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.”

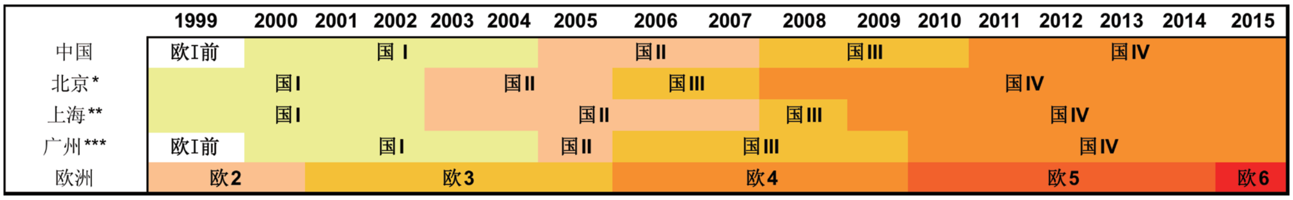
However, standards only limit the rate at which pollutants are emitted and not the total amount of pollutants released in the atmosphere. Controlling the total amount of vehicle pollution entails also addressing the number of vehicles in the fleet and how much they are used. These policies are traditionally 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。

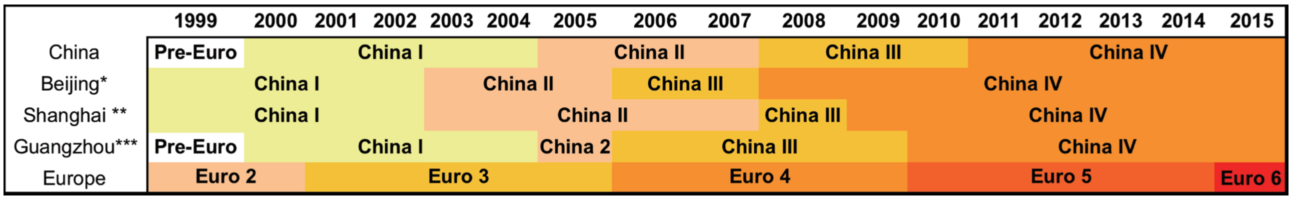
[18] 此处的实施时间是停止对达到前一阶段新车的生产、售卖和上牌的日期，即停止实施前一阶段标准的型式核准。

[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] .



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China	Pre-Euro	China I					China II			China III			China IV				
Beijing*	China I				China II			China III		China IV							
Shanghai **	China I				China II					China III	China IV						
Guangzhou***	Pre-Euro	China I					China 2	China III				China IV					
Europe	Euro 2		Euro 3					Euro 4				Euro 5					Euro 6

* 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).

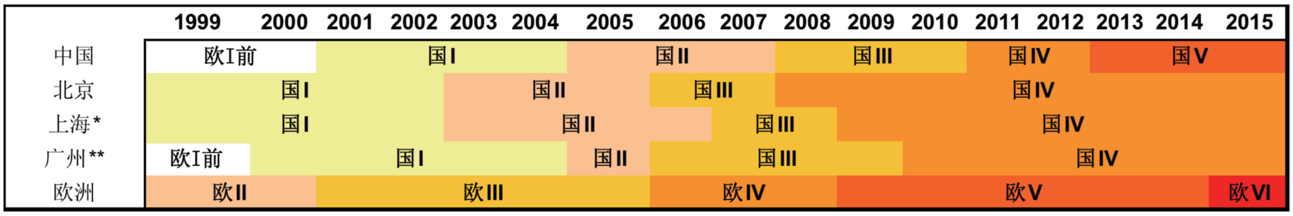
[18] Adoption timeline is the date by which vehicles meeting previous level of standards are prohibited from production, sales and registration. This is the date by which the MEP will stop type approval for vehicle models meeting the previous emissions standards.

[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）。

---

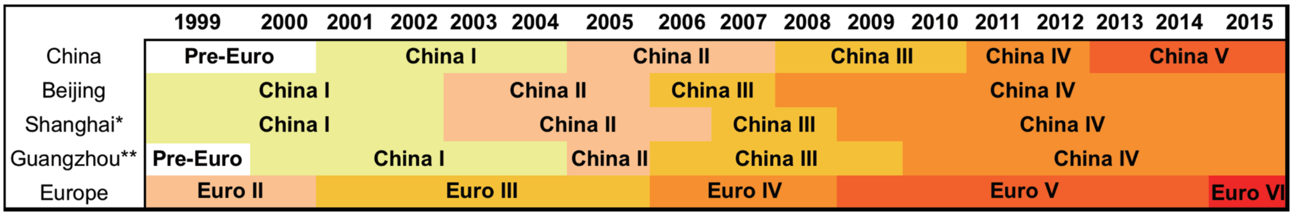
[20] 参考影响要求使用其它的测试数据和工程评价方法来评估车辆的其它组件对发动机排放的影响。

[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.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China	**Pre-Euro**		**China I**				**China II**			**China III**			**China IV**		**China V**		
Beijing	**China I**				**China II**			**China III**		**China IV**							
Shanghai*	**China I**				**China II**				**China III**		**China IV**						
Guangzhou**	**Pre-Euro**	**China I**					**China II**	**China III**				**China IV**					
Europe	**Euro II**		**Euro III**					**Euro IV**			**Euro V**						**Euro VI**

* 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：

- 生产企业的责任
- 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
- 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）。

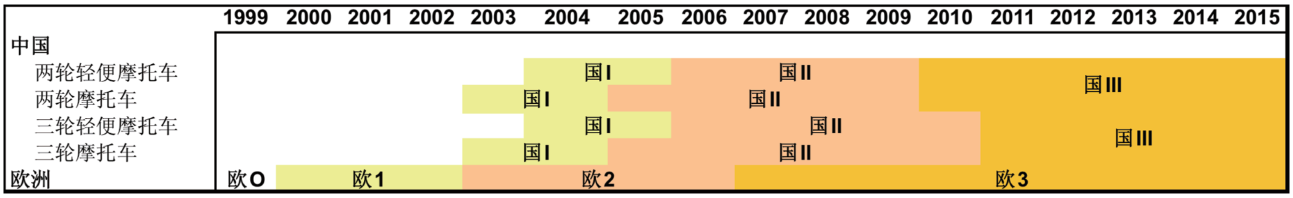


图3.3: 中国和欧盟两轮及三轮车标准实施时间表

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》。

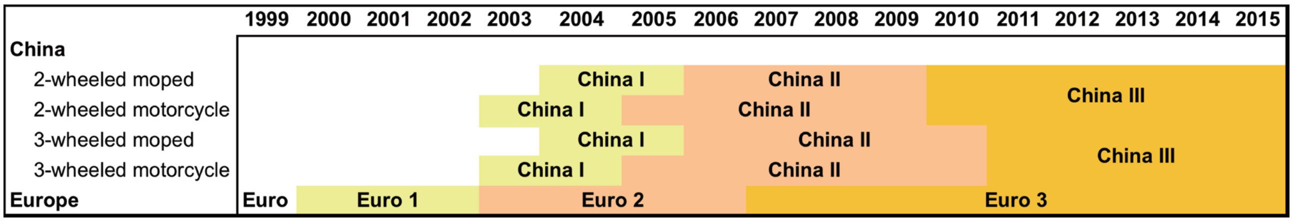
[26] 汽油车发动机的颗粒物排放率要比柴油车低很多。

[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.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China																	
2-wheeled moped						China I		China II				China III					
2-wheeled motorcycle					China I		China II					China III					
3-wheeled moped						China I		China II					China III				
3-wheeled motorcycle					China I		China II						China III				
Europe	Euro	Euro 1			Euro 2				Euro 3								

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.

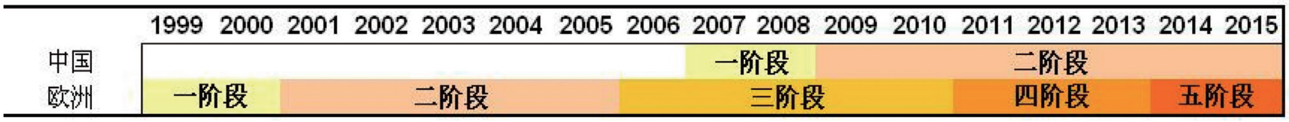
[25] Chinese Automotive Technology and Research Center. 2009. "China Automotive Industry Yearbook".

[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。



<table>
<tr><th></th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th>2015</th></tr>
<tr><td>中国</td><td colspan="8"></td><td colspan="2">一阶段</td><td colspan="7">二阶段</td></tr>
<tr><td>欧洲</td><td colspan="2">一阶段</td><td colspan="5">二阶段</td><td colspan="5">三阶段</td><td colspan="3">四阶段</td><td colspan="2">五阶段</td></tr>
</table>

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。

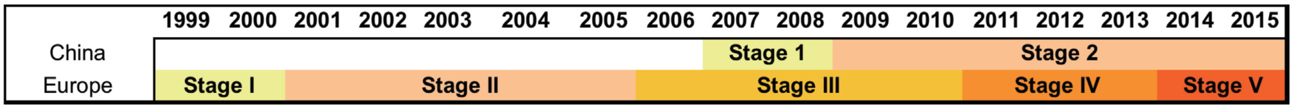
3) 对以国产企业主导的农用车和非道路机械设备缺乏管理。相比其它移动源，这类车辆和设备在标准引入方面落后很多，而且大部分都未进行登记注册。

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

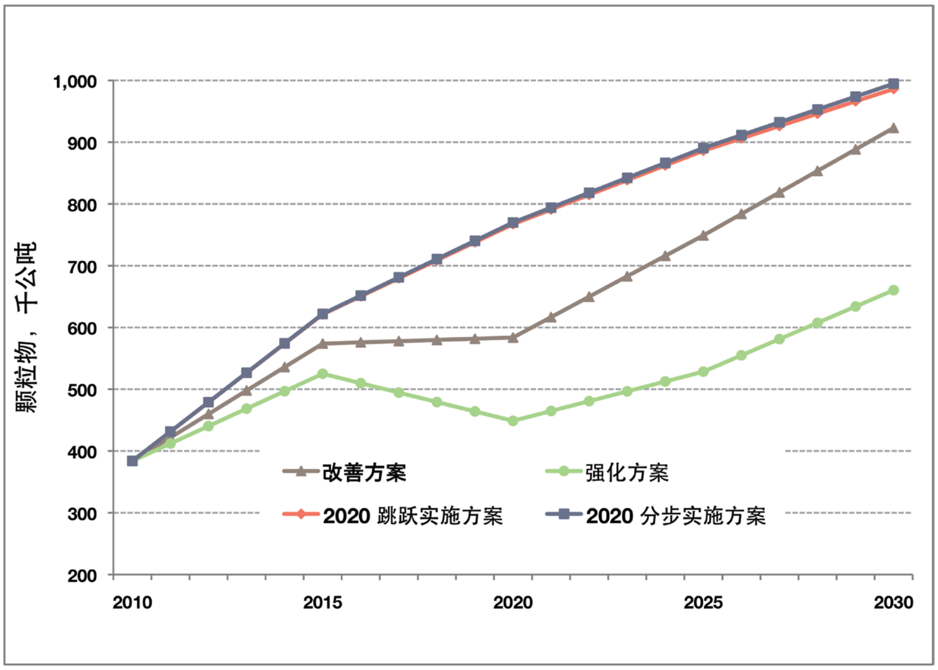


图3.5: 不同国VI实施路线下颗粒物（PM）的排放趋势

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

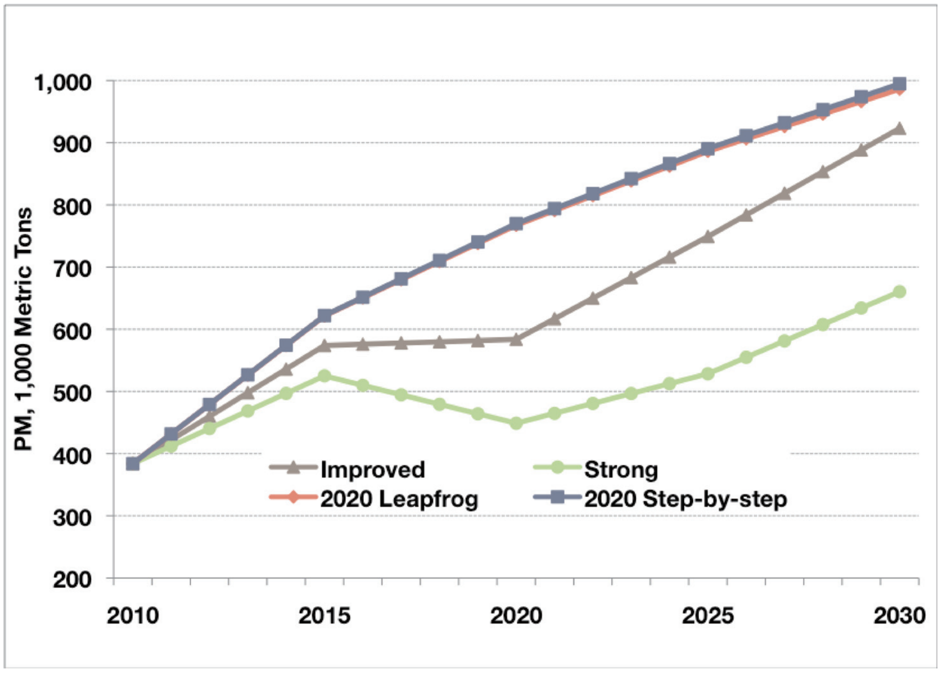


Figure 3.5: PM trends for different China VI adoption pathways

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

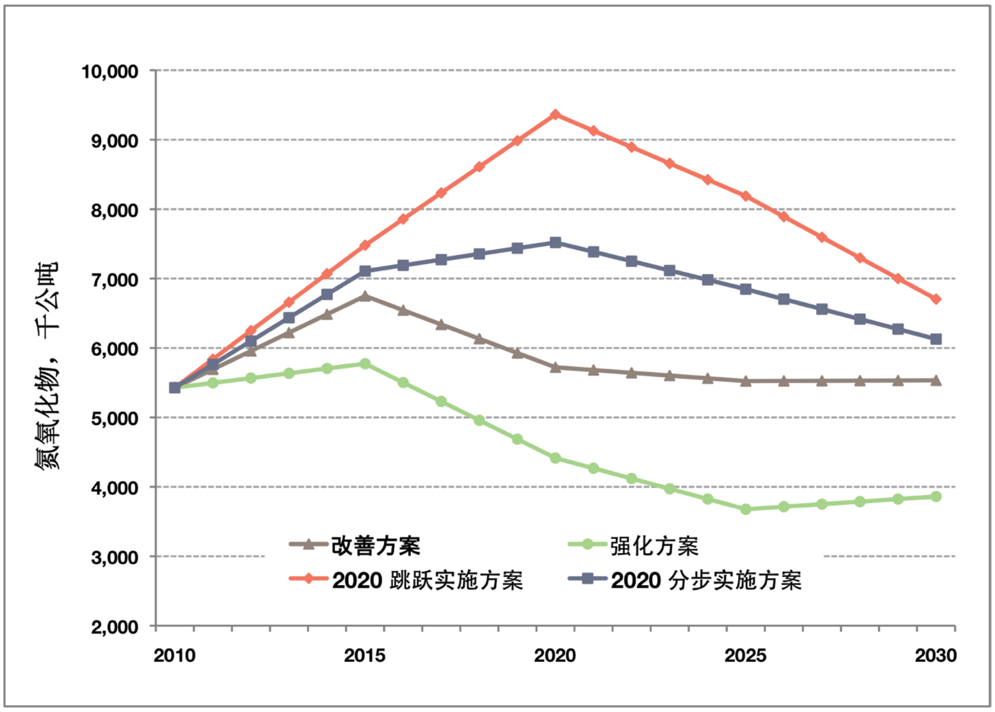


图 3.6: 不同国VI实施路线下氮氧化物（NOx）的排放趋势

---

[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

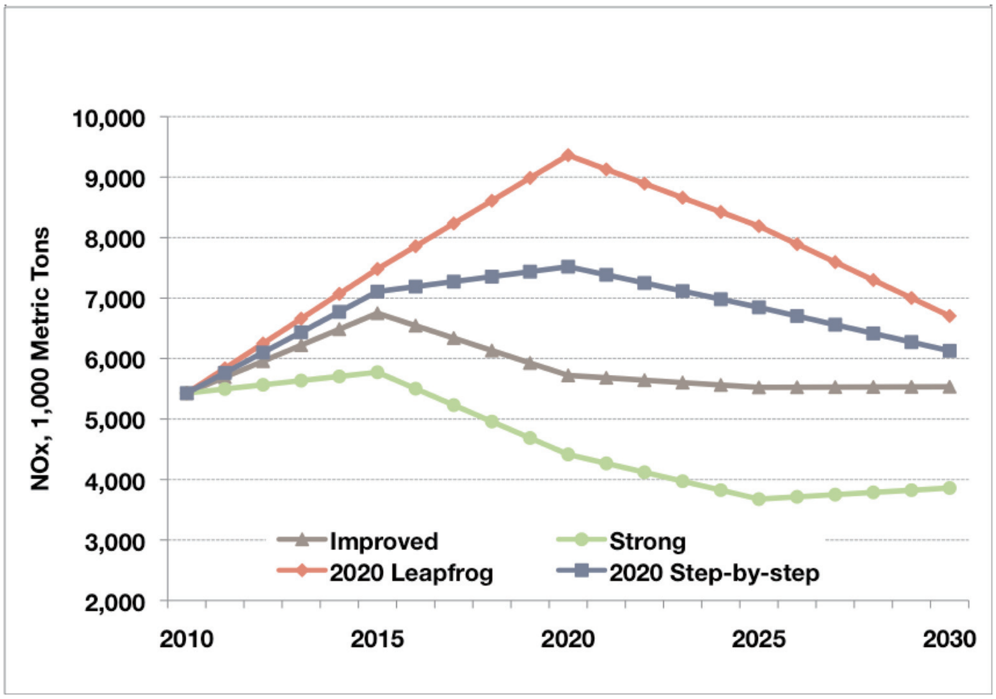


Figure 3.6: NOx trends for different China VI adoption pathways

---

[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.