correctly reporting results.

Non-compliance penalty

The CAA sets a maximum civil penalty of USD 37,500 [74] (or 256,000 RMB) per day per occurrence plus the amount of economic benefit or savings resulted from such violation. The actual penalties are determined by EPA based on various considerations including economic benefits, business size, and the gravity of violation (whether it results in significant increases in emissions). While the maximum fines are seldom assessed, EPA has levied heavy fines for severe violation. For instance, in 1985, EPA imposed fines of USD 266,000 (1.8 million RMB) against Decker Coal Co. for using leaded gasoline in 37 vehicles marked for unleaded fuel only [75]. In 2008, EPA assessed a penalty of USD 1.25 million (8.75 million RMB) against Biofriendly Corporation for failing to register an additive [76]. In addition, EPA can file criminal charges against refiners, importers and independent labs should they be found to have falsified or assisted in falsifying test results[77].

73 See 40 C.F.R. 80.613(d), for instance.

74 Per 40 CFR Part 19, the civil penalties are adjusted for inflation from the $25,000 cap on civil penalties when the CAA was enacted.

75 Associated Press. 1985. Fuel violation fines sought. Spokane Chronicle.

76 EPA. 2008. Biofriendly Corporation Clean Air Settlement. EPA website. http://www.epa.gov/compliance/resources/cases/civil/caa/biofriendlycorp.html (accessed April 29, 2010)

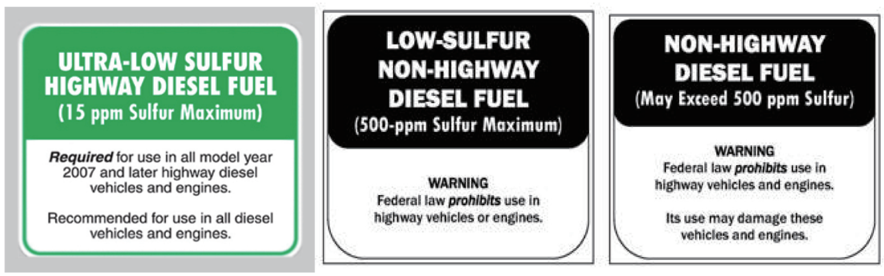
77 For instance, in 1998, Saybolt Inc., which performed testing and inspection services for refiners and importers, was fined a total of USD 4.9 million (33 million RMB) for submitting false statements to EPA about results of lab testing performed for refiners and importers.

其它政府机构的实施成果

美国对车用燃料征收燃油税，但是非道路燃料是豁免的。为保证税收，美国联邦税务局和一些州政府设立了自己的油品实施方案，确保非道路燃料不会被有意用于道路车辆。

达标的弹性机制

为了让企业利用最具成本效益的途径达标，EPA引入了一些弹性管理措施。在此介绍两大主要弹性措施。



标志内容为：

超低硫公路用**柴油** （最高 **15ppm** 硫含量） 要求所有 2007 车型年或以后公路柴油 车辆或发动机使用。 建议所有柴油车辆或发动机使用。	**低硫**非公路用**柴油** （最高 **500ppm** 硫含量） 警告 联邦法例禁止于 公路柴油车辆或发动机使用。	**低硫**非公路用**柴油** （可超过 **500ppm** 硫含量） 警告 联邦法例禁止于 公路柴油车辆或发动机使用。 使用这类柴油可损害车辆和发动机。

图 6.1: 油泵上粘贴的标志，注明硫含量和使用范围

平均、存储和贸易体系

平均、存储和贸易体系或称Average, Banking and Trading (ABT) 体系允许在不损伤环境的前提下在规定的达标期限内弹性达标。例如，在EPA的降硫方案中，假设一家炼油企业在一定时期内，超额完成达标，该炼油企业就可以储存信用额度在这一年晚些时候使用，当炼油企业进行设备升级或设备维修时，或在另一家炼油厂生产了硫含量稍高的车用油品时，炼油企业依然可以在整个达标周期内实现达标，通常达标周期为一年。尽管如此，燃料不得超过每加仑上限。信用额度只能用于平均值达标，不能用于每加仑上限达标。

EPA允许被管理对象产品的部分油品特性在年度平均基础上满足要求。表6.1总结了美国的油品指标和特性要求，以及哪些要求可以根据每加仑或年平均基础来满足。

指定分发和跟踪Designate and track

EPA允许道路和非道路柴油在2010年以前执行不同的硫含量要求，两种柴油可在同一系统中分发和运输，只要经手人按季度提交电子报告，列出他们所接收的柴油燃料种类（道路或非道路）并说明转手给了何人。因此，指定分发和跟踪方案使炼油企业和进口商能够最大程度的利用现有的燃料分发系统，同时允许EPA跟踪燃料的分发确保没有人违法将非道路柴油作为道路柴油销售。为方便管理，所有非道路柴油要在油库被染成红色，这样管理人员可以在下游检测时将燃料倒入白色的桶里，通过观察颜色来判定达标情况（又称白桶测试）。另外，要求加油站在油泵上粘贴标签，标明燃料的硫含量和使用范围（见图6.1）。一旦所有燃料都实施了15ppm的超低硫标准，对EPA来说，通过指定分发和跟踪来区分道路和非道路油品将不再重要。

Enforcement efforts of other government agencies

Motor vehicle fuels are subject to fuel tax, but non-road fuels are exempted. For tax purposes, Internal Revenue Service (IRS) and some state governments established their own enforcement programs to ensure non-road fuels are not intentionally used for onroad purposes.

Compliance flexibility

In order for the industry to meet the standards in the most cost-effective way, EPA has introduced a number of flexibility measures. The two major flexibility measures are discussed below.

Figure 6.1: Labels posted at fuel pumps stating diesel sulfur content and intended use

Averaging, banking and trading systems

Averaging, Banking and Trading systems or ABT systems allow flexibility in meeting the standard over a specific compliance period without hurting the environment. For example, in EPA's gasoline sulfur reduction programs, suppose a refinery over complies with the standard for a period of time; that refinery can bank credits for use at a later time of the year, when refinery units are being upgraded or are down for repairs, or at a different refinery, to make motor fuel with slightly higher levels of sulfur so that the refinery can meet the standard over the entire compliance period, typically a year. Nevertheless, the per-gallon caps cannot be exceeded. Credits can only be applied to meet the average, not the cap (i.e., the per-gallon requirements).

EPA allows regulated parties to meet some requirements on an annual average basis. Table 6.1 summarizes the US fuel property and performance requirements that can be met on a per-gallon and on an average basis.

Designate and track

EPA allows onroad and non-road diesels that are subject to different sulfur content requirements before 2010, to be distributed and transported through the same system, as long as all handlers file quarterly electronic reports listing what type of diesel fuel they received (non-road or onroad), and to whom it was delivered. The Designate and Track program hence enables refiners and importers to maximize utilization of the existing fuel distribution system while allowing EPA to track fuel distribution to ensure no party illegally represents off-road diesel as on-road. To facilitate enforcement, all non-road diesels have to be dyed red at the terminal so enforcement staff could determine compliance by place fuel in a white bucket and observe the color (so called white bucket test). Also, retail stations are required to put labels on the fuel pumps to identify the fuel sulfur level and the intended use of the fuel (see Figure 6.1). Designate and track is not important to EPA for distinguishing highway and non-road fuel once all fuels are subject to the ULSD 15-ppm sulfur standard.

控制汽油加油过程中的蒸发排放

汽油运输和存储过程中的油气排放是挥发性有机化合物（VOCs）和有毒物质（如苯）的污染源，美国已经采用了控制装置来控制和回收燃料运输和分发阶段和车辆在加油站加油时的蒸发排放。

在燃料运输和分发阶段（例如：储油罐、储配站、批发油库、加油站和油罐车）回收蒸发排放的设备被指定为一阶段控制 (Stage I control)。为满足环境空气质量标准，很多州在他们的州级实施方案（SIP）[78]中要求实施一阶段控制。

要控制加油过程中的油气，可以在加油站安装设备，捕集加油过程中排放的油气，并将它们回收至地下储油罐，这一过程为二阶段控制 (Stage II control)。另一种选择是在车上安装一个碳罐来捕集油气，又称车载油气回收系统（ORVR）。

根据EPA1994年发布的ORVR管理方案和《清洁空气法》的规定，所有乘用轿车和轻型卡车须安装ORVR，重型车和卡车（额定车辆最大总质量（GVWR）大于8500磅）可不安装ORVR。在臭氧不达标的地区，《清洁空气法》要求安装二阶段油气回收系统，直至ORVR在在用车上全面使用，并且该地区可以在不实施二阶段控制的情况下满足空气质量要求。

从2000年开始，所有乘用轿车被要求安装ORVR。从2006年起，所有轻型卡车（包括多功能车（SUV）、微型货车和GVWR不大于8500磅的小型卡车）被要求安装ORVR。2006年，EPA判定ORVR已经广泛应用，并且让臭氧不达标地区，除了部分地处臭氧运输区的地区（美国东北部的一些州）外，无须再按《清洁空气法》的要求实施二阶段控制。

比起二阶段控制，ORVR更有优势，因为ORVR系统安装在车上，比改造全州的加油站更具成本效益。现在，美国还有7个州要求在全州实施二阶段控制，有21个州要求在部分地区实施二阶段控制（通常是臭氧不达标区）以满足环境空气质量要求[79]。

实施方案的效果和成本

EPA的实施方案是成功的：每年只有不到1%的被审核的企业（机构）被发现违反燃料质量要求[80]。方案的成功主要归功于以下因素：

不达标处罚：如前文中提到的，油品达标方案重罚违规者，包括炼油企业、进口商或测试实验室。若发现有大型企业违规或发现任何企业有严重违规行为，EPA会征收数额可观的罚款（上百万美元）。一旦发现实验室对测试结果作假，会提起刑事控诉。因此，尽管EPA很少执行37,500美元 / 每天的最高限度民事罚款，高额罚款的可能性还是起到了威慑作用，迫使燃料生产商、进口商和经营者更努力的确保达标。

推定责任制：推定责任制鼓励配送体系的所有有关人员都努力确保其接收的燃料质量，阻止在燃料分发运输过程中混入非法燃料。由企业支付费用的零售燃料质量调查帮助确保了整个配送体系的达标，减轻了EPA的管理负担。

78 州级实施方案（SIP）是不能达到国家环境空气质量标准的州在指定期限内实施的具体控制措施，以实现达标。

79 要求执行二阶段控制的地区，详见http://www.ansdistributing.com/content/6546/StateStageII.pdf。

80 与EPA管理人员的谈话 (2010年2月)。

Controlling evaporative emissions from gasoline refueling

Gasoline vapors emitted during transportation and storage of gasoline is a source of VOCs and toxics (like benzene), and control devices have been developed to contain and recover vapors at the early phases of marketing and when vehicles are being refueled at the service stations.

Equipment for recovering evaporative emissions during early phases of gasoline marketing and distribution (e.g., storage tanks, bulk plants, bulk terminals, storage tanks at service stations and fuel trucks) are designated as Stage I controls. To meet the ambient air quality standards, many states require Stage I controls in their State Implementation Plans (SIP)[78].

To capture vapors during refueling, equipment can been installed at the service stations capturing vapors released during the refueling process and circulating them back to the underground storage tanks, so called Stage II controls. Alternatively, vapors could be captured through the use of a carbon canister installed on vehicles, so called onboard refueling vapor recovery (ORVR) system.

Under EPA's ORVR rule promulgated in 1994 and the CAA, ORVRs are required for all passenger cars and light trucks but ORVRs are not required for heavy-duty vehicles and trucks (those over 8,500 pounds gross vehicle weight rating (GVWR)). Worse ozone nonattainment areas, under the CAA, are required to use Stage II vapor recovery system, until ORVR have been widely implemented throughout the in-use vehicle fleet, and those areas can satisfy air quality requirements without Stage II controls.

Since 2000, all passenger cars are required to have ORVRs, and since 2006, all light trucks (including SUVs, minivans and pickups through 8,500 pounds GVWR) are required to have ORVRs. In 2006, EPA determined that ORVRs are in widespread use and relieved the worse ozone nonattainment areas, except for those in the ozone transport region (a group of states in the northeast of the US), from the CAA requirement to implement Stage II control(s).

ORVRs are preferred to Stage II controls because ORVR systems on vehicles are more cost-effective than converting all service stations across the nation. At present, seven states require the use of Stage II controls statewide and 21 states require Stage II controls in some areas of the state (usually the nonattainment areas) to achieve ambient air quality requirements[79].

Results and costs of the enforcement program

EPA's enforcement program has been successful: Less than 1% of facilities audited are found in violation with fuel quality requirements every year[80]. Below are the major factors attributing to the success of the program:

Non-compliance penalty: As mentioned previously, the fuel compliance program has aggressively pursued violators, including refineries, importers or testing laboratories. Substantial fines (millions of dollars) were imposed on big companies or when severe violations were found, and criminal charges have been filed against laboratories found to have falsified test results. Therefore, even though the maximum civil penalty of USD 37,500 per day per occurrence is seldom assessed, the possibility of being subjected to a hefty fine creates a deterrent effect forcing fuel producers, importers and handlers to more diligently ensure compliance.

Presumptive liability: The presumptive liability provisions encourage all parties along the distribution chain to undertake efforts to assure quality of fuel they received, and deter dropping of illegal fuel during fuel distribution. The industry-paid surveys for verifying retail fuel quality help to assure compliance along the chain and lessen the regulatory burden on EPA.

78 State Implementation Plans (SIPs) detail the control measures a state that is in non-attainment of National Ambient Air Quality Standards is undertaking to reach compliance within a given time period.

79 For a summary of states and areas requiring Stage II control system, see http://www.ansdistributing.com/content/6546/StateStageII.pdf.

80 Communications with EPA enforcement staff (Feb 2010).

独立的测试和审核：EPA要求由独立实验室测试每批燃料并由独立机构审核石化企业内部和独立实验室的测试结果，这让炼油企业或进口商很难在向EPA提交数据时作假。

EPA实施方案的运行成本

EPA每年要支付超过100万美元给负责燃料抽样和测试的承包机构，还要加上20名EPA全职工作人员，包括律师、工程师和检查人员。这些成本不包括企业实施的确保RFG和超低硫柴油达标的调查开支。EPA燃料达标管理方案的经费来源于国会划拨给EPA的预算。EPA不得使用任何罚款所得：所有罚款要收归美国国库。

6.2 日本的油品达标管理方案概述

日本从1996年4月起废止了进口石油产品的禁令，允许进口的成品油在国内销售。随着燃料来源于更多的企业和不同的地区，需要给予更加严格的燃料质量控制来确保石油产品的稳定供应及确保进口或国内炼制的燃料的质量能够满足所有必要要求。这促成了《汽油和其它燃料质量控制法》（《油品质量控制法》）的颁布。这部法律规定由经济产业省（METI）负责实施市售汽柴油和煤油的质量管理。

日本的油品质量管理实施方案[81]

基于环境和安全考虑，《油品质量控制法》强制规定了10种汽油指标和3种柴油指标规格（详见表6.2中的黑体字参数）。《油品质量控制法》还规定了一系列标准规范，包括对汽柴油燃料的所有强制性要求和附加的推荐性要求（见表6.2）。

81 有关日本石油质量管理资料参考：全国石油协会演讲文稿. 2006. 《日本车用燃料质量管理系统》 (Quality control system of on vehicle fuel in Japan) http://www.pecj.or.jp/japanese/overseas/koria/2006_2nd_oiltech/02_Quality_control_system.pdf. 2010年2月10日查阅; Keiko Hirota. 2008.《欧盟、美国和日本的燃料监督》 (Fuel Quality Monitoring {FQM} in EU, US and Japan).发表于印度-日本自动车研究所 2008 圆桌会议(Indo-JARI Roundtable 2008). http://petrofed.winwinhosting.net/upload/17-18Mar09/. 2010年2月10日查阅。

Independent testing and auditing: The EPA requirements of independent lab testing of every batch of fuels and independent auditing of in-house and lab test results make it difficult for refineries or importers to cheat by submitting falsified data to EPA.

Costs for running EPA's enforcement program

The EPA contractor for conducting field sampling and testing costs over one million US dollars, plus over 20 EPA full time staff that include lawyers, engineers and inspectors. This cost does not take into account the cost to the industry of the two field survey consortiums to ensure compliance with RFG and ULSD requirements. Budget of the fuel compliance program comes from EPA's budget appropriated by the Congress. EPA is not able to use any fees or money from the penalties assessed; all fines go to the U.S. treasury.

6.2 Overview of Japan's fuel compliance program

Japan dropped the ban on petroleum product imports in April 1996, allowing imported refined petroleum products to be sold in the country. With fuels offered by more companies and coming from different regions, there is a need for imposing stricter fuel quality control to ensure a stable supply of petroleum products and quality of fuel imported or refined domestically meet all necessary requirements. This led to the promulgation of the Law on the "Quality Control of Gasoline and Other Fuels" ("Fuel Quality Control Law"), which puts the Ministry of Economy, Trade and Industry (METI) in charge of enforcing quality of gasoline, diesel and kerosene sold on the market.

Japan's fuel quality enforcement approach[81]

Based on environmental and safety considerations, the "Fuel Quality Control Law" establishes mandatory specification for ten gasoline properties and three diesel properties (see properties in bold in Table 6.2). The "Fuel Quality Control Law" also specifies a set of Standard Specification that include all mandatory requirements and additional recommended requirements for gasoline and diesel fuels (see Table 6.2).

81 Reference materials regarding Japan's fuel quality management system can be found at: Presentation by the National Petroleum Association. 2006. Quality control system of on vehicle fuel in Japan. http://www.pecj.or.jp/japanese/overseas/koria/2006_2nd_oiltech/02_Quality_control_system.pdf. Accessed on Feb. 10, 2010; Keiko Hirota. 2008. Fuel Quality Monitoring (FQM) in EU, US and Japan. Presentation at Indo-JARI Roundtable 2008. http://petrofed.winwinhosting.net/upload/17-18Mar09/Hirota_sII%20.pdf. Accessed on Feb. 10, 2010.

表6.2: 《油品质量控制法》— 强制规定和标准规范

汽油			
		特性	标准
标准规格	强制规格	**铅**	**不得检出**
标准规格	强制规格	**硫含量**	**10 ppm**
标准规格	强制规格	**甲基叔丁基醚 MTBE**	**7%体积. 最大值**
标准规格	强制规格	**苯**	**1%体积. 最大值**
标准规格	强制规格	**煤油**	**4%体积. 最大值**
标准规格	强制规格	**甲醇**	**不得检出**
标准规格	强制规格	**胶质**	**5 毫克/100 毫升. 最大值.**
标准规格	强制规格	**颜色**	**橙色**
标准规格	强制规格	**氧含量**	**1.3% 质量% 最大值.**
标准规格	强制规格	**乙醇**	**3% 体积% 最大值**
标准规格		辛烷值	常规: 89 最小值. 优质: 96 最小值
标准规格		密度	0.783 克/立方厘米最大值
标准规格		馏程	T10/T50/T90
标准规格		铜片腐蚀 50℃	1 最大值
标准规格		雷氏蒸气压RVP	44-78千帕 (千克力/立方厘米)
标准规格		氧化安定性	240分钟 最小值

柴油			
特性	标准		
十六烷指数	**45 最小值**	强制规格	标准规格
硫含量	**10 ppm**	强制规格	标准规格
馏程, T90%	**360℃ 最大值**	强制规格	标准规格
脂肪酸甲酯FAME *	0.1 质量% 最大值		标准规格
甘油三酯 *	0.01 质量% 最大值		标准规格
闪点	45℃ 最小值		标准规格
倾点	根据地区和月份		标准规格
冷滤点	根据地区和月份		标准规格
残炭 **	0.1 质量% 最大值		标准规格
运动粘度 (30℃)	1.7 平方毫米/秒 最小值		标准规格

来源: 日本石油**連**盟，2009年，《2009年日本石油工业》

注: 上表中列出的所有属性都包含在标准规格当中：其中黑体字为强制规格。

* 此规格适用于没有在日本以外添加FAME的柴油燃料。强制标准允许的FAME添加上限为0.5 %.在这种情况下，附加标准包括:

甘油三酯: 不大于0.01质量%; 甲醇: 不大于0.01质量%; 酸度值: 不超过0.13 mgKOH/g; 甲酸+乙酸+丙酸: 不大于0.003质量%.; 酸稳定性: 不超过0.12 mgKOH/g。

** 残炭为10%蒸余物残炭中成分。

油品进口商和炼油企业的质量保障义务

《油品质量控制法》要求炼油企业和进口商在分配和销售之前测试燃料的质量，确保他们提供的石油产品达到所有强制要求。如果在加油站发现他们提供的不达标产品，炼油企业和进口商将与加油站共同担负责任。这就推动了石化行业定期检测配送体系中的油品。

Table 6.2: The Fuel Quality Control Law – mandatory and standard specifications

GASOLINE			
		PROPERTY	STANDARD
Standard specifications	Mandatory Specifications	**Lead**	**Non-detectable**
		Sulfur content	**10 ppm**
		MTBE	**7% vol. max.**
		Benzene	**1% vol. max.**
		Kerosene	**4% vol. max.**
		Methanol	**Non-detectable**
		Washed gum	**5 mg/100 ml. max.**
		Color	**Orange**
		Oxygen content	**1.3% mass% max.**
		Ethanol	**3% vol% max.**
		Octane	Regular: 89 min. Premium: 96 min.
		Density	0.783 g/cm^3 max.
		Distill	T10/T50/T90
		Copper corrosion @50℃	1 max.
		RVP	44-78kPa (kgf/cm^2)
		Oxidation stability	240min min.

DIESEL			
PROPERTY	STANDARD		
Cetane Index	**45 min.**	Mandatory	Standard specifications
Sulfur	**10 ppm**		
Distillation, T90%	**360ºC max.**		
FAME *	0.1 mass% max.		
Triglyceride *	0.01 mass% max.		
Flash point	45ºC min.		
Pour point	Depends on regions and month		
Cold Filter Plugging Point (CFPP)	Depends on regions and month		
Carbon residue **	0.1 mass% max.		
Kinematic viscosity @30℃	1.7 mm^2/s min.		

Source: Petroleum Association of Japan. 2009. Petroleum Industry in Japan 2009.

Note: All properties listed above are included in the standard specifications; items in bold are mandatory specifications.

* This specification is applicable to diesel fuels without international blending of FAME (Fatty Acid Methyl Ester). Mandatory standards allow FAME upper blending limit of 0.5 max%. In such a case, additional standards include:

Triglyceride: 0.01 mass% max.; Methanol: 0.01 mass% max.; Acid Value: 0.13 mgKOH/g max.; Formic Acid+Acetic Acid+Propionic Acid: 0.003 mass% max.; Acid Stability: 0.12 mgKOH/g max.

** CCR, from 10% distillation residue.

Quality assurance obligations of fuel importers and refiners

The "Fuel Quality Control Law" requires refineries and importers to test the quality of fuel prior to distribution and sale to ensure that the petroleum products they offer meet all the mandatory requirements. Refiners and importers share the responsibility should non-conforming fuel be found at any retail station they supply fuel to. This prompts the industry to regularly test fuel along the distribution chain.

汽油零售站登记注册和测试要求

所有出售汽油的加油站都必须在METI进行登记注册。《油品质量控制法》也规定加油站每隔10天要测试所出售的燃料是否满足表6.2中的强制要求。加油站可以委托METI授权的4家实验室中的任意一家来执行油品测试。

如果零售站可以证明1）其产品拥有确定的分发渠道；且2）有一家分销商与之共同承担产品质量保障责任，则可以向METI申请豁免频繁的测试要求（每10天一次的油品测试），只需要每年进行一次油品测试。

METI的实施方案

METI每年进行大量的油品抽样和测试。METI与全国石油协会(NPA)——一家独立的公立机构——签订合同，由其负责每年从全国45,000多家加油站逐个采集测试油品样本[82]。

NPA在日本拥有9家测试实验室，每家实验室负责所在地区的油品测试。NPA每年会在不预先通知的情况下从每家加油站购买一次或两次燃料样本，每次分别购买优质汽油、普通汽油、柴油和煤油各1升。买回的燃料样本会接受分析，看是否满足强制规格和标准规格。不达标的样本会被送往质量测试实验室，该实验室为NPA的9家实验室提供技术支持，样本在这里接受进一步分析。测试结果会被快速提交至METI和经济产业政策局（Economic and Industry Bureau, EIB）。METI和EIB会与警方和消防厅合作，突击检查出售不合格油品的加油站并可能采取惩罚行动（下令整顿或暂停营业）。2009年，NPA共采集和测试了超过29,000个汽油样本和超过54,000个柴油样本。

消费者信息：标准质量标志

为鼓励消费者选择高品质的燃料，所有出售满足所有标准规格（包括强制规格和推荐规格）的燃料的零售站都可以展示由EIB发放的标准质量标志(SQ标志)。

不达标处罚

若METI发现炼油企业、进口商或加油站出售不能达到强制规格的燃料将予以严惩，包括最高100万日元（7.6万人民币）的罚款及或最长1年监禁。METI还有权因分配销售不达标油品而中止炼油企业、进口商或加油站的商业经营权最长6个月并公布不达标商户名单。如果拥有标准质量标志的零售站被发现出售不符合标准规格的燃料，METI将收回标准质量标志。

管理行动抵制违法将重油混入柴油

出于保护环境和税收的目的，日本的税务部门和一些地方政府，包括东京市在内，已经采取了有力的措施，打击违法向柴油中混合重油。根据东京环境保护研究院2000年进行的一项研究，使用掺有50%重油的非法柴油，将造成颗粒物排放增加15%，氮氧化物排放增加7%，有毒物质排放也会增加（如苯和甲苯）。

从2000年起，东京市政府联合其它地方政府发起了“根除违法柴油”运动，包括严厉打击违法柴油生产基地、组织宣传教育活动和实施路边检查。在日本出售的柴油和重油中添加了一种化学香豆素（coumarin）指示剂。税务机构和地方政府可以通过检测在路边检查的柴油样品中香豆素指示剂的浓度轻松的判断是否违法添加了重油。

日本实施方案的效果和成本

来自汽车企业的油品质量监测数据显示，日本市场销售的柴油自2007年起已经能够达到10ppm硫含量限值(见图6.2)。

每年METI向NPA支付1570万美元（1.06亿人民币）用于油品质量测试[83]。这还不包括METI员工的工作时间成本和其他用来实施燃料质量管理方案和进行零售站突击检查的资源成本。

82 更多资料可以在全国石油协会网站找到：http://www.sekiyu.or.jp/qualitycontroll/index.html (日文网站)。

83 与京都环境局自动车公害政策部联系(2010年2月19日)。

Gasoline retail station registration and testing requirements

All retail stations selling gasoline must register with the METI. The "Fuel Quality Control Law" also stipulates retail stations test the fuels they sell against the compulsory requirements listed in Table 6.2 once every ten days. Retail stations may commission any one of four laboratories accredited by the METI for fuel testing.

If a retail station can show that it has 1) a clear distribution channel and 2) a distributor who is jointly responsible for ensuring product quality, it can apply to METI to be exempted from the frequent testing requirement (test fuel once every 10 days), and only need to test fuel once a year.

METI enforcement programs

METI conducts massive fuel sampling and testing every year—METI contracts the National Petroleum Association (NPA), an independent public corporation, to collect and test fuel samples at least once a year from every single one of the 45,000 plus retail stations in the country [82].

NPA owns nine testing labs around the country, and each lab is responsible for fuel testing in its region. NPA purchases one liter each of premium gasoline, gasoline, diesel and kerosene once or twice every year from each one of the retail stations without prior notice. Fuels purchased are analyzed against the mandatory and standard specifications. Non-conforming samples will then be sent to the Quality Testing Laboratories, which provides technical support to NPA's nine testing labs, for further analysis. Results are sent immediately to METI and the Economic and Industry Bureau (EIB). The METI and EIB, in collaboration with the Police and Fire Department, then conduct surprise inspections at retail stations selling off-spec fuels and regulatory actions (ordering improvements or suspension of operation) can be taken. Over 29,000 gasoline samples and over 54,000 diesel samples were collected and tested by NPA in 2009.

Consumer information: Standard Quality (SQ) Mark

To enable and encourage consumers to choose high-quality fuels, any retail station selling fuels that meet all the Standard Specifications (including all the mandatory and recommended specifications) can display a Standard Quality (SQ) logo issued by the EIB.

Non-compliance penalty

Refineries, importers or retailers found guilty of selling fuels that fail to meet all the mandatory specifications are subject to heavy punishment, including a fine of up to ¥1,000,000 (76,000 RMB) and/or up to 1 year of imprisonment. METI also has the authority to suspend any business for up to 6 months for distributing/selling non-conforming fuels and publicize the name of the non-compliant business to the public. METI will revoke the SQ logo if a retail station that displays a SQ logo is found selling fuel not meeting the Standard Specifications.

Regulatory actions against illegal mix of diesel fuel with heavy oil

Tax authorities and some local governments in Japan, including Tokyo, have also taken aggressive action against illegal use of mixed diesel and heavy oil for environmental and tax purposes. According to a 2000 study by Tokyo Research Institute for Environmental Protection, using illegal diesel fuel with 50% heavy oil content results in 15% high PM，7% higher NOx emissions, and higher toxic emissions (such as benzene and toluene).

Since 2000, the Tokyo Metropolitan Government together with other local governments launched an Illicit Diesel Fuel Eradication Campaign, including cracking down on illegal diesel manufacturing bases, launching education campaigns, and conducting roadside inspections. A chemical marker coumarin is added to diesel and heavy oil sold in Japan. Tax authorities and local government can easily determine if heavy oil is illegally added by testing the concentration of coumarin in the fuel samples collected from roadside inspections.

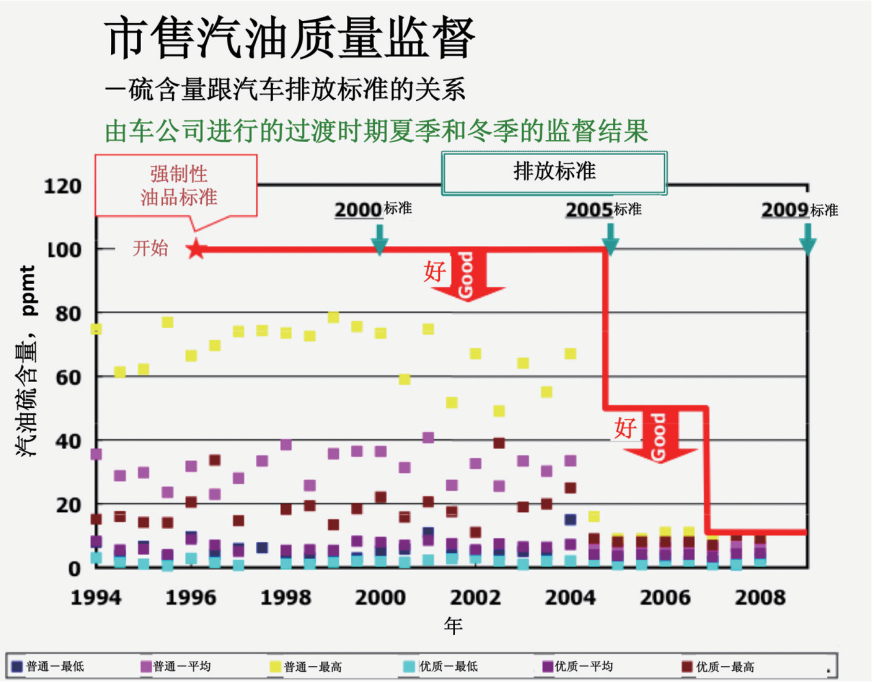
Results and Cost of Japan's enforcement program

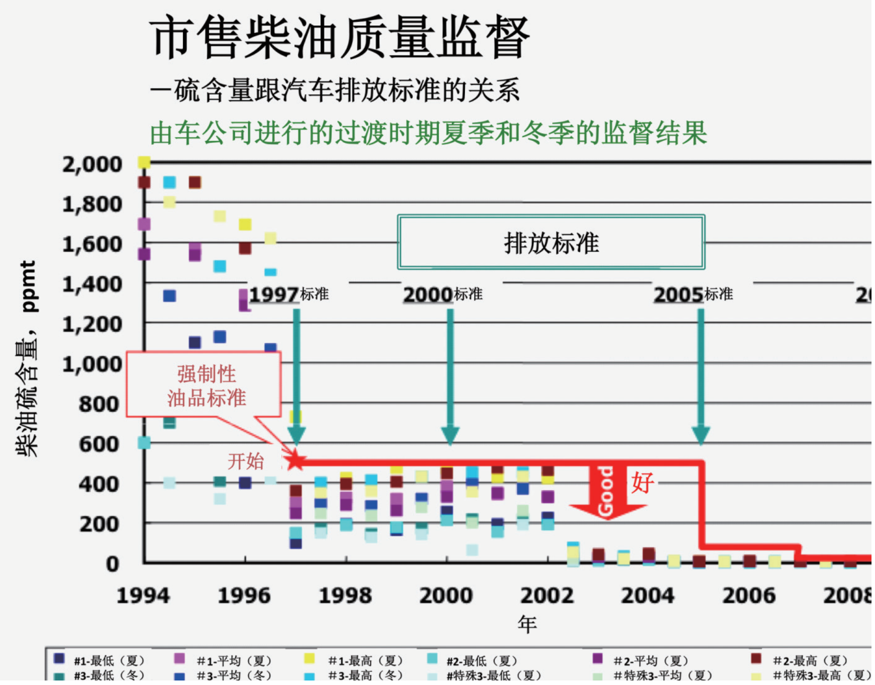
Fuel quality monitoring data from the auto industry suggest that diesel and gasoline sold in Japan has met the 10-ppm sulfur limit since 2007 (see Figure 6.2).

METI pays NPA USD 15.7 million (106 million RMB) every year for fuel quality testing[83]. This does not include the expenses for METI's staff time and other resources for managing the fuel quality enforcement program and conducting surprise inspections at retail stations.

82 More information could be found at the NPA website: http://www.sekiyu.or.jp/qualitycontroll/index.html (in Japanese)

83 Communications with Automotive Pollution Control Division of the Bureau of Environment of the Tokyo Metropolitan Government (Feb. 19, 2010).

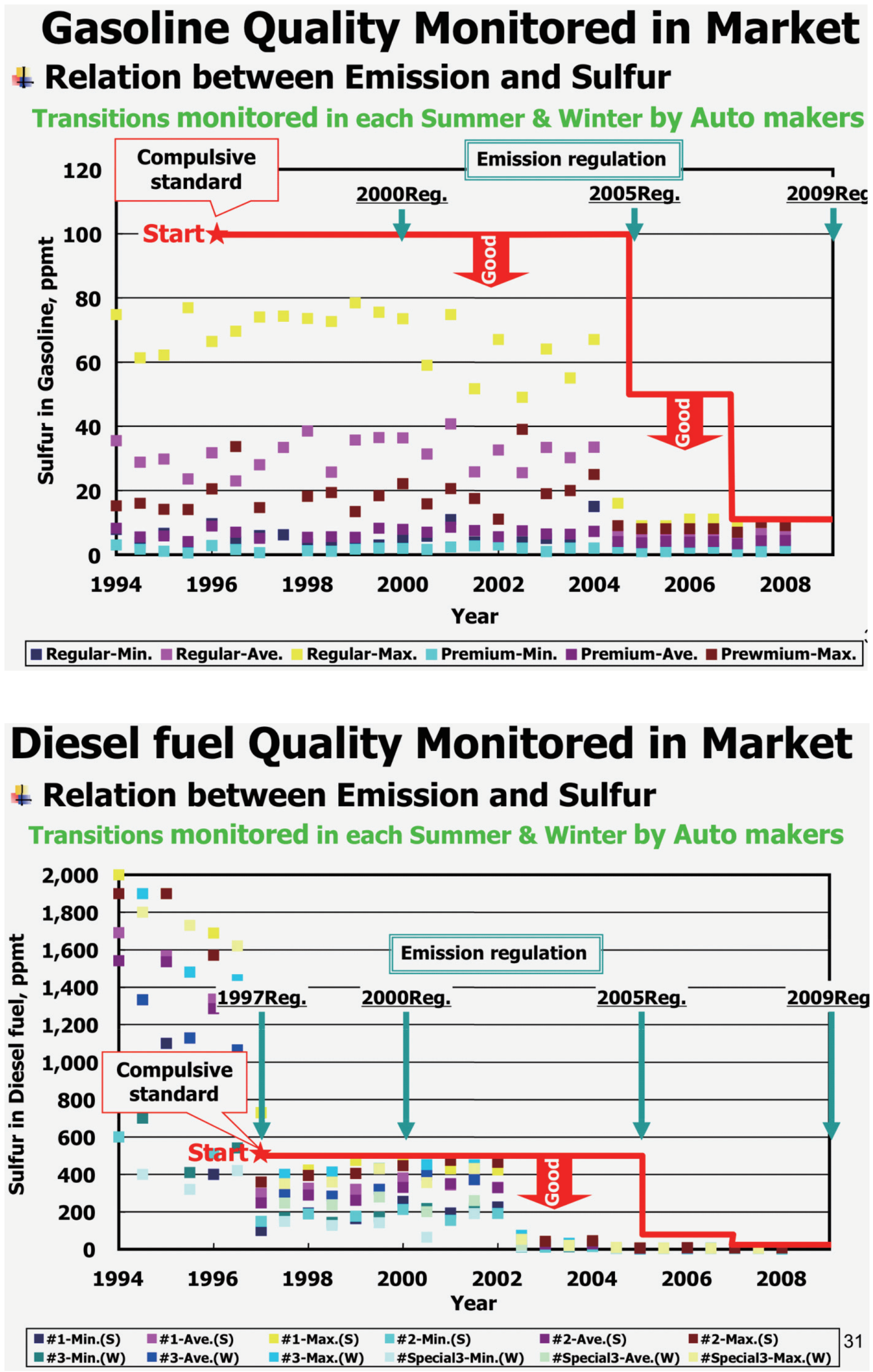




摘自Mitsuru Osawa，2009年，《控制日本市场油品质量的方法》，发表于 日本汽车制造商协会，燃料和润滑油小组委员会，中国圆桌会议。2月。

www.jari.or.jp/resource/pdf/china_2009/Session4-2_E.pdf

图6.2: 日本的汽柴油硫含量



Extracted from Mitsuru Osawa. 2009. "Measures of Maintaining Market Fuel Quality" in Japan, Presentation at the China Round Table 2009. Fuels and Lubricants Subcommittee. Japan Automobile Maunfacturers Association. Feburary.

www.jari.or.jp/resource/pdf/china_2009/Session4-2_E.pdf

Figure 6.2: Gasoline and Diesel Fuel Sulfur Content in Japan

6.3 中国的油品达标管理方案概述

油品质量管理实施方案

在本次的评估中，很难通过公开的资料找到详细说明各个部委在保障中国油品质量方面的具体地位和责任。在下文中总结了我们从相关的油品管理法规、《大气污染防治法》和与中方合作团队沟通后得出的见解。这些结论可能不能全面的反映出中国油品达标管理的全部内容。

《大气污染防治法》禁止生产、进口和销售含铅汽油并授权环保部实施此项禁令。《大气污染防治法》中还鼓励生产和使用优质油品，并支持减少燃料中的有毒物质，以对空气质量的影响减至最低[84]。但是，《大气污染防治法》中没有阐述控制或管理影响机动车排放的其它燃料特性的责任。

通过与中国环境科学研究院的交流，我们了解到燃料生产终端的油品质量归国家质量监督检验检疫总局（以下简称质检总局）管理，但是在全国各地管理力度和效果差异很大。我们从VECC了解到，加油站的油品质量由各地质检部门下属的质量技术监督司（处）负责监测。

根据中国石化行业标准SH 0164-92,《石油产品包装、贮运及交货验收规则》，关于保障运输和交货验收过程中的燃料品质的规定如下：

- 在燃料出售给加油站之前，依靠燃料销售商保障油品达标。
    - 发货单位根据适用标准对石油产品进行测试并认证产品质量。
    - 收货单位有权进行随机抽样核查产品质量。
- 中石化的石油化工科学研究院作为仲裁机构，仲裁购买方与销售方就产品质量问题产生的争议。
- 加油站出售的燃料的质量由各地的工商部门或质量技术监督部门负责监管。
    - 城市政府可以对零售站进行随机抽样。
    - 油品特性检测主要包括：

      汽油: 硫、苯、锰、胶质、芳烃、烯烃、蒸气压；

      柴油: 硫、闪点、馏程、酸度等。
    - 不同的城市，根据其实际情况，会实施不同的测试，然后将结果在管理机构网站上发布。

84 《大气污染防治法》第4章第34款。

6.3 Overview of China's fuel compliance program

Fuel quality enforcement approach

During this assessment public documentation detailing the role and responsibilities of various ministries responsible for assuring quality of fuel in China has been difficult to obtain. Below summarizes what is understood from reviewing fuel-relevant regulations and the Air Pollution Prevention and Control Law as well as communications with the team's Chinese partners. This may not reflect the full extent of activities related to fuel compliance in China.

The "Air Pollution Prevention and Control Law" bans the production, import and sale of leaded gasoline and authorizes MEP to enforce the ban. The law also encourages the production and use of good quality fuels and supports measures for reducing toxics in fuel to minimize impacts on air quality[84]. However, there is no mention of control or regulatory responsibility for other fuel characteristics that affect motor vehicle emissions.

According to communications with CRAES, fuel quality at the oil terminals is managed by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), but the enforcement efforts and their effect vary considerably across the country. Quality of fuel sold at the retail stations, according to VECC, is monitored by the local Quality Technology Supervision Bureaus under AQSIQ in provinces and municipalities.

According to Part 7 of the People's Republic of China petroleum refining industry standard SH 0164-92, "Rules for Storage, Transport, and Delivery Acceptance of Petroleum Products," regulation for guaranteeing petroleum product quality during transport and delivery acceptance stipulates that:

- Before fuels are sold to retail stations, rely on fuel sellers to ensure fuel comply with the standards.
    - The party delivering petroleum tests the product against applicable standards and certifies product quality.
    - The buyer has the right to take random samples to verify product quality.
- Sinopec's Research Institute of Petroleum Processing (RIPP) acts as the arbiter when disputes arises on product quality between fuel buyers and sellers.
- Quality of fuel sold at retail stations is supervised and managed by the local Industry and Commerce Bureau or the Quality Technology Supervision Bureau.
    - City governments can take random samples at retail stations.
    - The major fuel properties to be tested should include:

      Gasoline: sulfur, benzene, manganese, existent gum, aromatics, olefins, vapor pressure;

      Diesel: sulfur, flash point, distillation range, acidity, etc.
    - Different cities, according to actual conditions, perform different testing, then report the results on the bureau website.

84 Chapter 4, Article 34 of the "Air Pollution Prevention and Control Law".

中国油品管理实施方案的效果和成本

尽管我们未能找到对全国油品质量进行评估的报告或研究，但近期在中国不同地区进行的一些油品调查和车辆排放研究，表明油品规格超标并非罕见现象，显现出实施管理的不足。在此，总结了从油品调查和车辆测试中得到的发现，以及应对方案。

- 北京市质量技术监督局进行的2006和2007年油品质量调查表明95%以上的燃料样本能够达标，最普遍的不达标指标是硫含量。一些汽油样本被发现含有MMT。北京市质监局责令不达标的加油站立即停止销售不达标油品，并要求地方质检部门调查和处罚相关责任方。

- 深圳市质量技术监督局2008年秋实施的随机燃料检查结果显示，汽柴油的达标率分别为94%和97%。质监局对不达标企业提出了整改期限，要求改正问题并停止让不达标油品流入市场。

- 云南省产品质量监督检验研究院执行的燃料品质检查结果表明接受测试的785个精制油品、润滑油和机动车刹车油产品抽样中，只有81%符合标准。大多数不达标产品都不是来自中石油和中石化这两家最大的炼油企业，且都是在小型社区服务站发现的。

- 2008年7月由VECC出资，委托通标标准技术服务有限公司（SGS）进行了全国性的燃料质量调查，结果表明6%的柴油样本硫含量超过2000ppm限值，13%的汽油样本含有甲醇，13%的汽油未达到蒸气压标准，另外2%的汽油未能达到苯含量的要求。由于实施本次测试是出于研究目的，对未达标企业没有采取应对措施。

- 2008年中国环境科学研究院对中国北方地区的油品质量进行了研究，结果表明7.5%的柴油样本硫含量超过2000ppm的规定限值，12%的汽油样本硫含量在500ppm以上，超过当时的硫含量限值[85]。

- 中国环境科学研究院对北京的在用出租车进行了测试，结果表明催化转化器上有大量锰沉积，说明所使用的汽油可能锰含量较高。

实施达标管理的成本和资源

在中国环境科学研究院有5名工作人员，VECC有2名工作人员负责燃料和燃料添加剂的质量。目前没有掌握地方质检部门油品监管人员数量的信息。

85 张克松等人，2010年《中国北方汽柴油燃料硫含量》《能源政策》38期6号。

Results and costs of China's fuel enforcement program

Although reports or studies assessing the quality of fuel nationwide were not available, recent fuel surveys and vehicle emissions studies conducted in various areas in China found that fuels exceeding specification are not uncommon, an indication of a lack of enforcement. Summarized below are findings from fuel surveys and vehicle testing, as well as follow-up actions if any were taken.

- Fuel surveys conducted by Beijing Quality Technology Supervision Bureau in 2006 and 2007 showed that over 95% of fuel samples meet the standards, with the most common item out of compliance being high sulfur content. Some gasoline samples were found to contain MMT. The Beijing Quality Technology Supervision Bureau ordered the non-conforming retail stations to stop selling non-compliant fuel immediately and requested the Quality Technology Supervision Bureaus in related counties to investigate and penalize responsible parties.

- Random fuel inspection results conducted by Shenzhen Quality Technology Supervision Bureau in the fall of 2008 showed that gasoline and diesel were, respectively, 94% and 97% in compliance. The bureau imposed a deadline for out-of-compliance enterprises to correct the problems and stop nonconforming fuels from entering the market.

- Fuel quality inspection conducted by Yunnan Provincial Institute of Product Quality Supervision and Inspection found that only 81% of the 785 samples of refined oil, lubricants, and motor vehicle brake fluid tested comply with the standards. Most of the out-of-compliance products were not from PetroChina and Sinopec, the two largest oil companies, but were found in small community service stations.

- A nation-wide fuel quality survey funded by VECC and conducted by a private company SGS in July 2008 shows that 6% of diesel samples exceeded 2,000 ppm sulfur limits, 13% of gasoline samples contained methanol and 13% and 2% of gasoline did not meet the vapor pressure and benzene requirements respectively. No follow-up action was taken as the tests were performed for research purposes.

- A fuel quality study conducted by CRAES across northern China in 2008 showed that sulfur content of 7.5% of the diesel samples was above 2,000 ppm, the required limit, and 12% of gasoline samples contain over 500 ppm sulfur, the sulfur limit then in effect[85].

- Testing of in-use taxis in Beijing conducted by CRAES showed high level of manganese deposit in the catalytic converter, implying that gasoline used might have high manganese content.

Costs and resources for running the compliance program

There are five staff in CRAES and two staff in VECC whose duties are related to quality of fuel and fuel additives. Data regarding the number of staff in local Quality Technology Supervision Bureau involved in fuel inspections are not available.

85 Zhang, K., et al. 2010. Sulfur content of gasoline and diesel fuels in northern China. Energy Policy, Vol. 38, number 6.

6.4　中国方案与国际最佳实践经验的对比及中国发展道路上的障碍

环保部缺少管理与排放相关的油品质量的法律权力

《清洁空气法》明确授权EPA管理油品和实施油品质量标准，从而实现清洁空气这一核心目标。《清洁空气法》还规定了对不达标行为的最高罚款限额，EPA在发现违规行为时可以进行罚款。法律依据授权EPA建立了一套综合性的油品达标管理方案，对整个配送体系施加了推定责任制，从而迫使石化企业与整个配送体系的参与企业进行测试，并保存记录以证明自己的无责。法律还允许EPA对不达标行为实施高额罚款。推定责任制和罚款权是方案成果的两个关键。

日本的情况也类似，《油品质量控制法》授权METI管理油品质量和对违规者实施处罚（罚款、停业和监禁）。

中国目前的法律和管理规定基本上将燃料质量视为产品质量问题，而没有全面的考虑其对空气质量的影响。除了对汽油中的铅和有毒物质的规定，《大气污染防治法》中没有涉及油品对车辆排放的影响。因此，除了铅、有毒物质和清净剂，环保部没有管理燃料质量的法律依据，也无法采取任何措施来应对会造成车辆高排放的不合规格燃料销售行为。

燃料分发过程的质量监督和油品追踪力度不足削弱了实施效果

美国EPA建立的综合性方案得以确保油品质量，很大程度是依靠石化企业与配送体系有关企业出资进行的测试和分析，以及独立的实验室测试和审核。通过推定责任，使生产、分配和销售环节中的所有人在从炼油厂到加油站的每一阶段都积极地监测燃料品质。

在日本也推行类似的要求，炼油企业和进口商要对下游零售点发现的违规行为负责，导致炼油企业和进口商在整个配送体系实施测试，检查燃料质量。

在中国，保障燃料质量的责任落在质检总局、地方质检部门和石化企业的身上。从我们收集的资料看来，似乎是质检总局负责上游燃料质量监督（炼厂、油库），地方质检部门负责加油站的油品检查，但是除了购买者和销售者，没有明确的部门负责运送分发过程中的燃料质量。

缺少配送体系中的燃料质量监管造成在加油站发现不达标油品时，很难分离和查明问题的源头（例如在燃料分发过程中混入违法燃料）。油品调查结果清楚的表明在现有的实施方案中只要求加油站停止销售不达标燃料，而没有追溯和惩罚真正令燃料未能达标的始作俑者，是不足以杜绝不符合规格的燃料品流入市场的。

环保部需要实质的资源和明确的权力来改善中国的油品管理实施方案

美国和日本的经验表明，需要来自管理部门（EPA和METI）和企业的实质资源，用于油品分析、保存记录和审核，从而确保配送体系的燃品质量。

6.4 Comparison of China's program and international best practices and barriers to progress in China

MEP lacks the legal authority to enforce emission-related fuel standards

The CAA gives clear authority to EPA to regulate fuels and enforce fuel quality standards to meet the overarching goal of attaining clean air. The law also specifies a maximum non-compliance penalty, which EPA can assess when violations are found. The legal basis provided by the law empowers EPA to establish a comprehensive fuel compliance program that imposes presumptive liability on the entire distribution chain, thereby forcing the industry to bear the burden of testing and record keeping proving innocence. It also allows EPA to levy hefty, punitive fines in cases of noncompliance. The presumptive liability provision and the power to impose substantial fines are two keys of the program's success.

Similarly, the "Fuel Quality Control Law" in Japan grants the METI the authority to regulate fuel quality and assess punitive measures (fines, suspension of operation and imprisonment) against violators.

The current Chinese law and regulation treats fuel quality largely as a product quality issue, and does not fully accounts for its impact on air quality. Except for the provision on lead and toxics in gasoline, there is no mention in the "Air Pollution Prevention and Control Law" of fuel-related impacts on vehicle emissions. MEP, as a result, does not have the legal basis to regulate fuel quality other than lead, toxics and detergents, and cannot take any action against entities selling off-spec fuels that results in high vehicular emissions.

Poor quality monitoring and tracking along the distribution chain weakens the enforcement efforts

US EPA established a comprehensive program that relies substantially on industry-funded testing and analysis, and independent lab testing and auditing to verify and assure fuel quality. Subjecting all parties along the chain of production, distribution and sales with presumptive liability forces all parties, including refineries and importers, fuel handlers and distributors, and retail stations to diligently monitor fuel quality at every stage from the refineries to the retail stations.

Similar requirements were put in place in Japan, where refiners and importers are liable to any violations found at the downstream retail stations, leading refiners and importers to conduct tests to check fuel quality along the fuel distribution chain.

In China, the responsibilities for assuring fuel quality fall onto AQSIQ, local Quality Technology Supervision Bureaus, and the industry. It appears that AQSIQ is responsible for monitoring fuel quality upstream (refineries, fuel terminals) and the local quality bureaus are in charge of fuel inspection at retail stations, but it is not clear who, if any party, takes charge of assuring fuel quality during distribution other than the buyers and sellers.

A lack of fuel quality monitoring along the distribution chain makes it hard to isolate and identify the source of problems (such as dumping illegal fuel during fuel distribution) when non-conforming fuels are found at retail stations. Results from the fuel surveys clearly suggest that existing enforcement efforts, which only demand that service stations stop selling non-conforming fuels, but fail to track down and penalize the true culprit, are not sufficient to keep off-spec fuels off the market.

Substantial resources and clear authority are needed to improve China's enforcement program

The experience in the US and Japan show that substantial resources from both the regulatory agencies (EPA and METI) and the industry are needed for fuel analysis, record keeping, and audits to assure fuel quality along the distribution chain.

从资料上看，中国政府目前还没有实施全面和有系统的油品检查。一些私人公司，如SGS倒是在全国范围内执行了大规模的油品调查，但是服务和数据很昂贵。地方质检部门、环保部门和地方环保部（如北京市环保局）也实施过油品调查，但是这些调查都是零散的，并且只覆盖部分城市地区。

环保部要想建立一套与美国和日本方案一样严密的综合性实施方案，明显需要更多的资源（人员和资金）来进行燃料分析（自主或外包）和审核。同时环保部需要有明确的权力要求企业执行更多的油品测试，并将结果报告给环保部。

环保部在实施油品质量管理方面人员能力有限

EPA除了雇佣承包检测机构为其在全国范围内执行燃料测试和依靠企业执行的调查来监测燃料质量，在局里有25名以上的全职员工（包括一些科学家和检查人员）负责执行实验室和炼油企业审核，同时监督燃料测试承包机构采样和测试的设计与实施情况，以及监督由企业出资进行的新配方汽油和柴油燃料调查项目。这25名员工并不包括EPA负责燃料和燃料添加剂注册和报告部门的员工。

在中国，中国环境科学研究院拥有自己的测试实验室和5名职员来支持环保部和北京市环保局的油品测试和燃料标准制订，目前他们正在升级实验设备以便有能力测试国IV油品。在VECC也有两名职员全职负责燃料和清净剂的相关工作，但不包括燃料达标管理。相比中、美两国各类车辆的年度车用燃料消耗量，环保部在燃料工作方面可动用的人员比EPA要少得多。

表6.3:中美日实施油品监督和达标管理的资源配置

国家和机构	中国环保部/VECC/环科院		美国EPA		日本METI	
	员工	合约服务机构	员工	合约服务机构(每年)	员工	合约服务机构 (每年)
实施油品监督和达标管理的资源配置	7 (环科院5名，VECC2名)	不详	25+	每年680万人民币以上	不详	每年1.08亿人民币

6.5 建议

为确保中国市场销售的燃料能够满足相应标准，从而使车辆运行正常并满足不断加严的排放标准，环保部需要拥有执行与排放有关的燃料参数标准和进行不达标罚款的权力。因为燃料的质量不容易观测、分辨，只有企业和环保部（或其合约机构）进行全面定期的燃料采样和测试并实施良好的报告和审核计划，才能确保油品达标。要承担这一新的职责，环保部需要筹措资金，建设自身的技术能力和专业水平。以下提出了一些建议来实现这些目标。

力争修订《大气污染防治法》赋予环保部管理与排放有关的燃料质量的权力： 如我们在油品和车辆标准章节中所提到的，保障优质燃料的供应，特别是低硫燃料，是国家实施更加严格的车辆标准并由此有效控制机动车排放的必要条件。油品调查结果表明中国市场中还在销售硫含量高于标准规定的不达标燃料。赋予环保部管理与排放相关的燃料规格的权力是对这些与排放相关的燃料规格实现有效控制的众多步骤中的第一步。

From materials reviewed, it seems that there is no systematic and comprehensive fuel inspection performed by the government in China. Private companies such as SGS conduct large-scale fuel surveys across the country, but the service and data are expensive. Local Quality Technology Supervision Bureaus, and MEP and local EPB (like Beijing EPB) also conduct fuel surveys, but those surveys occur only sporadically and cover only a few cities/regions.

For MEP to establish a comprehensive enforcement program comparable in rigor to the US and Japan programs, it needs significantly more resources (staff and funds) to perform fuel analysis (either in-house or contracted-out) and auditing, as well as clear regulatory authority to demand the industry to perform more fuel testing and report results to MEP.

MEP has limited staff capacity on fuel quality enforcement

While EPA hires contractors to conduct fuel testing across the country and relies on industry-conducted surveys to monitor fuel quality, the agency has 25+ full time staff (including some scientists and inspection staff) who conduct laboratory and refinery audits, as well as oversee the design and implementation of fuel sampling and testing conducted by its contractor and by the industry-sponsored RFG and diesel fuel survey programs. The 25 staff do not include the EPA division responsible for fuel registration and reporting.

In China, CRAES has its own testing laboratory and five staff supporting MEP and Beijing EPB on fuel testing and fuel standard setting, and it is upgrading its laboratory equipment to be capable of testing China IV fuels. There are also two colleagues at VECC working full-time on fuel- and detergent-related efforts but are not involved in fuel compliance. MEP has far fewer staff than EPA has at its disposal relative to each fleet's annual motor fuel consumption.

Table 6.3: Resources for conducting fuel inspection and compliance in China, US and Japan

COUNTRY AND AGENGY	CHINA MEP/VECC/CRAES		US EPA		JAPAN METI	
	STAFF	CONTRACTOR SERVICES	STAFF	CONTRACTOR SERVICES (PER YEAR)	STAFF	CONTRACTOR SERVICES (PER YEAR)
Resources for conducting fuel inspection and compliance	7 (5 at CRAES, 2 at VECC)	Not known	25+	Over 6.8 million RMB per year	Not known	106 million RMB per year

6.5 Recommendations

To ensure that fuels sold on the market in China meet the applicable standards, so that vehicles function well and meet increasingly stringent emissions standards, MEP needs to have the authority to enforce standards for emission-related fuel parameters and assess non-compliance fines. Because fuels are fungible, compliance can only be assured through extensive, routine fuel sampling and testing conducted by industry and MEP (or its contractors), as well as a good reporting and auditing scheme. To assume this new role, MEP would need to raise fund and establish its own technical capacity and expertise. The following provides specific recommendations to achieve these goals.

Seek to modify the "China Air Pollution Prevention and Control Law" to give MEP authority to regulate emission-related fuel quality: As discussed in the fuel and vehicle standard chapter, ensuring the supply of good quality fuel, particularly low sulfur fuel, is essential for the country to advance to more stringent vehicle standards and thereby to effectively control motor vehicle emissions. Fuel survey results suggest that non-compliant fuels with sulfur levels higher than the standards are sold on the Chinese market. Granting MEP the authority to regulate emission-related fuel specifications is the first of many steps to enable effective control of fuel characteristics that are most relevant to vehicle emissions.

赋予环保部这样的权力非常重要，因为这样环保部就有权要求石油行业测试并向环保部报告燃料质量分析结果，这样就允许环保部（或其合约机构）执行站点审核和检查加油站，并对发现的违规行为实施处罚。

*为建立监督和达标管理方案寻求资金：*对美国和日本的燃料质量管理实施方案的分析明确指出，就算是企业被要求定期进行油品测试并将结果报告至管理部门，油品管理部门同样需要可观的资金、人员来支持燃料测试承包机构和管理部门进行广泛的燃料质量检查。一旦环保部获得了管理与排放有关的燃料参数的权力，就需要资金来雇佣燃料测试承包机构实施燃料采样、测试、站点审核和加油站检查，并加强环保部内部的资质和技术能力建设，从而监督承包机构的工作，管理整个油品管理工作。环保部可考虑燃料税、车辆税、车辆登记注册费和或I/M收费作为资金的来源。在争取获得授权，实施与排放相关的油品标准的同时，环保部应在近期内开始进行具体分析，判定以上提出这些潜在资金来源中哪些在法律上是可行的。

*与EPA或其它国家的管理机构合作，通过培训建设自身能力：*环保部的人员在EPA或其它地区的管理机构进行培训对环保部是有益的，可以更好地了解油品实施方案中技术方面的要求，同时可全面了解实施方案的管理。如之前所分析的，美国的燃料质量管理方案包含大量的企业报告和报告审核，以及有效地监督企业和EPA承包机构执行油品质量采样和测试。在设计管理方案和制定对企业报告及各类测试的要求时，不为管理部门和企业带来过多不必要的案头工作和油品测试要求，是保障管理方案成果的关键。与其它地区管理机构之间的培训班应在近期内开展，并定期举行（如每年或每半年一次）。

*力争修订《大气污染防治法》将油和车视为一个体系：*和我们在报告的其它章节中提出的建议一样，从根本上将燃料和车辆标准连成一体十分关键，只有这样才能够有效推行最佳的汽车排放控制技术。

Giving MEP such authority is also important because it provides the ministry with the power it needs to demand that the oil industry test and report fuel quality analysis results to MEP, allow MEP (or its contractors) to conduct on-site audits and inspect retail stations, and impose punitive fines if violations are found.

Seek funding to establish fuel inspection and compliance program: Review of the fuel quality enforcement programs in the US and Japan pointed to the need for substantial funding to cover comprehensive fuel quality inspections conducted by contractors and the regulatory agencies, even when the industry is required to test fuel periodically and report results to the regulatory agency. When MEP is granted the authority to regulate emission-related fuel parameters, funding would be needed to hire contractors to conduct fuel sampling, testing, on-site audits, and retail station inspections and to enhance capacity and technical capability within MEP to oversee contractors'work as well as manage the program. Potential sources of funding are fuel taxes, vehicle taxes, vehicle registration fees and/or I/M fees. MEP should start in the near term to conduct detailed analysis to determine which of these options are legally feasible while the ministry seeks the authority to enforce emission-related fuel standards.

Build up in-house capacity through training workshops with the EPA or regulatory agencies in other countries: MEP would benefit from having its staff trained at the EPA or other regulatory agencies to better understand the technical aspects of the fuel enforcement program, as well as the overall program management. As reviewed earlier, the US fuel quality program involves substantial industry reporting and report auditing, as well as effective oversight of fuel quality sampling and testing conducted by the industry and EPA contractors. Designing and executing the reporting and testing part of the program so that the regulatory agency and the industry are not over-burdened with paperwork and fuel testing needs is critical to the program's success. The training workshops with other regulatory agencies should be set up in the near term, and could be hosted on a regular (e.g., annual or bi-annual) basis.

Seek revisions of the "China Air Pollution Prevention and Control Law" such that fuels and vehicles are treated as one system: As recommended in other chapters of this report, it is key that ultimately fuel and vehicle standards be set in tandem and be effectively enforced to enable the best emission control technologies.

7. 排放标志识和相关管理方案

向消费者提供信息和进行宣传是交通排放控制战略中的重要组成部分，车辆排放标志正在成为日趋流行的消费者宣传手段。排放标志会在新车销售前被附加在车上，使消费者了解车辆的排放信息，让消费者能比较类似产品，清楚的做出购买决定。标志推广可以结合经济鼓励，帮助引导消费者选择更清洁更节能的车辆并由此逐步改善整体车的排放和油耗情况。在用车的排放标志通常是为了方便实施各种排放控制措施，比如划定限行（低排放）区。尽管在用车标志没有新车标志提供的信息那么详细，但它能影响车辆的使用，借此向车主进行宣传教育。

车辆排放标志或燃料经济性在世界各地被广泛应用。在美国，从上世纪70年代末期就有了强制性燃料经济性标志。在加州，新车标志上同时标有常规污染物排放评级和温室气体排放等级。欧洲的新车二氧化碳排放标志通常都结合有财税政策来支持欧盟的车辆二氧化碳减排目标。欧洲还在增加在用车标志的使用，以支持众多低排放区的实施。日本从本世纪初开始发给超低排放和超节油的车辆节能减排标志并配合以税收鼓励，这个政策多年来一直延续并不断加严。日本之所以能拥有世界上最清洁的车辆构成群体，这些政策起到了重要的作用。

在中国，车辆排放标志的概念要追溯至1999年，北京对未达到国I排放标准的车辆发放了黄标。接下来，部分省市也实施了机动车环保标志，每个地区都有各自不同的设计方案。在过去的10年中，排放标志主要用于配合高排放车辆的交通限行方案。2009年，环保部发布规定，要求实施统一的全国车辆排放标志，以便于协调管理不同地区的交通限行方案。同时，环保部和其它政府部门实施了补贴政策，鼓励黄标车提前淘汰，目标是到2015年淘汰1800万辆黄标车。这些尝试取得了成功，快速的将污染严重的车辆置换成清洁车辆。以北京为例，截止至2009年10月，已淘汰了9,7万辆黄标车，相当于黄标车总数的27%。

另一方面，从长远看，中国的标志管理方案及交通限制方案还可以从很多方面提高。例如，目前的标志不会影响新车（低排放车）的购买决定，可以改善标志的设计从而更好的适应今后加严的管理方案。本节中将介绍不同类型的排放标志并提供案例研究，对比国际上的实践经验可能会为改善中国方案提供见解。

7. Emission labeling and related programs

Consumer information and education is an important component in transportation emission control strategy and vehicle emission label is an increasingly popular tool for consumer education. Emission labels attached on new cars before sales inform consumers about the emission impact of a vehicle and enable them to compare similar products and make an informed purchase decision. The application of such labels can be combined with fiscal incentives, which help direct consumer choices towards cleaner and more efficient vehicles and therefore gradually improve the entire vehicle fleet. Emissions labels applied on in-use vehicles normally facilitate the implementation of various emission control programs such as a low emission zone. Though they provide less detailed information about a vehicle compared with new car labels, they may also educate car owners through influencing the use of the vehicles.

Vehicle emission labels or fuel efficiency labels are widely adopted in the world. In the US, a mandatory fuel economy label dates back to the late 1970s. In California, the new car label shows both emissions ratings of conventional pollutants and GHG emissions. The European new car CO_2 emission labels are often associated with fiscal policies to collectively support EU's fleet CO_2 reduction target. Europe also evidenced increase use of in-use emissions labels in support of numerous low emission zone initiatives. Japan established labels for super low emissions and super efficient vehicles with considerable tax incentives early this century, and has continued to enhance the policies since then. These policies played an important role in maintaining Japan's fleet as one of the world's cleanest.

In China, the concept of vehicle emission label dates back to 1999, when Beijing first introduced yellow sticker for vehicles that do not meet China I emission standards. Following that, a number of provinces and major cities implemented environmental labels for motor vehicles, with unique design for each region. During the past decade, the emissions labels are mainly used to facilitate the traffic restriction program for high polluting vehicles. In 2009, MEP published a rule to standardize the design of vehicle emission labels in China, which allows the harmonization of the traffic restriction programs across regions. At the same time, MEP and other state agencies initiated a subsidy program to encourage early scrappage of yellow sticker vehicles aiming at phasing out some 18 million yellow sticker vehicles by 2015. These efforts turned out to be very successful in quickly replacing the heavy polluters with clean vehicles. Beijing, for example, eliminated 97 thousand yellow sticker vehicles, or 27% of its total yellow sticker vehicles by October 2009.

On the other hand, looking forward, China' s labeling program, and the traffic restriction program can be improved in many ways. For example, current labels do not affect the purchase decision of new vehicles with low emissions. The design of the labels could be improved in order to better accommodate future tightening of the programs. This section introduces different types of emissions labels and provides case studies. A comparison of international practices provides some insight into possible improvements for the Chinese program.

7.1 国际方案概况

大体上，排放标志分为两类——新车标志和在用车标志。新车标志只在销售环节用于新车上，帮助消费者在购买前了解车辆排放油耗情况从而做出清楚的购买选择。在用车标志通常在每年登记时提供。接下来的章节中将更具体的介绍各种类型的标志。

新车标志

新车标志主要用于让消费者了解车辆的燃料经济性或温室气体排放水平。这是因为一旦选定了所购车型（及其节油技术组合），其燃料经济性（固定驾驶距离的油耗）和碳强度（固定驾驶距离的二氧化碳排放）在整个使用周期内的就不会改变。因此只有让销费者在做出购买决定前看到这些标志，标志才能发挥最大的影响作用。

新车上的燃料经济性或二氧化碳标志通常会包含具体的车辆信息，如车型种类、关键的技术参数和排放信息。一些标志还会提供燃料成本测算。英国的二氧化碳标志就是新车二氧化碳标志的一个实例，它是根据欧盟轿车标志指令实施的，将在下文中进行论述。

作为新车标志的三个实例，下面的章节将详细的介绍欧盟轿车的二氧化碳标志、加州的车辆环保性能标志以及日本的超节油汽车和清洁汽车的尾气排放和燃料经济性标志。

欧盟乘用车二氧化碳标志

2000年，欧盟议会通过立法要求所有新的乘用车向消费者提供燃料经济性和二氧化碳排放信息。各成员国根据议会的基本指导方针设计了不同的标志。大多数都在车辆标志上采用不同颜色对二氧化碳进行分级，就像家电上的能效标志（如冰箱）。消费者对类似标志设计的熟悉程度让车辆标志很容易被接受。

近几年来，在成员国中出现根据二氧化碳排放量来征收车辆税的趋势，根据车辆的二氧化碳排放范围来制订税率。2007年开始这种趋势日益增强，因为当年欧盟委员会宣布了新的欧盟2015年轿车二氧化碳减排目标，并把财税鼓励和消费者教育手段列为实现减排目标的综合途径之一。既含有车辆二氧化碳排放信息又含有二氧化碳税数额信息的标志对消费者来说就更具有实际意义，图7.1提供了英国的标志作为样例。

7.1 Overview of international programs

There are generally two types of emission labels – new vehicle labels and in-use vehicle labels. New vehicle labels are only placed on new vehicles at the point of sale, to enable consumers to make informed choices. In-use vehicle labels are generally provided at registration. The next sections will address each label type in greater detail.

New vehicle labels

New vehicle labels are mainly used to educate consumers about vehicle fuel efficiency or GHG emissions. This is because the type of car purchased determines the fuel efficiency (fuel consumption per distance of driving) and carbon intensity (CO_2 emission per distance of driving) throughout the vehicle lifetime. The labels are most effective when consumers see them before they make their purchase decision.

Fuel efficiency or CO_2 labels on new vehicles usually contain detailed vehicle information, such as model type, key physical specifications, and emissions. Some labels may also provide the estimation of fuel cost. The CO_2 label adopted in the UK required by the EU car-labeling Directive is an example of new vehicle CO_2 label and is further discussed below.

The next sections provide additional details on the EU car CO_2 label, California vehicle environmental performance label, and the Japanese exhaust emissions and fuel economy labels for super efficient and clean vehicles as three examples on new vehicle labels.

European Union Car CO_2 Label

In 2000, the EU Parliament in 2000 introduced legislation requiring that information on fuel economy and CO_2 emissions be provided to consumers for all new passenger cars. Member states have developed different label designs under the Parliament's general guidelines. Most have adopted a color-coded CO_2 band system for car labels that mirrors the energy-efficiency labels on appliances (such as refrigerators). The familiarity of such label designs has lead to their easy acceptance.

In recent years, a trend has emerged among member states to base vehicle taxes on CO_2 emission levels, setting tax rates according to a vehicle's CO_2 emission range. The trend has become stronger since 2007, when the European Commission announced a new EU-wide 2015 CO_2 emission target for cars and included fiscal incentives and consumer information programs as part of an integrated approach to reaching the target. Labels that include information on both CO_2 emission and CO_2-based vehicle tax, such as the UK's label provided as an example in Figure 7.1, are additionally valuable to consumers.

标识上的主要信息:

- 全部乘用车的二氧化碳排放等级以及本车所属的排放等级，使消费者能直接了解到与其它车辆相比本车的位置；
- 既标出本车的排放等级又给出本车的绝对排放水平（如克 / 公里），避免评级方法不同带来的主观影响；
- 燃料成本估算；
- 根据排放水平段决定的车辆税收数额（二氧化碳税收）；
- 城市、郊区和综合工况下的油耗数据；
- 车型信息和关键的车身数据让消费者可以和同类轿车进行比较；
- 声明驾驶习惯对实际排放的影响关系。

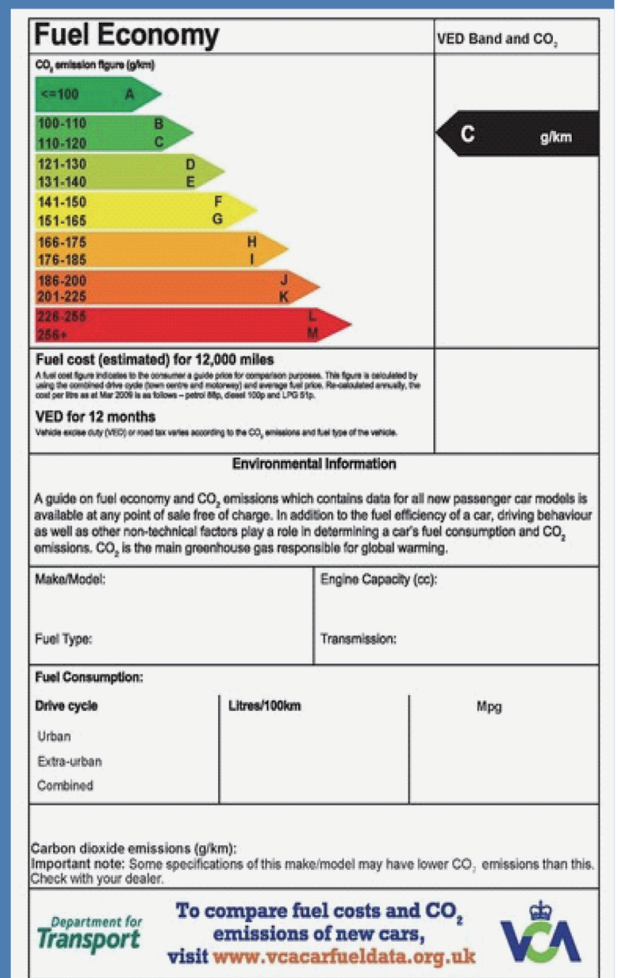


图 7.1: 英国轿车二氧化碳和燃料经济性标志

新车标志的第二个实例是加州的车辆环保性能标志。标志上同时标明了车辆的常规污染物信息和温室气体排放信息，但是没有像英国的二氧化碳标志一样提供具体的车辆信息。

Key information on the label:

- A full range of car CO_2 emission band information and the relative position of the particular vehicle to allow for easy comparison with other vehicles
- Information of both the emission category and the absolute emission level to avoid possible challenge to the subjectivity of the rating methodology
- An estimate on running cost of fuel
- VED (CO_2 tax) amount of the particular vehicle determined by the emission band it belongs to
- Fuel consumption data under urban, suburb and combineddriving cycles
- Detailed information on model type and key vehicle physical attributes to allow consumers to compare with other cars of the similar class
- Statement of relation between driving behavior and actual emissions
- Show sources for consumers to find more relevant information

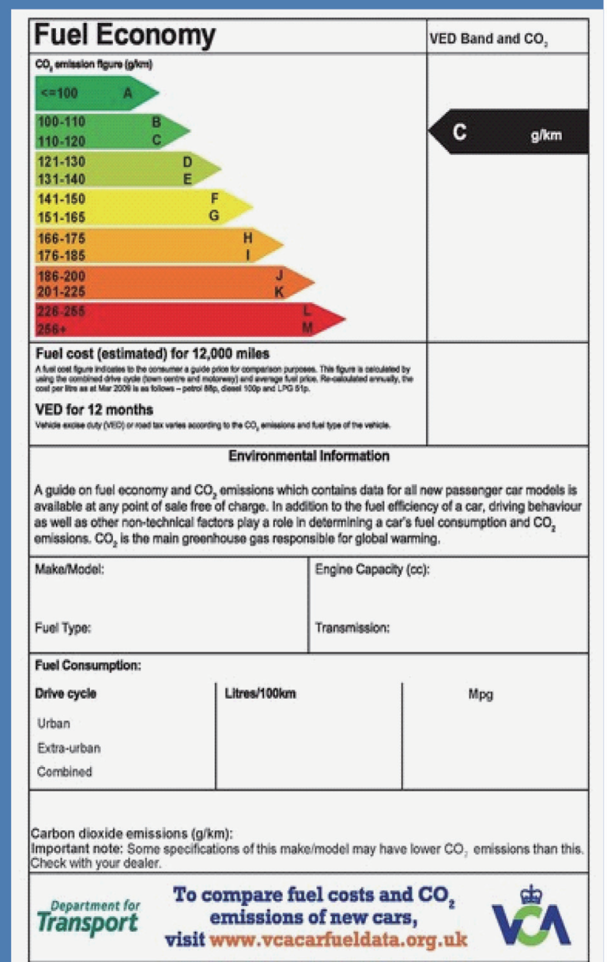


Figure 7.1: Car CO_2 and fuel economy label in the UK

The second example of new vehicle label is the Vehicle Environmental Performance Labels adopted in the State of California. The label presents both conventional pollutants information and GHG emissions information of a vehicle, but does not provide detailed vehicle information as the UK CO_2 label.

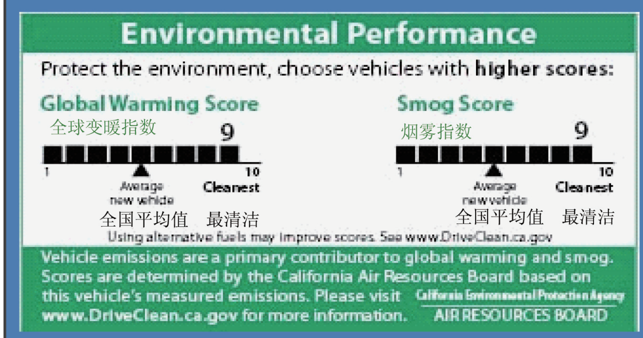
加州车辆环保性能标志

从1998年起要求所有在加州销售的新轿车带有烟雾指示标志。2005年，1229号议案要求加州空气资源局重新设计烟雾指示标志，要在其中包含全球变暖排放物的信息。2007年，空气资源局批准了新的环保性能标志，标志上包含车辆的烟雾评分和全球变暖评分，从2009年1月1日起，在加州销售的所有新轿车都必须在窗户上贴上标志。图7.2展示了标志的样例并介绍了标志的特点。

加州的环保性能标识

标识上的主要信息:

- 全球变暖评分主要基于温室气体排放，包括氧化亚氮、甲烷、氟利昂和二氧化碳
- 烟雾评分基于导致烟雾的污染物排放，包括氮氧化物、非甲烷有机气体和碳氢化合物
- 分为 1-10 分，其中 10 分是表示最清洁的分数
- 标明车辆平均水平以便进行对比
- 声明车辆尾气排放的环境影响
- 为消费者提供获取更多相关信息的渠道



使用替代燃料可能可以提高指数，详见 www.DriveClean.ca.gov
指数有加州空气资源局(CARB)通过对车辆排放进行测试得到。请登录 www.DriveClean.ca.gov 查询详情

图 7.2: 加州环保性能标志

日本的尾气排放和燃料经济性标志

日本实施了两款标志，用于确认超低排放车和超节油的车辆。政府对购买贴标车辆的消费者大幅减税。排放标志包括一个星级评价体系，以2005年全国排放标准为参考基准，来说明车辆的尾气排放情况。例如，一辆车的排放比国标要求低75%可以评为4星。燃料经济性标志也运用了与排放标志类似的评价系统，即标明车辆的燃料经济性比国标提高多少 。只有同时拥有4星排放标志和“+15%”或“+25%”燃料经济性评定的乘用车才能够获得减税幅度最高达75%的税收减免。表7.1提供了税收鼓励体系的全面信息。

California vehicle environmental performance label

Stating with the 1998 model year, all new cars sold in California began to carry a Smog Index Label. In 2005, Assembly Bill 1229 required the California Air Resources Board to redesign the Smog Index Label to include information about global warming emissions. Approved by the Board in 2007, the new environmental performance labels, which show both a Smog Score and a Global Warming Score for the vehicle, must be affixed to the window of every new car sold in California manufactured after January 1, 2009. Figure 7.2 shows an example of the label and highlights its features.

Environmental Performance Label in California

Key information on the label:

- Global warming score based on GHG emissions including N_2O, CH_4, HFC and CO_2
- Smog score based on smog pollutants including NO_x, NMOG and HC
- Adopts a scale from 1 to 10 with an indication of that 10 is the cleanest score
- Show average vehicle performance to allow easy comparison
- Statement of the environmental impacts of vehicle exhaust emissions
- Show sources for consumers to find more relevant information

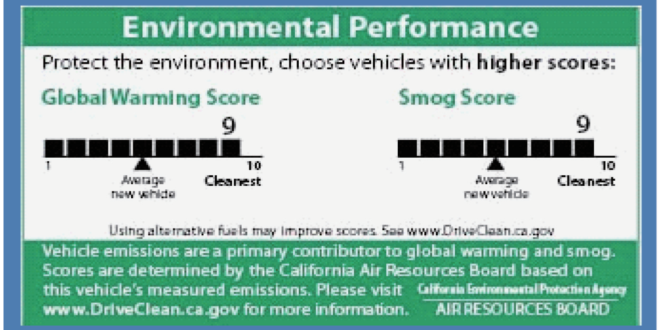


Figure 7.2: California environmental performance label

Japan's Exhaust Emission and Fuel Economy Label

Japan developed two labels to recognize vehicles with super low tail pipe emissions and super fuel-efficient vehicles. The government also provides significant tax cuts for consumers who purchase vehicles with the labels. The emissions label includes a star rating system indicating the tailpipe emission status of a vehicle using its 2005 national emission standard as the reference. For example, a vehicle with emissions 75 percent lower than the national requirements receives 4 stars. A parallel labeling system indicating how much improvement a vehicle achieved above the national fuel economy standard has been established on a separate fuel economy label. For passenger cars, only those that achieve both the 4-star emissions label and a “+15%” or “+25%” fuel efficiency rating simultaneously can receive up to 75 percent tax reduction. Table 7.1 provides complete information about this tax incentive system.

表7.1: 日本尾气排放和燃料经济性标志说明

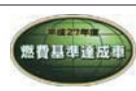
车辆类型	要求	核发标志		减税		
				购置税*	吨位税*	汽车税*
节油和低排放车辆（乘用车和微型车）	燃料经济性比2010年标准提高25%，排放比2005年标准低75%			75%	75%	50%
	燃料经济性比2010年标准提高15%，排放比2005年标准低75%			50%	50%	25%
重型车(车辆最大总质量大于3.5吨的卡车和巴士)	符合2015年燃料经济性标准和2009年排放标准			75%	75%	/
	符合2015年燃料经济性标准，氮氧化物或颗粒物排放比2005年标准低10%			50%	50%	/

注: 日本的机动车主要有三种税——在购买汽车时征收购置税；根据车辆重量每年征收吨位税；根据车辆发动机排量每年征收汽车税。财税鼓励都反映在这三项税收当中。

在用车标志

在用车标志在设计上比较简单，主要为配合实施其它的排放控制方案。一旦在年检或年度登记时取得了标志，就要求车主在规定的车身明显位置上一直粘贴标志。本文介绍的实例包括德国配合低排放区方案的排放分类标志和东京用于重型卡车限行的“通行证”类型的标志。这些标志利用不同的设计、颜色或数值标志，也能够在某种程度上为车主提供车辆的排放特征信息，但是因为标志是在车辆被购买以后才贴上的，这些信息不能直接影响新车的购买决策。另外，展现出的信息通常也不够详细，不足以让消费者进行同类车型比较。这也限制了标志在消费者选择购买二手车时的影响力。在下面的章节中，我们将更详细的介绍德国和日本的标志。

Table 7.1: Illustration of Japanese exhaust emission and fuel economy stickers

VEHICLE TYPE	REQUIREMENTS	CERTIFICATION STICKERS		TAX REDUCTION		
				ACQUISITION*	TONNAGE*	AUTOMOBILE*
Fuel-efficient and low-emission vehicles (passenger cars and mini cars)	Compliant +25% compared to 2010 fuel efficiency standards and emissions down by 75% from 2005 standards			75%	75%	50%
	Compliant +15% compared to 2010 fuel efficiency standards and emissions down by 75% from 2005 standards			50%	50%	25%
Heavy-duty vehicles (Trucks and buses with GVW above 3.5 tons)	Compliant with 2015 fuel efficiency standards 2009 emission standards			75%	75%	/
	Compliant with 2015 fuel efficiency standards with NOx or PM emissions down by 10% from 2005 standards		  	50%	50%	/
Note: Automobiles in Japan are subject to three major taxes—an Acquisition Tax due at vehicle purchase, an annual Tonnage Tax based on vehicle weight, and an annual Automobile Tax based on vehicle engine displacement. Tax incentives are reflected in all three tax items.						

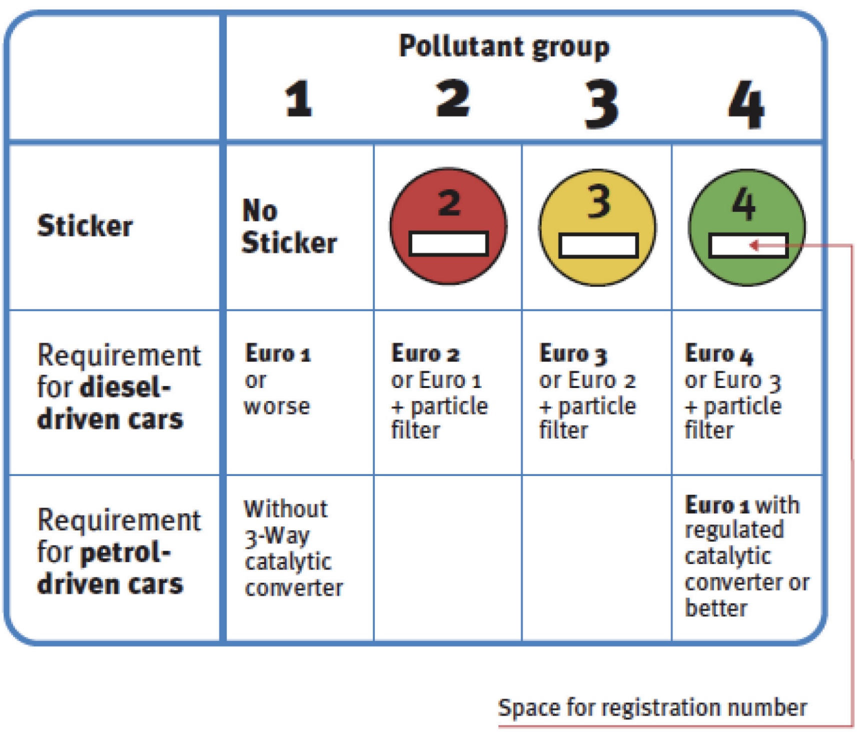
In-use vehicle labels

In-use vehicle labels have much simpler designs to facilitate the implementation of other emission control programs. Once obtained at annual vehicle registration or annual emissions test, the in-use labels are required to be attached in a prominent location on the vehicle at all time. Examples include the emission category stickers associated with the low-emission zone program in Germany and the "pass"-style sticker used in the traffic-banning program for heavy trucks in Tokyo. Such labels, differentiated by designs, color, or number, also inform car owners, to some extent, about the emission characteristics of their vehicles, but because they are affixed after a vehicle is purchased that information doesn't directly affect new vehicle purchasing decisions. In addition, the information shown often is not detailed enough to allow consumers to compare with similar vehicles. This also limits the label's influence on consumer choice when purchasing used vehicles. The next sections introduce in greater detail vehicle labels in Germany and Tokyo.

德国：低排放区标志

为了减少机动车的细颗粒物和氮氧化物排放，德国在主要城市设立了低排放区（LEZs）：目前已经设立或计划中的低排放区有43个。低排放区是一个地理区域，通常是城市的核心区，在这里只有尾气排放达到特定标准的车辆才允许通行。为辨别合格车辆，特别设计推行了一款按颜色分级的尾气排放标志。

与旨在为消费者提供购买信息的标志相比，德国的低排放区标志设计相对简单。共有3种不同的标志，每种都有明显的颜色和数字来说明车辆的排放等级（图7.3）。轿车车主会在进行车辆登记时会获得标志。即使设计简单，这些标志有效的起到了它们的基本作用——协助低排放区方案的实施，从而减少城市中心区的排放，加速车辆更新和柴油车改造。与此同时，这个简单并广泛普及的标志和低排放区制度本身也能推动大众对车辆污染的认识和对清洁车辆的需求。最后，车辆



	排放组别			
	1	2	3	4
标志	无标志			
对柴油车要求	欧1或以下	欧2或欧1加微粒过滤器	欧3或欧2加微粒过滤器	欧4或欧3加微粒过滤器
对汽油车要求	无三元催化转换器			欧1并有催化转换器或更好

图7.3: 德国低排放区标志

Germany: Low Emission Zone Sticker

Germany introduced low emission zones (LEZs) in major metropolitan cities in order to reduce fine particulate matter and NOx pollution from vehicles; 43 are now established or planned. A low emission zone is a geographical area, usually a city's inner core, where only vehicles meeting certain exhaust emissions standards are allowed to travel. To identify qualifying vehicles, a color-coded vehicle exhaust emissions sticker was specially designed and introduced.

Compared with consumer information labels, the design of the German LEZ stickers is relatively simple. There are three different designs of stickers, each with a distinct combination of color and number indicating the emissions class of a vehicle (Figure 7.3). Car owners obtain the labels when they register the vehicle. The labels effectively serve their primary purpose, to enable LEZ program enforcement in order to reduce emissions in the central city and accelerate fleet turnover and retrofits of diesel vehicles. At the same time, the simple and ubiquitous stickers, along with the program itself, may also promote greater awareness of vehicle pollution and the need for cleaner vehicles. Finally, car registration numbers are shown on the front of the label in a designated area.

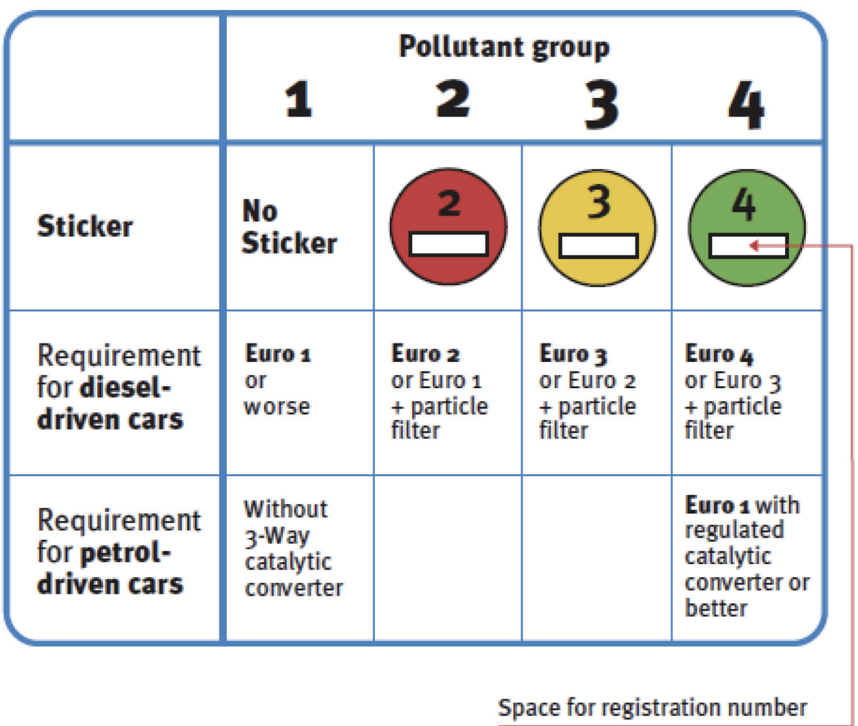


Figure 7.3: Germany LEZ labels

德国的低排放区方案根据不同城市的需求分阶段实施。例如柏林的低排放区，在第1阶段（2008年—2009年12月），贴有三种标志的车辆都允许通行，但不允许无标志（欧1或更差）车辆进入。在第2阶段，即从2010年1月起，只有绿标车允许在区域内通行。两阶段实施计划都是2007年宣布的，这样就给了车主几年的时间对上下班交通方式进行必要调整或来计划更新改造他们的车。

东京：重型柴油卡车排放标志

东京及其周边的8个县联合强制实施了一条柴油车排放管理法令，并在90年代末期发起了名为“对柴油车说不”的排放控制方案。该方案禁止不能满足法令规定的颗粒物标准的重型柴油卡车进入城市控制区。满足标准要求的车辆会核发给蓝色的标志，贴在挡风玻璃上。标志正面也有车辆的牌照号。

图 7.4: 东京的“对柴油车说不”标志

和德国的低排放区标志不同，“对柴油车说不”方案的标志没有标明车辆所能达到的标准，只是看车辆能否满足地方法令。每当标准加严，车辆就必须重新进行认证并获得新的标志。

总结

在国际标志和低排放区方案中，与中国关系最密切的特征总结如下：

- 新车标志能影响消费者的购买决定并可以配合财税鼓励方案，加强对消费者的宣传并引导购买决定。在标志内容方面，加州和英国的标志都为消费者提供了本车的排放水平在全体车队中的相对位置。英国的标志还标明了绝对排放水平，更进一步的告知消费者车辆的实际环境影响。

- 在用车标志是特别设计用来配合地方排放控制方案的，如交通限行方案。它们的设计简单但独特，始终贴在车身上，很容易被管理机构识别。在此总结国际案例的三个特点供中国政策制定者参考。

  o 在德国的低排放区，针对每个排放等级都一个特别的标志设计与之对应。这种设计即容易为车主理解和接纳，又不容易造成当低排区限行标准加严时公众可能产生的困惑（比如如果一种标志设计对应的是多个排放等级，当限行的排放标准加严时，有可能新的达标车和不达标车仍在使用同样设计的标志。这就需要替换原来的部分标志以便区分达标车辆，这样会给车主带来一定的困惑）。东京的颗粒物认证标志没有明显的区分排放等级。但是鉴于该管理方案只是针对商业物流公司，它们都是成批地检测车辆并领取标志，消费者的混淆也就不成为主要问题了。

The German LEZ programs are implemented in stages with varied schedules according to the needs of different cities. For example, in the Berlin LEZ program, during stage 1 (2008 to December 2009) vehicles with all three labels were allowed to travel into the zone but vehicles without stickers (Euro 1 or worse) were not allowed in. In stage 2, which began January 2010, only vehicles with green labels are allowed in the zone. The implementation plan of both stages was announced in 2007, allowing car owners several years to make necessary adjustments to their commute plan or replace or retrofit their vehicles.

Tokyo: Emission sticker for heavy diesel trucks

Tokyo and its eight neighboring prefectures joined forces to introduce an ordinance regulating diesel emissions and initiated a “Say No To Diesel” program in late 1990s. The program restricted diesel heavy trucks that did not meet PM standards defined in the ordinance from traveling into the controlled metropolitan areas. Vehicles that meet the standards are granted a blue certificate that is attached to their windshield. The label also shows the vehicle's license plate number on the front.

Figure 7.4: Tokyo's "Say No to Diesel" label

In contrast to Germany's LEZ label, the "Say No to Diesel" program label does not show what standard the vehicle complies with, only whether it meets that local ordinance. Each time the standards are strengthened vehicles must be recertified.

Summary

Features of the international labeling and LEZ programs most relevant to China are summarized below:

- New vehicle labels affect consumer purchase decisions and can be combined with fiscal incentive programs to enhance consumer education and steer purchasing decisions. In terms of label content, both California's and the UK's labels inform consumers of the relative position of a vehicle compared with the whole fleet. UK's label also shows the absolute emissions level, which further informs consumers about the vehicle's actual environmental impact.

- In-use vehicle labels are specially developed to assist local emission control programs, such as a traffic restriction program. Their design are simple but unique, to be placed on vehicles all the time, and to be easily recognized by enforcing parties. There are three specific observations related to in-use vehicle labels.

  o In the German LEZ program, each emissions class is associated with a distinct label. This helps reduce confusion the public's confusion when the program is strengthened and is a visually clear signal that can be understood by consumers. For example, if the same label design applies to more than one emission grades, when the traffic restriction program tightens, part of the vehicles associated with that label will be affected but the rest will not. Consumers cannot distinguish between vehicles affected or unaffected by referring to the label design. In this case, the government has to replace the labels for affected vehicles, in order to make the distinction. Tokyo's PM certificate label does not distinguish between emission classes. But given that the program only affects commercial logistics companies that test their vehicle fleet and obtain labels in a group, this is less of a concern.

o 在东京和德国的方案中，都要求一个标志对应一辆车，标志上明显的标明相关车辆的登记号或牌照号。这就降低了标志被盗或有意滥用的风险。

o 如果仅仅是为了配合交通限行方案，根据实施手段的先进程度，可能将不再需要一个实质的标志。例如，得益于数码拍照和图像传输技术，伦敦通过读取和匹配车牌号码来实施低排放区方案，而不是依赖于应用额外的排放标志。

• 地方性交通限行方案能有效帮助污染和拥堵最严重的城市中心区逐步淘汰高排放车。德国的低排放区方案表明，政府可以考虑为特定车型提供弹性达标方式，并给消费者足够的适应期。

o 除了单纯的禁止高排放车，低排放区方案为政府提供了其它可考虑的选择。针对氮氧化物和颗粒物排放，德国管理方案允许车辆通过改造（安装颗粒物捕集器）来提升一个等级。例如，没有颗粒物捕集器的欧3柴油轿车是黄标的，而同样的车型，装有捕集器就可以领取绿标。

o 德国的方案还从一开始就设置了分步实施计划，给消费者足够的时间在实施交通限制之前调整他们交通出行的选择或更新改造他们的车辆。

7.2 中国的排放标志和相关管理方案概况

中国的车辆排放标志方案意在逐步淘汰污染最严重的车辆。如今，中国的6400万道路行驶车辆中，有1800万，即28%是国I前汽油车或没有颗粒物控制装置（柴油车氧化催化器或颗粒物捕集器）的国III前柴油车。这些车的尾气总排放量占全部车辆排放的75%[86]。在拥堵严重的城市，大量高排放车辆造成严重的空气质量问题。在过去10年里，如北京、深圳、上海和广州这样的大城市都已经实施了车辆排放标志和交通限制方案。一些中型城市也跟着实施相关方案。

2009年7月，环保部发文在全国范围内统一了在用车标志。 中国所有进行登记注册的车辆都必须进行排放检测，基于测试结果来划定的排放等级，并依此获得排放标志。表7.2总结了新的全国统一的获得绿标的排放标准，图7.5展示了所使用的标志样式。可以领取绿标的车辆包括达到国I及国I以上排放标准的四轮点燃式汽车、到达国III及国III以上排放标准的四轮压燃式汽车和达到国III及国III以上排放标准的摩托车和轻便摩托车。不能达到这些最低标准要求的车辆则领取黄标。根据车辆的类型和使用年数，标志的有效期为6-12个月，在定期车辆排放检测时更换新标志。标志上除了（通过颜色）反映出车辆是否满足相应标准和认证有效期以外，没有其它更多的信息。

86 环境保护部机动车排污控制中心网上新闻，2008年8月18日http://www.vecc-mep.org.cn/news/news_detail.jsp?newsid=34386。

o In both the Tokyo and German programs, a label is specific to a particular vehicle—labels prominently show the registration or license plate number associated with that vehicle. This reduces the risk of label theft and intentionally misuse of labels.

o Finally, depending on enforcement tactics, a physical emission label may not be necessary if its only purpose is to help enforce a traffic control program. For example, thanks to the digital camera and image translation technologies, London enforced its LEZ program through reading and matching vehicles license plate numbers without relying on the application of an additional emission label.

• Local traffic restriction programs are useful tool to help phase-out heavy emitters in the most polluted and congested central urban areas. The German LEZ program shows that the government may consider flexible compliance methods for certain types of vehicle, and allow enough lead time for consumers to adapt.

o LEZ programs allow the government to consider alternative compliance pathways other than simply banning the high polluting vehicles. Focusing on NOx and PM emissions, the German program allows vehicles to move up one category through retrofits (particle filter installation). For example, a Euro 3 diesel car without a PM filter carries a yellow label, while the same model with a filter receives a green label.

o The German program also established a phase-in schedule from the beginning, providing consumers enough lead-time to adapt either their travel arrangements or replace or retrofit their vehicles before travel restrictions were in place.

7.2 Overview of China's emission labeling and relevant programs

China's vehicle emission labeling program aims at phasing out the most polluting vehicles. Of the 64 million motor vehicles operating in China today, 18 million, or 28 percent, are pre-China I gasoline vehicles or pre-China III diesel vehicles without particle control equipment (diesel oxidation catalysts or PM filters). These vehicles represent 75 percent of total exhaust emissions from all vehicles[86]. In most congested cities, the large numbers of high emission vehicles contribute to severe local air-quality problems. During the last decade large metropolitan areas such as Beijing, Shenzhen, Shanghai, and Guangzhou have introduced vehicle emission labels and traffic restriction programs. A number of other midsize cities have followed suit.

In July 2009, the MEP announced a new normalized labeling system nationwide. Table 7.2 summarizes the requirements for issuing the two types of labels, and Figure 7.5 illustrates the design of the labels. Vehicles receiving green labels include all spark ignition engine (SIE) four-wheelers that meet China I emission standard and above, compression ignition engine (CIE) four-wheelers that meet China III emission standard and above, and motorcycles or motor scooters that meet China III emission standard and above. Vehicles that do not meet these minimum requirements (but still meet their corresponding emission standards) receive yellow labels. Vehicles fail to meet their corresponding emission standards cannot be granted a label.

86 Online news from the Vehicle Emissions Control Center of the Ministry of Environmental Protection, August 18, 2008, online, http://www.vecc-mep.org.cn/news/news_detail.jsp?newsid=34386.

特别是，尽管标志背面有车牌号，但在标志正面没有明示车辆的具体信息。

表7.2: 中国车辆排放标志定义

车辆种类		绿标的最低要求
汽车	点燃式	达到国I标准
	压燃式	达到国III标准
摩托车 /轻便摩托车		达到国III标准

图 7.5:中国的车辆黄绿标

如前所述，中国引入车辆排放标志主要是为了配合实施排放控制措施。目前为止，标志已经被用于支持两项方案：区域交通限制和全国范围的报废鼓励。区域交通限制措施与欧洲的低排放区类似。在特定时间段禁止黄标车进入城区，北京从2009年10月起，不允许黄标车进入六环（这个限制区域较之当初扩大了很多，2003年刚刚开始实施限行措施时，仅仅是在二环路内限行）。

2009年6月，环保部、财政部和发改委等六家政府部门在全国范围内联合实施了为期一年的消费者补贴方案，来逐步淘汰高排放车辆。在这项方案中，车主（私人、政府机构或商业机构）凡是报废符合规定的老旧或黄标车辆，购买新车的，根据车辆类型，可以一次性获得3000-6000元人民币的现金返还。2010年1月，根据车辆类型，补贴金额被提升至最高1.8万元。一些地方政府还进一步提供额外的财税鼓励。以旧换新补贴方案将延期至2010年年底。

这些实施方案目前已经在全国成功的淘汰了数以千计的高排放车。不过，从另一方面，有报告指出并不是所有地方政府都要求以旧换新车辆提供报废证明。这样高排放车辆就可以被卖到其他地方，削弱了方案的减排效力。

Depending on vehicle type and age, labels are valid for 6 to 12 months, and renewal is contingent at results of their emission tests.

The labels contain no additional information other than whether a vehicle has met the relevant requirement and the certification's expiration date. Specifically, there is no vehicle-specific information shown on the front side of the labels although the license plate number is present on the back of the label.

Table 7.2: Definition of China's vehicle emission labels

Vehicle Type		Minimum requirement for Green label
4-wheelers	SIE	Meet China I Standard
	CIE	Meet China III Standard
Motorcycles / Scooters		Meet China III Standard

Figure 7.5: China's green and yellow vehicle labels

As indicated, China's vehicle emission labels are introduced mainly to assist in enforcing emission control programs. So far, the labels have been used to support two types of programs: local traffic restrictions and a national scrappage incentive. The concept of the local traffic restriction program is similar to the LEZs in Europe. Vehicles with yellow stickers are banned from travelling into the inner city area during some time period. For example, in Beijing beginning October 2009, yellow-sticker vehicles were not allowed to enter the 6th Ring Road. (This is an expansion of the restricted area, which only extended to the 2nd Ring Road when the program was initially introduced in 2003.)

In June 2009, MEP, MOF, NDRC, and six other government agencies collaboratively initiated a one-year nationwide consumer subsidy program to phase-out old and highly polluting vehicles. Under the program, vehicle owners (private, governmental, or commercial) who replace and scrap their qualified old or yellow-sticker vehicles with new purchases are eligible for one-time cash rebates ranging from RMB 3,000 to RMB 6,000, depending on vehicle class. The amount of subsidy was raised to up to RMB18,000 depending on vehicle type in January 2010. Some local governments provided additional financial incentives as well. The program is extended to end of 2010.

Such programs have successfully eliminated thousands of high-polluting vehicles across the country so far. But on the other hand, reports indicate that not all local governments require proof of scrappage of the vehicles traded-in. High-emitting vehicles could then be sold elsewhere, undermining the effectiveness of the program.

北京计划对混合动力车和零排放车使用另外的排放标志，不过目前还没有如何使用标志的计划。标志会是绿色底色，中间有“电动车”字样。

7.3 中国方案与国际经验对比

在前文中介绍的标志方案可以根据下列准则予以评估。

- 对消费者的影响。新车标志和在用车标志从不同角度影响消费者。新车标志会影响到消费者决定购买的车辆类型。当在用车标志运用于交通限制方案，会通过限制交通令高污染车辆的车主减少驾驶，鼓励他们升级车辆或更换新车。

- 长期使用计划。排放标志在设计上应当为方案日后的升级提供条件。各类标志必须严格定义并能够在方案升级时体现出对应的排放组别。例如，在一项交通限行方案中，如果下一步要限制欧3车并在今后进一步限制欧4车，那么每个组别就都应该用独立的标志来体现。另外，在方案实施之初就引入所有可能需要的标志会带来日后实施的便利，并且政府应当为方案实施中的每一步提供足够的过渡期。以上两点可以帮助消费者了解政策的长期影响并做出相应的出行计划调整决策。

德国的标志系统清楚的定义了各类车，可以适应长期政策的要求。德国政府在最初就宣布了长期要求，给出了几年的过渡时间。东京的标志是基于是否通过标准，不过该方案仅仅是针对商用卡车运输公司，更换标志不会对广大的普通车主带来困惑。另外，东京的方案给予商业运输公司7年的缓冲期。

尽管北京采用星级系统来表明车辆所达到的排放标准，全国绿标方案存在的最大问题就是没有明确的区分达到国I、国II、国III及以上标准的车辆。这样不利于实施更加严格的交通限制措施和对清洁车辆予以财政鼓励，例如财税激励政策如果要对绿标车给予财税鼓励，那么国V和国IV车将获得相同的激励力度，尽管国V理应得到更高的鼓励。另外，缺少今后加强交通限制方案的明确计划，这就削弱了消费者计划购买超低排放车的积极性。

- 非法使用、盗用标志的潜在可能。比起新车标志，滥用对在用车标志而言是一个大问题。 对于新车而言，显示车型信息（如排量、车重等）就足以防止经销商滥用。在这方面，加州不要求显示任何特定车型信息，而英国的标志上则有详细的车型信息。在用车标志应当对应特定车辆，这样一来，即使标志被偷也不能用于其它的车上。东京和德国的标志上都有车辆的车牌号码。中国的在用车标志没有在正面显示车辆的任何特定信息（尽管在背面有车牌号），这样就造成了更大的滥用可能。

表7.3总结了上述的标志方案是否满足上述这些准则。

Beijing is considering introducing additional emission labels for hybrid electric and zero emission vehicles, though there is no proposal on how to make use of the labels. The label has a green colored background and shows "Electric Vehicle" in the middle.

7.3 Comparison of the China's program and international practices

The labeling programs reviewed in the previous sections can be evaluated according to the following criteria.

• Impact on consumers. New vehicle labels and in-use vehicle labels influence consumers in different ways. New vehicle labels affect consumer decision on the type of new vehicle they purchase. In-use vehicle labels when combined with traffic restriction programs, may encourage owners of more polluting vehicles to drive less by shifting their transportation modes, or encourage them to upgrade their vehicles, or to replace them with new vehicles.

• Long-term programmatic use. The design of emission labels should allow for future strengthening of the program. The label categories must be well defined and should represent the individual emissions group targeted for each future step in strengthening the program. For example, in a traffic restriction program, if the next step is to restrict Euro 3 vehicles and a further step is to restrict Euro 4 vehicles, there should be separate labels representing each group. In addition, it is beneficial to introduce all potential label categories at the beginning of a program, and government should provide adequate lead-time before implementing each step of a program. These two points help consumers understand the longer-term impacts of the policy and make plans and decisions accordingly.

The German labeling system has distinct and well-defined categories that can accommodate longer-term policy requirements. The German government announced the longer-term requirements at the beginning, allowing several years' lead-time. The Tokyo label is based on a pass/fail standard, but because the program only targets commercial trucks, changing the label may not create much confusion. In addition, the Tokyo program granted a 7-year grace period to commercial logistics companies.

The biggest concern with China's standardized national green label program is that it does not distinguish among vehicles that meet China I, II, and III standards and above although Beijing used to have a star system indicating emission standard levels of a vehicle. This will impair both the label's abilities in facilitating a tightened traffic restriction program and its ability to support a fiscal incentive to encourage cleaner vehicles. In the latter case, if incentive is provided for green sticker vehicles, both a China V or China IV would receive the same level of incentive, despite the fact that China V vehicles should deserve higher incentive given that they are cleaner. In addition, there is no clear plan to strengthen the traffic restriction program in the future, which reduces the incentives for consumers to plan for buying the lowest emission vehicles.

• Potential for misuse. Misuse is more of an issue for in-use vehicle labels than for new vehicle labels. For new vehicles, showing vehicle model information (such as displacement, weight etc) will be sufficient to prevent from misuse by dealerships. In light of this, the California label does not show any model-specific information, while the UK label shows detailed model information. In-use labels should be specific to a vehicle, so that if a label is stolen it cannot be used on another vehicle. Both the German and Tokyo labels include the vehicle license plate number. China's in-use label does not show any vehicle-specific information on the front (though it shows the license plate number on the back), and thus is subject to higher potential misuse.

Table 7.3 summarizes how the labeling programs discussed here measure up to these criteria.

表7.3: 标志方案评估

	加州/英国	德国	东京	中国
标志类型	新车	在用车	在用车	在用车
标志目的	消费者教育与鼓励	实施低排放区	实施“对柴油车说不”方案	实施交通限制和报废方案
对消费者的影响 说明: 影响取决于标志的类型和设计方案	购买决定	使用行为	使用行为	使用行为
长期使用计划 说明:标志种类设计是否完善，管理方案是否提供了足够的过渡时间	不适用	简单 (好) 原因：标志种类定义完善，管理方案提供了合理的过渡时间	一般 原因：只有一种标志，不过管理方案提供了合理的过渡时间	困难 原因：标志种类定义不明确，管理方案没有提供合理的过渡时间
滥用的潜在可能 说明: 标志上是否由特定的车辆或车型信息	中等 原因：加州标志上没有车型信息	低 原因：标志上有车牌号	低 原因：标志上有车牌号	高 原因：标志上的车型信息有限
颜色注解: 绿色＝最理想，蓝色＝中等理想，红色＝最不理想				

7.4　支持消费者宣传计划

如果没有配套的消费者宣传计划，使消费者了解标志的基本含义并认识到哪些才是最环保的选择，车辆排放标志本身能起到的作用会很有限。当然，大多数标志或多或少的能提供一些这方面的信息。例如，加州的环保性能标志上指出了排放最清洁的评分，并同时显示了本车的评分。就算是在用车标志，上面使用的颜色和数字也可以说明车辆的清洁程度。但是鉴于标志大小有限，这些信息不能回答消费者可能存在的大量问题。具体问题可能包括车辆的实际环境影响或改善排放性能的方法。从长期角度，配套的消费者教育将会促进更多环保的消费行为。

Table 7.3: Labeling program evaluation

CRITERIA	CALIFORNIA/UK	GERMANY	TOKYO	CHINA
Type	New	In-use	In-use	In-use
Goal	Consumer education and incentive	Enforce LEZ	Enforce "Say No to Diesel"	Enforce traffic restriction and scrappage programs
Impact on Consumers Explanation: the impacts depend on label type and design	Purchase decision	In-use behaviors	In-use behaviors	In-use behaviors
Long-term programmatic use Indicator: if label categories are well defined and if program provides enough lead-time for consumer adjustment	Not applicable	Easy (Good) Reasons: label categories well defined; program provides reasonable lead-time	Fair Reasons: only one label category; but program provides reasonable lead-time	Difficult Reasons: label categories not well defined; program does not provide reasonable lead-time
Potential for misuse Indicator: if label shows specific information about a particular vehicle or model	Some Reason: the California label does not show model data	Low Reason: label shows license plate data	Low Reason: label shows license plate data	High Reason: label shows limited model data
Color code: Green=most desired; Blue=moderately desired; red=least desired				

7.4 Supporting consumer education programs

Vehicle emission labels alone may only achieve limited results without a matching consumer educational program that provides consumers with a basic understanding of what the label means and what the most environment-friendly choice is. Of course, most labels will display, to more or less extent, such information. For example, the California environmental performance labels point to the cleanest emission score at the same time showing the score for a particular vehicle. Even on the in-use vehicle labels, the use of colors and numbers may indicate the cleanness status of a vehicle. But given the limited space of a label, such information can never be thorough to answer a lot of important questions that consumers may have. Typical questions may include the vehicle's actual environmental impacts or ways to improve its emission performance. Such educational programs will foster more environment-friendly consumer behaviors in the long run.

美国EPA每年会在车辆燃料经济性标志基础上发布《绿色汽车指导手册》（指导）。指导中会介绍美国整体车队的燃料经济性情况和车辆的排放特征，并评出各类别车辆中最节油和最清洁的车型。《2007年能源独立与安全法》要求美国交通部（与能源部和EPA进行协商）制订综合的教育计划，增进消费者对标志的了解。

同样，德国在2007年， 即低排放去方案实施之前一年，就利用所有公共媒体进行了非常深入的消费者教育宣传活动。

7.5 建议

总的来说，环保部应制定中长期标志政策和区域排放控制战略。尽管近期的标志主要是为了支持排放控制措施，它们也可以作为向消费者进行宣传教育的重要手段。中国可以更多的考虑将环保标志与财税鼓励相结合。下面列出了环保部可能考虑的一些步骤，从长期角度强化管理方案：

- 为避免标志被盗或滥用，可考虑在在用车标志的显著位置附上某车辆的特有信息（如车牌号码）。

- 近期（未来5年），环保部应考虑改革现有的标志体系，以便可以更容易地过渡到未来加严的交通限制措施。目前的绿标需要分开，以便区分国I以上各个排放级别的汽油车和国III以上各个排放级别的柴油车。应允许包含改造车辆。每个新的排放级别都需要不同设计的标志。

- 环保部可以考虑将现有的在用车标志的功能拓展至售前消费者信息标志，并结合标志引入财税（例如税收鼓励）或非财税（例如指定停车位）鼓励政策。这些政策可以包括对清洁车辆减税，就像对国II车辆实施过的那样。这些鼓励措施应该在新排放标准实施之前的几年内执行。例如，在未来几年中可以在拥有低硫燃料的城市或地区针对国VI车辆使用先进标志，配以有力的鼓励政策（货币或非货币的），加速国VI车的商业化推进。

- 从中长期角度，城市和地区可以通过逐步加严对允许进入市中心区的车辆的要求来强化交通限制措施，在此特提供设计严格管理方案的三项基本指导原则。首先，交通限制措施应该允许特定车辆有多种达标途径，例如柴油车改造。德国的低排放区在这方面提供了可借鉴的经验。第二，在实施更严格的管理方案之前，定义好车辆种类是必要的。第三，政府应尽早发布长期实施计划，为生产企业和消费者提供足够的过渡期来适应新的要求。

- 环保部应在新车上引用温室气体排放标志来进行消费者宣传，或修订现有的油耗标志来满足这一用途。中国应当考虑向温室气体排放低的车辆提供鼓励（详见第8章）。

- 环保部应考虑支持消费者宣传教育计划来提高消费者对标志的认识。

- 如果环保部考虑使用消费者信息标志来影响消费者的购买决定，实施机构应确保消费者能够在销售环节看到这些标志。通常，在没有强效实施方案时，汽车经销商可能不会主动向消费者展示和讲解标志。

The US EPA publishes Green Vehicle Guide every year along with the issuance of vehicle fuel economy labels. The Guide introduces the overall fuel economy and emission characteristics of the US fleet, and ranks the most fuel-efficient and cleanest models in each vehicle class. The Energy Independence and Security Act of 2007 also required DOT (in consultation with DOE and EPA) to develop more comprehensive educational programs to improve consumer understanding of the label.

Similarly in Germany, comprehensive campaign, involving all public media, disseminated information about the low emission zone program and the emission stickers starting in from 2007, a year before the programs were implemented.

7.5 Recommendations

In general MEP should develop mid- to long-term labeling policy and regional emission control strategies. Though in the near-term labels primarily support emission control programs, they can also serve as an important consumer education tool. China might in addition consider combining label requirements with fiscal incentives. Listed below are some possible steps that MEP may consider to follow in order to strengthen its program over time:

- To avoid label theft or misuse, consider displaying vehicle-specific information (such as license plate number) prominently on the in-use vehicle label.

- In the near-term (next five years), MEP should consider a reform of the current labeling system to allow an easier transition to a strengthened traffic restriction program. The current green label category needs to be broken down to distinguish between gasoline vehicle emission classes above China I and diesel vehicle emissions classes above China III. Allowances should be made to include retrofitted vehicles. Each new category needs a distinct design.

- MEP may consider extending the function of the current in-use labels to pre-sale consumer information labels, and introducing fiscal (e.g. tax incentive) or non-fiscal (e.g. designated parking space) incentives to combine with the labels. Such policies may include, for example tax deduction for cleaner vehicles as was done for the introduction of China II vehicles. Such incentive programs should be introduced several years before the new emission standards are phased-in. For example, an advanced label for China VI vehicles could be introduced in cities/regions with at lower sulfur fuel, with favorable incentive policies (monetary or non-monetary) within the next few years, to speed up their commercialization.

- In the mid- to long- term, cities and regions may strengthen the traffic restriction programs by gradually tightening the requirements for vehicles allowed in the core city areas. No specific schedule is recommended, but rather three general guidelines for designing a more stringent program are provided. First, traffic restriction programs should allow alternative compliance pathways for certain vehicles, such as retrofitted diesel vehicles. The German LEZ program offers a useful experience in this respect. Second, allowing for better-defined categories is necessary before implementing a more stringent program. Second, the government should provide enough lead-time for manufacturers and consumers to adjust to new requirements by announcing the longer-term implementation plan early.

- MEP should introduce GHG emissions labels for new vehicles for consumer education or revise the existing vehicle fuel consumption labeling to serve the purpose. China should also consider offering incentives for low-GHG emission vehicles (see Chapter 8).

- MEP should consider introducing supporting consumer educational programs to improve consumer understanding of the labels.

- If MEP considers introducing consumer information labels that influence consumer purchase decision, the enforcing agencies should make sure that the labels are made available to consumers at the point of sale. Often without strong enforcement, auto dealers may lack of incentive to show and explain the labels to consumers.

8. 燃料经济性和温室气体管理方案

通常，国家能源安全是制订车辆燃料经济性标准的主要推动力。在过去的15年中，中国已经从一个原油自给自足的国家成为了世界上最大的原油进口国之一。20世纪末，中国成为仅次于美国和日本的世界第三大原油消耗国。在过去的20年里，中国的原油消耗量每年增长4%，到2000年达到2.1亿吨，2009年达到3.94亿吨。2000年中国原油进口量达到7000万吨，占当年原油消耗总量的30%，并且到2009年，这一数字已经上涨至2.04亿吨，占全年总量的52%[87]。 造成中国原油消耗量上涨的主要原因之一就是交通领域的快速增长，特别是机动车的快速增长[88]。2009年，中国原油消耗量的60%是用于交通领域。

如今，全世界各国政府都在日益担忧温室气体所带来的气候影响。目前，世界上最大的七个汽车市场已经实施了或至少计划实施燃料经济性标准或温室气体排放标准。中国是世界上最大的温室气体排放国之一并且拥有世界上机动车增长速度最快的市场。目前中国正面临着减少石油消耗和温室气体减排的双重挑战。

从减轻石油依赖性出发， 中国于2005年成为世界上为数不多第一批对轻型乘用车实施了燃料消耗量标准的国家。实施轻型车燃料消耗量一阶段和二阶段标准已经帮助将新车百公里燃料消耗量从2002年的9升(9 L/100km)降低至2008年的8升左右，或者说是降低了10%。目前，中国正在批准通过三阶段标准。中国还对摩托车也实施了燃料消耗量标准。重型车的燃料消耗量管理也在发展。这些管理标准中没有直接强调温室气体排放。

除了不断加严标准以来，改善标准的设计也能够帮助实现燃料或碳消耗量的减少。下文中总结了国际管理方案和中国管理方案，并通过比较得出今后的改善建议。

8.1 国际管理方案概述

本节将介绍世界各国正在实施和计划实施的轻型乘用车及商用车燃料经济性标准和温室气体排放标准。在此主要针对美国和欧盟的管理，因为美国和欧盟占据了世界汽车产量的半数以上。为方便和中国对比，各国原来规定的指标被转化为NEDC工况下的升/百公里，与中国采取的工况和单位相同，标注在原指标后的括号中。

美国

过去几十年来，美国联邦燃料经济性法规关注的主要是能源安全。2010年4月1日，美国国家环境保护局（EPA）和美国交通部（DOT）共同制定了新的温室气体排放和燃料经济性联合标准，主要针对2012至2016年型的轻型车（包括乘用轿车和轻型卡车）。EPA依据《清洁空气法》实施了有史以来第一个全国温室气体排放标准，DOT则依据《能源政策和节能法》实施了新的企业平均燃料经济性（CAFE）标准。规定的主要原则将在下文中予以归纳。

87 Wang Qian，2010年，《中国燃料进口量已达警戒线》（Oil imports hit alarming level in China: Study）《China Daily》。

88 He, Hao, Zhang, He, Walsh和Wang. 2005年，《中国道路交通燃料消耗量和CO_2排放的现状、未来趋势和政策指导》（Oil consumption and CO_2 emissions in China's road transport, current status, future trends and policy implications. ）《能源政策》第 33。

8. Fuel efficiency and greenhouse gas programs

Traditionally, national energy security has been the main driver for vehicle fuel economy standards. Over the past decade and a half, China has gone from being self sufficient in oil to becoming one of the largest importers in the world. By the end of the 20th century, China became the world's third largest oil consumer after the US and Japan. With an annual rate of increase of 4% in oil consumption experienced in the past 20 years, China's oil consumption reached 210 million tons in 2000 and 394 million tons in 2009.87 The amount of oil imported by China reached 70 million tons in 2000, accounting for 30% of that year's total oil consumption and has since risen to 204 million tons or 52% of the annual total in 2009. A major cause of the increase in Chinese oil consumption can be attributed to the rapid growth of the transportation sector in general and motor vehicles in particular[88].About 60% of China's oil consumption in 2009 was for transportation.

Nowadays, governments around the world are also increasingly concerned about the climate impacts of greenhouse gases (GHG). To date, seven world-leading auto markets have adopted or at least proposed vehicle fuel economy or GHG emissions standards. China, as one of the world's largest GHG contributors and with the world's most rapidly growing auto market, is confronting the dual challenge of reducing fossil oil consumption and curbing GHG emissions.

Driven by oil independence concerns, China was among the first countries in the world to adopt its first phase of fuel consumption standard for light-duty passenger vehicles in 2005. The implementation of Phase I and Phase II light-duty vehicle standards helped reduce the fleet fuel consumption from about 9 liters per hundred kilometer (9 L/100km) in 2002 to about 8 L/100km in 2008, or a 10 percent of reduction. Now China is in the process of approving the third phase of the standard. China also established fuel consumption standard for motorcycles. Fuel consumption regulations for heavy-duty vehicles are also in development. None of these regulations addresses GHG emissions directly.

The design of various regulations may be improved to enable more certain fuel or carbon reduction outcomes. The following provide a summary of international programs, China's programs and through a comparison highlights recommendations for future improvements.

8.1 Overview of international programs

This section reviews current and proposed light-duty passenger and commercial vehicle fuel economy or GHG emissions standards around the world. The focus is on the U.S. and EU regulations, as those two markets together account for over half of world's auto production. For easy comparison with China, country-specific targets are converted from their original metrics to liters per hundred kilometer (L/100km) under the NEDC cycle, the same metric adopted in China, in the brackets next to the original target values.

The United States

For decades, the focus of U.S. federal fuel economy regulation was energy security. On April 1st, 2010, the U.S. Environmental Protection Agency (EPA) and Department of Transportation (DOT) finalized a new joint regulation for greenhouse gas (GHG) emissions and fuel economy for light-duty vehicles (including passenger cars and light trucks) for model years 2012 through 2016. The EPA established the first-ever national greenhouse gas (GHG) emissions standard under the "Clean Air Act", and the DOT established an updated Corporate Average Fuel Economy (CAFE) standard under the "Energy Policy and Conservation Act". Key elements of the rule are summarized below.

87 Wang Qian. 2010. Oil imports hit alarming level in China: Study. China Daily.

88 He, Hao, Zhang, He, Walsh and Wang. 2005. Oil consumption and CO_2 emissions in China's road transport, current status, future trends and policy implications. Energy Policy 33.

*严格程度：*要求轻型车平均温室气体排放量从2008年型的平均342克CO_2/英里下降至2016年型的250克CO_2/英里，降幅为27%。2012-2015年期间会采用过渡标准。燃料经济性会从2008年型的平均每加仑26英里(10.3L/100km)提升至2016年型的每加仑34.1英里(7.6 L/100km)，总改善幅度为31%。每个车型年，温室气体平均排放降低3.8%，燃料经济性提高3.5%。

*污染物：*对包括车辆空调系统的氢氟碳化合物在内非二氧化碳的温室气体排放也有另外的要求， 对单车氧化亚氮和甲烷的排放量提出限值。其它气候影响物，如黑炭等没有被纳入管理范围。

*标准设置：*沿用当前DOT的燃料经济性标准框架，新的标准根据车辆的尺寸或称“脚印面积”（四个车轮围出的面积）来设定乘用轿车和轻型卡车的标准。与过去所采用的S型标准曲线不同，新的温室气体排放量标准是基于车辆尺寸制定的“分段线性”函数。这样，大体上，尺寸越大的车辆还是会依据曲线面临越来越松的标准，但是脚印面积最大的车型会面临一个固定的上限标准（即不再随着脚印面积增大面临较松的标准），这样的设置可以鼓励车辆尺寸小型化。

*灵活性：*主要的达标途径是提高车辆燃料经济性。但是，也可以通过其它方式获取达标信用额度，包括空调系统技术和发展灵活燃料车。

美国总统在2010年5月21日宣布要求EPA和DOT共同制定了下一阶段针对2017-25车型年的轻型车温室气体排放和燃料经济性的联合标准。有关这标准的主要内容，包括2017-25车型年可于全国范围达到的标准限值，会于2010年9月30日公布。

在过去几十年来，美国联邦燃料经济性法规关注的主要是能源安全。2010年4月1日，美国国家环境保护局（EPA）和美国交通部（DOT）共同制定了新的温室气体排放和燃料经济性联合标准，主要针对2012至2016年型的轻型车（包括乘用轿车和轻型卡车）。EPA依据《清洁空气法》实施了有史以来第一个全国温室气体排放标准，DOT则依据《能源政策和节能法》实施了新的企业平均燃料经济性（CAFE）标准。规定的主要原则将在下文中予以归纳。

美国目前没有设置重型车的燃料经济性或温室气体标准。但是《2007年能源独立与安全法》中要求美国交通部为重型卡车制订燃料经济性规定，最早将实施于2016车型年。美国科学院全面的研究了重型车从技术层面提高燃料经济性的潜能，这为今后制订规定提供了基础。同时，美国环保局也以温室气体为重点，开展了重型车排放控制方案的评估研究。美国总统在2010年5月21日指令环保局和交通局合作制定轻型与中、重型车温室气体排放和能源法规的发布中同时要求EPA和DOT合作在2011年7月完成制定重型车的温室气体/燃料经济性标准。 EPA和DOT共同制定的中、重型车温室气体排放 / 燃料经济型标准方案于2010年11月公布。

加州

2002年，加州颁布了第一个要求限制机动车温室气体排放的州立法案（AB1493）。依照法律规定，加州空气资源局（CARB）于2004年针对两类车发布了从2009车型年至2016车型年逐年的温室气体排放目标，给予车辆生产者5年的适应时间。2009年底，EPA给予了加州豁免权，令加州可以制定自己的2009年–2011年车辆的温室气体排放标准。加州随后修订了自己的管理方案，允许生产企业通过满足联邦标准来证明满足了加州标准。加州预期将在2010年底推出下一阶段标准，即2017年–2025年的标准。

Stringency: Average light-duty vehicle GHG emission rate would be reduced from the average of model year 2008, which was 342 gCO_2e/mile, to 250 gCO_2e/mile in model year 2016, a 27% reduction. Interim standards would apply for 2012-2015. Fuel economy would increase from an average model year 2008 level of 26 miles per gallon (10.3L/100km) to 34.1 miles per gallon (7.6 L/100km) by model year 2016, a 31% improvement. Annually, this would be a 3.8% reduction per model year in average GHG emissions, and 3.5% increase per model year in fuel economy.

Pollutants: Additional requirements would be imposed on non-CO_2 GHG emissions, including hydrofluorocarbons (HFCs) from vehicle air conditioning systems. Per-vehicle emission caps would be set for nitrous oxide (N_2O) and methane (CH4) emissions. Other climate forcers, such as black carbon, are not covered.

Structure: Following the current DOT fuel economy standard framework, the program sets separate numerical standards for vehicle size or “footprint” (i.e., the area defined by the wheelbase and average track width) for passenger cars and light trucks. In contrast to the S-shaped constrained logistical curve previously used, the new proposed system uses “piecewise linear” functions between vehicle footprint and the test-cycle GHG emission rate. This general shape allows for different-size vehicles to have different standards in the sloped portion, but constrains the largest vehicles at the upper bend and incentivizes vehicles below the lower bend.

Flexibility: The main compliance mechanism is improving vehicle fuel efficiency. But compliance credits can also be achieved via other mechanisms, including air conditioning system technology and the deployment of flexible fuel vehicles.

On May 21st, 2010, the President requested the EPA and DOT, in collaboration with the State of California, to jointly develop the next set of light vehicle GHG/fuel economy standards that will run from 2017 through 2025. A notice will be released by September 30th, 2010 that lays out the key components of the standards, including the potential standards that could be practically implemented nationally for the 2017-2025 model years.

The US currently does not have an established fuel economy or GHG standard for heavy-duty vehicles. But the"Energy Independence and Security Act of 2007" has requested US DOT to formulate fuel economy rule making for heavy trucks which at the earliest will be effective from Model Year (MY) 2016. The National Academy of Science has conducted thorough studies on technology potential for fuel economy improvement of heavy-duty vehicles, which will lay the grounds for the upcoming rule making. At the same time the US EPA had laid out in its review of policies to address GHGs several options for the control of emissions from heavy-duty vehicles. The announcement made by the President on May 21st, 2010 directing EPA and DOT to jointly develop policies for regulating GHG emissions and energy consumption of light vehicles and medium- and heavy-duty trucks, calls for EPA and DOT to jointly complete a final rule for heavy-duty vehicle GHG/fuel economy standards by July 2011. The two agencies have jointly released a proposal for the medium- and heavy-duty vehicle GHG/fuel economy standards in November 2010.

The State of California

In 2002, California enacted the first state law (AB 1493) requiring GHG emission limits for motor vehicles. As directed by the statute, the California Air Resources Board (CARB) issued a regulation in 2004 to establish year-by-year GHG emissions targets for two vehicle class categories from MY 2009 to 2016, giving automakers a 5-year lead time. In late 2009, EPA granted a waiver to California to implement its GHG standard for 2009–2011 vehicles. California subsequently revised its program to allow manufacturers to show compliance with California's standards by complying with the federal standards. It is expected that California will propose the next set of standards, for years 2017–2025, by the end of 2010.

欧盟

1998年，欧盟与向欧盟市场出售车辆的汽车生产企业签署了一份自愿协议，到2008年底，将车辆二氧化碳排放降至140g/km 。这一自愿目标并没有实现，到既定时期，欧盟范围内车辆平均二氧化碳排放量为159g/km 。欧盟决定设立强制标准来削减轿车的二氧化碳排放。2008年12月，欧盟委员会实施了新的管理规定，降低新乘用车的二氧化碳排放。主要管理特征如下：

*严格程度：*这一目标主要依靠提高车辆能效技术来实现，有10g/km的额外削减是通过其它方式实现的，包括改变胎压、变速箱指示器、空调，增加生物燃料使用量和财税政策。尽管欧盟委员会要到2013年才能考虑实现目标的技术路线，但已经宣布了更长远的目标，即到2020年降至95 g/km(3.8L/100km)。

标准设置： 标准是以重量为基础的平均二氧化碳排放量。法规规定了一个线性公式[89]，用来根据车重计算各个车辆的规定排放目标。生产企业的目标值则是再根据其生产的车型，按销售权重计算出来的。线性曲线的斜率参考了欧盟制造商当前的车辆质量和二氧化碳排放量关系的趋向线，但是经过修改，比实际趋势线的斜率要平缓。这样的设计是为了防止生产企业任意增大车队的质量来投机取巧，获得更宽松的排放目标。

轻型商用车标准： 2009年10月，欧盟委员会通过了新的提案，计划降低轻型商用车的二氧化碳排放（货车或欧盟分类中的N1车辆[90]）。到2014年，轻型商用车的平均排放值要降至175g/km。长期的目标是到2020年实现135g/km的目标。这一提案也是采用以重量为基础的线性曲线来计算各个车辆的目标值，标准设计与乘用轿车类似。

澳大利亚

联邦汽车工业联合会于2005年颁布了自愿性目标值，到2010年，将NEDC工况下的新乘用车全国平均碳排放（NACE）降低至每公里222克二氧化碳(9.5L/100km)。

加拿大

2009年12月，加拿大发布了2011–2016年限制乘用轿车温室气体排放量的管理草案。标准将采取美国最新制定的以车辆尺寸为基础的设置。虽然加政府还在进行更详尽的分析，初步预测2016年加拿大新轿车和轻型卡车的温室气体排放量均值将能达到美国设计的每公里153克二氧化碳(7.6 NEDC L/100km)。这与2007年在加拿大销售的新车群体相比，大约降低了20%。不过，加拿大的车辆平均尺寸比美国要小很多，采用相同的以尺寸为基础的标准设置，加拿大应当能实现比政府所预期的排放水平更低的排放。假设加拿大取得相似的年度燃料经济性提高比例[91], 则对加拿大而言将2016年车辆平均标准设为每公里149克二氧化碳(6.9L/100km NEDC工况下)更为接近现实状况。因此，每公里155克二氧化碳的官方目标可以被看做是一个低端目标。

89 新乘用轿车的二氧化碳排放目标计算公式为：目标值= 130 + a*(M-M0), 其中M是车辆质量，从2012到2015年，M0等于1372,，a等于0.0457。2016年以后，M0将被调整为之前三年新乘用轿车平均质量，系数a还是等于0.0457。生产企业的年度排放目标值应根据生产企业该年度登记注册的新乘用轿车的平均二氧化碳排放来计算。 来源：欧盟委员会：欧盟议会管理规定(EC) No 443/2009，2009年4月23日。

90 这类车在美国的车型分类中属于轻型车。

The European Union

In 1998, the European Union signed a voluntary agreement with auto manufacturers selling to the EU market to reduce fleet CO_2 emissions to 140 g/km by 2008. That voluntary target was not met, and at the end of the compliance period the EU-wide fleet average CO_2 emission rate was 159 g/km. The EU decided to establish mandatory standards to curb CO_2 emissions from cars. In December 2008, the European Commission adopted a new regulation to reduce the average CO_2 emissions of new passenger cars. Key features of the regulation are as follows:

Stringency: The fleet-wide CO_2 target was set at 130g/km (5.2L/100km) by MY 2015. That target is to be met with vehicle efficiency technology improvements alone, with an additional 10g/km cut achieved through additional measures including changes to tire pressure, gear shift indicators, and air conditioning, as well as an increased use of biofuels. A more far-reaching 2020 target of 95g CO_2/km (3.8L/100km) was also announced, though the European Commission will have to consider the technology pathways to achieving this target by 2013.

Structure: The standard is a weight-based corporate average of CO_2 emissions. The regulation specifies a linear equation[89] to calculate the specific emission target for each vehicle depending on its weight. The target for a particular manufacturer is then calculated by sales-weighting the specific targets of all vehicle models it produces. The slope of the linear curve is determined largely based on the current weight and CO_2 performance relationship trend line of manufacturers in EU, but is manipulated to be flatter than the slope of the actual trend line. This is to prevent manufacturers to cheat against the system by arbitrarily up-weighting their car fleet in order to gain a more lenient target.

Standard for light commercial vehicles: In October 2009 the European Commission adopted a new legislative proposal to reduce CO_2 emissions from light commercial vehicles (vans or N1 category under the European classification[90]). A fleet average for all new light commercial vehicles of 175g/km will apply as of 2014. A long-term target of 135g/km is specified for the year 2020. The proposal also adopts a weight-based linear curve to calculate the specific target for each vehicle, similar to the regulatory design for passenger cars.

Australia

The Federal Chamber for Automotive Industries established a voluntary target in 2005 to reduce National Average Carbon Emissions (NACE) for all new passenger vehicles to 222 grams of CO_2/km (9.5L/100km) under the NEDC driving test cycle by 2010.

Canada

In December 2009, Canada released a draft regulation to limit GHG emissions from passenger cars and light trucks in model years 2011 through 2016. The standards will adopt the footprint-based structure proposed in the latest U.S. rulemaking. While a more detailed analysis is being conducted, the Canadian government anticipates that the average GHG emission performance of the 2016 Canadian fleet of new cars and light trucks would match the average level of 155g CO_2/km (7.6 L/100-km) that has been projected for the U.S. That would represent an approximate 20% reduction compared to the new vehicle fleet that was sold in Canada in 2007. However, with a much smaller average fleet size than that in the U.S., by adopting the same footprint based standard structure, Canada should be able to achieve a lower average emissions level than what the government has anticipated. If it is assumed that Canada will achieve a similar annual fuel economy improvement rate, a more realistic target for Canada would be a fleet-average of 149g CO_2/km (7L/100-km under NEDC cycle) by 2016. The 155g CO_2/km target therefore could be considered as a low end target.

89 The equation to calculate the specific CO_2 emission target for each new passenger car is :Target= 130 + a*(M-M0), where M is the mass of a particular vehicle, from 2012 to 2015, M0 equals 1372, a equals 0.0457. After 2016, M0 will be adjusted to be the average mass of new passenger cars in the previous three calendar years, while the value of parameter a will still be equal to 0.0457. The specific emissions target for a manufacturer in a calendar year shall be calculated as the average of the specific emissions of CO_2 of each new passenger car registered in that calendar year of which it is the manufacturer. Source: The European Union Commission:

Regulation (EC) No 443/2009 Of The European Parliament and Of The of 23 April 2009.

90 This vehicle category is under light-duty vehicle classification in the US.

日本

2007年开始引入现有的燃料经济性管理，以重量为基础设置了2015车型年的平均标准。一旦实现2015目标值，在日本JC08测试工况下，车辆平均燃料经济性将达到16.8 km/L (5.4 L/100km)，比2004年(13.6 km/L)提高了23.5%。日本也为轻型商用车（货车）设定了2015年15.2 km/L (6 L/100km)的燃料经济性目标。

韩国

2009年7月，韩国针对2015车型年提出了17km/L和140gCO_2/km (6.4 L/100km)的燃料经济性标准和温室气体排放标准。新标准将以重量为基础，采用美国的CAFE综合测试工况。

8.2 中国燃料经济性管理方案概述

乘用轿车

2005年，中国针对新乘用车（欧盟分类中的M1车辆）引入了第一个全国燃料消耗量标准。三年后，二阶段的实施使标准加严了10%。2009年8月，中国进一步提出了更严格的三阶段标准。标准发展详见图8.1。

和世界其它地区实施的平均燃料经济性或车辆温室气体排放标准不同，中国标准的前两个阶段是针对单车认证油耗值标准。在这种体制下，每个新车型必须满足该重量等级的燃料消耗量要求才能进入市场。这样的管理方案，尽管能尽早淘汰技术落后的车辆，却不能鼓励生产企业采纳最先进的燃料经济性技术。在计划实施的三阶段标准管理中，中国正考虑将单车认证标准和公司平均标准体系相结合。不过目前具体的实施方案还未出台。

一阶段和二阶段标准促使新乘用车平均油耗量从2002年的9.1 L/100 km改善至2009年的8.1 L/100 km 。根据来自中国汽车技术研究中心的信息，计划实施的三阶段标准将到2015年全面实施，届时将把新乘用车的平均燃料消耗量降低至7 L/100 km。这代表从现在到2015年，车辆平均燃料经济性将提升13%，或者说每年提升1.8%。图8.2对比了世界各国轻型车燃料经济性（温室气体）标准。在同时期标准的严格程度上，中国的新目标落后于日本、欧盟和韩国，名列第四位。应注意的是，这里的绝对严格程度排名并没有考虑不同汽车市场的平均车辆重量的不同（一般来说重量轻的车油耗低）。

91 鉴于北美汽车市场的一致性，两个市场的技术水平提高情况非常接近，因此这里用美国每年技术改进的比例来预估加拿大的技术进步速度是比较合理的。

Japan

Introduced in 2007, the current fuel efficiency regulation sets weight-based binned corporate average standards for model year 2015. When the 2015 targets are met, the fleet average fuel economy is expected to be 16.8 km/L (5.4 L/100km) under the new Japanese JC08 driving test cycle, a 23.5% increase over 2004 (13.6 km/L). Japan also established a fuel economy target for light commercial vehicles (vans) of 15.2 km/L (6 L/100km) for 2015.

South Korea

In July 2009, South Korea proposed a combined fuel economy and GHG emissions target of 17km/L and 140gCO_2e/km (6.4 L/100km) for MY 2015. The new standards will be weight-based, and will use the U.S. CAFE combined cycle for testing purposes.

8.2 Overview of China's fuel efficiency programs

Passenger Cars

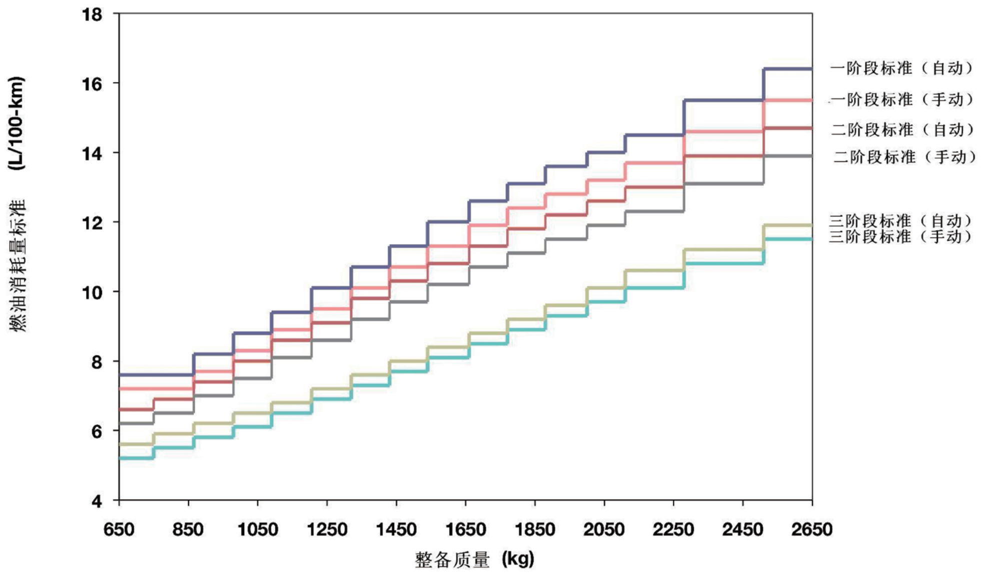
China introduced its first national fuel consumption standards for new passenger vehicles (M1 category under the European classification) in 2005. Three years later, as the second stage, the standards were made about 10 percent more stringent. In August 2009, China proposed a further strengthened Phase III standard. The evolution of these standards is illustrated in Figure 8.1.

Unlike the corporate average fuel economy or vehicle GHG emissions standards adopted in other parts of the world, the first two phases of the Chinese standards were per-vehicle certificate standards. Under that type of system, a new vehicle model must meet the minimum fuel consumption requirement for its weight class before it can enter the market. Such a compliance scheme, though useful to phase out vehicles with outdated technologies at an early stage, cannot encourage manufacturers to adopt state-of-the-art fuel efficiency technologies over time. In the proposed Phase III regulation, China is considering a combined per-vehicle certificate standard and corporate average standard system. So far a detailed implementation plan has not been released.

Phase I and Phase II standards helped improve the fuel efficiency of new passenger cars from 9.1 L/100 km in 2002 to 8.1 L/100 km in 2008. According to the China Automotive Technology and Research Center (CATARC), the proposed Phase III standards will reduce the fleet-average fuel consumption of the new car fleet to 7L/100 km when fully implemented in 2015. This represents a 13% improvement in fleet wide fuel efficiency between now and 2015, or 1.8% annual gain over the period. Figure 8.2 compares the world's light-duty vehicle fuel efficiency (GHG) regulations. China's new target ranks fourth after Japan, the European Union, and South Korea in terms of regulatory stringency. Note that such ranking does not correct for the differences of average vehicle weight among various markets. Generally speaking, the heavier a vehicle, the more fuel will be consumed to move it.

91 This is very likely because the technology improvements between the two markets are very close given the high harmonization of the North American auto market.

中国2015设定的全体乘用车队平均目标值是在假定届时车辆重量构成情况仍然与2008年相同的基础上的。实现这一目标的一个潜在障碍就是中国的轿车正在日趋大型化和重型化[92]。中国以重量为基础的油耗标准不利于鼓励生产企业采用轻型化技术来削减车重。随着市场对重型和高性能车辆需求的增加，车辆平均燃料消耗量可能将无法达到7 L/100 km的目标。



注: 在2016车型年以前，三阶段（自动挡）目标将适用于三排座以下的自动挡轻型车。2016车型年以后，所有轻型车都要遵守同样的三阶段（手动挡）目标。

图 8.1: 中国新乘用车燃料消耗量标准

其它车型

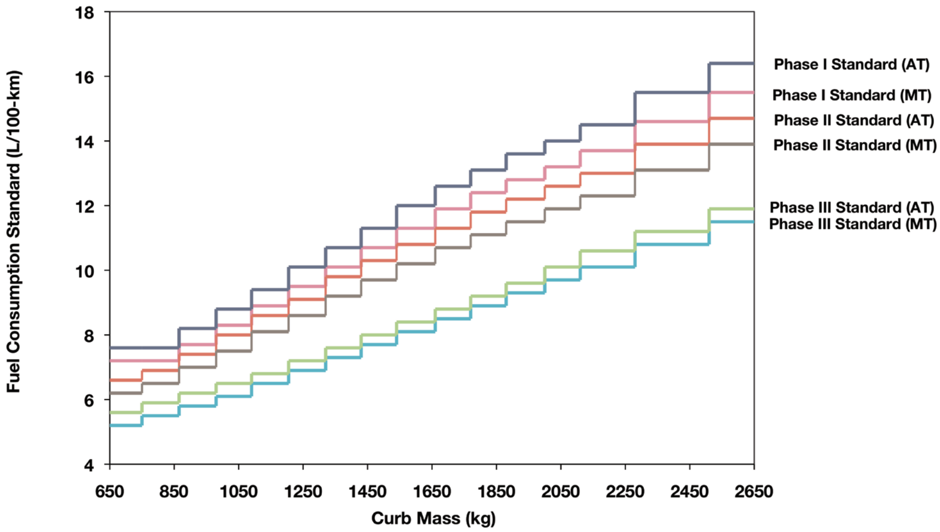
2005年，中国针对轻型车（欧洲分类中的N1和M2车辆）发布了两个阶段的燃料消耗量标准。类似于乘用轿车的一阶段和二阶段标准，标准的主要作用是加速车辆群体的现代化进程，淘汰落后技术。2008年，中国实施了摩托车燃料消耗量标准。中国目前正在开发测试程序以便最终制定重型车标准，并且即将完成二阶段摩托车燃料消耗量标准。

与世界各国燃料经济性标准的严格程度对比

表8.1总结了世界各国轻型乘用车标准的主要情况，包括强度和标准设置情况。表8.2则比较了中国、欧洲、美国和日本已经实施或计划实施的轻型商用车燃料消耗量标准。

92 来自中国汽车技术研究中心（CATARC）的数据表明2002年整备质量小于1,090 kg的车辆份额为44%，到2006年这一比率降低至27%。来源：CATARC 2008年，《乘用车燃料消耗量标准评估》。

The 2015 target value is projected assuming the fleet mix by vehicle weight will remain the same as in 2008. One potential barrier to reaching the target is that cars in China are getting larger and heavier[92]. China's weight-based fuel efficiency standard does not provide any incentive for manufacturers to adopt light-weighting technologies to cut vehicle weight. As market demand for heavier and higher-performance vehicles rises, the fleet-average fuel consumption will not be able to meet the 7L/100 km target.



Note: Before CY 2016, the Phase III (automatic transmission, AT) targets will apply to LDVs with three rows of seats or less and with automatic transmissions. After CY 2016, all LDVs will be subject to the same Phase III (manual transmission MT) targets.

Figure 8.1: Chinese new passenger vehicle fuel consumption standards

Other vehicle types

In 2005, China announced a two-phase fuel consumption standard for light commercial vehicles (N1 and M2 categories under European classification). Similar to the Phase I and Phase II passenger car standard, the main purpose of the standard is to speed up the phase-out of outdated technologies by accelerating the modernization of the fleet. In 2008, China introduced fuel consumption standard for motorcycles. China is currently developing a test procedure to eventually set a new standard for heavy-duty vehicles, and is about the finish the second phase of motorcycle fuel consumption standard.

Comparing the stringency of world fuel efficiency standards

Table 8.1 summarizes the key features, including stringency and structure, of light-duty passenger vehicle standards worldwide. Table 8.2 compares the design of China's light-duty commercial vehicle fuel consumption standards with those proposed or adopted in the EU, US and Japan.

92 Data from CATARC reveal that the share of models with curb mass below 1,090 kg was 44 percent in 2002, while that ratio dropped to 27 percent in 2006. Source: CATARC 2008, "Evaluation of Passenger Vehicle Fuel Consumption Standards".

表8.1: 世界各国轻型乘用车标准汇总

国家/地区	实施车型年	标准类型	未调整的车辆目标值/测量值††	标准设置	目标车辆群体	测试工况
美国	2016	燃料经济性 /温室气体	34.1 mpg* 或 250 gCO_2e/mil	以尺寸为基础企业平均	轿车/轻型车	美国综合工况
加拿大(计划)	2016	温室气体	153 (141)† gCO_2e/km	以尺寸为基础企业平均	轿车/轻型车	美国综合工况
欧盟	2015	二氧化碳	130 gCO_2/km	以质量为基础企业平均	轿车/轻型车	NEDC
澳大利亚(自愿性)	2010	二氧化碳	222 gCO_2/km	单车平均	轿车/轻型车	NEDC
日本	2015	燃料经济性	16.8 km/L	以质量为基础企业平均	轿车	JC08
中国(计划)	2015	燃料消耗量	7 L/100km	以质量为基础单车限值和企业平均	轿车/轻型车	NEDC
韩国(计划)	2015	燃料经济性/温室气体	17 km/L 或 140 gCO_2e/km	以质量为基础企业平均	轿车/ SUVs	美国综合工况

* 美国每加仑行驶的里程数目标值里面提供了燃料经济性信用额度的灵活达标手段，这个额度等于由改进空调系统获得的温室气体减排量。

† 加拿大的目标值是由加拿大政府宣布的。但鉴于加拿大车队的平均车辆尺寸比美国的车队要小，这个目标值只是一个底限目标。ICCT估计，对加拿大来说，2016年更合理的目标值为NEDC测试工况下149gCO_2/km或7L/100km。

†† gCO_2/km为每公里行驶排放的二氧化碳, gCO_2e/km为每公里行驶排放的二氧化碳当量。

尽管各个国家的计量单位和测试工况有所不同，ICCT在2007的一份报告，即《全球乘用车温室气体或燃料经济性标准的最新政策》中提出一项方法论来统一不同的测试行驶工况，实现不同标准之间的公平对比[93]。图8.2展示了比较结果，所有标准都被统一到NEDC工况下，以L/100km为单位。从绝对目标值的角度讲，欧盟和日本已经实施或即将实施将世界上最严格的标准。不过，在比较各国政策的严格程度时，不能忽视了车辆群体构成特点。车辆群体偏重型和大型的国家设置的目标绝对值会比较松。这意味着各国标准所要求的技术改进可能并不能直接反映在排放目标的绝对严格程度上。

93 ICCT. 2007年，Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update. (http://www.theicct.org/information/reports/car_and_light_truck_fuel_efficiency#)。

Table 8.1: Summary of world light-duty passenger vehicle standards

COUNTRY/ REGION	MODEL YEAR EFFECTIVE	STANDARD TYPE	UNADJUSTED FLEET TARGET /MEASURE††	STRUCTURE	TARGETED FLEET	TEST CYCLE
US	2016	Fuel economy /GHG	34.1 mpg* or 250 gCO_2e_2/mil	Footprint-based corporate average	Cars/LT	US combined
Canada (Proposal)	2016	GHG	155 (149)† gCO_2e_2/km	Footprint-based corporate average	Cars/LT	US combined
EU	2015	CO_2	130 gCO_2/km	Weight-based corporate average	Cars/LT	NEDC
Australia (Voluntary)	2010	CO_2	222 gCO_2/km	Single average	Cars/LT	NEDC
Japan	2015	Fuel economy	16.8 km/L	Weight-based corporate average	Cars	JC08
China (Proposal)	2015	Fuel consumption	7 L/100km	Weight-based Per vehicle and corporate average	Cars/LT	NEDC
S. Korea (Proposal)	2015	Fuel economy /GHG	17 km/L or 140 gCO_2e_2/km	Weight-based corporate average	Cars/ SUVs	US combined

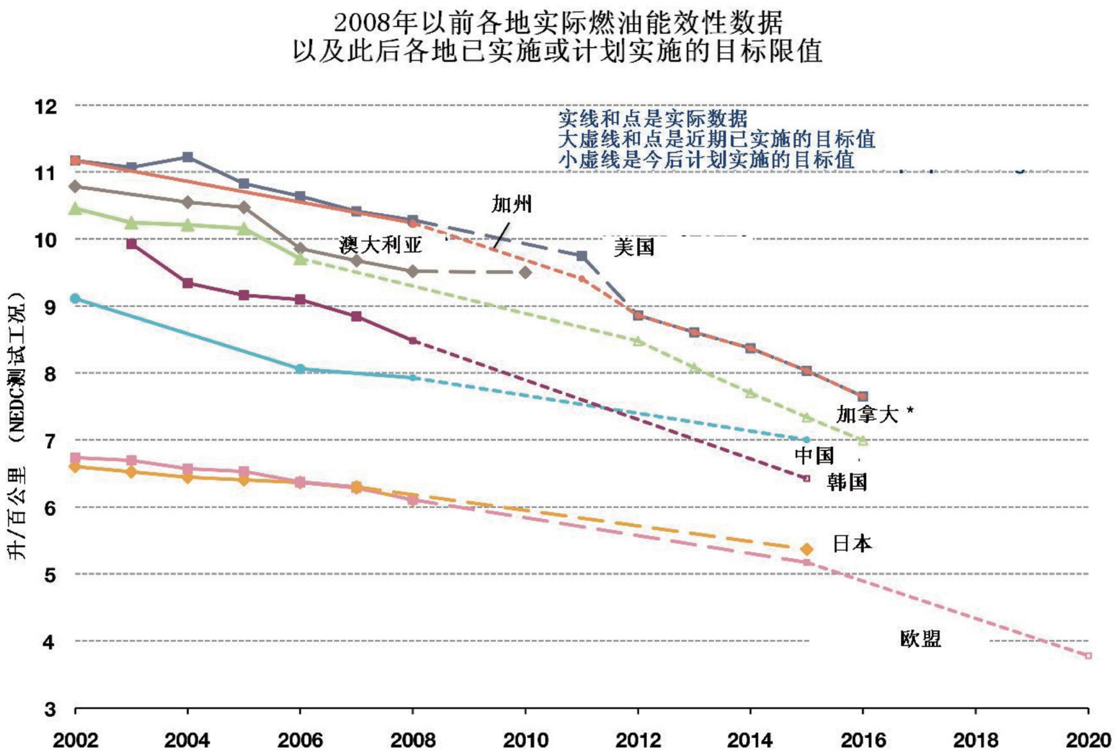
*The U.S. mpg target incorporates a fuel economy credit equivalent to the GHG emissions reduction achieved through the improvement of vehicle air conditioning system.

† The Canadian target is announced by the Canadian government. But this is only a bottom line target given that Canada has an averagely smaller fleet than the US. The ICCT estimates a more reasonable 2016 target for Canada to be 149.gCO_2/km, or 7L/100km under the NEDC test cycle.

†† gCO_2/km is the metric for CO_2 emissions per km traveled, gCO_2e/km is the metric for presenting the GHG emissions per km traveled that are equivalent to the global warming potential of the potential of CO_2.

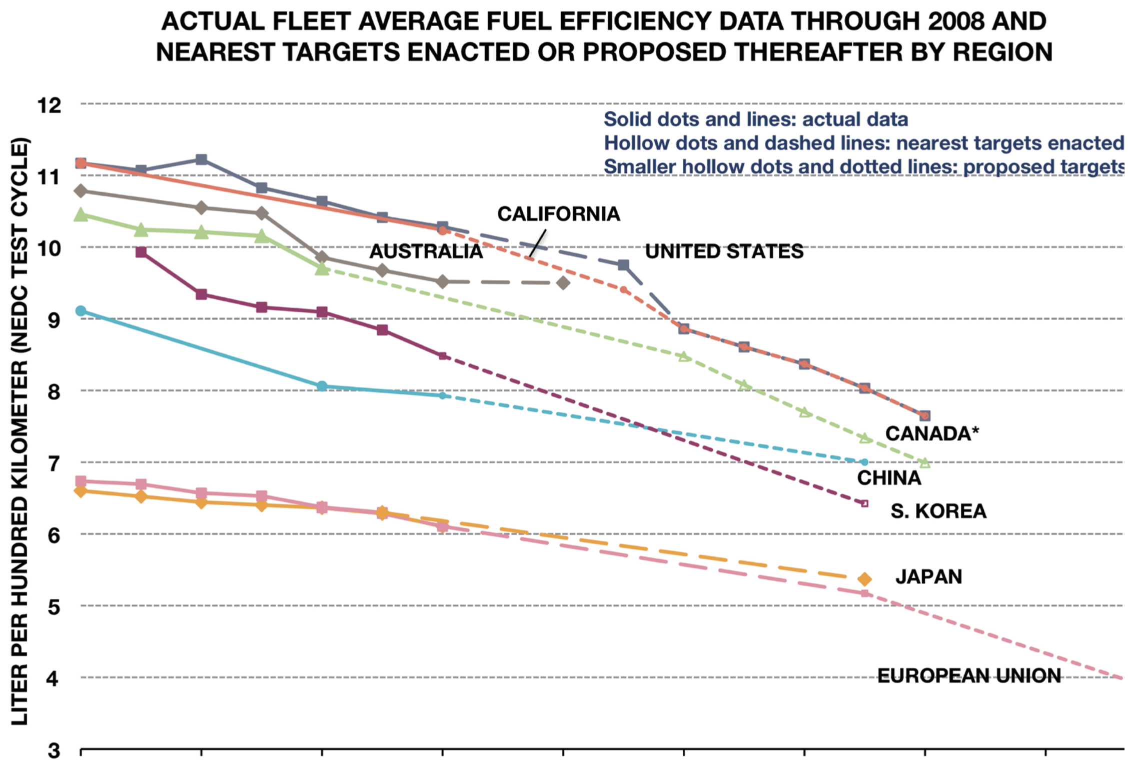
Though metrics and driving test cycles vary from country to country, the ICCT developed a methodology in its 2007 report – Passenger Vehicle Greenhouse Gas or Fuel Economy Standards: A Global Update -- to normalize the different driving test cycles to allow apples-to-apples comparison of different standards 92. Figure 8.2 shows this comparison, with standards normalized to the NEDC cycle in L/100km. In terms of absolute value performance and target, the EU and Japan have adopted or proposed the most stringent standards in the world. However, when comparing the stringency of various policies, one cannot ignore the variation of fleet characteristics. Countries with heavier and bigger cars tend to set less stringent targets in absolute terms. This also indicates that improvements in technology required under these various regulations may not be directly reflected in the absolute stringency of their emission targets.

93 ICCT. 2007. Passenger Vehicle Greenhouse Gas and Fuel Economy Standards: A Global Update. (http://www.theicct.org/information/reports/car_and_light_truck_fuel_efficiency#).



* 图中所示的加拿大2016年的目标值为ICCT的估计值，而非其官方公布值。原因如前文述。

图8.2: 世界各国乘用车燃料经济性或温室气体排放目标对比



* For Canada, the ICCT estimated target value for 2016 is shown, for reasons mentioned in the Canadian bullet point.

Figure 8.2: Comparison of standards by region

表 8.2: 世界各国轻型商用车燃料经济性标准

	欧盟	美国	日本	中国
目标车辆	N1类最大车辆总质量3.5吨，N2和M2	轻型卡车最大车辆总质量10000磅（=4.6吨）（包括SUV、短货合货车、乘用面包车，不包括工作卡车、多层车和中型车）	车辆最大总质量不超过3.5吨的货车	N1类 (最低设计时速50 km/h) 和车辆最大总质量不超过3.5吨的N2类
目前的二氧化碳平均排放水平[1]	203 g/km (2007)[2][NEDC]	388 g/mi = 241 g/km (2009)[3]	13.5 km/l ≈ 177 g/km (2004)[4] [JC08]	未知
达标后新车平均排放水平预测	175 g/km (2016) (从2014年起逐步实施管理) 135 g/km (2020)[5]	352 g/mi = 218 g/km (2012) 302 g/mi = 188 g/km (2016)[6]	15.2 km/l ≈ 157 g/km (2015)[4]	未知
标准设置	以重量为基础	以尺寸为基础	以重量为基础	以重量和排量为基础
目前的管理现状	计划中	已实施	已实施	已实施

1. 注: 由于车型定义不同，所以不能直接比较车辆平均值
2. 来源: AEA – 《轻型商用车二氧化碳排放立法途径评估》 第18页。
3. 来源: EPA – 《轻型车技术、二氧化碳排放和燃料经济性趋势：1975-2009年》第21页。采用了没有经过调整的测试数字。
4. 来源: METI – 《2007最佳汽车报告》，第11页。假设汽油车份额为90%进行了简单换算，详见第20页。
5. 来源: COM(2009) 593/3。
6. 来源: EPA管理通告2009年9月(EPA-420-F-09-047)。

8.3 标准设计要点

标准类型

世界上主要采用两大类标准：车辆燃料效率标准和温室气体排放标准。燃料效率标准包括燃料经济性标准，测量单位燃料行驶的里程长度(英里/加仑或公里/升)，还有燃料消耗量标准，测量既定距离使用的燃料数量（如升/百公里）。温室气体排放标准可以只考虑燃烧直接排放的二氧化碳，或是考虑车辆行驶和使用车辆配置的附件装置（如空调）排放出的一系列温室气体——如二氧化碳、甲烷、含氟碳氢化合物化合物和氧化亚氮。

黑炭（或称炭黑）是燃烧不完全产生的一种颗粒物（气溶胶），具有很强的气候影响作用（引起气候变暖）。但是到目前为止，任何车辆温室气体排放标准都没有将黑炭纳入管理。不过，因为黑炭是尾气排放出的细颗粒物的一部分，如果有严格的常规污染物标准就也对其有所限制。减少颗粒物就能减少黑炭排放。还有一种方案，是将黑炭的二氧化碳当量纳入到温室气体排放标准当中。这要求我们了解车辆黑炭排放和黑炭的全球变暖潜能值（GWP）。根据IPCC的官方数据，ICCT预测黑炭的100年GWP为460。但是考虑到减少黑炭给气候带来的短期影响，在制订温室气体标准时，应考虑各种温室气体污染物的20年GWP值。根据ICCT估计，黑炭的20年GWP值为1600 （远远高于CO_2)。

Table 8.2: World light-duty commercial vehicle fuel economy standard

	EU	US	Japan	China
Targeted Fleet	N1 max. GVW 3.5 tons, N2 and M2 monitoring only	Light trucks max. GVW 10.000 pounds (= 4.6 tons) (incl. SUVs, short-bed pickup trucks, passenger vans; excl. work trucks, multi-stage and medium-duty vehicles)	Freight vehicles max. GVW 3.5 tons	N1 (min. 50 km/h) and N2 max. GVW 3.5 tons
Current average CO_2 emissions[1] level[1]	203 g/km (2007)[2][NEDC]	388 g/mi = 241 g/km (2009)[3]	13.5 km/l ≈ 177 g/km (2004)[4] [JC08]	Unknown
Estimated effect of regulation on average new fleet performance	175 g/km (2016) (phase-in from 2014 on) 135 g/km (2020)[5]	352 g/mi = 218 g/km (2012) 302 g/mi = 188 g/km (2016)[6]	15.2 km/l ≈ 157 g/km (2015)	Unknown
Metric of target system	Weight-based	Footprint-based	Weigh-based	Weight and displacement based
Current status of regulation	Proposal	In force	In force	In force

1. note: average fleet values not directly comparable due to differences in vehicle definitions
2. source: AEA –"Assessment of Options for the Legislation of CO2 emissions from Light commercial Vehicles", p. 18
3. source: EPA – "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends": 1975 Through 2009, p. 21. The unadjusted test numbers were used.
4. source: METI – 2007 top runner report, p. 11. "Simplified Conversion Based on Assumption of a 90 % gasoline share", see p. 20
5. source: COM(2009) 593/3
6. source: EPA regulatory announcement, September 2009 (EPA-420-F-09-047)

8.3 Key regulatory design issues

Type of standard

Two broad types of standards are adopted worldwide: vehicle efficiency standards and GHG emissions standards. Efficiency standards include fuel economy standards, measured by distance traveled per unit of fuel (mpg, Km/L), and fuel consumption standards, measured by amount of fuel used for a given distance of travel (L/100km). GHG emissions standards may narrowly refer to CO_2 emissions directly from combustion or to a suite of GHGs— such as CO_2, CH_4, HFC and N_2O—emitted from operating a vehicle and auto accessories.

Black carbon (or soot) is an aerosol emitted from incomplete combustion, and has a strong positive climate forcing (which causes warming). But so far, the warming impact of black carbon is not regulated under any vehicle GHG standard. But because black carbon is a part of the fine particles in vehicle exhaust emissions, it is regulated under tight conventional pollutants standards. Removal of particulate matter can reduce the emission of black carbon as well. Alternatively, the CO_2-equivalent value of black carbon can be incorporated into a GHG standard. This requires knowledge of the black carbon emissions from the vehicle and its Global Warming Potential (GWP). The ICCT has estimated a 100-year GWP of 460 based on official IPCC data. But to take full account of the immediate climate benefits of black carbon reductions, the design of a GHG standard should take into consideration the role of 20-year GWP values, which would be necessary for all pollutants in the GHG basket. For black carbon ICCT estimates a 20-year GWP of 1600.

尽管相互关联，但燃料效率标准和二氧化碳标准不可相互取代。只有所有车辆都依赖于单一能量源的条件下，二者才可以互换。只要市场上有多种燃料可供选择，由于不同燃料（或能源）的碳含量不同，对不同燃料的车辆而言，相同的燃料消耗量标准并不能转换成相同的二氧化碳排放量。并且，各种燃料（或能源）生产过程中的上游二氧化碳排放量也有差异。因此，政策制定者必须考虑燃料效率标准和温室气体排放标准之间的差异。

温室气体排放标准还可以提供一些达标弹性，考虑发动机以外的技术来达到减排——例如空调系统和制冷剂改进。使用甚至是安装空调系统都会给发动机带来额外的负荷，这就造成更多的燃料消耗并排放出更多的二氧化碳。额外负荷所造成的排放可以依靠改进系统设计，提升空调的能效和使用替代制冷剂来削减。例如，外控变排量压缩机就是一个替代系统设计方案。

空调系统制冷剂泄漏会导致相当大的气候影响。目前美国最常用的空调制冷剂是HFC-134a，其全球变暖潜能值是二氧化碳的1300倍。虽然泄漏发生率相对难以控制，特别是车祸造成的泄漏，但是用GWP值较低的替代制冷剂可以显著减少泄漏造成的气候影响。目前，考虑在机动车上应用的替代制冷剂是R1234YF，其GWP值是4。用丙烷取代当前的制冷剂，可减少90%的由泄漏造成的等效二氧化碳排放。而提高车辆燃料能效是无法反映出上述收益的。

标准的类型是一种政策选择并取决于国家的政策目标的侧重点。过去，能源安全和石油依赖程度是制订燃料效率标准的主要原因。现在，随着全球对气候变化的认识不断深化，转而设置温室气体排放目标的倾向十分明显。2009年哥本哈根气候世界气候大会之后，中国承诺到2020年碳强度降低40%-45%。中国目前的轻型车标准或未来的重型车标准都没有将重点直接放在温室气体排放上，不过燃料消耗量限值可以临时转化为二氧化碳目标，因为目前几乎所有乘用轿车都是用单一燃料——汽油。然而，今后替代燃料车越来越常见，这种直接转化关系将不复存在。另外，如前文所提到的，燃料消耗量标准不能鼓励通过改进空调系统来减少温室气体排放。因此，将车辆燃料效率标准转型为温室气体排放标准会是实现这一目标的重要战略之一。

以重量为基础与以尺寸为基础的标准设置方式

以车辆物理参数为基础的车辆标准，如根据车辆重量或尺寸来制定不同标准能够减少对生产企业竞争力的影响，并避免令消费者的选择范围过于局限，同时这样的标准也更公平，在政策上更容易接受。这就是为什么世界上大多数政府都对轻型车采取这种以车辆技术参数为基础的标准。美国采取的是以尺寸为基础的标准，选择的尺寸量度标准是“脚印面积”，定义为轮胎之间的面积（轴距乘以轮胎之间的宽度）。欧洲、日本、中国和韩国则都是采取以整备质量为基础的标准。

除了政策本身的影响之外，参数的选择也会对销售趋势造成很大影响。1979年美国首次实施轻型卡车燃料经济性标准时，标准只适用于最大额定总质量（GVWR）不大于6000磅的车。到1980年，GVWR上限提升至8500磅并一直延续至今。生产企业巧妙地将很多原属轿车的车型重新分类为轻型卡车，从而争取到比较宽松的轻型卡车标准。生产企业还增加了部分车型的GVWR，这样这些车型就可以从CAFE标准中豁免。这在过去20年里，使车辆平均重量增加了28%，还降低了车辆平均燃料经济性[94]；当然，其它一些因素，比如消费者对于更豪华更高性能车辆的需求也是造成上述结果的原因。尽管有严格的基于汽车重量的税收方案，但在日本还是出现了类似的趋势。1993年开始实施以重量为基础的燃料消耗量标准，在此标准之下，常规轿车的重量比90年代水平增加了13%[95]。这一现象对中国有很重要的启示，中国也已经出现了车辆重量化、高动力化和燃料经济性低下的趋势。重量化趋势值得政策制定者认真思考，特别是在中国汽车工业快速增长的前提下。

94 EPA. 2008年. 《轻型车技术和燃料经济性趋势：1975-2008年》。可从以下链接获得http://www.epa.gov/oms/cert/mpg/fetrends/420s08003.pdf 2008年9月29日。

95 T&E. 2007年. 《减少新轿车的二氧化碳排放：2006年主要轿车生产企业进展情况研究》。可从以下链接获得http://www.transportenvironment.org/Publications/prep_hand_out/lid:513。

Although related, a fuel-efficiency standard and a CO_2 emission standard cannot replace each other. The two are interchangeable only if the whole fleet is relying on a single source of energy. When there are multiple fueling options in market, the same fuel consumption requirement does not translate into same CO_2 impact from tailpipe emissions of vehicles running on different fuels, given the different carbon content in the fuels (or energy). Furthermore, the upstream CO_2 emissions for producing the fuels (or energy) vary. Therefore, policy makers must take into consideration the difference between fuel efficiency and GHG emissions standards.

A GHG emission standard also provides compliance flexibility by taking into account non-engine technology improvements—to the air conditioning system and refrigerants, for example. Operating and even carrying the A/C system places an additional load on the vehicle engine, and causes additional fuel to be consumed and therefore more CO_2 emissions. Emissions as the result of such extra load can be mainly reduced by system redesign to increase the A/C efficiency, and using alternative refrigerants. For example, an alternative system design is the externally controlled variable displacement compressors (VDCs).

Leaking refrigerant from the A/C system can have a considerable climate impact. The most commonly used A/C refrigerant in the current U.S. fleet is HFC-134a, which has a global warming potential (GWP) 1,300 times that of CO_2. Although the incidence of leaks is relatively difficult to control, especially leaks that result from car accidents, adopting alternative refrigerant compounds with lower GWP can significantly reduce the leakage-related climate impacts. Alternative refrigerants that are being considered for vehicle application include R1234YF with a GWP of 4. Replacing the current refrigerant with propane, for example, reduces the CO_2–equivalent emissions from leakage by more than 90 percent. That benefit, however, is not reflected in the improvement of vehicle fuel efficiency.

The type of standard is a political choice and depends on national priority. In the past, energy security and oil dependence were the primary drivers of fuel efficiency standards. Today, as global awareness of climate change mounts, there is a noticeable shift toward setting GHG emissions targets. After the 2009 Copenhagen Climate Conference, China pledged a 40%–45% reduction in carbon intensity by 2020. Currently, China's light-duty or future heavy-duty vehicle standards do not directly address GHG emissions, though the fuel consumption limit may temporarily translate into a CO_2 target given that almost all passenger cars currently are using a single fuel -- gasoline. However, when alternative-fueled vehicles become more common in the future, such direct relation will not hold. In addition, as mentioned previously, a fuel consumption standard does not encourage improvements of A/C system to reduce GHG emissions. Therefore realigning the vehicle efficiency standard to GHG emissions standard could be part of the strategy to fulfill this goal.

Weight-based versus size-based structure

An attribute-based vehicle standard, such as one that differentiates by vehicle weight or size, can reduce the impact on manufacturers' competitiveness and avoid restricting consumer choices, and therefore may be fairer and more politically acceptable. This is the main reason why most governments apply attribute-based standards to light-duty vehicles. The U.S. adopted a size-based standard, and its chosen size metric is the vehicle "footprint", defined as the area between the tires (wheelbase times track width). The EU, Japan, China and South Korea have all adopted curb-weight based standards.

Choice of attribute can have a huge impact on sales trends, as well as on the results of the policy itself. When the U.S. light truck fuel economy rule was first established in 1979, it applied only to vehicles up to 6,000 pounds gross vehicle weight rating (GVWR). This ceiling was raised to 8,500 pounds GVWR in 1980, where it has remained. Manufacturers reclassified many models as light trucks, instead of cars, to take advantage of less stringent light truck standards. Manufacturers also increased the GVWR of some models so that they would be exempt from the CAFE standards. This has largely contributed to a 28% increase in average vehicle weight and a decrease of fleet-average fuel economy over two decades[94]; of course other factors such as consumer demand for more luxury models and performance also played a role. Despite a stringent weight-indexed vehicle taxation program, Japan has evidenced a similar trend. Under its weight-based fuel consumption standards, introduced in 1993, the average weight of normal cars increased by 13% over 1990 level[95]. The implications are important to China, where a trend of shifting to a heavier, more powerful, and less fuel-efficient fleet is already happening. The up-weighting trend is an important concern to current policy makers, especially given the rapid growth of China's auto industry.

94 EPA. 2008. "Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2008", available online at http://www.epa.gov/oms/cert/mpg/fetrends/420s08003.pdf as of Sept. 29, 2008.

95 T&E. 2007. Reducing CO_2 Emissions from "New Cars: A Study of Major Car Manufacturers' Progress in 2006", available online at http://www.transportenvironment.org/Publications/prep_hand_out/lid:513.

以重量为基础的标准体系，如中国目前实施的标准，不能有效阻止车辆平均重量的增加。以重量为基础的标准鼓励了生产企业去增加他们车辆的重量，从而有资格适用更宽松的标准，这对使用先进技术来降低车辆重量并提高燃料经济性的生产者来说是不公平的。理想的标准设置应当鼓励使用燃料经济性技术，包括更好的传动设计、缩小发动机规模和采用轻型材料，同时允许针对目标市场，全面生产各种尺寸的车辆。

相比以重量为基础的标准，美国以尺寸为基础的标准设置则拥有以下这些优势。标准有利于使用燃料经济性技术和轻型材料，而同时惩罚了另燃料消耗增加的车辆重型化。标准不鼓励以燃料经济性为代价去追求更大的发动机和更高的性能表现。另外，通过尺寸标准基础的定义（即脚印面积），能够减少生产企业“欺骗”的机会，避免在车上增加很大的保险杠或其它配件来增加车辆的外部尺寸，从而使车辆适用于更宽松的标准。

8.4 财税政策的作用

财税政策是交通和应对气候变化政策的重要组成部分。一方面，生产企业常常无法从消费者身上收回用于先进技术和清洁技术方面的投资，如汽油直喷、无级变速器、可变气门组以及混合动力等等。这是因为消费者严重的低估了这些技术在车辆使用寿命周期内带来的节油效益[96]。有了财税政策，生产企业采用这些技术的回报就更加确定。另外，财税政策可以向消费者提供鼓励高燃料经济性和低排放的价格信号，帮助这些更节能高效的车辆增加市场份额。

基于二氧化碳排放量或燃料消耗量设置的车辆税或其它税费应比以车辆物理参数（重量或排量）为基础的政策能更行之有效地鼓励低排放和燃料经济性高的车辆。这是因为生产企业会调整车辆的物理参数来获得财税鼓励，而这种调整并不一定会改变车辆的油耗性能和二氧化碳排放量。比如，在鼓励小型发动机的财税政策体系下，生产企业增加涡轮增压装置来减小发动机排量就可以获益，然而这个发动机可能和替换下来的大排量的自然吸气式发动机动力相仿，使用的燃料和排放的二氧化碳也都一样多。目前，美国和欧洲的部分国家已经开始实施以燃料经济性或二氧化碳为基础的财税政策。

在过去的几年里，中国对车辆消费税和购置税进行了改革，提高了大排量车的税率，同时减少了小排量车的税率。改革的目的是为了鼓励节油的车辆。但是，基于上述原因，这项政策的结果只能是车辆小型化，但并没有改善车辆的油耗水平。将政策的征税基础改为燃料消耗量或二氧化碳排放量则能更直接的鼓励生产企业和消费者，而不一定需要引入额外的税收负担。法国的奖惩机制根据二氧化碳排放性能来对消费者进行补贴或收税，这不但刺激了法国国内汽车市场还成功的引导消费者购买低碳汽车。英国和德国也都实施了以二氧化碳为基础的财政鼓励措施，推动低碳汽车的销售。ICCT2010年的一份报告（最佳财税奖惩方案的设计和实施）和即将完成的另一份报告（影响二氧化碳排放水平的轻型车财税政策的回顾和评估）中详细的介绍了不同的设计方案、国际财政补贴方案经验及减少轿车温室气体排放的财政鼓励方案。中国在制订自己的财政政策时可以参考这两本报告。在2010年6月1日，中国政府实施了一项新的财税政策，所有购置符合第三阶段油耗标准及发动机排放量为1.6升以下车辆的消费者都可以得到3000元/辆的一次性定额补助。这个新的财税政策是迈向正确方向重要的一步。

96 Greene, D.L., J. German 和 M.A. Delucchi, 2009年.《燃料经济性：市场失败案例》（“Fuel Economy: the Case for Market Failure”），第11章Ch. 11, D. Sperlin和J. Cannon,《降低交通领域气候影响》（ Reducing Climate Impacts in the Transportation Sector）; 斯普林杰科学与商务媒体（Springer Science and Business Media）。

A weight-based standard system, such as the one currently implemented in China, is ineffective in preventing an increase in average vehicle weight. Weight-based standards give manufacturers an incentive to up-weight their fleet in order to qualify for more lenient standards and penalize manufacturers who use advanced technologies to reduce vehicle weight and improve fuel efficiency. An ideal standard structure would encourage all fuel-efficient technologies, including better powertrain designs, engine downsizing, and lightweight materials, while at the same time allowing vehicles to be produced across the entire range of sizes typical for the targeted market segment.

The U.S.-style footprint-based standard structure has all these advantages over the weight-based standard. It rewards the use of fuel-efficient technology and lightweight materials, while punishing up-weighting of vehicles that is directly responsible for more energy consumption. It discourages pursuing bigger engines and higher performance at the expense of fuel efficiency. In addition, the footprint standard basis, by definition, can reduce the chances of manufacturer "cheating" by adding big bumpers or other accessories that would increase vehicle exterior size and qualify the vehicles for a weaker standard.

8.4 The role of fiscal policies

Fiscal policies are a crucial component of transportation climate policies. On one hand, manufacturers' investments in advanced and green technologies, such as gasoline direct injection, continuously variable transmission, variable valve train, hybridization, and so on, often cannot be fully passed on to consumers. This is because consumers tend to severely discount the lifetime fuel saving benefit from technologies[96]. With fiscal policies, the manufacturers' rewards for adopting such technologies are more certain. In addition, fiscal policies provide consumers with price signals for fuel efficiency and lower emissions, and help increase the mix of more efficient vehicles in the market.

Vehicle taxes or other charges that vary with vehicle CO_2 emissions or fuel consumption are potentially more effective than policies based on vehicle attributes (such as weight or displacement) in encouraging lower emissions and more fuel-efficient vehicles. This is because manufacturers may adjust vehicle attributes in response to an incentive based on that attribute, without changing vehicle performance and CO_2 emissions. For example, under an engine displacement incentive system, manufacturers are rewarded for adding turbochargers and downsizing the engine, even though the engine may be just as powerful and use just as much fuel and generate the same CO_2 emissions as the larger naturally aspirated engine it replaced. Currently, the U.S. and a number of European nations have adopted either fuel economy or CO_2 based fiscal policies.

In recent years, China reformed its vehicle excise tax and acquisition tax by raising the tax rate for larger engine vehicles while reducing that for smaller-engine vehicles. The purpose of the reform is to encourage a more fuel-efficient fleet. But for the reasons stated above, such a policy may only result in a fleet of small vehicles without much improvement in vehicle efficiency. Shifting the policy basis to fuel consumption or CO_2 emission could provide a more direct incentive to manufacturers and consumers without introducing an extra tax burden. The French Bonus-Malus program that rewards and penalizes buyers based on a vehicle's CO_2 emission performance not only stimulated the domestic vehicle market but have also successfully directed consumers to buy lower carbon vehicles. The United Kingdom and Germany have also introduced CO_2-based fiscal incentives to promote sales of low-carbon vehicles. A 2010 ICCT report (Best Practices of Feebate Program Design and Implementation) and an upcoming report (Review of Fiscal Policies to Influence Light-duty Vehicle CO_2 Emissions) detail various design issues and international experiences of feebate programs and broader vehicle fiscal incentive programs that aim at reducing GHG emissions from cars. These reports can be a reference for China when designing its own fiscal policies. Starting from June 1, 2010, the Chinese government offers a one-time 3000-yuan incentive to consumers who purchase small engine-size (<1.6 liter) vehicles that meet the Phase III fuel consumption standards. This new incentive is an important step towards the right direction.

96 Greene, D.L., J. German and M.A. Delucchi, 2009. "Fuel Economy: the Case for Market Failure", Ch. 11, in D. Sperling and J. Cannon, eds., Reducing Climate Impacts in the Transportation Sector, Springer Science and Business Media.

8.5 建议

以下建议主要针对环保部，涵盖五个方面：授权、严格性、标准设置、实施和辅助政策。

环保部应力争获得监测和管理机动车温室气体排放的授权

作为世界上最大的温室气体排放国之一和世界上汽车市场增长速度最快的国家，中国在减轻气候变化方面的作用十分重要。环保部应当牵头强调固定源和移动源的气候变化影响。近期，环保部应力争获得管理道路车辆温室气体排放的授权，并开始监测和收集新车及在用车的温室气体排放数据。这些数据可以用来开发温室气体排放清单，并与常规污染物排放清单数据库相整合，为今后制订温室气体标准做准备。由环保部来确保对常规污染物和气候变化影响物采取的管理措施相一致从而取得共同收益是最适宜的。为了获得管理权，环保部可能需要进行机动车温室气体排放影响方面的基础研究。2009年美国EPA发布了两份报告，得出如下结论：机动车排放的温室气体会引起的气候变化会危及我们及后代的健康和福利。从中长期角度（三阶段标准以后），环保部可以考虑对新车实施温室气体排放标准，或考虑和先进国家如美国和欧洲一样，统一燃料消耗量标准和温室气体排放目标值。

中国应加强现有燃料消耗量标准的力度

对乘用车而言，计划中的三阶段目标是实施严格程度在世界范围名列第四的标准。但是，如果将中国的目标与和中国车队的平均重量和尺寸相似的欧盟和韩国的目标进行比较，中国的目标是最宽松的。目前，2015年的目标是7L/100km，每年仅改善1.8%，而韩国同期的改善幅度是4.4%。尽管在欧盟新的管理方案中年度改善率为2.7%，但欧盟的基准（目前的水平）比中国要低很多。在改善情境设计中，中国应当力争到2030年以前，每年改善3%，即整体车队目标达到4.25L/100km。如果可能，应考虑4%的年度改善率，则到2030年可以实现3.5 L/100km。在本案的改善情景和强化情景中，模拟了实施上述两个目标的节油和温室气体减排效果。

对于重型商用车而言，中国目前的管理设计尚处于初级阶段。但是，基于美国进行的技术潜力研究的结论，以2015年为基准，到2030年中国的新车能够实现高达50%的改善。为阐明这一结论，本案在改善方案情景分析中设计了20%的车辆平均改善，在强化方案情景下设计了50%的改善幅度。

为了车辆群体实现更明确的燃料节约和碳减排，中国应调整现有燃料消耗量标准的设置

目前中国的乘用轿车燃料消耗量标准结构是以重量为基础的，这会鼓励车辆增加重量，令车队平均目标值降低。轻型商用车采取以发动机排量为基础，更加影响实施效果，生产企业可以很通过加装涡轮增加装置达到小型化发动机，从而获得宽松的标准。如果代之以以尺寸为基础的结构可以避免这些影响。另外，采用连续曲线取代阶梯形曲线来设置目标值也会带来收益。

中国应采取以二氧化碳温室气体排放为基础的财税政策取代现有的以排量为基础的汽车税，从而更好的支持燃料消耗量管理和全面的碳减排目标。

在过去的几年中，中国不断的做出努力，改革车辆税收政策来鼓励市场转向小型和节能的车辆。一方面，这些努力取得了积极的市场反应，小排量汽车的新车销售呈现大幅增长趋势。另一方面，现有的财政政策在支持车辆燃料消耗量和温室气体排放目标方面还不够理想。用直接与燃料消耗量或二氧化碳排放量挂钩的税收替代现有的以排量为基础的车辆税收会在引导消费者购买低碳、节油汽车方面取得更好的效果，欧洲实施以二氧化碳为基础的车辆税收的效果证明了这一点。如果环保部考虑实施财税政策鼓励购买低排放的车辆，也应该考虑将温室气体纳入设计当中，从而在最大程度上获取鼓励方案的效果，减少常规污染物和温室气体排放。

8.5 Recommendations

The following recommendations primarily aimed at MEP cover five areas: authority, stringency, structure, enforcement and complementary policies.

MEP should seek the authority to monitor and regulate GHG emissions from motor vehicles

As one of the highest contributors of gross national GHG emissions and with the most rapidly growing auto market in the world, China's actions in mitigating climate change are extremely important. MEP should take the lead in addressing climate change issues from both stationary and mobile sources. In the near term, MEP should seek the authority to regulate GHG emissions from on-road vehicles, and begin to monitor and collect GHG emissions data from both new and in-use vehicles. This data can be used to develop a GHG inventory that can be included in the conventional pollutants inventory database , as preparation for establishing any future GHG standards. MEP is best position to ensure that action both on conventional pollutants and climate forcers are consistent with each other and lead to co-benefits. In order to obtain the regulatory authority, MEP might need to conduct basic studies of GHG impacts from automobiles. In 2009, the US EPA issued two reports concluding that GHG emitted from motor vehicles contribute to climate change that endangers public health and the welfare of current and future generations. In the mid-term (post-Phase III standard), MEP may consider establishing GHG emissions standards for new vehicles, or consider harmonizing the fuel consumption standards with GHG emissions targets as was done in other leading markets such as the US and EU.

China should enhance the stringency of its current fuel consumption standards

For passenger vehicles, the proposed Phase III target is the fourth most stringent standard in the world in absolute terms. However, if China' s target is compared with those in EU and South Korea, where the fleet are of very similar average size and weight, China's target is the least stringent. Currently the 2015 target of 7L/100km represents an annual improvement rate of only 1.8%; while that rate for South Korea is about 4.4% over the same period. Although the annual improvement rate is 2.7% under EU's new regulation, EU has a much lower baseline (current performance) than China. China should pursue an annual improvement rate of 3% through 2030, which translates into a fleet-wide target of 4.25L/100km, as an improved program scenario. If possible, a 4% annual improvement that would achieve 3.5 L/100km fleet-wide, in 2030, should be considered. The fuel savings and GHG reductions from adopting these two targets are modeled in the improved program scenario and strong program scenario in this study.

For heavy commercial vehicles, China is currently in the preliminary stage of regulatory design. However, based on findings from US studies on technology potential, China could achieved as much as 50% improvements in new vehicles by 2030 from the 2015 baseline. To illustrate this, a 20% fleet-average improvement as the improved program scenario and a 50% improvement as the strong program scenario were analyzed in this study.

China should adjust the design structure of its current fuel consumption standards, in order to deliver more certain fuel and carbon reduction fleetwide

China's current weight-based structure for passenger cars fuel consumption standards encourages up-weighting, which may dilute the fleet-average target. The use of engine displacement, as is currently done for light commercial vehicles is even less effective, as it can be easily gamed by adding smaller displacement engines with turbochargers. These effects can be avoided by adopting a size-based standard structure instead. In addition, it would be beneficial to adopt a continuous line instead of step functions in determining the specific target for each attribute class.

China should replace the current displacement-based fiscal policies with a CO_2 / GHG-based scheme to better support the fuel consumption regulations and an overall carbon reduction goal

China in the past few years has made continuous efforts to reform its vehicle tax policies to encourage a market shift to smaller and thus more efficient vehicles. On one hand, these efforts have led to very positive market response and trends showing that new sales of smaller engine vehicles had grown drastically. On the other hand, current fiscal policies are not ideal for supporting vehicle fuel consumption or GHG emissions targets. Substituting direct taxes on fuel consumption or CO_2 emission for the existing displacement-based vehicle taxes would be more effective in directing consumers to purchase low carbon vehicles, as evidenced by the European experience with CO_2-based vehicle taxes. As MEP considers providing fiscal policies to encourage the purchase of low emission vehicles, the ministry should consider taking into account GHGs in the design so as to maximize the benefits of the incentive program in reducing conventional pollutants and GHG emissions.

9. 替代燃料和新能源汽车政策

替代燃料是指替代传统燃料即柴油和汽油的车辆替代能源。由于汽车保有量快速增长而石油供应相对有限，世界许多国家的政府都已经开始考虑推进非石化燃料和国产燃料作为适当的替代选择。除了能源安全问题，环保部门一定不能忽视这些替代燃料车的环境影响，包括其排放的空气污染物和温室气体排放。特别是在考虑燃料的全生命周期排放时，有些替代燃料对环境造成的影响可能比传统燃料还要大。

本章提供了一些基础信息，介绍了中国目前正在使用或计划使用的替代燃料带来的环境影响优势和缺点。这里主要包括甲醇、天然气（CNG/LNG）、乙醇和多种新能源汽车。中国定义的四种新能源汽车是传统混合动力车（HEV）、插入式混合动力车（PHEV）、氢燃料电池车（FCEV）和电池电动车（BEV，又称纯电动车）。

替代燃料可以根据原料（化石、生物质、风能等）的最终形态（液态、气态、电能）分类。最终的燃料的燃烧（或使用）决定尾气排放，而燃料的原料和生产过程决定其生命周期排放和能源消耗。本节在介绍各种燃料时，也会介绍车辆尾气排放及能效性和全生命周期影响。

替代燃料车辆的设计根据它们对燃料的不同使用方式而不同。其中，有只能使用单一替代燃料的车，有可以同时使用传统或替代燃料并储存在不同的燃料箱中的双燃料车，或只有一个燃料箱但可以既使用传统燃料又使用替代燃料的灵活燃料车。对于非单一燃料的替代燃料车而言，确保这些车真正使用了替代燃料是很重要的，这样才能实现节能和减排的双重目标。

另外，不是所有替代燃料车都是原厂设备制造商（OEM）生产的。传统的汽油或柴油发动机可以进行改造，适应燃烧替代燃料。但是，通常来讲，OEM生产的替代燃料车的发动机和排放性能会更好，因为它们的发动机设计和标定都是充分考虑发挥替代燃料优势的。

下面的各个段落从不同角度总结了国际和中国在推进使用替代燃料方面的经验和政策设计。基于各种燃料的排放特征和国内外的经验，每一节中都会为环保部提出建议，说明环保部在发展和实施各可持续替代燃料的各项政策中可能起到的作用。

9. Alternative fuels and new energy vehicle policies

Alternative fuels for vehicles refer to the replacements for conventional fuels such as diesel and gasoline. With rapidly growing vehicle population and limited oil supplies, many governments around the world have sought to promote non-petroleum and often home-grown fuels as suitable alternatives. Looking beyond energy security, environmental authorities must not overlook the environmental impacts, both in terms of the emissions of toxic air pollutants and in terms of greenhouse gas emissions, of these vehicles. Especially when taking into consideration the full fuel life cycle emissions, some alternative fuels may have greater negative impact on the environment than conventional fuels.

The chapter provides basic information on the environmental advantages and drawbacks of a range of alternative fuels and vehicle currently used or planned to be deployed in China. These include methanol, natural gas (CNG/LNG), ethanol and various new energy vehicles. The four types of vehicles defined as new energy vehicles in China are conventional hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), hydrogen fuel cell electric vehicles (FCEV) and battery electric vehicles (BEV, also often called pure electric vehicles).

Alternative fuels can be distinguished by their feedstock (fossil, biomass, wind energy,etc.) and their final form (liquid, gaseous, electrons). While the final fuel determines the tailpipe emissions and efficiency of vehicles, the fuel's feedstock and production process determine its life cycle emissions and energy use. Each fuel section discusses both vehicle emissions and efficiency and full life cycle impacts.

Alternatively fueled vehicles are designed differently depending on how they use the fuel. There are dedicated vehicles that only use one alternative fuel, dual fuel vehicle that can use either a conventional or an alternative fuel stored in separate tanks, or flexible fuel vehicles that can use either a conventional or an alternative fuel stored in the same tank. For non-dedicated alternative fuel vehicles, ensuring the actual use of the alternative fuels will be important to realize both energy consumption and emissions reduction goals.

In addition, all alternative fuel vehicles are not produced by original equipment manufacturers (OEMs). Conventional gasoline or diesel engines can be modified to accommodate the combustion of alternative fuels. However, generally speaking, OEM alternative fuel vehicles have better engine and emissions performance given the engine design and calibration are optimized alternative fuels.

Each of the following subsection summarizes the relevant aspects of international and Chinese experience and policies designed to promote the use of these fuels. Based on the emissions features of each fuel type, as well as the lessons learned in China and abroad, each section concludes with recommendations on MEP's potential role in the development and implementation of policies that support sustainable alternatives to petroleum fuels.

9.1 甲醇汽车

尽管理论上可以使用有机质生产甲醇，但出于价格的原因，通常绝大多数的甲醇是使用煤和天然气制得的。目前，甲醇可以适用于专用车或按一定比例在汽油中掺烧（通常是以5％到85％的比例，这些车辆称成为M5至M85车）。加州在上世纪90年代推行过甲醇燃料，当时甲醇汽车主要使用含15%汽油的M85燃料。中国目前大多数使用甲醇的汽车其实是使用M15燃料的普通汽油车。甲醇汽车可能可以减少特定的空气污染物，使用甲醇的潜在空气质量收益是推动使用该燃料的主要原因之一。加州1980年至1990年之间进行的M85试点方案显示，生产企业可以生产出满足加州低排放车辆标准的M85汽车，且非甲烷有机物排放量低于0.125克/英里，能减少氮氧化物和一氧化碳排放。特别是重型发动机的排放，与传统汽油车相比，颗粒物排放大幅降低并几乎消除了甲醛以外的所有空气有毒物质[97]。

但是，使用甲醇作为机动车燃料也存在一些问题。甲醇燃烧会排放大量的有毒物质甲醛，甲醛被世界卫生组织划归为致癌物。在美国，对甲醛排放的担忧是影响甲醇使用的主要因素。

甲醇是一种有毒物质。摄入10毫升的甲醇可致盲，而摄入60毫升以上可致命。除了直接摄入，液态甲醇会通过皮肤吸收，其挥发的气体也可以吸入肺部。甲醇蒸气比空气重，如果通风不够良好就会停留在近地面高度。如果空气中的甲醇浓度超过6.7%，就可能被火花点燃，并且在54 F / 12 C 以上会发生爆炸。一旦着火，火焰的光很淡，很不容易看见从而不能用肉眼估计火势大小。另外，甲醇的挥发度低，会导致冷启动困难。如果混合30%或更多的汽油则可以忽略这个问题[98]。安全隐患和燃烧特性都给采用甲醇作为车用燃料提出了挑战，特别是甲醇专用车。

甲醇还具有腐蚀性会侵袭和腐蚀特定金属，如镁和铝。 如使用高比例甲醇（如M85），还须车辆燃料系统使用不锈钢或碳素钢，并配备独立的燃料供给基础设施来防止腐蚀 。使用汽油与甲醇低比例混合（如M15），如果没有专门选择燃料系统的材料，长时间使用可能也会导致腐蚀和生锈问题。甲醇还会侵蚀合成橡胶，如橡胶、聚氨酯和一些塑料，推荐使用氟含量较高的合成橡胶、特氟隆和其它耐醇材料[99]。

最后，从生命周期角度考虑，如果使用煤作为原料，与传统燃料相比，甲醇在减少生命周期温室气体排放方面没有太多优势。据估计，使用煤基甲醇汽车的全生命周期温室气体排放，与传统汽油内燃机汽车的全生命周期排放量持平[100]。

国际经验

加州积极推广甲醇汽车来应对烟雾问题，应该在世界上具有最广泛的甲醇使用经验。为应对石油危机，早在70年代末起，加州就开始开展甲醇试点项目。早期的绝大多数甲醇都是煤制甲醇，依赖周边各州充沛的煤炭储备。80年代初，原油价格开始回落，空气污染取代能源安全成为使用甲醇的主要推动力。因此，加州政府从高污染的煤制甲醇转为天然气制甲醇。

97 Dolan, G. 2005年，《甲醇交通燃料：回顾和展望》（“Methanol Transportation Fuel: A Look Back and Look Forward”），国际醇燃料专题讨论会上的发言，圣地亚哥，加州，网址http://www.methanol.org/pdf/MIPaperforISAF.pdf。

98 Brustar, M. 和M. Bakenhus.《配合醇燃料的经济、高效的发动机技术》（Economical, high-efficiency engine technologies for alcohol fuels.）(http://www.methanol.org/pdf/ISAF-XV-EPA.pdf。

99 Dolan, G. 2005年.《甲醇交通燃料：回顾和展望》（“Methanol Transportation Fuel: A Look Back and Look Forward”），国际醇燃料专题讨论会上的发言，圣地亚哥，加州，网址http://www.methanol.org/pdf/MIPaperforISAF.pdf,2010年4月20日查阅。

100 同上。

9.1 Methanol vehicles

Though theoretically methanol can be made from any organic material, it is most commonly produced from coal and natural gas for cost reasons. Methanol is currently used in dedicated vehicles or blended at a range of ratios with gasoline (most commonly M5 to M85). In the State of California, when methanol fuel was promoted during the 1990s, methanol vehicles mainly used M85 with 15 percent of gasoline. In China, most so-called methanol vehicles to date are normal gasoline engine vehicles but use M15 as the motor fuel. Methanol vehicle may reduce certain regulated air pollutants and the potential air quality benefits from using methanol remains one of the key drivers for promoting its use. A M85 pilot program in California from 1980 to 1990 showed that manufacturers could produce M85 that met California's Low Emission Vehicle Standards, with non-methane organic gas emissions less than 0.125 grams per mile (g/mile), reduced NOx and CO emissions, especially from heavy-duty engines, dramatic reduction in PM compared with traditional gasoline vehicles, and almost eliminated all air toxics except formaldehyde[97].

However, there are several barriers to use of methanol as motor fuels. Combustion of methanol emits a lot of toxic formaldehyde, which is classified as a carcinogen by the World Health Organization's International Agency for Research on Cancer. Formaldehyde emissions, therefore, are a major concern surrounding the use of methanol in the US.

Methanol is a poisonous substance. Ingestion of only 10 ml can cause blindness and of above 60 ml can be fatal. In addition to direct ingestion, the liquid can be absorbed through the skin, and the vapors through the lungs. Methanol vapor is heavier than air and it will linger close to the ground without good ventilation. If the concentration of methanol is above 6.7% in air, it can be lit by a spark, and will explode above 54 F / 12 C. Once ablaze, the flames give out very little light making it very hard to see the fire or even estimate its size. In addition, the low volatility of methanol leads to cold start difficulties. This is less of an issue if methanol is blended with 30% or more gasoline[98]. These potential safety concerns and combustion characteristics are challenges to adapting methanol as a motor fuel, especially for dedicated methanol vehicles.

Methanol is also corrosive and will attack and corrode certain metals such as magnesium and aluminum. To prevent corrosion, stainless steel or carbon steel has to be used for the vehicle fuel system and separate fuel supply infrastructure has to be set up when fuel with high methanol concentration (e.g., M85) is used. Using gasoline with lower methanol blends (such as M15) might still lead to corrosion and rusting problems when used in the longer term if special attention is not given on the choice of materials for the fuel systems. Methanol will also attack elastomers, such as rubber, polyurethane, and some plastics, and it is recommended that high fluorine content elastomers, Teflon, and other methanol compatible materials be used[99].

Finally, from a life cycle perspective, if coal is used as a feedstock, methanol does not hold much promise in reducing life-cycle GHG emissions compared to conventional fuels. It is estimated that the well-to-wheel GHG emissions of coal-based methanol vehicles are equivalent to the life cycle emissions of gasoline-fueled ICEs[100].

International experience

California, which was the most aggressive state promoting methanol vehicles to address its smog problems, has probably the most extensive experience with methanol internationally. The state ran a pilot methanol program starting in the late 1970s as a response to the oil crises. In the early years most of the methanol was produced from coal relying on the access to abundant coal reserves in the nearby states. As oil prices started to fall in early 1980s, air pollution replaced energy security as the primary driver for the methanol program. Therefore, the Californian government turned away from highly polluting coal to natural gas as the preferred source of the fuel.

97 Dolan, G. 2005. "Methanol Transportation Fuel: A Look Back and Look Forward", presentation made on International Symposia on Alcohol Fuels, San Diego, California. Online available at: http://www.methanol.org/pdf/MIPaperforISAF.pdf

98 Brustar, M. and M. Bakenhus. " Economical, High-efficiency Engine Technologies for Alcohol Fuels." (http://www.methanol.org/pdf/ISAF-XV-EPA.pdf. Accessed on April 23, 2010).

99 Dolan, G. 2005. "Methanol Transportation Fuel: A Look Back and Look Forward", presentation made on International Symposia on Alcohol Fuels, San Diego, California. (http://www.methanol.org/pdf/MIPaperforISAF.pdf, accessed April 20, 2010).

100 Ibid.

考虑到甲醛排放、毒性、冷启动、火焰能见度和腐蚀问题，加州对甲醇或甲醇汽车提出了以下要求：

- 针对甲醇乘用轿车、轻型卡车和中型卡车，尾气甲醛排放标准设置为0.15毫克/英里[101]。

- 甲醇按85%的比例与汽油混合，加入添加剂帮助冷启动和使甲醇火焰更易被使用者看见。要采取特别的措施，确保这种有毒的燃料不会被误当做可食用的乙醇。

- 在加州销售的所有可以使用甲醇汽油的灵活燃料车（可以任意切换使用汽油和M85的车辆）都被要求采用不锈钢油路。

1998年，美国通过了《车用替代燃料法》，允许车辆制造商通过生产灵活燃料车（FFV）来获得额外的燃料经济性信用额度，用以满足企业平均燃料经济性（CAFE）标准。这一立法加速了甲醇FFV在加州的发展，如福特、克莱斯勒这样的大型汽车制造商积极的生产并在加州销售了大量车辆，以帮助他们减轻CAFE标准的负担，因为与普通同类汽油车相比，生产一辆FFV成本增加200美元，这比通过其它方法真正提高燃料经济性要便宜[102]。但是，立法到底增加了多少甲醇使用量是无法确定的，直到2007年进行修订，无论替代燃料车是否真的使用了替代燃料，都可以获得FFV信用额度（更多介绍详见乙醇部分）。

除了上面提到的环境和毒性问题，炼油企业开始通过争相生产新配方汽油来反击针对甲醇的优惠政策，这也导致了加州对于甲醇的热情的消退。燃烧新配方汽油的减排程度不亚于甲醇，这样一来使用甲醇的主要缘由，即改善空气质量，就不再有说服力了。另外，加甲醇的基础设施发展滞后，以及由于90年代中期生产甲基叔丁基醚（MTBE)需求大量甲醇造成的甲醇价格攀升，最终导致加州将甲醇作为替代燃料的方案失败。90年代末期，许多甲醇燃料站都关闭了并且新甲醇替代燃料车的销售量也直线下滑。在加州的经验中，甲醇所带来的一项持久贡献就是让石化行业和汽车行业发明了新配方汽油和灵活燃料车。

中国经验

由于中国的煤储量充沛，所以已经在通过推动生产煤基液体燃料从而减少原油进口。90年代中期，在中央政府的支持下，山西省进行甲醇燃料汽车试点。自此以后，中国的甲醇产量翻了几番。山西和陕西省政府已经开始推广甲醇作为交通燃料。2005年，中国煤基甲醇生产量达到350万吨。在2006年煤炭工业中长期发展计划当中，预期到2010年、2015年和2020年，产量可分别实现1600万、3800万和6600万吨。

中国甲醇燃料主要的混合比例是15%（即M15），这主要有两个原因。首先，汽油中混入15%的甲醇用于传统汽油车，一般认为是可不用对车进行任何改造，这样是最经济性的技术。其次，低比例混合的燃料抗爆性比较好[103]。

101 佛罗里达环保局。加州低排放汽车管理 (http://www.dep.state.fl.us/air/rules/ghg/california/62-285_rules_080908.pdf, (2010年4月23日查阅)及Nichols, Roberta. 2003年，《甲醇的故事：未来的可持续燃料》（The Methanol Story: A Sustainable Fuel for the Future.）《科学与工业研究》（Journal of Scientific & Industrial Research.）第62期，2003年1-2月刊，第97-105页。

102 Sperling, D.和Gordon D. 2009年，《20亿辆轿车》（Two Billion Cars），牛津大学出版社；生产FFV的最低成本，详见EIA2007年交通生物燃料部门，EIA网站，2月http://www.eia.doe.gov/oiaf/analysispaper/biomass.html. 2010年4月6日查阅。

103 Cheng, Y., Kang, L.,等人. 2008年，《中国低碳燃料标准和政策的背景与战略》（Background and Strategy of Chinese Low Carbon Fuel Standards and Policy）能源与交通创新中心 (iCET)。

To address concerns around formaldehyde emissions, toxicity, cold-start, flame visibility and corrosion problems, the following requirements were put in place for methanol or methanol vehicles in California:

- Formaldehyde exhaust emission standards of 0.15mg/mile was set for methanol-fueled vehicles passenger cars, light-duty trucks and medium-duty vehicles[101].

- Methanol fuel was blended at 85 percent with gasoline and additives to assist with cold start and impart visibility to the methanol flame. Special care was taken to assure that the poisonous fuel wasn't mistaken for ethanol, a drinkable alcohol.

- All methanol-gasoline flexible fuel vehicles (i.e., vehicles that could switch to use gasoline and M85 at any time) sold in California were required to have stainless-steel fuel lines.

In 1988, the Alternative Motor Fuels Act was passed in the United States allowing automobile manufacturers to make flexible fuel vehicles (FFVs) and receive extra fuel economy credits to comply with their Corporate Average Fuel Economy (CAFE) standards. This legislation sped up the deployment of methanol FFVs in California. Large-car makers such as Ford and Chrysler soon became eager to produce and sell large amounts of vehicles to the State to help relief their CAFE compliance burden because the additional cost of producing a FFVs, compared to a comparable gasoline model, is about $200 USD, a cheap modification than other options for actually improving fuel economy[102]. However, it was uncertain how effective the legislation have induced methanol use because, until a recent revision in 2007, FFV credits were offered regardless of whether alternative fuels were actually used (see further discussion in the ethanol section).

In addition to the environmental and toxicity concerns mentioned above, enthusiasm for methanol faded in California when oil industry fought back by producing reformulated gasoline, which when burned emit similarly low level of emissions as methanol, and therefore eliminated the compelling air quality rationale for methanol. In addition, the lack of refueling infrastructure, the price spike of methanol in the mid-1990s triggered by demand of methanol to produce MTBE also contributed to the failure of methanol as an alternative fuel in California. By the late 1990's many fueling stations had closed and new vehicle sales had plummeted. One of the lasting contributions of the methanol experience in California is the important innovation in the oil and automotive industries with the development of RFG and FFVs.

Experience in China

With abundant coal reserves, China has been pursuing the production of coal-based liquid fuels to reduce its oil imports. In mid-1990s, the central government supported the demonstration of methanol vehicles in Shanxi Province. Since then, methanol production in China has increased by several folds. Provincial governments in Shanxi and Shaanxi have been promoting methanol as a transportation fuel. In 2005, China had coal-based methanol production capacity of 3.5 million tons. In the proposal of the Mid to Long-Term Coal Industry Development Plan in 2006, the production capacity was expected to be further expanded to 16, 38 and 66 million tons in 2010, 2015 and 2020 respectively.

The dominant blend ratio of methanol in China is 15 percent (M15) for two reasons. First, it is believed that the methanol can be directly blended into gasoline and be used in traditional gasoline vehicles without any vehicle conversion needed and thus is the most economic technology. Second, the low blend fuel has better antiknock performance[103].

101 Florida Department of Environmental Protection . The California Low-Emission Vehicle Regulations (http://www.dep.state.fl.us/air/rules/ghg/california/62-285_rules_080908. pdf, accessed on April 23, 2010) and Nichols, Roberta. 2003. "The Methanol Story: A Sustainable Fuel for the Future".Journal of Scientific & Industrial Research. Vol. 62, January-February 2003, pp.97-105.

102 Sperling, D. and Gordon D. 2009. "Two Billion Cars". Oxford University Press. ; for marginal cost of producing FFVs, see EIA. 2007. Biofuels in the Transportation Sector. EIA website. February. http://www.eia.doe.gov/oiaf/analysispaper/biomass.html. Accessed April 6, 2010

103 Cheng, Y., Kang, L., et al. 2008. "Background and Strategy of Chinese Low Carbon Fuel Standards and Policy". The Innovation Center for Energy and Transportation (iCET)

2009年，中央政府批准了M85（85%体积的甲醇和15%体积的汽油）燃料（混合）标准。有关部门正在批准M15燃料标准。尽管官方统计不跟踪汽油中使用的甲醇数量，加油站监测数据显示，部分地区的汽油中确实混合了甲醇。这主要是因为对于加油站经营者而言，甲醇比汽油便宜。2010年初，山西等五省发布了一个方案，计划推进跨地区的甲醇汽车示范项目[104]。

总结与建议

下表总结了主要从环保性能角度考虑，甲醇汽车的优势和劣势。

表9.1: 使用甲醇汽车的优势和劣势总结

优势	劣势
▪ 能源安全：对煤和天然气丰富的国家来说是较好的石油替代燃料的选择（技术成熟成本低）。 ▪ 单价比汽油便宜 。 ▪ 相对于非新配方汽油，能够减少氮氧化物、一氧化碳和颗粒物排放。	▪ 有毒并具有腐蚀性。车辆使用高比例甲醇燃料必须采用特殊的设计和使用耐甲醇材料；即使低比例混合，长期使用也可能出现腐蚀问题 。 ▪ 甲醛排放。 ▪ 煤制甲醇会增加上游的温室气体排放。从全生命周期来讲，温室气体排放不比汽油车少。 ▪ 有了新配方汽油以后，使用甲醇就不存在排放优势了 。

鉴于一些省份对使用甲醇（特别是M15）作为车用燃料具有很大兴趣，以下建议主要针对如何优化甲醇汽车的环境影响：

▪ 应开展研究，量化研究使用M15的空气质量收益。之前美国进行的研究表明，与非新配方汽油相比，使用甲醇能够减少空气污染，不过随着美国提高了汽油标准，这些优势明显减少。分析甲醇（特别是M15）的空气质量收益能帮助环保部权衡大范围使用甲醇的环境收益和推广这种燃料的成本（包括经济和环境影响成本）。如果证明M15不能被用于现有燃料供应基础设施和普通汽油车，并需要特殊的燃料供应系统和车辆的话，这种分析就显得更加有用了。

▪ 应考虑腐蚀性和材料耐受性的问题。由于对M15的研究比较有限，应要求主张M15可以用于普通车辆并使用现有燃料供应系统进行传输的甲醇生产商和部分省份进行实验，证明常规汽油车和燃料供应系统长期使用M15不会出现腐蚀或耐久性问题。在山西和其它使用甲醇燃料车的地区进行的示范项目的结果可能能为这方面的分析提供一些优质数据。另外一个途径就是支持使用特殊设计的纯甲醇汽车，比如采用不锈钢油箱来装载甲醇燃料。不过，这样的车会比较贵，降低了甲醇的全生命周期价格优势。

▪ 必须有甲醛排放标准来控制这种危险污染物的排放。加州的方案可以提供有益的指导。

104 网址：http://chemease.cbichina.com/News/2566988,0,0,0,0.htm。

In 2009, a fuel (blending) standard for M85 (with 85% of methanol and 15% of gasoline by volume) was approved by the central government. Efforts are under way to approve an M15 fuel standard. Even though official statistics do not track methanol use in gasoline, station-monitoring data has shown that methanol is indeed blended into gasoline in some regions. This is primarily because methanol is typically cheaper than gasoline for fuel station operators. In early 2010, Shanxi and five other provinces unveiled a plan to promote a cross-regional methanol-fueled vehicle demonstration program [104].

Summary and recommendations

The table below summarizes the pros and cons of methanol vehicles.

Table 9.1: Summary of advantages and disadvantages of methanol in vehicle applications

ADVANTAGES	DISADVANTAGES
▪ Energy security: good substitute for petroleum for coal and natural gas-rich countries ▪ Typically cheaper than gasoline ▪ Potential reduction in tailpipe NOx, CO and PM emissions compared to non-reformulated gasoline	▪ Poisonous and corrosive. Vehicles using high blend methanol fuel must be specially designed using methanol-compatible materials; even for low blend there might be corrosion problems if for long-term use ▪ Formaldehyde emissions ▪ Methanol from coal will increase GHG emissions from upstream. No life cycle GHG improvements compared to gasoline vehicles. ▪ With reformulated gasoline available, the emissions benefit from using methanol is not significant

In view of the strong interest in some provinces in using of methanol (especially M15) as a motor fuel, the following recommendations are aimed at optimizing the environmental impacts of methanol vehicles:

▪ Research to quantify air quality benefits of using M15 should be conducted. While previous research conducted in the US has shown that use of methanol resulted in less air pollution compared to non-reformulated gasoline, those advantages diminished significantly as the US gasoline standards improved. Analysis of the air quality benefits of methanol (M15 in particular) could help MEP weight the environmental benefits of expanded use of methanol and costs for adopting this fuel. Such analysis would be particularly useful if M15 is shown to not be compatible with existing fuel infrastructure and normal gasoline vehicles, and special fuel supply system and vehicles are needed to enable the use of this fuel.

▪ Corrosion and material compatibility issues should be addressed. Because of the limited study on M15, methanol producers or provinces advocating that M15 could be used in normal vehicles and be distributed via the existing fuel supply system should be required to conduct testing to demonstrate no long term corrosion or durability problem would be caused by the use of M15 in regular gasoline vehicles and the fuel supply system. Findings from the pilot projects undergoing in Shanxi province and the cross-regional methanol-fueled vehicle demonstration program might offer good data for such analysis. Another solution would be to support neat methanol vehicles with specialized designs, such as using stainless steel tanks, for methanol fuel. However, these vehicles will be more expensive reducing the methanol life cycle cost advantage.

▪ A formaldehyde emission standard is also necessary to control the emission of this dangerous pollutant. California's program provides useful guidance.

104 http://chemease.cbichina.com/News/2566988,0,0,0,0.htm

▪ 如果中国选择扩大煤基甲醇的使用范围，需要实施相关规定有效捕集和封存煤制甲醇过程中产生的大量碳排放。碳捕集和封存（CCS）过程要求有适当的封存地点，安装良好的二氧化碳泄漏监测系统，最后还要设立应急预案，一旦发生碳泄漏予以阻止和控制。中国政府还需要建立有效的管理和实施体系，确保CCS工程严格的依照政府制订的指导方案和操作程序开展和实施[105]。

9.2 天然气汽车

本节所指的天然气单指从天然气田中提取的，不讨论其它原料（如沼气）生产的甲烷。

天然气汽车使用的燃料是压缩天然气（CNG）或液化天然气（LNG）。与传统汽柴油车相比，由于燃烧性质清洁，天然气汽车排放的氮氧化物和颗粒物明显低得多。拿轻型车来说，美国EPA的研究显示，与没有三元催化器的汽油车相比，CNG车辆能实现一氧化碳和氮氧化物分别减排97%和60%，且几乎没有颗粒物排放[106]。对重型车而言，从2002年-2004年开始，在美国一些城市已经进行了多项试点研究，涵盖城市运输巴士、商业运输卡车（邮政运输车）、清洁车和货车，结果显示纯粹使用CNG或LNG的重型车与柴油卡车和巴士相比，能实现明显的减排。尽管实际的减排收益情况取决于车辆的用途和行驶工况，与同级别的传统柴油车相比，研究结果还是显示出天然气车在氮氧化物和颗粒物排放方面减排的总体趋势。表9.2总结了这些研究的主要结果。该表的注释中给出了参照组车辆安装减排装置（如果有这些装置的话）的信息。

105 IPCC关于二氧化碳捕集和封存的特别报告，建议一旦实施此方面的要求，“地下封存二氧化碳的健康、安全和环境风险应提升至与天然气封存、强化采油和酸性气体深埋相同的高度。”更多信息详见IPCC. 2005年，《IPCC特别报告-二氧化碳捕集和封存》（IPCC Special Report – Carbon Dioxide Capture and Storage.）《政策制定者概要》（ Summary for Policymakers.）。

106 减排数据来源于美国能源部http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html. 20105年5月2日查阅。

- If China chooses to expand the use of methanol derived from coal, provisions need to be put in place to effectively capture and store the large amount of carbon emissions from coal-to-methanol production. Those carbon capture and storage (CCS) programs would require appropriate site storage, installation of good CO_2 leakage monitoring system, and finally a remediation program to stop and control carbon releases should it arises. The Chinese government also needs to establish an effective regulatory and enforcement system to assure these CCS projects are developed and operated following strict government-developed guidelines and operation procedures[105].

9.2 Natural gas vehicles

This section focuses on natural gas extracted and processed from natural gas fields and does not discuss methane produced from other feedstocks such as biogas.

Natural gas vehicles (NGVs) are fueled with compressed natural gas (CNG) or liquefied natural gas (LNG). Compared with conventional gasoline or diesel vehicles, NGVs produce significantly lower NOx and PM emissions due their clean burning properties. For light-duty vehicles, the US EPA studies showed that CNG vehicles can reduce CO, NOx by up to 97% and 60%, respectively compared with gasoline counterparts without three-way catalysts, and almost eliminate PM emission[106]. For heavy-duty vehicles, a variety of pilot studies, involving urban transit bus, commercial delivery truck, sanitation truck and freight truck fleets, conducted about the beginning of the past decade (2002-2004) in a number of US cities indicated that dedicated CNG or LNG heavy-duty vehicles could also result in significant emissions reduction over diesel trucks and buses. Though actual emissions benefits depend on what the vehicles were used for and their driving cycles, the studies showed a trend of emission reduction for NOx and PM of the NGVs compared with conventional diesel vehicles for the same duties. Table 9.2 summarizes the key results of these studies. Information on emission control technologies adopted on the reference group vehicles is also provided in the notes below the table.

105 The IPCC Special Report on Carbon Dioxide Capture and Sequestration suggested that if these requirements are in place, "the health, safety and environment risks of geological storage [of carbon dioxide] would be comparable to the risks of current activities such as natural gas storage, EOR and deep underground disposal of acid gas." For more information, see "IPCC. 2005. "IPCC Special Report – Carbon Dioxide Capture and Storage." "Summary for Policymakers."

106 Emission reduction data are from US DOE. Online available at http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html. Accessed: May 2nd, 2010.

表9.2: 美国重型天然气车车队工作结论汇总[107]

车辆类型	CNG 邮政车	LNG 公交车*	LNG 半挂卡车	LNG 双燃料垃圾车**
车辆群体	联合邮政速递公司 (UPS)	达拉斯地区快速公交车 (DART)	Raley's	洛杉矶市环卫局
替代燃料车数量	7	15	8	10
柴油车数量	3	5	3	3
驾驶工况	城市郊区重型车线路	中心商务区	5英里固定线路	空气质量管理区垃圾车线路
颗粒物减排	95%	NSS****	96%	NSS****
氮氧化物减排	49%	17%	80%	23%
非甲烷有机物减排	4%	96%	比参照柴油车总碳氢减少59% 以上	NSS****
一氧化碳减排	75%	95%	–263%***	NSS****

*在DART的研究中，采用带氧化催化器的柴油巴士。

** 洛杉矶环卫局的测试用柴油卡车装有颗粒物捕集器。

*** 带负号的减排数字表示污染物增长。

****NSS: 无明显统计数据是因为LNG巴士或LNG及柴油垃圾车（使用了颗粒物捕集器）的排放过低测试设备检测不出。减排百分比是以柴油车排放为基础，以克/英里为单位。

在发展中国家，为了在没有低硫燃料的情况下满足排放标准，一种很普遍的做法是用天然气车替代重型柴油车。分析表明传统柴油发动机使用高硫燃料 108时氮氧化物和颗粒物排放都无法达到欧IV标准，而这一标准即将在中国和印度两国全国范围内实施。要进一步减少氮氧化物，需要“先进”的发动机，包括电控喷油、废气再循环（EGR）和选择催化还原（SCR）。而进一步削减颗粒物则需要柴油车颗粒物捕集器（DPF），而如果没有硫含量低于50ppm的燃料，DPF将无法有效工作。相反，稀燃CNG发动机（发展中国家的常见技术）的颗粒物和氮氧化物排放水平在没有后处理系统的情况下就可以比传统的欧III柴油发动机排放更低。如果要求达到欧IV，在稀燃CNG车辆上加装一个为CNG车辆特别设计的氧化催化器，就可以达到先进的带有DPF的柴油发动机的排放水平。这就是为什么如今一些没有低硫燃料的城市会考虑增加重型CNG车辆来减少城市空气污染并满足排放目标的原因。不过，要说明的是，要达到更严格的标准（欧V以上），还是需要先进的CNG发动机（如闭环电控稀燃发动机或理论空燃比发动机）和三元催化器[109]。.

107 美国能源部http://www.afdc.energy.gov/afdc/vehicles/emissions_natural_gas.htm。

108 如果燃料硫含量大于500ppm，柴油车氧化催化器（DOC）无法有效工作。柴油车颗粒物捕集器的硫含量上限是50ppm。

109 Posada F. 2010年，CNG巴士减排技术路线图：从欧III到欧VI（CNG Bus Emissions Roadmap: from Euro III to Euro VI）, 2009年，国际清洁交通委员会 第5-6页。

Table 9.2: Summary of key findings in US heavy-duty NGV working fleets[107]

VEHICLE TYPE	CNG MAIL DELIVERY TRUCKS	LNG BUSES*	LNG SEMI-TRUCKS	LNG DUAL-FUEL REFUSE TRUCKS**
Fleet	United Parcel Service (UPS)	Dallas Area Rapid Transit (DART)	Raley’s	City of Los Angeles Bureau of Sanitation
Number of Alternative Fuel Vehicles	7	15	8	10
Number of Diesel Vehicles	3	5	3	3
Drive Cycle	City Suburban Heavy Vehicle Route	Central Business District	Five-Mile Route	Air Quality Management District Refuse Truck Cycle
PM Reduction	95%	NSS****	96%	NSS****
NO_x Reduction	49%	17%	80%	23%
NMHC Reduction	4%	96%	59% Less Than Diesel THC	NSS****
CO Reduction	75%	95%	–263%***	NSS****

*Diesel buses in DART study used oxidation catalysts.

** Diesel trucks in the Los Angeles Bureau of Sanitation test used catalyzed particulate filters.

*** Negative reduction values indicate an increase in pollutants.

****NSS: Not statistically significant because emissions were too low for the testing equipment for the LNG buses or both LNG and diesel (due to the use of catalyzed particulate filters) refuse trucks. Emission given in percentage reduced from diesel emissions, based on grams emitted per mile driven.

NGVs are a popular substitute for diesel heavy-duty vehicles in developing countries to meet emissions standards when low sulfur fuel is not available. Analysis shows that conventional diesel engines operated on high sulfur fuel108 cannot achieve Euro IV emission levels for NOx and PM, which is the forthcoming standard for new engines in China (nationally) and India. To further reduce NOx, "advanced" engine including electronic control of fuel injection, and exhaust gas recirculation (EGR) and/or selective catalytic reduction (SCR) is needed. To further cut PM, diesel particulate filters (DPF) are needed, but which cannot effectively function without fuel with less 50-ppm sulfur content. In contrast, the engine-out PM and NOx emission levels from a lean-burn CNG engine (most common technology in developing countries) without any after-treatment system are low enough to outperform a conventional diesel engine (Euro III). If Euro IV is required, then the lean burn CNG vehicle fitted with an Oxidation Catalyst (OC) specially designed for CNG operation would be needed, providing the same level of performance of an advanced diesel engine with DPF. This is the primary reason why cities without low sulfur fuel are considering increasing their CNG heavy-duty fleet to reduce urban air pollution and to meet emissions target today. However, as indicated, to meet more stringent standards (above Euro V), a modern CNG engine (like close-loop electronically controlled lean-burn engine or stoichiometric engine) and a three-way catalyst will still be needed[109].

107 US DOE. Online available at http://www.afdc.energy.gov/afdc/vehicles/emissions_natural_gas.html.

108 If the fuel sulfur content is above 500 ppm, diesel oxidation catalysts (DOC) cannot effectively function. The sulfur level threshold for diesel particulate filters to function well is 50 ppm or lower.

109 Posada F. 2010. CNG Bus Emissions Roadmap: from Euro III to Euro VI, 2009, International Council on Clean Transportation, p5-6.

根据阿贡国家实验室的数据，天然气车的全生命周期温室气体排放大体上比传统燃料车少20%[110]。并且因为压缩过程消耗的能源比液化过程少，所以在生产CNG过程中使用的石油能源和排放的温室气体也比LNG少。

天然气汽车比较不利的方面包括：地域限制、动力损耗和负载限制、甲醛排放和柴油发动机改造上的难度。首先，对于距离天然气田较远的地区来说，架设长距离的管路是很贵的。不过，如果这些管路可以同时用来传输居民做饭和取暖用的天然气，那么在交通领域应用天然气的成本就会明显降低。

由于每千克天然气蕴含的能量比汽柴油要低，因此天然气汽车输出的动力也比较低，可能在上坡、加速或负载较重时比较困难。CNG储存在特别设计的气罐中（200巴压强），这会增加车辆的重量并降低负载或载客能力或进一步降低燃料经济性。通常，由于这些限制因素，使CNG车辆不得不用于特定车辆，如用于固定线路、或能确保燃料补给线路的城市公交车和重型车。LNG车辆的能源密度要高的多，比CNG车更适合长距离使用。

如之前所述，越来越多的发展中国家有兴趣将柴油巴士转换为天然气汽车，从而获得排放收益。在加气设施不很充足的情况下，柴油巴士通常会被改造成既可以使用天然气也可以使用柴油的双燃料车。不过，在传统改造技术条件下，双燃料发动机使用天然气并不能最好的发挥性能。因此，双燃料车的燃料灵活反而常常会以发动机性能恶化和降低燃料经济性为代价。一些新技术，如高压直喷技术（HPDI)，可能会提供更好的发动机能效性并实现天然气对柴油的高度替代，但是其相应的保养成本会比较高。最终，改造双燃料车的成本效益可能还不如生产企业直接生产纯粹使用CNG的CNG专用汽车。

国际经验

美国的天然气汽车主要用作公交车或垃圾车。1992年《能源政策法》将CNG和LNG纳入替代燃料范畴并对燃料、燃料基础设施和替代燃料车实施税收鼓励（大部分鼓励方案现在已经期满）。在过去的20年中，尤其是轻型车，新发动机排放标准的不断加严刺激了新柴油和汽油发动机以及燃料技术的发展，使其在排放水平上能够与CNG发动机媲美。因此，对轻型CNG汽车的兴趣大大衰退。目前，只有本田仍然在生产一款CNG思域轿车，并且这款车型是唯一还符合条件，能够获得新替代能源汽车减税激励的轻型车。不过，在重型车市场还有一些可以选择的产品。

纵观世界，天然气汽车在阿根廷、巴西等南美国家最为流行，这些国家天然气资源丰富但缺少石油。阿根廷并没有对天然气汽车实施鼓励政策，但通过对汽油征收很高的税，使得天然气的售价只是汽油的四分之一[111]。

本世纪初，印度的首都德里建立世界上最大的CNG公交车队[112]。90年代，德里经历了私人车辆保有量飞速上涨，导致空气质量和公众健康严重恶化。为应对这一问题，印度国会下令要求2001年3月以前将德里所有的公交车（柴油）全部换成CNG专用车，自此以后，各项空气污染物表面上看有所改善[113]。但是，拥堵、路况差、超载和缺乏保养等问题逐渐抵消了CNG公交车带来的收益。近年来，人们认识到使用超低硫柴油和DPF能够更进一步的减少传统柴油车的排放，不过直到2010年为止，印度还没有引入这种燃料的计划。在此期间，CNG公交车依然是德里限制空气污染的主要战略之一。并且，印度还计划在该国的另外300个城市使用CNG汽车。

110 减排数据来源于美国能源部http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html。

111 Sperling, D., Gordon, D.,《20亿辆轿车》（Two Billion Cars）, 牛津大学出版社，第93页。

112 德里交通公司http://dtc.nic.in/ccharter.htm。

113 由于可用数据的数量和质量都有限，不能完全确定德里的空气质量实质上是否切实改善。

According to Argonne National Lab, the life cycle GHG emissions from NGVs are generally about 20% less than the conventional fuel vehicles[110]. And CNG uses less petroleum and emits fewer GHGs than LNG because the compression requires less energy than liquefaction.

On the downside NGVs are associated with geographical limitation, power loss and load limitations, emissions of formaldehyde, and issues associated with diesel engine conversion. For regions far from natural gas field, building long-distance pipeline can be expensive. But if the pipeline will also be used to deliver natural gas for residential cooking and heating, the marginal cost of transportation applications could be significantly brought down.

Because of natural gas' lower energy content per kilogram compared with gasoline or diesel, NGVs yield lower power output, which may cause difficulties in climbing, accelerating, or driving with heavy loads. CNG is stored in specially designed tanks (at 200 bar pressure), which increase vehicle weight and may displace load or passenger capacity or further reduce fuel economy. In general these limitations has reduced CNG vehicles to niche applications such as city buses or heavy vehicles with fixed route and secured refueling sources. Vehicles fueled with LNG, which has a much higher energy intensity, are better suited to long-haul applications.

As indicated previously, there has been a growing interest in developing countries in converting diesel buses into NGVs for their emissions benefit. When refueling facilities are scarce, the diesel buses are often modified to be bi-fuel vehicles running either on natural gas or diesel. However, with the conventional conversion technologies, bi-fuel engines cannot be optimized for use with natural gas. Thus the flexibility of bi-fuel vehicles often comes at a cost of worse engine performance and lower fuel economy. Newer technologies, such as high-pressure direct injection, may provide better engine efficiency and realize high diesel replacement, but are also associated with high maintenance costs. In the end, retrofitted bi-fuel vehicles might not be as cost-effective compared to OEM built dedicated CNG vehicles.

International experience

In the US, NGVs are primarily used in bus or refuse truck applications. The "Energy Policy Act" of 1992 included CNG and LNG as alternative fuels and provided tax incentives for the fuels, fueling infrastructures and the alternative fuel vehicles (most of the incentive programs have now expired). Especially for light-duty vehicles, the imposition of more stringent emission standards for new engines over the last 20 years has stimulated the development of new diesel and gasoline engine and fuel technologies that are competitive with CNG engines from an emissions standpoint. As a consequence, interest in light-duty CNG vehicles has waned. Currently, only Honda is still producing a CNG-based light-duty model (Civic) and that model is the only one that is still eligible for the new alternative fuel vehicle tax credit for light-duty vehicles. However, there are more product options on the heavy-duty market.

Worldwide, NGVs are most popular in South American countries like Argentina and Brazil that are rich in natural gas but not petroleum. Rather than providing incentives to natural gas vehicles, Argentina assessed a high tax on gasoline so that natural gas sells for one-fourth of the price of gasoline[111].

Delhi, the capital city of India, built the world's largest CNG bus fleet early in this century [112]. Delhi experienced skyrocketing growth of private vehicles in the 1990s that resulted in worsened air quality and severe public health deterioration. In response, the Supreme Court of India issued an order that required the entire (diesel) bus fleet of Delhi to be converted to dedicated CNG vehicles by March 2001, and since then there has been apparent decline of various air pollutants [113]. However congestion, poor road conditions, overloading and lack of maintenance have gradually eroded the benefits of the CNG buses. In recent years, it was recognized that the use of ultra low sulfur diesel and DPF could make further emission reduction possible for conventional diesel vehicles, however suchfuel is not scheduled to be introduced until 2010. In the meantime, CNG buses are still one of the main strategies Delhi is deploying to limit air pollution. Furthermore, the use of CNG vehicles is scheduled to be spread to 300 other cities in India.

110 Emission reduction data is from US DOE. Online available at http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html

111 Sperling, D., Gordon, D., Two Billion Cars, Oxford University Press 2009. Page 93.

112 Delhi Transport cooperation. http://dtc.nic.in/ccharter.htm

113 Given the limited data availability and poor data quality, it is not completely certain whether the air quality has improved in Delhi.

中国经验

中国的天然气资源和天然气田主要位于西南部各省（四川、新疆等）。90年代中期，科技部宣布了清洁空气行动计划，在中国主要城市推广替代燃料车。自此以后，中国在西南部的一些城市推广了天然气汽车，在这些地区天然气与汽油相比有明显的价格优势（天然气的价格是汽油的40-50%）。本世纪初，由于西气东输工程，天然气在上海和北京这样的东部城市也成了容易获得能源，为这些地区发展天然气汽车提供了基础。到2008年底，已经有80个城市推广了天然气汽车，总计超过17万辆，在全国有500家以上的CNG加油站，其中四川省仍然拥有中国最大的CNG车队。在重庆市（位于四川省内的直辖市），到2009年，共有CNG汽车5-6万辆，其中约有1万辆是双燃料CNG出租车，有7000至8000辆是CNG专用公交车。全市共有约70家CNG车辆加气站。

总结与建议

表9.3总结了天然气汽车在环保方面的优势和劣势。

表9.3: 天然气汽车优势和劣势汇总

优势	劣势
▪ 与欧III技术的汽柴油车辆相比，无论是轻型或重型CNG汽车，颗粒物和氮氧化物排放都明显减少。没有黑炭排放。 ▪ 在没有低硫燃料的发展中国家，稀燃天然气汽车是满足更严格的排放标准（欧III和欧IV) 的过渡技术（若稀燃天然气汽车加装氧化催化器可达欧IV）。相比之下，传统柴油车要达到这些标准比较困难。 ▪ 先进的CNG技术加上后处理技术（理论空燃比发动机加装三元催化器）几乎能够实现目前世界上最严格的排放标准（欧VI）。 ▪ 与传统燃料车相比，全生命周期温室气体排放减少约20%。 ▪ 在离天然气供应点较近的地方，天然气的价格比传统燃料便宜很多。	▪ 地域限制-只有离天然气供应点较近的地方才具有较高的成本效益。 ▪ 动力损失，对山地或丘陵地区、长距离或高负载运输来说并不理想（LNG车辆会好一些），还会降低公交车（巴士）的载客能力。 ▪ 如果不是HPDI的原装CNG发动机，燃料经济性会比传统汽车低（油耗高）。不过，如天然气的价格显著低于汽柴油价格，可以抵消加装HPDI和维护的成本。对于原装CNG发动机来说，燃料经济性与相应的柴油车相仿或稍高。 ▪ 增加甲醛排放 。 ▪ 改造的双燃料车(CNG/柴油)发动机性能和排放都较差。

下列建议的主要目的是减少天然气汽车的环境影响：

▪ 天然气汽车在临近天然气供应点的地区推广具有很高的成本效益。

▪ 鉴于CNG汽车动力和范围方面的限制，它们更适合用于固定线路的交通运输，如城市公交、快递、垃圾车或其它可以返回总站集中加气的车辆。LNG可以更好的应用于长距离交通。

▪ 相对而言，支持制造商生产专门的天然气汽车会有更高的成本效益，相比之下，改造的天然气汽车（或双燃料车）在发动机性能、排放和燃料经济性方面都比较差。

China's Experience

Most of China's natural gas resource and fields are located in its southwest provinces (Sichuan, Xinjiang, etc). In mid 1990s the Ministry of Science and Technology (MOST) announced the Clean Air Action Plan to promote AFVs in major Chinese cities. Since then, China has promoted NGVs in a number of southwest cities, where there is significant price premium for gasoline compared to natural gas (natural gas price is about 40%-50% of that of gasoline). At the beginning of the new century, enabled by the East Gas Line Project, natural gas became a commonly available energy source for eastern cities like Shanghai and Beijing, which also laid a ground for developing NGVs in these regions. By end of 2008, NGVs were being promoted in 80 cities, with more than 170,000 NGVs and more than 500 CNG refueling stations nationwide, while Sichuan province still maintained the largest CNG fleet in China. In Chongqing city (a municipality neighboring Sichuan province), there were 50,000-60,000 CNG vehicles by 2009; of those, about 10,000 were dual-fuel CNG taxi cars and 7,000-8,000 were dedicated CNG buses. The city had about 70 CNG refueling stations to serve CNGVs.

Summary and recommendations

Some of the pros and cons of NGVs are summarized in Table 9.3

Table 9.3: Summary of advantages and disadvantages of natural gas in vehicles

ADVANTAGES	DISADVANTAGES
▪ Significant reduction of PM and NOx for both light-duty and heavy-duty CNG vehicles compared with conventional fuel vehicles with Euro III technologies. No black carbon emission. ▪ In developing countries without low sulfur diesel fuel, lean burn NGVs are a bridge technology to meet more stringent emissions norms (Euro III and Euro IV if the lean burn NGV is fitted with oxidation catalyst), which is more difficult for conventional diesel vehicles. ▪ Advanced CNG technologies together with after-treatment technologies (stoichiometric engines with three-way catalyst) will achieve the most ambitious emissions norms worldwide (Euro VI) ▪ About 20% life cycle GHG reduction compared with conventional fuel vehicles ▪ Natural gas can be much cheaper than conventional fuels near natural gas supply	▪ Regional limitation – only cost-effective for regions with NG supply ▪ Power loss, not ideal for hilly regions, or long-distance or heavy loading transportation (LNGV is better), or reduced passenger capacity for buses ▪ Lower fuel economy (more fuel consumption) than conventional vehicles for non-OEM CNG engines without HPDI. However, cost impact can be offset when NG price is lower than gasoline and diesel. For OEM engines, fuel economy can be similar to or a little bit higher than the diesel counterpart. ▪ Increased formaldehyde emissions ▪ Converted bi-fuel vehicles (CNG/diesel) have worse engine performance and emission.

The following recommendations are aimed at optimizing the environmental impacts of natural gas vehicles:

▪ NGVs are most cost effectively implemented in regions in proximity to natural gas supply.

▪ Given the power and range limitations of CNG vehicles, they are more suitable for fixed route transportation, such as urban buses, ground parcel delivery, refuse trucks, or other return to base fleets with central fueling. LNGVs perform better in long-distance hauling applications.

▪ It is relatively more cost-effective to support OEM dedicated NGVs with natural gas-optimized engines than converted NGVs (or bi-fuel vehicles) that have worse engine performance, emissions, and fuel economy.

- 当前的改造方案中应要求严格控制改造组件并进行认证测试，以便实现氮氧化物和颗粒物排放的改善。

9.3 乙醇汽车

和甲醇类似，乙醇也可以低比例（5-10%）、中比例（15-20%）或高比例（85%）的和汽油混合。低比例混合乙醇的燃料由于不能明显取代汽油，在美国，它不算是替代燃料。乙醇比汽油的辛烷值高，并有较好的抗爆性，因此在美国用它来取代MTBE使燃料燃烧氧化过程更充分。一般来说，使用乙醇燃料能够减少主要空气污染物的排放，包括一氧化碳、非甲烷碳氢化合物、颗粒物和苯之类的空气有毒物质。不过蒸发排放可能更会有所升高，升高情况根据混合的比例而定。

E10燃烧时会产生对人体有毒害作用的乙醛。根据发动机工作状况，燃烧E10排放出的氮氧化物可能比使用纯汽油还高[114]。另外，低比例混合乙醇会提高汽油的雷氏蒸汽压（RVP），产生更高的蒸发排放。如把燃烧排放和蒸发排放都考虑在内，E10只能减少一氧化碳，其碳氢化合物、非甲烷碳氢化合物、甲醛、乙醛和臭氧形成潜能都是增长的[115]。

E15和E20等中比例混合乙醇能更多的取代汽油，但是在美国，它们和E10一样都不算替代燃料，并且事实上联邦政府并不认为中比例乙醇混合燃料是合法燃料，即在没有获得EPA豁免的前提下是不能用于未经改造的传统燃料发动机的。在美国，明尼苏达州率先使用了中比例混合的乙醇燃料并于2005年通过法案要求2013年以前在该州的汽油中使用20%的乙醇。使用中比例混合的乙醇燃料的影响目前还没有研究定性。明尼苏达州进行的一项研究指出，使用E20不会对现有发动机或燃料传输系统造成直接影响[116]。然而澳大利亚环保部的一份文献评论指出，与使用E10相比，燃烧E20可能造成氮氧化物排放增加30%。研究还同时指出使用这种燃料可能增加蒸发排放、甲醛排放、降低燃料经济性和驾驶性能，并提出燃料可能有腐蚀性。根据该研究结果，E20的全生命周期温室气体排放很可能和E10没有太大差异，这是因为尾气的二氧化碳排放只占全部排放的很小一部分。美国对E20影响的研究仍在进行中[117]。

在美国，只有混合了85%（E85）或更高比例的乙醇的燃料才能被视为替代燃料。2008年，美国国家可再生能源实验室进行的一项研究表明，平均来看，E85的所有常规排放物与汽油相比或减少或没有明显变化。但是，使用E85会增加甲醛、乙醛和甲烷排放[118]。

乙醇汽车的其它问题包括降低燃料经济性，这是由于乙醇燃料的能量值比较低，和使用高比例混合的燃料会产生的冷启动困难。灵活燃料车在使用E85时，每加仑燃料行驶的英里数一般比使用汽油减少约20-30%。在美国部分州，在特定季节E85会被调整成E70来解决冷启动问题，虽然仍然叫做E85。

114 美国进行的部分研究认为E10会增加氮氧化物排放。但是另一些人反对这一说法，认为氮氧化物的排放取决于空燃比，认为根据E10特性而优化的发动机使用E10能够减少排放。

115 减排数据来源于美国能源部http://www.afdc.energy.gov/afdc/vehicles/flexible_fuel_emissions.html。

116 明尼苏达农业局http://www.mda.state.mn.us/renewable/ethanol/e20testresults.aspx。

117 澳大利亚环境、水资源、遗产和艺术部http://www.environment.gov.au/atmosphere/fuelquality/publications/review-vehicle-fleet/index.html。

118 减排数据来源于美国能源部http://www.afdc.energy.gov/afdc/vehicles/flexible_fuel_emissions.html。

▪ Existing conversion programs should require strict controls and certification testing for conversion kits and converted vehicles to realize improvements in NOx and PM.

9.3 Ethanol vehicles

Similar to methanol, ethanol can be blended with gasoline at low (5-10 percent), intermediate (15 to 20 percent) or high (85 percent) ratios. Since it does not significantly displace gasoline use, low blend ethanol is not considered as an alternative fuel in the US. Ethanol has higher octane rating than gasoline and offer some anti-knock benefits so have been replacing MTBE in the US for oxygenating fuel. Generally speaking, using ethanol fuel reduces tail pipe emissions of major regulated air pollutants including CO, NMHC and PM, and air toxics such as benzene. However, evaporative emissions may increase and the extent of increase depends on blend ratios.

Combustion of E10 emits acetaldehyde, which is toxic to humans. Depending on engine operating conditions, NOx emissions from burning E10 can be higher than that from pure gasoline [114]. In addition, ethanol at low-blend levels increases the Reid vapor pressure (RVP) of gasoline thus creates higher evaporative emissions. Combining combustion and evaporative emissions, E10 only reduces CO, but increases emissions of HC, NMHC, formaldehyde, acetaldehyde emissions and ozone forming potential[115].

Intermediate ethanol blends have higher gasoline displacement effect, but similar to E10, E15 to E20 blends do not qualify as alternative fuels in the US and are actually not considered by the Federal government as legal fuels for unmodified engines without a waiver from EPA. In the US, the State of Minnesota is at the forefront of efforts to use intermediate blends and passed a law in 2005 mandating use of 20% ethanol in the state's gasoline by 2013. Research on the impact of using intermediate blends of ethanol fuel so far has not been conclusive. A study sponsored by Minnesota suggests that using E20 will not cause immediate problems to current engine or fuel dispensing system [116]. While a literature review conduced by Department of Environment of Australia indicates that burning E20 may increase NOx emission by 30% compared with using E10. The same study also mentioned possible increase in evaporative emissions, formaldehyde emission, as well as reduced fuel economy and driveability, and also mentioned possible corrosive effect of the fuel. The life-cycle GHG emissions, also according to the study, is unlikely to be different from that of E10 vehicles given that the tail-pipe CO_2 emission is only a small fraction of overall emission. Federal studies on the impact of E20 are still underway[117].

Only ethanol blends of 85 percent (E85) or higher are considered alternative fuels in the US. A 2008 study conducted by US National Renewable Energy Laboratory showed that on average, all regulated emissions either decreased or showed no significant difference with E85 compared with gasoline. But using E85 increases emissions of formaldehyde, acetaldehyde and methane[118].

Other issues with ethanol vehicles include reduced fuel economy due to the lower energy content of ethanol fuel and difficulties with cold start while using high blend fuel. FFVs typically get about 20-30% fewer miles per gallon when fueled with E85. In some states in the US, E85 is seasonally adjusted to E70 to allow cold start, though it is still called E85.

114 A few studies conducted in the US concluded that E10 increases NOx. But others argue that NOx emissions strongly depend on the fuel/air ratio, implying that engine optimization for E10 could decrease emissions.

115 Emission reduction data are from DOE. Online available at: http://www.afdc.energy.gov/afdc/vehicles/flexible_fuel_emissions.html

116 Minnesota Department of Agriculture. Online available at: http://www.mda.state.mn.us/renewable/ethanol/e20testresults.aspx

117 The Department of Environment, Water, Heritage and Art. Online available at http://www.environment.gov.au/atmosphere/fuelquality/publications/review-vehicle-fleet/index.html.

118 Emission reduction data are from DOE. Online available at: http://www.afdc.energy.gov/afdc/vehicles/flexible_fuel_emissions.html.

在从油箱到车轮的阶段，无论使用哪个混合比例的乙醇燃料，二氧化碳排放都会减少，但全生命周期（从油井到车轮）排放情况评估起来则比较复杂。这是因为有多种原料和方法可以生产乙醇。乙醇可以是炼油时生产的副产品（主要用于工业用途）。世界上最普遍的乙醇生产方法是通过将玉米（美国）、甘蔗（巴西）或陈化粮及木薯（中国）等碳基原料，经过发酵和蒸馏方法生产乙醇。目前还有技术可以将非粮原料转化为乙醇，如水藻、纤维素、动物粪便或庭院垃圾等，但是目前这些都不能实现经济性量产。原料种类和生产工艺决定了种植、生产和储运过程中的温室气体排放量。

土地使用方式的变化也会产生间接的温室气体排放（ILUC）。对乙醇燃料需求的增长可能导致更多原本生产粮食作物的农田转而生产乙醇原料。这会造成食品价格上涨，会刺激农民将雨林或草场转变成新的农场，这将大幅度削弱土壤吸收和封存碳的能力并由此增加温室气体排放。除了增加温室气体排放，开垦还会带来显著的环境和社会影响，包括对当地生物多样性、土壤、水质量和原始部族文化的延续性带来压力。政策制定者需要考虑生物燃料的直接和间接温室气体排放影响和其他影响，以确保旨在能源独立性的政策不会以环境为代价。

国际经验

世界乙醇燃料市场由美国和巴西两国主导——两国共计生产和消耗全世界90%的乙醇燃料。在美国，有半数以上的汽油中混合了10%的乙醇。在部分州和城市规定必须使用E10燃料。至今，美国还有800万辆灵活燃料车在路上行驶，这些车既可以使用汽油，也可以使用任何混合比例（最高E85）的乙醇燃料。E85灵活燃料车在美国中西部十分普遍，因为那里玉米是主要农作物并且是乙醇燃料的原料。

美国乙醇燃料和车辆的支持政策可以追溯至上世纪70年代。1988年的《车用替代燃料法》以企业平均燃料经济性（CAFE）信用额度的形式来鼓励车辆生产企业通过生产灵活燃料车来获得相对宽松的车辆平均燃料经济性目标值。与巴西的甘蔗乙醇相比，美国的玉米乙醇造价昂贵，因此政府给这种燃料提供了很多补贴。对于某些州来说，玉米种植是当地经济的重要组成部分，来自这些州的利益团体四处进行游说支持玉米乙醇，这些游说行为取得了很大的成功。2006年进行的一项研究表明，用于玉米乙醇的补贴总额高达50亿美元并还在持续增长[119]。

2008年10月，沿着I-65公路（贯穿玉米种植为主的中部多个州）开通了首条“生物燃料走廊”，这条公路是美国中部的主要州际公路。从北部的印第安纳延伸至南部的阿拉巴马，在这条走廊上有200家以上的乙醇加油站，使得从密西根湖驶到墨西哥湾的E85灵活燃料车总能在一箱乙醇燃料用完之前就能找到新的加油站加到乙醇汽油[120]。

尽管美国的许多车辆可以使用乙醇燃料，但事实上却并没有使用。这主要有三方面的原因。首先，最初的CAFE灵活燃料车方案并不要求证明确实使用了替代燃料，直到近期才根据《2007年能源独立与安全法案》（EISA）的要求对此进行了修订。第二，灵活燃料车销售量快速增长，但是燃料基础设施相对落后。截止至2010年，全美的12.1万家加油站中只有2000家向公众出售E85[121]，这些E85加油站还大部分集中在“玉米带”上的各个州[122]。在加州，只有44家E85加油站。最后一点是很多车主可能都不知道自己的车是灵活燃料车，因为灵活燃料车的外观和同类的非灵活燃料车是一模一样的。要想知道车辆是否可以使用乙醇燃料，需要查看油箱盖里面的指示标签或车辆说明书。相反，巴西要求生产企业在车身上设置明显标志，表明是灵活燃料车。

119 Sperling D., Gordon, D.,《20亿轿车》（Two Billion Cars）2009年，牛津大学出版社。

120 印第安纳能源发展办公室http://www.in.gov/oed/2396.htm。

121 加油站数字来源于美国统计局http://www.census.gov/econ/census02/data/us/US000_44.HTM#N447。

122 “玉米带”上的各州指主要生产玉米的各个州。减排数据来源于美国能源部http://www.afdc.energy.gov/afdc/fuels/stations_counts.html。

Although CO_2 emission from tank-to-wheel using fuels with all ethanol blend levels will be reduced, on life cycle basis (well-to-wheel) performance is not as straightforward. Ethanol can be produced from different feedstocks. It can be produced from a by-product in petroleum refining (mainly for industrial use). The common practice worldwide, however, is to make ethanol through fermentation and distillation of carbon-based feedstocks such as corn (in the US), sugarcane (in Brazil), or aged grain stock or cassava (in China). There are existing technologies to convert non-food feedstock like algae, cellulosic, animal or yard waste into ethanol, but currently none of them can be economically scaled up for mass production. The type of feedstock and processing methods determines GHG emissions during the cultivation, processing, storage and dispensing.

There are also indirect GHG emissions due to the changes in land use (ILUC). The growing demand for ethanol fuel may drive more conversion of croplands used for food into lands for ethanol feedstock. The resulting higher food price may incentivize farmers to convert rainforests or grasslands into new farms, which will largely undermine the soil's ability to sequester and store carbon and therefore increase GHG emissions. The clearing of wildness also induces significant environmental impact and social impact beyond increased GHG emissions. Such impacts include putting pressure on biodiversity, soil, water quality, and local communities and culture. Policy makers need to consider both direct and indirect GHG emissions impact from biofuels in order to ensure that policies securing energy independence do not come at a cost to the environment.

International experience

The US and Brazil dominate the world ethanol fuel market – together both countries produce and consume nearly 90 percent of world ethanol fuel. In the US, more than half of the gasoline is blended with 10 percent of ethanol. Some states and cities mandate the use of E10. The US also has about 8 million flexible fuel vehicles that can run either on gasoline or any blend levels up to E85 on the road today. E85 FFVs are extremely common in Midwest where corn is a major crop and feedstock of ethanol fuel.

The political support of ethanol fuel and vehicles dates back to the 1970s. The Alternative Motor Fuels Act of 1988 established vehicle manufacturer incentives in the form of Corporate Average Fuel Economy (or CAFE) credits, with which manufacturers can meet a less stringent fleet-average fuel economy target by producing FFVs. The fuel was also heavily subsidized given that producing ethanol from corn is quite expensive, especially when compared with Brazilian sugarcane ethanol. Interest groups from states with corn farming as an important economic activity have been lobbying strongly to support corn ethanol and such lobbying was quite successful. One study found that in 2006 total corn ethanol subsidies amounted to more than $5 billion and were growing[119].

In October 2008, the first "biofuels corridor" was officially opened along I-65, a major interstate highway in the central United States that passes through several major corn growing states. Stretching from northern Indiana to southern Alabama, this corridor consists of more than 200 individual fueling stations allowing flex-fueled vehicles no more than the distance of a tankful fuel away from the next biofuel pump when driving from Lake Michigan to the Gulf of Mexico[120].

Although many vehicles in the US can, they actually are not running on ethanol fuel. There are three major reasons. First, the initial CAFE FFV credit program did not require the proof of actual use of alternative fuel until its recent revision under the requirement of EISA 2007. Second, as the sales of FFVs grew rapidly, the fueling infrastructure lagged behind. By 2010 there were about only 2,000 filling stations selling E85 to the public in the entire US compared with over[121] thousand gasoline fueling stations[121], with a great concentration of E85 stations in the “Corn Belt” states [122]. In California, there are only 44 E85 stations. Lastly, flexible fuel vehicle owners may not know that they own one, since these flexible fuel vehicles have the exact same exterior look as their non-flexible fuel counterparts. To know if a vehicle is ethanol fuel compatible, one needs to check the inside of the vehicle's fuel filler door for an identification sticker or the car manual. In contrast, Brazilian automakers are required to show clearly with a mark on the body of the cars.

119 Sperling D., Gordon, D., Two Billion Cars. 2009. Oxford University Press.

120 Indiana Office of Energy Development. Online available at: http://www.in.gov/oed/2396.htm.

121 Data on the number of gasoline stations are from US Census 2002. Online available at: http://www.census.gov/econ/census02/data/us/US000_44.HTM#N447.

122 “Corn Belt” states refer to those states that are major producers of corn. Emission reduction data are from US DOE. Online available at: http://www.afdc.energy.gov/afdc/fuels/stations_counts.html.

巴西经常被作为推动乙醇燃料政策的典范。70年代末石油危机的时候，巴西政府比所有其它国家都提早一步采取了替代汽油的措施。依靠良好的甘蔗工业基础，巴西开始推广甘蔗乙醇和乙醇专用车。为解决冷启动困难的问题，巴西的工程师在发动机舱内安装了一个小油罐可以直接喷出汽油帮助冷启动。随着政府提供大量补贴，到1984年，巴西销售的90%以上的轿车都是纯乙醇汽车（E100）。

但是，随着石油危机减退和糖价的上涨，许多甘蔗加工企业转而生产糖。这造成了80年代末期严重的乙醇短缺，乙醇轿车销售量几乎降至零点。经过这次教训，巴西从90年代开始推广从美国学到的灵活燃料车技术。在过去的30年里，巴西一直实施着可靠的乙醇政策，并提供可观的财政补贴。

美国联邦政府和加州政府在制订他们的生物燃料目标时（包括生物乙醇）已经考虑到了改变土地用途所带来的间接影响。2009年4月，加州通过了世界上第一个交通低碳燃料标准，要求到2020年，交通燃料的碳强度比当前的传统燃料即含10%乙醇的新配方汽柴油碳强度减低10%，这包括直接和间接的温室气体排放。2010年2月，美国EPA发布了新的可再生能源标准（RFS2）。其中规定了温室气体减排标准，根据燃料类型的不同，要求减排20-50%的直接和间接排放的温室气体，并且还设定了各种可再生燃料的供应量目标。例如，新建炼厂生产的可再生燃料必须比传统燃料温室气体减排20% 123, 才能符合RFS2对可再生燃料的定义。根据最终规定，2010年可再生燃料的总量目标是129.5亿加仑，到2022年会逐步增加至360亿加仑[124]。

EPA已经确认了几种原料和燃料生产方式，即使是加上ILUC排放，也至少可以让可再生燃料实现20%的温室气体减排。使用天然气作为能源，采用干铣削工艺生产的玉米乙醇的平均减排量处于20%的减排底限，而采用生物化学工艺生产的纤维素生物燃料温室气体排放强度最低。EPA的结论详见图9.1。

123 不过，EISA对大多数目前已经在生产的玉米乙醇的企业（非新建企业）豁免了温室气体减排20%的要求。2009年，美国约生产96亿加仑玉米乙醇。

124 美国EPA法规简介：EPA2010年及以后全国可再生燃料标准的最终管理办法http://www.epa.gov/otaq/renewablefuels/420f10007.pdf。

Brazil is often cited as a policy model for promoting ethanol fuel. When the world oil crisis hit in late 1970s, the Brazilian government took an earlier step than any other country to replace gasoline. Leveraging on a well-established sugarcane industry, Brazil began to promote sugarcane ethanol, and dedicated ethanol vehicles. To deal with the cold-start difficulty, Brazilian engineers built a small tank in the engine compartment that directly inject gasoline to help starting in cold weather. With large governmental subsidies provided, by 1984, more than 90 percent of cars sold in Brazil were neat ethanol vehicles (E100).

However, when oil crisis faded and price for sugar went up, sugarcane producers switched to sugar. This caused severe shortage of ethanol supply in late 1980's and ethanol car sales almost evaporated to zero. Learning from this lesson, Brazil adopted flexible fuel technology from the US starting in the 1990's. Brazil has maintained a durable ethanol policy for over three decades, providing considerable financial subsidies.

The US federal government and the state of California, when setting their bio-fuel targets (including bio-ethanol), have already included the indirect land use change effect criteria. In April 2009, California passed the world's first ever transportation low carbon fuel standard that requires 10 percent reduction in carbon intensity –with both direct and indirect GHG emissions included-- for transportation fuel compared to conventional fuels (reformulated gasoline and diesel with 10 percent ethanol blend) by 2020. In February 2010, the US EPA published its new Renewable Fuel Standard (RFS2). The rule imposes both a GHG reduction standard, requiring from 20 to 50 percent GHG reduction of combined direct and indirect emissions depending on the fuel category, and a set of volumetric targets for various renewable fuel supplies. For example, renewable fuels defined by RSF2 must cut GHG emissions by 20 percent compared to conventional fuels for newly established plants 123. According to the final rule, the volumetric target for renewable fuel for 2010 is 12.95 billion gallons, which will be gradually increased to 36 billion gallon in 2022[124].

EPA has identified several feedstocks and fuel pathways that can deliver renewable fuels with at least 20% GHG reduction threshold even after including ILUC GHG emissions. The average value for corn ethanol obtained from dry milling process with natural gas as process energy lies on the borderline of the 20% reduction threshold, while cellulosic biofuel produced using a biochemical process has the lowest GHG intensity. Figure 9.1 shows EPA's result.

123 However, EISA exempted the 20% GHG reduction requirement for almost all the existing corn ethanol produced in the U.S. About 9.6 billion gallons of corn ethanol was produced in the U.S. in 2009.

124 US EPA factsheet: EPA Finalizes Regulations for the National Renewable Fuel Standard Program for 2010 and Beyond. Online available at http://www.epa.gov/otaq/renewablefuels/420f10007.pdf.

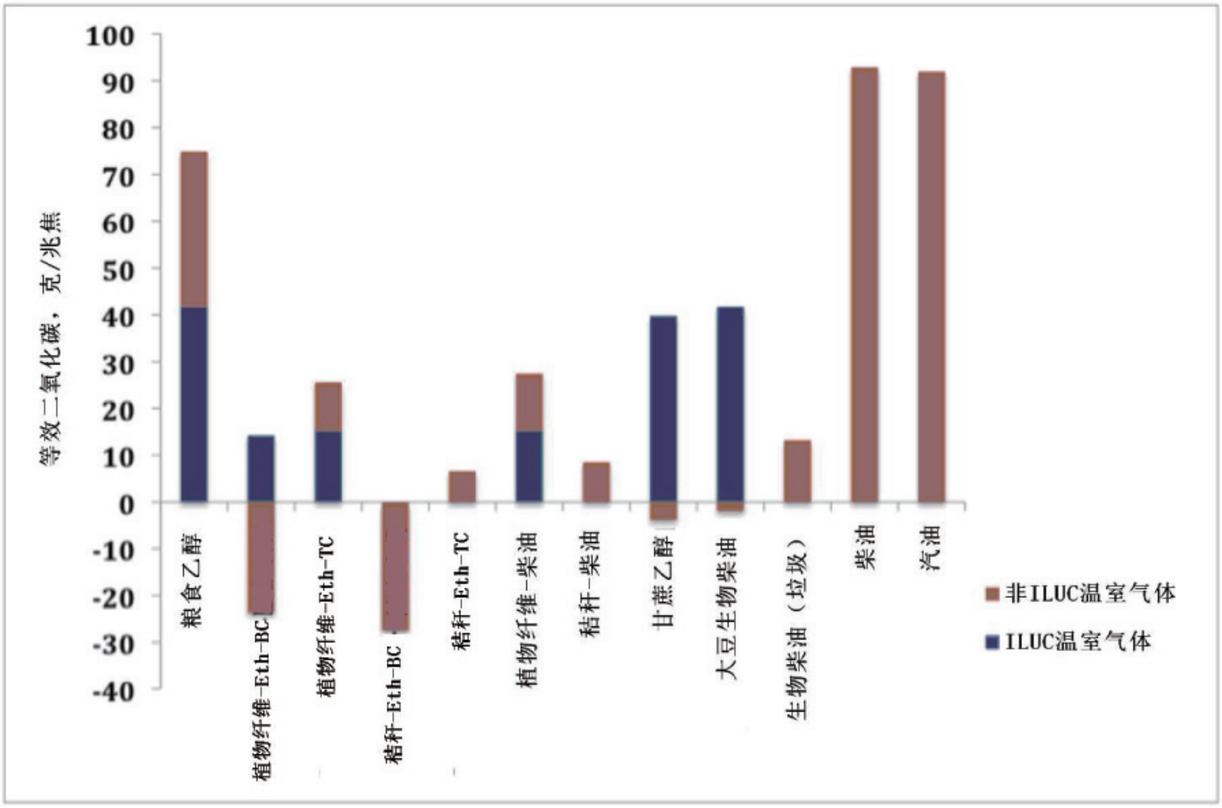


图9.1: 多种原料和生产方式的全生命周期温室气体排放评估[125]

Eth = 乙醇, BC =生物化学转化, TC = 热化学转化。评估基于30年的时间范围且假设贴现率为零。上图中玉米乙醇的数据是使用天然气的干磨粉工艺的平均值。

欧盟也考虑到了土地使用带来的间接影响，并纳入了下一次可再生燃料指令的修订当中。表9.2简要对比了世界各国的可再生或低碳交通燃料标准。

125 EPA. 油品和油品添加剂管理：可再生燃料标准的修改40 CFR Part 80 [EPA-HQ-OAR-2005-0161; FRL-XXXX-X], RIN 2060-A081. 交通与空气质量司，评估与标准处，EPA。

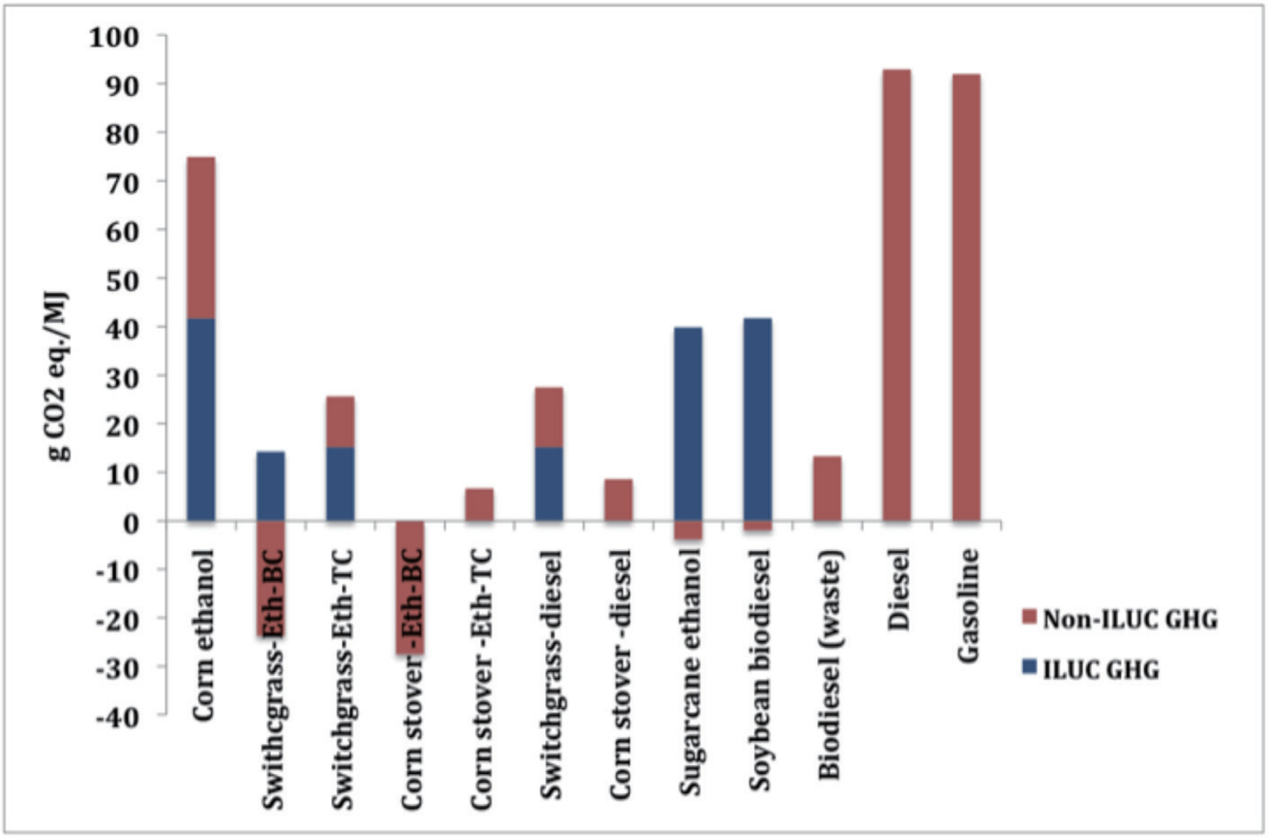


Figure 9.1: Life cycle GHG estimates of various feedstock and pathways[125]

Eth = ethanol, BC = biochemical conversion, TC = thermochemical conversion. Estimates are based on 30-year time frame and zero percent annual discount rate. Corn ethanol data in above figure refers to average value for dry milling process using natural gas.

The European Union is also considering an indirect land use impact analysis in its next revision of the Renewable Fuel Directive. Table 9.2 briefly compares world's renewable or low carbon fuel standards for transportation fuel.

125 EPA. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program. 40 CFR Part 80 [EPA-HQ-OAR-2005-0161; FRL-XXXX-X], RIN 2060-A081. Assessment and Standards Division, Office of Transportation and Air Quality, EPA.

表9.4: 世界可再生或低碳交通燃料标准

特征	美国的RFS2	加州的LCFS	燃料标准指令(欧盟)	可再生能源指令 (欧盟)	英国可再生交通燃料规范 (RTFO)
基准燃料	柴油和汽油	含10%玉米乙醇的新配方汽油、柴油	柴油和汽油	柴油和汽油	柴油和汽油
目标	到2022年，实现360亿加仑生物燃料，温室气体减排5.6%	到2020年温室气体减排10%	到2020年温室气体减排10% (最低强制达到6%)	10% 生物燃料(能源含量)	2010/2011年达到5% 生物燃料 (能源含量)，温室气体减排1.9%
达标方式	纤维素乙醇，先进的生物燃料，可再生生物燃料	生物燃料、LPG, 天然气、电力和氢燃料	生物燃料、减少燃烧和排气、碳封存和碳捕集	生物燃料	可持续生物燃料
ILUC温室气体排放	计划中但尚不确定	已包括	待定 (计划到2010年12月)		无

在美国的RSF2中认为巴西的甘蔗乙醇是一种先进的生物燃料，根据评估，包括直接和土地使用带来的间接排放在内，该燃料可以减少61%的温室气体排放。由于巴西独特的气候条件适合甘蔗生产，并且使用甘蔗的残渣发电，巴西的甘蔗乙醇生产效率非常高，这些特点使世界其它国家很难照搬巴西的成功经验。

中国经验

中国生物乙醇产量居世界第三位，2006年年产量达到163万吨。中国生产生物乙醇的主要原料是陈化粮、木薯和甘薯。中国使用的乙醇燃料主要是E10，与前文介绍的M10相似，E10也是用于普通汽油车。

2001年，中央政府实施了中国第一个乙醇燃料方案，主要是为了减少陈化粮库存。在中国北方批准建立了四家谷物乙醇生产厂，每年可生产乙醇3500万加仑。中央政府为这四家乙醇工厂提供补贴，补贴额度与美国玉米乙醇补贴水平类似。目前有十个省在汽油中混合入10%的乙醇。由于意识到粮食乙醇的缺点，2008年起，中央政府决定推广生产非粮乙醇，同时允许这四家已有的粮食乙醇工厂继续正常生产。由于政府对非粮乙醇的鼓励政策，在广西已经建立投产了一个大型的木薯乙醇生产厂，并且另外一家工厂也正在建设中。此外，中国也已经建立了几家小规模的纤维素乙醇试点工厂。

Table 9.4: World's transportation renewable or low carbon fuel standards

FEATURES	US-RFS2	CA- LCFS	THE FUEL QUALITY DIRECTIVE (EU)	THE RENEWABLE ENERGY DIRECTIVE (EU)	UK RENEWABLE TRANSPORT FUEL OBLIGATION (RTFO)
Baseline fuels	Diesel and gasoline	Reformulated gasoline and 10% corn ethanol, diesel	Diesel and gasoline	Diesel and gasoline	Diesel and gasoline
Targets	36 billion gallons of biofuels by 2022, GHG emission reduction of 5.6%	10% reduction in GHG emissions by 2020	10% reduction in GHG emissions by 2020 (6% mandatory)	10% of biofuels (energy content)	5% of biofuels (energy content) by 2010/2011, GHG emission reduction of 1.9%
Compliance pathways	Cellulosic ethanol, advanced biofuel, renewable biofuel	Biofuels, LPG, NG, electricity, H_2	Biofuels, reductions in flaring and venting, carbon sequestration and capture	Biofuels	Sustainable biofuels
GHG emissions from ILUC	Proposed but uncertain	Included	TBD (proposal by Dec. 2010)		None

Brazilian sugarcane ethanol is referred to as an advanced bio-fuel under the US RSF2 due to its estimated 61 percent reduction in GHG emissions including both direct and indirect land use change emissions. Due in part to favorable climate for sugarcane growth and the use of the sugarcane residual (bagasse) for electricity generation, Brazil has a very efficient sugarcane ethanol production, which would be difficult to replicate in other parts of the world.

China's experience

China is now the third largest producer of bio-ethanol with an annual production of 1.63 Mt in 2006. The main feedstock of bio-ethanol in China is aged grain stock, cassava and sweet potato. Ethanol-capable vehicles in China mainly run on E10.

In 2001, the central government established the first ever ethanol program in China with the intent of reducing aged corn stocks in China. Four grain-based ethanol plants were approved in Northern China with production of 350 million gallons of ethanol a year. The central government provided to the four ethanol plants a subsidy level similar to the U.S. corn ethanol subsidy. Ethanol is blended into gasoline at 10% by volume in ten provinces. Recognizing the limitation of grain-based ethanol in China, in 2008, the central government decided to promote non-grain-based ethanol production, while allowing the four grain-based ethanol plants to continue their operation. The government policy of encouraging non-grain-based ethanol resulted in a large cassava ethanol plant in Guangxi Province now in operation and another one under construction. Furthermore, several small-scale pilot cellulosic ethanol plants have been developed in China.

总结和建议

表9.5总结了车用乙醇从环保角度的优势和劣势。

表9.5: 车用乙醇的优势和劣势汇总

优势	劣势
■ 替代化石燃料。 ■ 可通过高能效生产方式，利用可再生原料和低碳原料生产。低碳乙醇燃料能够减少全生命周期温室气体排放量 。	■ 具有腐蚀性，特别是高比例混合要求特殊设计的油箱和油路。 ■ 高比例混合要求单独的供油基础设施。 ■ 根据发动机的情况，氮氧化物排放有可能增加。 ■ 增加乙醛排放。 ■ E10燃料的蒸发排放和车辆运行中的损失可能较高。 ■ 会造成冷启动困难。 ■ 与传统车用燃料相比，燃料经济性较低。 ■ 部分原料和生产方式会导致全生命周期温室气体排放（包括ILUC排放）增加。 ■ 纤维素、水藻和垃圾制乙醇成本很高。

以下建议的主要目的是减少乙醇汽车的环境影响：

从低碳视角出发来制订所有燃料和温室气体相关政策。必须建立方法论，计算因土地用途改变所带来的直接和间接的温室气体排放，并且在定义低碳燃料时要设定碳减排标准。

如使用中、高比例乙醇混合燃料，须要求适当的配套设备来解决腐蚀性问题。高比例混合的乙醇燃料需要单独的供油基础设施。 中比例混合的腐蚀问题也不容忽视。另一种方案是使用E20时，考虑对燃料油路系统进行金属表层特殊处理，使之能抵御燃料的腐蚀性。环保部在制订乙醇燃料相关政策时，应考虑专用燃料供应系统带来的成本。

监测氮氧化物和乙醛排放是很重要的。氮氧化物排放必须满足排放标准。关于乙醛，美国EPA正在进行一项关于乙醇燃料车乙醛排放的综合性研究。

目前中国没有E85或其它高比例混合的灵活燃料车。如果中国的政策今后将引导使用这些燃料，应当要确保替代燃料的切实使用。

9.4 新能源汽车

在中国，四种车辆被认为是新能源汽车：传统混合动力车（HEV）、插入式混合动力车（PHEV）、氢燃料电池电动车（FCEV）和电池电动车（BEV）。这一节论述发展与部署这类车辆的国际经验。鉴于有些技术类型的某些特性非常相似（例如，电池电动车和氢燃料电池电动车），在论述这些特征时，可能会将它们划分为一类。

传统混合动力车（HEV）和插入式混合动力车（PHEV）结合了内燃机（ICE）、电池和电动机，因此其同时具备了传统内燃机和电动车的优缺点。根据所采用的技术和混合动力程度，混合动力车的燃料经济性可以是传统内燃机车辆2-3倍。和其它三种新能源车辆不同，混合动力车并不是电驱动的，因为其推动力是由内燃机提供的。传统混合动力车不需要充电设施，而插入式混合动力车和电动车则需要。插入式混合动力车和某些传统混合动力车能够实现全电动模式运行，在此期间，电能会完全替代传统燃料的使用。和传统混合动力车不同，插入式混合动力车通过插头向车辆电池充电，从而使其全电动模式运行时间得以延长。要想充分利用插入式混合动力车的全电动模式优势，需要投资发展充足的充电基础设施。

Summary and recommendations

The following Table 9.5 summarizes the pros and cons of ethanol use in vehicles

Table 9.5: Summary of advantages and disadvantages of ethanol use in vehicles

ADVANTAGES	DISADVANTAGES
■ Displaces fossil fuel ■ Can be produced from renewable and low carbon feedstocks by energy-efficient pathways. Such low carbon ethanol fuel can reduce life-cycle GHG emissions.	■ Corrosive especially at high blend and requires specially designed tanks and fuel lines ■ High blend ethanol requires separate supply infrastructure ■ NOx may increase but also depends on engine condition ■ Increased emissions of acetaldehyde ■ E10 may emit more regulated exhausts from evaporation and running loss ■ Cold start difficulty with E100 ■ Lower fuel economy than conventional fueled vehicles ■ Life-cycle GHG emissions (including ILUC) may increase with certain feedstock and production pathways ■ High cost to produce ethanol from cellulosic, algae and waste

The following recommendations are aimed at optimizing the environmental impacts of ethanol vehicles:

A low-carbon perspective is necessary in all fuel and GHG related policy-making. It is essential to establish a methodology that counts both direct and indirect land use change emissions, and establish carbon reduction criteria when defining low carbon fuels.

For higher blends, corrosion issues must be addressed by requiring appropriate equipment. The possible corrosive effect of intermediate blend ethanol fuel should not be overlooked. Separate fuel supply infrastructure would be needed for high blended ethanol. Another option to consider is a special treatment on the metal surface within the fuel system to guard against corrosion with the E20 blend. MEP should take into account costs associated with the specialized fuel supply system in determining policies related to ethanol fuel.

It is important to monitor NOx and acetaldehyde emissions. NOx emissions must be maintained in line with emission standards. For acetaldehyde, the US EPA is undertaking a comprehensive study on emissions of ethanol-fueled vehicles.

Currently China does not have E85 or other high blend flexible fuel vehicles. If China's policy leads to these fuels in the future, they should ensure the actual use of the alternative fuel.

9.4 New energy vehicles

In China, four vehicle types are considered new energy vehicles: conventional hybrid vehicles (HEVs), plug-in hybrid vehicles (PHEV), hydrogen fuel cell electric vehicles (FCEV) and battery electric vehicles (BEV). This section also addresses international experiences in developing and deploying these vehicles. Given the similar characteristics of certain vehicle types (for example, battery electric vehicles and hydrogen fuel cell electric vehicles) they may be grouped together when certain features are discussed.

Conventional hybrid (HEV) and plug-in hybrid electric vehicles (PHEV) combine an ICE, a battery and an electric motor, and thus may share pros and cons of both traditional ICE vehicles and BEVs. HEV technologies can achieve two to three time higher fuel efficiency than conventional ICE vehicles depending on technologies adopted and degree of hybridization. Unlike the other three vehicle types, HEVs are not electric-drive because the propulsion energy is provided by the ICE. HEVs do not required recharging infrastructures,which is otherwise needed for PHEVs and BEVs. PHEVs and certain HEVs can all be operated on electric mode and during that time fully displace conventional fuel use. Unlike HEVs, the all-electric operation mode of PHEVs can be extended by plugging in to recharge the vehicle battery. To fully take advantage of the PHEV all-electric mode requires investment in developing an adequate charging infrastructure.

大范围推行氢燃料电池电动车（FCEV）和电池电动车（BEV）对城市空气质量的改善会有很大作用，因为这些车辆的尾气排放量为零。另外，内燃机的排放控制系统会随时间而劣化，FCEV和BEV则不会，因此不要求实施检测和维修保养方案。传统燃料车辆所面临的燃料和机油供应、储存、处理以及燃料污染等问题对BEV和FCEV来说都不再是问题。FCEV和BEV还有其它优势，包括在超静音环境下实现即时扭矩和平缓提速的卓越驾驶体验。

除了环保，发展FCEV和BEV各自还有一些其他的好处。BEV和PHEV一样，设计一个良好的充电方案能够填充电网电谷，从而优化用电负荷。氢燃料电池发动机比BEV行驶的距离更长，其能效性是传统内燃机的2-3倍，可以用于长距离或高负载的交通运输。较之BEV，氢燃料电池车更适合应用于巴士和卡车。要说明的是，至今为止，所有的FCEV都是混合动力的，除了燃料电池也有蓄电池。这样，交替蓄电可以提高行驶里程范围。

电力和氢燃料的生产和传输会产生上游排放。可以采用化石燃料、生物质或电解水制氢，生产过程中所使用的电能也可来自再生能源，如水力发电、风力和太阳能发电，制氢工艺也有多种方式。多种多样的原料和生产工艺会造成不同水平的上游排放。阿贡实验室对10种制氢方法进行了全生命周期温室气体排放分析。图9.2展示了研究结果，可以看出与传统汽油车相比，很多制氢方法都能够减少氢燃料电池车的全生命周期温室气体排放，当然也有一些方法，比如在美国典型的电网能源结构下，电解制氢就可能导致增加排放量。

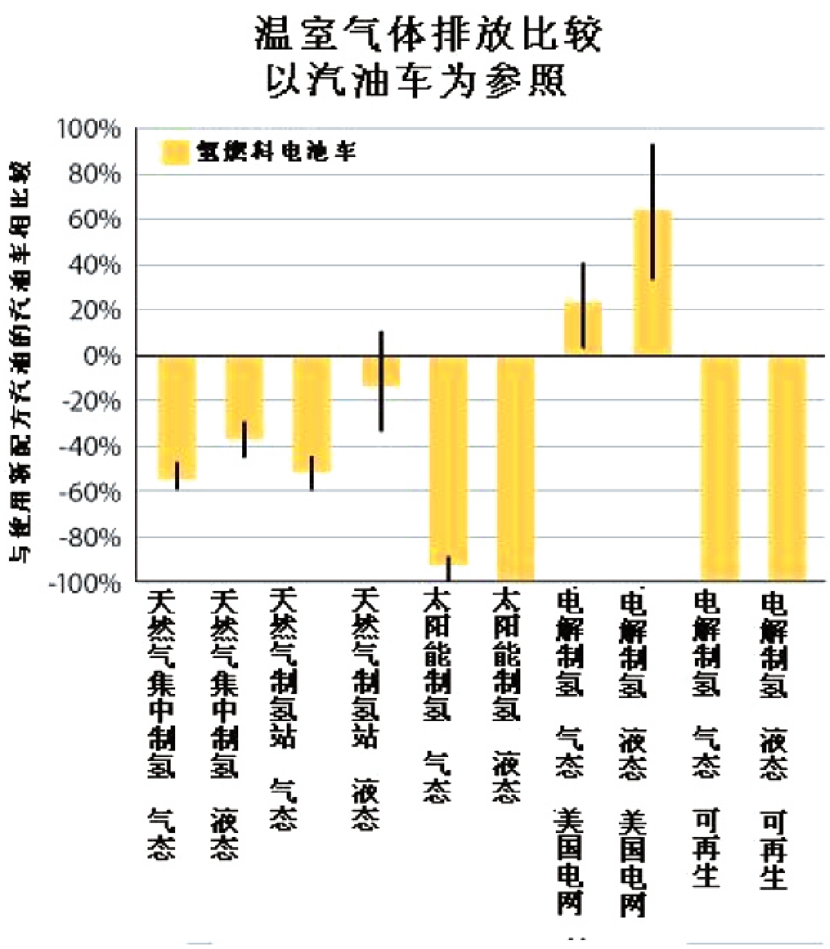


图9.2:以汽油车为参照，各种制氢方法全生命周期温室气体排放比较[126]

126 美国能源部，Online available at http://www.afdc.energy.gov/afdc/vehicles/emissions_hydrogen.html。

Large scale deployment of hydrogen fuel cell electric vehicles (FCEV) and battery electric vehicles (BEV) would have a dramatic impact on air quality in urban areas as they have zero tailpipe emissions. In addition, unlike ICE engines where emission control systems deteriorate overtime, a FCEV and BEV fleet does not require an inspection and maintenance program. Other issues related to fuel and motor oil supply, storage, disposal and contamination are also eliminated. Other general benefits of FCEVs and BEVs include a superior driving experience with instant torque and smooth acceleration in an ultra-quiet environment.

FCEVs and BEVs each offer some specific benefits as well. BEVs, like PHEVs, with well-designed charging schedule could fill the valley of the electricity grid thus help optimize electric load shifting. Hydrogen fuel cell engines can achieve longer ranges than BEVs and can be two or three times more efficient than the conventional ICE, thus can serve long-distance and/or high load transportation. This technology is better suited than BEVs to bus and truck applications. It also should be noted that to date, FCEVs are all hybrid, with batteries in addition to the fuel cell. In this way, advantage can be taken of regenerative breaking to increase their range.

Electricity and hydrogen production and delivery does generate upstream emissions. Hydrogen can be produced from fossil fuels, biomass or through the electrolysis of water using electricity from renewable sources such as hydroelectricity, wind and solar, and by a number of processes. This diversity of feedstock and production methods results in a wide range of upstream emissions levels. ANL analyzed the life-cycle GHG emissions of 10 pathways to produce hydrogen. As shown in Figure 9.2, the study found that most pathways will reduce life cycle GHG emissions from hydrogen fuel cell vehicles compared with life cycle GHG emissions from conventional gasoline vehicles, while certain pathways, such as when hydrogen is produced through electrolysis from typical US grid electricity, may increase the emissions.

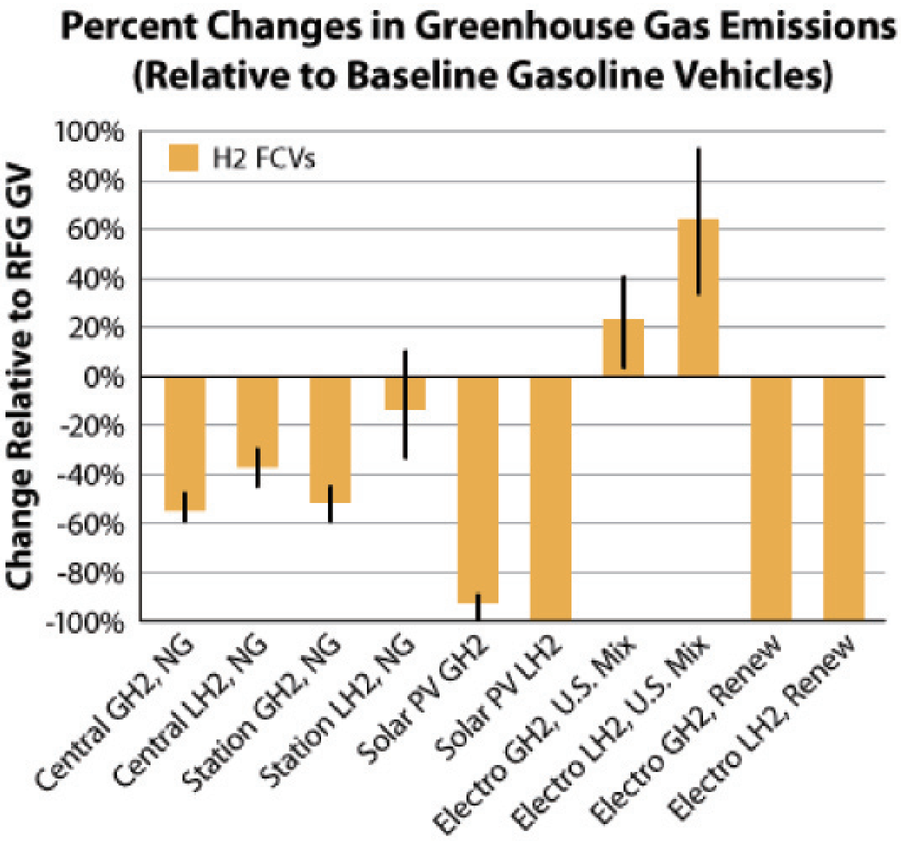


Figure 9.2: Life-cycle GHG emissions change relative to baseline gasoline vehicles[126]

126 US DOE. Online available at http://www.afdc.energy.gov/afdc/vehicles/emissions_hydrogen.html.

同样,BEV的电力来源也可以很广泛，这些车辆的全生命周期排放取决于当地电网能源结构、主要充电时间以及电网特点。以目前的美国电网为例，根据阿贡实验室的研究，使用BEV替代一辆传统汽车，整个生命周期可以实现城区内挥发性有机化合物、一氧化碳、硫氧化物、氮氧化物和颗粒物分别减排100%、100％，75%、69%和31% [127]。研究还指出，鉴于大部分电厂都在郊区，使用BEV（无论在哪里使用）可能增加远郊区部分常规污染物的排放（硫氧化物、氮氧化物和颗粒物）。在美国典型的电网结构下，BEV的全生命周期温室气体排放比汽油车下降19%，而如果使用加州电网，由于该州的电力能源更清洁，可以实现74%的减排[128]。对于采用火力发电来供应用电高峰期额外电量的地区，如果给BEV充电需用这部分额外电量，则BEV的温室气体排放可能会较高。

除了上游排放的不确定性，发展氢燃料电池车和电池电动车还面临着技术与管理方面的双重挑战。在目前和今后一段时期内，利用可再生资源生产氢燃料都将十分昂贵。车载储氢技术，特别是对于轻型车而言，还依然面临着储量、耐久性和成本方面的挑战。BEV的主要技术挑战包括电池容量和行驶范围的限制，还有高成本的问题。尽管低容量电池能够满足用于短途和低速交通的城市轿车的需求，但电动车电池依然无法以具有竞争力的价格达到传统车辆每次加油可以行驶300英里以上的水平。

要适应FCEV、BEV（和PHEV）的新特征，必须修订目前以内燃机车辆为主导的管理规定。修订内容包括燃料（或能源）能效性行驶测试工况、纳入从油井到车轮这部分排放在内的全生命周期的新排放标准以及适用于电动推进系统的安全标准。电动车还需要有新的设定充电系统、电池回收和处理标准的管理规定，目前美国正在制订这些方面的管理规定。

充电基础设施的缺乏和滞后是发展BEV和FCEV的重大障碍。当然，建设充足的基础设施需要相当可观的投资。另一方面，值得一提的是，从长期来看，维护现有的汽柴油设施和安装新的汽柴油设施（包括修理泄漏油罐）也一样需要大量资源。

国际经验与政策

美国主要出于对能源安全的考虑，在2005年《能源政策法》中将多种电驱动车纳入替代燃料车名单，并且开始对购买HEV和FCEV新车的消费者实施税收鼓励。2007年《能源独立与安全法》将插入式混合动力车也纳入了税收鼓励范围。之后，2009年《美国复苏与再投资法》又加上了低速电动车（LS EV）。表9.6展示了近年来电动车税收鼓励的具体细节。这些法案还授权联邦支持制造先进汽车和零件、进行研发、建设基础设施和开展示范项目。

127 减排数据来自美国能源部http://www.afdc.energy.gov/afdc/vehicles/emissions_electricity.html。原始信息：GREET 1.5交通燃料周期模型。网址：Online available at http://www.transportation.anl.gov/modeling_simulation/GREET/pdfs/esd_39v1.pdf。模型的生命周期排放包括主要燃料获取、制备、运输和车辆使用过程的排放。他们并没有计算生产车辆所使用的能源。

128 美国能源部Online available at http://www.afdc.energy.gov/afdc/vehicles/emissions_hydrogen.html。

Similarly, electricity for BEVs can be generated from a wide spectrum of sources, thus these vehicles' life cycle emissions depend on the local grid mix, the timing when most recharging take place and the grid characteristics. For example, with the current US grid mix, replacing a conventional vehicle with a BEV could reduce life cycle VOCs, CO, SOx, NOx and PM emissions by 100%, 100%, 75%, 69% and 31% respectively in urban settings, according to an ANL study[127]. The same study also suggests that using BEVs may increase certain conventional pollutants (SOx, NOx and PM) in suburban areas given that it is usually where the power plants are located. The life cycle GHG emissions of BEVs is 19% lower than a gasoline vehicle with the US average grid mix, and is 74% lower with California's grid mix since the state uses more clean electricity [128]. For regions where marginal power generation are provided by coal-fired power plants, the GHG emissions from BEVs could be higher if recharging lead to additional power generation.

In addition to the uncertainty about upstream emissions, the development of hydrogen fuel cell and battery electric vehicles still faces both technological and regulatory challenges. Hydrogen fuel produced with energy from renewable sources is and will be quite expensive for some time. On-board hydrogen storage technologies, especially for light duty vehicles, are still facing volume, durability, and cost challenges. Major technological challenges for BEVs include battery capacity and limited driving range, as well as costs. Although low capacity batteries may be sufficient to operate city cars with short driving range and lower maximum speed, they still cannot compete with the 300 plus miles driving range per fueling offered by conventional vehicles, at a competitive price.

Existing conventional ICE-focused regulations must be modified in order to accommodate the new features of FCEVs, BEVs (and PHEVs). Such modifications include redetermination of fuel (or energy) efficiency driving test cycle, new emissions standards that accounts for the well-to-wheel emissions, and safety standards adapted to the electric propulsion system. The various electric vehicles also require new regulations on a standardized recharging system, and on battery recycling and disposal, which are under development in the US.

Lack or delay of charging infrastructure could be a great barrier to the development and deployment of BEV and FCEV vehicles. Of course, building an adequate infrastructure will require significant investment. On the other hand, it should be noted that maintaining the existing and installing new infrastructure (including treatment for leaking in tanks) for gasoline and diesel also requires large amount of resources over the long run.

International experience and policies

Driven mainly by energy security concerns, the US includes the various forms of electric vehicles in the list of alternative fuel vehicles and began to provide consumer tax incentives for new purchases of HEVs and FCEVs under the "Energy Policy Act" of 2005. The "Energy Independence and Security Act" of 2007 expanded the tax credits to plug-in hybrids. Low-speed electric vehicles (LS EV) were later added under the "American Recovery and Reinvestment Act" of 2009. Table 9.6 details the tax incentives for electric vehicles in recent years. These bills also provide federal grants to support the manufacturing of these advanced vehicles, parts, R&D, infrastructures and demonstration programs.

127 Emission reduction data are from US DOE. Online available at: http://www.afdc.energy.gov/afdc/vehicles/emissions_electricity.html. Original source: GREET 1.5 Transportation Fuel-Cycle Model. Online available at http://www.transportation.anl.gov/modeling_simulation/GREET/pdfs/esd_39v1.pdf. Lifecycle emissions in the model account for primary fuel recovery, preparation, delivery, and use by the vehicle. They do not account for energy used to produce the vehicle.

128 US DOE. Online available at http://www.afdc.energy.gov/afdc/vehicles/emissions_hydrogen.html.

表 9.6: 替代燃料车税收鼓励方案总结

类型	税收鼓励方案（个人所得税抵扣）[129]	立法
HEV	轻型车 (车辆额定总质量（GVWR）≤ 8,500磅) 根据与同级别汽油车相比所提升的燃料经济性和使用周期内所节约的汽油数量，减税额度为650美元至3400美元不等。每家企业在售出6万辆车后不再享受全额的减税激励。 中重型车 (GVWR>8,500磅) 减税额度基于采用混合动力技术增加的成本，有一定限制： <14,001 GVWR: 7,500美元 14,001-26,000 GVWR: 15,000美元 26,001 + GVWR: 30,000美元	《能源政策法》2005
FCV	轻型车(GVWR ≤ 8,500磅) 2010年以前购买为8000美元，2010年以后为4000美元。 中重型车(GVWR>8,500磅) 根据车重决定数额	《能源政策法》2005
PHEV	轻型和中型车(GVWR ≤ 14,000磅) 2010年及以后购买的符合条件的车辆，电池容量在4千瓦/时或以上，并且能满足尾气排放标准。减税额度根据额定质量和电池容量，从2500美元至7500美元不等。每家生产企业销售出20万辆车以后不再享受全额的减税激励。	《能源独立与安全法》
BEV	2010年及以后购买的电池电动车（EV）可享受联邦所得税优惠，最高额度为7500美元。具体额度由为车辆提供动力的电池的容量决定。	《能源独立与安全法》
LS EV	2011年以前，低速电动车、两轮及三轮电动车可享受总车价10%，最高2500美元的税收优惠。	《美国复苏与再投资法》2009

除了财政鼓励，美国政府还设定了一系列定额市场销售目标，意在提高先进车辆的市场竞争力。2003年，布什总统在发表国情咨文时强调要强力支持氢燃料电池车。2009年奥巴马总统也宣布了到2015年将100万辆环保汽车推向美国道路的目标（每年新车的1.25%）。加州非常重视排放并早在1990年就制订了零排放车（ZEV）规定。在最近的修订中（2003年），ZEV规定设置了宏大的目标，从2012年到2014年，实现6万辆PHEV。目前，加州空气资源局正计划进一步修订规定，要求到2035年，80%的新车为PHEV、EV或燃料电池车。

为了鼓励电动车商业化，美国在温室气体排放和燃料经济性标准上对轻型电动车也设有“特殊待遇”。2010年4月发布的最终法规中规定，各家生产企业在生产包括PHEV、BEV和FCEV在内的先进技术车辆时，根据他们生产的电动车总量，将其生产的前20万辆或前30万辆车视为0克/英里排放的车辆，并以此来计算这些企业的平均GHG排放水平（用于判断达标）。当生产企业的PHEV、BEV和FCEV产量超过这些上限时，计算它们的公司平均GHG排放水平时，则需要进一步估算这些车辆的上游二氧化碳排放量。

129 各项方案的详细信息来源于美国能源部联邦鼓励政策和法律中心，网址：http://www.afdc.energy.gov/afdc/laws/fed_summary。

Table 9.6: Summary of alternative fuel tax credit programs

TYPE	TAX CREDIT PROGRAMS[129]	LEGISLATION
HEV	Light-duty vehicle (≤ 8,500 lb GVWR) Amount of credit varied from $650 to $3,400 dependent on fuel efficiency gains and lifetime gasoline saved compared to vehicles of the same weight class. Phase out after 60,000 sales per manufacturer. Mid to heavy-duty vehicles (>8,500 lb GVWR) Amount of credit is based on incremental cost limitations: <14,001 GVWR: $7,500 14,001-26,000 GVWR: $15,000 26,001 + GVWR: $30,000	EPAct 2005
FCV	Light-duty vehicle (≤ 8,500 lb GVWR) $8,000 if purchased before 2010, $4,000 after 2010 Mid to heavy-duty vehicles (>8,500 lb GVWR) Amount is determined by vehicle weight	EPAct 2005
PHEV	Light and medium-duty vehicles (≤14,000 lb GVWR) Qualified vehicles purchased in or after 2010 must have at least 4 kWh battery capacity and meet certain emission standards. Credit amount is based on weight rating and battery capacity and is from $2,500 to $7,500. Phase out after 200,000 sales per manufacturer.	EISA
BEV	Battery electric vehicles (EVs) purchased in or after 2010 may be eligible for a federal income tax credit of up to $7,500. The credit amount will vary based on the capacity of the battery used to fuel the vehicle.	EISA
LS EV	10% of cost of qualified low-speed electric vehicles, electric 2 and 3 wheelers, up to $2,500, expires 2011.	ARRA 2009

In addition to the financial incentives, a series of targets were set to boost the market penetration of the various advanced vehicles. President George W. Bush in his 2003 State of Union speech expressed strong support to hydrogen fuel cell vehicles. President Barack Obama in 2009 announced a target of putting a million environmental friendly vehicles on US roads by 2015 (1.25% of the new fleet each year). California has a strong focus on emissions and established the Zero Emission Vehicle (ZEV) mandate in 1990. In its recent revision in 2003, the ZEV mandate sets up ambitious target of 60,000 PHEVs for the 2012-2014 timeframe. Now, California Air Resources Board is proposing to further revise the mandates to require 80% of new vehicles to be PHEVs, EVs or fuel cell vehicles by 2035.

The US light-duty vehicle GHG emissions and fuel economy standard also treats electric drive vehicle differently in order to encourage their commercialization. In the final rule making released in April 2010, advanced technology vehicles including PHEVs, BEVs and FCEVs are assigned for the corporate average standard compliance a 0 g/mil value for the first 200,000 or 300,000 vehicles produced by each manufacturer depending on the total number of electric vehicle they produced. Fleet average GHG emissions would include calculated upstream CO_2e emission values when a manufacturer's PHEV, BEV and FCEV production exceeds these caps.

129 Detailed information about each program is from US DOE's Federal Incentives and Laws Center. Online available at: http://www.afdc.energy.gov/afdc/laws/fed_summary

除了美国以外，各国政府也越来越多地关注HEV和电驱动车，并有越来越多的鼓励方案。表9.7列举了部分欧洲国家和日本鼓励购买新电驱动汽车的实例。尽管一些鼓励政策是针对特定技术的使用，也就是说只要是HEV或BEV就有条件获得鼓励，但在另一些国家，激励力度是和车辆的二氧化碳减排性能挂钩的。例如，在法国是通过以二氧化碳为基础的奖惩机制来确定电驱动车补贴的多少，这一奖惩机制适用于所有燃料类型的轻型车。具体的说，一辆HEV只有在其尾气二氧化碳排放低于60克/公里，才可以获得5000欧元的补贴。

表9.7: 欧洲和日本购买电动车的消费者鼓励政策[130]

国家	消费鼓励政策
法国	在以二氧化碳为基础的奖惩机制下，二氧化碳排放低的车辆（低于60克/公里），包括各种电驱动车，可以获得最高5000欧元的补贴。政府还计划免收电动车的停车费。
德国	电动车在购买后的前五年可以免交每年的流通税。
英国	私人电动车可以免交流通税。企业购买的电动车在购买后的前五年可以免交每年的流通税。从2011年起，BEV和PHEV购买者可以获得车辆标价25%的折扣，最高5000英镑。
日本	如果能达到一定的燃料经济性和排放要求，BEVs, HEVs和PHEVs可免收购置税和每年的吨位税。(自2009年起)

中国的经验与政策

尽管中国早在上世纪90年代就开始发展电动汽车，可直到本世纪初，电动汽车才开始成为汽车工业的焦点。2001年（“十五”计划初），中国首次将多个电动汽车研发项目作为重点内容纳入国家高技术研究发展计划（又称863计划）。自此以后，政府设置了“三纵”（即燃料电池车、混合动力车和纯电动车）和“三横”（多能源动力总成系统、驱动电机和动力电池）战略，并且向电动汽车领域投入大量资金。截止至2008年，共计向替代能源汽车研发投资20亿人民币。在接下来的“十一五”期间（2006-2010年），中国政府加强了电动汽车研发活动并开始开拓商业化路径。

首次公开广泛的应用电动车是为2008年北京夏季奥运会部署的新能源汽车示范项目，共计595辆新能源汽车——主要是纯电动车、燃料电池车和混合动力车一共行驶370万公里，运送乘客440万人次。

2008年底，国内生产企业经历了全球经济危机的影响。在此背景下，中国发布了《汽车产业调整和振兴规划》，其中再次强调推进新能源汽车将是中国长期工业战略的关键。因此，2009年12月，由科技部（MOST）牵头，中国启动了大范围的试点方案，称为“十城千辆”计划—是广泛应用新能源汽车的第二次主要尝试。这一项目的目的是在近期内刺激中国汽车工业，为将来把中国汽车企业打造成世界电动汽车技术的领跑者。

130 法国、德国和英国的政策信息来源于：欧洲汽车工业协会（ACEA），2010年，《欧盟的电动汽车财税鼓励概况》，网址： http://www.acea.be/images/uploads/files/20100420_EV_tax_overview.pdf。日本能源政策来源于：日本自动车协会，2009年，《2009年日本汽车工业》。

There are increasingly more attention and programs to encourage HEVs and electric-drive vehicles outside the US. Table 9.7 lists some examples of consumer incentives for purchasing new electric vehicles in selected European countries and Japan. Though, in many cases the incentives are technology-specific, meaning as long as a vehicle is a HEV or BEV it will be eligible for the incentives, in some nations, the amount of incentive is tied with emission reduction performance of a vehicle. For example, in France, the subsidy to various electric drive vehicles is integrated in a CO_2-based bonus-malus system that applies to light-duty vehicles of all fuel types. Specifically, only if a HEV emits less than 60 g/km of CO_2 from tailpipe emissions, it can receive a subsidy of 5,000 Euro.

Table 9.7: Consumer incentives for purchasing EVs in Europe and Japan[130]

COUNTRY	CONSUMER INCENTIVES
France	Under a CO_2-based bonus-malus system, a subsidy of up to €5,000 is provided to low CO_2 emissions (below 60g/km) vehicles including various electric-drive vehicles. The government is also planning to exempt EVs from parking fees.
Germany	EVs are exempt from annual circulation tax for the first five years after purchase.
United Kingdom	Private EVs are exempt from annual circulation tax. Company EVs are exempt from annual circulation tax for first five years after purchase. From 2011, BEV and PHEV buyers will receive a discount of 25% of vehicle's list price with a maximum of £5,000,
Japan	BEVs, HEVs and PHEVs are exempt from acquisition tax and annual tonnage tax if they meet certain fuel economy and emissions standards. (as of 2009)

China's experience and policies

Although the initial efforts to develop EVs in China date back to early 1990s, they were not a focus of the auto industry's strategy until early this century. In 2001 (the beginning of the tenth Five Year Plan), China included for the first time various EV R&D projects as a key component in the National High-tech Development Plan (usually called the 863 Program). Since then, the government has established a so-called "Three Transverses" (i.e., Fuel Cell Vehicles, Hybrid Electric Vehicles, and Pure Electric Vehicles) and "Three Longitudes" (i.e., Multi-Energy Powertrain System, Drive Motor and Power Battery) strategy and a massive amount of investment began to flow into EV development. A total of 2 billion RMB was invested on alternative vehicle R&D including EVs by the end of 2008. In the following five-year period (2006-2010), the Chinese government reinforced the EV R&D activities and also started to explore initial paths for commercialization.

The first attempt of wide and public application of EVs was the demonstration new energy vehicle fleet deployed for the 2008 Summer Olympic Games in Beijing. During the Games, a total of 595 new energy vehicles -- mainly battery, fuel cell and hybrid electric vehicles -- operated for 3.7 million kilometers transporting 4.4 million passengers.

Towards the end of 2008, domestic auto manufacturers began to experience the effects of the extended global economic crisis. In this context, China announced the Auto Industry Adjustment and Revitalization Plan, which reasserted that promoting new energy vehicles would be the key for China's longer-term industrial strategy. As a result, in December 2009, China launched a large-scale demonstration program called "Ten Cities by Thousand"—a second major attempt of wide application of new energy vehicles, led by the Ministry of Science And Technology (MOST). This program aims to stimulate China's auto industry in the near term, and to promote the Chinese automakers to be the world leader on electric-drive technologies in the long term.

130 Source of French, German and UK's policies: ACEA (European Automobile Manufacturer's Association), 2010. Overview of Tax Incentives for Electric Vehicles in the EU. Online available at: http://www.acea.be/images/uploads/files/20100420_EV_tax_overview.pdf. Source of Japanese policy: JAMA (Japan Automobile Manufacturer Association) 2009. The Motor Industry in Japan 2009.

这个项目计划在选定的10个城市向购买电动汽车的政府部门和商业企业提供财政补贴，在三年之内每年每个城市引入至少1000辆新能源汽车。补贴金额取决于新能源汽车（与同类传统车辆相比）的燃料能效性收益、技术类型和成本增量。表9.8列出了不同车型的补贴金额。2010年1月，这个项目扩展到20个城市。目前，参与的城市正处于计划采购过程中。最近，政府宣布一项计划，要在选定的另外五个试点城市，向私人购买者提供类似的补贴。因此，许多汽车生产企业已经设立了子公司，专门研发和生产电动汽车。

表9.8: 中国“十城千辆”计划下HEV和电动车技术补贴金额（人民币每车）

车辆类型	成用轿车和轻型车	巴士
HEVs	最高 50,000[a]	80,000-420,000[b]
BEVs	60,000	500,000
FCVs	250,000	600,000

a 实际补贴金额取决于HEV的燃料能效性收益大小。

b 实际补贴金额取决于混合动力巴士使用的电池类型。

尽管已经设置了有利的财政补贴，但技术标准仍然滞后。这些标准是必要的，用来定义新能源汽车的关键技术要求并协助判定哪些新能源汽车（技术）应当推广。在淘汰技术落后的电动车（使用过时的低能效电池对车辆进行改造，当做“电动汽车”出售）方面，标准将起到重要作用，这种落后的电动汽车在郊区越发普及。在本文撰写时，尚没有针对BEV的最终的技术标准。

总结与建议

下面的表9.9总结了混合动力车和电动汽车在环保方面的优势和劣势：

表 9.9: 混合动力车（HEV）和电动汽车（BEV）的优势和劣势总结

优势	劣势
■ HEV: 燃料经济性和排放性能提高。提高幅度取决于所采用的技术。不需要充电设备。 ■ PHEV: 燃料经济性提高。在一定里程范围内，可以像BEV一样 在全电动模式下行驶，在这一范围内具有BEV的所有优势。 ■ BEV:零尾气排放。没有内燃机相关的各种问题（I/M、排放劣化、传输过程中的油品污染）。可在帮助电网削峰填谷，实现双赢。 ■ FCEV: 享有BEV的所有收益。因为氢的能源密度高，可提高能效性，比BEV更适合长距离行驶或中等及高负载运行。	■ HEV: 拥有大多数内燃机车的相关问题。成本高。 ■ PHEV: 同时拥有内燃机和电动机双方面的问题。需要充电系统（包括住宅充电系统）。电池模式行驶范围有限。车辆和基础设施成本高。和BEV一样，上游排放具有不确定性。 ■ BEV: 根据原始发电能量源和发电方法，上游排放可能会很高。行驶范围有限（无法和内燃机相比）。车辆和基础设施成本高。需要更换电池。由于需要为车辆增加额外的发电量，会增加郊区的排放。 ■ FCEV: 除了行驶里程范围问题外，面临和BEV一样的挑战。轻型车需要更高效的氢燃料运输和储存方法。

The program is intended to introduce at least 1,000 new energy vehicles per year in each of the ten selected cities (later expanded to more than 20 cities) by providing financial subsidies to new governmental and commercial electric vehicle purchases. The amount of subsidies is determined by the fuel efficiency gain, type of technology and cost difference between the new energy vehicle and a comparable conventional vehicle. Table 9.8 shows the current amount of subsidies for various types of vehicle. As of January 2010, the program was extended to twenty cities. At present, the participating cities are in the process of vehicle procurement. Most recently, the government announced a plan to introduce similar subsidies for private purchases and has selected five pilot cities for the demonstration. As a result, many vehicle manufacturers have established subsidiaries with focus on research, development, and production of EVs.

Table 9.8: Subsidy Levels for HEVs and electric drive technologies under the Chinese "Ten Cities by Thousand" program (RMB per vehicle)

VEHICLE TYPE	PASSENGER CARS AND LIGHT DUTY VEHICLES	BUSES
HEVs	Up to 50,000[a]	80,000-420,000[b]
BEVs	60,000	500,000
FCVs	250,000	600,000

a The actual subsidy level depends on fuel efficiency gain of a given HEV.

b The actual subsidy level depends on the type of batteries used in a given hybrid electric bus.

While favorable financial subsidies have been established, technology standards still lag behind. These standards are supposed to define the key technological requirements for new energy vehicles and help determine what types of new energy vehicles (technologies) should be promoted. The standards are important to help filter out dead-end technology EVs (vehicles modified with outdated and inefficient battery technologies but sold as “electric vehicles”), which are increasingly common in rural areas. The Technology Standard for BEVs has still not been finalized at the time when this paper is written up.

Summary and recommendations

The following Table 9.9 summarizes the pros and cons of HEVs and electric-drive vehicles.

Table 9.9: Summary of advantages and disadvantages of HEVs and electric-drive vehicles

ADVANTAGES	DISADVANTAGES
■ HEV: Improved fuel economy and emissions performance. The level of improvement depends on technology. No recharging facilities needed. ■ PHEV: Fuel economy improvement. Has the potential to function like a BEV for a limited range, thus may share all benefits of BEVs when driven on all-electric mode. ■ BEV: Zero tailpipe emissions. No ICE-related issues (I/M, emission deterioration, oil contaminant of dispense issues). May realize co-benefit of filling grid valley. ■ FCEV: Share all benefits of BEVs. Improved efficiency due to high energy density of H_2, better for long-distance or medium and heavy load than BEV.	■ HEV: Suffer from most ICE-related problems. High cost. ■ PHEV: May suffer from both ICE and electric motor issues. Need recharging system (including residential). Limited range on battery mode. High cost in both vehicle and infrastructure. Uncertainty in upstream emissions as BEVs. ■ BEV: Upstream emissions can be high depending on original energy sources and processing. Limited range (cannot compete with ICE vehicles). High Cost in both vehicles and infrastructure. Need battery recycling. Increased emissions in rural area due to extra electricity generation for the vehicles. ■ FCEV: Similar challenges as BEVs except for the range issue. Need more efficient hydrogen transportation and storage for light-duty vehicles.

以下建议的主要目的是减少混合动力车和电动汽车的环境影响：

- 尽管应该让市场来做出选择制定先进技术汽车政策的总原则，但考虑近期和长期的战略对中国而言十分重要。例如，相对于其它类型的技术，混合动力车辆技术更加成熟，可实现商业化，这可能不需要政府过多的投入，就能在短期内产生影响。但是，从长期角度，以清洁能源为基础的电动车和燃料电池车才能真正实现零排放。

- 环保部应同时考虑各种新能源车辆的尾气排放收益和全生命周期排放影响。环保部应带头进行这些车辆的全生命周期排放综合研究，并考虑中国国情下的电网能源构成情况。这些研究结果将为今后制订新能源汽车政策奠定基础。

- 在中国，PHEV、BEV和FCEV的长期环境影响取决于上游排放的不断改善，包括更多的依赖于可再生资源产生的能源。环保部应与其它部委合作，在引进PHEV、BEV和FCEV的同时扩大对可再生能源的支持。

- 需要针对电池回收和处理的管理规定。

- 随着中国车辆保有量的增长，相对于继续大量投资于建设更多的传统汽柴油基础设施，中国的发展战略可以考虑将未来的投资主要用于为电动汽车建设电力或氢能基础设施，这可以被当做一个实现跳跃发展的契机。

9.5 综合性建议

除了针对各类燃料车辆提出的专门建议外，下面还提供了一些全局性建议，适用于所有替代燃料和新能源汽车方案中：

- *环保部应发展自身能力和专业技术，评估各种替代燃料汽车的环境影响。*综合分析这些燃料的全生命周期排放，在分析时要着重考虑中国特殊的能源原料情况，以供制定这一领域的政策所需。

- *替代燃料车应当被纳入普通车辆的常规污染物和温室气体/燃料能效性管理框架和财政政策体系。*替代燃料车应遵守适用于所有其它车辆的排放性能（包括可能的二氧化碳排放性能）标准规定。应尽量对减排性能较好的车予以奖励，以便鼓励其商业化进程。同样，财政鼓励也应当和替代燃料车的减排幅度挂钩，而不是单纯针对替代燃料技术的使用。

- *一旦环保部有更强的能力分析燃料的全生命周期环境影响，环保部应考虑采纳低碳燃料标准（LCFS），在其中对不同的燃料的碳影响进行规定，并推广使用低碳车用燃料。*在好的LCFS和车辆温室气体标准的共同作用下，可以促成持续推动汽车低碳化。

- *大体而言，原装（OEM）替代燃料车的发动机排放性能更好，其长期性能比改造车更有保障。*因此，在适用的情形下，政策制定者应鼓励使用原装车辆。应开展认证和达标方案，确保改造组件和改造车能满足环境、安全和其它方面的要求。

- *投资基础设建设应与替代燃料车同步发展。*根据现实案例，加油基础设施滞后于车辆普及，灵活燃料车或双燃料车车主就经常会不使用替代燃料。电动车缺少充电设施会妨碍这类车辆的发展乃至技术创新。应制订政策确保切实使用替代燃料。例如，美国实施了强制规定，要求联邦政府机构的双燃料车必须使用替代燃料。各州和地方政府也必须提交计划，说明鼓励切实使用替代燃料的方法，包括向替代燃料提供减税鼓励，加强替代燃料基础设施建设和增加加油站点。

The following recommendations are aimed at optimizing the environmental impacts of HEVs and electric-drive vehicles:

- Although the general principle for developing advanced technology vehicles should be to let the market choose, it is important for China to consider both short- and long-term strategies. For example, HEV technologies are currently more mature than the other types for commercialization, thus may make an impact in the near term without significant governmental input. But in the long-run, BEVs and FCEVs based on clean energy sources will truly realize low to zero emissions.

- MEP should consider tail-pipe emissions benefits as well as the life cycle emissions impact of these vehicles. MEP should take the lead in conducting comprehensive studies on life-cycle emissions of these vehicles, taking consideration of China's specific grid mix situations. The results of these studies will serve as a ground for future policy making regarding new energy vehicles.

- The long-term environmental impacts of PHEV, BEV and FCEVs in China depend on the continuous improvement of upstream emissions including a greater reliance on renewable sources of energy. MEP should work with other ministries on expansion of renewable energy supply that go in parallel with the introduction of PHEVs, BEVs and FCEVs.

- Regulations addressing battery recycling and disposal are needed.

- As the Chinese vehicle population grows, investment in electricity or hydrogen infrastructure for electric drive vehicles can be seen as a leapfrog opportunity, in contrast to building more conventional fuel-based infrastructure.

9.5 Overall recommendations

In addition to the specific recommendations for each fuel/vehicle type, the following overarching recommendations apply to all alternative fuels and new energy vehicle programs:

- *MEP should develop in-house capacity and expertise in evaluating the environmental impacts of various alternative fuel vehicles.* A comprehensive analysis of life-cycle emissions of these fuels, taking consideration of the China-specific energy feedstock profile is needed to set priorities and inform policy efforts in this area.

- *Alternatively fueled vehicles should be incorporated into the general vehicle conventional pollutant and GHG/fuel efficiency regulatory framework and fiscal policies.* Alternatively fueled vehicles should comply with the performance standards applicable to all other vehicle types. Whenever possible, better performing vehicle should be rewarded for emission reduction benefits in order to encourage their commercialization. Similarly, fiscal incentives for various alternative fuel vehicles should be linked to their emissions reduction contribution, rather than simply being technology-specific.

- *As MEP develops more capacity in life cycle environmental impacts of fuels, the ministry should consider adopting a low carbon fuel standard (LCFS) that characterizes the carbon profile of various fuels and promotes the use of low carbon vehicle fuels.* A well-designed LCFS and a vehicle GHG standard can work together to promote continuous decarbonization of automobiles.

- *In general, manufactured (OEM) alternative fuel vehicles have better engine and emissions performance, and their longer term performance is more guaranteed than retrofitted vehicles.* Therefore, when applicable, policy makers should encourage the use of OEM vehicles. Certification and compliance programs should be developed to ensure that retrofit kits and retrofitted vehicles meet environmental, safety and other requirements.

- *Infrastructure investment should go hand-in-hand with the development and deployment of alternative fueled vehicles.* Real world cases suggest that when refueling infrastructures lags behind vehicle adoption, owners of flex-fuel or dual fuel vehicles often will not use the alternative fuel for their vehicles. Lack of recharging infrastructure for electric drive vehicles will also inhibit the deployment and even technology innovation of such vehicle types. There should be policies to assure the actual use of the alternative fuels. For example, the US issued mandatory requirements for federal fleets to use alternative fuel in dual-fuel vehicles. State and local governments must submit plans of measurements to encourage actual use of alternative fuels including providing tax incentives on alternative fuels, expanding alternative fuel facilities and charging stations.

10. 本文所有建议汇总

以下是ICCT为环保部提供的建议汇总，意在改善当前的车辆排放控制方案。这些建议在相关章节的结尾都有更加具体的论述。

关于新车标准（第3章）：

• 近期内，结合低硫燃料（50ppm即可使用，但推荐10ppm）供应的规定，考虑实施国VI的路径。从国IV直接跳跃实施国VI可能会有优势，主要有以下几点原因：

o 为工业企业提供充分的准备时间，同时进一步拉近与欧洲之间的标准实施差距；

o 直接过渡到国V/VI燃料可能比实现国IV（50ppm）之后再实现国V/VI(10ppm)更具成本效益；

o 目前欧洲城区发现欧V重型车在实际路况行驶时氮氧化物排放较高的问题（详见3.2节），可能会削弱这些车辆在空气污染严重区域使用的空气质量改善效益。

o 国VI（及国V轻型柴油车）要求装备柴油车颗粒物捕集器，该装置是控制对健康危害最大的柴油车颗粒物的最佳应用控制技术。

• 在过渡期间，避免空气质量进一步恶化是很重要的，要继续依照实施时间表实施标准。若迫不得已，也可以在使用符合国III燃料标准的燃油的情况下实施国IV排放标准，但只有使用国IV燃料(50-ppm)或更佳的燃料，才能全面体现实施国IV标准的效果。

• 在《大气污染防治法》中纳入规定，允许各地区提前实施比全国标准更加严格的标准。只要各城市能够证明其实施的标准至少与全国标准一样严格，就可以提前实施。这一过程对于尽快在有低硫燃料的城市地区引入国VI车辆而言十分关键。

• 利用部分地区拥有低硫燃料的优势，要求实施更加严格的颗粒物标准，迫使新车装备柴油车颗粒物捕集器，实现最大的健康收益。

关于油品标准 (第4章):

• 环保部应在近期内寻求通过《大气污染防治法》增大权力，制订和管理控制车辆排放的必要油品参数（包括燃料硫含量标准）。

• 力争在今后《大气污染防治法》的修订中，将油品和车辆标准作为一个体系管理。

• 加大环保部在制订与排放相关的燃料质量标准过程中的影响力，包括增加环保部和汽车工业代表在制订油品标准的技术委员会中的席位数，确保制订油品标准时能充分考虑空气质量和排放控制技术提升。

• 通过与美国EPA或其它国家的管理机构合作开展培训合作，逐步建设自身制订油品标准的能力。

• 在争取获得制订与排放相关的油品参数的权力的同时，环保部应考虑支持直接跳跃实施国V油品标准，因为这是清洁燃料发展道路上最具成本效益的途径，并且应力争统一道路和非道路柴油硫含量限值。

• 由于成本是阻碍清洁燃料发展的一个非常重要的因素，环保部应和相关部委联合，寻求方法为石化工业筹措资金来进行低硫化设备或其它燃料品质改善方面的投资，并且应设计过渡计划关闭那些或因技术落后不具备生产低硫燃料的改造价值，或其产品无法在短期内转用于非移动源的小型炼油厂。

• 从长期来说，应与各部委开展讨论改革油价控制政策。

10. Summary of recommendations

The following is a summary of the ICCT's recommendations to the Ministry of Environmental Protection to improve the current vehicle emission control program. These recommendations are discussed in more detail at the end of each relevant chapter.

For new vehicle standards (Chapter 3):

• Consider pathways for the introduction of a future China VI in the near term in conjunction with the provision of lower sulfur fuels (50-ppm is adequate, however 10-ppm is preferable). There are several reasons why leapfrogging directly from China IV to China VI may be advantageous:

o Provides adequate lead time for industry while further closing the gap with the adoption of standards in Europe

o Transitioning directly to China V/VI fuels may be more cost effective than meeting China IV (50-ppm) then China V/VI(10 ppm);

o Current issues with high in-use NOx emissions from Euro V heavy-duty vehicles in urban application in Europe (see Section 3.2) may limit the air quality benefits of these vehicles in the areas most affected by air pollution

o China VI (and China V for light-duty diesel vehicles) will require diesel particle filters, the best available control technology for the control of dangerous diesel particulate matter.

• In the interim, it is important to avoid further air quality deterioration to continue implementing standards according to the adopted schedule. If necessary, China IV can be implemented with current China III fuels but will only deliver its full benefits with China IV fuels (50-ppm) or better.

• Streamline the process for regions to adopt more stringent emission standards ahead of national standards by including provisions in the Air Pollution Prevention and Control Law. Establish the ability for early adoption if cities can prove that the standards are at least as stringent as those in vigor nationally. This process is critical to introduce China VI vehicles as soon as possible in urban areas that have lower sulfur fuel.

• Take advantage of the availability of lower sulfur fuels in some regions to require tighter PM standards that would force diesel particle filters on new vehicles to maximize health benefits.

On fuel standards (Chapter 4):

• In the near term, seek enhanced authority through the "Air Pollution Prevention and Control Law" for MEP to set and regulate fuel parameters necessary to control vehicle emissions (including fuel sulfur levels).

• Seek amendments of the "Air Pollution Prevention and Control Law" to treat fuel and vehicle standards as one system in future revisions.

• Expand MEP’ s role in setting emission-related fuel quality standards, including expanding MEP and auto industry's representation in the technical committee for setting fuel standards to make sure that air quality and advancements in emission control technologies are fully accounted for in setting of fuel standards.

• Gradually build up in-house capacity for setting fuel standards through MEP training collaborations with the US EPA or regulatory agencies in other countries.• While seeking the authority to set and enforce emission-related fuel parameters, MEP should consider supporting a leapfrog to China V fuel standards as the most cost-effective pathway to clean fuels and strive to align onroad and non-road diesel sulfur limits.

• Because cost is one of more important factors hindering progress to cleaner fuels MEP should indentify with partner ministries ways to finance industry's capacity investment on desulfurization units or other costs for fuel quality improvements and a transition plan for closing down small refineries with outdated technology that cannot be cost effectively upgraded to produce lower sulfur fuels or whose products cannot be temporarily diverted to non-mobile source applications.

• In the longer term, initiate discussion among partner ministries on the reform of the fuel price control policy.

关于车辆达标和实施管理方案（第5章）：

• 在用车检测是实施成熟的车辆管理方案的基础，也应当是环保部的终极目标。环保部要想制订这样的长远方案，在短期内应当：

o 寻求获得明确的授权以执行在用车检测并对不达标车辆予以处罚（包括召回车辆的权力），并制订在用车检测和召回方案；

o 筹措资金，资金来源包括对车主征收排放费/税或向车辆生产企业征收认证费用，来填补实施管理所需的支出；

o 寻求获得授权，要求车辆和发动机生产企业根据环保部制订的方法进行在用车和在用发动机测试并将原始数据上报环保部，这些数据可能被用于达标管理方案当中。

• 在争取额外的资源增加自身专业能力的同时，环保部应准备好人力资源用于发展在用车测试项目。

o 环保部通过与美国EPA和其它管理机构合作开展培训，增强自身在不达标车辆召回方面的管理能力。

• 在提高环保部权威性和筹措资源执行在用车测试的工作逐步开展的同时，现有的管理方案尚存在很多不足之处，环保部可以在近期内通过以下这些成本效益较高的方案进行改善：

o 提高环保部的技术人员的能力和测试能力，确保认证测试和企业出资进行的COP测试执行良好；建设环保部的测试能力对于发展召回管理方案也很重要，环保部的测试质量决定了生产企业是接受环保部提出召回的要求还是向环保部提出质疑。

o 在主要城市建立良好的I/M制度，从而找出并维修或淘汰“高排放车辆”并提供宏观数据，帮助环保部更好的确定高排放目标车型来进行在用符合性检测的。应考虑创建基金，保证高排放车辆接受维修或报废；

o 利用研究机构的技术专长和他们的在用车排放研究数据；

o 推行其它手段，迫使生产企业遵守排放标准（例如向公众曝光不达标车型/生产企业名单）.

关于油品监督和管理方案（第6章）：

• 环保部应寻求授权，管理与排放相关的油品规格并实施油品标准。

• 筹措资金雇佣合约机构实施全面的油品采样和测试，建设和提高环保部内部的业务能力和技术水平，以便开展和监督管理方案；在近期应开展具体分析，探究可用作支持这些工作潜在的财政资源，包括燃料税、车辆税、车辆登记注册收费和I/M收费。

• 同时，环保部应通过与美国EPA或其它国家的管理机构合作开展培训，逐步构建自身的技术专业能力和管理能力，以便监督油品管理方案的实施。

排放标志和相关管理方案（第7章）：

• 为避免标志被窃或滥用，考虑在在用车标志的显著位置设置车辆特定信息（如车牌号码）。

• 近期（未来5年），环保部可以考虑改革现有的标志系统，以便顺利过渡到加严后的交通限制措施。环保部还应考虑支持消费者宣传教育方案，增强消费者对标志的了解。

• 环保部可以考虑扩展现有的在用车标志的功能，引入售前消费者信息标志，并结合标志实施财税（例如，税收鼓励）或非财税（例如，给低排放车设定指定停车位）鼓励手段。如果环保部考虑采用消费者信息标志来影响消费者的购买决定，实施机构应确保这些标志在车辆销售时让消费者看得到。

On vehicle compliance and enforcement programs (Chapter 5):

• In-use testing is currently the cornerstone of mature vehicle enforcement programs and should be MEP's ultimate goal. To develop such programs MEP should in the near term:

o Seek clear authority to conduct in-use testing and impose penalties for non-compliance (including the ability to recall vehicles) and establish an in-use testing and recall program;

o Raise funds from emissions fee/vehicle taxes on vehicle owners or increased certification application fees on vehicle manufacturers to cover higher enforcement expenses ;

o Seek authority to require vehicle and engine manufacturers to carry out in-use vehicles and engines testing using protocols established by MEP and to provide the raw data results to MEP for possible use in its compliance program.

• MEP should prepare its staff for the development of in-use testing program while MEP seeks additional resources to enhance its in-house expertise:

o Increase in-house proficiency in recall program administration through MEP training collaborations with the US EPA and regulatory agencies in other jurisdictions.

• As progress is made to increase MEP's authority and resources to conduct in-use testing, there are significant gaps in the current program that can be remedied in the near term and cost effectively by:

o Increasing technical capacity and testing capability at MEP to ensure certification tests and industry-funded COP testing are being done properly; establishing MEP's testing capacity and capability is also essential for developing a recall program as manufacturers' acceptance of vehicle recalls – or likelihood to challenge–depends on the quality of MEP's testing;

o Establishing good I/M programs in major cities to identify and eliminate “gross emitters” and provide macro level data to help MEP better target high-emission models for in-use compliance testing. Consider creating a fund to ensure all gross emitters are repaired or scrapped.

o Leveraging the technical expertise in existing research institutes and utilizing data collected from their research on in-use vehicle emissions

o Pursuing other measures to coerce manufacturers to comply with emissions standards (e.g., a “name and shame” campaign to publicize non-compliant models and/or manufacturers).

On fuel inspection and enforcement programs (Chapter 6):

• MEP should seek authority to regulate emission-related fuel specifications and enforce fuel standards.

• Funding should be raised to hire contractors to conduct extensive fuel sampling and testing, and to establish the capacity and technical capability within MEP to develop and oversee the program; detailed analysis should be conducted in the near term to explore potential financial sources include fuel taxes, vehicle taxes, vehicle registration fees or I/M fees.

• Meanwhile, MEP should gradually build up in-house technical expertise and management capacity to oversee the fuel enforcement program through training workshops with the US EPA or regulatory agencies in other countries.

On emissions labeling and related programs (Chapter 7):

• To avoid label theft or misuse, consider displaying vehicle-specific information (such as license plate number) prominently on the in-use vehicle label.

• In the near-term (next five years), MEP may consider a reform of the current labeling system to allow an easier transition to a strengthened traffic restriction program. MEP should also consider introducing supporting consumer educational programs to improve consumer understanding of the labels.

• MEP may consider extending the function of the current in-use labels to pre-sale consumer information labels, and introducing fiscal (e.g. tax incentive) or non-fiscal (e.g.,designated parking space) incentives to combine with the labels. If MEP is considering the introduction of consumer information labels that influence consumer purchase decision, the enforcing agencies should make sure that the labels are made available to consumers at the point of sale.

- 从中长期角度，城市和地区可以不断加严交通限行区设定的排放标准来强化交通限制措施。

- 环保部应在新车上采用温室气体排放标志对消费者进行宣传教育，或修改现有的车辆燃料消耗量标志来达到这一目的。中国应向温室气体排放低的车辆实施鼓励，可考虑结合标志进行。

关于燃料效率和温室气体管理方案（第8章）：

- 环保部应力争获得授权，管理机动车温室气体排放并负责实施管理，包括对不达标行为实施罚款。

- 中国应加严目前对乘用轿车和摩托车实施的管理方案，并在即将出台的标准中对重型商用车设定严格的标准和管理方案。

- 为了实现整体车队的节油和碳减排，中国应调整目前的标准结构设计。这包括将以重量为基础的标准转换为以尺寸为基础的标准，采纳并确保实施企业平均标准，使用连续线性函数确定标准值并替代目前的阶梯形函数结构。

- 保障强有力的实施与严格的标准限值本身同等重要。

- 中国应当以燃料效率或二氧化碳/温室气体排放取代目前的主要以排量财税政策征收基础，即车辆排量，这样能更好的支持燃料消耗量管理和实现整体的碳减排目标：如果环保部考虑采用财税政策来鼓励购买低（常规污染物）排放车辆，就也应将温室气体纳入政策设计，以便利用财税激励实现同时减少常规污染物和温室气体排放，使政策获得最大程度的收益。

关于替代燃料和新能源汽车（第9章）：

- 环保部应提高自身管理能力和专业水平，开展研究来评估各种替代燃料车的环境影响，包括全生命周期排放，为政策制订提供参考。

- 替代燃料车应纳入普通车辆的常规污染物和温室气体/燃料能效性管理框架和财税政策框架。

- 一旦环保部有更强的能力分析燃料的全生命周期环境影响，环保部应考虑采纳低碳燃料标准（LCFS），对不同的燃料设定碳排放标准，并推广使用低碳车用燃料。

- 大体而言，原装（OEM）替代燃料车的发动机和排放性能更好，其长期性能比改造车更有保障。

- 投资基础设施建设应与推广替代燃料车同步发展。

• In the mid- to long- term, cities and regions may strengthen the traffic restriction programs by gradually tightening the requirements for vehicles allowed in the core city areas.

• MEP should introduce GHG emissions labels for new vehicles for consumer education or revise the existing vehicle fuel consumption labeling to serve the purpose. China should also offer incentives for low-GHG emission vehicles.

On fuel efficiency and GHG programs (Chapter 8):

• MEP should seek the authority to monitor and regulate GHG emissions from motor vehicles and enforce these regulations including imposing fines for non-compliance.

• China should enhance the stringency of its current program for passenger cars, motorcycles and adopt a stringent program for heavy commercial vehicles.

• China should adjust the design structure of its current standards, in order to deliver more certain fuel and carbon reduction fleetwide. This includes shifting from weight-based to footprint-based standards, adopting and ensuring the enforcement of corporate average standards, and developing continuous standard curves to replace the current step function structure.

• Strong enforcement is equally important as a stringent standard limits .

• China should replace the current fiscal policies that primarily based on displacement with a CO_2/GHG-based scheme to better support the fuel consumption regulations and an overall carbon reduction goal; as MEP considers providing fiscal policies to encourage purchase of low emission vehicles, the ministry should take into account GHGs in the policy design so as to maximize the benefits of the incentive program in reducing both conventional pollutants and GHG emissions.

On alternative fuel and new energy vehicles (Chapter 9):

• MEP should develop in-house capacity and expertise in evaluating the environmental impacts of various alternative fuel vehicles including life-cycle emissions to inform policy-making

• Alternatively fueled vehicles should be incorporated into the general vehicle conventional pollutant and GHG/fuel efficiency regulatory framework and fiscal policies.

• As MEP develops more capacity in life cycle environmental impacts of fuels, the ministry should consider adopting a low carbon fuel standard (LCFS) that characterizes the carbon profile of various fuels and promotes the use of low carbon vehicle fuels.

• In general, manufactured (OEM) alternative fuel vehicles have better engine and emissions performance, and their longer term performance is more guaranteed than retrofitted vehicles.

• Infrastructure investment should go hand-in-hand with the development and deployment of alternative fueled vehicles.

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附录 A: 术语表

ANL:美国阿贡国家实验室

BAU: 常规管理

CFM: 中国机动车模型

CAA: 清洁空气法

CARB: 加州空气资源局

CO: 一氧化碳

DPF: 柴油车颗粒物捕集器

EGR:废气再循环系统

EU:欧盟

EUDC:额外城市行驶工况

GDP: 国内生产总值

GHG:温室气体

HC:碳氢化合物

HCHO: 甲醛

HDV/HD: 重型车

HIA: 健康影响评估工具

ICE:内燃机

LDV/LD: 轻型车

MEP: 环境保护部

NEDC: 新的欧洲行驶工况

NMOG: 非甲烷有机化合物

NOx: 氮氧化物

NTE:排放上限

OBD: 车载诊断系统

PEMS: 便携式排放测量系统

PM:颗粒物

RFG: 新配方汽油

SCR: 选择性催化还原装置

SEA: 选择性达标审核

US EPA: 美国国家环境保护局

THC:总碳氢化合物

TWC: 三元催化器

VECC:机动车排污监控中心

VOCs:挥发性有机化合物

Appendix A: List of acronyms

ANL: Argonne National Laboratory

BAU: Business as usual

CFM: China Fleet Model

CAA: Clean Air Act

CARB: California Air Resources Board

CO: Carbon monoxide

DPF: Diesel particle filter

EGR: Exhaust gas recirculation

EU: European Union

EUDC: Extra urban driving cycle

GDP: Gross domestic product

GHG: Greenhouse gases

HC: Hydrocarbon(s)

HCHO: Formaldehyde

HDV/HD: Heavy-duty vehicle

HIA: Health impact assessment tool

ICE: Internal combustion engine

LDV/LD: Light-duty vehicle

MEP: Ministry of Environmental Protection

NEDC: New European driving cycle

NMOG: Non methane organic gases

NOx: Oxides of nitrogen

NTE: Not-to- exceed

OBD: On-board emission diagnostics

PEMS: Portable emissions measurement system

PM: Particulate matter

RFG: Reformulate gasoline

SCR: Selective catalytic reduction

SEA: Selective enforcement audit

US EPA: United States Environmental Protection Agency

THC: Total hydrocarbons

TWC: Three-way catalyst

VECC: Vehicle Emission Control Center

VOCs: Volatile organic compounds

附录 B- 中国机动车模型及健康影响评估方法学，数据来源和相关假设条件

B. 1 中国机动车模型（CFM）

中国机动车模型可以对整个中国机动车车辆群体在过去及将来不同政策情景下的排放量和燃料消耗进行评估。此模型包括所有影响空气质量和气候变化的主要排放污染物，如：一氧化碳，氮氧化物，总碳氢化合物，颗粒物，二氧化碳，氧化亚氮，甲烷以及黑炭。模型用户可以自定义包括新车排放标准，燃料硫含量，车辆燃料限值等政策情景。同样，模型用户可以调节政策的执行实施效果及电动车的推广程度。

车辆组成参照下表的车辆分类标准。

表 AB1: CFM中的车辆类型

名称	缩写	定义
重型卡车	HDT	车长大于等于6米，总质量大于等于12000公斤
中型卡车	MDT	车长大于等于6米，总质量大于等于4500公斤且小于12000公斤
轻型卡车	LDT	车长小于6米，总质量小于4500公斤
微型卡车	MT	车长小于3..5米，总质量小于750公斤
重型巴士	HDB	车长大于6米,乘坐人数大于20人
中型巴士	MDB	车长小于6米，乘坐人数10-19人
轻型巴士	LDB	车长小于6米，乘坐人数小于等于9人
微型巴士	MB	车长小于3.5米
大型轿车	Lcar	车长小于3.5米，发动机排量大于1.6升
小型轿车	Scar	车长小于3.5米，发动机排量小于1.6升
摩托车	MC	城市或者郊区摩托车
低速汽车	RV	三或四轮

CFM模型评价以下种类的排放污染物：氮氧化物 (NO_x)，颗粒物 (PM)，一氧化碳 (CO)，碳氢化合物 (HC)，氧化亚氮 (N_2O)，甲烷(CH_4)，黑炭[131] (BC)以及二氧化碳(CO_2)。燃料方面，模型只针对汽油和柴油燃料，并没有对其他机动车燃料（如：天然气，液化石油气，甲醇以及生物燃料[132]）进行评估。

下面是CFM中关键政策的时间轴以及情景设置：

- 机动车排气污染物标准的实施，如，国IV, V, VI以及延伸
- 汽柴油硫含量水平
- 政策执行实施的广度和严格程度的增强
- 燃料经济性的改善
- 电动汽车的推广

131 黑炭是颗粒物中的具有强吸光性的固体部分，也是一种强效的气候变暖气溶胶。

132 CFM模型将来自电网的电力作为一种未来情景中的燃料囊括进来，但是并没有对这类机动车消耗的总能源(kWh)进行评估。在未来的电动车汽车的相关讨论部分，电动汽车模块评价了上游电力生产中造成的污染物(NOx, PM, CO, HC, 和 CO_2)的排放情况。

Appendix B- China fleet model and health impact assessment methodology, data sources and assumptions

B. 1 China Fleet Model

The CFM can estimate emissions and fuel consumption from the entire Chinese vehicle fleet under a variety of past and future policy scenarios. The model includes all the major emissions of concern for air quality and climate change such as carbon monoxide, oxides of nitrogen, total hydrocarbon, particulate matter, carbon dioxide, nitrous oxide, methane and black carbon. The model user can customize policy scenarios that cover new vehicle emission standard levels, fuel sulfur concentration and vehicle fuel consumption limits. The model user can also adjust the effectiveness of enforcement and compliance programs and the penetration of all electric vehicles.

The vehicle fleet is represented using the following standardized vehicle groupings.

Table AB1: Vehicle categories in the CFM

NAME	ABBREVIATION	DESCRIPTION
Heavy-duty truck	HDT	Longer than 6m and greater than 12,000kg
Medium-duty truck	MDT	Longer than 6m and between 4,500 and 12,000kg
Light-duty truck	LDT	Shorter than 6m and less than 4,500kg
Mini-truck	MT	Shorter than 3.5m and less than 750kg
Heavy-duty bus	HDB	Longer than 6m and holding 20 or more people
Medium-duty bus	MDB	Shorter than 6m and holding 10-19 people
Light-duty bus	LDB	Shorter than 6m and holding 9 or less people
Mini-bus	MB	Shorter than 3.5m
Large car	Lcar	Shorter than 3.5m and engine displacement > 1.6 liter
Small car	Scar	Shorter than 3.5m and engine displacement < 1.6 liter
Motorcycle	MC	Urban or rural motorcycle
Rural vehicles	RV	3 and 4-wheelers

The CFM estimates the following emitted species: oxides of nitrogen (NOx), particulate matter (PM), carbon monoxide (CO), hydrocarbons (HC), nitrous oxide (N_2O), methane (CH_4), black carbon[131] (BC), and carbon dioxide (CO_2). For fuels, the model is limited to gasoline and diesel and does not account for other vehicle fuels such as natural gas, liquid petroleum gas, methanol, and biofuels[132].

- The following are the key policy timelines and scenario features of the CFM:
- Vehicle emission standard adoption, i.e. China IV, V, VI and beyond
- Gasoline and diesel sulfur levels
- Increased breadth and stringency of compliance and enforcement programs
- Fuel economy improvements
- Electric vehicle penetration

131 Black carbon is the solid fraction of PM that strongly absorbs light and is a potent climate warming aerosol.

132 The CFM does include electricity from the grid as a fuel source in future scenarios but does not estimate the total energy (kWh) consumed by these vehicles. As is discussed further in the 'Electricity' section, the electric vehicle module estimates upstream emissions (NO_x, PM, CO, HC, and CO_2) resulting from electricity production.

接下来三部分将会介绍CFM评价以下三方面的方法论：1)标准限定的污染物排放量评估; 2)燃料消耗量以及二氧化碳排放量评估；以及 3)电动汽车相关动力上游的污染物排放量评估。

机动车标准限定的污染物排放量的评估

用来评价非CO_2排放污染物的模块是基于机动车活动排放因子组建的，以下公式可以对其进行介绍：

[机动车保有量] * [机动车排放因子, g/km] * [机动车行驶里程, km] = 排放量 (单位)

(公式 1)

表AB1中的每种机动车种类在CFM模型中都有独有的工作表(Microsoft Excel) 来评价NOx，PM、CO、HC、N_2O、CH_4、BC排放量[133] 。

在模型中用户界面的‘输入’表中，用户可以选择使用"ICCT"或者“VECC-ICCT综合”排放因子。ICCT排放因子主要是由Michael Walsh开发的，同时也包括了由加州空气资源局开发的排放模型(EMFAC2007)中的数据。VECC-ICCT 排放因子由机动车排污监控中心(VECC)开发的NOx，PM，CO以及 HC数据，以及采用与ICCT排放因子设置相同的N_2O, CH_4排放因子共同组成。在ICCT和 VECC-ICCT数据中, BC 排放因子都被确定为颗粒物排放因子的一定百分比。具体BC占PM的百分比是通过咨询加州空气资源局的相关专家来确定的[134]。本次评价的所有结果全部采用的是ICCT排放因子。

克每公里 (g/km)排放因子极好的诠释了ICCT对一辆车全生命周期平均排放率的评价。另一方面，ICCT正在尝试了解车辆排放控制装置的劣化情况对单种污染物排放因子的影响。在表AB1中的每种车型并不是都有相应的排放因子，但是机动车可以按照表AB2中的分组中获得各车型组对应排放因子。

133 由于缺少相关排放因子数据，CFM模型没有进行低速汽车N_2O 以及 CH_4的评价。

134 Alberto Ayalo, CARB, 2008年10月17日。

The next three sections will describe the methodology of the CFM in estimating 1) criteria pollutant emissions, 2) fuel consumption and carbon dioxide emissions, and 3) the upstream emissions associated with powering electric vehicles.

Vehicle Criteria Pollutant Emissions

The modules for estimating non-CO_2 emissions are based on vehicle activity emission factors and are summarized in the following equation:

[vehicle population] * [vehicle specific emission factors, g/km] * [vehicle activity, km] = mass emissions (units)

(Equation 1)

Each vehicle category in Table AB1 has its own worksheet in the CFM workbook (Microsoft Excel) that estimates NOx, PM, CO, HC, N_2O, CH_4, and BC emissions[133].

On the 'Inputs' sheet, which is the user interface for the model, the user can choose between "ICCT" and "VECC-ICCT hybrid" emission factors. The ICCT emission factors were primarily developed by Michael Walsh, but also include values that were derived from the California Air Resources Board's EMission FACtor (EMFAC2007) model. The VECC-ICCT emission factors are comprised of NOx, PM, CO, and HC data that was developed by the Vehicle Emission Control Center (VECC) and N_2O, CH_4 data that is identical to the ICCT emission factor set. For both the ICCT and VECC-ICCT data sets, BC emission factors are a percentage of the PM emission factors. The fraction of PM that is BC is based on communications with California Air Resources Board experts[134]. The ICCT emission factors were used to develop all of the results in the Retrospective Study.

The gram per kilometer (g/km) emission factors represent ICCT's best estimate of an average emission rate over a full vehicle lifetime. In other words, ICCT is attempting to capture the deterioration of the vehicle's emission control system over time in one single emission factor. There are not individual emission factors for every vehicle type in Table AB1; rather, vehicles are binned according to the designations in Table AB2.

133 Due to lack of emission factor data, the CFM does not have N_2O or CH_4 estimates for rural vehicles.

134 Alberto Ayalo, CARB, October 17, 2008.

表AB2: 排放因子模型的机动车分类

排放因子分组	详细车辆分类	
重型柴油车 (HDDV)	HDT (柴油)	重型柴油卡车
	HDB (柴油)	重型柴油巴士
重型汽油车 (HDGV)	HDT (汽油)	重型汽油卡车
	HDB (汽油)	重型汽油巴士
中型柴油车 (MDDV)	MDT (柴油)	中型柴油卡车
	MDB (柴油)	中型柴油巴士
中型汽油车 (MDGV)	MDT (汽油)	中型汽油卡车
	MDB (汽油)	中型汽油巴士
轻型柴油车(LDDV)	LDT (柴油)	轻型柴油卡车
	MT (柴油)	微型柴油卡车
	LDB (柴油)	轻型柴油巴士
	MB (柴油)	微型柴油巴士
	Lcar (柴油)	大型柴油轿车
	Scar (柴油)	小型柴油轿车
轻型汽油车 (LDGV)	LDT (汽油)	轻型汽油卡车
	MT (汽油)	微型汽油卡车
	LDB (汽油)	轻型汽油巴士
	MB (汽油)	微型汽油巴士
	Lcar (汽油)	大型汽油轿车
	Scar (汽油)	小型汽油轿车
摩托车 (MC)	MC (汽油)	汽油摩托车
低速汽车(RV)	RV (柴油)	柴油低速汽车

对于轻型，中型以及重型车，基于逐步提高的欧洲标准共分九种不同的排放水平[135]。表AB3是对轻型汽油车排放因子设置的一个示例。其中，“无管理”类是指没有采用任何排放控制措施的机动车的排放率。“发动机改良（Engine Mods）”类体现了国I 标准之前发动机技术带来的改善。针对轻型车，“超低排放车” 类是按照最理想情况预测的欧7标准。超低排放车中HC，CO和NOx 的数据源自EMFAC2007，代表了加州典型的2010年型乘用车的水平。PM，N_2O，CH_4和 BC的数据是在欧6数据的基础上简单的减半得到的。对中重型车而言，欧VI标准的数值是每种污染物在欧VI的基础上减半得到的。低速汽车只有两种排放分类：分别是三轮和四轮低速汽车的排放水平。评价分析中低速汽车排放因子是基于清华大学环境科学与工程学院贺克斌教授研究团队提供的数据，包括HC，CO， NOx，PM (其中认为颗粒物中90%为BC)。

135 与世界上许多国家类似，中国选择了参照欧盟制定的机动车和燃料标准的路线。从而，中国的机动车排放控制和燃料质量控制都是以欧洲标准作为蓝本的。轻型和重型车的排放阶段分别用阿拉伯数字和罗马数字进行标注。标准严格程度的加深由数值的增加来表示。

Table AB2: Vehicle groupings for emission factor modeling

EMISSION FACTOR GROUP	SPECIFIC VEHICLES INCLUDED	
Heavy-duty diesel vehicle (HDDV)	HDT (diesel)	Heavy-duty diesel truck
	HDB (diesel)	Heavy-duty diesel bus
Heavy-duty gas vehicle (HDGV)	HDT (gas)	Heavy-duty gas truck
	HDB (gas)	Heavy-duty gas bus
Medium-duty diesel vehicle (MDDV)	MDT (diesel)	Medium-duty diesel truck
	MDB (diesel)	Medium-duty diesel bus
Medium-duty gas vehicle (MDGV)	MDT (gas)	Medium-duty gas truck
	MDB (gas)	Medium-duty gas bus
Light-duty diesel vehicle (LDDV)	LDT (diesel)	Light-duty diesel truck
	MT (diesel)	Mini diesel truck
	LDB (diesel)	Light-duty diesel bus
	MB (diesel)	Mini diesel bus
	Lcar (diesel)	Large diesel car
	Scar (diesel)	Small diesel car
Light-duty gas vehicle (LDGV)	LDT (gas)	Light-duty gas truck
	MT (gas)	Mini gas truck
	LDB (gas)	Light-duty gas bus
	MB (gas)	Mini gas bus
	Lcar (gas)	Large gas car
	Scar (gas)	Small gas car
Motorcycle (MC)	MC (gas)	Gas motorcycle
Rural vehicle (RV)	RV (diesel)	Diesel rural vehicle

For light-, medium- and heavy-duty vehicles, there are nine different emission levels based on a progression through the 'Euro'standards[135]. Table AB3 is an example emission factor set for light-duty gasoline vehicles. The "Uncontrolled" level represents emission rates from a vehicle without any emission control systems in place, and "Engine Mods" category characterizes advances in engine technology that preceded the China I standard. For light-duty vehicles, the "SULEV" category is the best guess for 'Euro 7' levels. For HC, CO, and NOx, the Super Low Emission Vehicle (SULEV) values are derived from EMFAC2007 and represent a typical model year 2010 passenger car in California. Values for PM, N_2O, and CH_4, and BC are simply half of the Euro 6 values. For medium- and heavy-duty vehicles, Euro VII values for every pollutant are estimated as being half of Euro VI values. Rural vehicles only have two emission levels: one each for 3- and 4-wheeled vehicles. The rural vehicle emission factor set used in the Retrospective analysis is based on data from Prof. He Kebin's research group at the Department of Environmental Science and Engineering at Tsinghua University and includes HC, CO, NO_x, PM (and BC is estimate to be 90% of the PM value).

135 Like many countries around the world, China has chosen to mirror its vehicle and fuels programs after those set forth by the European Commission. As such, the 'Euro' standards are the blueprint for the 'China' vehicle emission limits and fuel quality guidelines. The Arabic numerals and Roman numerals denote standards for light- and heavy-duty vehicles respectively. Increasing number values imply greater stringency of the standard.

表AB3: 轻型汽油车排放因子(g/km)

	无管理	发动机改良	国 I	国 II	国 III	国IV	国 V	国VI	“超低排放车”
THC	8.373	4.174	1.203	0.620	0.364	0.182	0.182	0.182	0.036
CO	59.533	37.253	13.736	11.124	7.800	3.391	3.391	3.391	0.469
NOx	2.137	2.701	0.975	0.498	0.599	0.159	0.119	0.119	0.029
PM	0.186	0.186	0.025	0.025	0.012	0.001	0.001	0.001	0.000
N2O	0.010	0.010	0.032	0.051	0.029	0.018	0.018	0.018	0.009
CH4	0.135	0.120	0.070	0.030	0.040	0.025	0.025	0.025	0.013
BC	0.112	0.112	0.015	0.015	0.006	0.000	0.000	0.000	0.000

每个机动车排放量工作表在2000-2030年间，以5年为间隔选取目标年，对其排放量进行评估。对每个目标年来说，计算其排放量用到的每个模型年（MY）都会得到“输入”表格赋予一个排放标准的阶段。举例来说，由于2005年全国范围实施国II阶段标准，2007年全国范围实施国III阶段标准，模型会赋予模型年MY2005和MY2006国II的排放因子，赋予模型年MY2007国III的排放因子。

所有的机动车排放量工作表都具有相同的组织架构。图AB1显示了数据和计算的流程。

Table AB3: Emission factors (g/km) for a light-duty gasoline vehicle

	UNCONTROLLED	ENGINE MODS	CHINA I	CHINA II	CHINA III	CHINA IV	CHINA V	CHINA VI	"SULEV"
THC	8.373	4.174	1.203	0.620	0.364	0.182	0.182	0.182	0.036
CO	59.533	37.253	13.736	11.124	7.800	3.391	3.391	3.391	0.469
NOx	2.137	2.701	0.975	0.498	0.599	0.159	0.119	0.119	0.029
PM	0.186	0.186	0.025	0.025	0.012	0.001	0.001	0.001	0.000
N2O	0.010	0.010	0.032	0.051	0.029	0.018	0.018	0.018	0.009
CH4	0.135	0.120	0.070	0.030	0.040	0.025	0.025	0.025	0.013
BC	0.112	0.112	0.015	0.015	0.006	0.000	0.000	0.000	0.000

Each vehicle emissions worksheet estimates emissions at five-year intervals between 2000 and 2030. For each year, every model year (MY) is assigned an emission level based on controls on the 'Inputs' sheet. For example, since China II was adopted nationwide in 2005 and China III in 2007, the model assigns China II emission factors to MY 2005 and MY 2006 vehicles and China III emission factors to MY 2007 vehicles.

All of vehicle emission sheets are structured identically, and the flow of data and calculations is shown below in Figure AB1.

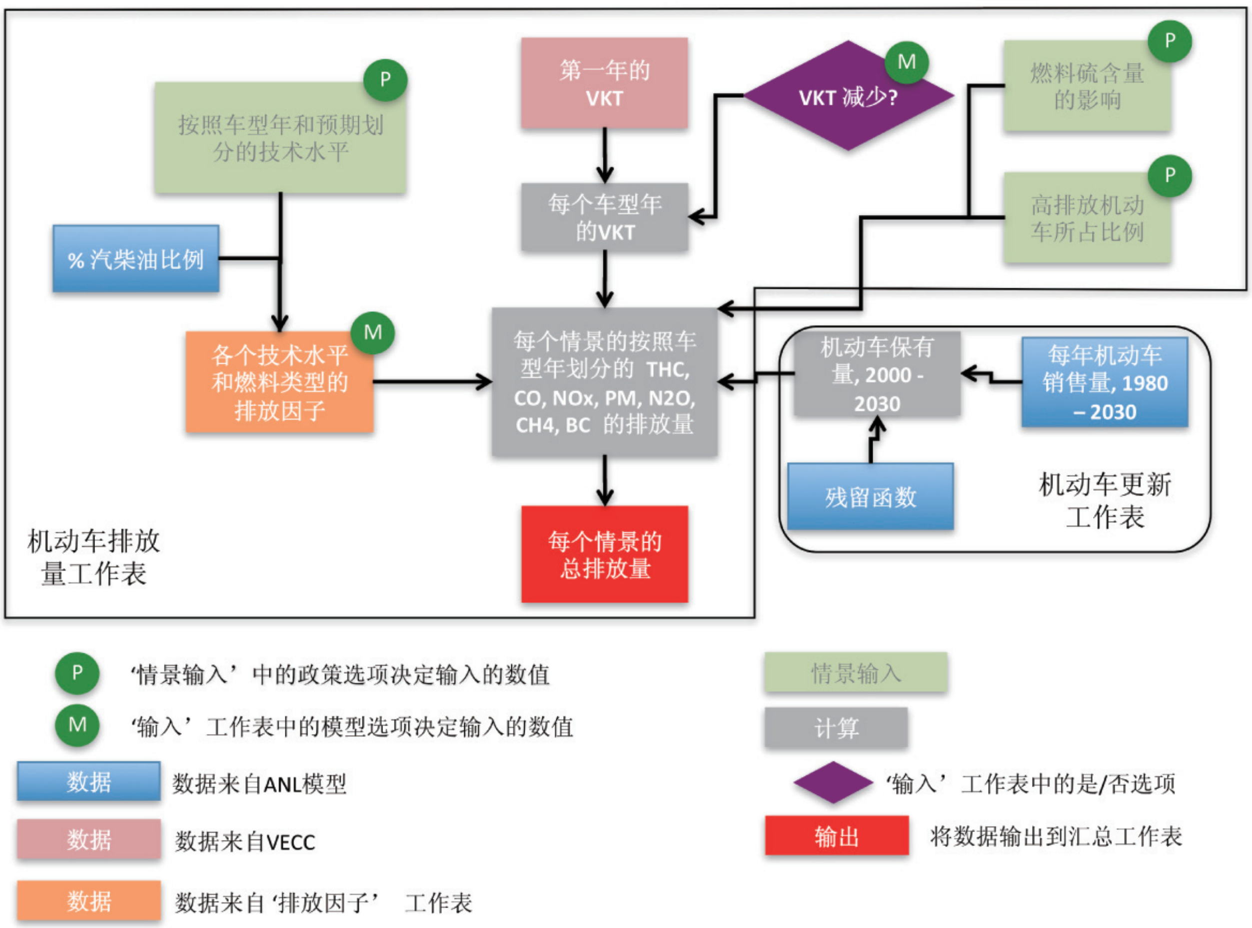

图 AB1: 排放量工作表流程图

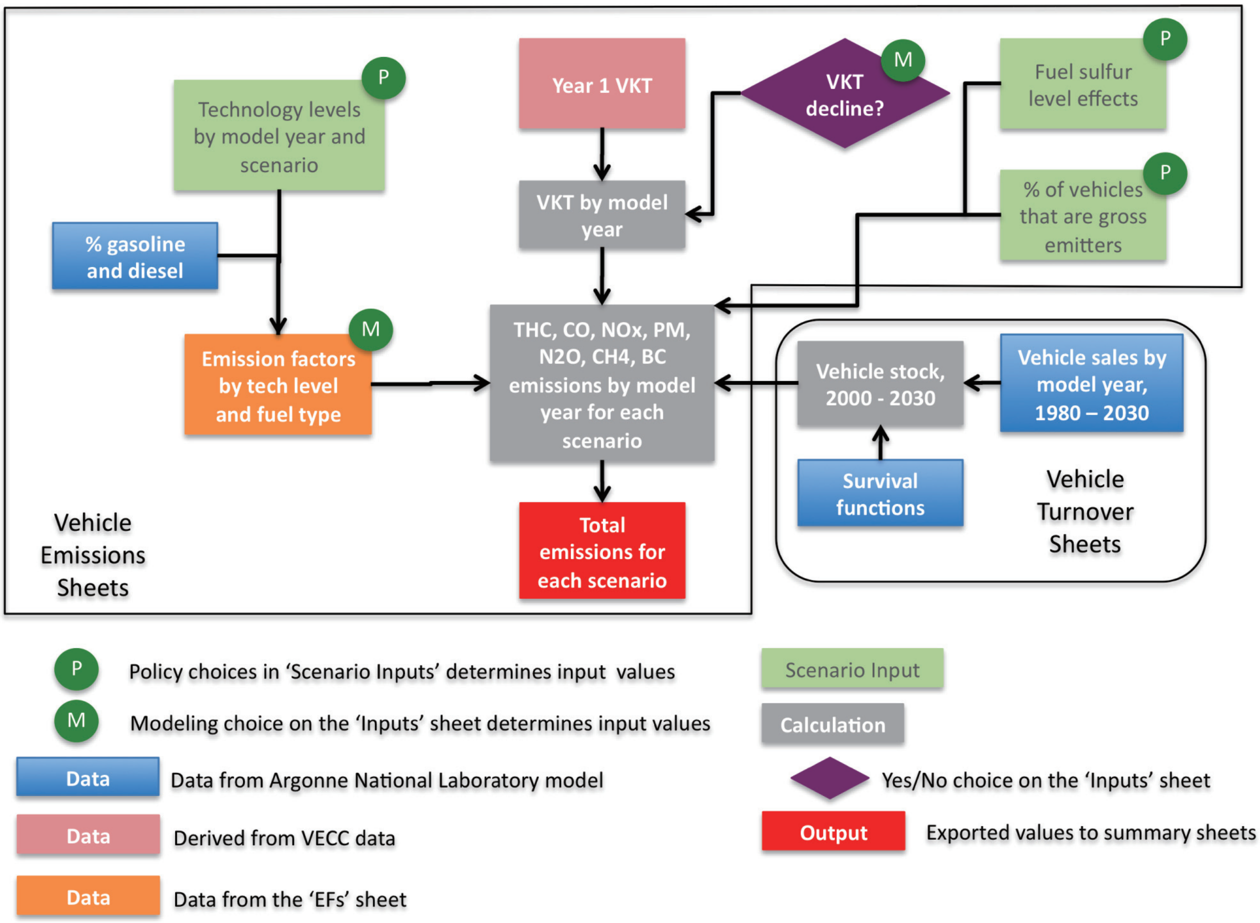

Figure AB1: Flow diagram for vehicle emissions sheets

如上图所示，除排放因子之外，排放量计算还需要另外4个输入项。

1. VKT （车辆行驶里程）– 每个模型年的年行驶里程是基于VECC的2007年行驶里程数值得到的。2007年以外其他模型年的行驶里程采用以2007年为基准，乘以霍红博士模型（即ANL 模型）[136] 中目标年与2007年VKT比例的方法得到。例如：

- VECC 2007 VKT = 10,000 km
- ANL 2007 VKT = 11,000 km
- ANL 2010 VKT = 12,000 km
- CFM 2010 VKT = 10,000 * (12,000/11,000) = 10,909 km

用户可以选择是否使VKT随着车龄的增加而减少。通常来说，一辆车的VKT会随着他的生命周期而减少。目前ICCT团队尚且没有开发出适合中国机动车的VKT的衰减曲线。如果用户选择VKT会衰减（评价研究中选择VKT会衰减），VKT会按照下面所给的2001年EPA的报告[137]的公式进行衰减。

VKTt = VKT1 * (exp ^ (α * t)) (公式 2)

其中 VKTt = t年的VKT

VKT1 =第一年的 VKT

α = VKT衰减因子 (用户可以调节这个数值)

t =车龄

2. 硫含量影响–目前燃料中硫含量对于排放水平有着一定影响。为了评价硫含量对于中国汽柴油车排放的影响程度，引用了刘欢等人[138] 2008年发表论文中表 2和表 3。下表是以氮氧化物为例介绍数据是如何组织起来的。

表AB4: 汽油车氮氧化物排放变化的百分比

硫含量	国 I	国II	国III	国 IV	国 V
800 ppm	100.0%	108.4%	129.1%	257.2%	257.2%
500 ppm	98.6%	100.0%	122.5%	207.9%	207.9%
150 ppm	95.0%	89.6%	100.0%	136.4%	136.4%
50 ppm	91.7%	86.0%	93.7%	100.0%	100.0%
10 ppm	86.8%	63.3%	88.6%	88.3%	88.3%

3. 机动车保有量 – 机动车现存量函数直接采用了ANL模型中相应部分。对每种车型（不包括低速汽车）都有三种关于现存量的设置： 1)车型年1997之前, 2) 车型年1997-2020，以及 3)车型年2020以后。

4. 高排放车辆 –研究表明车队中一小部分高排放车贡献了很大部分的排放量[139]。 在“输入”工作表中，用户可以自行定义车队中高排放车（即在任意车型年，其排放因子为“无管理”类的车）的比例。对高排放车辆比例的选择是用来模拟相关政策的管理和实施情况的。政策越有效，车队中高排放车辆的数量越少。

136 报告采用了霍红博士在美国阿贡国家实验室建立的模型，“2050年中国机动车增长，燃料需求量，CO_2排放量的预测（Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions through 2050）”。

137 Jackson, T. 2001. MOBILE6的车队特征数据: MOBILE6中使用的车龄分类的开发与使用，平均年行驶里程累积速率，以及机动车保有量统计的设计。美国国家环境保护局。

138 刘欢，贺克斌等人2008年发表的"燃料硫含量对中国机动车排放影响分析（Analysis of the impacts of fuel sulfur on vehicle emissions in China）." Fuel。Vol. 87(13-14): 3147-3154。

139 Niemeier, D., K. Shafizadeh, 等. 2004.高排放车辆: 文献综述。加州大学戴维斯分校-加州交通局空气质量计划。城市与环境工程学部, 加州大学戴维斯分校。

Looking at the diagram, in addition to emission factors, there are four inputs that go into the emissions calculations.

1. VKT – For each MY, the VKT in year one is based on the VECC VKT value for 2007. To estimate the year one VKT for all non-2007 MYs, back- and forecasting is done by taking ratios of the year one VKT values from Dr. Hong Huo's model (henceforth referred to as the ANL model)[136]. For example,

- VECC 2007 VKT = 10,000 km
- NL 2007 VKT = 11,000 km
- NL 2010 VKT = 12,000 km
- CFM 2010 VKT = 10,000 * (12,000/11,000) = 10,909 km

The user can decide whether or not VKT diminishes as a vehicle ages. Typically, a vehicle's VKT will decline over its lifetime; however, the ICCT team was unable to find VKT degradation curves for Chinese vehicles. If the user chooses VKT decline (as was done for the Retrospective analysis), VKT is given by the following equation, which is based on the EPA's 2001 report[137].

$$VKTt = VKT1 * (\exp \wedge (\alpha * t)) \quad \text{(Equation 2)}$$

where VKTt = VKT in year t

VKT1 = VKT in year 1

α = VKT decline factor (user may control value)

t = vehicle age in years

2. Fuel sulfur effects – The sulfur levels present in fuels have an effect on emission levels. To estimate how sulfur levels in gasoline and diesel affect vehicles in China, Tables 2 and 3 of Liu et al.'s 2008 paper are used[138]. An example of how this data is organized is shown in the table below.

Table AB4: Percent changes in NOx emissions in gasoline vehicles

SULFUR LEVEL	CHINA I	CHINA II	CHINA III	CHINA IV	CHINA V
800 ppm	100.0%	108.4%	129.1%	257.2%	257.2%
500 ppm	98.6%	100.0%	122.5%	207.9%	207.9%
150 ppm	95.0%	89.6%	100.0%	136.4%	136.4%
50 ppm	91.7%	86.0%	93.7%	100.0%	100.0%
10 ppm	86.8%	63.3%	88.6%	88.3%	88.3%

3. Vehicle stock (population) – vehicle survival functions are taken directly from the ANL model. There are three sets of survival assumptions for each vehicle type (excluding rural vehicles): 1) pre MY1997, 2) MY1997-MY2020, and 3) post MY2020.

4. Gross emitters – Studies have shown that a relatively small portion of the fleet contributes to a large percentage of the emissions[139]. On the 'Inputs' sheet, the user can control the percent of the fleet that are gross emitters (assumed to have the emission factors of an 'uncontrolled' vehicle regardless of model year). This gross emitters control is meant to model the effects of a compliance and enforcement program. The more effective the program is, the fewer gross emitters there are in the fleet.

136 Dr. Hong Huo created a model while at Argonne National Laboratory in support of the report, "Projection of Chinese Motor Vehicle Growth, Oil Demand, and CO_2 Emissions through 2050".

137 Jackson, T. 2001. Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE6, U.S. Environmental Protection Agency.

138 Liu, H., K. He, et al. 2008. "Analysis of the impacts of fuel sulfur on vehicle emissions in China." Fuel . Vol. 87(13-14): 3147-3154.

139 Niemeier, D., K. Shafizadeh, et al. 2004. Gross Emitting Vehicles: A Review of the Literature. UC Davis-Caltrans Air Quality Project. Davis, CA, Department of Civil and Environmental Engineering, Univ. of California Davis.

由于缺少销售量、更新率和详细的排放因子数据，低速汽车的计算方法论与其它的车辆类型不同。每年的保有量数据直接采用ANL模型的数据，然后乘以VKT（同样采用ANL模型的数据）以及由清华大学贺克斌教授研究团队开发的排放因子。

燃料消耗量和二氧化碳排放量

与机动车排放量工作表相比，燃料消耗模块就简单很多，所有的计算都囊括在一个工作表中。

图AB2是相关方法学的流程图。

1. 2010年基准燃料经济性即每升燃料行驶的公里数的数值是直接从ANL模型中选取的。在每一种情景下，用户都可以在燃料经济性“输入表”中输入每年燃料经济性增加的百分比。在评价分析中，基准燃料经济性年改善的百分比(2%)模拟了中国I，II， III阶段燃料经济性法规对轻型车的效果。在改善和强化情景中设定的3%和4%的年改善率是基于混合动力和高能效汽车的市场占有率不断增加的假设上的。重型车的基准值为1%，反应了没有相关的燃料经济性管理措施的假设。美国历史上中重型车的燃料经济性每年的改善比例大概为1%。改善情景中设定了到从2015年到2030的改善率为20%，也就是燃料经济性每年的改善率为1.2%。同样的时间段内，强化情景设定了50%的总体改善率，相当于每年的改善比例为2.7%。ICCT团队认为如果目前正在发展中的重型车燃料消耗限值可以促进重型车采用更先进的空气动力学设计，低滚动阻力的轮胎以及先进的发动机技术，从而推进燃料经济性的改善。

2. 不同燃料类型的各个机动车型的总 VKT采用机动车排放量工作表中的数据。

3. 汽柴油的密度 (kg/L)和燃料CO_2强度因子选自ANL模型。

Due a lack of sales, turnover, and detailed emission factor data, the calculation methodology for rural vehicles differs from the other vehicle types. Population values for each calendar year are taken directly from the ANL model and multiplied by VKT values (also from the ANL model) and emission factors, which were developed by Prof. He Kebin's research group at Tsinghua University.

Fuel Consumption and Carbon Dioxide Emissions

Compared to the vehicle emissions sheets, the fuel consumption module is much simpler, and all of the calculations are contained in one worksheet. Figure AB2 is a flow diagram of the methodology.

1. The baseline kilometer per liter fuel economy (FE) values for 2010 are taken directly from the ANL model. For each scenario, the user may input the annual percentage improvement in FE on the 'Inputs' sheet. For the Retrospective analysis, the baseline FE percent (2%) models the effect that the Phase I, II, and III FE regulations in China have had on the light-duty fleet. The annual percent improvements for the Improved and Strong programs—3% and 4% respectively—assume that there is increased penetration of hybrid and high efficiency vehicles. For heavy-duty vehicles, the baseline value (1%) assumes that there is no FE regulation. In the US, fuel efficiencies of medium- and heavy-duty vehicles have historically shown roughly 1% annual improvements. The 20% improvement by 2030 (starting in 2015) of the Improved Program translates to a 1.2% annual increase in FE. Over this same timeframe, the Strong's Program's 50% improvement is equivalent to a 2.7% annual increase. The ICCT team assumed that increased adoption of advanced aerodynamics, lower rolling resistance tires, and improved engine technologies induced by HDV fuel consumption limits being currently developed would account for FE progress.

2. Total VKT by vehicle category and fuel type comes from the vehicle emissions sheets.

3. The density (kg/liter) values and CO_2 intensity factors for gasoline and diesel come directly from the ANL model.

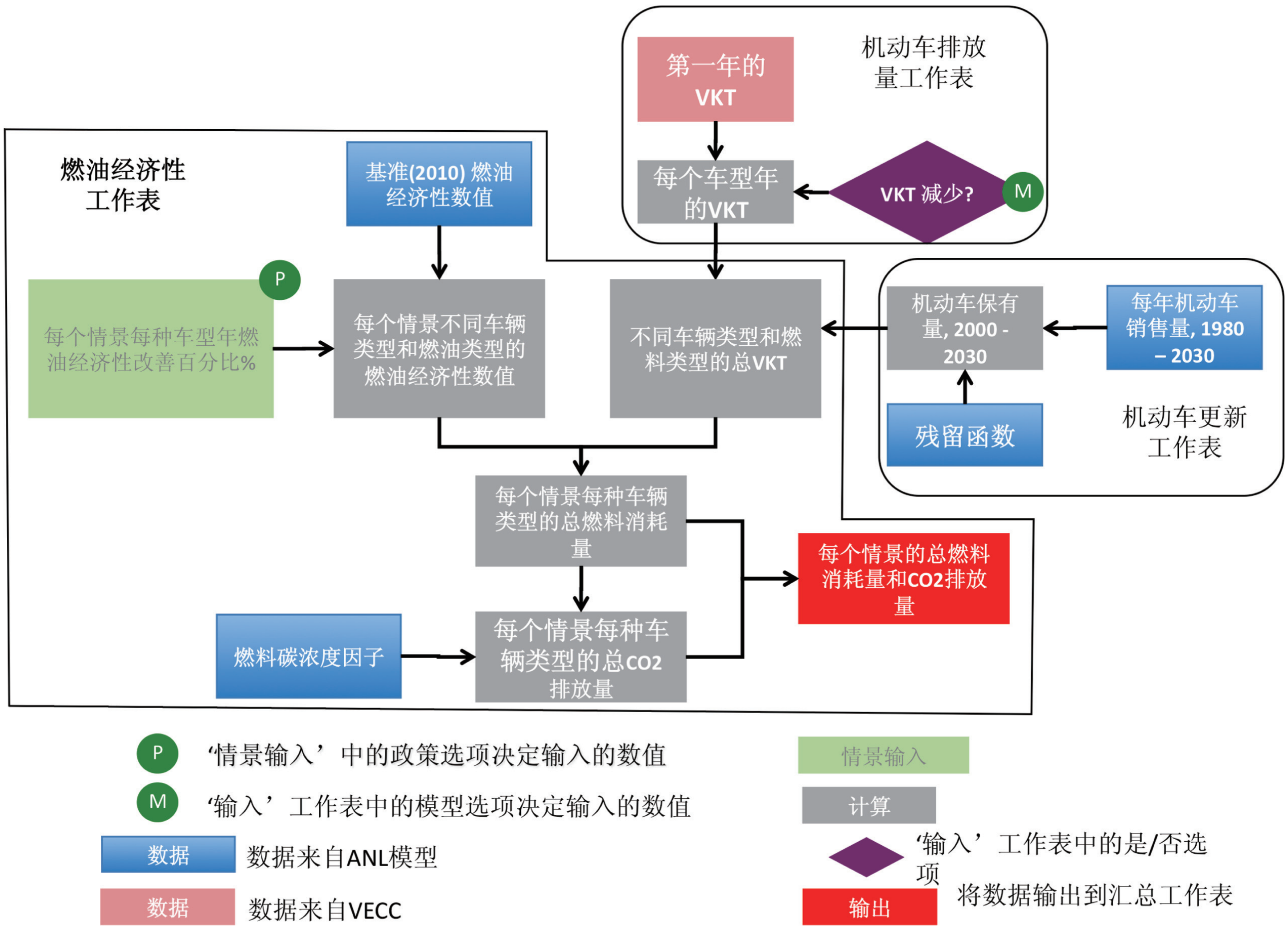

图 AB2: 燃料消耗和CO_2排放量工作表流程图

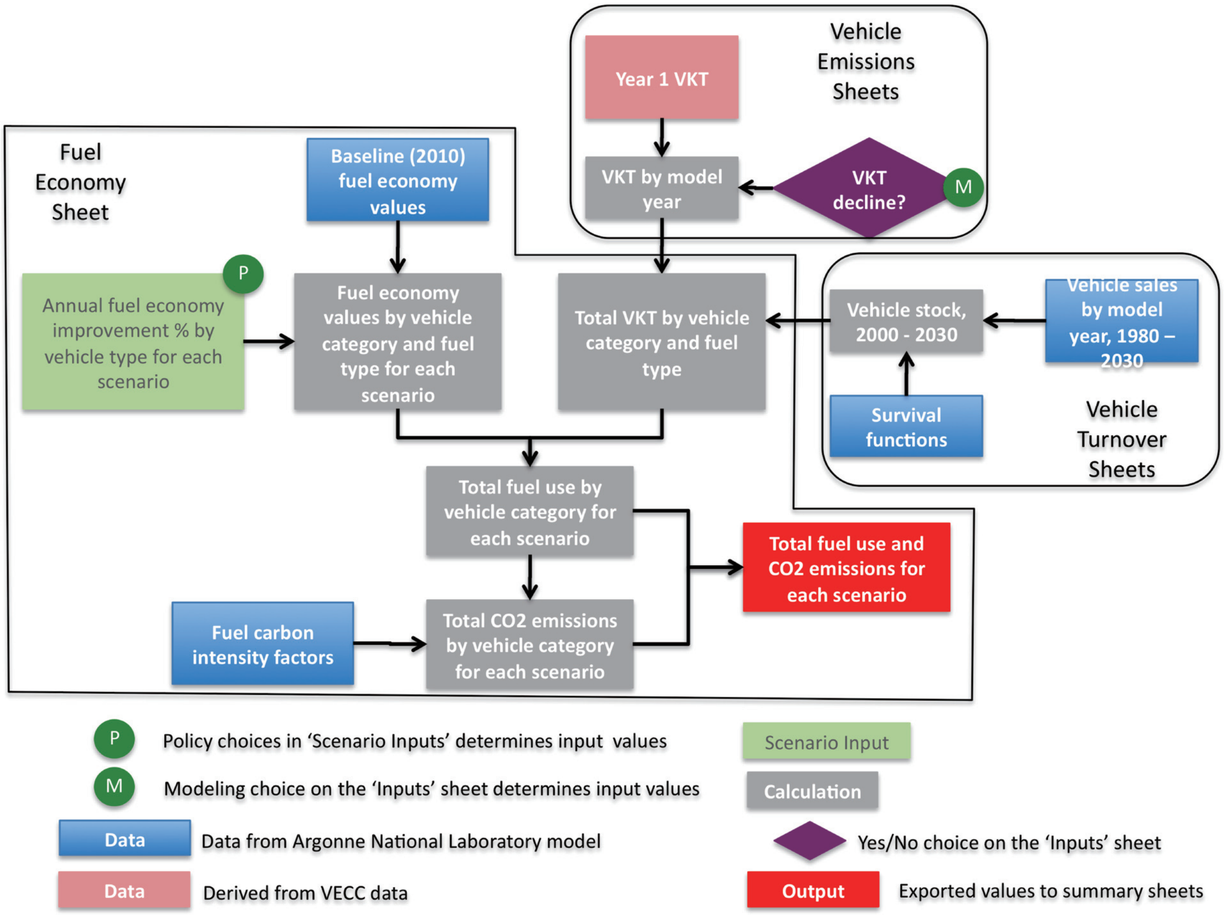

Figure AB2: Flow diagram for the fuel consumption and CO_2 emissions sheet

电动汽车

在CFM模型中，只在轻型车改善和加强情景中会有电动汽车(EV)的市场推广假设，所有情景都没有考虑电动自行车的年销售量增加；但用户可以在“输入”工作表中调整2010年以后电动自行车的增长比例。评价研究中，基于历史数据和ICCT对于未来情况的最佳预测，将电动自行车的增长率设置为4%。轻型车方面，基于ICCT团队的判断和清华大学的欧阳明高教授[140] 的演讲得到了电动车推广比例（见表AB5）。

表 AB5:轻型电动汽车所占的新车销售比例

情景	2010	2015	2020	2025	2030
现行管理	0%	0%	0%	0%	0%
改善方案	0%	0.5%	1%	3%	5%
强化方案	0%	1%	4%	7%	10%

为了计算电动汽车生命周期的上游（如发电厂）排放量，我们评估了各个车型每公里的平均耗能(kWh)，并且使用了Cherry等[141]文中的电厂平均单位能耗排放因子（克/千瓦时）(CO，NOx，PM，HC，CO_2)数据。电动汽车模块的工作流程如图AB3所示。

注:基于电动汽车行驶范围和充电的限制，ICCT团队设置电动汽车的VKT为传统燃料汽车的70%。

140 欧阳明高. 2009.中国电动汽车的发展FISITA 世界机动车高级会议. Falkenstein, 德国。

141 Cherry, C., J. Weinert等人 2009. "中国电动自行车的环境影响." 交通运输研究部分 Part D: 交通与环境.卷. 14(5): 281-290。

Electric Vehicles

In the CFM, all electric vehicle (EV) market penetration is assumed to happen in the Improved and Strong scenarios for the light-duty sector only. Annual sales growth in electric bikes is not included in any scenarios; however, the user may control the percent growth rate beyond 2010 on the 'Inputs' sheets. For the Retrospective analysis, this e-bike growth rate was set to 4% based on historical data and the ICCT's best estimates for the future. For light-duty vehicles, the electric vehicle adoption rates (see Table AB5) are based on the judgment of the ICCT team and a presentation given by Prof. Ouyang Minggao of Tsinghua University[140].

Table AB5: Light-duty electric vehicles – percent of new vehicle sales

SCENARIO	2010	2015	2020	2025	2030
Business as Usual	0%	0%	0%	0%	0%
Improved Program	0%	0.5%	1%	3%	5%
Strong Program	0%	1%	4%	7%	10%

To calculate the upstream (i.e. power plant) emissions associated with electric vehicles, the team estimated the average energy (kWh) use per kilometer for each vehicle type and used average gram/kWh emission factors (CO, NOx, PM, HC, and CO_2) for the power sector, which are taken from Cherry et al[141]. The functionality of the electric vehicle module is shown in Figure AB3.

Note: based on the range and charging limitations of electric vehicles, the ICCT team estimates that an EV has 70% of the VKT of a conventional vehide.

140 Ouyang, M. 2009. Development of Electric Vehicles in China. FISITA World Automotive Summit. Falkenstein, Germany.

141 Cherry, C., J. Weinert, et al. 2009. "Comparative environmental impacts of electric bikes in China". Transportation Research Part D: Transport and Environment. Vol. 14(5): 281-290.

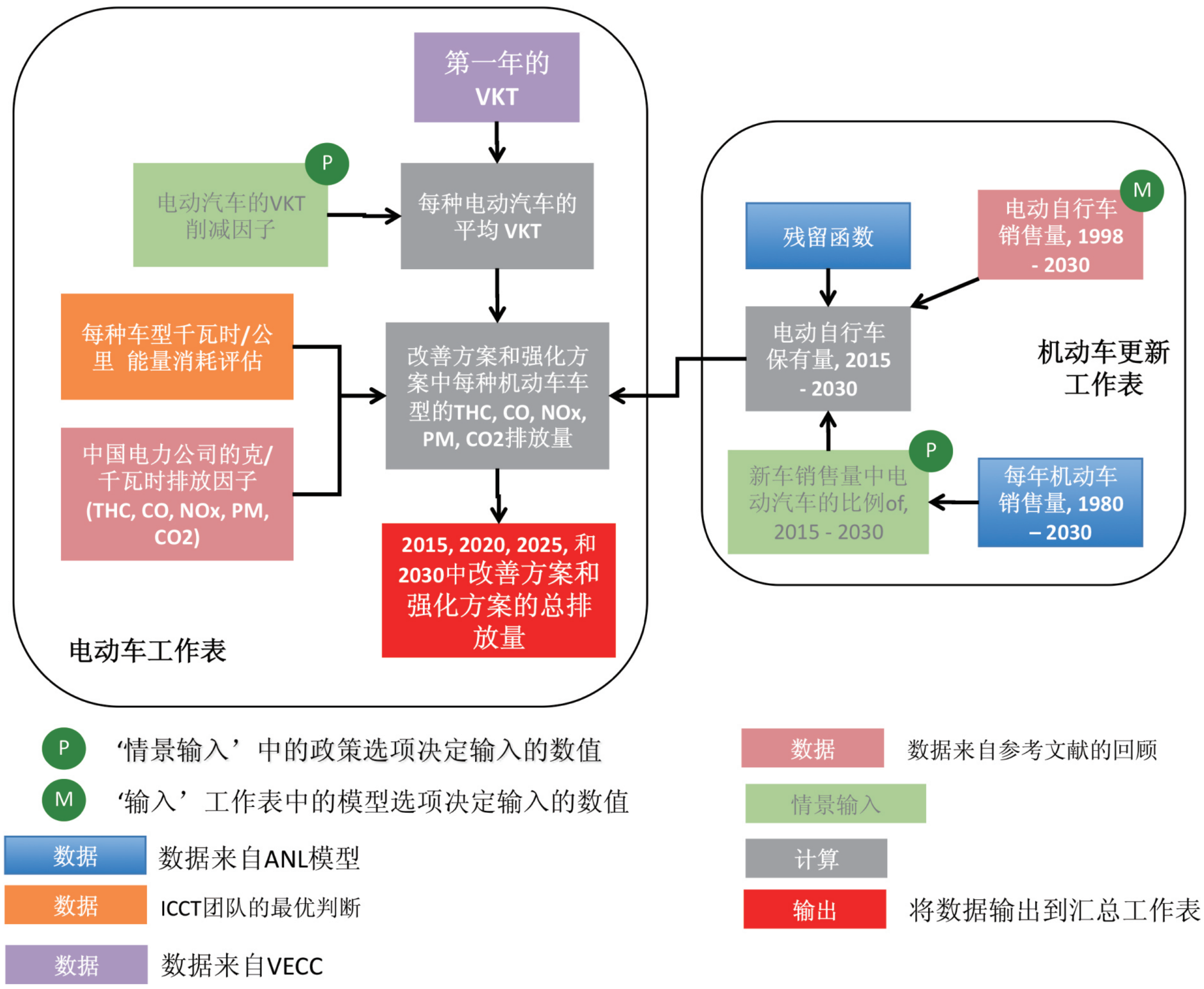

图 AB3: 电动车工作表流程图

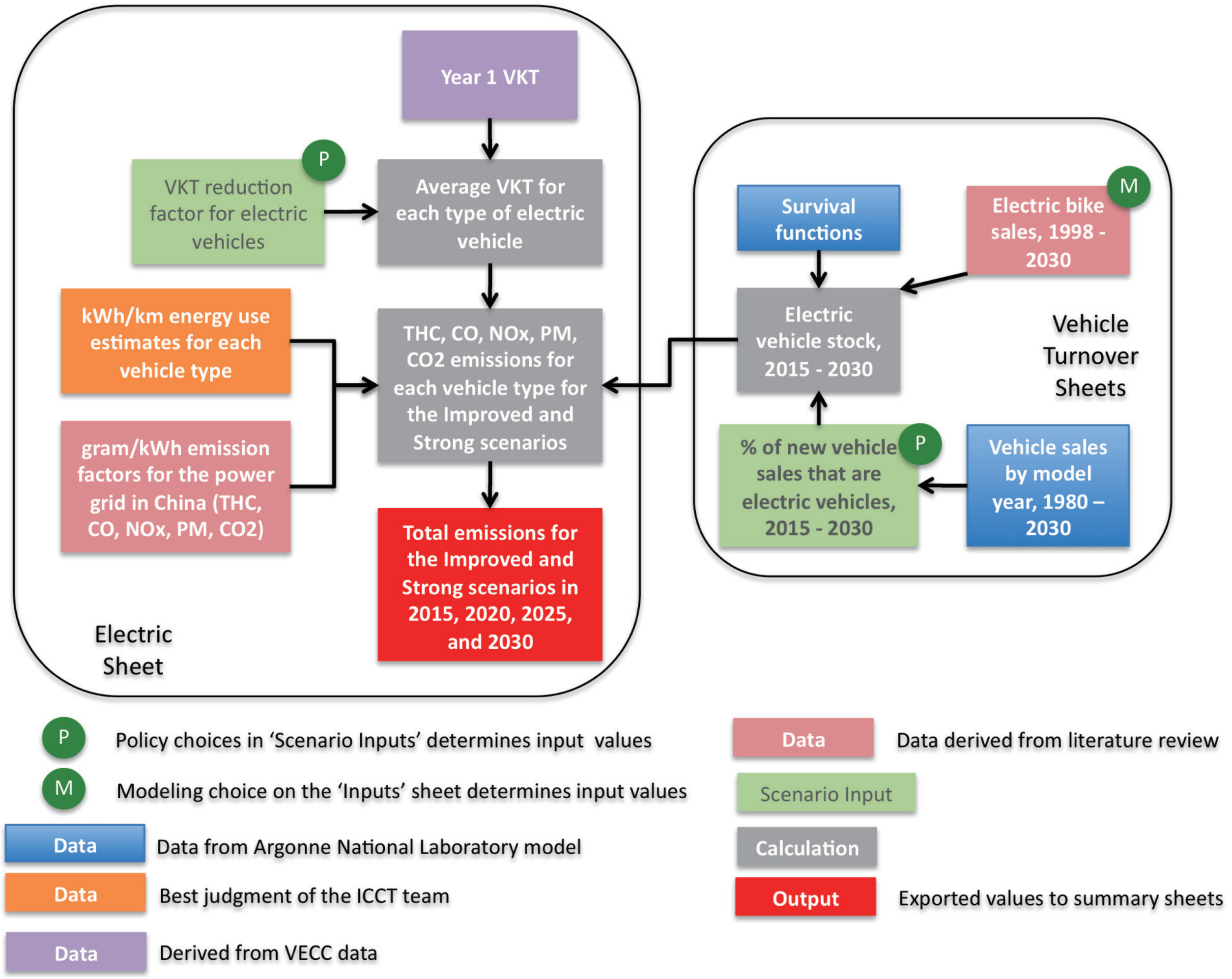

Figure AB3: Flow diagram for the electric vehicle shee

排放控制设备的成本

CFM模型评估了与“无管理”类车辆相比采用排放控制的装置和发动机技术的成本。Michael Walsh开发了成本评估部分，其中包括了基于“欧洲”排放标准的推进的成本的增加(即 Euro 1/I, 2/II,…,6/VI)。其中没有考虑通货膨胀的因素，也没有考虑中国市场的特殊的技术和成本。

B.2健康影响评估

为了评估中国燃料硫含量降低的影响，在2005年和2006年首次开发了健康影响评估 (HIA)的工具。ICCT与清华大学联合研究了中国燃料硫含量削减的成本和效益（2006）。通过引入近期研究中的多个变量对该工具进行了升级。此外，为了确保此次研究对中国机动车健康影响的潜力提出一个低端的评估，在此次研究中尽可能的采用了比较保守的数据。大部分的方法论论述都是源自2006年的研究。

此次分析对直接颗粒物排放和由氮氧化物排放造成的大气中二次颗粒物排放（减排）的效益进行了量化分析。但对以下的额外影响没有进行量化分析：

■ 中国臭氧暴露量的减少——很难量化分析，但可能效益相对明显，这是因为中国臭氧排放水平高并还在不断增加；

■ 农业的效益——农业的效益在中国可能比在欧洲和美国更大，一部分是因为死亡率和发病率的影响在中国被赋予的价值较低，以及农业在中国所有经济中的重要地位；

■ 对能见度，旅游业以及环境和实物损失方面损害的削减——这方面的效益可能也比较大，因为旅游业日趋重要，和古建筑工艺品的易损性。

通过最近美国和欧洲的管理评价，包括《欧洲对大气污染的主要策略的影响评价》及美国EPA对燃料和机动车近期出台的三项法规，发现这些附带的效益大概可以增加净效益值的2-3%。

暴露量分析

分析计算了可以在大气中形成颗粒物的颗粒物和氮氧化物排放。分析选取了59个最大的城市 (基于2002 人口数据)。由于城市中污染源和人类受体的高度集中，城市人口通常可以从机动车排放削减中获得更多的效益。由于颗粒物的大气化学性质相对的明确，所以有可能通过使用一个缩放比例——称作吸入因子——来估计每个城市区域中造成人体直接暴露的那部分排放。我们对所研究的城市区域及国内其余的城市进行了颗粒物暴露的评价以及效益的量化。

吸入因子(iF)的方法应用于评价所有移动源的排放在特定城市区域实际被人群吸入的部分。无量纲的吸入因子数值是吸入的污染物与污染物排放总量的比值，又被称为暴露效率。因此，吸入因子揭示了排放量和暴露量的关系，这个关系可以用来将暴露或者浓度反应与各种健康影响进行关联，来对减排的健康效益进行量化。吸入因子的定义如下：

$$\text{吸入因子} = \frac{\text{人群吸入量}}{\text{总排放量}} \quad (\text{公式3})$$

Costs of Emission Control Equipment

The CFM estimates the costs of emission control devices and engine technology compared to an 'uncontrolled' vehicle. The costs were developed by Michael Walsh, and there are incremental cost deltas based on the 'Euro' emission standard progression (i.e. Euro 1/I, 2/II,…,6/VI). The values do not account for inflation and are not specific to the technologies and costs in the Chinese market.

B.2 Health Impacts Assessment

The Health Impacts Assessment (HIA) tool was first developed in 2005 and 2006 in order to assess the impacts of reduced sulfur fuels in China. The Costs and Benefits of Reduced Sulfur Fuels in China (2006) was collaboration between ICCT and Tsinghua University. The tool was updated with variables drawn from more recent research. In addition, wherever possible, more conservative values were chosen for this analysis, in order to ensure that this study provides a low-end estimate of the potential impacts of vehicles in China. Much of the methodology description below was drawn from the 2006 study.

This analysis quantifies the benefits that would result only from direct particulate matter emissions and secondary particle formation in the atmosphere from NOx emissions. It does not quantify the following additional impacts:

■ Reduced exposure to ozone in China—difficult to quantify but may be relatively significant, due to high and increasing ozone levels;

■ Benefits to agriculture—may be more significant in China than in Europe or the US, partly due to the lower values placed on mortality and morbidity impacts, and to the importance of agriculture to China's overall economy;

■ Reduced impairments in visibility, tourism, and environmental & material damage—may also be significant, due to the growing importance of the tourism industry and the fragility of ancient buildings and artifacts.

Recent regulatory assessments in the United States and Europe, including the European Impact Assessment of the Thematic Strategy on Air Pollution and the three recent U.S. EPA regulations on fuels and vehicles, suggest these added benefits would add approximately 2–3 percent to the net value of benefits.

Exposure analysis

This analysis accounts for emissions of PM and of NOx, which forms PM in the atmosphere. The analysis focuses on the 59 largest cities in China (based upon 2002 population data). Urban populations generally benefit more from vehicle emissions reductions because of the high concentration of both sources and human receptors in cities. Because the atmospheric chemistry of PM is relatively straightforward, it is possible to use a scaling factor—called an intake fraction—to estimate the portion of emissions that would result in direct human exposure within each urban area. PM exposure is estimated and benefits quantified for each of the urban areas studied as well as for the rest of the country.

An intake fraction (iF) approach is used to estimate the portion of overall mobile source emissions actually inhaled by people within a given urban area. Also known as exposure efficiency, the dimensionless iF number is a ratio of the amount of pollutant inhaled to the amount of pollutant emitted. As such, it describes an emissions-to-exposure relationship that can be used in conjunction with exposure- or concentration-response relationships for various health endpoints to quantify the health benefits of reducing emissions. Specifically, the intake fraction is defined as:

$$iF = \frac{Population\ Intake}{Total\ Emissions} \quad \text{(Equation 3)}$$

吸入因子的估计方法既可以简单也可以复杂。Evans 等人 (2002) 所描述的暴露效率，或称吸入因子，是设置完善的环境健康政策的重要工具[142]。

此次分析中，59个城市中每个城市的吸入因子的评价是通过一个简单的单格箱模型得到的。计算吸入因子所需的城市人口和区域如表AB6所示。由于收集和核实有详细人口的区域面积的数据需要一个长时间的过程，所以ICCT在此再次使用了2006年研究中的数据。为了确保这一假设不会有太大偏差，对几个城市的人口清单进行核实，确认了变化很小，并且不会对分析结果造成重要影响。遗憾的是城市区域边界的界定是一个难以确定的部分 (可以通过差别很大的人口密度看出)，但是ICCT发现吸入因子的结果跟其它类似的比较分析比很接近或者更趋于保守，如下表所示。

142 Evans, J. S. 等 2002. 暴露效率： 一个时机成熟的想法?"Exposure efficiency: an idea whose time has come?" Chemosphere 49:1075-1091. 这篇文章对已发表的吸入因子进行了综述，本研究中对农业和二次颗粒物吸入因子的部分很大程度上借鉴了该文献综述的信息。

Estimations of intake fractions can range from simple to complex. Evans et al. (2002) described exposure efficiency, or intake fraction, as an important tool in setting sound environmental health policy[142].

In this analysis, a simple one-compartment box model is used to derive estimated intake fractions for each of the 59 cities. City populations and areas needed to derive the intake fraction are included in Table AB6. Because collecting and verifying the district area data that could be assigned to a particular population was a time-intensive process, ICCT used the data collected for the 2006 study again. In order to verify that this is not a highly flawed assumption, several urban population lists were checked and it was determined that the changes were minor and unlikely to impact the outcome of the analysis significantly. Unfortunately the definition of the limits of urban areas is an area of uncertainty (as can be seen by the highly variable population density), but ICCT found that the resulting intake fractions were similar or more conservative than other comparable analysis, as described below.

142 Evans, J. S. et al. 2002. Exposure efficiency: an idea whose time has come? Chemosphere 49:1075-1091. This article provides a literature review of published intake fractions that were drawn upon heavily for the rural and secondary particle intake fractions in this analysis.

AB6. 本研究中使用的城市、人口和城区[143]

城市名称		人口	区域面积	人口密度
中文	英文		(km^2)	(人/km^2)
鞍山	Anshan	1,454,772	624	2,331
包头	Baotou	1,419,017	2,696	526
北京	Beijing	10,177,849	12,484	815
长春	Changchun	3,100,132	3,603	860
长沙	Changsha	1,962,561	556	3,530
常州	Changzhou[144]	2,134,121	1,650	1,293
成都	Chengdu	4,525,719	2,176	2,080
赤峰	Chifeng	1,131,095	7,012	161
重庆	Chongqing	10,101,208	16,291	620
大连	Dalian	2,747,783	2,415	1,138
佛山	Foshan[145]	3,442,440	3,813	903
抚顺	Fushun	1,415,138	714	1,982
福州	Fuzhou, Fujian	1,662,411	1,043	1,594
广州	Guangzhou	5,882,553	3,179	1,850
海口	Guiyang	2,401,839	8,034	299
邯郸	Handan	1,382,100	434	3,185
杭州	Hangzhou	3,931,864	3,068	1,282
哈尔滨	Harbin	3,151,917	1,660	1,899
合肥	Hefei	1,558,671	596	2,615
淮安	Huaian	2,681,688	3,171	846
淮南	Huainan	1,420,155	1,091	1,302
呼和浩特	Huhehaote/Hohhot[146]	1,096,955	2,054	534
湖州	Huzhou	1,077,227	1,567	687
吉林	Jilin	1,795,531	3,636	494
济南	Jinan	3,348,025	3,257	1,028
昆明	Kunming	2,242,199	4,033	556
兰州	Lanzhou	1,949,146	1,632	1,194
洛阳	Luoyang	1,489,328	544	2,738
南昌	Nanchang	1,794,988	563	3,188
南京	Nanjing	4,897,571	4,729	1,036
南宁	Nanning	1,457,726	1,834	795
宁波	Ningbo	2,069,098	1,033	2,003
莆田	Putian	2,016,336	2,012	1,002
青岛	Qingdao	2,467,702	1,349	1,829

143 所有数据来自于2005. www.bjinfobank.com/irisweb/infobank.htm; Brinkhoff, T. 城市人口www.citypopulation.de; 福建大学http://www.fzu.edu.cn; 海口政府www.haikou.gov.cn/haikougov.asp。

144 常州总商会. www.czsh.org.cn/english/shdh/index.asp。

145 佛山市政府. www.foshan.gov.cn/english。

146 清洁能源行动. 呼和浩特 www.cct.org.cn/cea_asptest/eng/city/huhehaote.htm。

Table AB6. Cities, populations, and urban areas used in the analysis[143]

CITY NAME		GIVEN POPULATION	DISTRICT AREA	POPULATION DENSITY
CHINESE	ENGLISH		(km^2)	($people/km^2$)
鞍山	Anshan	1,454,772	624	2,331
包头	Baotou	1,419,017	2,696	526
北京	Beijing	10,177,849	12,484	815
长春	Changchun	3,100,132	3,603	860
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福州	Fuzhou, Fujian	1,662,411	1,043	1,594
广州	Guangzhou	5,882,553	3,179	1,850
海口	Guiyang	2,401,839	8,034	299
邯郸	Handan	1,382,100	434	3,185
杭州	Hangzhou	3,931,864	3,068	1,282
哈尔滨	Harbin	3,151,917	1,660	1,899
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淮安	Huaian	2,681,688	3,171	846
淮南	Huainan	1,420,155	1,091	1,302
呼和浩特	Huhehaote/Hohhot[146]	1,096,955	2,054	534
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吉林	Jilin	1,795,531	3,636	494
济南	Jinan	3,348,025	3,257	1,028
昆明	Kunming	2,242,199	4,033	556
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洛阳	Luoyang	1,489,328	544	2,738
南昌	Nanchang	1,794,988	563	3,188
南京	Nanjing	4,897,571	4,729	1,036
南宁	Nanning	1,457,726	1,834	795
宁波	Ningbo	2,069,098	1,033	2,003
莆田	Putian	2,016,336	2,012	1,002
青岛	Qingdao	2,467,702	1,349	1,829

143 All sources accessed via the internet in 2005. www.bjinfobank.com/irisweb/infobank.htm; Brinkhoff, T. City Population. www.citypopulation.de; Fujian University. http://www.fzu.edu.cn; Haikou Government. www.haikou.gov.cn/haikougov.asp.

144 Changzhou General Chamber of Commerce. www.czsh.org.cn/english/shdh/index.asp.

145 Foshan City government. www.foshan.gov.cn/english.

146 Clean Energy Action. Hohehot. www.cct.org.cn/cea_asptest/eng/city/huhehaote.htm.

齐齐哈尔	Qiqihar	1,426,710	4,365	327
上海	Shanghai	12,293,700	5,299	2,320
汕头	Shantou	1,280,625	294	4,356
沈阳	Shenyang	4,884,076	3,459	1,412
深圳	Shenzhen	1,512,073	1,949	776
石家庄	Shijiazhuang	2,110,894	456	4,629
苏州	Suzhou, Jiangsu	2,168,663	1,964	1,104
太原	Taiyuan	2,502,727	1,460	1,714
台州	Taizhou[147]	1,460,452	1,536	951
唐山	Tangshan	2,949,101	1,182	2,495
天津	Tianjin	7,636,137	7,418	1,029
乌鲁木齐	Urumqi	1,732,947	10,800	160
潍坊	Weifang	1,423,294	1,472	967
温州	Wenzhou	1,346,505	1,187	1,134
武汉	Wuhan	7,811,855	8,494	920
无锡	Wuxi	2,195,973	1,623	1,353
厦门	Xiamen[148]	1,417,579	1,565	906
西安	Xian	5,102,553	3,502	1,457
徐州	Xuzhou	1,673,296	1,038	1,612
烟台	Yantai	1,708,328	2,722	628
扬州	Yangzhou	1,125,165	980	1,148
宜昌	Yichang	1,209,741	527	2,296
湛江	Zhanjiang	1,442,522	1,460	988
郑州	Zhengzhou	2,398,460	1,010	2,375
淄博	Zibo	2,733,691	2,960	924

模型将每个空气品质区作为一个箱子，污染物通过长时间空气流动传输出这个箱子。对于长时间不反应或反应缓慢的广泛分布于地面源（如来自轻重型车)的污染物，事实证明单格箱模型能对其在城市区域内空间平均浓度提供比较准确的评估[149]。 由于细颗粒(PM2.5) 的生命周期明显比在城市区域中的滞留时间长，所以假设这些颗粒物是不发生变化的。

单格箱吸入因子的公式如下：

$$iF_{compartment} = \frac{QP}{uH\sqrt{A}} \quad \text{(公式 4)}$$

147 www.zhejiang.gov.cn/gb/node2/node1619/node1622/node1810/userobject13ai707.html。

148 美国驻北京大使馆. 1999. Greener that green: 厦门, 一个环境达标模型 www.usembassy-china.org.cn/sandt/Xiamweb.htm。

149 Marshall J. D., Teoh, S. K.,和 Nazaroff, W. W. 2005.美国城市区域不反应的机动车排放的吸入因子.大气环境 .Vol. 39(7), pp. 1363-1371。

齐齐哈尔	Qiqihar	1,426,710	4,365	327
上海	Shanghai	12,293,700	5,299	2,320
汕头	Shantou	1,280,625	294	4,356
沈阳	Shenyang	4,884,076	3,459	1,412
深圳	Shenzhen	1,512,073	1,949	776
石家庄	Shijiazhuang	2,110,894	456	4,629
苏州	Suzhou, Jiangsu	2,168,663	1,964	1,104
太原	Taiyuan	2,502,727	1,460	1,714
台州	Taizhou[147]	1,460,452	1,536	951
唐山	Tangshan	2,949,101	1,182	2,495
天津	Tianjin	7,636,137	7,418	1,029
乌鲁木齐	Urumqi	1,732,947	10,800	160
潍坊	Weifang	1,423,294	1,472	967
温州	Wenzhou	1,346,505	1,187	1,134
武汉	Wuhan	7,811,855	8,494	920
无锡	Wuxi	2,195,973	1,623	1,353
厦门	Xiamen[148]	1,417,579	1,565	906
西安	Xian	5,102,553	3,502	1,457
徐州	Xuzhou	1,673,296	1,038	1,612
烟台	Yantai	1,708,328	2,722	628
扬州	Yangzhou	1,125,165	980	1,148
宜昌	Yichang	1,209,741	527	2,296
湛江	Zhanjiang	1,442,522	1,460	988
郑州	Zhengzhou	2,398,460	1,010	2,375
淄博	Zibo	2,733,691	2,960	924

The model describes each air basin as a box, with emissions transported out of the box through the flow of air over time. For conserved or slowly reacting emissions from broadly distributed ground-level sources, such as light- and heavy-duty vehicles, the one-compartment model has been found to offer a reasonably accurate estimate of spatially averaged concentrations in urban areas.[149] Because the lifetime of fine particles (PM2.5) is significantly longer than their residence time in urban areas, these particles can be assumed to be conserved.

The equation for a one-compartment intake fraction is as follows:

$$iF_{compartment} = \frac{QP}{uH\sqrt{A}} \quad \text{(Equation 4)}$$

147 www.zhejiang.gov.cn/gb/node2/node1619/node1622/node1810/userobject13ai707.html.

148 U.S. Embassy Beijing. 1999. Greener that green: Xiamen, a model of environmental achievement. www.usembassy-china.org.cn/sandt/Xiamweb.htm.

149 Marshall J. D., Teoh, S. K., and Nazaroff, W. W. 2005. Intake fraction of nonreactive vehicle emissions in US urban areas. Atmospheric Environment. Vol. 39(7), pp. 1363-1371.

公式中, Q 表示人口平均的呼吸速率(立方米每人每秒)。 P代表人口。U代表大气混合层高度的平均风速(米每秒) 。H (米)。A代表城市区域面积 (平方米)。由于ICCT没有每个城市风速和混合层高度的详细数据，所以标准化稀释速率中值uH采用美国使用的数据[150] 。

分析中同样包括了城市区域外的PM2.5排放以及城市及郊区NOx转化为硝酸盐的二次颗粒物的健康影响。虽然接下来要提及的一些研究中对吸入因子的估计值都较高，ICCT比较保守地选择了同行评审文献中的平均吸入因子。

为了对模型进行测试，ICCT将其与一个更加复杂的吸入因子模型进行比较。王书肖等人通过使用一个基于75个典型路段的交通流的模型，完成了中国北京、济南和大连三个城市机动车排放吸入因子分析。结果三个城市PM10的排放加权的平均吸入因子为7.72±0.60x10-5，与本次分析使用的平均值相比高很多[151]。 王书肖的研究发现机动车排放的一次颗粒物排放的吸入因子与工业源相比高一个数量级，机动车排放的SO_2的吸入因子几乎要（比工业源）高两个数量级，比PM10的吸入因子高两倍。由于大多数机动车颗粒物的排放是细颗粒和超细颗粒，这种颗粒物可以在大气中滞留相对较长的时间(类似于 SO_2)。王书肖的结果可能低估了预测的机动车PM2.5的排放吸入因子。

表AB7a提供了本次研究中采用的所有的吸入因子，表 AB7b 展示了王书肖等人的结果与其进行比较。正如所看到的，简易的箱式模型可能低估了现实城区的暴露水平，在这些区域中颗粒物被近距离排放于人群，并且这些排放也达不到平均稀释速率。本次研究中最大的不确定因素是每个城市的人口区域和稀释速率。预计每个因素都导致了对iF的估计过低。

表AB7a.本次研究采用的吸入因子

污染物	范围	平均iF	最大 iF	最小 iF	区域	方法学	来源
$PM_{2.5}$	城区	1.7E-05	5.0E-05	4.0E-06	59 个城市	单格箱模型	HIA 的工具
	郊区	4.7E-06	—	—	中国其余地区 (按照人口进行衡量)	大气扩散	采用Evans.等人数据 2002年
二次颗粒物 (来源于 NO_x)	城区	2.3E-07	—	—	城区	大气扩散	Greco等 2007年
	郊区	1.0E-07	—	—	中国其余地区	大气扩散	Greco 等2007年

150 同前。

151 王书肖，郝吉明等2005第五章草案—地方人口对主要工业部门和交通污染物的暴露量。选自麻省理工大学出版的一本书。

In this equation, Q represents the population average breathing rate (m3 person-1 s-1), P is the population, u is the wind speed (m s-1) averaged over the mixing height, H (m), and A is the urban land area (m^2). Because ICCT did not have detailed information on wind speed and mixing height for each city, the median normalized dilution rate uH derived for the United States was used[150].

The analysis also includes health impacts of $PM_{2.5}$ emissions outside of these urban areas and impacts of secondary particle formation of NO_x into nitrates in both urban and rural areas. While higher values were estimated in the study described below, ICCT chose to be conservative by using average intake fractions described in peer-reviewed literature for all these values.

In order to test the model, ICCT compared it to a more complicated model for intake fractions. Wang et al. completed an analysis of the intake fractions for vehicle emissions in three Chinese cities—Beijing, Jinan and Dalian—using a model based on traffic flows on 75 modeled road segments. The resulting emission-weighted average intake fraction for PM_{10} was 7.72±0.60x10-5 for the three cities, much higher than the average value used in this analysis[151]. Wang's analysis found intake fractions for primary particle emissions to be an order of magnitude higher for vehicle emissions than for industrial sources. Vehicle intake fractions for SO_2 were almost two orders of magnitude higher and were two times higher than the PM_{10} intake fraction, according to the analysis by Wang et al. Because the majority of the particles emitted from vehicles are in the fine and ultrafine size range, which remain in the atmosphere longer (similar to SO_2), Wang's results may underestimate intake fractions intended to represent the $PM_{2.5}$ emissions from vehicles.

Table AB7a provides all the intake fractions used in this analysis and Table AB7b shows the Wang et al results described above for comparison. As can be seen, this simple box model is likely to underestimate real exposure levels in these urban areas, where particles are emitted in close proximity to exposed populations and where emissions may not be diluted as quickly as averaged rates would suggest. The largest sources of uncertainty in the approach used for this study are the population areas being considered and the dilution rate for each city. It is expected that each factor will contribute generally to an underestimation of the iF.

Table AB7a. Intake Fractions used in this analysis

POLLUTANT	SCALE	MEAN iF	MAX iF	MIN iF	LOCATION	METHODOLOGY	SOURCE
$PM_{2.5}$	Urban	1.7E-05	5.0E-05	4.0E-06	59 cities	One-compartment model	HIA tool
	Rural	4.7E-06	—	—	Rest of China (population -scaled)	Atmospheric dispersion	Adopted from Evans et al. 2002
Secondary PM (from NO_x)	Urban	2.3E-07	—	—	Urban	Atmospheric dispersion	Greco et al. 2007
	Rural	1.0E-07	—	—	Rest of China	Atmospheric dispersion	Greco et al. 2007

150 Ibid.

151 Wang, S., J. Hao, Y. Lu, J. Li. 2005 draft. Chapter 5—Local population exposure to pollutants from major industrial sectors and transportation. From a book by MIT Press.

表 AB7b 本次研究未采用的吸入因子

污染物	范围	平均iF	最大 iF	最小 iF	区域	方法学	来源
$PM_{2.5}$		7.72E-05	1.54E-04	1.84E-05	北京，济南，大连	75个典型路段	王书肖等. 2005年
二次颗粒物 (来源于 NO_x)		3.10E-06	6.25E-06	4.42E-05	无详细信息		王书肖等2005年

健康影响

健康影响由吸入因子、平均吸入速率与浓度反应 (CR)方程共同计算得出。公式如下所示:

$$cases_{i,j} = \frac{iF_j \quad E_j \quad CR_i \quad I_i}{BR} \text{(公式5)}$$

其中 iFj代表区域j的吸入因子， Ej代表区域j的颗粒物排放变化， CRi代表健康影响i的浓度反应系数， Ii代表i的每年基准值，BR代表平均呼吸率。

CR 系数如表AB8中所示。以下数据表明了颗粒物浓度每微克每立方米(mg/m^3)的变化造成的死亡率和发病率比例的变化。误工时间，误学时间，额外的呼吸症状（感冒等），急诊次数的 CR系数在此次研究中没有考虑。

Table AB7b. Intake Fractions not used in this analysis

POLLUTANT	SCALE	MEAN iF	MAX iF	MIN iF	LOCATION	METHODOLOGY	SOURCE
$PM_{2.5}$		7.72E-05	1.54E-04	1.84E-05	Beijing, Jinan & Dalian	75 modeled road segments	Wang et al. 2005
Secondary PM (from NO_X)		3.10E-06	6.25E-06	4.42E-05	Not specified		Wang et al. 2005

Health impacts

To determine the health impacts, intake fractions are used with concentration-response (CR) functions, in combination with the average population inhalation rate. The general equation is as follows:

$$cases_{i,j} = \frac{iF_j \quad E_j \quad CR_i \quad I_i}{BR} \text{ (Equation 5)}$$

where iFj represents the intake fraction for area j, Ej is the change in PM emissions for area j, CRi is the concentration response coefficient for health impact i, Ii is the annual baseline rate for i, and BR is the average breathing rate.

CR coefficients are listed below, in Table AB8. These values represent the percent change in morbidity and mortality expected in response to a 1 microgram per cubic meter (mg/m^3) change in PM concentration. CR functions for work-loss days, missed school days, additional respiratory symptoms (colds, etc.), or emergency rooms visits are not included in this analysis.

表AB8. 浓度反应(CR)系数和死亡率和发病率的基准值

健康结果	污染物	受影响年龄	CR 系数 每 Δ 1 mg/m³颗粒物 (95%置信度)	I –基准值 (每人比例)	参考文献
成年人全原因死亡率 *	$PM_{2.5}$	30岁及以上	0.41% (0.1%-1.1%)	0.0068–0.0097 (随年龄增加而增加)	Pope 等 2002年; Wang 和 Mauzerall 2005年
婴幼儿死亡率 **	PM_{10}	27 天至1年	0.39% (0.2%-0.7%)	0.02696–0.00441	Woodruff 等. 1997年; CIA 2000-2006年
慢性支气管炎	PM_{10}	全年龄段	0.45% (0.15%-0.77%)	0.0139	Chen 等. 2005年; Chen等. 2002年
急性支气管炎	PM_{10}	全年龄段	0.46% (0.0%-0.92%)	0.0372	Wang等. 1994年
心血管疾病入院	PM_{10}	65岁及以上	0.1% (0.067%-0.15%)	0.01	Kan 和 Chen 2004年; Samet 等. 2000年; CMH 2005年
呼吸疾病入院	PM_{10}	全年龄段	0.036% (0.012%-0.06%)	0.0042	Kan 和Chen 2004年; CMH 2005年
哮喘发病	PM_{10}	15 岁以下	0.44% (0.27%-0.62%)	0.0693	Kan和 Chen 2004年
哮喘发病	PM_{10}	15 岁及以上	0.39% (0.19%-0.59%)	0.0561	Kan 和 Chen 2004年
活动受限天数	$PM_{2.5}$	18 至 65岁	0.94% (0.79%-1.09%)	3.0	Ostro 1990年; Kan和Chen 2004年

* 随着人口年龄增加而增加。

** 每1,000出生婴幼儿的死亡率，这里假设现有按照指数递减的婴幼儿的死亡率的趋势延续。考虑到收入的增加和更佳的医疗服务，将城市的平均比例调整为0.4。

中国几个关于空气污染影响的急性死亡率影响的研究已经完成，但是即使世界范围内也很少有对长期、综合的研究来探究空气污染对慢性死亡率的影响。因此我们使用了美国的流行病学相关研究中的相对风险因子（特别是借鉴了由Pope等人和美国癌症协会通过追踪120万人超过16年时间的研究中分析得出风险因子)[152] 。 EPA提供给科学顾问委员会用来评估颗粒物污染造成的死亡率的建议也是根据这些研究结果[153]。另一方面，英国也确定了采用0.6%的CR系数来评估提前死亡率的相对风险为最佳的评估[154]。因此我们采用了CR 系数0.41%作为对死亡率影响的相对保守的假设。为了避免重复计算，本研究没有对空气质量对短期死亡率的影响进行分析。

152 Pope, C. A., 等。2002年. 肺癌，心肺疾病死亡率和长时间暴露在空气污染的细颗粒。美国医学联合会的期刊 287(9)1132-1141。

153 美国国家环境保护局科学顾问委员会2004年. EPA第二次预测分析—清洁空气法的成本收益分析1990-2020年中对健康影响分析计划的建议。顾问委员会健康影响分会对清洁空气达标分析的建议。华盛顿，美国国家环境保护局科学顾问委员会办公室 (1400A). EPA-SAB-COUNCIL-ADV-04-002。

154 大气污染医学影响委员会。2001年 颗粒物对发病率的长期影响的综述。健康处，英国，伦敦。

Table AB8. Concentration response coefficients and baseline incidence rates for mortality and morbidity

HEALTH ENDPOINT	POLLUTANT	AGES AFFECTED	CR COEFFICIENT per Δ 1 mg/m³ PM (95% confidence)	I – BASELINE INCIDENCE (RATE PER PERSON)	REFERENCES
Adult all-cause mortality*	$PM_{2.5}$	Age 30 & over	0.41% (0.1%-1.1%)	0.0068–0.0097 (increases over time with aging population)	Pope et al. 2002; Wang and Mauzerall 2005
Infant Mortality*	PM_{10}	27 days to 1 year	0.39% (0.2%-0.7%)	0.02696–0.00441	Woodruff et al. 1997; CIA 2000-2006
Chronic bronchitis	PM_{10}	All ages	0.45% (0.15%-0.77%)	0.0139	Chen et al. 2005; Chen et al. 2002
Acute bronchitis	PM_{10}	All ages	0.46% (0.0%-0.92%)	0.0372	Wang et al. 1994
Cardiovascular hospital admission	PM_{10}	Age 65 & over	0.1% (0.067%-0.15%)	0.01	Kan and Chen 2004; Samet et al. 2000; CMH 2005
Respiratory hospital admission	PM_{10}	All ages	0.036% (0.012%-0.06%)	0.0042	Kan and Chen 2004; CMH 2005
Asthma attack	PM_{10}	Under 15	0.44% (0.27%-0.62%)	0.0693	Kan and Chen 2004
Asthma attack	PM_{10}	Age 15 & over	0.39% (0.19%-0.59%)	0.0561	Kan and Chen 2004
Restricted activity day	$PM_{2.5}$	Age 18 to 65	0.94% (0.79%-1.09%)	3.0	Ostro 1990; Kan and Chen 2004

* Increases over time as the population ages.

** Per 1,000 live births, with the current trend of exponential decrease assumed to continue. The average rate was adjusted by 0.4 for cities, to account for higher income and better health care.

Several studies on the acute mortality impacts of air pollution have been conducted in China, but very few long-term, cohort studies have been done anywhere in the world to investigate the chronic mortality impacts of air pollution. Accordingly, relative risk factors from epidemiological studies conducted in the United States—specifically, risk factors developed by Pope at al. in their reanalysis and extension of the American Cancer Society study, which followed 1.2 million adults for over 16 years—are used for this analysis[152]. EPA used the same study on the recommendation of the Health Effects Subgroup of the Science Advisory Board to estimate mortality from particulate matter pollution[153]. On the other hand, the United Kingdom determined that a CR coefficient of 0.6% for the relative risk of premature mortality was the best central estimate[154]. With a CR coefficient of 0.41%, this analysis may, therefore, be considered a relatively conservative assessment of the likely mortality impacts. To avoid double counting, no attempt was made in this analysis to determine short-term air quality impacts on mortality.

152 Pope, C. A., et al. 2002. Lung cancer, cardiopulmonary mortality and long-term exposure to fine particulate air pollution. Journal of the American Medical Association 287(9)1132-1141.

153 U.S. Environmental Protection Agency Science Advisory Board. 2004. Advisory on Plans for Health Effects Analysis in the Analytical Plan for EPA's Second Prospective Analysis – Benefits and Costs of the Clean Air Act, 1990-2020. Advisory by the Health Effects Subcommittee of the Advisory Council on Clean Air Compliance Analysis. Washington, D.C.: U.S. Environmental Protection Agency Science Advisory Board Staff Office (1400A). EPA-SAB-COUNCIL-ADV-04-002.

154 Committee on the Medical Effects of Air Pollutants. 2001. Statement on long-term effects of particles on mortality. Department of Health. London, UK.

效益评估

要全面分析收益，将每一种健康结果进行货币化是很必要的，由于每个生命都是宝贵并有价值的，个体之间不存在价值差异，所以这部分是很困难的。在健康影响评估中，ICCT参照了经济学家提出的通用做法，根据支付意愿额度（如同条件价值评估法中所衡量的）和疾病的开销来评定的健康结果的货币价值[155]。这个方法不用来也不能用来计算一个人的实质价值、患病或者生活质量下降的价值。

为了让评估方法可以被中国的政策制定者采纳，此次分析依托于中国大陆最近完成的支付意愿（即愿意为避免疾病（发病率）和提前死亡（发病率）支付的费用）研究。尽管这些研究中的数值明显比美国、欧洲及许多其他地区的报告中的数值低，本报告采用了中国的研究数据来确保在中国国情下空气质量改善的效益不被过高地估计。虽然我们采用了这些研究数据，但我们并不鼓吹它们就一定是最适合的数据来源，更不表示中国人的生命价值比美国和欧洲低。其他政府和地区的范例证明此处使用的数值是保守的，减少未过早死亡率的实际年效益很可能要高很多。

中国大陆近期研究中得出的为减少发病率和过早死亡的WTP数值明显低于世界其他地区研究的数值。北京以及安庆城区郊区的研究表明平均统计学生命价值(VSL)在124,000元人民币到1,470,000 元人民币之间（美国（1999年）15,000-178,000美元）[156]。 该研究的作者们认为，如果这些研究中的问题采取不同的设计，结果（WTP）可能会高出10倍。因此，Zhou和Hammitt指出他们的估计值应该被“谨慎地解释，也许仅仅是评价的下限”。

Wang和 Mullahy (2006年)的早期研究提出了重庆的平均统计学生命价值为 287,660元人民币。这个研究指出随着年收入每增长1207元人民币（145.8美元），VSL会增加120,450元人民币（14,550美元），即弹性系数为1.42[157]。弹性系数是指年收入每增加一美元所引起的VSL的变化率。将上面的结果应用于到2005年中国的平均收入增长，VSL将会是1,110,930元人民币 (US美元(2010年)162,760)[158]。另外一项1999年进行的北京的研究表明中国城市的VSL处于500,000—1,600,000元人民币之间(1999年美元60,000-200,000)[159]。

155 支付意愿额度描述了个人认为减少健康风险等价的货币量。条件价值评估法用多种与研究主题相关的不同假设情景来询问问卷调查受访者在不同风险和财政结果中如何选择。疾病费用研究只考虑了患病的实际医疗费用，并没有包括个人的选择和其他患病的替代方案。

156 统计学的的生命价值是统计学上避免提前死亡的平均支付意愿的货币量。它不具有描述个人生命价值的含义。Zhou, Y和 J. K. Hammitt. 2005年草案，第八章—中国大气污染相关的健康风险的经济价值：一项条件价值评估。源自麻省理工大学即将出版的一本书籍。

157 Wang, H.和J. Mullahy. 2006. 通过改善空气质量减少死亡风险的支付意愿：中国重庆的一项条件价值评估。环境科学，正在出版中。

158 人口评价源自：联合国, 2006年. 国民经济核算主数据库。联合国统计处，纽约市，纽约州。

159 Zhang, X.和Y. Zheng. 2001年. 中国的气候变化，健康风险和经济分析。 在第四届中韩美经济环境模型研讨会上发表，北京，5月23-25日。

Valuation of benefits

To complete the benefits analysis, it is necessary to monetize each health endpoint, which is difficult because every life is valuable and precious and no individual life is worth more or less than any other. In the HIA, ICCT follows the standard practice developed by economists to assign monetary values for health endpoints based upon willingness-to-pay (WTP), as measured in contingent valuation (CV) studies, and the cost of illnesses[155]. This approach does not and cannot account for the essential worth of a person, nor for suffering or reduction in quality of life.

In order for it to be acceptable to local policy-makers, the analysis relies heavily on recent studies that have been conducted in mainland China to estimate WTP to avoid illness (morbidity) or premature death (mortality). Even though the values reported in these studies are much lower than the values reported in the United States, Europe and many other regions, they are used here in order to make certain that the benefits of improved air quality were not overestimated in the Chinese context. These studies are not advocated as necessarily the most appropriate and their use here is not intended to suggest that Chinese lives have a lower value than U.S. or European lives. Examples from other governments and regions are provided to demonstrate that the values used here are very conservative and the actual benefits of reducing premature mortality are likely to be substantially higher.

Recent studies of WTP for avoided morbidity or premature mortality in mainland China have typically found much lower values than studies elsewhere in the world. A study conducted in Beijing and in rural and urban areas of Anqing, found the mean value of a statistical life (VSL) to range from ¥124,000 to ¥1,470,000 (US$(1999)15,000-$178,000)[156]. The authors of this study suggest that, had they designed the questions differently, the resulting value could have been as much as 10 times higher. Accordingly, Zhou and Hammitt recommend that their estimates be “interpreted cautiously, perhaps as lower bound estimates.”

An earlier study by Wang and Mullahy (2006) reported an average VSL of ¥287,660 (US$(1998)34,750) for Chongqing. That study reported a marginal increase in VSL of ¥120,450 (US$14,550) with an annual income increase of ¥1,207 (US$145.8), implying an elasticity of 1.42[157]. This elasticity represents the ratio of change in VSL for every dollar of change in annual income. By applying these results to the growth in average income in China to 2005, the VSL would be ¥ 1,110,930 (US$(2010)162,760)[158]. One additional study conducted in Beijing in 1999 found that urban VSL in China ranged from ¥500,000 to ¥1,600,000 (US$(1999)60,000-$200,000)[159].

155 Willingness to pay describes the amount of money that an individual finds equally valuable to the reduction in health risk. Contingent valuation studies ask survey respondents how they would choose between alternatives that differ in risk and financial consequences, using a variety hypothetical settings that relate to the situation being studied. Cost of illness studies consider only the actual medical costs of illnesses and do not include any personal preferences or other surrogate for suffering.

156 Value of a Statistical Life is the amount of money attributed to a statistically averaged willingness to pay to avoid the risk of premature death. It is not intended to represent the value of any individual person's life. Zhou, Y. and J. K. Hammitt. 2005 draft. Chapter 8—The economic value of air-pollution-related health risks in China: A contingent valuation study. From a forthcoming book for MIT Press.

157 Wang, H. and J. Mullahy. 2006. Willingness to pay for reducing fatal risk by improving air quality: A contingent valuation study in Chongqing, China. Science of the Total Environment. In press.

158 Population estimates from: UN, 2006. National Accounts Main Aggregates Database. United Nations Statistics Division. New York, New York.

159 Zhang, X. and Y. Zheng. 2001. Climate Change, Health Risk and Economic Analysis in China. Presented at the 4th Sino-Korean-U.S. Economic Environmental Modeling Workshop. Beijing. May 23-25.

台湾的研究表明VSL的差异可能部分是由于文化的差异造成的，但它也可能随着收入的增加而迅速变化。一项近期的研究表明避免空气污染引起的发病率的WTP，台湾人比居住在台湾的大陆人明显更高[160]。此外一项早期研究表明台湾的VSL在最近十年中快速增长。这项研究得出的弹性系数在2-3之间，明显比重庆的研究要高[161]。Bowland和Beghin同样也发现了VSL介于1.7–2.3, 中值为1.95[162]。这些研究有力地证明了VSL增加比收入增加更快，并且在中国随着近年收入的增长，VSL可能已经提高很多了。遗憾的是，中国没有更近期的研究。

表AB9展示了中国大陆，台北，美国，欧洲和泰国VSL研究的结果。

160 Hammitt, J. K.和 J. T. Liu. 2002年. 基于发病率风险价值的疾病类型和潜伏期的影响 Effects of disease type and latency on the value of mortality risk.《Risk and Uncertainty》期刊 Journal of Risk and Uncertainty 28(1)73-95。

161 Hammitt, J. K., J. L. Liu, 和J. L. Liu. 2000年. 生存是一种奢侈品。Survival is a luxury good. 为国家经济研究局 (NBER) 夏季学会公共政策和环境研讨会而著。坎布里奇, 马萨诸塞州。

162 Bowland, B. J.,和J. C. Beghin. 1998年. 发展中国家统计学生命价值的评估：对圣地亚哥地区污染和死亡率的应用。Robust estimated of value of a statistical life for developing economies: An application to pollution and mortality in Santiago. 农业和郊区发展中心，爱荷华州立大学，埃文斯市，爱荷华州. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa. 工作论文 Working Paper 99-WP 214。

Studies conducted on the island of Taiwan suggest that the divergence in VSL could be partly due to cultural differences but might change rapidly with rising income. A recent study found that WTP to avoid morbidity impacts of air pollution was significantly higher for Taiwanese natives than for people from mainland China living on the island of Taiwan[160].And an earlier study found that the VSL in the island of Taiwan has risen rapidly in recent decades, significantly more so than the growth of income. This study found an elasticity of 2–3, significantly higher than the Chongqing study[161]. Bowland and Beghin also found elasticity for VSL to be within the range of 1.7–2.3, with a median estimate of 1.95[162].These studies provide strong confirmation that VSL rises more quickly than income and that, with recent income growth in China, VSL's may have grown substantially higher. Unfortunately, more recent studies in the region were not available.

Table AB9 shows the results of available studies of VSL in mainland China, Taipei, the United States, Europe, and Thailand.

160 Hammitt, J. K., and J. T. Liu. 2002. Effects of disease type and latency on the value of mortality risk. Journal of Risk and Uncertainty 28(1)73-95.

161 Hammitt, J. K., J. L. Liu, and J. L. Liu. 2000. Survival is a luxury good. Prepared for the NBER Summer Institute Workshop on Public Policy and the Environment. Cambridge, Massachusetts.

162 Bowland, B. J., and J. C. Beghin. 1998. Robust estimated of value of a statistical life for developing economies: An application to pollution and mortality in Santiago. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa. Working Paper 99-WP 214.

表AB9. 统计学生命价值研究结果汇总

VSL 范围 美元	区域	研究类型	参考文献
15,000–178,000	北京和安庆 (1999年)	条件价值– 空气污染	Zhou 和Hammitt 2005年
34,600	重庆 (1998年)	条件价值 – 空气污染	Wang 和 Mullahy 2006年
60,000–200,000	北京 (1999年)	条件价值 – 空气污染	Zhang 和 Zheng 2001年
5,000,000	台北 (1997年)	补偿工资差异-风险	Hammitt 等人2000年
5,500,000	美国 (1999年)	使用Meta-analysis方法*对工资风险的研究	EPA 2004年
1,180,000–2,400,000	欧盟 (2005年)	空气污染	DG 环境 2005年
959,700–1,523,000	泰国 (2003年)	条件价值 – 空气污染	Vassanadumrongdee 2003年

* Meta-analysis 目前没有权威的翻译方法，台湾一些学者称之为“整合分析”。

本研究使用了从111个中国城市的近期评价的平均值，并按照上面提到的Wang 和Mullahy的研究进行调整得到的，来反映出本研究评估的健康影响主要作用于中国财富相对集中地区的城区和城区居民[163]。如前所述，即使用了Wang和Mullahy提出的1.42的弹性系数来修正收入差异的，这个数据也要比世界上其他的国家的数据要更加的保守。

表AB10是本研究中使用的2004年度发病率和死亡率的价值，基本是采用了Zhang近期的分析。当疾病费用不能作为适当的估算方法时，我们使用了经调整的EPA的WTP, 调整因子为中美避免感冒的WTP的比值。Zhou和Hammitt发现中国参与调查的人愿意支付24–48元人民币 (3–6美元)来避免他们近期患感冒[164]。美国避免一天感冒症状的WTP处于130–1600元人民币 (2005年美元16–200美元)，我们用平均值，即1000 人民币(120美元) 来计算两国WTP比值。ICCT尽可能地在所有的部分都对发病率采用了更加保守的数据。例如，ICCT对轻微症状(急性支气管炎，哮喘发作，和活动受限天数)采用了调整因子（即如上面例子里的缩放比例）因为它们更加保守，但对慢性支气管炎则使用了Zhang研究的数值，因为如果还用调整因子得到的数值可能更高。

163 Zhang, M.等人2008年. 通过使用疾病经济负担分析法对中国111个城市与颗粒物相关的健康影响的经济评估。环境管理期刊88:947-954。

164 Zhou, Y. 和J. K. Hammitt. 2005年 草案. 第八章—中国大气污染相关的健康风险的经济价值：一种条件价值评估分析。源自麻省理工大学即将出版的一本书籍。

Table AB9. Value of a Statistical Life study results

VSL RANGE ORIGINAL US$	ORIGINAL LOCATION	TYPE OF STUDY	REFERENCE
15,000–178,000	Beijing and Anqing (1999)	CV – air pollution	Zhou & Hammitt 2005
34,600	Chongqing (1998)	CV – air pollution	Wang and Mullahy 2006
60,000–200,000	Beijing (1999)	CV – air pollution	Zhang & Zheng 2001
5,000,000	Taipei (1997)	Compensating wage differential – risk	Hammitt et al. 2000
5,500,000	US (1999)	Meta-analysis of wage-risk studies	EPA 2004
1,180,000–2,400,000	EU (2005)	Air pollution	DG Environment 2005
959,700–1,523,000	Thailand (2003)	CV – air pollution	Vassanadumrongdee 2003

To account for the fact that health impacts measured in this analysis occur primarily in or to resident in urban areas, where wealth in China is concentrated, this study uses an average value taken from a recent health assessment for 111 Chinese cities adjusted from the Wang and Mullahy study referenced above[163]. As mentioned earlier, this is also a much more conservative value than is used by other governments around the world, even when corrected for difference in income and with the elasticity of 1.42 reported by Wang and Mullahy.

The values for morbidity and mortality that are used in this analysis are included in Table AB10 for the year of 2004 and were mostly drawn from Zhang's recent analysis. Where cost of illness does not necessarily provide an appropriate measure, EPA's WTP values are scaled using the ratio of Chinese to U.S. WTP to avoid a cold. Zhou and Hammitt found Chinese respondents are willing to pay ¥24–¥48 ($3–$6) to avoid their most recent cold episode[164]. WTP to avoid one day's cold symptoms in the United States ranges from ¥130–¥1600 (US$ (2005)16–200); the estimated mean of ¥1000 ($120) is used to derive the ratio. In all cases ICCT uses more conservative values for morbidity when possible. For example, ICCT uses the scaled values for minor symptoms (acute bronchitis, asthma attacks, and restricted activity days) because they are more conservative but uses Zhang's value for chronic bronchitis because the value that was arrived at through this same method is much higher.

163 Zhang, M., et al. 2008. Economic assessment of the health effects related to particulate matter pollution in 111 Chinese cities by using economic burden of disease analysis. Journal of Environmental Management 88:947-954.

164 Zhou, Y. and J. K. Hammitt. 2005 draft. Chapter 8—The economic value of air-pollution-related health risks in China: A contingent valuation study. From a forthcoming book for MIT Press.

表AB10. 发病率和死亡率价值

健康影响	基础	货币价值	
		人民币 (2004)	美元(2004)
提前死亡率 (VSL)	WTP (Zhang等人. 2008年)	570,480	83,575
婴幼儿死亡率 (VSL)	与成年人相同	570,480	83,575
慢性支气管炎 ($/每避免一例)	WTP (Zhang等人. 2008年)	29,050	4,256
呼吸疾病入院 ($/每避免一例)	COI (Zhang等人. 2008年)	3,430	503
心血管疾病入院 ($/每避免一例)	COI (Zhang等人. 2008年)	7,004	1,026
急性支气管炎 ($/每避免一例)	由中美避免感冒的WTP的比值得到	89	15
哮喘发作 ($/每避免一例)	由中美避免感冒的WTP的比值得到	14	2
活动受限天数 ($/每避免一例)	由中美避免感冒的WTP的比值得到	14	2

中国2000－2008年的统计数据源于世界银行组织[165]。收录的数据包括总人口，以当前美元计算的国内生产总值（GDP），以购买力评价法得到人均国民总收入（GNI）。表AB11包括基于人口和GDP增加预测的2030年人口和经济指标增长的评价和预测[166]。这里默认中国经济会在接下来的20年中继续保持相对高速增长，缩小对发达国家经济的差距。

表AB11. 中国经济与人口增长的预测

	国务院发展研究中心	中国社会科学院数量经济与技术经济研究所		美国
时期	平均经济增长率 (%)	平均经济增长率 (%)	最终年的人口预测 (亿)	最终年的人口预测 (亿)
2001-2010	7-7.9	8.1	14.23	13.65
2011-2020	5.5-6.6	6.4	15.18	14.29
2021-2030	5.4	5.4	15.72	14.50
2031-2040	4.5	4.9	15.85	--
2041-2050	3.4	4.3	15.52	--

中国收入的增长迅速。本研究中参照Wang和Mullahy对重庆的研究对所有发病率价值使用弹性系数为1，对死亡率采用保守的弹性系数1.42。这意味着发病率价值的增长与收入增长同步，死亡率价值（VSL）比收入增长快，如图AB4所示。

165 世界银行组织。 2009年。世界经济发展指标。 http://go.worldbank.org/U0FSM7AQ40。

166 2009年度， GDP增长采用了Chinability网站的评价 (www.chinability.com/GDP.htm) ，2010年及以后采用了国务院发展中心(DRC)和中国社会科学院(CASS)数量经济与技术经济研究所的研究。人口预测采用了中国社会科学院和美国的数据。美国的预测源自： 联合国. 2004年世界城市化前景：2003年修订，联合国出版社 ，纽约。

Table AB10. Mortality and morbidity values

HEALTH IMPACT	BASIS	MONETARY VALUE	
		RMB (2004)	US$(2004)
Premature mortality (VSL)	WTP (Zhang et al. 2008)	570,480	83,575
Infant mortality (VSL)	Same as adult	570,480	83,575
Chronic bronchitis ($/case avoided)	WTP (Zhang et al. 2008)	29,050	4,256
Respiratory hospital admissions ($/case avoided)	COI (Zhang et al. 2008)	3,430	503
Cardiovascular hospital admissions ($/case avoided)	COI (Zhang et al. 2008)	7,004	1,026
Acute bronchitis ($/case avoided)	China to US ratio of WTP to avoid a cold	89	15
Asthma attack ($/case avoided)	China to US ratio of WTP to avoid a cold	14	2
Restricted activity day ($/case avoided)	China to US ratio of WTP to avoid a cold	14	2

China statistics for the years 2000 to 2008 come from the World Bank Group[165]. Data collected include total population, gross domestic product (GDP) in current US$, gross national income (GNI) per capita on a purchasing power parity (PPP) basis. Population and economic indicators are extended out to 2030 based on population and GDP growth estimates and forecasts included in Table AB11. [166] There is general agreement that China's economy will continue to maintain relatively robust growth over the next twenty years, narrowing the gap that currently separates the China from the economies of the developed world.

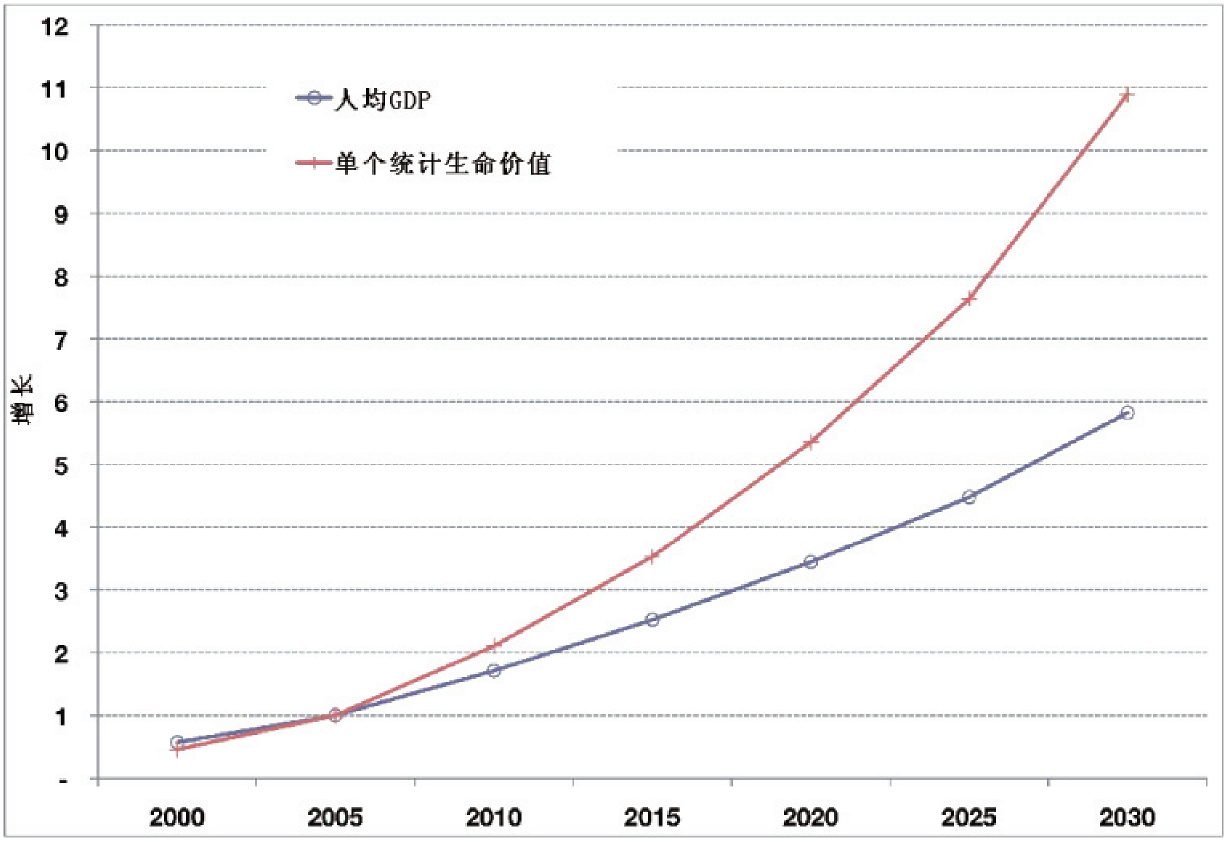
Table AB11. Forecasts for economic and population growth in china

	DRC, STATE COUNCIL	CASS INSTITUTE OF QUANTATIVE AND TECHNICAL ECONOMICS		UNITED NATIONS
PERIOD	AVG. ECONOMIC GROWTH RATE (%)	AVG. ECONOMIC GROWTH RATE (%)	POPULATION FORECAST FOR FINAL YEAR (BILLION)	POPULATION FORECAST FOR FINAL YEAR
2001-2010	7-7.9	8.1	1.423	1.365
2011-2020	5.5-6.6	6.4	1.518	1.429
2021-2030	5.4	5.4	1.572	1.450
2031-2040	4.5	4.9	1.585	--
2041-2050	3.4	4.3	1.552	--

Income is increasing very rapidly in China. For this analysis an elasticity of 1 is used for all morbidity values and a conservative elasticity of 1.42 is used for mortality, as reported by Wang and Mullahy for Chongqing. This means that morbidity values rise at the same rate as income while mortality values (VSL) rise more rapidly, as demonstrated in Figure AB4.

165 World Bank Group. 2009. World development indicators. http://go.worldbank.org/U0FSM7AQ40.

166 For the year 2009, the GDP growth estimate from Chinability was used (www.chinability.com/GDP.htm) and for 2010 and beyond the estimates from Development Research Center (DRC) of the State Council and the Chinese Academy of Social Sciences (CASS) Institute of Quantitative and Technical Economics were used. Population forecasts came from CASS and the United Nations. The United Nations forecasts are available in: United Nations. 2004. World urbanization prospects: The 2003 revisions. United Nations Publication, New York.



图AB4. 随着时间的推移人均GDP (PPP) 和VSL 增长

在本研究涉及的30年时间跨度内，即使采用调整过的弹性系数，中国减少提前死亡的货币价值也远远赶不上其他国家所使用的价值。美国EPA使用的数据按照中国GDP增长进行调整后，仍然将近高出本研究中使用的2030年数据的六倍。这表明本研究中使用的VSL或者弹性系数（或者两者都有）可能要比现实情况低。本研究对健康效益货币化的保守假设可能导致其比预期净效益低。

结论

正如本文所指出的，健康影响分析的结论应该是保守的下限评价。通过与近期Zhang等人的分析相比较，本分析指出机动车排放仅占健康影响的10%[167]。鉴于移动源排放在工业化国家主要城市的大气污染中占到50%甚至80%[168]，非常接近人群的呼吸范围（高度），并且是中国快速增长的污染源，所以估计目前中国的移动源污染会占健康影响的至少20-30%或有可能更大，并会不断增加[169]。本研究与其他近期研究比较表明这些结论应该被作为一个保守的下限评价的影响。

167 Zhang, M等人 2008年。 通过使用疾病经济负担分析法对中国111个城市与颗粒物相关的健康影响的经济评估。环境管理期刊88:947-954。

168 Han, X.,和Naeher, L.P. 2006年. 发展中国家交通相关的大气污染评价研究的回顾。 国际环境32:106-120。

169 北京近期PM2.5的研究表明机动车是城市颗粒物的主要来源 (Chan, C.T.等人 2005年, 北京PM2.5, PM10以及含碳物质垂直分布特征和来源。大气环境39:5113-5124; Dan 等人. 2004年.北京PM2.5的来源和其中碳的种类的特征. 大气环境38:3443-3452.). 2001-2002年间 Dan 等人的研究，冬季PM2.5 浓度会上升50—100 %，表明家庭取暖是一个主要排放源，尽管由于使用更清洁的燃料来代替燃煤家庭取暖排放已经比从前降低。

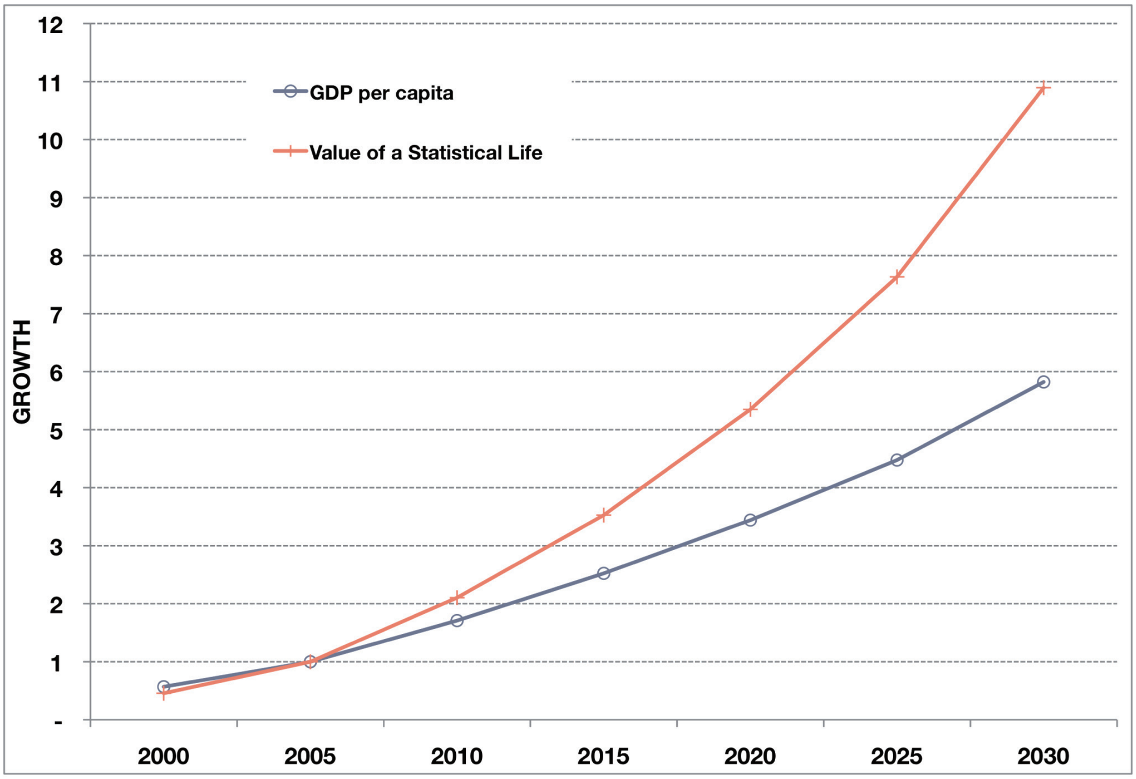


Figure AB4. GDP (PPP) per capita and VSL growth over time

Within the 30-year timeframe of this study, the value assigned to reducing premature mortality in China does not come close to catching up with values used in other countries, even with the elasticity adjustment. The value used by U.S. EPA, when adjusted for the forecasted growth in Chinese GDP, is still almost six times higher than the 2030 value used in this analysis. This suggests that VSL and/or elasticity used in this analysis may be lower than is realistic. The conservative assumptions used in this study to monetize health benefits may lead to lower than expected net benefits.

Findings in context

As stated previously in this document, the findings of the HIA should be taken as conservative, low-end estimates. As compared to a recent analysis by Zhang et al., this analysis would suggest that vehicle emissions account for only 10 percent of health impacts[167]. As mobile sources tend to be responsible for 50 to more than 80 percent of air pollution in major cities in industrialized countries[168], are in close proximity to people breathing, and are a rapidly growing source in China, mobile sources would be expected to be responsible for at least 20 to 30 percent, if not a significantly larger portion, of the health impacts currently and growing over time. Comparison of this analysis with other recent studies suggests that these findings should be viewed as conservative, low-end estimates of impacts[169].

167 Zhang, M., et al. 2008. Economic assessment of the health effects related to particulate matter pollution in 111 Chinese cities by using economic burden of disease analysis. Journal of Environmental Management 88:947-954.

168 Han, X., and Naeher, L.P. 2006. A review of traffic-related air pollution assessment studies in the developing world. Environment International 32:106-120.

169 Recent studies of PM2.5 sources in Beijing found vehicles to be one of the major sources of particles in the city (Chan, C.T. et al. 2005, Characteristics of vertical profiles and sources of PM2.5, PM10, and carbonaceous species in Beijing. Atmospheric Environment 39:5113-5124; Dan et al. 2004. The characteristics of carbonaceous species and their sources in PM2.5 in Beijing. Atmospheric Environment 38:3443-3452.). In the 2001-2002 study by Dan et al., however, PM2.5 concentrations rose by 50 to 100 percent in winter months, suggesting that home heating has been a significant source of emissions, although this source is declining as other, cleaner fuels are replacing coal.

将此研究放入相关背景来看，英国政府近期公布了欧盟环境总署的英国过早死亡可以达到50,000 每年或者占到总死亡率的10%的结论[170]。中国有着更高的人均排放量，大气污染造成死亡会占到更大比例。本研究中，机动车造成的大气污染造成的死亡的百分比在0.2%和最高3%之间(3%对应的是假设不进行额外污染控制情况下2030年的排放情况)。

本研究分析得出的排放引起的健康影响在2010GDP的0.5％（由现行方案带来的收益）到2030年GDP的2.6%（假设采取强化方案带来的收益）之间。世界银行评价显示2003年大气污染带来的经济损失（提现在发病率和死亡率）占到GDP的1.16%[171]。基于2005年的结果，本研究表明道路机动车会占到大气污染相关费用的15—20%。

本研究中的保守因素意味着本研究提供了下列影响的下限估计：

- 城市吸入因子的评价可能比实际值偏低，特别是这些城市持续扩大，人口越来越密集。从2010年到2030年间，中国城市化水平预计会由40%增长到60%[172]。

- 二次颗粒物吸入因子的评价中使用了相对保守的数据。虽然一些研究发现NOx 排放的影响(更高的排放，更低的吸入因子) 与一次颗粒物的影响相约，本研究发现NOx 排放的影响不足一次颗粒物排放的影响的十分之一。

- 虽然中国的收入与美国和欧洲比较只低一个数量级，但是健康影响的价值尤其是死亡率比美国和欧洲使用的价值低两个数量级。

- 随着时间推移死亡率价值的增长可能被低估了。

如果研究中使用其他研究开发的更高的吸入因子来计算，影响会变为现在两倍以上，将占到死亡率比例的5%和2030年GDP的5.5%。

170 下议院，环境审计委员会，空气质量，第五次会议报告2009年10月22日， 2010年3月22日。

171 世界银行. 2007年. 中国污染费用。

172 联合国. 2004年. 世界城市化前景: 2003修订版。

To put this study in context, the UK government recently publicized findings by the European Environment Agency that premature deaths in that country could be as high as 50,000 per year, or 10 percent of all deaths[170]. China has much higher emissions per capita, which could result in an even larger portion mortality impacted by air pollution. In this analysis, the percentage of deaths due to air pollution from vehicles varied between 0.2 percent and three percent at the extreme (2030 emissions with no additional controls in place).

Health impacts of the emissions estimated in this analysis were equal to between 0.5 percent of GDP in 2010 for the impacts avoided due to the current program to 2.6 percent of the GDP in 2030 for the Strong program. The World Bank estimates that the economic cost of air pollution in 2003, in terms of mortality and morbidity, was 1.16 percent of GDP[171]. Based on the 2005 results, this analysis suggests on-road vehicles would be responsible for 15-20 percent of air pollution related costs.

The conservative factors in this analysis suggest that the analysis provides a low-end estimate of impacts include:

- Intake fraction estimates for cities are likely to be lower than justified, especially as cities continue to grow and become more densely populated. China is expected to move from 40 to almost 60 percent urban in between 2010 and 2030[172].

- Conservative values are used for the secondary particle intake fraction estimates. Some studies have found impacts from NOx emissions (higher emissions but lower intake fraction) to be roughly on par with primary PM, while this study found them to be more than an order of magnitude lower.

- Values of health impacts, especially mortality, were two orders of magnitude lower than those used in the United States and Europe, while income differs by only one order of magnitude.

- The growth of mortality values over time was likely to be underestimated.

Were this study to have used the higher intake fractions values, which were developed in other studies, impacts more than twice as high would have been found, accounting for up to five percent of deaths and 5.5 percent of GDP in 2030.

170 House of Commons, Environmental Audit Committee, Air Quality. Fifth Report of Session 2009-10. March 22, 2010.

171 World Bank. 2007. Cost of Pollution in China.

172 United Nations. 2004. World Urbanization Prospects: The 2003 Revision.

附录 C: 美国、欧盟、中国和日本的排放标准

美国: 轻型车排放标准 (FTP-75 底盘测功机测试)*

TIER 2 标准							
标准	车型年	车型	全使用寿命中的排放限值(100 – 120,000 英里) 规定的每英里排放上限(G/MI)				
			NO_X	NMOG	CO	PM	HCHO
Bin 1	2004+	LDV, LLDT, HLDT, MDPV	0.00	0.00	0.0	0.00	0.000
Bin 2	2004+	LDV, LLDT, HLDT, MDPV	0.02	0.01	2.1	0.01	0.004
Bin 3	2004+	LDV, LLDT, HLDT, MDPV	0.03	0.055	2.1	0.01	0.011
Bin 4	2004+	LDV, LLDT, HLDT, MDPV	0.04	0.070	2.1	0.01	0.011
Bin 5	2004+	LDV, LLDT, HLDT, MDPV	0.07	0.090	4.2	0.01	0.018
Bin 6	2004+	LDV, LLDT, HLDT, MDPV	0.10	0.090	4.2	0.01	0.018
Bin 7	2004+	LDV, LLDT, HLDT, MDPV	0.15	0.090	4.2	0.02	0.018
Bin 8a	2004+	LDV, LLDT, HLDT, MDPV	0.20	0.125	4.2	0.02	0.018
Bin 8b	2004-2008	HLDT, MDPV	0.20	0.156	4.2	0.02	0.018
Bin 9a	2004-2006	LDV, LLDT	0.30	0.090	4.2	0.06	0.018
Bin 9b	2004-2006	LDT2	0.30	0.130	4.2	0.06	0.018
Bin 9c	2004-2008	HLDT, MDPV	0.30	0.180	4.2	0.06	0.018
Bin 10a	2004-2006	LDV, LLDT	0.60	0.156	4.2	0.08	0.018
Bin 10b	2004-2008	HLDT, MDPV	0.60	0.230	6.4	0.08	0.027
Bin 10c	2004-2008	LDT4, MDPV	0.60	0.280	6.4	0.08	0.027
Bin 11	2004-2008	MDPV	0.90	0.280	7.3	0.12	0.032
TIER 1 标准							
LDV	1994-2003	LDV	0.60	0.31	4.2	0.10	-
LDT1	1994-2003	LDT1	0.60	0.31	4.2	0.10	0.800
LDV 柴油	1994-2003	LDV柴油	1.25	0.31	4.2	0.10	-
LDT1 柴油	1994-2003	LDT1柴油	1.25	0.31	4.2	0.10	0.800
LDT2	1994-2003	LDT2	0.97	0.40	5.5	0.10	0.800
LDT3	1994-2003	LDT3	0.98	0.46	6.4	0.10	0.800
LDT4	1994-2003	LDT4	1.53	0.56	7.3	0.12	0.800

*从车型年2000开始，机动车必须额外进行US06工况(极速加速和高速行驶)和SC03工况(使用空调)的测试。

Appendix C- Emission Standards in the United States, European Union, China, and Japan

United States: Light-duty Vehicle Emission Standards (FTP-75 chassis dynamometer test)*

TIER 2 PROGRAM							
STANDARD	MODEL YEAR	VEHICLES	EMISSION LIMITS AT FULL USEFUL LIFE (100 – 120,000 MILES) MAXIMUM ALLOWED GRAMS PER MILE (G/MI)				
			NO_x	NMOG	CO	PM	HCHO
Bin 1	2004+	LDV, LLDT, HLDT, MDPV	0.00	0.00	0.0	0.00	0.000
Bin 2	2004+	LDV, LLDT, HLDT, MDPV	0.02	0.01	2.1	0.01	0.004
Bin 3	2004+	LDV, LLDT, HLDT, MDPV	0.03	0.055	2.1	0.01	0.011
Bin 4	2004+	LDV, LLDT, HLDT, MDPV	0.04	0.070	2.1	0.01	0.011
Bin 5	2004+	LDV, LLDT, HLDT, MDPV	0.07	0.090	4.2	0.01	0.018
Bin 6	2004+	LDV, LLDT, HLDT, MDPV	0.10	0.090	4.2	0.01	0.018
Bin 7	2004+	LDV, LLDT, HLDT, MDPV	0.15	0.090	4.2	0.02	0.018
Bin 8a	2004+	LDV, LLDT, HLDT, MDPV	0.20	0.125	4.2	0.02	0.018
Bin 8b	2004-2008	HLDT, MDPV	0.20	0.156	4.2	0.02	0.018
Bin 9a	2004-2006	LDV, LLDT	0.30	0.090	4.2	0.06	0.018
Bin 9b	2004-2006	LDT2	0.30	0.130	4.2	0.06	0.018
Bin 9c	2004-2008	HLDT, MDPV	0.30	0.180	4.2	0.06	0.018
Bin 10a	2004-2006	LDV, LLDT	0.60	0.156	4.2	0.08	0.018
Bin 10b	2004-2008	HLDT, MDPV	0.60	0.230	6.4	0.08	0.027
Bin 10c	2004-2008	LDT4, MDPV	0.60	0.280	6.4	0.08	0.027
Bin 11	2004-2008	MDPV	0.90	0.280	7.3	0.12	0.032
TIER 1 PROGRAM							
LDV	1994-2003	LDV	0.60	0.31	4.2	0.10	-
LDT1	1994-2003	LDT1	0.60	0.31	4.2	0.10	0.800
LDV diesel	1994-2003	LDV diesel	1.25	0.31	4.2	0.10	-
LDT1 diesel	1994-2003	LDT1 diesel	1.25	0.31	4.2	0.10	0.800
LDT2	1994-2003	LDT2	0.97	0.40	5.5	0.10	0.800
LDT3	1994-2003	LDT3	0.98	0.46	6.4	0.10	0.800
LDT4	1994-2003	LDT4	1.53	0.56	7.3	0.12	0.800

* Effective for model year 2000, vehicles had to be additionally tested on the US06 cycle (aggressive, high speed driving) and the SC03 cycle (use of air conditioning).

美国:重型柴油卡车发动机排放标准 (FTP瞬态和SET 测试工况)

	克每制动马力小时(G/BHP-HR)			
	HC	CO	NO_X	PM
1988	1.3	15.5	10.7	0.60
1990	1.3	15.5	6.0	0.60
1991	1.3	15.5	5.0	0.25
1994	1.3	15.5	5.0	0.10
1998	1.3	15.5	4.0	0.10
2004	0.5	-	2.0	0.10
2010	0.14	-	0.2	0.01

耐久性要求：

- 重型柴油发动机（轻型） (8,500 – 19,500 磅最大总质量): 8年/110,000 英里 (以先达到的为准)
- 重型柴油发动机（中型） (19,500 – 33,000磅最大总质量): 8年/185,000英里
- 重型柴油发动机（重型） (> 33,000磅最大总质量): 8年/290,000英里

United States: Heavy-duty Diesel Truck Engine Emission Standards (FTP Transient and SET test cycles)

	GRAMS PER BRAKE HORSEPOWER-HOUR (G/BHP-HR)			
	HC	CO	NO_X	PM
1988	1.3	15.5	10.7	0.60
1990	1.3	15.5	6.0	0.60
1991	1.3	15.5	5.0	0.25
1994	1.3	15.5	5.0	0.10
1998	1.3	15.5	4.0	0.10
2004	0.5	-	2.0	0.10
2010	0.14	-	0.2	0.01

Useful Life Requirements：

- Light heavy-duty diesel engines (8,500 – 19,500 lbs GVWR): 8 years/110,000 miles (whichever occurs first)
- Medium heavy-duty diesel engines (19,500 – 33,000 lbs GVWR): 8 years/185,000 miles
- Heavy heavy-duty diesel engines (> 33,000 lbs GVWR): 8 years/290,000 miles

欧盟: 乘用车排放标准 (ECE15 + EUDC 底盘测功机测试)*

		克每公里 (G/KM)				
柴油	实施日期	CO	HC	HC+ NO_X	NO_X	PM
欧 1[f]	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.140 (0.180)
欧2, IDI	1996.01	1.00	-	0.70	-	0.080
欧2, DI	1996.01[a]	1.00	-	0.90	-	0.100
欧3	2000.01	0.64	-	0.56	0.50	0.050
欧4	2005.01	0.50	-	0.30	0.25	0.025
欧5	2009.09[b]	0.50	-	0.23	0.18	0.005[e]
欧6	2014.09	0.50	-	0.17	0.08	0.005[e]
汽油						
欧1[f]	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	-
欧2	1996.01	2.20	-	0.50	-	-
欧3	2000.01	2.30	0.2	-	0.15	-
欧4	2005.01	1.00	0.1	-	0.08	-
欧5	2009.09[b]	1.00	0.1[c]	-	0.06	0.005[d,e]
欧6	2014.09	1.00	0.1[c]	-	0.06	0.005[d,e]

* M1类车。欧 1 到欧 4阶段, 车重超过 2,500 kg 被作为 N1类车进行型式认证

a –1999年9月30日之后，装有直喷发动机的车要求达到非直喷限值

b – 2011年1月起对所有车型进行要求

c – 非甲烷碳氢化合物限值= 0.068 g/km

d – 仅适用于装有直喷发动机的机动车

e – 0.0045 g/km 使用颗粒物测量规程时

f – 欧 1 括号里的数值为生产一致性限值

耐久性要求

■ 欧 3: 80,000 公里或者5 年(以先达到的为准); 生产制造商可以使用下面的劣化因子替代实际的劣化试验：

o 点燃式发动机 (汽油): CO, HC和NOx为1.2

o 压燃式发动机(柴油): CO, NOx, HC+NOx,为1.1， PM为1.2

■ 欧4: 100,000公里或者5 年 (以先达到的为准)。

■ 欧5/6: 使用一致性要求为100,000公里或者5年;型式核准的污染物控制装置的耐久性要求 160,000公里或者5年(以先达到的为准); 生产制造商可以使用下面的劣化因子替代实际的劣化试验(欧 6的劣化因子尚未确定):

o 点燃式发动机: CO为1.5, HC为1.3, NOx为1.6, PM为1.0

o 压燃式发动机: CO为1.5, NOx和HC+NOx, PM为1.0

European Union: Emission Standards for Passenger Cars (ECE15 + EUDC chassis dynamometer test)*

		GRAMS PER KILOMETER (G/KM)				
DIESELS	DATE	CO	HC	HC+ NO_X	NO_X	PM
Euro 1[f]	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.140 (0.180)
Euro 2, IDI	1996.01	1.00	-	0.70	-	0.080
Euro 2, DI	1996.01[a]	1.00	-	0.90	-	0.100
Euro 3	2000.01	0.64	-	0.56	0.50	0.050
Euro 4	2005.01	0.50	-	0.30	0.25	0.025
Euro 5	2009.09[b]	0.50	-	0.23	0.18	0.005[e]
Euro 6	2014.09	0.50	-	0.17	0.08	0.005[e]
GASOLINE						
Euro 1[f]	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	-
Euro 2	1996.01	2.20	-	0.50	-	-
Euro 3	2000.01	2.30	0.2	-	0.15	-
Euro 4	2005.01	1.00	0.1	-	0.08	-
Euro 5	2009.09[b]	1.00	0.1[c]	-	0.06	0.005[d,e]
Euro 6	2014.09	1.00	0.1[c]	-	0.06	0.005[d,e]

* Category M1 vehicles. For Euro 1 through 4, vehicles greater than 2,500 kg were type approved as Category N1 vehicles

a – After Sept 30, 1999, vehicles with DI engines had to meet the IDI limits

b – Jan 2011 for all models

c – NMHC limit = 0.068 g/km

d – applicable only to vehicles with DI engines

e – 0.0045 g/km using the PMP measurement procedure

f – Euro 1 values in brackets are conformity of production limits

Useful Life Requirements

■ Euro 3: 80,000 km or 5 years (whichever occurs first); in lieu of an actual deterioration run, manufacturers may use the following deterioration factors:

o Spark ignition (gasoline): 1.2 for CO, HC, and NO_x

o Compression ignition (diesel): 1.1 for CO, NOx, HC+NOx, and 1.2 for PM

■ Euro 4: 100,000 km or 5 years (whichever occurs first).

■ Euro 5/6: in-service conformity of 100,000 km or 5 years; durability testing of pollution control devices for type approval is 160,000 km or 5 years (whichever occurs first); in lieu of a durability test, manufacturers may use the following deterioration factors (Euro 6 deterioration factors to be determined):

o Spark ignition: 1.5 for CO, 1.3 for HC, 1.6 for NOx, and 1.0 for PM

o Compression ignition: 1.5 for CO, 1.1 for NOx and HC+NOx, and 1.0 for PM

欧盟:重型柴油发动机的排放标准

			克每千瓦时 (G/KWH)			
	实施日期	测试工况	CO	HC	NO_X	PM
欧 I	1992, < 85 kW	ECE R-49	4.5	1.1	8.0	0.612
	1992, > 85 kW		4.5	1.1	8.0	0.36
欧II	1996.10		4.0	1.1	7.0	0.25
	1998.10		4.0	1.1	7.0	0.15
欧 III	1999.10, 仅适用于环境友好汽车*	ESC & ELR	1.5	0.25	2.0	0.02
	2000.10		2.1	0.66	5.0	0.10 0.13[a]
欧 IV	2005.10		1.5	0.46	3.5	0.02
欧 V	2008.10		1.5	0.46	2.0	0.02
欧 VI	2013.01		1.5	0.13	0.4	0.01

a –适用于每个汽缸工作排量小于0.75立方分米并且额定功率转速大于3000转/分钟的发动机

			克每千瓦时 (G/KWH)				
	实施日期	测试工况	CO	NMHC	CH_4[A]	NO_X	PM[B]
欧III	1999.10, 仅适用于环境友好汽车	ETC	3.0	0.40	0.65	2.0	0.02
	2000.10		5.45	0.78	1.6	5.0	0.16 0.21[c]
欧IV	2005.10		4.0	0.55	1.1	3.5	0.03
欧V	2008.10		4.0	0.55	1.1	2.0	0.03
欧VI	2013.01		4.0	0.16[d]	0.5	0.4	0.01

a – 仅适用于点燃式发动机：欧III 至欧 V：仅适用于天然气发动机；欧VI：天然气和液化石油气

b – 对欧III 和欧 V汽油发动机不适用

c –适用于每个汽缸工作排量小于0.75立方分米并且额定功率转速大于3000转/分钟的发动机

d –对柴油发动机是总碳氢化合物

European Union: Emission Standards for Heavy-duty Diesel Engines

			GRAMS PER KILOWATT-HOUR (G/KWH)			
	DATE	TEST CYCLE	CO	HC	NO_X	PM
Euro I	1992, < 85 kW	ECE R-49	4.5	1.1	8.0	0.612
	1992, > 85 kW		4.5	1.1	8.0	0.36
Euro II	1996.10		4.0	1.1	7.0	0.25
	1998.10		4.0	1.1	7.0	0.15
Euro III	1999.10, EEVs* only	ESC & ELR	1.5	0.25	2.0	0.02
	2000.10		2.1	0.66	5.0	0.10 0.13[a]
Euro IV	2005.10		1.5	0.46	3.5	0.02
Euro V	2008.10		1.5	0.46	2.0	0.02
Euro VI	2013.01		1.5	0.13	0.4	0.01

a – for engines with swept volume per cylinder less than 0.75 dm^3 and rated power speed greater than 3000min^{-1}

			GRAMS PER KILOWATT-HOUR (G/KWH)				
	DATE	TEST CYCLE	CO	NMHC	CH_4[A]	NO_X	PM[B]
Euro III	1999.10, EEVs only	ETC	3.0	0.40	0.65	2.0	0.02
	2000.10		5.45	0.78	1.6	5.0	0.16 0.21[c]
Euro IV	2005.10		4.0	0.55	1.1	3.5	0.03
Euro V	2008.10		4.0	0.55	1.1	2.0	0.03
Euro VI	2013.01		4.0	0.16[d]	0.5	0.4	0.01

a – for spark ignition engines only; Euro III through V: natural gas only; Euro VI: natural gas and liquid petroleum gas

b – not applicable for Euro III and IV gasoline engines

c – for engines with swept volume per cylinder less than 0.75 dm^3 and rated power speed greater than 3000min^{-1}

d – total hydrocarbon for diesel engines

耐久性要求

2005年10月对新车型进行型式核准，2006年10月对全部车型进行型式核准：生产制造商必须保证在下列耐久性周期内达到排放限值：

车辆类型	耐久性要求 (以先达到的为准)	
	欧 IV, V	欧 VI
N1 和 M2	100,000 公里/5年	160,000公里/5年
N2	200,000公里/6年	300,000公里/6年
N3 < 16 吨		
M3 I级, A类, 以及B类< 7.5 吨		
N3 > 16吨	500,000公里/7年	700,000公里/7年
M3 III级, 以及B类> 7.5 吨		

Useful Life Requirements

Effective October 2005 for new type approvals and October 2006 for all type approvals, manufacturers must adhere to emission limits over the following useful life periods:

VEHICLE CATEGORY	PERIOD (WHICHEVER EVENT OCCURS FIRST)	
	EURO IV, V	EURO VI
N1 and M2	100,000 km/5 years	160,000 km/5 years
N2	200,000 km/6 years	300,000 km/6 years
N3 < 16 tonnes		
M3 Class I, Class A, and Class B < 7.5 tonnes		
N3 > 16 tonnes	500,000 km/7 years	700,000 km/7 years
M3 Class III, and Class B > 7.5 tonnes		

中国: 轻型车新车†型式核准排放标准(ECE15 + EUDC 底盘测功机测试)*

柴油	全国	北京	上海	广州	生产一致性	在用符合性	耐久性	OBD 要求
国 I	2000.01 (T1) 2001.01 (T2)[a]	1999	/	/	抽一辆样车	不要求	80,000 公里	不要求
国 II	2004.07 (T1) 2005.07 (T2)	2002	2003.03	2005.07	抽一辆样车	不要求	80,000公里	不要求
国 III[b]	2007.07	2007.01	2007.12.31	2006.09	抽三辆样车	要求	5 年或80,000公里	2008.07 (< 6座, GVWR < 2.5吨); 2010.07 起对其他车型进行要求
国 IV	2010.07	/	/	/	抽三辆样车	要求	5年或 80,000公里	2010.07
汽油								
国 I	2000.01 (T1) 2001.01 (T2)[a]	1999	/	/	抽一辆样车	不要求	80,000 公里	不要求
国 II	2004.07 (T1) 2005.07 (T2)	2002	/	/	抽一辆样车	不要求	80,000公里	不要求
国 III[b]	2007.07	2005.12.31	/	/	抽三辆样车	要求	5 年或80,000公里	2008.07 (< 6座, GVWR < 2.5吨); 2010.07 起对其他车型进行要求
国 IV	2010.07	2008.03	2009.11	/	抽三辆样车	要求	5年或 80,000公里	2010.07

† 自型式核准执行日期之后一年起，不达标的新车和新发动机不得销售、注册或使用。标准不适用于在型式核准执行日期之前已登记注册的车型

* 速度点与ECE15和EUDC工况基本相同，除了有部分瞬态速度点

a – T1 M1类轻型车要求不多于 6 座，并且质量不超过25吨；T2是其他非T1类的轻型车

b –国III 标准原定在2007年对所有新车型实施，但是允许有一年的过渡期，所以所有车型在2008年之前都可以销售（重型车截止1月，轻型车截止7月）

China: Emission Standards for New† Light-duty Vehicle Type Approval (ECE15 + EUDC chassis dynamometer test)*

DIESELS	CHINA	BEIJING	SHANGHAI	GUANGZHOU	PRODUCTION CONFORMITY	IN-USE SURVEILLANCE	DURABILITY	OBD REQUIREMENT
China I	2000.01 (T1) 2001.01 (T2)[a]	1999	/	/	Sample of one	No	80,000 km	No
China II	2004.07 (T1) 2005.07 (T2)	2002	2003.03	2005.07	Sample of one	No	80,000 km	No
China III[b]	2007.07	2007.01	2007.12.31	2006.09	Sample of three	Yes	5 years or 80,000 km	2008.07 (< 6 seats, GVWR < 2.5t); 2010.07 for other vehicles
China IV	2010.07	/	/	/	Sample of three	Yes	5 years or 80,000 km	2010.07
GASOLINE								
China I	2000.01 (T1) 2001.01 (T2)[a]	1999	/	/	Sample of one	No	80,000 km	No
China II	2004.07 (T1) 2005.07 (T2)	2002	/	/	Sample of one	No	80,000 km	No
China III[b]	2007.07	2005.12.31	/	/	Sample of three	Yes	5 years or 80,000 km	2008.07 (< 6 seats, GVWR < 2.5t); 2010.07 for other vehicles
China IV	2010.07	2008.03	2009.11	/	Sample of three	Yes	5 years or 80,000 km	2010.07

† Standards for existing models typically implemented one year later than standards for new models prior to the implementation of China IV. Starting from China IV, standards will apply on both new and existing models at the same time

* Speed points are mostly the same as in ECE15 and EUDC cycles, except for some transient speed points

a – Type 1 M1 LDVs carry no more than 6 seats and weigh no more than 25 tonnes; T2-other non-type 1 LDVs

b – The China III standard was supposed to be effective in 2007 for all new vehicle type approval, but a transition period of one year was allowed, so all approved vehicles could still be sold until 2008 (Jan for HDV and July for LDV)

*中国:重型车新车†型式核准排放标准 **

柴油	全国	北京	上海	广州	生产一致性	在用符合性	耐久性	OBD 要求
国 I	2000.09	1999	1999	/	抽一辆样车	不要求	-	不要求
国 II	2003.09	2002	2003.03	2005.07	抽一辆样车	不要求	5 年或80,000公里[e]; 5年或100,000公里[f]; 6年或250,000公里[g]	不要求
国 III[b]	2007.01	2005.12.31	2007.12.31	2006.09	抽三辆样车	不要求	同欧II	不要求
国 IV	2010.01	2008.07[a,c]	2009.11[c]		抽三辆样车	要求	同欧II	要求
汽油								
国 I	2002.07	1999	/	/	抽一辆样车	不要求	5年或80,000公里	不要求
国 II	2003.09	/	/	/	抽一辆样车	不要求	5年或80,000公里[d]	不要求
国 III[b]	2009.07	2005.12.31	/	/	抽三辆样车	不要求	5年或 80,000公里[d]	2009.07
国 IV	2012.07	2008.07[a]	/	/	抽三辆样车	要求	5年或80,000公里	2012.07

† 自型式核准执行日期之后一年起，不达标的新车和新发动机不得销售、注册或使用。标准不适用于在型式核准执行日期之前已登记注册的车型

* 中国沿用欧盟的重型柴油车的测试循环，但是在国III 及以后的耐久性测试中采用了日本05试验

a – 对NOx 进行OBD要求

b –国III 标准原定在2007年对所有新车型实施，但是允许有一年的过渡期，所以所有车型在2008年之前都可以销售（重型车截止1月，轻型车截止7月）

c – 在北京，国IV 标准在柴油公交车和邮政、环卫（垃圾收集）用柴油车中实施；在上海，除在北京实施的车型外还对建筑用卡车进行了要求

d –2007年10月1日实施

e –对质量大于3.5吨的M1类车，和M2类车的耐久性要求

f –对质量小于7.5吨的 M3 类车，和质量小于16吨的N2类车的耐久性要求

g –对质量大于7.5吨的M3 类车，和质量大于16吨的N2类车的耐久性要求

*China: Emission Standards for New† Heavy-duty Vehicle Type Approval**

DIESELS	CHINA	BEIJING	SHANGHAI	GUANGZHOU	PRODUCTION CONFORMITY	IN-USE SURVEILLANCE	DURABILITY	OBD REQUIREMENT
China I	2000.09	1999	1999		Sample of one	No	-	No
China II	2003.09	2002	2003.03	2005.07	Sample of one	No	5 years or 80,000 km[e]; 5 years or 100,000 km[f]; 6 years or 250,000 km[g]	No
China III[b]	2007.01	2005.12.31	2007.12.31	2006.09	Sample of three	No	Same as Euro II	No
China IV	2010.01	2008.07[a,c]	2009.11[c]		Sample of three	Yes	Same as Euro II	Yes
GASOLINE								
China I	2002.07	1999			Sample of one	No	5 years or 80,000 km	No
China II	2003.09				Sample of one	No	5 years or 80,000 km[d]	No
China III[b]	2009.07	2005.12.31			Sample of three	No	5 years or 80,000 km[d]	2009.07
China IV	2012.07	2008.07[a]			Sample of three	Yes	5 years or 80,000 km	2012.07

† Standards for existing models typically implemented one year later than standards for new models prior to the implementation of China IV. Starting from China IV, standards will apply on both new and existing models at the same time

* China follows the same test cycle schedule as the EU but uses the Japan05 test for durability in Euro III and later models

a – Requires OBD for NOx

b – The China III standard was supposed to be effective in 2007 for all new vehicle type approval, but a transition period of one year was allowed, so all approved vehicles could still be sold until 2008 (Jan for HDV and July for LDV)

c – In Beijing, China IV covers diesel public buses and diesel trucks used for postal and public sanitary (garbage collection) services; in Shanghai, it covers those categories regulated under China IV in Beijing plus construction trucks

d – Took effect on October 1, 2007

e – Durability requirement for M1 vehicles with gross vehicle weight greater than 3.5 tons and M2 vehicles

f – Durability requirement for M3 vehicles less than 7.5 tons; N2 and N3 vehicles less than 16 tons

g – Durability requirement for M3 vehicles over 7.5 tons and N3 vehicles over 16 tons

中国:摩托车新车†型式核准排放标准 *

实施年	发动机排量 (cc)	CO (g/km)	HC (g/km)	NO_x (g/km)	HC+ NO_x (g/km)	PM (g/km)	工况	冷启动	耐久性 (km)
两轮车二冲程发动机									
2003	<50 cc (轻便式)	6			3		ECE R47	否	6,000 [1]
	≥50 cc	8	4	0.1			ECE R40	否	6,000 [1]
2004	≥50 cc	5.5	1.2	0.3			ECE R40	否	10,000 [1]
2005	<50 cc (轻便式)	1			1.2		ECE R47	否	10,000 [1]
两轮车四冲程发动机									
2003	<50 cc (轻便式)	6			3		ECE R47	否	6,000 [1]
	≥50 cc	13	3	0.3			ECE R40	否	6,000 [1]
2004	≥50 cc	5.5	1.2	0.3			ECE R40	否	10,000 [1]
2005	<50 cc (轻便式)	1			1.2		ECE R47	否	10,000 [1]
2008	< 50 cc	1			1.2		ECE R47	是	10,000
	50-150 cc	2	0.8	0.15			ECE R40	是	18,000 [2] 30,000 [3]
	≥ 150 cc	2	0.3	0.15			ECE R40 +EUDC	是	18,000 [2] 30,000 [3]
三轮车二冲程发动机									
2003	< 50 cc (轻便式)	12			6		ECE R47	否	6,000 [1]
2003	≥50cc	12	6	0.15			ECE R40	否	6,000 [1]
2004	≥50cc	7	1.5	0.4			ECE R40	否	10,000 [1]
2005	< 50 cc (轻便式)	3.5			1.2		ECE R47	否	10,000 [1]
2008	< 50 cc (轻便式)	3.5			1.2		ECE R47	是	10,000
	≥ 50cc	4	1	0.25			ECE R40	是	12,000 [4] 18,000 [2] 30,000 [3]
三轮车四冲程发动机									
2003	< 50 cc (轻便式)	12			6		ECE R47	否	6,000 [1]
2003	≥50cc	19.5	4.5	0.45			ECE R40	否	6,000 [1]
2005	< 50 cc (轻便式)	3.5			1.2		ECE R47	否	10,000 [1]
2005	≥50cc	7	1.5	0.4			ECE R40	否	10,000 [1]
2008	< 50 cc (轻便式)	3.5			1.2		ECE R47	是	
	≥50cc	4	1	0.25			ECE R40	是	12,000 [4] 18,000 [2] 30,000 [3]

注: 1 是否装有尾气空气装置; 2 最高时速在130 km/h以下并且发动机排量高于 150cc; 3 最高时速在130 km/h或以上并且发动机排量高于150cc; 4 发动机排量在50 和150 cc之间; 轻便式摩托车: 最高时速小于等于50 km/h 并且发动机排量晓于等于50 cc

China: Emission Standards for New Motorcycle Type Approval

Year Began	Engine Size (cc)	CO (g/km)	HC (g/km)	NO_x (g/km)	HC+ NO_x (g/km)	PM (g/km)	Driving Cycle	Cold Start	Durability (km)
Two-Wheeler with Two-Stroke Engine									
2003	<50 cc (moped)	6			3		ECE R47	No	6,000 [1]
	≥50 cc	8	4	0.1			ECE R40	No	6,000 [1]
2004	≥50 cc	5.5	1.2	0.3			ECE R40	No	10,000 [1]
2005	<50 cc (moped)	1			1.2		ECE R47	No	10,000 [1]
Two-Wheeler with Four-Stroke Engine									
2003	<50 cc (moped)	6			3		ECE R47	No	6,000 [1]
	≥50 cc	13	3	0.3			ECE R40	No	6,000 [1]
2004	≥50 cc	5.5	1.2	0.3			ECE R40	No	10,000 [1]
2005	<50 cc (moped)	1			1.2		ECE R47	No	10,000 [1]
2008	< 50 cc	1			1.2		ECE R47	Yes	10,000
	50-150 cc	2	0.8	0.15			ECE R40	Yes	18,000 [2] 30,000 [3]
	≥ 150 cc	2	0.3	0.15			ECE R40 +EUDC	Yes	18,000 [2] 30,000 [3]
Three-Wheeler with Two-Stroke Engine									
2003	< 50 cc (moped)	12			6		ECE R47	No	6,000 [1]
2003	≥50cc	12	6	0.15			ECE R40	No	6,000 [1]
2004	≥50cc	7	1.5	0.4			ECE R40	No	10,000 [1]
2005	< 50 cc (moped)	3.5			1.2		ECE R47	No	10,000 [1]
2008	< 50 cc (moped	3.5			1.2		ECE R47	Yes	10,000
	≥ 50cc	4	1	0.25			ECE R40	Yes	12,000 [4] 18,000 [2] 30,000 [3]
Three-Wheeler with Four-Stroke Engine									
2003	< 50 cc (moped)	12			6		ECE R47	No	6,000 [1]
2003	≥50cc	19.5	4.5	0.45			ECE R40	No	6,000 [1]
2005	< 50 cc (moped)	3.5			1.2		ECE R47	No	10,000 [1]
2005	≥50cc	7	1.5	0.4			ECE R40	No	10,000 [1]
2008	< 50 cc (moped)	3.5			1.2		ECE R47	Yes	
	≥50cc	4	1	0.25			ECE R40	Yes	12,000 [4] 18,000 [2] 30,000 [3]

Notes: 1 If installed with emission control device; 2 Maximum speed under 130 km/h and displacement above 150cc; 3 Maximum speed equal to or above 130 km/h and displacement above 150cc;

4 Displacement between 50 and 150 cc; Moped: Maximum speed under or equal to 50 km/h and displacement under or equal to 50 cc

日本: 汽油和LPG燃料汽车排放标准

	新车型	所有车型/ 进口车型	测试工况	单位	CO	HC[a]	NOx	PM
新短期 (平均值/最大值[b])								
乘用车	2000.10	2002.09	10-15 工况	克/公里	0.67/1.27	0.08/0.17	0.08/0.17	-
			11工况	克/次	19.0/31.1	2.20/4.42	1.40/2.50	-
微型商用车	2002.10	2003.09	10-15工况	克/公里	3.30/5.11	0.13/0.25	0.13/0.25	-
			11工况	克/次	38.0/58.9	3.50/6.40	2.20/3.63	-
轻型商用车	2000.10	2002.09	10-15工况	克/公里	0.67/1.27	0.08/0.17	0.08/0.17	-
			11工况	克/次	19.0/31.1	2.20/4.42	1.40/2.50	-
中型商用车	2001.10	2003.09	10-15工况	克/公里	2.10/3.36	0.08/0.17	0.13/0.25	-
			11工况	克/次	24.0/38.5	2.20/4.42	1.60/2.78	-
新长期 (平均值/最大值)								
乘用车	2005.10	2007.09	10-15工况+ 11工况	克/公里	1.15/1.92	0.05/0.08	0.05/0.08	-
微型商用车	2007.10	2008.09/ 2007.09			4.02/6.67	0.05/0.08	0.05/0.08	-
轻型商用车(轻型)	2005.10	2007.09			1.15/1.92	0.05/0.08	0.05/0.08	-
轻型商用车(中型)					2.55/4.08	0.05/0.08	0.07/0.10	-
后新长期[c]								
乘用车	2009.10	2009.10/ 2010.09	JC08H + JC08C	克/公里	1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007
轻型商用车(轻型)					1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007
轻型商用车(中型)					2.55/4.08	0.05/0.08	0.07/0.10	0.007/0.009

a –2005年以后HC按照非甲烷碳氢化合物测试

b – 平均值: 作为产品平均水平的型式核准要求来达标；最大值：如果每年每车型销售少于2000辆，可以作为型式核准的限制，通常是要求一系列产品中所有单个车型都达标

c – 新颗粒物测试方法；采取了技术改进的方法对CO和其他气体进行测试

耐久性要求

- 最大总质量小于3.5吨的乘用车，卡车和巴士：80,000公里
- 最大总质量大于3.5吨的乘用车，卡车和巴士：250,000公里

Japan: Emission Standards for Gasoline and LPG fuelled Vehicles

	NEW MODEL	ALL MODELS/ IMPORTS	TEST CYCLE	UNIT	CO	HC[a]	NOX	PM
NEW SHORT TERM (MEAN/MAX[b])								
PC	2000.10	2002.09	10-15 mode	g/km	0.67/1.27	0.08/0.17	0.08/0.17	-
			11 mode	g/test	19.0/31.1	2.20/4.42	1.40/2.50	-
Mini CV	2002.10	2003.09	10-15 mode	g/km	3.30/5.11	0.13/0.25	0.13/0.25	-
			11 mode	g/test	38.0/58.9	3.50/6.40	2.20/3.63	-
Light CV	2000.10	2002.09	10-15 mode	g/km	0.67/1.27	0.08/0.17	0.08/0.17	-
			11 mode	g/test	19.0/31.1	2.20/4.42	1.40/2.50	-
Medium CV	2001.10	2003.09	10-15 mode	g/km	2.10/3.36	0.08/0.17	0.13/0.25	-
			11 mode	g/test	24.0/38.5	2.20/4.42	1.60/2.78	-
NEW LONG TERM (MEAN/MAX)								
PC	2005.10	2007.09	10-15 mode + 11 mode	g/km	1.15/1.92	0.05/0.08	0.05/0.08	-
Mini CV	2007.10	2008.09/ 2007.09			4.02/6.67	0.05/0.08	0.05/0.08	-
Light CV	2005.10	2007.09			1.15/1.92	0.05/0.08	0.05/0.08	-
Medium LCV					2.55/4.08	0.05/0.08	0.07/0.10	-
POST NEW LONG TERM[C]								
PC	2009.10	2009.10/ 2010.09	JC08H + JC08C	g/km	1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007
Light LCV					1.15/1.92	0.05/0.08	0.05/0.08	0.005/0.007
Medium LCV					2.55/4.08	0.05/0.08	0.07/0.10	0.007/0.009

a – From 2005, HC is measured as NMHC

b – Mean: to be met as a type approval limit and as a production average; max: to be met as type approval limit if sales are less than 2,000 per vehicle model per year and generally as an individual limit in series production

c – New PM measurement method; technically modified methods for CO and other gases

Useful Life Requirements

■PC, trucks, and buses with GVWR less than 3.5tonnes: 80,000 km

■PC, trucks, and buses with GVWR greater than 3.5tonnes: 250,000 km

OBD – 柴油，汽油，液化石油气

- J-OBDII: 对最大总质量小于3.5吨的乘用车和商用车自2008年10月加强OBD要求
- 同样接纳欧盟/美国 OBD 标准作为等价标准

日本: 柴油车排放标准

	新车型	所有车型/进口车型	测试工况	单位	CO	HC[a]	NOx	PM
新短期 (平均值/最大值[b])								
乘用车< 1,265 千克	2002.10	2004.09	10-15 工况	克/公里	0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11
乘用车> 1,265 千克					0.63/0.98	0.12/0.24	0.30/0.45	0.056/0.11
轻型商用车					0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11
中型商用车	2003.10				0.63/0.98	0.12/0.24	0.49/0.68	0.06/0.12
新长期 (平均值/最大值)								
乘用车< 1,265 千克	2005.10	2007.09	10-15 工况 + 11 工况	克/公里	0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017
乘用车> 1,265 千克					0.63/0.84	0.024/0.032	0.15/0.20	0.014/0.019
轻型商用车					0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017
中型商用车					0.63/0.84	0.024/0.032	0.25/0.33	0.015/0.020
后新长期[c]								
乘用车	2009.10	2009.10/ 2010.09	JC08H + JC08C	克/公里	0.63/0.84	0.024/0.032	0.08/0.11[e]	0.005/0.007
轻型商用车(轻型)					0.63/0.84	0.024/0.032	0.08/0.11	0.005/0.007
轻型商用车(中型)	2010.10[d]				0.63/0.84	0.024/0.032	0.15/0.20	0.007/0.009

a –2005年以后HC按照非甲烷碳氢化合物测试

b – 平均值：作为产品平均水平的型式核准要求来达标；最大值：如果每年每车型销售少于2000辆，可以作为型式核准的限制，通常是要求一系列产品中所有单个车型都达标

c – 新颗粒物测试方法：采取了技术改进的方法对CO和其他气体进行测试

d –2010年10月对最大总质量处于1,700 —3,500 千克的中型商用车实施，2009年10月对最大总质量处于2,500—3,500千克的中型商用车实施

e –对于最大总质量不超过1,265千克的机动车及最大总质量大于1,265千克的机动车，限值为 0.15/0.20

OBD – Diesel, Gasoline, and LPG

- J-OBDII: enhanced OBD requirement for PCs and CVs with GVWR less than 3.5 tonnes from Oct 2008
- EU/US OBD standards accepted as equivalent

Japan: Emission Standards for Diesel Vehicles

	NEW MODEL	ALL MODELS/ IMPORTS	TEST CYCLE	UNIT	CO	HC[a]	NOX	PM
NEW SHORT TERM (MEAN/MAX[b])								
PC < 1,265 kg	2002.10	2004.09	10-15 mode	g/km	0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11
PC > 1,265 kg					0.63/0.98	0.12/0.24	0.30/0.45	0.056/0.11
Light CV					0.63/0.98	0.12/0.24	0.28/0.43	0.052/0.11
Medium CV	2003.10				0.63/0.98	0.12/0.24	0.49/0.68	0.06/0.12
NEW LONG TERM (MEAN/MAX)								
PC < 1,265 kg	2005.10	2007.09	10-15 mode + 11 mode	g/km	0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017
PC > 1,265 kg					0.63/0.84	0.024/0.032	0.15/0.20	0.014/0.019
Light CV					0.63/0.84	0.024/0.032	0.14/0.19	0.013/0.017
Medium CV					0.63/0.84	0.024/0.032	0.25/0.33	0.015/0.020
POST NEW LONG TERM[c]								
PC	2009.10	2009.10/ 2010.09	JC08H + JC08C	g/km	0.63/0.84	0.024/0.032	0.08/0.11[e]	0.005/0.007
Light LCV					0.63/0.84	0.024/0.032	0.08/0.11	0.005/0.007
Medium LCV	2010.10[d]				0.63/0.84	0.024/0.032	0.15/0.20	0.007/0.009

a – From 2005, HC is measured as NMHC

b – Mean: to be met as a type approval limit and as a production average; max: to be met as type approval limit if sales are less than 2,000 per vehicle model per year and generally as an individual limit in series production

c – New PM measurement method; technically modified methods for CO and other gases

d – Oct 2010 for Medium CV with 1,700 kg < GVWR < 3,500 kg; Oct 2009 for Medium CV with 2,500 kg < GVWR < 3,500 kg

e – For vehicles not exceeding 1,265 kg; for vehicles greater than 1,265 kg, the values are 0.15/0.20

术语：

10-15 工况 – 日本适用于轻型车的排放浓度和燃料经济性测试的工况；在10-工况基础上加上另一个最高速度为70公里/小时

15-工况段组成

11-工况 – 日本适用于轻型车的排放浓度和燃料经济性测试负载车重=空载质量和最大总质量的平均值

CH_4 –甲烷

CO – 一氧化碳

CV – 商用车

DI – 直接喷射

ECE R-49 –稳态柴油发动机13-工况 (速度和负载)

ECE15 –城市行驶工况, 也被称为UDC,是欧洲开发用于描述城市行驶条件的工况

EEV –环境友好汽车

ELR – 发动机烟雾测试试验

ESC – 欧洲稳态工况，也被称为OICA/ACEA 工况，稳态发动机测试13-工况代替了 R-49工况

EUDC – 额外城市行驶工况：变速更迅速、高速行驶工况

FTP Transient – 用来模拟重型卡车和巴士城区和高速公路行驶情况的发动机台架试验

FTP-75 – 美国的轻型车测试工况，分为三个部分： 1) 冷启动, 2) 瞬态， 3) 热启动

GVWR – 额定车辆总质量=车辆最大负荷质量

HC – 碳氢化合物

HCHO – 甲醛

HLDT –轻型卡车（重型）；最大总质量为 6,001至8,500磅, 包括LDT3和LDT4

IDI – 间接喷射

JC08 –日本开发的排放和燃料经济性测试的新的城市行驶工况，从2011年起将完全替代10-15工况

JC08C – “冷的”JC08试验

JC08H – “热的”JC08试验

LCV – 轻型商用车; 最大总质量小于3,500千克 (2005年之前为2,500千克)

LDT1 – 轻型卡车1; 最大总质量小于6,000磅，满载车质量小于3,750磅

LDT2 –轻型卡车2; 最大总质量小于6,000磅，并且满载车质量为3,750至5,750磅

LDT3 –轻型卡车3; 最大总质量为6,001至8,500磅，并且满载车质量为3,750至5,750磅

LDT4 –轻型卡车4; 最大总质量为6,001至8,500磅，并且满载车质量大于5,750磅

LDV – 轻型车

Light LCV – 轻型商用车（轻型）; 最大总质量< 1,700 千克

LLDT – 轻型卡车（轻型）：最大总质量小于6,000磅，包括 LDT1和LDT2

Acronyms

10-15 mode – cycle used in Japan for emission certification and fuel economy for light duty vehicles; derived from the 10-mode cycle by adding another 15-mode segment of a maximum speed of 70 km/h

11-mode – a cold start cycle used in Japan for emission certification and fuel economy for light duty vehicles

ALVW – adjusted loaded vehicle weight = average of the curb (empty) weight and the GVWR

CH4 – methane

CO – carbon monoxide

CV – commercial vehicle

DI – direct injection

ECE R-49 – 13-mode (speed and load) steady-state diesel engine test cycle

ECE15 – urban driving cycle, also known as UDC, devised to represent city driving conditions in the EU

EEV – enhanced environmentally friendly vehicle

ELR – engine test for smoke opacity measurement

ESC – European Stationary Cycle, also known as the OICA/ACEA cycle, 13-mode steady-state engine test that replaces the R-49

EUDC – Extra Urban Driving Cycle; more aggressive, high speed driving modes

FTP Transient – an engine dynamometer test designed to simulate both urban and freeway driving for heavy-duty trucks and buses

FTP-75 – test cycle for light-duty vehicles in the US consisting of three phases: 1) cold start, 2) transient, and 3) hot start

GVWR – gross vehicle weight rating = maximum fully leaded vehicle weight

HC – hydrocarbon

HCHO – formaldehyde

HLDT – heavy light-duty truck; between 6,001 and 8,500 lbs GVWR, includes LDT3 and LDT4

IDI – indirect injection (s)

JC08 – new urban driving cycle for emission and fuel economy measurement that will fully replace the 10-15 mode cycle by 2011

JC08C – JC08 test performed'cold'

JC08H – JC08 test performed'hot'

LCV – light commercial vehicle; GVWR less than 3,500 kg (2,500 kg before 2005)

LDT1 – light-duty truck 1; up to 6,000 GVWR and up to 3,750 lbs LVW

LDT2 – light-duty truck 2; up to 6,000 GVWR and between 3,750 and 5,750 lbs LVW

LDT3 – light-duty truck 3; between 6,001 and 8,500 lbs GVWR and between 3,750 and 5,750 lbs ALVW

LDT4 – light-duty truck 4; between 6,001 and 8,500 lbs GVWR and over 5,750 lbs ALVW

LDV – light-duty vehicle

Light LCV – light light commercial vehicle; GVWR < 1,700 kg

LLDT – light light-duty truck; up to 6,000 lbs GVWR, includes LDT1 and LDT2

LVW –满载车质量=整车整备质量 + 300 磅

M1 – 指包括驾驶员座位在内，座位数不超过九座的载客汽车

M2 – 指包括驾驶员座位在内座位数超过九座，且最大质量（”最大设计总质量”）不超过5吨的载客汽车

M3 –指包括驾驶员座位在内座位数超过九座，且最大设计总质量超过5吨的载客汽车

MDPV – 中型乘用车，最大总质量为8,500至10,000磅的卡车

Medium LCV – 轻型商用车（中型）：1,700 千克<最大总质量< 3,500 千克

N1 – 最大设计总质量不超过3.5吨的载货汽车

N2 – 最大设计总质量超过3.5吨，但不超过12吨的载货汽车

N3 – 最大设计总质量超过12吨的载货汽车

NMHC –非甲烷碳氢化合物

NMOG – 非甲烷有机气体

NOx – 氮氧化物

OBD – 车载诊断系统

PC – 乘用车

PM –颗粒物

PMP –颗粒物测试方法

SET – 补充排放试验(SET); 美国用于认证的稳态发动机台架试验

LVW – loaded vehicle weight = nominal empty vehicle weight + 300 lbs

M1 – vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat

M2 – vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass ("technically permissible maximum laden mass") not exceeding 5 tonnes

M3 – vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes

MDPV – medium-duty passenger vehicle; light truck (SUV or minivan) between 8,500 and 10,000 lbs GVWR

Medium LCV – medium light commercial vehicle; 1,700 kg < GVWR < 3,500 kg

N1 – vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes

N2 – vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tons but not exceeding 12 tonnes

N3 – vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes

NMHC –non-methane hydrocarbons

NMOG – non-methane organic gas

NOx – oxides of nitrogen

OBD – on-board diagnostics

PC – passenger car

PM – particulate matter

PMP – Particle Measurement Programme

SET – Supplemental Emission Test (SET); steady-state engine dynamometer test used for certification in the US

附录D: 达到欧4/IV, 5/V, 6/VI 所需的技术

轻型车

表 D-1 介绍了达到欧4，欧5和欧6常规污染物排放水平的基本技术。

表 D-1. 轻型车常规污染物控制技术要求

柴油车	轻型车. (1.2<排量<2.0 升) 轻型卡车最大总质量< 2.5 吨		
	欧 3 到欧4	欧4到欧5	欧 5到欧6
控制的污染物	(NOx/PM/CO)	(NOx/PM/CO)	(NOx/PM/CO)
排放目标克/公里	0.25/0.025/0.5	0.18/0.005/0.5	0.08/.0045/0.5
排放削减比例	50% / 50% / 22%	28% / 80% / 0	66% / 10%/ 0
基本技术	*电控燃料定时和定量 *电控EGR, 加装冷却系统 *直接喷射 (DI) 燃烧和高压喷油 (HPFI) * 柴油车氧化催化装置 (DOC)	欧4装置基础上增加	欧5装置基础上增加
发动机排出的污染物 空燃比控制	* 4 气门技术 *涡轮增压中冷（TCI）	-	*燃烧研究 PCCI, LTC *可变截面涡轮增压器 (VGT)
后处理装置	-	轻型车 Class B,C级: DOC + DPF 或者仅 DPF	DOC + DPF + LNT 或者 DPF + LNT

Appendix D- Technologies required to meet Euro 4/IV, 5/V, 6/VI

Light Duty Vehicles

Table D-1 presents the basic technologies required to comply with Euro 4, Euro 5 and Euro 6 emission levels of conventional pollutants.

Table D-1. LDV Technology requirements for control of conventional pollutants

DIESEL	LDVS. (1.2<VD<2.0 LITERS) LDTS GVW < 2.5 TONS		
	EURO 3 TO EURO 4	EURO 4 TO EURO 5	EURO 5 TO EURO 6
Reg. pollutants	(NOx/PM/CO)	(NOx/PM/CO)	(NOx/PM/CO)
Emissions target, g/km	0.25/0.025/0.5	0.18/0.005/0.5	0.08/.0045/0.5
Emissions reduction	50% / 50% / 22%	28% / 80% / 0	66% / 10%/ 0
Base technology	*Electric fuel timing & metering *Electric EGR, with cooling system *Direct injection (DI) combustion and High pressure fuel injection (HPFI) * Diesel Oxidation Catalyst (DOC)	Euro 4 equipment plus	Euro 5 equipment plus
Engine -out emissions A/F control	* 4 valves per cylinder *Turbocharging with intercooling	-	*Combustion research PCCI, LTC *Variable geometry turbocharger (VGT)
Aftertreatment System	-	LDVs Class B,C: DOC + DPF or DPF only	DOC + DPF + LNT or DPF + LNT

汽油车	轻型车. (1.2<排量<2.0 升) 轻型卡车最大总值< 2.5 吨		
	欧 3 到欧4	欧4到欧5	欧 5到欧6
控制的污染物	CO/NOx/HC	CO/NOx/HC	CO/NOx/HC
排放目标克/公里	1.0/0.08/0.1	1.0/ 0.06/ 0.1	1.0/ 0.06/ 0.1
排放削减比例	57% / 50% / 50%	0 / 25% / 0	0 / 0 / 0
基本技术	*配比燃烧 *电子喷射 *电子点火 *多点喷射 (MPI) *OBD要求额外的一个氧传感器 *改善控制器和硬件 *三元催化器(车底)	-欧 4 装置 -增加缸内直喷 (GDI) -稀薄燃烧- 加强对GDI车颗粒物排放水平的控制	欧 5 装置
发动机排出的污染物 空燃比控制	与欧 3装置相同： *改善燃料策略来保证冷启动排放控制中紧密耦合(CC)催化器在合理的温度范围内 *增加EGR的使用来控制NOx	与欧4车相同，再加上： *改善燃烧系统 *可变气门正时系统(VVT) -缸内直喷的要求: *改善喷嘴 *高压喷射 *空燃比控制的线性范围氧传感器	与欧5车相同，再加上： *改善燃烧系统 *涡轮增压，降低排量(燃料经济性效益) *混合动力 (燃料经济性效益) -缸内直喷的要求: *空燃比控制的线性范围氧传感器, 闭环控制下通常要求有两个
后处理装置	-测试循环中去除了预热阶段并且对HC 和CO排放控制要求增加紧密耦合(CC)冷启动催化器	*紧密耦合催化器要求使用储氧装置 *缸内直喷要求安装稀燃氮氧化物吸附装置(LNT)	与欧5车相同

GASOLINE	LDVS. (1.2<VD<2.0 LITERS) LDTS GVW < 2.5 TONS		
	EURO 3 TO EURO 4	EURO 4 TO EURO 5	EURO 5 TO EURO 6
Reg. pollutants	CO/NOx/HC	CO/NOx/HC	CO/NOx/HC
Emissions target, g/km	1.0/0.08/0.1	1.0/ 0.06/ 0.1	1.0/ 0.06/ 0.1
Emissions reduction	57% / 50% / 50%	0 / 25% / 0	0 / 0 / 0
Base technology	*Stoichiometric combustion *Elec. Injection *Elec. ignition *Multi-point injection (MPI) *A second O_2 sensor is required for OBD *Improved controller and Hardware *Three way catalyst (underbody)	-Euro 4 equipment -Increased use of gas direct injection (GDI) -lean combustion- forces regulations to include PM emissions levels for GDI vehicles	Euro 5 equipment
Engine -out emissions A/F control	-Same as Euro 3 plus: *Improved fueling strategy to keep closed coupled (CC) catalyst at right temperature range for cold start emissions control *Increased use of EGR for NOx control	-Same as Euro 4 vehicles plus: *Comb. Syst. improvements *Variable valve timing (VVT) -GDIs require: *Improved injectors *Higher press. Injection *Linear range O_2 sensor for A/F control	-Same as Euro 5 vehicles plus: *Comb. Syst. improvements *Turbo. and downsizing (FE) *Hybridization. (FE) -GDIs require: *Linear range O_2 sensors for A/F control, usually two under closed loop control
After-treatment system	-The elimination of warm up period during the test cycle and increased restriction on HC and CO emissions required the addition of a closed coupled (CC) cold start catalyst	*CC catalyst require the use of oxygen storage components *GDIs require Lean NO_x Traps (LNT)	Same as Euro 5 vehicles

重型车

表 D-2 总结基本排放控制技术和实现每种技术要求的燃料硫含量。

表D-2: 基本排放控制技术

技术	控制效率，% 削减				燃料硫含量要求, ppm	备注
	PM	NOX	HC	CO		
三元催化器	-	>90	>90	>90	<500	适用于配比燃烧的汽油和天然气发动机 是一种成熟的技术
EGR (带有冷却系统)	(a)	20-80	(a)	-	<500	NOx 的削减取决于负载的情况： 高的负载可以进行更高的削减 (a) 不使用空燃比控制系统发动机内的颗粒物和碳氢化合物会增加：电子燃料定时和定量系统和可变截面涡轮增压系统(VGT) 装有适当的空燃比控制系统的美国2010年型发动机和欧V发动机有可能实现氮氧化物和颗粒物的缸内共同削减。 在中等负载的汽油和天然气配比发动机中使用EGR
柴油车氧化催化装置 (DOC)	20-25 (a) ~50 (b)	-	>80	>80	<500 可行 <350 推荐	(a) 高负载试验 (b) 低负载试验 DOC只能减少总颗粒物中的可溶性有机组分 (不能减低细颗粒) 可以削减甲醛和乙醛达 50%-90%
部分流捕集器(PFF)	40-70	-	>80	>80	<350	也被称为部分流技术 (PFT),这种催化捕集器是直流式的DPF.位于尾气上游的DOC提供NO_2，用来在下游通过金属或者纤维网涂层上的接触反应来氧化碳烟。 PFF产生的背压较低，不需要维护

Heavy Duty Vehicles

Table D-2 summarizes the basic emission control technologies and the fuel sulfur levels required for implementing each technology.

Table D-2: Basic emission control technologies

TECHNOLOGY	CONTROL EFFICIENCY, % REDUCTION				FUEL SULFUR REQUIRE-MENT, PPM	COMMENTS
	PM	NOX	HC	CO		
Three Way Catalyst	-	>90	>90	>90	<500	Applies to gasoline and natural gas engines with stoichiometric combustion Well established technology
EGR (w/ cooling)	(a)	20-80	(a)	-	<500	NOx reduction depends on load conditions: higher loads provides higher reductions (a) PM and HC increases in engines without A/F management systems: electronic fuel timing and metering and variable geometry turbocharger (VGT) US2010 engines and Euro V engines with proper A/F management systems may be able to achieve in-cylinder reduction of both NOx and PM EGR is used at mid loads in Stoichiometric engines, both gasoline and NG
Diesel oxidation catalyst (DOC)	20-25 (a) ~50 (b)	-	>80	>80	<500 viable <350 preferred	(a) High load tests (b) Low load tests DOC only reduces SOF out of the total PM (no fine particles reduction) Formaldehyde and acetaldehyde can be reduced by 50%-90%
Partial Flow Filter (PFF)	40-70	-	>80	>80	<350	Also known as Partial Flow technologies (PFT), this catalyzed filter is a flow-trough DPF. It is composed of a DOC upstream which provides NO2 for soot oxidation downstream in catalytic coated metallic or fiber mesh. PFFs generate lower exhaust back-pressure and no maintenance is required.

柴油车颗粒捕集器(DPF)	>70-95 (a) 50-90 (b)	-	60 (c)	-	<50 必需	是指催化颗粒物捕集器，及与DOC联合使用不进行催化的壁流式捕集器—商业上称为CRT 唯一能够削减超细颗粒的技术。低硫燃料可以改善DPF的效果 (a) 元素碳过滤 (碳烟) (b) 可溶性有机组分(SOF). 通过催化氧化机型转化 (c) 催化器再生可以由氧化反应对HC进行削减 对燃料中的硫引起的硫酸盐没有过滤效果 可以削减甲醛和乙醛达 50%-90% DPF在低负载工况-低排气温度下可能增加纳米级颗粒物的数量
稀燃氮氧催化器	-	5-15 (a) 50-60 (b)	-	-	<50必需	正在开发的技术 (a) 被动再生 (基于催化) (b) 主动再生. 需要延迟燃料喷射或者在上游增加燃料
氮氧化物吸附器或稀燃氮氧吸附装置	-	70-90	-	-	<50 必需	再生阶段燃料经济性会下降 在缸内直喷发动机上已经商业化 在道奇和奔驰 E320上商业化应用 重型车上的应用仍在开发中
选择性催化还原装置(SCR)	(a)	50-95%	-	-	不要求	(a) 燃料硫含量水平会影响颗粒物排放 削减水平取决与控制系统的构造 可以改善发动机效率(燃料经济性) 要求尿素供应的基础设施和对适当操作和防止系统失灵的详细规定

Diesel particle filter (DPF)	>70-95 (a) 50-90 (b)	-	60 (c)	-	<50 required	It refers to catalyzed particle filters and the combination DOC+uncatalyzed wall- flow filter – commercially known as CRT- Only technology that significantly reduces ultra-fine particles. Low sulfur fuels improve DPF performance (a) Elemental carbon filtration (soot). (b) Solid organic fraction (SOF). Conversion by catalytic oxidation (c) HC reduction due to catalytic oxidation intended for catalyst regeneration No filtration capabilities for sulfate particulates from fuel sulfur. Formaldehyde and acetaldehyde can be reduced by 50%-90% DPFs may increase nanoparticle number emissions during low load cycles –low temp. exhaust gases-
Lean NOx catalyst	-	5-15 (a) 50-60 (b)	-	-	<50 required	Technology in development (a) Passive regeneration (catalyst based) (b) Active regeneration. It requires late fuel injection or upstream fuel addition
NOx adsorber or Lean NOx traps	-	70-90	-	-	<50 required	Fuel economy penalty associated with regeneration periods Commercialized in GDI engines Commercial applications in Dodge Ram and Mercedes-Benz E320 Heavy duty application still in development
Selective catalytic reduction (SCR)	(a)	50-95%	-	-	No require-ments	(a) PM emissions may be affected by fuel sulfur level Reduction levels depend on control system configuration Allows improved engine efficiency (fuel economy) Require urea supply infrastructure and special provisions for proper operation avoiding system tampering

表D-3 目前达到欧 IV, 欧 V 和欧 VI常规污染物排放水平的基本技术。

表D-3: 中型车常规污染物控制技术的要求

柴油车	规定		
	欧 3 到欧4	欧4到欧5	欧 5到欧6
控制的污染物	NOx/PM/HC/CO	NOx/PM/HC/CO	NOx/PM/HC/CO
排放目标, 克/千瓦时 (a)	3.5 / 0.02 / 0.46 / 1.5	2.0 / 0.02 / 0.46 / 1.5	2.0 / 0.02 / 0.13 / 1.5
排放削减比例 (a)	30%/80%/30%/30%	43% / - / - / -	80%*/ 50%* / 70%/-
基本技术	* 高压喷油 *电控燃料定时和定量 *带冷却系统的电控EGR * DOC	欧4的装置	欧5的装置
空燃比控制和发动机排出的污染物	* 改善发动机燃烧和标定 *涡轮增压中冷 *NOx控制 (b): 带冷却装置的EGR	*改善发动机燃烧和标定 *多点燃料喷射系统(预-主-后喷射) 可变截面涡轮增压器 (VGT) * NOx控制 (b): 带冷却装置的EGR	*可变截面涡轮增压器 (VGT) *燃烧研究PCCI, LTC
后处理装置	NOx 控制 (b): SCR 系统(开环) PM控制l: DOC+ 流通式DPF (PFF)	NOx 控制 (b): SCR 系统(开环) PM控制l: DOC+ 流通式DPF (PFF)	NOx 控制: SCR系统(闭环) PM 控制: DOC+ DPFs

*ETC 测试工况

(a) ESC/ELR工况

(b) 生产制造商选择EGR或者SCR作为NOx的控制手段

PCCI: 预混合压燃. 包括多个燃料的定时和定量控制，允许了多燃烧方式内燃机的使用

LTC: 低温燃烧.针对高温造成NOx形成的空燃比控制的改善

Table D-3 presents the basic technologies required to comply with Euro IV, Euro V and Euro VI emission levels of conventional pollutants.

Table D-3: HDV Technology requirements for control of conventional pollutants

DIESEL	REGULATION		
	EURO III TO EURO IV	EURO IV TO EURO V	EURO V TO EURO VI
Reg. pollutants	NOx/PM/HC/CO	NOx/PM/HC/CO	NOx/PM/HC/CO
Emissions target, g/kWh (a)	3.5 / 0.02 / 0.46 / 1.5	2.0 / 0.02 / 0.46 / 1.5	2.0 / 0.02 / 0.13 / 1.5
Emission reduction (a)	30%/80%/30%/30%	43% / - / - / -	80%*/ 50%* / 70%/-
Base technology	* High pressure fuel injection *Electric fuel timing & metering *Electric EGR, with cooling system * DOC	Euro 4 equipment	Euro 5 equipment
A/F control & Engine -out emissions	* Improvements in engine combustion and calibration *Turbocharging with intercooling *NOx control (b): EGR cooled	* Improvements in engine combustion and calibration *Multiple injection fuel system (pilot-main-post) Variable geometry turbocharger (VGT) *NOx control (b): EGR cooled	*Variable geometry turbocharger (VGT) *Combustion research PCCI, LTC
Aftertreatment System	NOx control (b): SCR systems (open loop) PM control: DOC+ flow trough DPFs (PFF)	NOx control (b) : SCR systems (closed loop) PM control: DOC+ flow trough DPFs (PFF)	NOx control: SCR systems (closed loop) PM control: DOC+ DPFs

*ETC test cycle

(a) ESC/ELR cycle

(b) NOx control through EGR or SCR is manufacturers choice

PCCI: Premixed charge compression ignition. Includes multiple fuel timing and metering, allowing for multimodal combustion engine

LTC: Low temperature Combustion. A/F management improvements aiming to avoid high temperatures that led to NOx formation.

表 D-4: 达到欧1,2,3摩托车排放标准所需的技术

	欧1之前至欧1	欧1 至欧 2	欧 2 至欧 3
控制的污染物	NOx/HC/CO	NOx/HC/CO	NOx/HC/CO
排放水平	0.3/3/13	0.3/1.2/5.5	0.15/0.8/2
排放削减比例	/	0%/60%/60%	50%/33%/63%
基本技术	化油器	/	/
空燃比控制和发动机排放污染物	/	化油器或开环燃料喷射	闭环燃料喷射
后处理装置	催化氧化器	带有二次空气喷射的催化氧化器或三元催化器	带有二次空气喷射的催化氧化器三元催化器

Table D-4: Motorcycles technology requirement to meet Euro 1, 2, and 3

	PRE-EURO TO EURO 1	EURO 1 TO EURO 2	EURO 2 TO EURO 3
Reg. pollutants	NOx/HC/CO	NOx/HC/CO	NOx/HC/CO
Emission levels	0.3/3/13	0.3/1.2/5.5	0.15/0.8/2
Emission reduction	/	0%/60%/60%	50%/33%/63%
Base technology	Carburetor	/	/
A/F control & Engine -out emissions	/	Carburetor OR Open loop fuel injection	Closed loop fuel injection
Aftertreatment System	Oxidation catalyst	Oxidation catalyst with secondary air injection OR Three –way catalyst	Oxidation catalyst with secondary air injection OR Three-way catalyst

附录 E:燃料参数对排放水平的影响

表 E-1: 汽油组分对轻型车排放的影响

汽油	不装催化器	欧1	欧2	欧 3	欧4	欧5/6[173]	备注
铅↑	Pb, HC↑	随着催化器的失效CO, HC, NO_x全部增加					中国自2000年起禁止使用含铅汽油
硫↑(50至450 ppm)	SO_2↑	CO, HC, NO_x增加15%-20% SO_2和 SO_3增加					可能引起OBD指示灯误报
烯烃↑	增加1,3-丁二烯,增加HC反应性, NO_x, 欧3及以后阶段HC会有少量增加						可能形成积碳沉积
芳烃↑	增加尾气中的苯含量						增加进气阀和燃烧室的积碳
	可能引起HC, NO_x增加	HC↑, NO_x↓, CO↑		HC, NO_x, CO ↑			
苯↑	增加尾气和蒸发排放中的苯含量						
乙醇↑小于 3.5% O_2	降低 CO, HC, NO_x略微增加, (当大于2%氧含量), 醛排放增加	对装有氧传感器和适应性记忆控制系统的新车的影响很小					如果不调整RVP，会增加蒸发排放, 可能对燃料系统组件造成影响，可能造成积碳，及少量燃料经济性的损失
MTBE甲基叔丁基醚↑小于 2.7% O_2	降低CO, HC,增加醛类	对装有氧传感器和发动机控制单元设有适应性记忆控制系统(adaptive learning system)的新车的影响很小					引起水污染
蒸馏特性 T50, T90↑	可能引起 HC↑	HC↑					/
MMT甲基环戊二烯三羰基锰↑	增加锰排放	/	/	可能引起催化器堵塞	可能引起催化器堵塞		可能损坏氧传感器和OBD, 引起故障指示灯误报
RVP雷氏蒸汽压↑	增加HC的尾气和蒸发排放						由于亚洲环境温度高，所以是亚洲国家最严格控制的参数
防积碳添加剂↑	/	可能会减低HC, NO_x排放					有益于减少燃料喷嘴，化油器，进气阀，燃烧室的积碳

173 计划2000年执行欧5排放标准，2005年执行欧6标准。

Appendix E: Impacts of fuel specifications on emission performance

Table E-1: Impact of Gasoline Composition on Emissions from Light Duty Vehicles

GASOLINE	NO CATALYST	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5/6[173]	COMMENTS
Lead ↑	Pb, HC ↑	CO, HC, NO_x all increase dramatically as catalyst destroyed					Lead is banned in China since 2000
Sulfur ↑ (50 to 450 ppm)	SO_2 ↑	CO, HC, NO_x all increase 15%-20% SO_2 and SO_3 increase					Onboard Diagnostic light may come on incorrectly
Olefins ↑	Increased 1,3 butadiene, increased HC reactivity, NO_x, small increases in HC for Euro 3 and cleaner						Potential deposit buildup
Aromatics ↑	Increased benzene in exhaust						Deposits on intake valves and combustion chamber tend to increase
	potential increases in HC, NO_x	HC ↑ , NO_x ↓ , CO ↑		HC, NO_x, CO ↑			
Benzene ↑	Increased benzene exhaust and evaporative emissions						
Ethanol ↑ up to 3.5% O_2	Lower CO, HC, slight NO_x increase (when above 2% oxygen content), Higher aldehydes	Minimal effect with new vehicles equipped with oxygen sensors, adaptive learning systems					Increased evaporative emissions unless RVP adjusted, potential effects on fuel system components, potential deposit issues, small fuel economy penalty
MTBE ↑ up to 2.7% O_2	Lower CO, HC, higher aldehydes	Minimal effect with new vehicles equipped with oxygen sensors, adaptive learning systems					Concerns over water contamination
Distillation Characteristics T50, T90 ↑	Probably HC ↑	HC ↑					/
MMT ↑	Increased Manganese Emissions	/	/	Possible Catalyst Plugging	Likely Catalyst Plugging		O_2 sensor and OBD may be damaged, MIL light may come on incorrectly
RVP ↑	Increased evaporative and exhaust HC Emissions						Most critical parameter for Asian countries because of high ambient temperatures
Deposit control additives ↑	/	Potential HC, NO_x emissions benefits					Help to reduce deposits on fuel injectors, carburetors, intake valves, combustion chamber

173 Euro 5 emissions standards were adopted for implementation in 2010; Euro 6 was also adopted for 2015 implementation.

表 E-2: 汽油组分对摩托车排放的影响

汽油	不装催化器	印度 2005	欧 3	印度2008	中国3阶段	备注
铅↑	Pb, HC↑	随着催化器的失效CO, HC, NO_x全部增加				
硫↑（50至450 ppm)	SO_2↑	CO, HC, NO_x增加 SO_2和SO_3增加				/
烯烃↑	增加1,3-丁二烯,增加HC反应性, NO_x					可能形成积碳沉积
芳烃↑	增加尾气排放中的苯含量					/
苯↑	增加尾气和蒸发排放中的苯含量					/
乙醇↑小于 3.5% O_2	减少 CO, HC, 略微增加NO_x	对装有氧传感器的车影响很小				如果不调整RVP，会增加蒸发排放, 可能对燃料系统组件造成影响，可能造成积碳，及少量燃料经济性的损失
MTBE甲基叔丁基醚↑小于2.7% O_2	减少CO, HC	对装有氧传感器的车影响很小				引起水污染，略微降低燃料经济性
蒸馏特性 T50, T90 ↑	可能引起 HC↑	HC↑				不像乘用车那样可以量化
MMT 甲基环戊二烯三羰基锰↑	增加锰排放	可能引起催化器堵塞				孔密度越小催化器堵塞的风险越小，但是对火花塞和燃烧室也有影响
RVP 雷氏蒸汽压↑	增加HC的蒸发排放					
防积碳添加剂↑	/	减低排放				有益于减少燃料喷嘴，化油器的积碳

注: CO =一氧化碳; HC =碳氢化合物; Pb = 铅; RVP = 雷氏蒸汽压; MMT =甲基环戊二烯三羰基锰; MTBE =甲基叔丁基醚; NOX =氮氧化物; O_2=氧气; SO_2= 二氧化硫; T50 =汽油50%馏出温度; T90 =汽油90%馏出温度。

Table E-2: Impact of Gasoline Composition on Emissions from Motorcycles

GASOLINE	NO CATALYST	INDIA 2005	EURO 3	INDIA 2008	CHINA STAGE 3	COMMENTS
Lead ↑	Pb, HC ↑	CO, HC, NO_x all increase dramatically as catalyst destroyed				
Sulfur ↑ (50 to 450 ppm)	SO_2 ↑	CO, HC, NO_x all increase SO_2 and SO_3 increase				
Olefins ↑	Increased 1,3 butadiene, HC reactivity and NO_x					Potential deposit buildup
Aromatics ↑	Increased benzene exhaust					
Benzene ↑	Increased benzene exhaust and evaporative emissions					
Ethanol ↑ up to 3.5% O_2	Lower CO, HC, slight NO_x increase	Minimal effect with oxygen sensor equipped vehicles				Increased evaporative emissions unless RVP adjusted, potential effects on fuel system components, potential deposit issues, small fuel economy penalty
MTBE ↑ up to 2.7% O_2	Lower CO, HC	Minimal effect with O_2 sensor equipped vehicles				Concerns over Water Contamination small fuel economy penalty
Distillation characteristics T50, T90 ↑	Probably HC ↑	HC ↑				**Not as quantifiable as in** passenger cars
MMT ↑	Increased Manganese Emissions	Possible Catalyst Plugging				With low cell density, catalyst plugging risk seems small but there are concerns regarding deposits on spark plugs and in the combustion chamber
RVP ↑	Increased evaporative HC Emissions					/
Deposit control additives ↑		**potential emissions benefits**				Help to reduce deposits on fuel injectors, carburetors

Notes: CO = carbon monoxide; HC = hydrocarbon(s); Pb = lead; RVP = Reid vapor pressure; MMT = methylcyclopentadienyl manganese tricarbonyl; MTBE = methyl tert-butyl ether; NOX = oxides of nitrogen; O_2 = oxygen; SO_2 = sulfur dioxide; T50 = temperature at which 50% of the gasoline distils; T90 = temperature at which 90% of the gasoline distils.

表 E-3:燃料对轻型柴油车的影响

柴油参数	欧1前	欧1	欧 2	欧 3	欧 4	欧 5/6	备注
硫↑	SO_2, PM↑		如果使用氧化催化器, SO_3, SO_2, PM↑		如果采用捕集装置, 燃料硫含量至多50 ppm, 推荐10-15 ppm		如果使用NO_X吸附器，要求硫含量基本为零(<10 ppm) 使用低硫燃料的同时，使用润滑添加剂
十六烷值↑	减少CO, HC, 苯, 1,3 –丁二烯, 甲醛和乙醛						十六烷值低的燃料会排放更多的白烟
密度↓	PM, HC, CO, 甲醛, 乙醛和苯↓, NO_X↑						/
挥发性 (T95由370至 325 C)	NO_X, HC增加, PM, CO降低						/
多环芳烃↓	NO_X, PM, 甲醛和乙醛↓但是HC, 苯和CO↑						一些研究表明总芳族与多环芳烃一样对排放有重要影响

注: CO = 一氧化碳; HC = 碳氢化合物; NO_X = 氮氧化物, PM = 颗粒物; ppm = 百万分之一; SO_2 = 二氧化硫; SO_3或三氧化硫是一种中间产物

表 E-4: 燃料对重型柴油车的影响

柴油参数	欧1前	欧1	欧 2	欧 3	欧 4	欧 5	备注
硫↑	SO_2, PM↑		如果使用氧化催化器, SO_3, SO_2, PM↑		如果采用捕集装置,燃料硫含量至多 50 ppm, 推荐10-15 ppm		如果使用NO_X吸附器，要求硫含量基本为零(<10 ppm) 使用低硫燃料的同时，使用润滑添加剂
十六烷值↑	减少CO, HC, 苯, 1,3 –丁二烯, 甲醛和乙醛						十六烷值低的燃料会排放更多的白烟
密度↓	HC, CO ↑, NO_X↓						/
挥发性 (T95由 370至325 C)	略微降低NO_X但是HC增加						燃料中在370 ℃仍不挥发部分过多造成黑烟和颗粒物的增加
多环芳烃↓	NO_X, PM, HC ↓						一些研究表明总芳族对排放有重要影响

注: CO = 一氧化碳; HC = 碳氢化合物; NO_X = 氮氧化物, PM = 颗粒物; ppm = 百万分之一; SO_2 = 二氧化硫; SO_3或三氧化硫是一种中间产物

Table E-3: Impact of Fuels on Light Duty Diesel Vehicles

DIESEL FUEL CHARACTERISTIC	PRE-EURO	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5/6	COMMENTS
Sulfur ↑	SO_2, PM ↑		If oxidation catalyst is used, SO_3, SO_2, PM ↑		If Filter, 50 ppm maximum, 10-15 ppm better		If NO_x adsorber used requires near zero sulfur (<10 ppm) With low S, use lubricity additives
Cetane ↑	Lower CO, HC, benzene, 1,3 butadiene, formaldehyde & acetaldehyde						Higher white smoke with low cetane fuels
Density ↓	PM, HC, CO, formaldehyde, acetaldehyde & benzene ↓ , NO_x ↑						/
Volatility (T95 from 370 to 325 C)	NO_x, HC increase, PM, CO decrease						/
Polyaromatics ↓	NO_x, PM, formaldehyde & acetaldehyde ↓ but HC, benzene & CO ↑						some studies show that total aromatics are important for emissions in a manner similar to polyaromatics

Notes: CO = carbon monoxide; HC = hydrocarbon; NO_X = oxides of nitrogen, PM = particulate matter; ppm = parts per million; SO = sulfur dioxide; SO_3 or sulfur trioxide is an intermediate compound.

Table E-4: Impact of Fuels on Heavy Duty Diesel Vehicles

DIESEL FUEL CHARACTERISTIC	PRE-EURO	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	COMMENTS
Sulfur ↑	SO_2, PM ↑		If oxidation catalyst is used, SO_3, SO_2, PM ↑		If Filter, 50 ppm maximum, 10-15 ppm better		If NO_x adsorber used requires near zero sulfur (<10 ppm) With low S, use lubricity additives
Cetane ↑	Lower CO, HC, benzene, 1,3-butadiene, formaldehyde & acetaldehyde						Higher white smoke with low cetane fuels
Density ↓	HC, CO ↑ , NO_x ↓						/
Volatility (T95 from 370 to 325 C)	Slightly lower NO_x but increased HC						Too large a fraction of fuel that does not volatilize at 370 C increases smoke and PM
Polyaromatics ↓	NO_x, PM, HC ↓						Some studies show that total aromatics are important

Notes: CO = carbon monoxide; HC = hydrocarbon; NO_X = oxides of nitrogen, PM = particulate matter; ppm = parts per million; S = sulfur; SO_2 = sulfur dioxide; SO_3 or sulfur trioxide is an intermediate compound

附录 F. 中国，欧盟，美国，加州燃料参数的对比

表 F-1. 选定的汽油参数

	国 III	欧 3	欧4	欧5	EPA新配方汽油平均值 (2005)[1]		EPA 传统汽油平均值 (2005) [2]		CARB [3] (CARFG3)			世界燃料宪章种类4 [4]
					夏季	冬季	夏季	冬季	下限	平均限值	上限	
芳烃, 体积分数%, 最大值	40	42	35	35	20.7 [5]	19.5 [5]	27.7	24.7	25	22	35	35
烯烃, 体积分数%, 最大值	30	18	18	18	11.9	11.2	12	11.6	6	4	10	10
苯, 质量分数%,最大值	1	1	1	1	0.66 [6]	0.66 [6]	1.21 [6]	1.15 [6]	0.8	0.7	1.1	1
硫, ppm, 最大值	150	150	50	10	71 [7]	81 [7]	106 [7]	97 [7]	20	15	30 20 [8]	10
RVP雷氏蒸汽压, 千帕	夏季: 72 冬季: 88	60/70 最大值	60/70 最大值	60/70 最大值	47.6 [9] (6.91 psi) 最大值	82.0 (11.89 psi) 最大值	57.2 [9] (8.3 psi)	83.6 (12.12 psi)	48.2 或 47.6 [10] 最大值 (7 或 6.9 psi)	NAP	44.1-49.6 (6.4-7.2 psi)	与国IV 推荐的相同
锰, 微克/升	16	NS	NS	MMT<6 (2011起) MMT<2 (2014起)	NA [11]	NA [11]	NA	NA	ND	ND	ND	ND
氧含量, 质量%	2.7 (最大值)	2.7 (最大值)	2.7 (最大值)	2.7 (最大值)	2.49	2.37	0.95	1.08	1.8-2.2	NAP	0 - 3.5 1.8[12] - 3.5	2.7

NS =未规定; NA = 无法获得; ND = 不能检测出; NAP = 不适用

Appendix F. Comparison between China, EU, US, California fuel specifications

Table F-1. Selected Gasoline Parameters

	CHINA III	EURO 3	EURO 4	EURO 5	EPA RFG AVERAGE (2005)[1]		EPA CONV. GASOLINE AVERAGE (2005)[2]		CARB[3] (CARFG3)			WORLDWIDE FUEL CHARTER GATEGORY 4[4]
					SUMMER	WINTER	SUMMER	WINTER	FLAT LIMITS	AVERA-GING LIMITS	CAP LIMITS	
Aromatics, vol%, max	40	42	35	35	20.7[5]	19.5[5]	27.7	24.7	25	22	35	35
Olefin, vol%, max	30	18	18	18	11.9	11.2	12	11.6	6	4	10	10
Benzene, wt%, max	1	1	1	1	0.66[6]	0.66[6]	1.21[6]	1.15[6]	0.8	0.7	1.1	1
Sulfur, ppm, max	150	150	50	10	71[7]	81[7]	106[7]	97[7]	20	15	30 20[8]	10
RVP, kPa	Summer: 72 Winter: 88	60/70 max	60/70 max	60/70 max	47.6[9] (6.91 psi) Max	82.0 (11.89 psi) max	57.2[9] (8.3 psi)	83.6 (12.12 psi)	48.2 or 47.6[10] max (7 or 6.9 psi)	NAP	44.1-49.6 (6.4-7.2 psi)	Same as proposed China IV
Manganese, mg/liter	16	NS	NS	MMT<6 (by 2011) MMT<2 (by 2014)	NA[11]	NA[11]	NA	NA	ND	ND	ND	ND
Oxygen, % m/m	2.7 (max)	2.7 (max)	2.7 (max)	2.7 (max)	2.49	2.37	0.95	1.08	1.8-2.2	NAP	0 - 3.5 1.8[12] - 3.5	2.7

NS = Not specified; NA = Not available; ND = Non-detectable; NAP = Not applicable

注:

1. 这里是2005年新配方汽油调查数据的全国平均值。虽然EPA对新配方汽油（RFG）制定了硫含量，夏季RVP，芳香烃系族和苯的限值，但达标管理是依据一个复杂模型对挥发性有机化合物（VOC），有毒有害物质和氮氧化物排放的估计值与1990年基准汽油的情况相比而执行的。

2. 这里展示的是2005年传统汽油调查数据的平均值。EPA对苯含量，硫含量与夏季蒸汽压一样设定了限值，但是没有对其他的参数进行限定。个别的生产商和进口商通过证明其生产或进口的传统汽油产生的VOC, CO, NOx和有毒有害物质不比1990年生产或进口的传统汽油相应排放的水平高来达标。如果一个产品或进口商无法获得1990年的数据，就必须要使用一个“法定基准值”即1990年美国汽油的平均值。随着实施低硫汽油规定(80 ppm最大值, 30 ppm平均值), EPA不再强制执行VOC标准，因为硫含量达标即可满足VOC标准的要求。同样的，从2011年起，EPA将不再实施有毒有害空气污染物标准。这些标准会被更严格的年均为0.62%体积分数的苯含量标准替代。

3. 炼油厂和燃料进口商可以选择达到上限限值（单一值），或者带封顶的平均值限值。炼油厂和进口商也可以通过使用模型预测数据来证明其他组分的燃料排放量与可以达到上限标准或者平均值标准的汽油相同。

4. 美国EPA的Tier2或2007/2010车型道路重型车排放标准适用于要求欧4，欧5重型柴油车的市场。

5. 《清洁空气法》中规定新配方汽油的芳香烃系族体积含量不高于25%。

6. 《清洁空气法》中规定新配方汽油的苯含量限值为体积分数1%；《移动源空气有毒有害物质》最终标准将所有汽油（新配方汽油和传统汽油）的年平均苯含量限值加严到0.62%体积分数，并定于2011年1月1日起实施。0.62%的限值可以通过企业平均，信用预留和企业间信用额交易的灵活手段来达成，但是自2012年7月1日起所有生产商和进口商所生产和进口的汽油的实际年平均值必须小于1.3%。

7. 从2006年起，所有汽油的硫含量年平均限值为30ppm，所有产品的硫含量最大值不超过80ppm。

8. 2011年12月31日起实施。

9. 《清洁空气法》要求所有在高臭氧季节(6月1日至9月15日)销售的汽油达到62.1 kPa (9 psi)的限值。对新配方汽油设置了更加严格的挥发性（夏季蒸汽压）要求，这些要求随着区域，月份的不同在48.3-62.1 kPa (70-90 psi)范围内变动。EPA允许含有9-10体积百分比乙醇的汽油的雷氏蒸汽压高1.0-psi 。

10. 当生产上使用CaRFG3预测模型的蒸发排放单元时，47.6 kPa (6.9 psi) 适用；汽油不可以超过上限49.6 kPa (7.2 psi)；否则则适用48.2 kPa (7.00 psi)限值。

11. 《清洁空气法》要求新配方汽油不含有包括铅、锰的重金属。

12. 1.8%的冬季最小值适用于南海岸地区(South Coast Area)和因皮里尔郡(Imperial County)的11月1日至2月29日。

Notes:

1. National average of the 2005 RFG survey data are shown here. Even though EPA establishes limits on sulfur, summer RVP, aromatics and benzene for reformulated gasoline (RFG), compliance is determined based on the complex model estimates of VOC, toxic and NOx emissions relative to the emissions of the 1990 baseline gasoline.
2. Presented here are national average in 2005 based on conventional gasoline survey data. EPA sets limits on benzene and sulfur content as well as summer RVP, but not for other parameters. Individual producer or importer demonstrates compliance with the conventional gasoline standard by showing that emissions of VOC, CO, NOx and toxic air pollutants from conventional gasoline produced or imported do not increase over levels from the gasoline it produces or imports in 1990. If a producer or importer is unable to develop adequate 1990 data, it must use a "statutory baseline", which is the average quality of all 1990 U.S. gasoline. With the adoption of the low sulfur gasoline requirement (80 ppm maximum, 30 ppm average), EPA no longer enforces the VOC standards as compliance with the sulfur limit assures compliance with the VOC requirements. Also, starting 2011, EPA will begin to phase out the toxic air pollutant standards. These standards will be replaced by the more stringent benzene standard that requires annual average of 0.62% by volume.
3. Refiners and fuel importers could choose to comply with the maximum (flat) limit, or the averaging limit coupled with a cap limit. Refiners and importers could also certify alternative specification by using the predictive model to demonstrate that emissions are equivalent to those of a gasoline meeting the flat limits or the averaging limits plus cap values.
4. Applicable to markets requiring Euro 4, Euro 5 heavy duty, US EPA Tier 2 or 2007/2010 Heavy Duty On-Highway or equivalent emission standards.
5. The reformulated gas provision of the "Clean Air Act" (CAA) limits the aromatic content of RFG to 25% by volume.
6. CAA limits benzene content of RFG gasoline to 1% by volume; the Mobile Source Air Toxics final rule further tightens the benzene limit to 0.62% for all gasoline (reformulated and conventional) on an annual average basis beginning Jan. 1, 2011. While the 0.62% limits could be met through an averaging, banking and trading program, the actual annual average of gasoline produced or imported by any refiner or importer must not exceed 1.3% by volume beginning Jul. 1, 2012.
7. Effective from 2006, the gasoline sulfur limit for all gasoline is 30 ppm for the annual refinery average and a cap of 80 ppm for all production.
8. Applies on December 31, 2011.
9. "Clean Air Act" specifies a limit of 62.1 kPa (9 psi) for any gasoline sold during the high ozone season (Jun. 1 to Sept. 15). More stringent volatility (summer RVP) requirements are set for RFG, which vary by the region and month, and range from 48.3-62.1 kPa (70-90 psi). EPA provides a 1.0-psi RVP allowance for gasoline containing ethanol at 9 to 10 volume percent.
10. 47.6 kPa (6.9 psi) applies when a producer is using the evaporative emissions element of CaRFG3 Predictive Model; gasoline may not exceed a cap of 49.6 kPa (7.2 psi); otherwise, the 48.2 kPa (7.00 psi) limit applies.
11. CAA requires that RFG to contain no heavy metal, including lead and manganese.
12. 1.8% winter minimum applies from Nov. 1 to Feb. 29 in the South Coast Area and Imperial County.

表F-2: 选定的柴油参数

	国II	国III	欧 3	欧4	欧5	EPA	CARB		世界燃料宪章种类4[2]	美国卡车协会 ASTM D975 (美国)
	(有效至2011年6月)	(2009年6月发布实施)				传统柴油	基准燃料[1]	指定的等效限值[1]		
多环芳烃, 体积%, 最大值	NS	11	11	11	8	NS	1.4	3.5	2.0	
硫含量, ppm, 最大值	2000	350	350	50	10	15	15	15	10	500 / 15 (ULSD)
十六烷值, 最小值	45	49 (5, 0 和 -10°C PP) 46 (-20°C PP) 45 (-35 和 -50°C PP)	51	51	51	十六烷指数 >= 40 或芳香烃 <= 35%[3]	48	53	55	40
密度 @ 15°C, kg/m3,最小值	实际测试 @ 20°C	810 - 850 (5, 0 和 -10°C PP) 790 - 850 (-20, -35 和 -50°C PP)	820 - 845	845	845	NS	NS	NS	820 [4]	NS
闪点, °C, 最小值	55 (10, 5, 0, 10 和-20°C PP) 45 (-35 和 -50°C PP)	55 (5, 0 和 -10°C PP) 50 (-20°C PP) 45 (-35 和 -50°C PP)	55	与欧III相同	与欧 III 相同	NS	54	NS	55	52
灰分含量, 质量%, 最大值	0.01	0.01	0.01	与欧III相同	与欧 III 相同	NS	NS	NS	0.001	0.1
黏度 @ 40°C, mm2/s	3.0 - 8.0 (5, 0 和 -10°C PP) 2.5 - 8.0 (-20 °C PP) 1.8 - 7.0 (-35 和 50°C PP) @ 20°C	3.0 - 8.0 (5 和 0°C PP) 2.5 - 8.0 (-10 和 -20°C PP) 1.8 - 7.0 (-35 和 50°C PP) @ 20°C	2 - 4.5	与欧III相同	与欧 III 相同	NS	2 - 4.1	NS	2.0 [5]	1.9 - 4.1

PP = 柴油倾点（或凝点）; NS=未规定

Table F-2: Selected Diesel Parameters

	CHINA II	CHINA III				EPA	CARB			
	(EFFECTIVE THRU JUNE 2011)	(EFFECTIVE BEGINNING JULY 2011)	EURO 3	EURO 4	EURO 5	CONVENTIONAL DIESEL	REFERENCE FUEL[1]	DESIGNATED EQUIVALENT LIMIT[1]	WORLDWIDE FUEL CHARTER CATEGORY 4 [2]	AMERICAN TRUCK ASSOCIATION ASTM D975 (US)
Polyaromatics, vol%, max	NS	11	11	11	8	NS	1.4	3.5	2.0	
Sulfur, ppm, max	2000	350	350	50	10	15	15	15	10	500 / 15 (ULSD)
Cetane number, min	45	49 (5, 0 and -10°C PP) 46 (-20°C PP) 45 (-35 and -50°C PP)	51	51	51	Cetane index >= 40 or aromatics <= 35%[3]	48	53	55	40
Density @ 15 °C, kg/m3, min	Actual measurement @ 20°C	810 - 850 (5, 0 and -10 °C PP) 790 - 850 (-20, -35 and -50°C PP)	820 - 845	845	845	NS	NS	NS	820 [4]	NS
Flash point, °C, min	55 (10, 5, 0, 10 and -20°C PP) 45 (-35 and -50°C PP)	55 (5, 0 and -10°C PP) 50 (-20°C PP) 45 (-35 and -50°C PP)	55	Same as Euro III	Same as Euro III	NS	54	NS	55	52
Ash content, % m/m, max	0.01	0.01	0.01	Same as Euro III	Same as Euro III	NS	NS	NS	0.001	0.1
Viscosity @ 40°C, mm2/s	3.0 - 8.0 (5, 0 and -10°C PP) 2.5 - 8.0 (-20 °C PP) 1.8 - 7.0 (-35 and 50°C PP) @ 20°C	3.0 - 8.0 (5 and 0°C PP) 2.5 - 8.0 (-10 and -20 °C PP) 1.8 - 7.0 (-35 and 50° C PP) @ 20°C	2 - 4.5	Same as Euro III	Same as Euro III	NS	2 - 4.1	NS	2.0 [5]	1.9 - 4.1

PP = Diesel pour point; NS=Not specified

注:

1. 加州法规在芳香烃系族达标方面允许给予一定的灵活性。生产商和进口商生产的燃料需要达到指定的蒸发排放标准，或者通过论证指定燃料的排气污染物减排等效于基准燃料来认证该燃料；“低排放”燃料与基准燃料相比一般十六烷值更高，硫含量更低，但芳香烃系族含量、多环芳烃、氮含量更高。
2. 美国EPA的Tier2或2007/2010车型年道路重型车排放标准适用于要求欧4，欧5重型柴油车的市场。
3. EPA要求以下标准满足其一：十六烷最小值为40或者芳香烃系族含量最大值为35%。国家标准和技术所(NIST) 定义的优质柴油须满足十六烷最小值为47的标准。各州可以自行决定是否采用NIST优质柴油标准。
4. 当大气温度低于-30°C时，可以放宽至800kg/m^3 。从环境考虑出发，可以施行815 kg/m^3作为最小值。
5. 当大气温度低于-30°C时，可以放宽至1.5 mm^2/s ，当大气温度为-40°C时，可以放宽至 1.3 mm^2/s 。

Notes:

1. The California regulations allow flexibility in meeting the limit on aromatics. Producers or importers could either produce a fuel that meets the designated equivalent limits, or certify a fuel formulation by demonstrating that the exhaust emission reduction of a candidate fuel is equivalent to those with the reference fuel; the "low emission" fuels typically have much higher cetane number, lower sulfur, but higher aromatics, higher polycyclic aromatics and higher nitrogen than the reference fuel.

2. Applicable to markets requiring Euro 4, Euro 5 heavy duty, US EPA Tier 2 or 2007/2010 Heavy Duty On-Highway or equivalent emission standards.

3. EPA requires either a minimum cetane index of 40 or a maximum aromatic content of 35%. Premium diesel fuel defined by National Institute of Standards and Technology (NIST) requires minimum cetane number of 47.0. It is up to individual states to adopt the NIST premium diesel requirements.

4. Can be relaxed to 800 kg/m^3 when ambient temperatures are below -30°C. For environmental purposed, a minimum of 815 kg/m^3 can be adopted.

5. Can be relaxed to 1.5 mm^2/s when ambient temperatures are below -30°C, and to 1.3 mm^2/s when ambient temperatures are -40°C.

附录 G. 加州和美国空气质量法规中移动源排放控制要求的发展进程

机动车排放和光化学烟雾的联系在1952年由Haagen-Smit教授首先提出。20世纪50年代中期，加州立法机关和美国国会提出了要求研究空气污染原因，影响和控制的法案。随后加州开展了一项机动车空气污染控制项目，但是直到1965年，国会才通过了《机动车空气污染控制法》，其中制定了第一套联邦机动车排放标准，联邦才对机动车开展了立法工作。1970年颁布了《清洁空气法》修订案，认识到机动车作为空气污染源的重要性，要求机动车排放要比未作要求以前的水平降低90%。1970年《清洁空气法》修订案及其后来1977年和1990年的修订，进一步加强了对机动车污染的控制，并且将环境部门的权限扩展到其他移动源。随着1970年《清洁空气法》的颁布，美国国家环境保护局（EPA）建立于1970年，是执行《清洁空气法》中各种要求的主管部门。迄今为止，美国国家环境保护局与各州政府合作，通过执行新车、在用车、发动机排放标准，燃料标准，在用车检查与维修保养制度，以及通过各州执行规划进行交通规划[174]来控制移动源的排放。

通过过去四十年的努力，美国空气质量立法中移动源的涵盖范围有所扩大（从起初关注道路源，扩展到非道路，船舶，火车机车和非道路源），将EPA的职权扩展到燃料方面，并且提高了违规的处罚。这些改变从很大程度上保证了更加严格的排放和燃料标准得以推行和有效的实施，来确保机动车保有量持续增加和运输量增长情况下的空气质量。所管辖的排放源覆盖面的扩大（包括非道路，船舶和火车机车），也保证EPA可以对这些方面设置更严格的标准，而不仅仅是局限于机动车方面，这样更加先进的排放控制技术和更加清洁的燃料会应用于控制几乎所有移动源排放。虽然1977年和1990年修订案中允许各州不遵从联邦标准而设置他们自己标准的规定有所变更，允许加州（和其他州来参照加州）设置至少与联邦标准同样严格的州标准来达到各州空气质量的要求的这一基本原则没有实质改变，甚至还得到了加强。

随着过去十几年中机动车保有量快速增长，中国在移动源排放控制方面正面临着与美国20世纪60年代相仿或更大的挑战。虽然目前的《大气污染防治法》（简称《大气法》）中对移动源的规定太过简单、涵盖内容有限、也并未具体化，该法规的修订工作目前已提上日程。美国空气污染立法的历程可以为《大气法》目前和未来的法规修订中提供宝贵的经验。

下面是美国及《清洁空气法》中开展空气质量控制计划中与移动源排放相关的重要里程碑的总结：

1955

- 《联邦空气污染控制法》颁布，授权对空气污染的原因，影响和控制进行研究。

174 尽管EPA没有直接参与交通规划中，但是各州执行规划提交规划分析包含了未来交通运输的飞速增长对空气质量的影响，表明了排放不可以超过空气质量限值，一旦超过，州政府如何对削减排放达到空气质量目标进行计划。

Appendix G. Evolution of mobile source emission control in California and US air quality laws

The relationship between motor vehicle emissions and photochemical smog was first established by Prof. Haagen-Smit in 1952. In the mid1950s, the California legislature and the US Congress introduced laws that mandated studies of the causes, effects and control of air pollution. An automobile air pollution control program was subsequently developed in California, but federal automobile legislation was not enacted until 1965 when the Congress passed the "Motor Vehicle Air Pollution Control Act", which established the first set of federal automobile emission standards. The "Clean Air Act" Amendments in 1970, recognizing the importance of automobiles as air pollution sources, mandated a 90% reduction of vehicle emissions from the levels previously prescribed. The 1970 CAA Amendments and its subsequent amendments in 1977 and 1990, further strengthened control of pollution from automobiles, and further expanded the legal authority of environmental agencies to regulate other mobile sources. The US Environmental Protection Agency (EPA), created in 1970 under "Clean Air Act Amendments" of 1970, is the primary agency charged with implementing various requirements included in the Clean Air Act[174].To date, US EPA, working with the state governments, control mobile source emissions through enforcement of emission standards for new and in-use vehicles and engines and fuel standards, in-use vehicle inspection and maintenance, as well as transportation planning via developing the State Implementation Plans.

Over the past four decades, the provisions on mobile sources in the US air quality legislation have widened in scope (from primarily focused on onroad sources to covering non-road, marine, locomotive and non-road sources), broadened EPA's authority over fuels, and heightened penalties for noncompliance. These changes were made largely to ensure that tighter emission and fuel standards could be introduced and effectively enforced to protect air quality even with continued vehicle population growth and increasing amount of travel. The broader coverage of sources (including non-road, marine and locomotive) also ensures that EPA sets stringent standards for those modes, not just motor vehicles, such that advanced emission control technologies are deployed and cleaner fuels are used to control nearly all sources of mobile emissions. While the provisions granting states exemptions to set their own standards have been revised in the 1977 and 1990 amendments, the fundamental principle of allowing California (and other states who choose to follow California) to set regulation at least as stringent as the federal regulation in order to meet its specific air quality needs has not changed and has even been strengthened.

China, with a rapidly growing vehicle population in the past decade or so, is facing similar if not more daunting challenges in mobile source emission control as what US faced back in the 1960s. While the motor vehicle provision of the "Air Pollution Prevention and Control Law" in its current form is brief, limited in scope and short of specificity, revision to the law is now underway. The evolution of the US air pollution legislation could offer valuable lessons learned to inform the current and future revisions of the law.

Below summarized the key milestones related to mobile source emissions in the evolution of the air quality control program in the US and the Clean Air Act:

1955

- "Federal Air Pollution Control Act" is enacted, which authorizes research on the causes, impacts and control of air pollution.

174 Although EPA is not directly involved in transportation planning, however an analysis of transportation plans submitted with the SIPs including impacts of future projection of traffic growth on air quality need to show that emissions do not exceed air quality limit, and if exceedences is shown, how the state is planning to reduce emissions to meet air quality goals.

- 在加州，洛杉矶空气污染控制区成立了加州洛杉矶市机动车污染排放实验室，湾区（旧金山湾区）空气污染控制区建立。这两个区域后来更名为南海岸空气质量管理区和湾区空气质量管理区。

1959

- 加州立法通过要求加州建立空气质量标准，和必要的排放控制措施；这引导了美国颁布其第一个全国范围的总悬浮颗粒物，光化学氧化剂，二氧化硫，二氧化氮和一氧化碳排放的标准。

1960

- 加州机动车管理局建立，其首要职能是测试和认证加州销售的汽车加装的装置。
- 国会通过联邦机动车法案，确定联邦对机动车造成的空气污染进行研究调查。

1963

- 美国国会通过第一版联邦《清洁空气法》。法案授权于健康，教育和社会福利部来根据科学研究的结果定义空气质量标准，并为州和地区空气污染控制区提供资金。

1965

- 美国国会通过机动车空气污染控制法案；随后颁布了首个联邦机动车标准于1968车型年生效。

1967

- 颁布了联邦空气质量法。它扩展了机动车的研究，要求对燃料添加剂进行登记，并且设立了一个资助州机动车检查计划的项目。1967年联邦法案也确立了新车排放控制项目的联邦授权制度，即除加州外，其余的州不允许设置自己的排放控制法规。加州由于空气质量问题的特殊性，以及其空气质量控制的领先行动，成为美国唯一一个可以设置更加严格标准的州。十年之后，其他的州也可以采用加州标准了，前提是这些标准至少应与联邦要求同样严格。
- 加州机动车污染控制局和空气卫生局及其试验室合并成为加州空气资源局。

1970

- 国家空气质量的持续恶化，加速了国会在1970年通过《清洁空气法》（CAA）的修订案，该法案是空气污染控制法律依据的首要来源，建立了美国空气污染控制体系的基本规模。

- In California, Los Angeles County Motor Vehicle Pollution Control laboratory is established within the Los Angeles Air Pollution Control District, and the Bay Area Air Pollution Control District was established. These two were later switched to South Coast Air Quality Management District (AQMD) and Bay Area AQMD.

1959

- Legislation is passed in California requiring the state to establish air quality standards and necessary controls for motor vehicle emissions; this leads to the promulgation of the first statewide air quality standards in the US for total suspended particulates, photochemical oxidants, sulfur dioxide, nitrogen dioxide and carbon monoxide.

1960

- The Motor Vehicle Control Board of California is established with a primary function of testing and certifying devices for installation on cars for sale in California.
- Federal Motor Vehicle Act is passed by the Congress stipulating federal research to address air pollution from motor vehicles.

1963

- US Congress passes the first federal "Clean Air Act". The Act empowers the Department of Health, Education and Welfare to define air quality criteria based on scientific studies and offers grants to state and local air pollution control districts.

1965

- US Congress passes the Motor Vehicle Air Pollution Control Act; the first federal vehicle standards apply to MY1968 vehicles is subsequently promulgated.

1967

- The federal Air Quality Act is enacted. It expands motor vehicle research, requires federal registration of fuel additives and establishes a grant program for state vehicle inspection programs. The 1967 federal statue also establishes federal preemption of new vehicle emission controls, i.e., states, except for California, are not allowed to set its own vehicle emission control regulation. California is the only state in the US that is allowed to set more stringent standards because of the state's special air quality problems, and pioneering efforts in the control of air quality. A decade later, other states are allowed to adopt California's standards if proven to be at least as stringent as federal requirements.
- The California Air Resources Board is created from the merging of the California Motor Vehicle Pollution Control Board and the Bureau of Air Sanitation and its Laboratory.

1970

- The country's air quality continues to deteriorate, prompting the Congress to pass the "Clean Air Act" (CAA) Amendments in 1970 which serve as the principal source of legislative authority for air pollution control and establish the basic US program for controlling air pollution.

- 在该法案下，美国EPA成立，要求EPA基于健康影响研究结果制定六种污染物(标准污染物包括颗粒物，二氧化硫，一氧化碳，氮氧化物，臭氧和铅)的国家空气质量标准（NAAQS），并授权EPA管理机动车排放。

- 修订案采用了通过四种途径管理移动源来控制大气污染的策略：
  - o 新车和发动机排放
  - o 油品质量和油品添加剂
  - o 在用车排放
  - o 交通规划

- 此外，《清洁空气法》1970版在1977年和1990年的修订中又进一步加严，通过以下步骤对移动源排放建立了双重策略：
  - o 由EPA牵头，强制实施新车和发动机排放标准，并管理油品及油品添加剂。
  - o 联邦和各州联合制定方案，控制固定源和在用车/发动机，使其达到空气质量标准，主要通过州执行规划(SIP)[175]实施。
- 1970年《清洁空气法》与移动源相关的其他主要规定：
  - o 以在1975/76年时间段实现HC，CO和NOx减排90%为目标制定联邦机动车排放标准[176]。
  - o 授权各州强制实施旨在削减在用车年行驶里程或保障在用车进行适当维护的项目。
  - o 要求燃料进行试验的额外规定，并且将民事罚款增加到10,000美元每天。
  - o 要求EPA禁止或者控制使公众健康福利受损或排放控制装置受损的燃料和燃料添加剂。
  - o 不允许各州制定不同于联邦政府的油品和油品添加剂标准。

1971

- 加州空气资源局在国内建立了第一个机动车NOx标准。

1977

1970年的《清洁空气法》在1977年进行了修订。添加了非达标区的规定，允许有达不到NAAQS要求区域的州用更长时间（更现实的时间表）来达标。下列是相关的机动车标准，燃料和在用车排放的关键环节的概述：

新车标准

- 在汽车制造商的反对之下，国会将更加严格的CO和HC标准延迟到1980车型年实施，并且将1981及以后车型年的NO排放标准从0.4 gpm轻微放宽倒1gpm[177]。

175 州执行规划SIP包括州政府为了达到以公众健康为基础的大气环境质量标准和清洁空气法要求的规定和其他项目 。

176 1970年清洁空气法修订案要求截止1975车型年车辆排放的HC和CO的排放比1970车型年削减90%。这些目标是EPA制定CO,HC和NOx新车排放标准的依据。

177 生产厂商争辩催化转化器，作为当时唯一的达标技术，还没有完全成熟并且费用昂贵。见 Gerard, D. 和 L.B。

Lave. 2003年.实施技术主导的政策： 1970年清洁空气法修订案和先进的机动车排放控制的介绍。五月。

http://www.epp.cmu.edu/people/bios/papers/gerard/Gerard_Lave%20TF1.pdf (2010年4月30日查得)。

- The Act establishes the US EPA, requiring EPA to set National Ambient Air Quality Standards (NAAQS) for six pollutants (criteria pollutants, including particular matters, sulfur dioxide, carbon monoxide, nitrogen oxides, ozone and lead) based on scientific studies on health impacts and giving it board responsibility for regulating mobile vehicle emissions.

- The amendments adopt a four-pronged approach to control air pollution from mobile sources through regulating:
  - o Emissions from new engine and vehicle
  - o Fuel quality and fuel additives
  - o Emissions from in-use vehicles
  - o Transportation planning

- In addition, the Clean Air Act Amendments of 1970, which was further strengthened by the amendments in 1977 and 1990, established a dual strategy to control mobile source emissions through:
  - o A federal program led by EPA to adopt and enforce emission standards applicable to new motor vehicles and engines, and to regulate fuels and fuel additives.
  - o A joint federal and state program to control stationary sources and in-use motor vehicles and engines to meet atmospheric air quality standards, which is implemented primarily through the State Implementation Plan (SIP) process[175].

- Other key elements in the 1970 CAA amendments related to mobile sources include:
  - o Establishing the federal motor vehicle emission standards with the goal of reducing HC, CO, and NOx emissions from automobiles by 90% in the 1975/76 timeframe[176].
  - o Authorizing states to impose programs aimed at in-use vehicles to reduce the VMT or to keep in- use vehicles properly maintained.
  - o Adding provisions to allow fuels to be tested, and increasing civil penalties to USD10,000 per day.
  - o Demanding EPA to prohibit or control fuels or fuel additives if public health or welfare was endangered or emission control devices would be impaired.
  - o Preempting states from setting separate standards for fuels and fuel additives.

1971

- California Air Resources Board adopted the first automobile NOx standards in the nation.

1977

The Clean Air Act of 1970 was amended in 1977. Provisions on nonattainment are added, allowing states with areas not meeting the NAAQS a much longer and realistic time frame to comply. The following summarizes the key elements related to vehicle standards, fuels and in-use vehicle emissions:

New vehicle standards

- Under the opposition of the automakers, congress delays the more stringent CO and HC standards until MY1980 and slightly relaxes the NO emission standard from 0.4 gpm to 1 gpm for MY1981 and thereafter[177] .

175 A SIP includes regulations and other programs a state government will carry out for meeting health-based ambient air quality standards and the associated Clean Air Act requirements.

176 The 1970 CAA amendment requires a 90% reduction by MY 1975 of HC and CO emissions that were emitted from 1970 cars, and 90% reduction by 1976 of NOx that was allowed for MY 1971 cars. These goals led EPA to set new vehicle emissions standards for HC, CO and NOx.

177 Automakers argued that catalytic converters, the only technology that could meet the standard at that time, were not yet ready and would be too costly to be used. See Gerard, D. and L.B. Lave. 2003. Implementing Technology-Forcing Policies: The 1970 Clean Air Act Amendments and the Introduction of Advanced Automotive Emissions Controls. May. http://www.epp.cmu.edu/people/bios/papers/gerard/Gerard_Lave%20TF1.pdf (accessed April 30, 2010).

- 以推迟和放宽全国排放标准为（与汽车制造商的）交换条件，国会允许加州继续保有更加严格的排放标准，其他存在有非达标区的州可以在EPA的认证下采取加州标准，只要他们不要求制造“第三种车”(《清洁空气法》177节). 这个规定一方面允许难以达到联邦空气质量要求的州施行比联邦要求更加严格的标准，另一方面也把对生产企业的影响降到最低（因为这样一来美国就只有两套车辆排放标准）。
- 修订了加州特权的条件，要求加州标准如联邦标准一样保护公众健康和福利。
- 放宽高海拔地区销售的机动车的标准。
- 简化小型生产企业的试验要求。
- 要求EPA制定重型车和摩托车的标准。
- 允许对加油进行相关要求。

在用车排放

- 添加了保证书和防篡改措施。
- 在臭氧和CO非达标区要求检查和维修保养(I/M)计划。

燃料和燃料添加剂

- 加严了燃料和燃料添加剂的相关规定，包括授予EPA权力管理某种燃料成份（如铅）。事实证明这一举措对催化转化器的广泛使用十分重要。
- 放宽小型炼油厂含铅添加剂的要求。

1990

1990年《清洁空气法》修订案对1970年《清洁空气法》修订案中移动源的规定进行修订并增加了两倍内容。法律主要的补充和修订包括:

对常规污染物更加严格的控制:

- 加强轻型车(LD)和轻型卡车的排放控制。控制包括限制低温工况下的排放，控制蒸发损耗 (包括加油中的损耗)[178]。
- 加强重型发动机的标准，来缩小重型发动机标准和相应轻型车标准的差异。
- 要求机动车加装车载诊断系统(OBD) 来确保在机动车使用生命周期中符合排放标准，确保贯彻新的质保书要求。
- 增加了新的一节 (217节) ，允许EPA向生产制造商收费来支付认证和召回试验的费用。

为减少空气污染而对汽柴油设置的新控制方案

- 要求燃料燃烧的排放更少
- 扩展EPA管理非道路机动车使用的燃料或燃料添加剂的权力。
- 指导EPA研究控制机动车排放的危险大气污染物的需求，确定控制的手段和方法。这些要求推进了EPA国家空气有毒有害物质项目，该项目管理移动源的危险大气污染物 (包括苯和甲醛)。
- 通过允许各州为了达到特定的空气质量要求采用特有的燃料要求，来减少联邦优先执行权规定的影响。
- 将民事处罚的金额上限由10,000美元每日上调到25,000美元每日（包括通货膨胀的调节表）。
- 要求使用预防发动机和燃料系统积碳的汽油清净剂。
- 要求臭氧非达标区使用新配方汽油。
- 提高高臭氧季节使用的燃料所允许的雷氏蒸汽压（RVP）水平。

178 CAA中涉及的标准的修订比清洁空气法主体的修订更频繁。

- In exchange for delaying and relaxing emission standards, congress allows California to continue to have more stringent emissions standards, and other states with nonattainment areas can adopt California standards with EPA's approval as long as they do not require the creation of a "third car" (Sec. 177 of Clean Air Act). This provision allows states with difficulties achieving the federal air quality requirements to adopt standards more stringent than the federal requirements, but at the same time limits the impacts on manufacturers as there are only two sets of vehicle emission standards in the U.S.
- The waiver condition for California is modified, requiring the state's standards to be as protective of the public health and welfare as federal standards
- The standards applicable to vehicles sold at high altitudes is relaxed
- Testing requirements for small manufacturers is reduced
- EPA administrator is required to set standards for heavy duty vehicles and motorcycles
- Refueling requirements is allowed to be imposedIn-use vehicle emissions

In-use vehicle emissions

- Warranty and tampering provisions are added
- Inspection and maintenance (I/M) programs in ozone and CO nonattainment areas is required

Fuels and fuel additives

- Provisions concerning fuels and fuel additives are tightened, including granting EPA authority to regulate certain fuel content (such as lead). This proves to be important in the wide adoption of catalytic converters.
- Lead additive requirements for small refineries are relaxed.

1990

The 1990 CAA Amendments revised and tripled the size of the mobile source provisions in the 1970 CAA Amendments. Key additions and revisions to the law include:

More stringent control on conventional vehicle emissions:

- Strengthening the emissions control for light-duty (LD) vehicles and LD trucks. These controls include limiting emissions from cold temperature operation, control of evaporative losses (covering losses during refueling)[178].
- Strengthening the standards for HD engines to reduce the disparity between the standards for HD engines and those applied to LDVs.
- Demanding vehicles to have onboard diagnostic (OBD) system to ensure emissions standards are met throughout vehicles' useful life and ensuring compliance with the new warranty requirements.
- Adding a section (Sec. 217) allowing EPA to collect fees from manufacturers to cover expenses of certification and recall testing.

New control on gasoline and diesel fuels to reduce air pollution emissions:

- Requiring fuel combustion to result in fewer emissions.
- Expanding EPA's authority to fuels or fuel additives used in non-road vehicles.
- Directing EPA to study the need to control hazardous air pollutants emitted from vehicles, and identifying means and measures for control. This led to the launch of EPA's National Air Toxics Program that regulates mobile source hazardous air pollutants (including benzene and formaldehyde).
- Limiting the effect of the preemption provision by allowing states to adopt unique fuel requirements if it is necessary to achieve specific air quality needs .
- Raising the maximum civil penalty from USD 10,000 per day to USD25,000 per day (an adjustment schedule for inflation was included).
- Mandating the use of detergents in gasoline to prevent deposits in engine or fuel systems.
- Demanding the use of reformulated gasoline in ozone nonattainment areas.
- Raising the allowable Reid Vapor Pressure (RVP) levels for fuels used during the high ozone season.

178 Standards revisions that are included as revision of CAA occur more often than major revisions of the act.

对包括非道路机动车和发动机、船舶、机车和移动设备的移动源加强控制：

- 要求EPA制定摩托车、重型发动机、非道路机动车和船用发动机的标准。

鼓励“清洁燃料”汽车的发展

- 制定“清洁燃料”汽车的排放标准：“清洁燃料”汽车是可以达到更加严格的“清洁燃料”汽车标准的某类或某个（排放）等级的机动车。

1990-1999及2000+

随着1990年《清洁空气法》法赋予的权力和职责的扩充，EPA引进了更加严格的机动车和燃料标准，并于90年代和本世纪初先后颁布了新的非道路、船舶和机车发动机标准。针对最高法院裁定温室气体属于《清洁空气法》中大气污染物定义范围，EPA在美国历史上首次颁布了轿车和轻型卡车的温室气体标准。

- 1991年颁布了更低的HC和NOx 尾气标准，从1994车型年实施，1992年首次实施了低温CO标准。
- 1992-1993年进行了冬季含氧燃料计划，并且在1993年实施了燃料硫含量的限制。
- 1995年在10个有严重光化学烟雾问题的大城市实施了新配方汽油 (RFG) 项目。
- 1996-2000年间颁布了船舶发动机，机车发动机和用于非道路建筑，农业和工业设备上的柴油发动机的排放标准。
- 1999年EPA宣布SUV和轻型卡车采用与轿车相同的（排放）标准：第一次将车和燃料作为同一系统考虑，并且宣布更低的汽油硫含量来保证低排放控制技术和降低空气污染的效果。
- 2000年，EPA提出了一个全国控制计划来对重型柴油车和他们所使用的燃料作为一个系统进行管理：提出2007车型年重型道路机动车适用的新的重型车排放标准，连同提出一个在2006年将硫含量降低到15ppm的道路柴油方案。
- EPA颁布了减少移动源21种危险污染物（大气有毒有害物质）的最终规定，并制定了新汽油有毒有害物质排放标准。
- 2007年，最高法院裁定温室气体符合《清洁空气法》中对大气污染物的定义，并要求EPA计算温室气体对美国公民健康和福利的影响。
- 2009年，EPA宣布了温室气体威胁公众健康和环境的结论，为EPA按照《清洁空气法》管理温室气体提供了法律依据。
- 2010年4月，EPA和交通部颁布了一个联合规定，为2012-2016车型年的轿车和轻型卡车制订温室气体排放和燃料经济性联合标准。

More control on mobile sources including non-road vehicles and engines, ships, trains and mobile equipment:

- Requiring EPA to set standards for motorcycles, heavy-duty (HD) engines, non-road vehicles, and marine engines.

Encouraging the development of "clean-fuel" vehicles

- Setting emission standards for "clean-fuel" vehicles; "clean-fuel" vehicles could be any category or class of vehicles that could meet the more stringent "clean-fuel" vehicle standards.

1990s and 2000+

With the expanded responsibility and authority granted by the 1990 CAA, EPA introduced more stringent standards for vehicles and fuels and issued new standards for non-road, marine and locomotive engines in the 1990s and 2000s. Responding to the Supreme Court decision that greenhouse gases fall under the definition of air pollutants in the CAA, EPA recently issued GHG standards for cars and light-trucks for the first time in the US history.

- Lower tailpipe standards for HC and NOx were issued in 1991 to take effect beginning with 1994 models, and standards for CO at cold temperatures were established for the first time in 1992.
- Wintertime oxygenated fuel program began in 1992-1993 and limits on fuel sulfur content took effect in 1993.
- Reformulated gasoline (RFG) program began in 10 metropolitan areas with severe smog problems in 1995.
- Emissions standards were issued for marine engines, locomotive engines, and diesel engines used in non-road construction, agricultural and industrial equipment in 1996-2000.
- In 1999 EPA announced that SUVs and other light-trucks are to be subject to the same standards as cars; vehicles and fuels are considered one system for the first time, and tighter sulfur level in gasoline were announced to ensure the effectiveness of low emission-control technology and lower air pollution.
- In 2000, EPA introduced a national control program to regulate heavy-duty diesel vehicles and the fuel they used as one system; new HDV emissions standards applicable to MY2007 heavy-duty on-road vehicles were introduced together with a plan to lower onroad diesel sulfur to 15 ppm by 2006.
- EPA issued a final rule to reduce emissions of 21 hazardous pollutants (air toxics) from mobile sources and set new gasoline toxic emission performance standards.
- In 2007, Supreme Court determined that greenhouse gases (GHGs) fit within the "Clean Air Act" definition of air pollutants, and demanded EPA to evaluate the impacts of GHGs on human health and welfare of US citizens.
- In 2009, EPA announced the findings that GHGs threaten public health and the environment, which establishes the legal basis for EPA to regulate GHG emissions under the CAA.
- A joint final rule was issued by EPA and the Department of Transport in April 2010 that sets GHG emission and fuel economy standards for MY2012-16 cars and light-trucks.

图 G-1. 美国国家环境保护局制定执行机动车和燃料标准的部门组织图

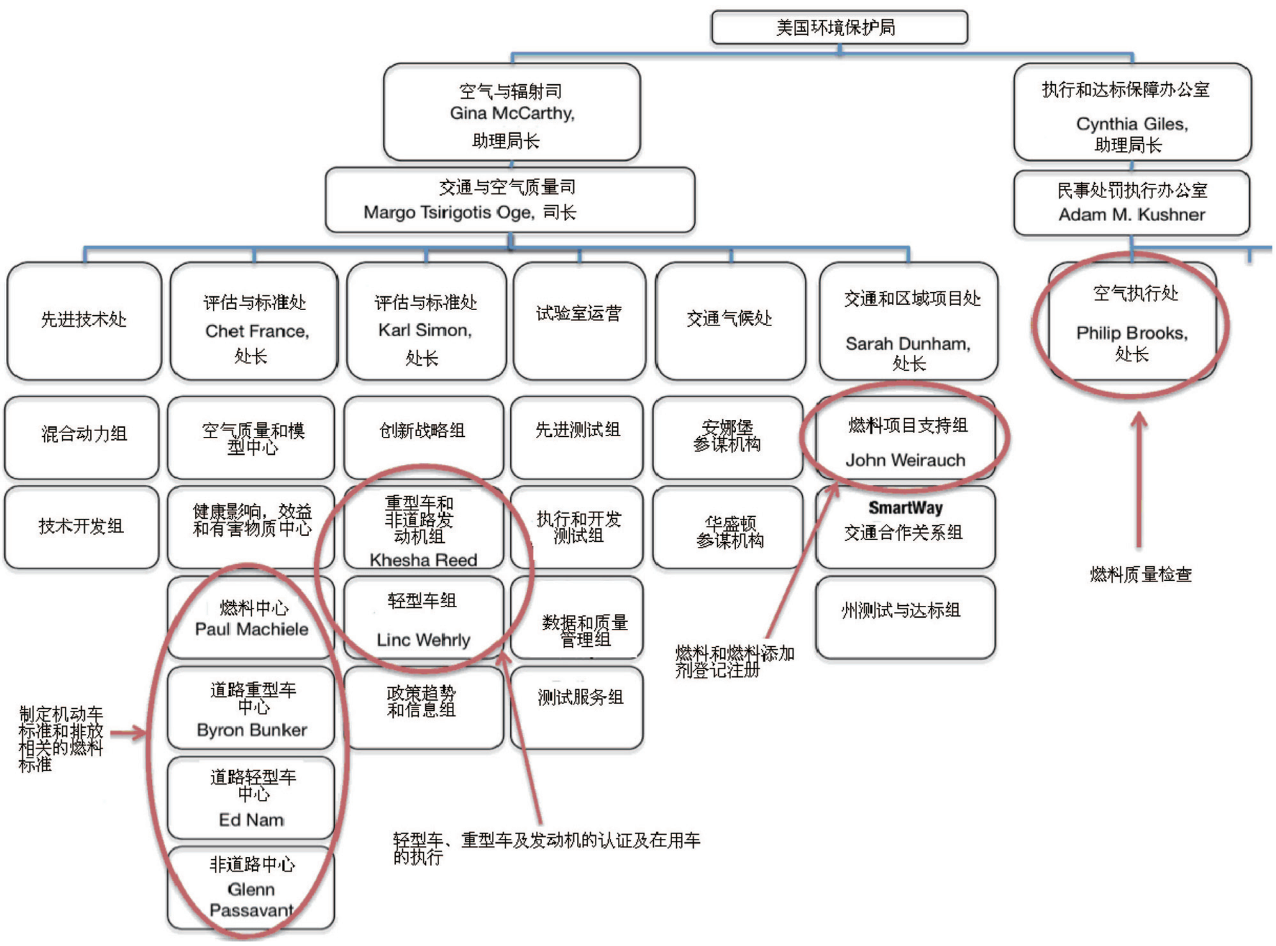
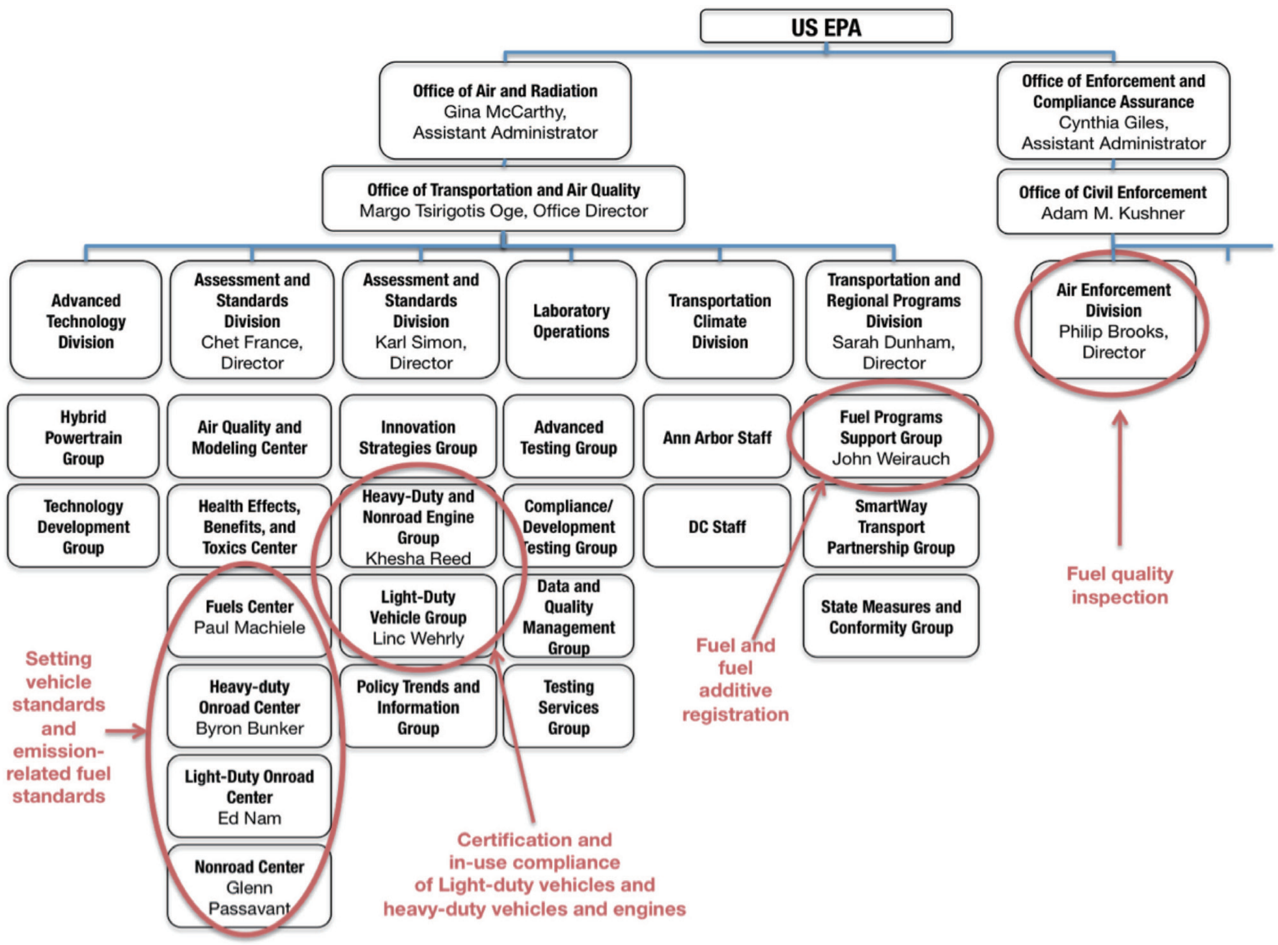


Figure G-1. Organization chart of US EPA divisions responsible for setting and enforcing vehicle and fuel standards



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