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Policy measures to finance the transition to lower sulfur motor fuels

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Background and objective

Shifting to ultra low sulfur motor fuels (diesel and gasoline with sulfur content not exceeding 0.001% or 10 parts per million [ppm]) has tremendous environmental and health benefits. Using ultra low sulfur fuel directly reduces vehicle exhaust emissions, especially sulfur dioxide and sulfate particulate matter emitted from combustion. More importantly, it also ensures that advanced after-treatment technologies such as diesel particulate filters and oxides of nitrogen (NOx) absorbers will function well and lead to significant reduction in vehicular emissions of particulate matter (PM) and NOx. Existing and new catalytically equipped gasoline fueled vehicles will have lower emissions if lower sulfur fuels replace higher sulfur fuels. As a result, all the countries and regions in the world that have adopted the strictest vehicle emissions standards (e.g. Euro 5/V or above or US Tier 2 standards for light-duty vehicles and US model year 2010 standards for heavy-duty vehicles) also require the concurrent use of ultra low sulfur fuels in order to enable well-functioning and durable emissions control technologies.

Ultra low sulfur fuels (ULSFs) are more expensive for refineries to produce than higher sulfur fuels primarily because of the required investment in the equipment and processes to remove naturally occurring sulfur from petroleum, in addition to increased operating costs. Therefore, many countries and regions have deployed a variety of policies to incentivize an accelerated transition to ULSFs.

This working paper is intended to provide an overview of successful international experiences related to financing motor fuel desulfurization by introducing fiscal and other policy measures with examples from five countries or regions in Europe, North America and Asia. The policies showcased include tax differentials at the pump, tax incentives or subsidies for refiners, and regulatory mandates with flexibility. The following sections describe the policy packages implemented in Japan, Hong Kong, the United Kingdom, Germany, and the United States. The paper concludes with a set of lessons learned from the international experiences to date.

Japan

Nitrogen oxides (NOx) and particulate matter (PM) pollution had become a national concern in the 1980s in Japan. In 1989, the national government established short- and long-term emission standards to reduce NOx and PM emissions from diesel engines[1]. The emission limits were set in parallel with a requirement to use lower sulfur content diesel fuel (less than 0.05% or 500-ppm) to ensure that the advanced exhaust after-treatment system (exhaust gas recirculation and oxidation catalyst) would function well. The government instituted direct tax incentives in two phases, from 1990-1992 and from 1993-1997, to subsidize refinery investments for reducing sulfur in diesel fuel first to below 2,000 ppm and then further to 500-ppm. Refineries had a choice of a 7 percent

1 Petroleum Association of Japan. 2011. Petroleum Industry in Japan 2011, page 49. Accessed on July 3, 2012. http://www.paj.gr.jp/english/industry/.

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deduction in corporate tax or a 30 percent accelerated depreciation on the purchased equipment[2].

Recognizing the severe deterioration in air quality caused by diesel emissions, the Tokyo metropolitan government (TMG) decided to step ahead of the national government to implement a strict diesel vehicle control program. Led by governor Shintaro Ishihara, TMG shifted from "lobbying the national government" to "initiating national changes from Tokyo" and launched the "Say No to Diesel Vehicles" campaign in 1999. Under the program, heavy diesel trucks that could not meet the PM standards defined by Tokyo government would be banned from driving in 8 major prefectures in the Greater Tokyo area.

In parallel, the Tokyo government partnered with the Petroleum Association of Japan for early distribution of low sulfur diesel fuel. Before 2000, diesel fuel with 50-ppm or less sulfur was only available in small volume for use in laboratory experiments and was as expensive as 1,200 yen per liter. The Tokyo government initiated a two-year incentive program in 2001 to subsidize up to 10 yen per liter[3] to oil companies that supply ≤ 50-ppm sulfur diesel fuel[4]. These Tokyo regulations quickly sparked negotiations at the national level between the then Ministry of International Trade and Industry (MITI, now formally the Ministry of Economy, Trade and Industry) and industry stakeholders such as the Japan Automobile Manufacturers Association (JAMA) and Petroleum Association of Japan (PAJ), resulting in an agreed timeline for bringing ≤ 50-ppm diesel to market by end of 2004, with federal assistance in the form of tax breaks, depreciation allowances, and research sponsorship on diesel particulate filters.[5] The outcome of these negotiations in early 2000 was the nation-wide availability of 50-ppm sulfur diesel by mid-2003, 21 months earlier than required by the national government's regulation[6]. Not long thereafter, 10-ppm near zero sulfur fuel became available nation-wide in 2005, two years ahead of the national schedule[7]. Since vehicular emissions are the dominant source of black carbon aerosols (a potent climate forcer and air pollutant) in Tokyo, these policies led to direct and significant reductions (80%) in mass concentration of black carbon between 2003 and 2010.[8]

Hong Kong

Hong Kong was another frontrunner in setting sulfur limits in motor fuel. In 1995, the government reduced the sulfur content of diesel fuel from 5,000-ppm to 2,000-ppm and again to 500-ppm in 1997[9]. And in 2000 Hong Kong became the first region in Asia to introduce 50-ppm sulfur diesel fuel to the market.

To promote the supply of 50-ppm diesel fuel, in July 2000, the government reduced the import duty for 50-ppm sulfur diesel to HK$1.11 per liter, from a previous diesel tax of HK$ 2.00 per liter (in 2000 HK$)[10] . Within two months, 50-ppm sulfur diesel became the main diesel fuel supplied at local filling stations[11]. In the following year, although the duty on 50-ppm sulfur diesel rose, the tax differential between the two fuel types (500-ppm vs. 50-ppm) remained at HK$ 0.89 per liter[12]. When all diesel vehicles switched to using only 50-ppm sulfur diesel, the government estimated that respiratory suspended particulate (RSP) and NOx emissions from the whole diesel fleet would be reduced by about 15% and 5%, respectively[13]. The concessionary duty (import tax reduction) cost was estimated at HK $680 million for the first 2 years (2000–2002) and HK$1.2 billion for the third year (2002–2003)[14].

Riding on the momentum of the appreciable improvements in air quality resulting from combining standards with fiscal incentives, the Hong Kong Environmental Protection Department in 2007 issued a HK$0.56 per liter concessionary duty to promote market penetration of 10-ppm sulfur diesel fuel in anticipation of implementing Euro V requirement for all diesel vehicles in 2009.[15] Compared to 50-ppm fuel, using 10-ppm fuel resulted in an 80% and 5% reduction of SO_2 and PM emissions,

2 K. Gallagher and O. He. 2005. Providing Low-Sulfur Fuels for Transportation Use: Policy Options and Financing Strategies in the Chinese Context.

3 TMG estimated that the desulfurization will cost about 500-600 billion yen nationwide. If this cost is to be absorbed over ten years, the price of diesel fuel would only rise by one yen per liter, asserting that the level of subsidy is high enough for incentivizing the early supply of low sulfur fuel.

4 E. Takahashi, Bureau of Environment, Tokyo Metropolitan Government. Presentation: "The Diesel Vehicle Control in Tokyo".

5 D. Rutherford. *Policy Change in Japan: the Tokyo Metropolitan Government's Regulation of Diesel Emissions.* Doctoral dissertation, Stanford University. Palo Alto: Sept 2006.

6 Bureau of Environment, Tokyo Metropolitan Government, 2003. In Introducing Diesel Vehicle Control.

7 E. Takahashi, Bureau of Environment, Tokyo Metropolitan Government. Presentation at Symposium on Regulations on Diesel Vehicles as a Measure against Climate Change: "The Diesel Vehicle Control in Tokyo". January 17, 2011.

8 Kondo, Y., Ram, K., Takegawa, N., Sahu, L., Morino, Y., Liu, X., Ohara, T., 2012. Reduction of black carbon aerosols in Tokyo: Comparison of real-time observations with emission estimates. Atmospheric Environment 54, 242–249

9 W. Hung. 2004. Taxation on Vehicle Fuels: its impacts on switching to cleaner fuels. Energy Policy 34 (2006) 2566-2571.

10 Hong Kong Economic Services Bureau. 2000. Legislative Council Panel on Economic Services: Major Fuel Prices and Competition in the Market.

11 W. Hung. 2004. Taxation on Vehicle Fuels: its impacts on switching to cleaner fuels. Energy Policy 34 (2006) 2566-2571

12 Hong Kong Special Administrative Region Government. 2000. Tax Incentives to Encourage Switching to ULSD.

13 Ibid.

14 W. Hung, 2004. Taxation on Vehicle Fuels: its impacts on switching to cleaner fuels. Energy Policy 34 (2006) 2566-2571

15 Hong Kong Environmental Protection Department (HKEPD). 2007. HKEPD Press Release: "Concessionary duty rate for Euro V diesel to start from tomorrow." November 30. Accessed on July 3, 2012. http://www.epd.gov.hk/epd/english/news_events/press/press_071130b.html

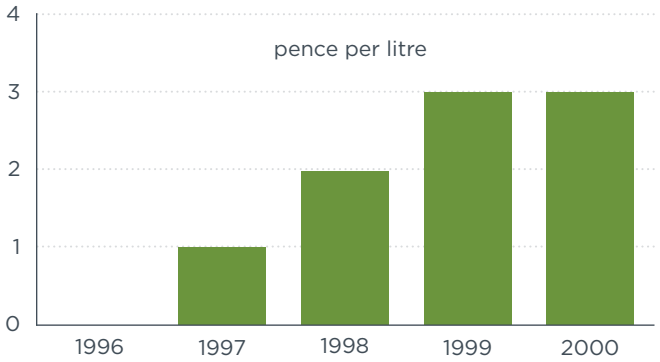

Figure 1-A. Duty differential between 50-ppm sulfur diesel and 200-ppm sulfur diesel

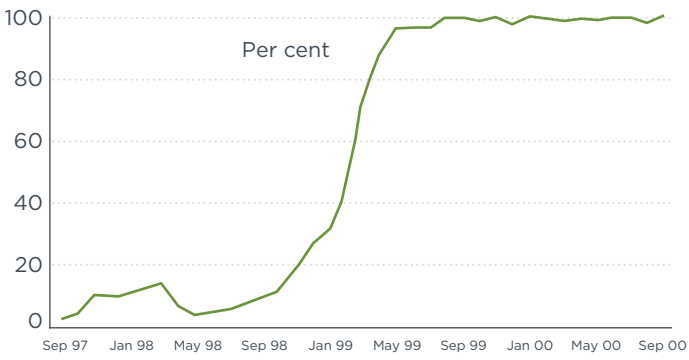

Figure 1-B. Market share of the 50-ppm suflur diesel

Source: HM Revenue and Customs (2000)

respectively.[16] By mid-2008, the duty rate for 10-ppm sulfur diesel was waived altogether and filling stations began to exclusively carry this fuel.[17] The government continued to waive the concessionary duty for 10-ppm sulfur diesel fuel even after the 10-ppm sulfur limit was mandated in July 2010.[18] A study assessing the health impacts of the earliest 1990 restriction to 5,000-ppm sulfur found a significant decline in respiratory and cardiovascular disease induced premature death between 1985 and 1995, supporting claims that air pollution control measures can bring about significant short and long term public health benefits.[19]

United Kingdom

In the European Union, the Euro IV fuel and vehicle emission standards were implemented in 2005, requiring a maximum of 50-ppm sulfur in onroad and nonroad diesel. A subsequent EU directive (Euro V) mandated that ultra-low-sulfur diesel with a maximum of 10-ppm of sulfur be exclusively available by 2009. However, it became widely available as early as the beginning of 2008 in the United Kingdom.

In the UK, the conversion of its diesel motor fuel market to 50-ppm diesel was achieved six years ahead of the EU schedule and well ahead of most other EU member states. This can largely be attributed to a series of 50-ppm diesel tax incentives. Beginning in fiscal year 1997, the tax differential was set at 1 pence per liter, and the amount ratcheted up each year until full market penetration of 50-ppm diesel in the market was achieved in year 2000[20]. Figures 1-A and 1-B below illustrate the scale of tax differences between regular (200-ppm) and 50-ppm sulfur diesel fuel in 1997-2000 and the resulting trend of 50-ppm diesel market share.

The fuel tax incentive was accompanied by vehicle tax incentives. In 1998-1999, when the 2 pence tax differential in 50-ppm and conventional (> 50-ppm) diesel was introduced, the government also reduced the vehicle excise duty (VED) of £500 for heavy-duty diesel vehicles that had particulate traps and other pollutant abatement technologies installed (meeting a preexisting Reduced Pollution Certificate qualification). In the following year, the VED reduction increased to £1,000[21]. The incentives for cleaner fuel and cleaner vehicles worked together to promote a rapid shift to a cleaner diesel fleet in the UK and significantly reduced PM emissions (by 21% in 1999)[22].

Germany

Focusing on improving air quality from transportation for health benefits, the German Federal government decided to roll out a series of fiscal measures for the early introduction of diesel and gasoline with ≤ 50-ppm sulfur content in 2001. As a financial disincentive, the government issued an extra tax of 3 pfennigs/liter on fuel with a higher-than-50ppm sulfur level beginning in November 2001, then was strengthened by extending the 3 pfennigs/liter extra tax on fuel with higher than 10-ppm sulfur content from January 1, 2003[23]. As early as 2004, virtually all fuel sold in Germany contained ≤ 10-ppm sulfur with minimal and

16 Ibid.

17 HKEPD. 2012. "Cleaning the Air At Street Level." HKEPD website. Accessed on July 3, 2012. http://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/cleaning_air_atroad.html

18 Communications with Vanessa Au, Environmental Protection Officer of Hong Kong Environmental Protection Department, October 26, 2012.

19 Hedley, A.J., Wong, C.-M., Thach, T.Q., Ma, S., Lam, T.-H., Anderson, H.R., 2002. Cardiorespiratory and all-cause mortality after restrictions on sulphur content of fuel in Hong Kong: an intervention study. Lancet 360, 1646–1652.

20 HM Customs and Excise. 2000. Using the Tax System to Encourage Cleaner Fuels: The Experience of Ultra-low Sulfur Diesel.

21 B. Olivastri and M. Williamson. 2000. A Review of International Initiative to Accelerate the Reduction of Sulfur in Diesel Fuel.

22 Ibid

23 Olivastri, op. cit.

Table 1. Summary by type of policies adopted in Japan, Hong Kong, Germany, the Unite Kingdom and the United States.

Policy type	Region	Magnitude	Result
Tax differentials at the pump	Hong Kong	• HK$ 0.89/L for 50-ppm difference; HK$ 0.56/L for 10-ppm	• Became the first region to introduce 50-ppm sulfur diesel in Asia; • Exclusive availability of 10-ppm sulfur diesel by 2008
	United Kingdom	• 1~3 pence/L from 1997-1999	• Rapid transition to full 50-ppm diesel market in 1999
	Germany	• An extra 3 pfennigs /L tax on diesel greater than 50 ppm sulfur in 2001 • Extend the 3 pfennigs/liter extra tax for diesel with sulfur ≥ 10 ppm in 2003	• Rapid shift to 50-ppm and 10-ppm sulfur diesel
Tax incentive for refiners	Japan (national)	• 7% deduction in corporate tax, or a 30% accelerated depreciation on equipment purchase	• 5,000-ppm→ 2,000-ppm (1992)→ 500-ppm (1997)
	United States	• $0.05 per gallon of 15-ppm diesel for small refiners	• Shift to 30-ppm average gasoline in 2006, 15- ppm diesel in 2009
Direct government subsidy to refiners	Tokyo	• 10 yen/L	• 500-ppm → 50-ppm (2003) →10-ppm (2005) respectively 21 months and 2 years ahead of national regulatory schedule
Regulatory mandates with flexibilities	United States	N/A	• Shift to 30-ppm average gasoline in 2006 • 15-ppm diesel in 2009

short-lived fuel price disruption due to competition and gains in efficiency from refining technology[24].

United States

The United States has taken a predominantly regulatory approach to achieve the implementation of clean fuels. The U.S. Environmental Protection Agency (EPA) issued regulations requiring lower sulfur gasoline by 2006 (average 30-ppm sulfur, with an 80-ppm cap), 15-pm sulfur highway diesel (phased in from 2006-2009), and non-road diesel (15-ppm sulfur maximum) by 2010. Prior to the promulgation of these standards, sulfur was capped at an average of 300-350 ppm in gasoline and a maximum of 500-ppm in highway diesel, and a maximum of 3,000-ppm in non-road diesel[25].

Refiners were expected to comply with these regulations with little fiscal assistance from the government. As a result, incremental costs of desulfurization would be passed on to consumers and reflected as an increase in the fuel prices at the pump[26]. However, the government did provide some flexibility to assist refiners in meeting these targets, such as allowing credit trading among refiners and extension of the target deadline for small refineries[27]. From fiscal years 2003 to 2009, a tax credit of $0.05 per gallon of 15-ppm diesel was granted to small business refiners[28]. Such regulatory efforts were combined with a limited tax incentive issued to customers for the purchase of advanced lean-burn technology diesel vehicles ranging from $1,300 to $1,800 USD beginning in 2008 and gradually phased out after the manufacturer reports the sale of the 60,000th vehicle.[29]

Summary and Conclusions

This short paper reviewed policy measures in five countries/regions implemented to finance the transition to lower sulfur motor fuels. The policies can be grouped into four categories as presented in the table below. The table also summarizes the policy type, magnitude of fiscal policies, and results of each case, followed by a set of lessons learned from these cases.

We've also summarized some general lessons from the above cases:

24 Walsh, Michael P. Car Lines. Issue 2. April 2004.

25 K. Gallagher and H. He Oliver. 2005. Providing Low-Sulfur Fuels for Transportation Use: Policy Options and Financing Strategies in the Chinese Context. Conference Paper for the Kennedy School of Government, Harvard University.

26 The transition to ULSD is not without substantial costs. The US Government had estimated that pump prices for diesel fuel will increase between $.05 and $.25 per gallon as a result of the transition.

27 B. Olivastri and M. Williamson. 2000. A Review of International Initiative to Accelerate the Reduction of Sulfur in Diesel Fuel.

28 U.S. Tax Code Section Number 45H: Low Sulfur Diesel Fuel Production Credit. Code available online at: http://www.law.cornell.edu/uscode/text/26/45H

29 Qualifying vehicles have engines that use more air than necessary to ensure complete combustion of the fuel and also incorporate direct fuel injection technology. IR-2008-113. Vehicles certified as advanced lean-burn technology vehicles. Oct. 2008. Accessed on July 3, 2012. http://www.irs.gov/newsroom/article/0,,id=187546,00.html

- To accelerate the supply of low sulfur fuel, governments may choose to implement regulatory mandates (setting lower sulfur standards) and leave it to the market to determine the cost burden that will be passed on to consumers. To ease the hardship to refineries with difficulties meeting the standards or small refineries with less available capital to upgrade, governments may consider providing compliance flexibilities through credit trading and/or extended compliance timeline.
- Governments could also use various policy tools to lower the financial burden on refiners. Setting differentiated tax rates on lower sulfur fuels compared to higher sulfur fuels, providing tax reduction/credits to refiners that provide lower sulfur fuels, and directly subsidizing the supply of lower sulfur fuels are all common financial measures and showed success in encouraging early and rapid adoption of lower sulfur fuel in various countries and regions.
- Incentives targeting consumers, such as tax reductions implemented at the pump, could be combined with an increased tax at the pump for higher sulfur diesel.
- Fiscal incentives are almost always combined with regulatory mandates on fuel quality, with the regulation serving as a "backstop." That is, regulatory mandates set a definite date by which lower sulfur fuel requirement must be met, and fiscal incentives could be used (and proven successful) to shorten the transition time to lower sulfur fuels.
- A well-set magnitude of fiscal incentive can foster rapid transition to lower sulfur fuels market, even ahead of the regulatory schedule. For some countries, like UK, not equipped with the supply infrastructure to deliver fuel with two different sulfur levels, the magnitude of incentives were set large enough to promote rapid transition. However, it is well established that whatever the fiscal incentive chosen, it must manifest in a price differential at the pump that favors the lower sulfur fuel as consumers will not make the shift if the cleaner fuel is not competitively priced.[30] The incentive will be successful if it encourages individual refiners to proactively invest, in advance, in the capital costs for refining technology that would ultimately be borne by all refiners in order to satisfy the regulation.[31]

30 K. Gallagher and H. He Oliver. 2005. Providing Low-Sulfur Fuels for Transportation Use: Policy Options and Financing Strategies in the Chinese Context. Conference Paper for the Kennedy School of Government, Harvard University.

31 B. Olivastri and M. Williamson. 2000. A Review of International Initiative to Accelerate the Reduction of Sulfur in Diesel Fuel.