

## SHAPING ENVIRONMENTAL REGULATION THROUGH TECHNOLOGY DEMONSTRATION: EVIDENCE FROM THE DIESEL VEHICLE INDUSTRY

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### ABSTRACT

Environmental regulations are often treated as exogenous to technology development, with companies responding to standards as a given. This paper investigates how companies can shape regulations by communicating their technological progress to regulators. Regulators often set standards based on their assessment of industry progress, and are inherently biased towards leading-edge technology. Technology leaders are therefore poised to influence future regulatory stringency and gain competitive advantage from superior technology. However, they are usually reluctant to dissent from their industry peers or upset their cost-conscious customers, who may prefer more lenient regulations.

A study of industry-government interaction during recent diesel vehicle emission and fuel standard-setting processes in Europe, Japan, and the US illustrates the tension between seizing this competitive opportunity and adhering to industry norms. Rather than publicly advocating more stringent regulation, diesel technology leaders more subtly communicated their technology preparedness to regulators through written submissions, private consultations, public technology demonstrations, or small-scale commercial introduction. In some cases, environmental NGOs seized upon the knowledge about new technologies, and used them as leverage to press regulators for tighter standards. Semi-structured interviews and documentary sources, such as regulatory documents, technical journals, research reports, and trade press, show that demonstrating technology had a significant influence on regulatory decision-making. The findings show that environmental regulations have the potential to satisfy the dual goals of rewarding technology leadership and protecting human health and the environment.

Keywords: Critical infrastructures, institutions, and incentives; Environmental regulation; Diesel emissions; Technology assessment; Competitive advantage

### INTRODUCTION

In the 1970s and 1980s, with the onset of more environmental regulations, most business and economics research treated regulations as exogenously determined by government and firms as passive “regulation-takers” (Gray 1987). In reality, firms actively influence regulations, not only through political lobbying, but through technological progress and competitive strategy. There has been increased recognition of the value in treating regulations as endogenous to innovation because influencing regulations can be an integral part of firm strategy (Barrett 1992; Hackett 1995; Maloney and McCormick 1982; Maxwell, Lyon et al. 2000; Rugman and Verbeke 1998). Firm strategy to influence regulations for competitive advantage is known as “competitive regulatory strategy.”

Economists have addressed this type of strategy as one way of “raising rivals’ cost.” Mandatory product standards or other government regulation can raise rivals’ compliance cost, which will benefit the firm with the lower cost or better technology (Salop and Scheffman 1983). Various theoretical duopoly models been used to illustrate how the technology leader/first-mover can benefit from more stringent standards (Gersbach 2002; Hackett 1995; Innes and Bial 2002; Puller 2005; Salop, Scheffman et al. 1984; Salop and Scheffman 1983).

Governments will often pursue more stringent standards in the public interest. For example, new scientific evidence may support greater stringency or public pressure may encourage government action. Governments may also use regulation as an instrument to promote national competitiveness. Setting more stringent regulations encourages domestic firms to innovate and potentially expand their export market share. Foreign companies and countries have skeptically accused these “first-mover countries” of using regulations as nontariff trade barriers to favor domestic firms and protect them from foreign competition. If government regulations are also aligned with public goals, like environmental protection or safety, they may also have the backing of public interest groups and NGOs (non-governmental organizations). NGOs may team with government officials and lead companies to support regulation (Baron 1995).

Given the potential competitive advantage for lead firms and public support for greater stringency, lead firms often have an incentive to support more stringent regulations. However, there are several reasons to deter them from proactive behavior. Being early or first to introduce a new technology exposes firms to additional business risk, especially where there is uncertainty about the new technology’s performance, compatibility to existing infrastructure, and market acceptance. Also, rival firms may discourage lead firms from stepping forward with new technologies. Industry associations generally prefer more lenient regulation, and lead firms may be reluctant to deviate from the industry position. Even vendor companies that sell more products with stringent standards may not openly advocate more regulations because they do not want to upset potential customers, who would have to pay more for the cleaner products.

Technology demonstration offers an alternative to direct lobbying. Lead firms still have to make the investment necessary to develop the product to prototype or demonstration stage, but they do not have to expand to full production unless demand for their product – whether driven by regulation or by customer interest – is more certain. Regulators often use technological progress as the basis for regulatory standards, so demonstrations of technology capable of surpassing existing regulations may lead regulators to consider increased stringency. The regulated firms usually have better information about their technologies and costs than regulators. Reluctant to encourage more regulation, firms may be inclined to downplay their progress. However, competition based on technology performance alleviates the information asymmetry between regulators and the regulated firms. Firms offer information to regulators about their progress with the expectation that their openness may lead to more favorable standards. Technology demonstration may also resolve infrastructure compatibility issues because it gives lead firms the opportunity to test how new products interact with complementary technologies and to develop the necessary infrastructure. Small-scale introductions offer positive publicity for the firms and generate customer and regulatory interest in the new technologies.

This paper addresses how lead firms use technology demonstration to influence environmental regulations. A key measure of success would be regulatory outcomes that generate positive environmental benefits as well as positive competitive benefits for the firm.

While financial benefits like increased profitability, sales, and market share growth are clear private benefits, other benefits like reputational gains are less tangible but important for long-term success.

## **APPLICATION TO THE DIESEL VEHICLE INDUSTRY**

The emission and fuel standards faced by the diesel vehicle industry provide a rich setting to study how technology demonstration influences regulations. Vehicle and equipment manufacturers and oil companies must respond to increasingly stringent standards. Recent scientific studies have attributed exposure to particulates in diesel exhaust to many serious health impacts, including respiratory diseases, cardiovascular mortality, and lung cancer. Compared to gasoline vehicles, diesels also generate higher nitrogen oxide (NO<sub>x</sub>) emissions, which contribute to smog formation and subsequent respiratory ailments. As a result, environmental groups have encouraged regulators to consider stronger restrictions on diesel vehicles. Meanwhile, diesel vehicles are valued for their higher fuel efficiency and lower CO<sub>2</sub> emissions compared to gasoline vehicles. Industry and government alike are very interested in “clean diesel” technologies that can capitalize on diesel’s benefits while mitigating its health impacts.

Companies in the European Union (EU), Japan, and the US are world leaders in vehicle technology. Their governments have established the world’s most stringent emission and fuel standards. Standards have been repeatedly reviewed and updated at various intervals. They challenge companies to continuously innovate and adopt more effective emission control technologies. Technology demonstration can affect regulators at any stage in a regulatory cycle, from regulatory proposal to implementation, but influence on standard-setting is likely to occur in the earlier stages of proposal and public review.

This study examined regulatory cycles for light-duty diesel vehicle emissions, heavy-duty diesel engine emissions, and on-road diesel fuel sulfur levels. Coverage included the EU, Japan, and the US from the 1990s to the present. The public accessibility of records for the most recent regulatory cycles led to a relatively contemporary timeframe.

## **DATA SOURCES**

A combination of documentary sources, quantitative data, and personal interviews provided information about the regulatory processes, new technologies, and corporate strategies. Documentary sources included industry databases, professional/trade journals, research project summaries, patent databases, company reports, and regulatory documents. Descriptive statistics about individual companies, industries, and countries were obtained from company financial reports, industry associations, and government agencies. Semi-structured interviews were conducted with over 50 experts in industry, government, NGOs, academia, and research institutes who had been involved with at least one of the regulatory cycles in the 3 regions studied. The interview questions, which were open-ended and customized for each expert, built on information already derived from the documentary sources and quantitative data.

## CASE STUDY EXAMPLES

After a review of multiple regulatory cycles in the EU, Japan, and the US, it was found that regulated firms rarely introduced technologies ahead of environmental regulation. Although fiscal incentives, especially in the EU and Japan, did encourage firms to introduce technologies ahead of regulatory deadlines, there were few cases of “first-mover” firms that introduced technologies in the absence of any known standards. Even emission control manufacturers, who would be expected supporters of greater stringency, did not explicitly push for more regulation. The next section describes the cases where firms did use technology demonstration as a more indirect and subtle way of communicating to regulators their technology readiness.

### PSA PEUGEOT CITROEN’S DIESEL PARTICULATE FILTER

Although diesel cars have grown in popularity in Europe since the oil crises of the late 1970s and early 1980s, the last decade has witnessed a diesel boom in Europe. It is largely attributable to high fuel taxes and differential tax schemes favoring more-efficient diesels. The diesel share of passenger cars in Western Europe soared from 15% in 1990 to 50% in 2005. Accompanying diesels’ growth has been rising public concern about their higher nitrogen oxide (NO<sub>x</sub>) and particulate matter (PM) emissions compared to gasoline vehicles.

In 1996, the European Commission adopted the Euro 4 passenger car emission standards for 2005. At the time, the PM standard was expected to require the installation of diesel particulate filters, which removes particles from engine exhaust. Filter suppliers had already developed filters with over 95% efficiency but their added cost and fuel economy penalty made them an unattractive add-on for automakers. Because of progress in engine design, auto manufacturers were able to meet the Euro 4 standards in the early 2000s without filters. Environmental groups, bolstered by scientific studies reporting the serious health impacts of diesel particulates, argued that the Euro 4 PM standard was too lenient. From 1994 to 1996, the diesel market share in France, Germany, and UK actually dipped slightly, attributed largely to concerns about diesel exhaust’s health effects (ACEA 2005).

French automaker PSA Peugeot Citroën decided to introduce diesel particulate filters in its vehicles, in response to medical studies reporting on the negative effects of diesel exhaust. Because PSA’s product portfolio focuses on small and medium diesel cars, the growing attention to the health impacts of diesels threatened to dampen diesels’ popularity and erode PSA’s future market share. After 18 months of R&D and €66 million (US\$71 million), PSA had a filter system ready for integration into its production vehicles. Initially, in 2000, PSA offered the filter on the Peugeot 607 model only, but over the next three years, it introduced the system as standard on six more models (PSA 2000-2005).

PSA provided its filter-equipped Peugeot 607 diesel car for a third-party test sponsored by Germany’s environmental agency (Umweltbundesamt, or UBA) and the German Auto Club (ADAC). The resulting August 2001 publication claimed that the filter-equipped car emitted only 0.001 g/km PM over 80,000 km, the distance required by the EU type approval testing. This level was 25 times lower than the level required by the 2005 Euro 4 standard (Rodt 2003). From 2001 to 2003, PSA also conducted field testing with a Paris taxi fleet of four Peugeot 607s. The study was designed to evaluate the durability of the first-generation filter prior to its first maintenance. The filters removed over 95% of the particles throughout the 80,000 km interval,

with an average of 0.0027 g/km from all the tests (Jeuland, Dernenthon et al. 2004; Jeuland, Dernenthon et al. 2002).

Following reports about the new filter system’s effectiveness, health and environmental NGOs seized upon PSA’s filter introduction as an opportunity to criticize other auto manufacturers for not adopting filters. In Germany, where environmental awareness is particularly strong, an alliance of interest groups coordinated a “shame campaign” in November 2002, aimed at German automakers (VW, DaimlerChrysler, BMW) which did not offer filter-equipped diesel cars. With the tagline, “No Diesel without Filter,” the campaign called for a government mandate requiring filters on all diesel cars, while commending PSA for already voluntarily equipping six of their car models with filters (Peckham 2003a).

The “No Diesel without Filter” alliance successfully used press conferences, press releases, and public dramatization to build awareness and gain media attention. Even the Germany environmental agency, UBA, participated in some public events, adding a more official tone to the NGO campaign. A 2003 consumer awareness survey showed that 93% of Germans surveyed were familiar with diesel particulate filters (PSA 2005a). Although PSA did not fund the alliance’s activities and made a concerted effort to keep its marketing activities separate, the firm did benefit from the campaign. PSA did not want to appear to be involved in pushing for greater regulatory stringency. Nevertheless, PSA experienced backlash from rival automakers in the form of public criticism of its technology. The other automakers felt that its filter introduction would unfairly force other manufacturers to adopt filters.

PSA posted strong sales following the debut of its first filter-equipped model. In Germany, its passenger car market share climbed from 2.7% in 1999 to 5.8% in 2003; in Western Europe, its market share increased from 12.1% in 1999 to 14.8% in 2003. During this time period, PSA was able to increase its sales even as total passenger car sales in Western Europe declined. PSA’s market share has since fallen slightly in Western Europe, to 14% in 2004-2005, but this is still substantially higher than its pre-2000 levels.

PSA executives have been hesitant to attribute any quantifiable financial benefits from their early filter introduction, because it is difficult to separate out the impact of the popularity of their new car models and the restructuring of their sales and distribution system, which also began in 1999-2000. However, praise from environmental groups and government agencies undoubtedly boosted PSA’s reputation. Because of its particulate filter, PSA won numerous awards from environmental groups, automobile clubs, and auto enthusiast magazines in France, Germany, Italy, UK, and Austria. It also had a head start in filter systems, which allowed PSA to work through three generations of filter systems by 2003 before many of their rivals had introduced any. In early 2005, PSA had already sold its millionth filter-equipped car, and the second closest was Mercedes-Benz with only 110,000.

Influenced by the growing interest in filters and the desire to encourage the technology’s adoption by other manufacturers, German Environment Minister Jürgen Trittin proposed a €600 tax break for filter-equipped diesels. Customers began to demand filters, and other automakers began to offer them at an additional cost. The German automakers, represented by their trade association, VDA, were perhaps the most strongly opposed to filters. Eventually bowing to customer pressure and negotiating an agreement with Chancellor Gerhard Schroeder, the German automakers agreed to voluntarily adopt filters in all their models by 2008. Filter adoption and its impact on regulations spread outside the lead market of Germany. Other European countries began promising tax incentives for filters. By 2005, the European Commission had to release a

guidance document on tax incentives to establish some uniformity. The Euro 5 PM standard proposed for 2008 is probably the best indicator of the filter introduction’s significant regulatory impact. The standard was tightened to 5 mg/km, 5 times lower than the previous Euro 4 standard and only attainable with filter technology. Even in the US, whose stringent regulation has long been hostile toward diesels, regulators have shown interest in German environmental officials’ presentation of the merits of filter technology.

## **BP AND TOSCO’S ULTRA-LOW SULFUR DIESEL**

Ultra-low sulfur diesel (ULSD) is essential to modern diesel emission control. Using ULSD already reduces emissions, but more importantly, the low sulfur levels enable the use of emission control systems that are sulfur-sensitive. These include catalyzed diesel particulate filters and NO<sub>x</sub> adsorbers. Since the early 1990s, several European countries have led the global trend toward lower sulfur levels. Sweden, Finland, and the UK used fiscal incentives to encourage oil companies to produce clean, low-sulfur fuels early. As a result, their transition to ultra-low sulfur diesel has been rapid. In Japan, negotiations among government officials, auto companies, and oil companies resulted in jointly accelerated efforts to tighten diesel fuel sulfur and vehicle emission standards, aided by subsidies in Tokyo. Meanwhile, in the US, in the absence of fiscal incentives, most oil refineries have sought to weaken or delay standards for low sulfur levels.

In 2000, EPA proposed a new diesel fuel sulfur standard of 15 ppm for 2006, a dramatic reduction from the existing standard of 500 ppm. It was greeted with praise by the automobile, engine, and emission control manufacturers, but the majority of the oil industry considered the 15 ppm limit unnecessarily low and prohibitively costly for refineries. The American Petroleum Institute (API) and the National Petrochemical and Refiners Association (NPRA), industry associations representing the oil industry, submitted formal comments to EPA, expressing their opposition to the 15 ppm standard.

In contrast, British Petroleum (BP), the world’s second largest oil company, and Tosco, the largest independent US refiner, openly supported the 15 ppm standard. Both companies had already begun supplying ultra-low sulfur diesel (15-30 ppm) to municipalities for their fleet vehicles. Environmental campaigns and medical reports had persuaded municipalities to switch from diesel buses to compressed natural gas (CNG) buses. Diesel fuel suppliers and diesel bus manufacturers were under pressure to demonstrate the merits of clean diesel technology in order to preserve diesel market share. In large metropolitan areas with serious air quality problems, government air quality and transit agencies provided subsidies to cover the costs of CNG buses and well as diesel retrofits and ULSD. In 1999, ARCO, later acquired by BP, began providing 15 ppm fuel to California municipal fleets for an additional 5 cents per gallon. ARCO also initiated the EC-Diesel program, a fleet technology validation program, to evaluate the use of catalyzed diesel particulate filters with ULSD. BP had fuel contracts with transit authorities in Ann Arbor, Chicago, Cleveland, Minneapolis, and several California cities (Blake 2004; BP 2002; BP 2003). In 2001, Tosco began supplying 126,000 gallons of fuel per day to New York City’s transit buses (Tosco 2001).

The California Air Resources Board used the initial results of ARCO/BP’s projects to specify the use of ULSD with retrofitted or new diesel buses in its 2000 public transit bus fleet rule. EPA also cited BP and Tosco’s ability to supply ULSD in its defense of the new 15 ppm

standard's cost feasibility: “Statements by refining companies, such as BP Amoco and Tosco, that they will desulfurize their highway diesel fuel earlier than necessary is further evidence that this rule is affordable” (EPA 2000).

According to senior EPA officials, BP and Tosco were at odds with the other oil companies and their own trade associations by not opposing the 15 ppm limit. BP in particular had positioned itself as a supplier of cleaner fuels and saw market share growth potential in acting early. BP's early introduction of 10 ppm sulfur diesel in Europe, especially in the UK and Germany, had given it experience to roll out ultra-low sulfur diesel in the US. BP and Tosco's larger size allowed them to benefit from scale economies in rolling out ULSD, while many small independent refineries did not have enough resources to upgrade their refineries.

Other than retrofit and fuel subsidies from municipal transit agencies, there were few fiscal incentives for early adoption of ULSD. Without some form of tax differentiation as in the EU, it was not cost-competitive for refineries to produce ULSD before the 2006 deadline. As a result, adoption of ULSD in the US has been very slow compared to the EU and Japan, and mainly limited to local public bus fleets.

## **TOYOTA'S D-CAT NO<sub>x</sub> ADSORBER AND PM FILTER SYSTEM**

In the 1990s, Toyota began working on its D-CAT (Diesel Clean Advanced Technology) system to reduce NO<sub>x</sub> and PM emissions from diesel engines. The D-CAT system features a NO<sub>x</sub> adsorber and a particulate filter, which can reduce PM by 80% and NO<sub>x</sub> by 50% below Euro 4 levels (Toyota 2003). The NO<sub>x</sub> adsorber adsorbs and stores NO<sub>x</sub> under lean conditions. During brief periods of rich conditions, the NO<sub>x</sub> is released (“desorbed”) in the presence of CO and catalytically reduced to N<sub>2</sub>. Because the adsorber also adsorbs sulfur oxides, which interferes with NO<sub>x</sub> adsorption, it is important that the diesel fuel used has very low sulfur content (AECC 2006). Its first commercial use was in heavy-duty diesel engines developed by Toyota's affiliate, Hino Motors, to meet Japanese heavy-duty emission standards. Toyota saw the opportunity to apply the technology for light-duty vehicles for the European market.

To demonstrate the performance of the D-CAT system in passenger cars, Toyota conducted an 18-month field test of 60 D-CAT-equipped Avensis cars in seven European countries. Toyota actively promoted its D-CAT system, publishing trade articles, presenting at industry meetings, and discussing the technology with regulators. In the EcoTest testing program sponsored by ADAC, the German automobile club, the D-CAT-equipped Toyota Avensis scored the best in overall low pollutant and CO<sub>2</sub> emissions. ADAC and the UBA, the German environmental agency, referred to the D-CAT's low NO<sub>x</sub> emissions of 120 mg/km in their submissions to the European Commission during the Euro 5 consultation process. They argued that a more stringent NO<sub>x</sub> emission standard beyond the proposed 200 mg/km was feasible (ADAC 2005; Rodt 2003).

Although Toyota's D-CAT technology was received favorably by European and US regulators, it came under a lot of fire from automobile associations in Europe and the US, who questioned the durability of the NO<sub>x</sub> adsorber (Peckham 2002). Regulators were unwilling to base Euro 5 NO<sub>x</sub> standards on a technology available from only one automaker. Toyota was also constrained by the limited availability of low-sulfur diesel fuel. Sales were restricted to the UK and Germany, where fuel sulfur levels were less than 50ppm. Environmental groups and regulators prioritized PM reduction over NO<sub>x</sub> reduction, so the PSA-led particulate filter

adoption received far greater media and NGO attention than Toyota’s significant NO<sub>x</sub> reductions. Sales of D-CAT-equipped vehicles were small relative to Toyota’s total sales volume in the EU, but Toyota did benefit from positive publicity and overall increased market share in the EU. The D-CAT introduction, which occurred alongside Toyota’s hybrid introductions, was part of a larger corporate strategy to showcase clean vehicle technology. D-CAT may still have an impact on the stringency of Euro 6 standards and diesel acceptance in the US; it has given Toyota a head start on NO<sub>x</sub> reduction technology.

## **DAIMERCHRYSLER AND SIEMENS’ SINO<sub>x</sub> SCR TECHNOLOGY**

A Germany-based consortium of engine and aftertreatment manufacturers, which included DaimlerChrysler, IVECO, MAN, and Siemens, conducted joint research in the 1990s on selective catalyst reduction (SCR) systems. Siemens had already developed its SINO<sub>x</sub> SCR aftertreatment system for stationary engines, and now wanted to extend it to vehicles. Beginning in 1992, the consortium set out to develop an SCR system for heavy-duty trucks. They hoped to obtain very high NO<sub>x</sub> reduction rates while avoiding the 3-5% fuel economy penalty that plagued EGR (exhaust gas recirculation) systems, the preferred technology of American manufacturers. The SINO<sub>x</sub> system has long been a favorite of the German government, which actively promoted the merits of SCR technology to the European Commission. Germany even adopted a road tolling scheme that favored Euro 5-compliant vehicles equipped with SCR. The SINO<sub>x</sub> consortium had influence over Euro 4 and 5 standard-setting, which required the use of aftertreatment devices. Their promotion of SCR technology resulted in regulators’ support of SCR as the dominant NO<sub>x</sub> reduction strategy in Europe.

The consortium conducted two sets of on-road demonstration tests to evaluate the SCR system’s NO<sub>x</sub> reduction performance, durability, and readiness for volume production. Trucks equipped with SINO<sub>x</sub> systems were driven by commercial trucking companies. Results were published in Society of Automotive Engineers (SAE) technical papers. ACEA, the European Automobile Manufacturers Association, representing 13 European vehicle manufacturers, supported SCR technology. In 2003, ACEA issued a public statement of the industry’s decision to introduce SCR technology starting in 2005, accompanied by a new production and distribution infrastructure for AdBlue, a commercial 32.5% urea-based solution required for the SCR system (ACEA 2003). Companies like MAN and Scania that chose EGR for NO<sub>x</sub> reduction faced criticism from DaimlerChrysler and other SCR advocates. MAN actually appealed for increased regulatory scrutiny of SCR technology, such as specifying guidelines for proper end-user compliance (Semple 2004).

It was very important for pro-SCR truck manufacturers to encourage collective adoption of SCR technology because they could spread the costs of establishing an EU-wide urea infrastructure. They had to convince national and EU governments that investing in urea infrastructure is worthwhile. DaimlerChrysler, the biggest champion of SCR, cast doubt on the effectiveness of cooled EGR, the emission control strategy adopted by most US manufacturers for the 2007 US standards (EPA 2000a). Since DaimlerChrysler was already developing SCR systems for trucks in Europe, expanding to the US market would allow it to increase sales volume and lower per unit costs.

US regulators had initially been reluctant to seriously consider SCR technology because its effectiveness depends on the truck operator’s responsibility to refuel the vehicle with the urea

additive. DaimlerChrysler, in hopes of using SINOx to meet future US heavy-duty engine emission standards, participated in a demonstration project hosted by the Institute of Transportation Studies at the University of California, Davis. Its subsidiary companies Freightliner and Detroit Diesel participated in testing 10 trucks equipped with SINOx technology. Part of the program was funded by air pollution control districts in the San Joaquin Valley and Sacramento and the California Air Resources Board (CARB), demonstrating the growing US interest in the technology (Brodrick, Farsh-chi et al. 1999). On the East Coast of the US, Mack Trucks, owned by Volvo AB, collaborated with the SINOx consortium to test SINOx-equipped Mack trucks in commercial use (Block, Clark et al. 2005).

Although engine manufacturers plan to use EGR to meet the 2007 US heavy-duty standards, SCR may still be a possibility for 2010 and beyond. According to representatives in industry and EPA, EPA has been more receptive to SCR technology in the past few years because manufacturers have been working actively with the Agency to address concerns about urea infrastructure and end-user compliance. Testing and demonstration projects have indicated ways to remedy the end-user concerns about urea refilling.

## **EMISSION CONTROL MANUFACTURERS**

Unlike the auto, truck, engine, and oil industries, emission control manufacturers have an inherent interest in more stringent regulation because it creates demand for their new products. However, it is difficult for them to directly lobby for more regulation because doing so might jeopardize their business with their clients – vehicle and engine manufacturers, who usually prefer more lenient and less costly regulation. Keeping a low profile in regulatory activities has become increasingly important, because more vehicle and engine manufacturers are working exclusively with one catalyst supplier at the early stages of product development, rather than selecting a supplier at the end of the development process, or sourcing from various suppliers for the same engine platform.

Emission control manufacturers also submit testing data to regulatory agencies, which often face criticism by the regulated industries for being overly optimistic. Emission control manufacturers have been very forthcoming about presenting their latest technologies at conferences, publishing in leading industry journals like SAE, and participating in pilot projects and subsidy programs – more indirect ways of backing more stringent regulations.

Technology demonstration, in collaboration with government agencies and other companies, has been a powerful tool in communicating progress to regulators and potential customers. Involving third parties helps to increase the credibility of technology claims. Johnson Matthey and Engelhard, industry leaders in catalyzed diesel particulate filter (CDPF) technology, participated in many government-sponsored field tests and fleet retrofits in the US and Europe, even though there were no regulations requiring CDPFs at the time. Although the availability of retrofit subsidies did partially drive their efforts, they anticipated that future regulations would require truck and bus manufacturers to use their technology. The on-road experiences also helped them see how their emission control systems operated once integrated into the vehicle.

In some cases, emission control manufacturers have tried to make their support of regulatory activities anonymous, preferring to demonstrate their technologies “behind the scenes.” During the first year of Germany’s “No Diesel without Filter” campaign, the NGO

organizers were unable to get any financial support from filter manufacturers. Even though they clearly had a financial interest in promoting filter use, they were afraid to anger their potential clients. Later in the campaign, some filter manufacturers did contribute funds but requested anonymity. DUH, the German environmental NGO leading the campaign, had broad level support from the manufacturers but could not publicize the individual donor companies. When DUH installed a filter on a Mercedes SmartCar, it could not reveal the brand of filter used.

## **CASE STUDY LESSONS**

The cases described above reveal several important points about how technology demonstration affects regulation. Although lead firms may have a clear technological advantage over their competitors, early technology introductions are often motivated by market preservation or technology development, not an explicit strategy to influence regulation. Firms may be reluctant to push an uncertain technology or take a different stance from the rest of their industry.

Lead firms’ technologies still have an influence on regulation, because firms conveyed their technological performance through various public outlets, such as demonstration projects, publications, and industry meetings. The degree of regulatory influence depends largely on the level of NGO and regulatory interest. Environmental groups can use technology demonstration to leverage more stringent regulations, arguing that cleaner technology is already available. They help generate customer demand for cleaner products, as in the case of the “No Diesel without Filter” campaign. Regulators can encourage the diffusion of the technology by introducing fiscal incentives or tightening the standards.

Pressure to maintain a common industry position may limit proactive behavior by lead firms. Firms that did step forward with a new technology faced harsh criticism from their rivals, who publicly challenged the effectiveness and durability of their product. While proactive lead firms do not face any explicit retaliation, they did express the desire to maintain a congenial industry atmosphere. Encouraging more costly regulation might upset customers, who are at the receiving end of higher product costs. Therefore, pushing for regulation for individual competitive advantage was often frowned upon by other firms and customers.

Private benefits, if observable, came in the form of stronger sales and contracts, either through technology licensing or supply contracts. In many cases, private benefits to the companies were not easily measurable or directly attributable to environmental performance. Instead, the benefits were often intangible: improved relations with environmental groups and regulators, preparedness for the next round of regulations, or an environmentally-friendly public image. Public benefits usually consist of emission reductions occurring earlier than required by the upcoming compliance deadline.

## **MECHANISMS FOR INFLUENCING POLICY**

Companies have a variety of instruments at their disposal to influence environmental policy. Many will lobby elected officials who have influence on senior environmental officials or raise national competitiveness and employment concerns at the time of rulemaking. However, companies also rely on more “passive” means of promoting their technology. Wary of

introducing a product for which there is no regulatory or market demand and concerned about reproach from fellow companies, lead firms have turned to the following:

- Presenting new technology at industry events, conferences, and other public forums.
- Publishing in technical publications.
- Meeting one-on-one with regulators to confidentially discuss proprietary technology under development.
- Teaming with public and private partners on technology demonstration projects.
- Selling the product in small volumes or on a limited basis to a niche market.

These less aggressive ways of showcasing a product or technology still influence regulators, who are eager to find evidence of technological progress. Regulators may then use the technology leader’s success to set standards or to persuade other companies to follow suit. Environmental interest groups and other NGOs with a strong focus on diesel issues are also quick to pick up on the latest technology developments. They often do the more vocal campaigning in favor of a certain technology or more stringent standards. Instead of engaging in self-promotion and advertising, a company gains more credibility among the public when its technology is validated by regulators or environmental groups.

## RECOMMENDATIONS

The following recommendations focus on fostering the use of technology demonstration to shape environmental regulation, in order to reward technology leadership and improve environmental quality.

For companies: Use third-party sponsored studies and technology demonstrations to communicate technology readiness in an environment that may be resistant to regulatory change and skeptical of technology claims.

For public groups and NGOs: Leverage performance documented in technology demonstrations to promote cleaner technologies and influence regulatory decision-making.

For regulators: Use fiscal incentives and adaptable short-term emission targets within established longer-term emission goals to encourage early technology introductions by lead firms. Setting shorter-term targets (e.g. 3-4 years) gives more opportunities for technologies to influence regulatory changes than waiting 8 to 10 years for major changes.

## CONCLUSION

Technology demonstration by lead firms had a significant influence on regulatory decision-making. It operates as a mechanism to influence policy without active lobbying or upsetting potential customers or industry peers with different regulatory positions. For technologies that require additional infrastructure (e.g. special fuels, additives) or that deviate significantly from existing technology, technology demonstration can make the case for a particular technology path. Although immediate financial benefits to the lead firms were limited, proactive behavior generated reputational gains and preparedness for future standards. Environmental benefits hinge on customer demand, industry-wide technology adoption, and regulators’ willingness to base standards on the performance of a lead firms’ technology. The

influence of technology demonstration on regulation shows that simultaneously satisfying public and private interests is possible.

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