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.

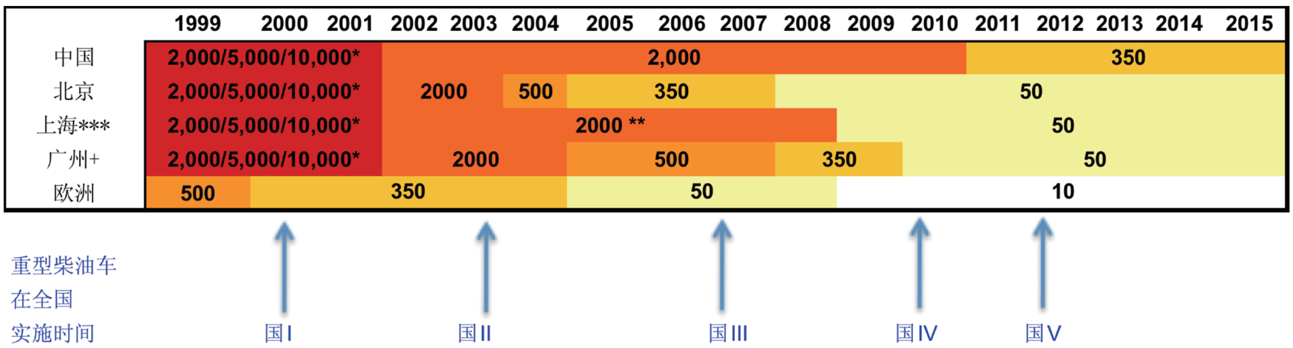


图 4.1: 柴油燃料标准实施时间表

* 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。

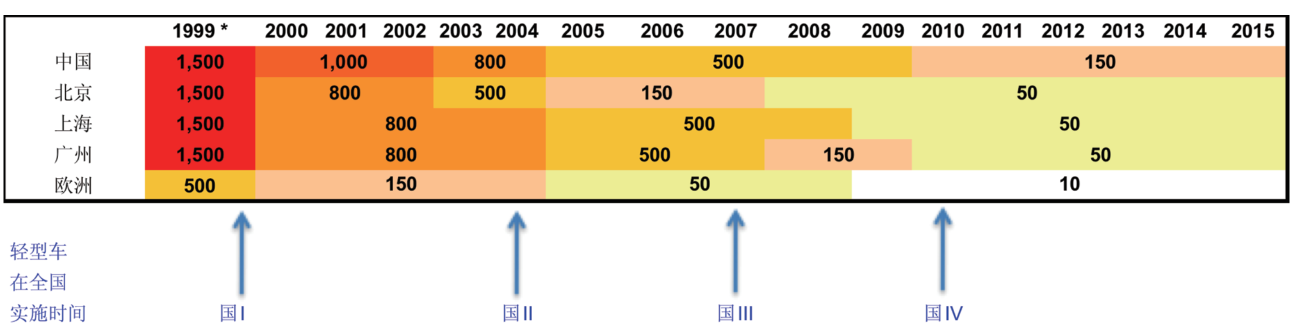


图 4.2: 汽油燃料标准实施时间表

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。

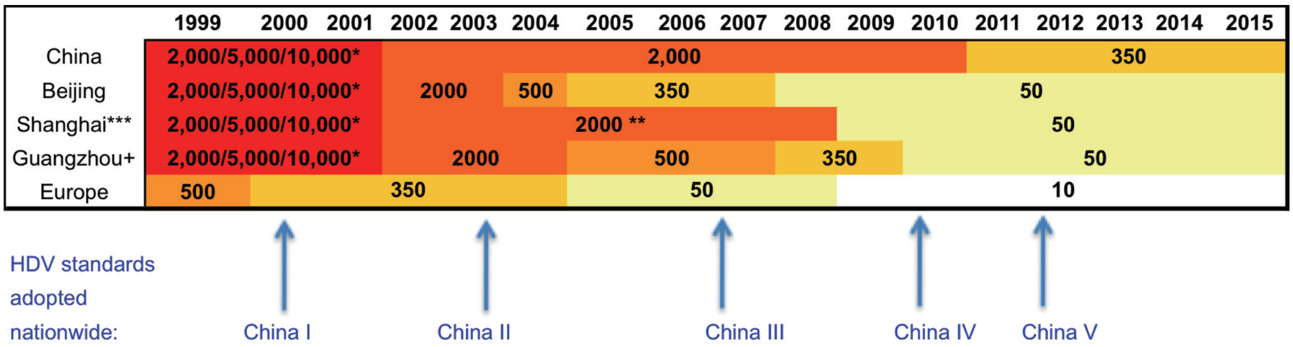


Figure 4.1: Diesel fuel standard adoption timeline

* 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.

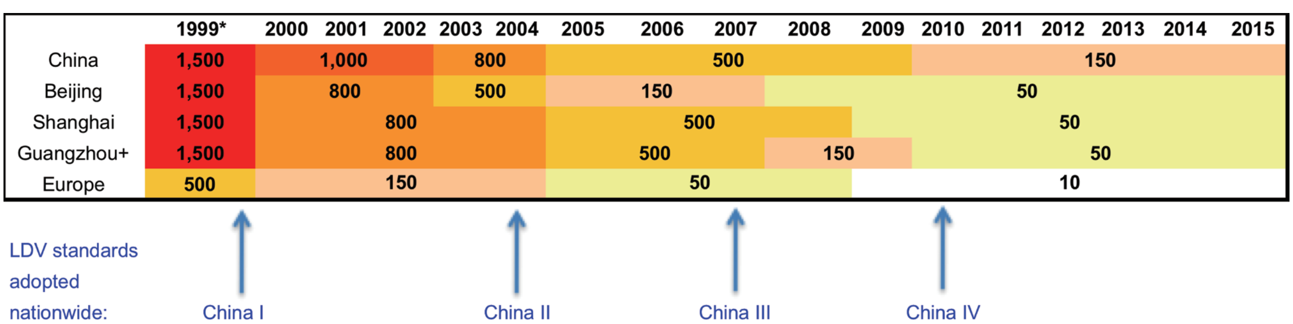


Figure 4.2: Gasoline fuel standard adoption timeline

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。

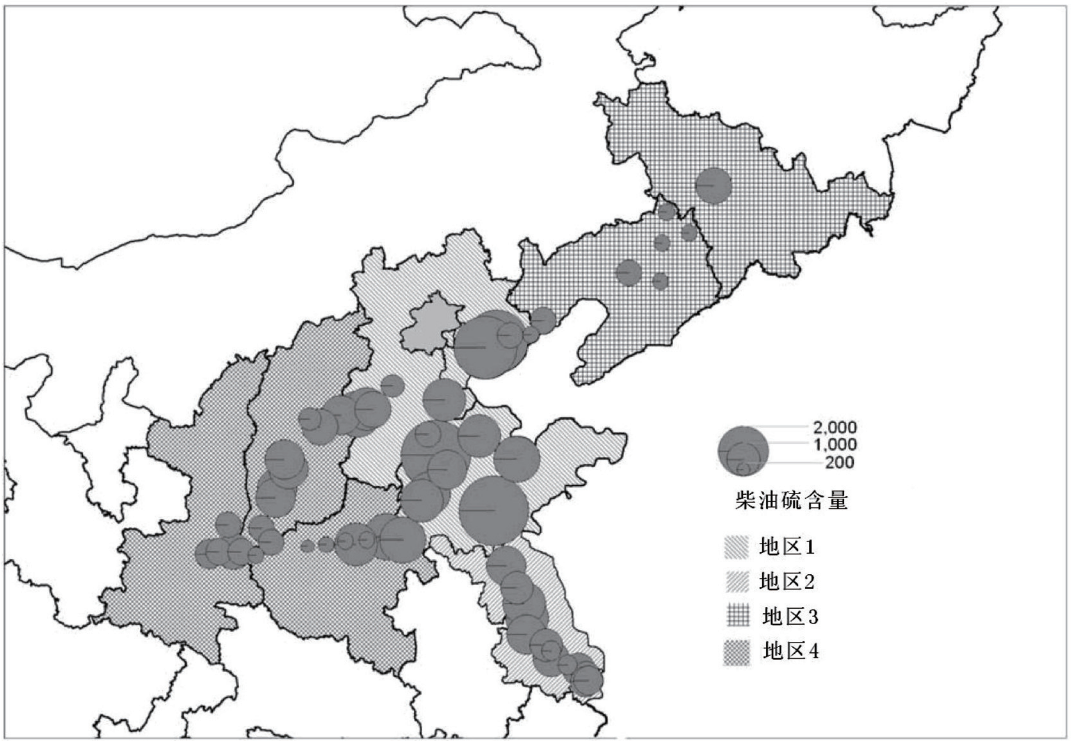
A mandatory diesel standard limiting sulfur content to 2,000 ppm (light diesel standard) was adopted nationwide in China in 2002, and a year later, a voluntary standard for automotive diesel fuel of 500-ppm sulfur was introduced. However, fuel sampling conducted in Northern China and other locations 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。

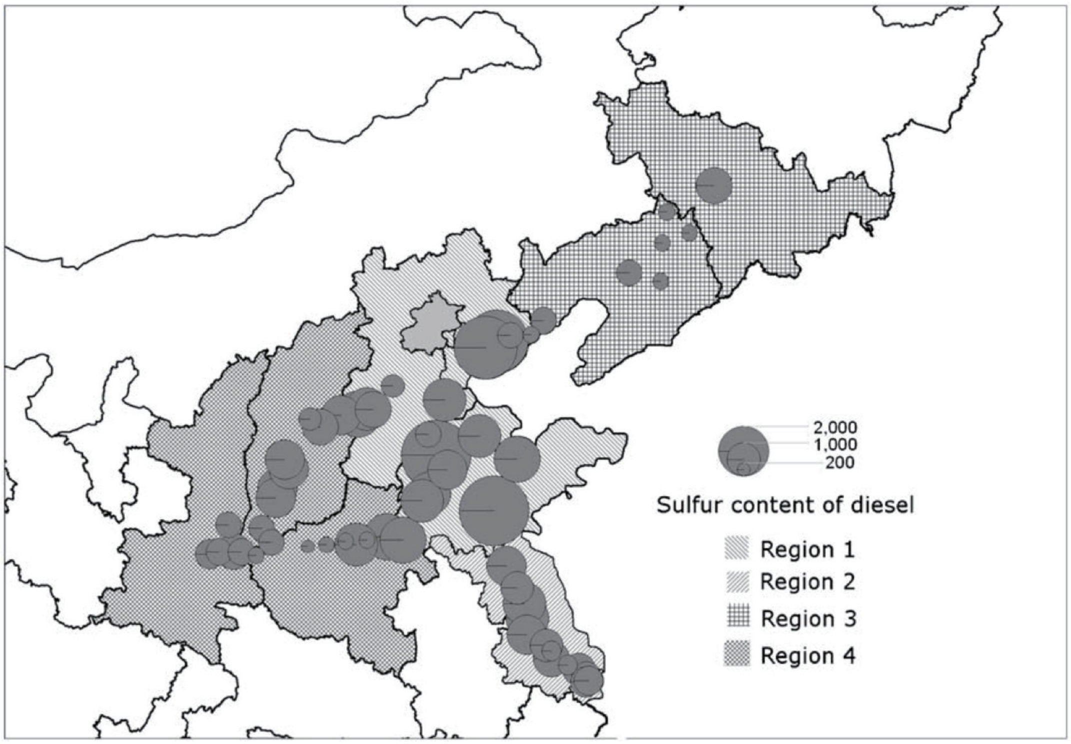
图4.3: 中国北方地区高速公路加油站柴油硫含量抽样情况

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)