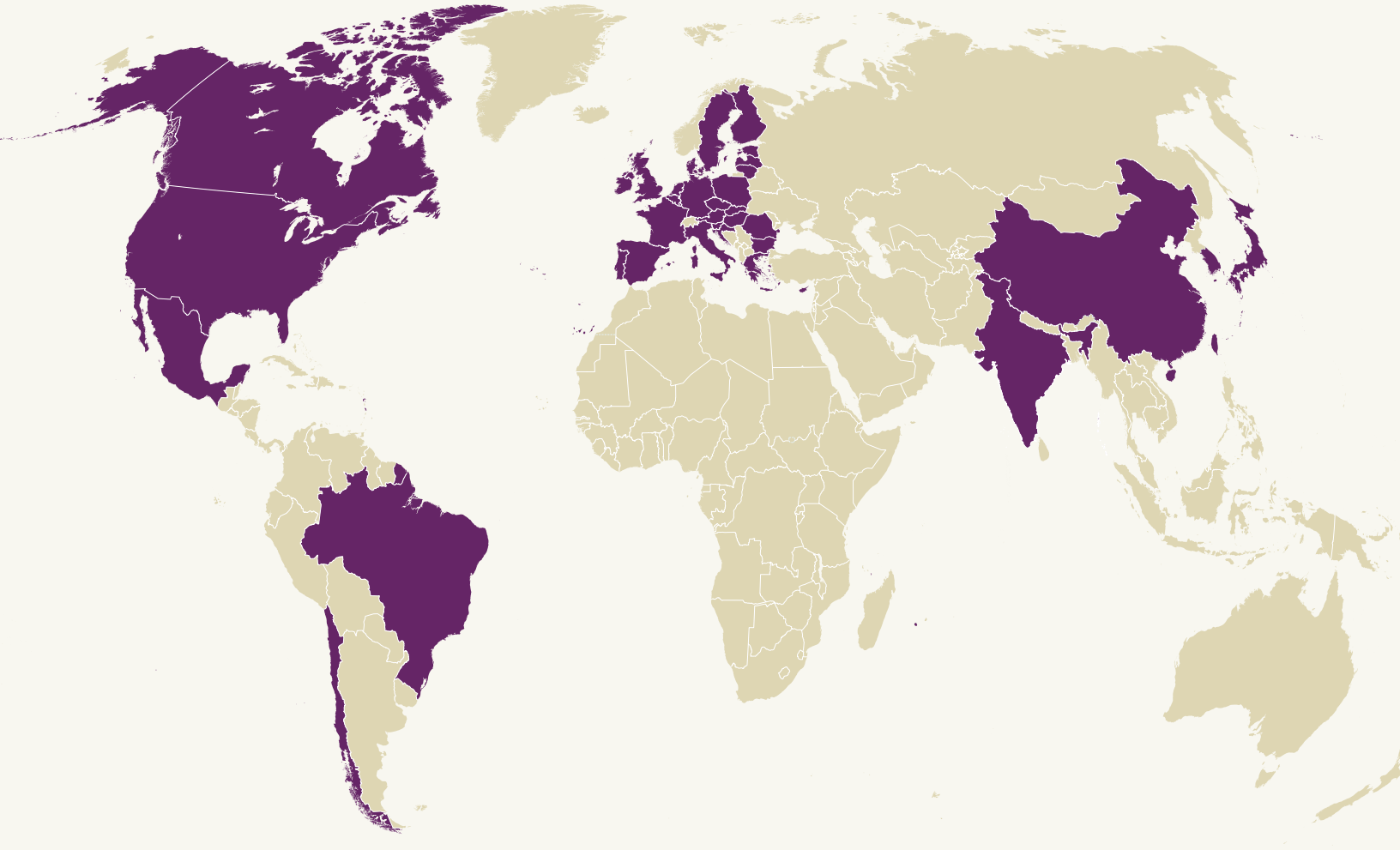
GLOBAL BASELINE ASSESSMENT OF COMPLIANCE AND ENFORCEMENT PROGRAMS FOR VEHICLE EMISSIONS AND ENERGY EFFICIENCY



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EXECUTIVE SUMMARY

As vehicle emission and efficiency regulations have become more stringent, the technologies used to mitigate emissions and reduce fuel consumption have become increasingly complex. A modern car or truck has essentially the equivalent of a small chemical plant attached to its exhaust and a powerful computer under the hood, meaning there are many potential areas for system failure—or manipulation. In the 1990s, many major diesel truck and engine manufacturers in the United States were caught cheating to meet emission standards. Nowadays, regulators face the significant challenge of ensuring compliance of diesel cars to emission standards in Europe, the United States, and elsewhere. Similarly, carbon dioxide (CO_2) emission/fuel efficiency standards noncompliance is also an issue, with cases discovered in Europe, Japan, and the United States. As investigations reveal that manufacturers have cheated to meet emission and fuel efficiency standards for years, many countries face significant challenges to ensure proper operation of modern engine and emission-control systems. Technology will continue to advance quickly, and manufacturer deception will remain a risk; therefore, government agencies around the world must upgrade their compliance and enforcement (C&E) programs to ensure that the intended outcomes from emission-control and fuel-efficiency programs materialize throughout the vehicle life cycle.

This study reviews existing C&E activities in 14 major vehicle markets (12 national, 1 subnational, and 1 multinational) on a range of key elements, including legislative framework and resources; vehicle testing campaigns; and the use of corrective actions, such as recalls and fines. We found that C&E practices vary significantly among vehicle markets, not only in their regulatory structure and capacity to ensure compliance, but in the willingness at the highest level of political leadership to prioritize C&E. Despite the differences in policy background, our investigation found the following trends and observations on the current C&E practices in major vehicle markets:

- Not all regulatory agencies are sufficiently empowered to enforce compliance of the standards, including the authority to mandate recalls and impose punitive penalties.
- Regulators are fighting against budget and resource constraints by improving cost-effectiveness and sustainability of their C&E programs.
- Regulators intend to test vehicles at different stages of their useful life and put the testing burden on manufacturers with sufficient independent audits.
- The cost of noncompliance varies significantly across regions.
- Transparency of C&E activities is extremely low.
- The C&E requirement and activities in most regions studied focuses more on the compliance with emission standards than greenhouse gas/fuel consumption standards, especially for vehicles in production and in use.
- Policymakers in many markets consider C&E to be an important part of vehicle regulations and simultaneously acknowledge that enhancing their C&E programs is necessary.

Based on specific program details collected from a survey of experts and stakeholders from each of the 14 markets and a review of the most recent and relevant literature, we propose seven best practices for C&E programs for legislators and regulators to follow:

1. **Establish clear legal authority** to hold manufacturers accountable for vehicle emission and efficiency performance throughout the useful life of vehicles.
2. **Avoid conflicts of interest** that could undermine the program's effectiveness; align the lead agency's mission with regulatory goals and break the financial link between testing agencies and manufacturers.
3. **Obtain the necessary resources** to continuously and properly enforce regulations.
4. **Conduct reliable testing and checks at all stages of production and use** on both emissions and efficiency, with the strongest focus on in-use testing.
5. **Use corrective actions,** such as implementing mandatory recalls and fiscal penalties, to fix known issues and promote compliance.
6. **Prioritize data and information transparency** to foster confidence in the program and facilitate third-party participation.
7. **Create a roadmap for program development** that considers future regulations and technological advances.

This study also assesses the 14 vehicle markets on the degree to which they meet each best practice. Table ES1 shows that C&E programs in major global markets are at diverse stages of maturity, with no single program fully meeting all best practices. In general, the United States (including California), South Korea, and Japan have the most comprehensive programs, with better C&E schemes in legal framework, conflicts of interest prevention, resource sustainability, testing design, and enforcement. Mexico has the least comprehensive program, which can be improved in many ways. Among the identified best practices, poor data transparency and having an unclear vision for program development are two aspects that need be improved across all 14 vehicle markets.

Table ES1. Evaluation of best practices for compliance and enforcement programs in major vehicle markets.

Region/country		Best Practices						
		Establish clear legal authority	Avoid conflicts of interest	Obtain the necessary resources	Conduct reliable testing and checks at all stages of production and use	Use corrective actions	Prioritize data and information transparency	Create a roadmap for program development
Asia	China	●++	●+	●+	●++	●+	●	●+
	India	●+	●+	●+	●+	●	●	●+
	Japan	●++	●++	●+	●++	●++	●	●+
	South Korea	●++	●++	●++	●++	●++	●+	●+
Europe	EU	●	●+	●+	●	●+	●	●+
	France	●+	●	●+	●+	●+	●	●+
	Germany	●+	●	●+	●+	●+	●	●+
	UK	●+	●	●+	●+	●+	●+	●+
North America	California	●++	●++	●++	●++	●++	●+	●+
	Canada	●+	●++	●+	●++	●	●	●+
	Mexico	●+	●+	●	●	●	●	●
	U.S.	●++	●++	●++	●++	●++	●+	●+
South America	Brazil	●++	●+	●+	●	●+	●	●
	Chile	●+	●+	●+	●+	●	●+	●+

● *The country does not sufficiently meet any criteria for this practice.*

●+ *The country meets some criteria for this practice.*

●++ *The country meets all criteria for this practice.*

Additional key findings from the various regions include the following:

» Asia: Government agencies in Japan and South Korea—home to major automotive manufacturers that sell their products worldwide—have better structured C&E programs with strong legislative support, clear governmental liability, and serious penalties (financial or reputational) and corrective methods in place for noncompliance. Both countries monitor compliance with necessary independent testing, although South Korea shapes its program in a more financially sustainable way. On the other hand, China and India do not have a lengthy history of compliance work; however, because of the need to address poor air quality in both countries, these governments are realizing the importance of C&E. This is most apparent in China, where the latest vehicle emission regulations include strengthened compliance and testing requirements, and where the legislative framework has recently been revamped to allow for stronger regulatory enforcement. While waiting for the enhanced emission regulatory system to take effect, boosting C&E of fuel efficiency standards becomes more imperative in China. India needs more powerful enforcement authority and better regulatory structure to break the financial link between testing agencies and manufacturers and conduct independent testing throughout a vehicle's useful life.

» Europe: The single market structure of the European Union combined with the independent administrative power of member states has led to a unique dynamic in Europe. Although it is the European Commission that sets up the framework for C&E of relevant standards, there is no centralized implementation authority. The cross-border compliance framework has an inherent potential for conflicts

of interest. The European system does little to incentivize member states to take compliance actions, especially with independent retesting absent from the framework. The enforcement authority of regulatory agencies in member states is also restricted. The extremely high levels of NO_X emissions from diesel cars that regulators are currently attempting to address in the European Union can be directly linked to the lack of a strong C&E procedure. The observed practices in France, Germany, and the UK also show insufficient resource sustainability. Ongoing negotiations among the European Commission, Parliament, and Council on the new motor vehicle type-approval framework in Europe create an opportunity to improve the above-mentioned aspects.

- North America: The United States has a 5-decade history of developing and refining its C&E program, which is the oldest and most advanced in the world. The U.S. program today focuses heavily on testing in-use vehicles for compliance and has a history of implementing recalls and other corrective actions for enforcement. The program operates with the support of experienced experts and sustainable resources. This has created a level playing field among manufacturers and has fostered an environment where the cost of noncompliance is higher than the cost of compliance. Improving information transparency will help the United States further strengthen its program. Canada and Mexico tend to harmonize with U.S. emission standards, so both countries can leverage the U.S. compliance program to implement their own regulatory requirements. Canada and the United States have a long history of collaboration under the framework of the U.S.–Canada Air Quality Agreement toward the development of aligned vehicle and engine emission regulations and their coordinated implementation. While Canada runs its own compliance program, it has generally focused its testing effort on vehicles that are not sold in the U.S., with additional capabilities used to complement U.S.-certified vehicle testing as a result of the collaboration. That being said, Canada is now working to enhance its program sustainability in response to the defeat device situation. Mexico does not have a meaningful program in place to monitor new vehicles that are not covered by the U.S. certification, nor do Mexican regulatory agencies have the legal authority to intervene regarding compliance of in-use vehicles.
- South America: Brazil is by far the largest automotive manufacturing market in South America, but the country's C&E capacity and activity are minimal. Most major manufacturers in Brazil have their headquarters in Europe, so Brazil typically follows the regulatory structure of the EU, where compliance protocols fall short. Brazil has relatively clear legislative system, but needs to build up regulatory capacity and start regular independent testing. In contrast to Brazil, Chile presents an interesting case study, because it is a country without its own automotive manufacturing and relies solely on imports. However, Chile has committed to developing a program designed for this specific market situation and has grown a strong technical capacity with some of the best government-run testing facilities in South America. Future priorities for Chile for improvement include strengthening legislative authority for enforcement, expanding test capacity and scope, and leveraging additional resources to support compliance checking.

This paper is the first to take stock of C&E practices with regard to emission and efficiency standards in key vehicle markets. We found room for improvement, even in markets with mature regulatory systems, and we expect to see more efforts by stakeholders to support such improvements.

1. OVERVIEW OF COMPLIANCE AND ENFORCEMENT

1.1 BACKGROUND

Over the past 40 years, progressively tighter vehicle emission standards in the world's major markets have resulted in modern vehicles emitting a fraction of the amount of criteria pollutants that were released in the years before vehicle emissions were controlled. Fuel efficiency standards promote the adoption of advanced technologies on new vehicles to reduce fuel consumption and carbon dioxide (CO_2) emissions while maintaining or improving vehicle performance.

Although remarkable progress has been made in reducing vehicle emissions and fuel consumption, recent studies and events have highlighted the discrepancy between official test results and real-world performance.

Nitrogen oxide (NO_X) emissions of early Euro 6 diesel passenger cars have been found to be nearly 7 times higher, on average, than indicated by their official laboratory test results (Franco, Posada, German, & Mock, 2014). In September 2015, the vehicle industry was rocked by the so-called "dieselgate" scandal, after the Volkswagen group companies were discovered to be using a NO_X emissions defeat device on more than 11 million vehicles globally.

The same concern applies for CO_2 emissions as the gap between on-road and certified CO_2 emissions of passenger cars has been growing. In recent years, this gap increased from 8% to 40% (2001 to 2015) in the European Union, from 23% to 44% (2009 to 2014) in Japan, and from 12% to 27% (2007 to 2015) in China (Tietge, Diaz, Yang, & Mock, 2017). In Japan, Mitsubishi Motors Corporation was found to have been using inaccurate road-load parameters for measuring fuel efficiency for more than a decade (Ministry of Land, Infrastructure, Transport and Tourism [MLIT], 2016a); this increased the fuel efficiency by 4% to 11%. This follows similar shortcomings observed in Canada and the United States on multiple Hyundai/Kia vehicles spanning several model years (U.S. Environmental Protection Agency [EPA], 2014).

Such incidents have resulted not only in higher than anticipated emissions from vehicles on the road—with resulting public health and climate impacts—but they also have eroded public trust in vehicle manufacturers and, in some cases, underlying regulatory programs. Moreover, such incidents reveal that the field on which vehicle manufacturers compete may not necessarily be level. Finally, these incidents underscore the fact that to fully deliver emission and fuel consumption reductions in practice, stringent regulations must be combined with effective compliance and enforcement (C&E) programs.

C&E is an integral part of the vehicle emission and fuel efficiency regulatory framework. C&E refers to the system of laws, regulations, agencies, and practices intended to ensure that vehicle and equipment performance meets the standards in force and delivers real and permanent emission reductions. This broad definition distinguishes itself from the narrow legal definition that equates "compliance" with strict interpretation of certification or type-approval emission limits.

Compliance activities ensure that the registered vehicles meet regulatory requirements and identify cases of noncompliance when they exist. Compliance monitoring activities, such as pre-, in-, and post-production vehicle emissions

and efficiency testing under laboratory and real-world conditions, are necessary to establish compliance status and to deter noncompliance. Detailed compliance activities include:

- Receiving, reviewing, negotiating, and approving manufacturers' applications for emission type approval/certification and/or fuel economy verification, and in-production and in-use conformity reports.
- Monitoring relevant vehicle emission/fuel efficiency information and data (e.g., warranty and defect information), testing vehicles or carrying out on-site inspections, and identifying potential noncompliance.
- Conducting research to check the reliability of the existing compliance system and improve future policymaking.

Enforcement activities are necessary when vehicles are found to be out of compliance with the standards and intervention is needed to hold responsible parties accountable and correct the situation. Enforcement activities, such as noncompliant vehicle recalls and financial penalties, are essential to achieving widespread compliance with standards. In practice, detailed enforcement activities include:

- Collecting evidence, if necessary, to prove noncompliance identified through either manufacturer self-reporting or the regulator's compliance program and ordering manufacturers to take corrective actions.
- Reviewing the manufacturer's corrective action plan to fix noncompliant vehicles, supervising implementation of the corrective action plan, and compelling manufacturers to react—through legal means, when necessary.
- Determining and imposing penalties, if necessary.

Even though C&E of vehicle emission and efficiency standards has started to get the attention of regulators, it remains an uncharted topic in the field. This report aims to summarize the existing status of C&E activities in major vehicle markets and suggest practices that could enhance the effectiveness of these programs.

1.2 SCOPE AND METHODOLOGY

This report reviews C&E activities in 14 major vehicle markets: 12 countries (Brazil, Canada, Chile, China, France, Germany, India, Japan, Mexico, South Korea, the United Kingdom [UK], the United States [U.S.]), one multinational region (the European Union [EU]), and one subnational region (the U.S. state of California). These regions accounted for 87% of global vehicle sales in 2015. Although this report focuses heavily on national-level C&E activities, given the differences in regional legislative and regulatory structure, subnational agencies may play an important role in C&E.

This report includes the EU and California because these are special regions that play an important role in C&E. The EU, via the European Commission (EC), promulgates regulations that may dictate the C&E activities in all member states. Member states have the authority to enhance their C&E activities above the minimum limits set by the EU regulations. However, the EC has no authority over the enforcement of the regulation; thus, member states are responsible for implementing the regulations. California put in place a strong motor vehicle pollution control and greenhouse gas (GHG) program prior to the national law being adopted; thus, the U.S. Clean Air Act grants California the authority to run its own C&E program of vehicle

and engine emission and efficiency standards (U.S. Environmental Protection Agency [EPA], 2016a). As a result, California has a comprehensive motor vehicle compliance program with similarities and differences compared with that of the U.S. Environmental Protection Agency (U.S. EPA).

The practices discussed in this report cover C&E for existing vehicle tailpipe emission regulations (i.e., emission and fuel efficiency standards[1]) of light-duty vehicles (LDVs) and heavy-duty vehicles (HDVs) and engines. The scope of most C&E programs also includes 2- and 3-wheelers, nonroad engines and equipment, and fuel quality, even though these are not explicitly discussed in this report. Nevertheless, the best practices identified in this report are highly relevant and applicable to the C&E of counterpart regulations of 2- and 3-wheelers and nonroad engines and equipment.

The findings in this report are based primarily on the results of an online survey (see Appendix A), as well as in-person interviews and email exchanges with relevant experts and stakeholders working on the implementation, compliance, and enforcement of regulations. In addition, in-depth desk research on relevant legislation, regulations, and policy reports contributed to the analysis. The online survey was sent to 86 contacts in 19 countries/regions. We collected responses from 28 contacts in 17 countries/regions through the online survey portal, email exchanges, and one-on-one interviews and chose 14 countries/regions for analysis in this research. Table 1 lists details of the number of survey participants for each country/region, their affiliation background, and response method.

1 In this paper, we refer to fuel efficiency, fuel consumption, CO_2, or GHG standards as "fuel efficiency" standards.

Table 1. Overview of survey participants.

Country/region	No. of responses	Background	Response method
Summarized in this report			
Brazil	2	Agency	Online, interview
	1	Consultant	Online
California	1	Agency	Interview, email
Canada	1	Agency	Online, email
Chile	1	Agency	Online
	1	Testing laboratory	Online, interview
China	2	Agency	Interview
EU	1	Agency	Online
	1	Consultancy firm	Online
France	1	Testing laboratory	Online, email
Germany	2	Nongovernmental organization (NGO)	Online, email
India	2	Agency	Online, email
	1	Testing laboratory	Online
Japan	2	Agency	Online, email
Mexico	1	Agency	Online
South Korea	1	Agency	Online
UK	1	NGO	Online, email
U.S.	2	Agency	Online
	1	Agency	Email
Not summarized in this report			
Austria	0	–	–
Greece	1	NGO	Online
Netherlands	0	–	–
Spain	1	Agency	Online
Switzerland	1	Agency	Online

2. GLOBAL STATUS OF C&E

In many regions, the C&E program evolved alongside the standards for vehicles and engines. Figure 1 records the timelines for different phases of LDV and HDV emission standards and the introduction of key C&E activities. In Canada, the EU, India, Japan, South Korea, and the United States, the C&E activities were introduced several years after the emission standards. In Brazil, Chile, and China, the C&E programs started only after the adoption of more advanced emission standards. Over the years, additional elements have been added to C&E programs that consist of required actions from both manufacturers and regulatory agencies. Figure 1 does not reflect the timeline for the fuel efficiency/GHG requirement because it is relatively new, compared to emission standards, and many C&E activities are still under development.

Table 2 provides an overview of C&E activities in the major markets, including the following:

- Establishing a defeat device provision that defines and prohibits the use of defeat devices;
- Requiring an auxiliary emission control device (AECD) report;
- Building emissions and efficiency testing capacity (e.g., government-owned laboratory, authorized independent laboratory);
- Requiring original equipment manufacturer (OEM) testing and conducting government surveillance testing pre-, in-, and post-production;
- Testing for fuel efficiency in addition to emissions;
- Testing to check road load, an important factor that influences efficiency test results;
- Mandating emission defect reports;
- Establishing warranty requirements;
- Enhancing sustainability of resources for C&E activities; and
- Mandating recalls of noncompliant vehicles and engines and whether there have been mandatory or voluntary emissions-related recalls from 2011 to 2015.

Table 2 provides an initial indication of the strength of the different C&E programs. However, the effectiveness of each individual program cannot be understood without a more detailed investigation of each programmatic element. Section 3 of this report reviews the legislative structure and resources for the different C&E programs. Section 4 discusses how compliance is determined for emission and efficiency standards in the different markets. Section 5 examines the enforcement mechanisms being used in the different markets. Section 6 focuses on data and information transparency. Section 7 summarizes the key observations regarding C&E programs in major markets. Based on the findings presented in Sections 3–7, Section 8 proposes universal best practices for C&E programs.

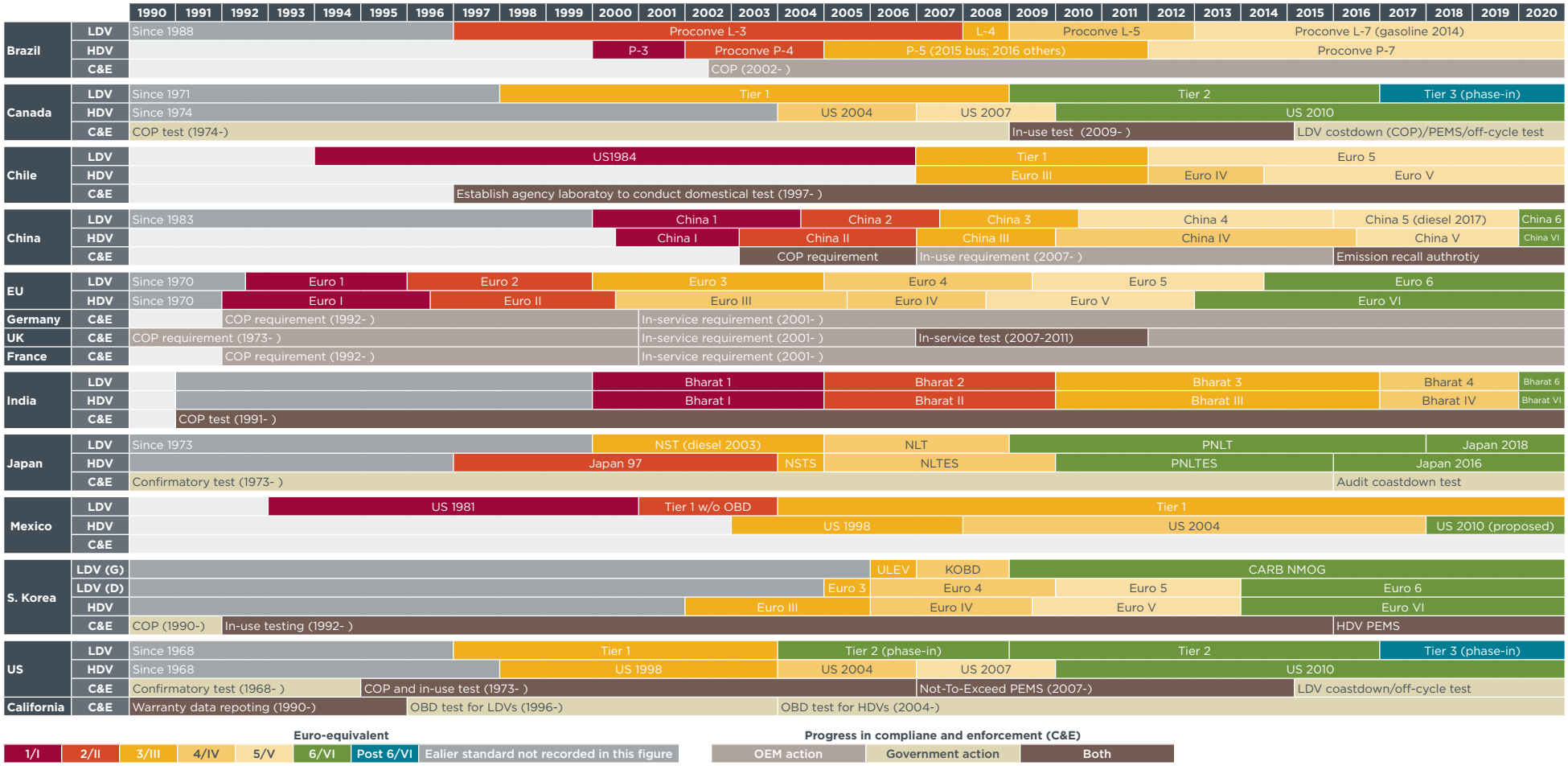

Figure 1. Timelines for the phase in of LDV and HDV emission standards (not including CO_2/ fuel economy standards) and related C&E activities.

Note. LDV = light-duty vehicle; HDV = heavy-duty vehicle; C&E = compliance and enforcement; COP = conformity of production; OBD = on-board diagnostic; OEM = original equipment manufacturer; G = gasoline; D = diesel. Activities with open-ended time frames work in parallel with new activities.

Table 2. Overview of C&E capacity and activities for vehicles and engines in some major markets.*

Country	Defeat device provision	AECD report	Agency test capacity	Test during production phases			Agency test covers CO_2/fuel economy	Agency road-load check	Emission defect report	Emission warranty	Resource sustainability	Recall history	
				Pre-	In-*	Post-						Clear authority	Mandatory/ voluntary
Brazil	✔		Authorize	✔	✔						Medium	Yes	N/N
California	✔	✔	Own lab	✔✔	△△	✔✔	✔	✔	✔	✔	High	Yes	Y/Y
Canada	✔	✔	Own lab	✔	△✔	△✔	✔	●	✔		Medium	No	N/Y
Chile			Own lab	✔▲	✔▲		✔				Medium	No	N/N
China	✔		Authorize	✔✔	✔✔	▲✔			O	O	Medium	Yes	N/Y
France	✔		Authorize	✔	✔△	✔▲		●			Medium	Partly	Y/Y
Germany	✔		Authorize	✔	✔△	✔▲					Medium	Partly	Y/Y
India	✔		Authorize	✔	✔✔						Medium	No	N/Y
Japan	●		Own lab	✔✔	✔✔	✔	✔	✔	✔		Medium	Yes	Y/Y
Mexico			Authorize	✔							Low	No	N/N
S. Korea	✔		Own lab	✔✔	✔✔	✔✔	✔		✔	✔	High	Yes	Y/Y
UK	✔		Authorize	✔	✔△	✔▲		●			Medium	Partly	N/Y
U.S.	✔	✔	Own lab	✔✔	△△	✔✔	✔	✔	✔	✔	High	Yes	Y/Y

✔ Manufacturers conduct mandatory tests; ✔Agencies conduct surveillance tests

△ Manufacturers conduct voluntary tests; △ Agencies reserve the right to test, but test is not carried out regularly

▲ Manufacturers test part of the fleet only; ▲ Agencies test part of the fleet only

✔ Fully fulfilled; ● Partially fulfilled; O Expected to fulfill in future regulation

* The EU is not included in this table because the EU has no control over C&E of emission and efficiency standards in its member states.

3. LEGISLATIVE FRAMEWORK AND RESOURCES

3.1 LEGISLATIVE AND REGULATORY FRAMEWORK

At the core of any C&E system are the laws and regulations that specify the requirements for vehicle emissions and/or efficiency performance, and those that establish government agencies' ability to hold manufacturers legally accountable for vehicle performance, including measures such as surveillance testing, equipment recalls, fines, and other penalties.

Empowering regulatory agencies with strong and clear authority is the foundation for a robust vehicle emission compliance program; therefore, the agencies need clear authority to:

- Establish emission and efficiency standards;
- Establish and carry out the compliance activities of vehicle emission and efficiency standards, such as establishing protocol for compliance testing and reporting; supervising the implementation of emission standards, requiring manufacturers to conduct tests, and collecting relevant data (e.g., warranty and defect data) from manufacturers;
- Issue type approval for compliant vehicles and engines, and cease/revoke type approval for noncompliant vehicles and engines;
- Mandate recalls or other corrective actions to bring noncompliant vehicles into compliance and mitigate negative environment impacts; and
- Impose punitive fines on noncompliant vehicle manufacturers.

Table 3 lists the legislation that empowers the regulatory agencies in each market to carry out C&E of vehicle emission standards. Most legislation authorizes the lead agency or agencies to establish vehicle emission and efficiency standards; establish a compliance strategy; and issue, cease, and revoke type approval. In addition to the U.S. federal practices, California is authorized to establish more stringent emission standards and carry out the C&E of vehicles sold in the state. The legislation in Mexico authorizes only the national regulatory agencies to manage emissions of new vehicles before they are sold to the market; any intervention regarding in-use vehicles is the responsibility of local authorities. For the EU member states, the EC establishes the basic principles of compliance and empowers the member state countries to specify the compliance methods and implement and enforce the regulation.

The greatest inconsistency in the legislative system across regions lies in their authority to mandate recalls to repair noncompliant vehicles and to impose fiscal penalties on noncompliant vehicles. Only Brazil, California, China, the EU member states, Japan, South Korea, and the United States empower the lead agencies with both authorities. In the EU, only the member state agency that issues the type approval of the vehicle can mandate the recall of that vehicle, even if the vehicle was found to be noncompliant by another member state.[2] Canada is in the midst of implementing an Administrative Monetary Penalties regime under the Environmental Violations Administrative Monetary Penalties Act.

2 A proposal currently being discussed by European policymakers would allow any member state that discovers noncompliance to take corrective action.

Table 3. Compliance and enforcement legislation for controlling vehicle emissions in major markets.

Region	Country	Legislative document	Authorized function[a]				
			Establish standards	Establish compliance method	Issue, suspend, or withdraw type approval	Mandate recall	Impose fines
Asia	China	Environment Protection Law (since 1989)	✔	✔			
		Air Law (2017)			✔	✔	✔
	India	Central Motor Vehicle Act (1988)	✔	✔			
		Central Motor Vehicle Rules (1989)	✔	✔	✔		
	Japan	Air Pollution Control Act (1968)	✔				
		Road Vehicle Act (1972)	✔	✔	✔	✔	✔
		Act on the Rational Use of Energy (1979)	✔				
	South Korea	Clean Air Conservation Law (1990)	✔	✔	✔	✔	✔
Europe	EU (European Commission authority)	Framework for the type approval of vehicles (2007/46/EC)	✔	✔			
		Directive 98/69/EC		✔			
	France	Official decree	✔	✔	✔	o	✔
	Germany	Road Traffic Licensing Regulation	✔	✔	✔	o	✔
	UK	Road Vehicle Construction and Use (1986)	✔	✔	✔	o	✔
		In-service exhaust emission standards	✔	✔			
North America	California	Clean Air Act (1970)	✔	✔	✔	✔	✔
	Canada	Canadian Environmental Protection Act (1999)	✔	✔	✔[b]		
		Environmental Violations Administrative Monetary Penalties Act (2009)					✔ (Draft 2016)
	Mexico	Federal Ministry of Environment & Natural Resources Internal Rule	✔	✔ (for new vehicles)	✔		
	U.S.	Clean Air Act (1970)	✔	✔	✔	✔	✔
South America	Brazil	LAW No. 8723/1993 Law 140/2011	✔	✔	✔		
		Decree 4059/2001	✔	✔			
		Decree 6514/2008				✔	
		Law No. 9605/1998					✔
	Chile	Transportation Law (1995)	✔	✔	✔		

Note. **o** *denotes that only the agency that issues the type approval of the vehicle can mandate recall of that vehicle.*

[a] *Legislation either specifies the details of the function or authorizes agencies to establish relevant regulations.*

[b] *Canada does not issue certificates but rather accepts U.S. EPA certificates to reduce the administrative burden on companies. In the case of vehicles that are not U.S. EPA certified, Canadian regulations require companies to submit evidence of conformity for departmental review prior to introducing these vehicles into market.*

Another discrepancy across regions is the regulatory framework that supports the enforcement of regulations. A well-designed regulatory framework clearly defines each component of the C&E system and streamlines the C&E procedure for both regulatory agencies and manufacturers. It equips an agency with the capacity and sufficient resources to carry out C&E activities, ranging from surveillance testing to verify compliance and identify illegal activities (e.g., use of prohibited defeat devices, cheating on tests) to enforcing corrective actions on noncompliant vehicles (e.g., suspending or withdrawing type approval, mandating recalls, imposing fines).

The provisions that prohibit the use of defeat devices in different countries provide an example of the different levels of comprehensiveness of regulatory frameworks. Many countries have legislation or regulation that prohibits the use of a defeat device intended to circumvent a vehicle emissions test, but only some of them clearly define "defeat device" and exceptions to the prohibition of a defeat device, and even fewer establish relevant provisions that make it easier for the regulatory agency to detect illegal use of defeat devices. Brazil, California, Canada, China, the EU, South Korea, and the United States clearly define what constitutes a prohibited defeat device with nearly identical language. Japan plans to introduce and prohibit defeat device use after the adoption of WLTP Global Technical Regulations. However, the difference in enforcement of this identical provision lies in how manufacturers obtain the exemption approval and how they are penalized for failure to disclose information (Muncrief, German, & Schultz, 2016). California, Canada, and the United States provide a separate definition for "auxiliary emission control device" (AECD) and specify certain conditions under which an AECD shall not be considered a defeat device and then prohibit all use of defeat devices. Manufacturers are required to submit a list of all AECDs at the time of their application for a certification, including rationale for why the AECDs should not be considered defeat devices. The regulations provide detailed and clear guidelines regarding the responsibility of manufacturers, including the information they are required to disclose. With such supporting resources, the regulatory agency can evaluate and confirm that they are in compliance with the provision. In fact, regulatory agencies in California and the United States as a whole invest a fair amount of resources in reviewing and signing permits based on the information provided by manufacturers. In comparison, other countries prohibit all use of defeat devices and specify some exceptions of that general prohibition. However, there are no explicit procedures in these countries by which manufacturers will disclose information about the devices that fall under those exceptions. Thus, the ban on defeat devices is not scrutinized during the certification/type-approval process.

A comprehensive regulatory framework is also important for compliance with fuel efficiency/GHG standards. This includes selecting representative vehicles to determine compliance with corporate average fuel efficiency targets and determining proper road loads and weights for vehicle testing. Many other C&E aspects of the regulatory framework are discussed in this report in Section 4. Because the regulatory framework covers a variety of issues, it is not evaluated as one single aspect in the best practices evaluation in Section 8 of this report.

3.2 LEAD AGENCY

The regulatory agencies in charge of specific C&E activities are determined by the target of the regulation (conventional pollutants or fuel efficiency/GHG), the type of responsibility (compliance or enforcement), and the role in action (supervisory or implementing).

The agency's authority and capacity imparted by the legal framework typically determine its role in C&E programs. Sometimes, the regulatory agencies that oversee fuel efficiency C&E are separate from those that manage conventional pollutants, as is the case in China and Brazil. In most markets, there is a lead agency in charge of C&E for both emission and efficiency standards, but they often collaborate with other agencies on the C&E of efficiency standards. For example, in the United States, the U.S. EPA is in charge of C&E for both emission and efficiency standards, but the Agency collaborates with the National Highway Traffic Safety Administration (NHTSA) to enforce efficiency standards.

In some regions, the agencies that conduct compliance investigations do not have full power of enforcement. For example, the Vehicle Certification Agency (VCA) in the UK monitors compliance with standards, whereas the Driver and Vehicle Standards Agency (DVSA) carries out enforcement activities. Although the U.S. EPA and Environment and Climate Change Canada (ECCC) have enforcement power, the U.S. EPA must involve the Department of Justice and ECCC must involve the Public Prosecution Service of Canada (PPSC) because their legislation requires criminal proceedings for the prosecution of vehicle emissions-related issues. In China, the Ministry of Environmental Protection (MEP) needs support from Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) to carry out enforcement.

In many cases, the agencies that oversee compliance activities need to collaborate with other technical agencies with more resources and expertise to carry out necessary compliance work. Some examples of these technical agencies include the National Institute of Environment Research (NIER) in South Korea, National Agency for Automobile and Land Transport Technology (NALTEC) in Japan, Vehicle Emission Control Center (VECC) in China, UTAC in France, Vehicle Control and Certification (3CV) Center in Chile, Automotive Research Association (ARAI) and International Center for Automotive Technology (ICAT) in India, and Kraftfahrt Bundesamt (KBA) in Germany.

Table 4 lists the agency responsibilities in different markets. In most regions, the core mission of the agencies responsible for C&E of emission and/or efficiency regulations is either environmental protection or energy conservation. Aligning the mission of the lead agency with the goal of the regulation it is enforcing can reduce the potential conflict of interest. In some regions like Germany and the UK, the type-approval authority is part of ministry for transport.

The EU member states are in a unique situation in that vehicles certified by any EU type-approval agency may be sold in all EU member states, and only the type-approval agency that issues type approval of the vehicle can mandate recall of that vehicle. There is an inherent potential for conflict of interest in this cross-border type-approval system, especially if the government owns part of the car maker while overseeing that car maker's compliance with emission standards.

In practice, it is more effective if only one key agency takes charge of the C&E of emission and efficiency standards, especially when they are overseen by different agencies. Benefits include the lower compliance burden on the manufacturer when testing vehicle emissions and efficiency simultaneously and more streamlined management and monitoring of the process for government agencies when information and resources are more integrated. Table 4 shows that in Canada, Chile, India, Japan, South Korea, and the United States, agencies may collaborate on various aspects of the C&E of emission and/or efficiency standards.

Table 4. Compliance and enforcement responsible agencies in major markets (full agency names are in Appendix B).

Market	Regulation	Compliance		Enforcement	
		Oversee	Carry out	Oversee	Carry out
Brazil	Emission	• CONAMA	• IBAMA • CETESB	• IBAMA	
	GHG	• INMETRO • MDIC			
Canada	Emission	• ECCC		• ECCC • PPSC	
	GHG	• ECCC and NRCAN			
Chile	Emission	• MTT	• 3CV Center • (technical agency)	• MTT • SMA	
	GHG	• MTT • MOE		• MTT • MOE	• MTT • SMA
China	Emission	• MEP	• MEP • VECC (technical agency)	• MEP • AQSIQ • MOA/MOT (non-road)	
	FE	• MIIT			
France	Emission	• DGEC	• CNRV • UTAC (technical agency)	• DGEC	• CNRV
	GHG				
Germany	Emission	• BMVI	• KBA	• BMVI	• KBA
	GHG				
India	Emission	• MORTH		• MORTH • MOP	• MORTH • Test Agencies
	GHG	• MORTH • MOP	• MORTH		
Japan	Emission	• MLIT	• MOE • NALTEC (technical agency)	• MLIT	
	FE	• METI • MLIT			
Mexico	Emission	• PROFEPA (regarding new vehicles only)			
	GHG				
South Korea	Emission	• MOE	• MOE • NIER (technical agency)	• MOE	
	GHG		• MOE • MOTIE		
UK	Emission	• VCA		• DVSA	
	GHG				
U.S.	Emission	• EPA		• EPA • DOJ	
	GHG/fuel efficiency (FE)	• EPA		• EPA • NHTSA/DOT • DOJ	

3.3 GOVERNMENT RESOURCES AND CAPACITY

3.3.1. Staff and budget

Securing designated staff and budget resources is a prerequisite of an effective and sustainable C&E program. The required resources need to be scaled up according to the size of the market and complexity of the regulations.

Deployment of staff and the budget is based on the responsibilities of the specific agency. It is challenging to conduct an apples-to-apples comparison of staffing and budget needs because the scope of responsibility of one agency may differ from another, and some work is outsourced to government-owned technical agencies. This report collects information of only key agencies to illustrate the level of capacity to carry out C&E activities.

In terms of staffing, Japan has 30 full-time equivalent (FTE) employees in its Ministry of Land, Infrastructure, Transport and Tourism (MLIT) working on C&E of both emission and efficiency standards and safety standards. An additional 10 FTE employees at the technical agency National Traffic Safety and Environment Laboratory (NTSEL) of the National Agency for Automobile and Land Transport Technology (NALTEC) work on emission tests for vehicle type approval. The U.S. EPA has 100 FTE employees working on compliance, including the employees working at test facilities, and 20 FTE employees working on enforcement of vehicle emission and efficiency standards. In Canada, ECCC has around 29 FTE employees dedicated to C&E of regulations on emissions of criteria pollutants and greenhouse gas emissions. Mexico has 2 or 3 employees working not only on C&E of vehicle emission and efficiency standards but also on other tasks related to environmental issues.

The employees working on compliance with emission standards at some government-owned technical agencies in other regions include MEP-VECC in China, with 10 FTE employees; NIER in Korea has 30 FTE employees; 3CV center in Chile has 10 employees; and UTAC in France has 60 FTE employees working on vehicle type approval.

The program budget covers the cost of staff time spent on certification, inspection, reviewing C&E reports, and administration; cost of testing; and facility maintenance. The regulatory agencies typically propose the C&E budget for a given fiscal year to secure approval from the government. Some regulatory agencies charge certification fees to manufacturers or consumers (e.g., Japan, Mexico, United States) and some charge testing fees to manufacturers (e.g., France, India, Japan, South Korea, UK, United States) to partly or fully cover the cost of C&E activities. In some regions, the fees collected are required to be spent on C&E activities only (e.g., Japan, United States), whereas in some regions, the fee is totally independent from budget planning for C&E activities (e.g., China, South Korea). Below are some examples of leading agencies' budgets for C&E activities, along with descriptions of how the money is collected and distributed.

- The California Air Resources Board (CARB) has been authorized since 1989[3] to collect $2 to $4 per vehicle, adjusted annually based on inflation, through the Department of Motor Vehicles. The governor and the legislature allocate these routine funds to CARB programs, which may be devoted to reducing air pollution from motor vehicles and carrying out related planning, monitoring, enforcement,

3 Personal communication with Tom Cackette, former executive officer, CARB (February 18, 2016).

and technical studies.[4] The penalty paid by noncompliant manufacturers goes into a special fund that can be spent only on clean air activities. Because fines vary greatly year by year, the funds are typically spent on one-time items, such as laboratory equipment, rather than on operating costs, such as staff.[5]

- The technical agency in Chile, 3CV Center, plays an essential role in testing vehicles for compliance. The center operates with an annual budget of about $1.6 million, with 75% from testing fees paid by manufacturers and 25% from the government. Therefore, the net annual operation budget of the regulatory agency for its compliance program is around $0.4 million. Other investment costs, including facilities and instrumentation, are covered by the government.
- VECC, the technical agency of China's MEP, has a budget of more than 1 million Chinese yuan ($0.15 million) for compliance activities every year. The budget covers staff working on compliance and relevant confirmatory testing. Each year, VECC works with MEP to develop a budget for compliance activities. When MEP gets final approval of its budget from the Ministry of Finance, VECC will receive the allocated money for its compliance work.
- NIER in South Korea, the technical agency owned by the Ministry of Environment (MOE), operates with an annual budget of $2.5 million allocated from the MOE. Manufacturers must pay for all confirmatory tests, but the funds go to the national treasury. MOE receives a budget for conducting compliance tests upon approval of the national treasury.
- The U.S. EPA has a budget of $20 million per year for compliance activities.[6] The agency collects fees from manufacturers on most of the certificates it issues. These fees go to the U.S. Treasury instead of to U.S. EPA directly, and the U.S. EPA receives funds for compliance from the total U.S. EPA budget approved by the Treasury every year. To make the program sustainable, U.S. EPA periodically audits the compliance program costs and adjusts fees to match the cost of the compliance program.[7]

Table 5 summarizes the staff numbers and budgets for C&E of emission and efficiency standards of leading regulatory agencies and, in some cases, their technical agencies. Although the table does not cover all available resources for C&E from all relevant agencies, it reflects the level of government investment in each region. It is important to be mindful of the different vehicle market sizes of these regions. Although the United States has the largest staff and highest budget for C&E activities, it has a much larger vehicle market to monitor than most other regions. While Canada has a much lower number of vehicle sales compared to the United States, there are a comparable number of different vehicle models available in Canada and the United States. The C&E activities in regions like Korea and Japan may extend beyond their domestic markets because they export many vehicles and engines to other regions, especially emerging markets. Vehicles and engines commonly obtain type approval from regions where they are manufactured if the markets that the vehicles are exported to do not have the capacity for type-approval testing or if they accept type-approval test reports from other regions.

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4 On average, $1 per vehicle goes to the C&E work.

5 Based on internal communication with CARB staff.

6 In 2017, there is "a $4.2 million increase to enhance vehicle, engine and fuel compliance programs, including critical testing capabilities, to ensure compliance with emission standards." (From survey)

7 Personal communication with Byron Bunker, U.S. EPA office director (February 25, 2016); California Clean Air Act Air Resources [39000-44474]

Table 5. Resources of major vehicle C&E regulatory agencies and technical agencies (full entity names are in Appendix B).

Market	Entity name	Type of institution	FTE staff[a]	Budget (USD)[b]	2015 vehicle sales[c] (M)	2015 vehicle production[c](M)
Canada	ECCC	Regulatory agency	29 (C&E)	Not available Treasury → ECCC	2.0	2.3
California	CARB	Regulatory agency	17 (C&E)	Not available **Certificate fee** → Treasury → CARB	2.3	N/A
Chile	3CV Center	Test facility (Owned)	10 (C)	$1.6M[d] **Testing fee** → MTT → 3CV (75%) MTT → 3CV (25%)	0.3	0.0
China	MEP-VECC	Regulatory agency	10 (C)	~ $150K on compliance MOF → MEP → VECC	24.6	24.5
France	UTAC	Test facility (Assigned)	50 (C)	~ $9.2M **Testing fee** → UTAC	2.4	2.0
India	Technical services	Test facility (Assigned)	~ 300[e]	Budget ~ $13.5M **Testing fee** → technical services (Partly)	3.4	4.1
Japan	MLIT	Regulatory agency	30 (C&E)[f]	Not available **Certificate fee** → MLIT (Partly)	5.1	9.3
	NTSEL	Test facility (Funded)	10 (C)	~ $9.8M (incl. safety and excl. facility)[4] **Testing fee** → NTSEL (testing) MLIT → NTSEL (facilities)		
Mexico	PROFEPA	Regulatory agency	2-3 (C&E)	Not available Treasury → PROFEPA (Majority) **Certificate fee** → PROFEPA (Minor)	1.4	3.6
S. Korea	NIER	Test facility (Owned)	30 (C)	$2.5M **Testing fee** → Treasury → MOE	1.8	4.6
UK	VCA	Test facility (Owned)	Not available	$290K (2007-2011 for in-service test) Treasury → VCA	3.1	1.7
U.S.	EPA	Regulatory agency	100 (C) 20 (E)	$20M on compliance **Certificate fee** → Treasury → EPA	17.5	12.1

[a] *FTE staff that work on compliance (C) and/or enforcement (E). Numbers are not directly comparable because the organizations may have used different assumptions to develop the estimates.*

[b] *Exchange rate assumptions: Indian rupees to U.S. dollars (USD) = 0.015, Yen to USD = 0.0094, Chinese yuan to USD = 0.15, GBP to USD = 1.45, euros to USD = 1.15, Canadian dollars to USD = 0.75. Numbers are not directly comparable because the organizations may have used different assumptions to develop the estimates.*

[c] *California vehicle sales figure is estimated. More shading indicates a higher number of vehicles sold or produced in each region.*

[d] *Operational budget; budget including test facility installment and upgrade could vary greatly from year to year*

[e] *Include testing two- and three-wheelers, work on both emission/efficiency standards and safety standards*

[f] *Work on both emission/efficiency standards and safety standards*

C&E programs with stable funding sources are more sustainable. For example, the UK government conducted in-service vehicle testing at its own expense from 2007–2011, but stopped testing after 2011 because of a limited budget. Many agencies have established a mechanism with stable revenue to partly or fully support their C&E work. Indian, South Korean, and U.S. agencies have fully covered the C&E program cost with fees collected from the manufacturers. The German Ministry of Environment also proposed collecting a fee of 2.85 euros per newly registered car from manufacturers to support market surveillance testing.[8]

Limited resources and budgets affect all C&E programs. Even in the United States, where the government has allocated a relatively large amount of resources to the C&E of vehicle emission and efficiency standards, resources remain constrained. With limitations regarding staff capacity, expertise, and budget, regulatory agencies seek to maximize the effectiveness of C&E activities.

3.3.2. Testing capacity

Vehicle and engine testing capacity varies across countries. Of the 13 regulatory agencies that are authorized to monitor C&E of emission and efficiency standards, eight regulatory agencies have their own laboratories to support C&E activities. Some government-owned laboratories are part of government systems; thus, the laboratory staff are government employees, such as the government-owned laboratories in Brazil, California, Canada, Chile, South Korea, the UK, and the United States. The laboratory in Japan operates as an independent organization, but it is still under the control of the regulatory agency and receives funding for the establishment of the testing facilities. All regions that were surveyed have only one government-owned laboratory, although sometimes the laboratory has multiple locations.

How government-owned laboratories are used for emissions C&E testing differs. Chile and Japan rely heavily on their laboratories to test every representative model for which manufacturers apply for certification, whereas Canada, South Korea, and the United States accept testing results from the manufacturers while using the government-owned laboratories to selectively check manufacturers' results. Brazil allows manufacturers to test vehicles at their own authorized laboratories inspected by Environment and Renewable Resources of Brazil (IBAMA) and accredited to Federal Ministry of Environment & Natural Resources of Brazil (INMETRO), but the country tests some vehicles in the government laboratory for select small manufacturers or importers that do not have laboratories.[9] In addition, all of these laboratories conduct tests for research and policy/standards development.

Governments that do not own laboratories, such as China, France, Germany, India, and the UK, typically authorize public-private[10] or private laboratories to conduct tests for C&E. These laboratories must meet certain standards and pass regular inspections to maintain the authorization from the government, which allows them to conduct emissions testing that manufacturers can use to prove compliance. The authorized laboratories operate independently and generate profit from conducting tests for

8 Bundesrat. Dritte Verordnung zur Änderung der Fahrzeug-Zulassungsverordnung und anderer straßenverkehrsrechtlicher Vorschriften. (Dec 2016) http://www.bundesrat.de/SharedDocs/drucksachen/2016/0701-0800/770-16.pdf?__blob=publicationFile&v=1

9 The laboratory in Brazil is currently used mostly for research rather than C&E.

10 Private entity that is supported and closely supervised by a regulatory agency

clients. Canada, Japan, and the United States have government-owned or funded laboratories, but they may also contract additional testing to third-party laboratories. The United States frequently authorizes third-party laboratories to conduct additional contract work. Japan accepts test results from six laboratories the country has authorized overseas, such as UTAC of France and TUEV of Germany. There are also instances where a laboratory in one region cooperates with a laboratory in another region to provide type-approval service. For example, the ICAT in India and IBAMA in Brazil have linked with VCA in the UK, which means that, if needed, they would use the test results from the other laboratory directly for compliance purposes.

The authorized laboratories provide testing services to various parties, including to manufacturers and regulatory agencies. Brazil and China have 35 and 15 authorized laboratories, respectively, that conduct vehicles tests. According to the EU regulation, each member state has technical services (i.e., authorized laboratories) appointed by the type-approval agency (i.e., the regulatory agency), and manufacturers can select any authorized laboratory to carry out the test for emissions type approval. Regulatory agencies in EU member states recognize type-approval certificates from any type-approval agency in the EU. For market surveillance purposes, regulatory agencies in France, Germany, and the UK contract with these authorized laboratories—typically the appointed laboratories in their respective countries—to conduct market surveillance tests, as needed.[11] France accepts only UTAC as its authorized laboratory.

In Mexico, the regulatory agencies do not own a laboratory, but a laboratory owned by the Mexican Institute of Petroleum can conduct certain emissions tests, although it is rarely used for compliance purposes. Without sufficient testing capacity, Mexico relies heavily on the compliance program in the United States to monitor compliance of vehicle emission and efficiency standards. In the case of heavy-duty vehicles, type approval from a European entity is also accepted. Regulatory agencies in Mexico will grant type approval to a vehicle model if the manufacturer can prove compliance with the equivalent U.S. regulation;[12] demonstrate type approval from a European entity; or provide type-approval test results from an authorized laboratory, which can be owned by a manufacturer. Such a compliance mechanism is feasible in Mexico only because Mexico typically harmonizes its vehicle emission and efficiency standards with the United States, with 1 to 9 years of delay,[13] and the U.S. EPA agreed to continue issuing certificates for HDVs that meet Mexico emission standards even after they were no longer valid for sale in the United States. Mexico's lack of test capacity means that it does not have a mechanism by which to check the manufacturer-supplied emission results of LDVs and other vehicles that are not available in the United States.

Table 6 shows the details of testing capacity in each region, including laboratory type and number, what the laboratories are used for, and what kinds of tests they can perform. Although the EC has its own testing center, it is not on the list because the EC does not have authority to grant type approval.

11 Currently, market surveillance testing is done on a voluntary basis by EU member states. A proposal is being discussed in the EU that, if passed, would require member states to conduct market surveillance testing.

12 That is, providing certification to the equivalent U.S. emission standards or using fuel efficiency value certified in the U.S.

13 The delay regarding the harmonization with the U.S. standards depends on several factors, including the fuel quality supplied within the Mexican territory, among other issues.

Table 6. Testing facility, usage, and capacity for LDV, HDV, and heavy-duty engine compliance.

	Government owned/ authorized	Number of laboratories	Laboratory usage for compliance	Testing capacity*			
				LD chassy dyno	HD chassy dyno	HD engine dyno	PEMS
Brazil	Owned	1	Type approval	✔		✔	
	Authorized	35	Type approval, conformity of production (COP) test	✔	✔	✔	✔
California	Owned	1	Type approval, confirmatory, COP, and in-use surveillance test	✔	✔	✔	✔
Canada	Owned	1	COP, in-use surveillance test	✔	✔	✔	✔
Chile	Owned	1	Type approval, COP test of LDVs	✔	✔		
China	Authorized	15	Type approval, confirmatory, COP, and in-use surveillance test	✔	✔	✔	✔
France	Authorized	1	Type approval, COP test	✔	✔	✔	✔
Germany	Authorized	12 for whole vehicles	Type approval, in-use surveillance test	✔		✔	
India	Authorized	6	Type approval and COP test	✔	✔	✔	✔
Japan	Funded	1 (2 locations)	Type approval, confirmatory, COP, and in-use surveillance test	✔		✔	
	Authorized (Overseas)	6	Type approval	✔			
Mexico	Authorized	1	Type approval	✔		✔	
South Korea	Owned	1 (3 locations)	Type approval, confirmatory, COP, and in-use surveillance test	✔	✔	✔	✔
UK	Owned	1	Type approval, in-use surveillance test	✔	✔	✔	✔
	Authorized	13	Type approval, in-use surveillance test	✔	✔	✔	✔
US	Owned	1	Type approval confirmatory, COP, and in-use surveillance test	✔	✔	✔	✔
	Authorized	1	Contract with U.S. EPA for compliance testing	Unavailable			

** This table reflects the basic testing capacity of each market; state-of-the-art testing capacities, such as use of an environmental chamber, are not specified in the table.*

Testing conducted by government-owned laboratories is generally considered to be credible because the funding structure does not create any perverse incentives, such as pressure to please clients or to compete for business. Conversely, government-authorized laboratories are typically profit driven and compete with other authorized laboratories for business. This may compromise the quality of the testing; therefore, it is necessary for the regulatory agencies to perform checks that verify the reliability of the test results from these public–private or private laboratories.

Authorized laboratories in China are mandated to connect test facilities to the MEP over a computer network and share real-time test results (Ministry of Environmental Protection [MEP], 2016a).[14] Some authorized laboratories also voluntarily install

14 Before April 11, 2016, the Chinese MEP reviewed annual reports from authorized testing laboratories to assess their test and management capacities. The MEP remains authorized to conduct periodic on-site inspections of laboratories. (MEP, 2016a)

cameras in the testing room, which allows MEP representatives to witness the tests remotely. South Korea accepts test results from manufacturer laboratories, and the Ministry of Energy in Korea audits manufacturers' laboratories every 3 years to validate manufacturers' capacity to properly carry out testing. Some countries, such as China and the United States, have provisions in their legislation that hold the authorized laboratories responsible for their test results.

In general, some regulatory agencies already have their own test laboratories that can carry out a range of dynamometer and on-road testing. These laboratories ensure that the regulatory agencies have the test capacity to check and monitor the compliance of emission and efficiency standards. For regulatory agencies that do not own test laboratories, but instead use authorized independent laboratories to carry out testing, it is important to have a management system in place to guarantee the credibility of test results from those laboratories.

4. COMPLIANCE WITH VEHICLE EMISSION AND EFFICIENCY STANDARDS

Compliance with emission and efficiency standards applies to vehicles and engines before they are produced (pre-production compliance), while they are in production (in-production compliance), and after they are sold to customers (post-production compliance).

Pre-production compliance ensures that the design of the vehicle or engine and its emission-control system is capable of meeting emission standards throughout the vehicle's life before the vehicle is authorized for production and sale.

In-production compliance ensures that vehicles or engines, either on the production line or in the sales yard of the dealership, meet the emission standards to which their pre-production counterparts were certified. In-production compliance is typically proven through conformity of production (COP) testing, which consists of checking production line quality and testing production line vehicles or engines.

Post-production compliance ensures that the vehicle or engine continues to meet emission standards throughout the vehicle's life with no design defects, durability issues, or other compliance violations.

These three types of compliance can be demonstrated by emissions and efficiency[15] tests performed by manufacturers, regulators, and/or third parties, such as authorized laboratories, depending on the regulatory requirements.

Depending on the objective and purpose of the testing, there is a range of testing methods and procedures to verify compliance.

- Test the vehicles in the laboratory on the chassis dynamometer. Vehicles are driven on a chassis dynamometer at specific speeds following the required testing procedure while analyzers collect tailpipe emission and fuel efficiency data. This may include an upfront coastdown test to evaluate the road load of the vehicle, which determines the simulated driving resistance during chassis dynamometer testing. This type of test is commonly used to test LDVs and sometimes HDVs.
- Test the engine on the engine dynamometer, instead of testing the whole vehicle on the chassis dynamometer, to evaluate the emissions and efficiency of the engine. This type of test is only common for HD engines.
- Measure real-world vehicle emissions with a portable emission measurement system (PEMS) while driving on the road. This type of test has been used more frequently for HDVs but is now starting to be used more often for LDVs.
- The testing entity may follow the same test procedure that was originally used to verify the manufacturers' test results or may perform additional testing outside of the standard protocol, such as running special test cycles on the chassis or engine dynamometer and PEMS. These types of tests may help to detect illegal defeat devices and off-cycle emissions issues.

15 Demonstration of the compliance of fleet-average fuel efficiency standards for pre-production vehicles sometimes requires an estimation of annual vehicle sales.

In addition to individual vehicle testing, there are other cross-cutting programs that play a complementary role in vehicle emissions compliance, including defect reporting, warranty reporting, inspection and maintenance programs, roadside testing, and consumer reporting initiatives. These programs provide data that allow for the identification of potential compliance issues and are especially valuable for regulatory agencies with limited resources.

Figure 2 illustrates potential elements in a vehicle emission and efficiency C&E scheme over a vehicle's useful life. There is significant variation among regions, including the role of the regulator, the method for selecting test vehicles, and the location of the test. Regions have different priorities in monitoring and investigating each type of compliance. The C&E activities have been evolving in most regions, although at different paces. The following subsections summarize, by region, practices for each element of the compliance program.

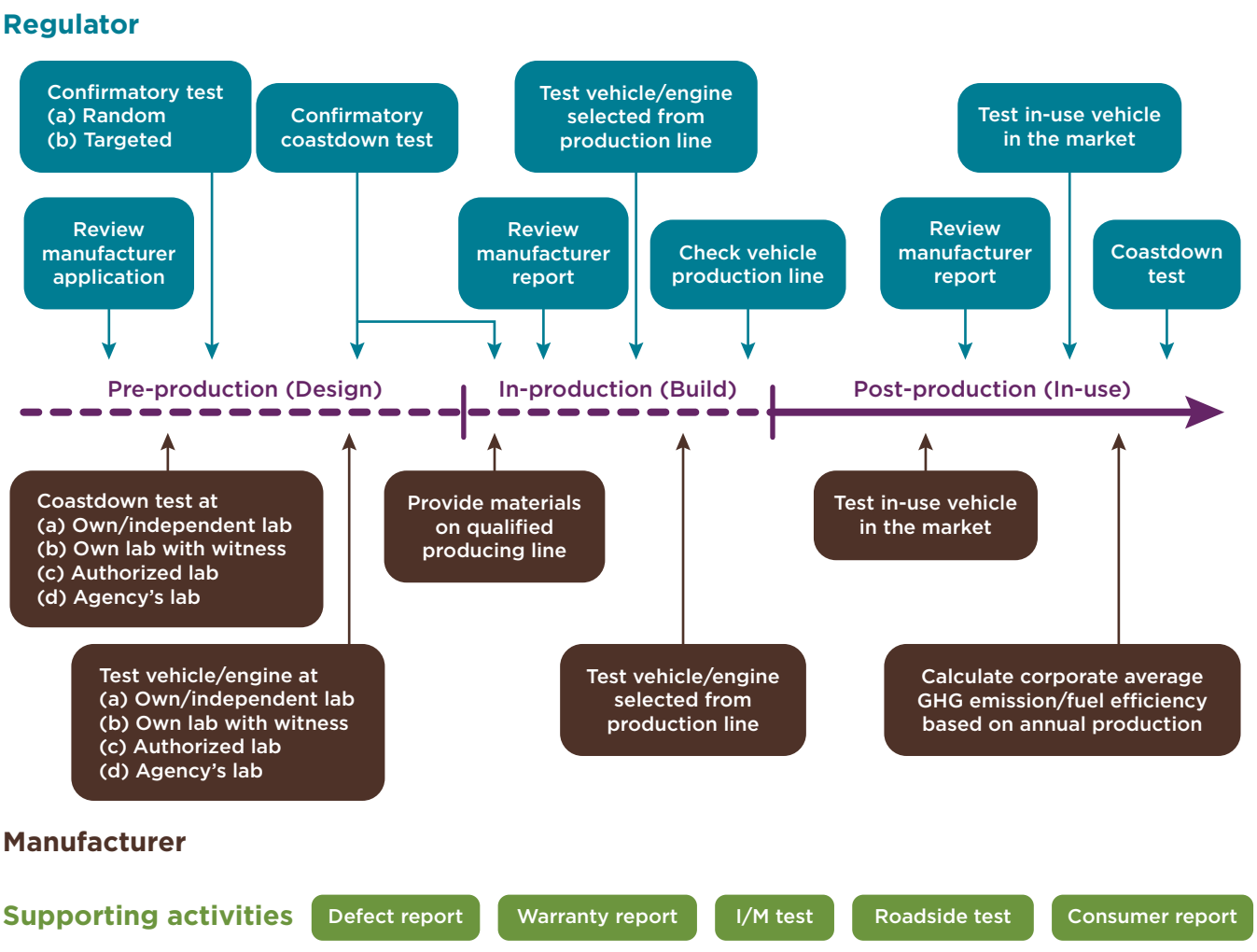

Figure 2. Elements in vehicle emission and efficiency C&E schemes.

4.1 PRE-PRODUCTION COMPLIANCE

To enter the market, vehicles and engines are typically required to demonstrate that the vehicle or engine conforms with applicable emissions and efficiency requirements. Based on evidence submitted by manufacturers and, sometimes, the regulatory agency's investigation, the regulatory agency issues a type-approval certification[16] or other form of approval that allows the vehicle to be sold on the market.

In most cases, manufacturers must conduct tests to prove their vehicles or engines meet the standards. Because Canada harmonizes its emission and efficiency standards with the United States and its vehicle market extensively overlaps with the U.S. vehicle market,[17] Canada relies on the U.S. type-approval program and accepts the certification issued by the United States. For vehicles not covered by the U.S. EPA certificates, Canada assigns experts to examine manufacturers' applications. Mexico accepts the type-approval certification issued by the United States and EU, if it is available, or certifies models based on test results from laboratories that can be owned by the manufacturers. In California, manufacturers must submit separate applications to show that the vehicles meet California emission standards to sell their vehicles there.

Manufacturers must perform the testing at their own expense at the type of facility required by the legislation or regulation. Depending on the market, a manufacturer must perform the pre-production certification testing at one of the following:

- At its own laboratory, which is established and operated by the manufacturer, or contract the service to independent laboratories that are authorized to provide such services (e.g., Brazil,[18] California, Canada, South Korea, United States)
- At an authorized independent laboratory or at its own laboratory with a witness from the authorized independent laboratory (e.g., China, France, German, India, UK)
- At the regulator's laboratory (e.g., Chile and Japan) or at its own laboratory with a witness from the regulatory agency (e.g., Japan)

In the EU, each member state assigns one or more technical services[19] with authorized laboratories to conduct or witness type-approval testing. The type-approval agency of each member state issues a type-approval certificate based on test results from its authorized technical services and recognizes certificates from other type-approval authorities across the EU. That means manufacturers can choose in which member state to apply for emissions type approval, test their vehicles in any technical services authorized by that member state, and sell vehicles to all member states with certified type approval.

To decrease the number of tests a manufacturer needs to conduct, regions categorize vehicles into a test group/family and approve vehicles that are representative of the group/family. For emissions testing, the representative vehicles are typically the

16 The term for this process varies by regions. See Appendix B.

17 Approximately 98.5% of the models (99.5% of sales) sold in Canada are also certified and sold in the United States.

18 Brazil monitors only some of the tests conducted at the importers' or manufacturers' laboratories. For example, for flexible fuel vehicles that are required to test with gasoline, ethanol, and gasoline/ethanol mixture (50%/50%), CETEST, Brazil's technical agency, witnesses the test with one of the three types of fuels.

19 In the EU, a technical service is an organization or a body designated by the national approval authority to carry out tests or assessments on behalf of the approval authority.

models with the highest emissions of each test group/family. For conformity with fuel efficiency standards, manufacturers sometimes need to test additional vehicles (more than one per group/family). For example, in the United States and Canada, 90% of vehicle subconfigurations produced should be represented by pre-production test data. To prove they have met this requirement, manufacturers need to estimate the number of vehicles they will produce at the beginning of the calendar year and verify the estimation with the actual number of vehicles produced by the end of calendar year.

The submitted certificate/type-approval application typically includes test results and technical details for the vehicle. The regulatory agencies then review and audit the materials and approve or reject the manufacturer's application. This review process consists of automatic computer screening and/or a manual exam by technical staff to check the completeness of the report and identify unreasonable information. If the initial application is rejected, which is not unusual in some countries, the manufacturers may communicate with regulators to discuss the issues with the application and resubmit it after revision. In China, around 30% of type-approval applications are returned for various reasons (e.g., unreasonable road load given the vehicle characteristics, incorrect report format).

In addition to reviewing manufacturers' applications, some regulatory agencies also conduct confirmatory tests to validate the test results reported in certification applications. The confirmatory test is especially rigorous in regions where manufacturers conduct certification testing with no or limited government supervision. For example, to verify tests conducted by manufacturers without any supervision, South Korea and the United States select vehicles and engines for confirmatory testing. Each year, the U.S. EPA selects about 15% of LDVs of all test groups through a combination of random and targeted selection. South Korea randomly selects vehicles and engines for confirmatory testing. To verify the credibility of the testing performed by authorized independent laboratories, China MEP-VECC contracts with independent laboratories to conduct confirmatory tests on randomly selected vehicles.

BOX 1. ROAD LOAD AND REFERENCE MASS

The road load simulates forces from driving resistance of a moving vehicle, such as rolling resistance and aerodynamic drag, when testing stationary vehicles tied down on a chassis dynamometer. It is partially influenced by vehicle reference mass. The road load is important because it determines the amount of force that the dynamometer places on the vehicle for it to overcome during testing. If the road-load values are too low, the test will require the vehicle to use less power and thus less fuel, which leads to inaccurate fuel efficiency testing results.

The road load is measured through a coastdown test, an independent test that evaluates a vehicle's resistance at certain speed and load conditions and then reproduces them during testing on dynamometers. Monitoring or auditing the road-load test is considered important in some regions, but has not yet been adopted by most regions.

For certification tests at the agency's laboratory in both Chile and Japan, the agencies weigh the test vehicle on site. Chile uses the road-load value provided by the manufacturer. Japan started to perform unannounced witnessing of manufacturers' coastdown tests from September 2016, after a fuel economy scandal there.[20] In China and India, the authorized laboratories test the mass and road load that are used for the type-approval test. China also makes it optional for manufacturers to determine road-load factor using preset values adjusted to vehicle specifications in the regulation rather conducting tests, but all manufacturers prefer to conduct coastdown tests for better results. China audits road-load values through data screening to make sure the road-load value is within a reasonable range given certain vehicle characteristics. The EU does not specify the way that the mass and road load should be collected for the type-approval test. Technical services in France and the UK test or witness the mass and road load that are used for the type-approval test. In Brazil, the government agency does not witness any coastdown tests.

We found that all agencies in the examined regions that perform confirmatory testing weigh the test vehicle on site. China and South Korea use road-load factors provided by manufacturers or authorized laboratories for their confirmatory testing. Some countries audit the road-load test on in-production or post-production vehicles, such as Canada, Japan, and the United States (see Sections 4.2 and 4.3).

Table 7 summarizes pre-production compliance requirements in each region. Regarding where manufacturers are required to conduct type-approval tests, the level of government supervision increases, from manufacturer-owned or selected laboratories to agency-authorized independent laboratories to laboratory testing with an agency witness, and finally to agency-owned laboratories. Having the agency or authorized laboratory check the road load used for vehicle testing adds another

20 Mitsubishi admitted cheating on fuel economy coastdown tests in Japan in 2016 (Mitsubishi Motors, 2016).

level of government oversight. The regulatory agency may check the compliance of pre-production vehicles through monitoring the quality of the laboratory where the manufacturer conducted the test, conducting confirmatory test of vehicles and engines, or conducting other auditing tests to check key inputs such as mass and road load. Only in select regions (e.g., China, South Korea, and the United States) are manufacturers paying for the confirmatory and auditing tests conducted by the regulatory agencies.

Table 7. Manufacturer and agency testing to verify pre-production compliance.

	Manufacturer testing					Agency monitoring/testing				
	At OEM laboratory	At authorized laboratory or with laboratory witness	With agency witness	At agency laboratory	Agency or authorized laboratory check road load	Check laboratories	Confirmatory test	Audit mass	Audit road load	Test paid by OEM
	More government oversight					More comprehensive monitoring				
Brazil	✔		✔[a]			✔				
Canada	✔									
	Or submit certification issued in the U.S.									
Chile				✔		–	–	–		–
China		✔			✔	✔	✔	✔		✔
France		✔			[b]	✔				
Germany		✔				✔				
India		✔			✔					
Japan			✔	✔	✔	–	–	–		–
Mexico	✔									
	Submit certification issued in the US and EU									
South Korea	✔						✔	✔		✔
UK		✔			[b]	✔				
US	✔					✔	✔	✔		✔

[a] *Brazil monitors only some of tests of flex fuel vehicles conducted at the importers' or manufacturers' laboratories.*

[b] *The manufacturer coastdown test is fully witnessed by the technical service in France and partially witnessed (witnessing of some runs or some brief verifications) by the technical service in the UK.*

Note. The – symbol means that the level of agency monitoring is sufficient during manufacturer testing.

4.2 IN-PRODUCTION COMPLIANCE

In-production compliance, typically called *conformity of production* (COP), ensures that the vehicles and engines in the production line or in the sales yard of the dealership are in accordance with the approved specifications in the pre-production application. The required testing of in-production vehicles is typically the same as in the type-approval test, although the regulatory agency sometimes may conduct additional testing to screen for a specific issue, such as the use of a defeat device.

In many regions, manufacturers must demonstrate that their newly produced vehicles and engines comply with the regulations, in the same way that they are certified during the type-approval process. Manufactures demonstrate in-production compliance by

routinely checking production line quality,[21] testing products as they leave the assembly line, and submitting COP reports periodically. The sample size for the test should suffice for verifying compliance of each vehicle/engine group that has received a certificate. The testing procedure and requirement of key tests[22] are usually the same as pre-production test, but where to conduct the test can differ from pre-production testing. For example, manufacturers in China and EU member states can conduct COP tests in their own laboratories instead of using agency-authorized laboratories, as must be done for the initial type-approval test. Chile and India are the only two regions in this report that require manufacturers to test vehicles in an agency's laboratory or agency-authorized laboratory.

For compliance of produced vehicles with fuel efficiency standards, India, Brazil, and EU member states allow the COP test to be, at most, 8% higher than the type-approval value for LDVs. The COP tolerance margin for fuel consumption in China is 4% for LDVs and 6% for HDVs in the regulation, but it is never checked in practice.

In addition to reviewing the manufacturer's COP reports, most regulatory agencies that we surveyed take additional actions to verify in-production conformity. China, the EU, and Japan check the manufacturer's production line to verify its capability of producing vehicle systems and components and to ensure that the assembly is consistent with the certified criteria.

Many regulatory agencies carry out confirmatory testing of production vehicles. For regions where vehicle or engine manufacturing occurs, the agencies can select vehicles from the production line directly; some agencies also select new vehicles that have not been sold from dealership stock, as is the case in Canada and Chile. In most cases, the regulatory agency randomly selects vehicles without prior notice to avoid possible cheating (i.e., swapping a production vehicle and engine with an example model). Paying surprise visits is a critical strategy to ensure effective confirmatory testing. For example, China conducts surprise visits to manufacturers to select vehicles for COP testing, because, for a long time, manufacturers knew when the agency was coming and would choose the model for COP tests via informal information channels and would prepare accordingly. Thus, China has learned to adopt a more confidential approach to prevent information leaking to manufacturers.

Most regions require manufacturers to cover the cost of the agency's COP testing, except Canada, where the regulatory agency purchases new vehicles from the dealership for testing and then sells the vehicles at public auction if they are found to be compliant.

21 In the EU member states and China, it is sufficient for the manufacturer to demonstrate that it has a quality-management system (e.g., as defined by ISO 9001) in place (Mock & German, 2015).

22 *Key tests* refer to testing to check tailpipe emissions and fuel efficiency/CO_2 emission of vehicles. Other tests (e.g., evaporative emissions test, durability test) may not be required for in-production testing.

BOX 2. CHECK COMPLIANCE OF ON-BOARD DIAGNOSTICS SYSTEM

Some agencies take additional steps to ensure functionality of the on-board diagnostics (OBD) system. The OBD system is designed to help ensure proper operation of the vehicle's emission-control system by alerting the driver in case of malfunctions until they are repaired. It monitors the performance of engine and aftertreatment components, especially those responsible for controlling harmful pollutant emissions. Therefore, defective OBD systems could directly lead to high in-use emissions. Note that according to the U.S. EPA's periodical progress/compliance reports, malfunction of the OBD was one of the most frequent causes of emissions related to vehicle defects in reports for 2012 and 2013 models (EPA, 2015).

Canada, France, Japan, South Korea, and the UK check OBD functionality in three ways: (a) check the malfunction indicator lamp when emissions exceed standards during testing, (b) replace some components in the emissions-control system with broken parts to check whether the OBD system can identify the problem, and (c) apply malfunction simulators to check whether the OBD system can identify the problem. The second and third approaches may need support from the manufacturer. South Korea clearly specifies that, upon request, the manufacturer shall make available to the authorities all test equipment (e.g., malfunction simulators, deteriorated threshold components) necessary to determine the malfunction criteria (Posada & German, 2016). Canada recently started to check the OBD system by comparing OBD readings to actual emission-control system signals. California[23] checks compliance of the OBD requirement on in-use vehicles, which is discussed further in Section 4.3.

Regulatory agencies in the EU member states and the United States do not currently conduct COP testing, but they reserve the right to do so. Although the EU empowers the regulatory agencies of member states to conduct in-production testing, France, Germany, and the UK do not actively audit in-production compliance. Prior to 2000, the U.S. EPA conducted a significant amount of COP testing (He & Jin, 2017). To avoid failing, manufacturers would voluntarily test thousands of new cars each year to find emission problems before the agency conducted its testing. The COP auditing was a very effective program for a few decades, and by 2000, both light- and heavy-duty audits rarely failed. The U.S. EPA stopped performing its own COP testing in 2000 except in cases of possible fraud. At that time, the agency shifted focus to in-use testing, as described in the next section. The development of the U.S. in-production compliance testing program demonstrates that if the regulatory agency has enough capacity to carry out testing—and presumably take actions when noncompliance is found—the manufacturers are more likely to implement effective practices to confirm they are producing compliant vehicles and engines. By contrast, regulatory agencies in Mexico take no action on COP verification because they have limited authority to verify the emission conformity of produced vehicles.[23]

23 Most vehicles in the United States demonstrate compliance with the federal OBD standards through an OBD approval from the state of California.

Canada conducts confirmatory COP testing on approximately 10 LDVs and 2 HDVs[24] every year on chassis and/or with PEMS. As previously mentioned, the majority of vehicles sold in Canada are also sold in the United States. Accordingly, Canada's testing is conducted in coordination with the U.S. EPA to help broaden the scope of testing coverage and maximize efficiencies in the administration of the respective programs. There is no in-production compliance testing requirement in Mexico for vehicles that are not sold and certified by the U.S. program. South Korea conducts COP testing on about 100 vehicles annually, with LDVs tested on a chassis dynamometer and HDVs tested with PEMS. Canada and Japan started to audit coastdown tests on new vehicles produced since 2016.

Table 8 summarizes in-production compliance requirements in each region.

Table 8. Requirement for in-production compliance.

	OEM				Agency					
	Test	Require agency/ authorized laboratory testing	Mandatory	Report	Check production line	Audit emission	Test CO_2/FE	Audit road load	Agency select vehicle	OEM pay
Brazil	✔		✔	✔						
Canada	>98% models covered by U.S. program					✔	✔	Partial	✔	
Chile	✔	✔	✔	✔		✔			✔	✔
China	✔		✔	✔	✔	✔			✔	✔
France Germany UK	✔		✔	✔	✔	Reserve right			✔	✔
India	✔	✔	✔	✔		✔	✔		✔	✔
Japan	✔		✔	✔	✔			✔		
Mexico	No existing program									
South Korea	✔		✔	✔		✔	✔		✔	✔
U.S.	✔					Reserve right	Reserve right		✔	✔

Beyond checking the production line and dealership stock, regulatory agencies sometimes design special programs to address certain compliance issues. For example, in 2014, China's regulatory agency discovered that some new vehicles were not equipped with devices, such as common rail injectors and diesel particulate filters, that were installed on the originally certified engine. China requires that local regulatory agencies conduct visual checks to confirm the installation of relevant devices on new vehicles at their first registration. Because these devices can be identified by visual observation, it is possible to tell if the device is not installed when it is sold as new to consumers. This approach cannot replace laboratory testing, but it can effectively screen for vehicles that do not have the key hardware required to meet certain standards.

24 Sometimes heavy-duty engines are chosen for testing on an engine dynamometer.

4.3 POST-PRODUCTION COMPLIANCE

Post-production compliance ensures that in-use vehicles meet applicable standards after they enter the market and are used in the real world. Some countries use the term *in-use compliance* or *in-service compliance*. Post-production compliance can identify issues that pre- and in-production testing cannot. It (a) verifies durability of key emission control and efficiency technologies, and (b) identifies vehicles that emit excessive pollutants due to poor design and defects in or deterioration of the emission-related parts, which are mainly the fault of manufacturers.

BOX 3. IN-USE VEHICLE COMPLIANCE AND IN-USE VEHICLE MANAGEMENT

There is a wide range of possible reasons for observing high in-use emissions from vehicles and engines. These include emission-control manufacturing defects, durability issues, defeat devices, poor maintenance, and tampering, although poor maintenance and tampering are generally not the responsibility of the manufacturer.

Post-production compliance testing and related activities, such as defect reporting, are focused on identifying issues that are the responsibility of the manufacturer and that would likely be resolved through a recall or other corrective action. This makes in-use C&E different from in-use vehicle management, such as inspection and maintenance (I/M), which aims to avoid high emissions as a result of poor maintenance or removal of or tampering with the emission-control parts.

Currently, mandatory in-use compliance tests focus mainly on checking the conventional pollutant emissions of in-use vehicles and engines. Canada and the United States are the only two regions that have CO_2 emission requirements for in-use vehicles. The United States is currently the only region that requires manufacturers to check and report CO_2 emissions from in-use vehicles. An in-use vehicle can be determined to be noncompliant if the CO_2 emission value exceeds its certified CO_2 value by more than 10%.

To check in-use compliance with emission standards, the basic test protocol is to bring the in-use vehicle back into the laboratory and retest it on the chassis dynamometer using the same test procedure as for the type-approval test. However, many regions are moving away from a simple repeat of the original type-approval test to a more diverse test protocol that measures emissions with a PEMS while the vehicle is being driven on the road. Some regions share the testing burden relatively equally between manufacturers and regulatory agencies, whereas some rely more on one than the other.

China, the EU (including France, Germany, and the UK), South Korea, and the United States require manufacturers to regularly test in-use vehicles on chassis dynamometers, although the details of the requirements vary.

» China has required manufacturers to test in-use LDVs since 2007. Manufacturers are required to submit quarterly and annual reports of their test results. In addition to chassis dynamometer tests, LDVs that are certified for China 6 emission standards

are required to undergo in-service conformity PEMS testing. The proposed China VI HDV emission standards require manufacturers to conduct PEMS testing for in-use vehicles with mileage higher than 10,000 km.

- The European Commission introduced the in-service conformity testing of LDVs in 2001. Manufacturers must test vehicles selected from consumers and report back every year to the agency that initially granted the type approval. The regulation allows the manufacturer to determine its own methodology for testing to prove in-use compliance; however, in most cases, the manufacturer opts for a straightforward repeat of the type-approval test. The European Commission also introduced in-service conformity PEMS testing for HDVs that has been in effect since 2013.
- The U.S. in-use verification program (IUVP) requires manufacturers to carry out chassis dynamometer testing for LDVs, medium-duty passenger vehicles (MDPVs), and complete Class 2B/3 HDVs up to 14,000 lb without prior screening for proper maintenance at both low and high mileage. Manufacturers must report immediately if any vehicle fails the test and report quarterly if no failure is found. If the failure rate under the IUVP reaches a predefined level, manufacturers must then proceed to test more vehicles under the more rigorous in-use confirmatory program (IUCP). The IUCP requires manufacturers to test properly maintained vehicles in order to exclude the potential impact of improper maintenance. The United States also requires manufacturers to conduct in-use PEMS testing of heavy-duty diesel engines.

In the ideal manufacturer in-use testing program, the quantity of tests would be designed so that the test results would represent nearly complete coverage of the fleet. For tailpipe emissions, depending on the sales of the test group/family, the United States requires manufacturers to test somewhere between zero and six vehicles per test group (defined in Appendix B), whereas China and the EU require manufacturers to test between zero and three batches per in-service family (defined in Appendix B) with a minimum of three vehicles per batch. In addition, the United States requires manufacturers to test one vehicle per evaporative/refueling family (defined in Appendix B) to verify evaporative and refueling emissions.

In most countries, the regulatory agency plays a supervisory role in in-use surveillance programs—also referred to as market surveillance in some regions—including reviewing test results submitted by manufacturers and performing in-use surveillance testing. Reviewing manufacturer self-monitoring reports could help regulators discover design defects and verify the durability of emission control devices. The U.S. EPA refers to these reports to help determine if the agency needs to conduct its own in-use surveillance test on a vehicle. In the United States, manufacturers commonly agree to perform a voluntary recall if they find a vehicle that has failed the IUVP/IUCP testing has a problem that can be easily diagnosed. In China, there are no documented cases of regulators ever receiving an in-use report showing that any vehicle has failed the test. It is unlikely that this indicates that there are no defects on any in-use vehicles in China, but more likely indicates that there are loopholes in the testing program that are being exploited.

Some regulatory agencies carry out their own in-use surveillance testing to examine the reliability of manufacturers' in-use reports, verify potential issues identified through other resources (see Section 4.4), and detect illegal defeat devices that reduce the effectiveness of emission control systems in real-world operation. Additional actions from specific regions include the following:

- California conducts confirmatory emissions testing of a manufacturer's test vehicle.
- Under the Framework of the U.S.-Canada Air Quality Agreement, Canada coordinates with the U.S. regulatory agency to conduct in-use testing to broaden the scope of testing coverage and maximize the efficiencies in the administration of the respective programs. The number of vehicles tested by Canada varies from year to year based on budget and available test capacity, with an average of 10 to 15 LDVs and five HDVs annually. Canada typically acquires a low-, mid-, and high-mileage vehicle to assess its in-use compliance.
- China has been conducting its own in-use vehicle testing since 2016.
- The European Commission does not currently mandate that type-approval agencies in member states conduct confirmatory in-use testing.[25] In the past, some member states, such as Germany and the UK, have conducted voluntary in-use surveillance testing programs, but those programs were terminated because of budget constraints. From 2007 to 2011, the UK tested approximately 30–45 vehicles per year. Sweden has been conducting regular in-use surveillance testing since 2009, testing an average of 21 vehicles per year. The Netherlands has had an in-use compliance program for passenger cars since 1987 and for HDVs since 2011 that periodically tests in-use vehicles. After the Volkswagen defeat device scandal broke in September 2015, the regulatory agencies in some member states, including the UK, France, and Germany, launched projects to test in-use diesel vehicles in 2016. The UK tested 38 vehicles, Germany tested 53 vehicles, and France tested 86 vehicles. It is not clear if these in-use testing programs were one-time occurrences in response to the dieselgate scandal or if these programs will continue. Currently, none of these regions has announced any plan for a regular in-use testing program.
- Japan's MLIT selects about five models and 20 vehicles on which to conduct in-use testing each year.
- South Korea tests about 30 to 40 vehicle types and 3–4 samples of each type, following up with confirmatory tests of vehicle types that fail the screening tests (5–10 samples per vehicle type).
- The U.S. EPA selected 33 classes of vehicles in 2012 and 25 classes in 2013 and tested approximately three vehicles per class. If a vehicle class fails the screening test, U.S. EPA conducts confirmatory testing of 5–10 vehicles of that class. Since 2010, the United States has conducted confirmatory coastdown testing on 10–20 vehicles per year to verify the road-load coefficient used in the chassis dynamometer for emissions and fuel economy testing.

Some agencies check the malfunction light illumination and read and analyze the historical OBD code record to verify the condition of the tested vehicle and repair as needed before starting any confirmatory in-use testing, such as in the United States and Canada. Canada also has started tests to verify the OBD system details of the in-use vehicle, the same as for the confirmatory COP test, including comparing OBD readings to actual emission control system signals. California conducts special tests for confirming OBD system functionality on production vehicles. The regulatory agency may replace components monitored by the OBD system with components that are sufficiently deteriorated or simulated to cause malfunctions that exceed the malfunction

25 The type-approval framework proposal that is under discussion would change this. More information at http://eur-lex.europa.eu/procedure/EN/2016_14

criteria in the regulations. California and South Korea require the manufacturer to make available to the authorities all test equipment upon request for the in-production vehicle OBD test. The typical test sample size in California is 10 to 12 manufacturers and one vehicle model from each.[26]

Unlike most government-run COP confirmatory tests, the costs of government-run in-use surveillance testing are not all covered by manufacturers in all regions. Only South Korea and the United States require manufacturers to pay for in-use surveillance testing. In other regions, such as Canada, China, and Japan, in-use surveillance testing is covered by the government agency's budget. Table 9 summarizes post-production compliance requirements in each region.

Table 9. Requirement for post-production compliance by region.

	OEM		Agency					
	Test	Tested vehicle/engine	Review report	Test	Selected vehicle	Annual no.	Audit road load	OEM pay
Brazil	No existing program							
Canada		>98% models covered by U.S. program		✔	Targeted	10–15 (LDV) 5 (HDV)		
California	✔	LDVs low mileage (≥10,000 mi/1 yr) and high mileage (>50,000 mi/4 yr)	✔	✔	Not available	Not available		✔
China	✔	LDVs between 15,000 km/6 months and 100,000 km/5 years (China 5) LDVs low mileage (10,000–60,000km)/ medium (60,000–110,000 km)/high (110,000–160,000km) (China 6)	✔	✔	Targeted	Not available		
Chile	No existing program							
France	✔	LDVs between 15,000 km/6 months and 100,000 km/5 years Lighter HDVs ≤ 300,000 km/6 years Heavier HDVs ≤ 700,000 km/7 years	✔	One-time				
Germany	✔		✔	One-time				
UK	✔		✔	One-time				
India	No existing program							
Japan				✔	Not available	20 (HDV)		
Korea	✔	LDV	✔	✔	Targeted	80–140		✔
		HDV						
Mexico	No existing program							
U.S.	✔	LDVs low mileage (≥10,000 mi/1 yr) and high mileage (>50,000 mi/4 yr)	✔	✔	Targeted	75–100	✔	✔
		Heavy-duty diesel engines	✔					

26 Manufacturers also conduct self-testing of production cars for every individual fault, usually with simulation by software and calibration.

4.4 RESOURCES SUPPORTING REGULATORY AGENCY COMPLIANCE ACTIVITIES

In-depth vehicle emissions testing, either on a dynamometer or with PEMS, to identify the cause of emission system failures is quite expensive. With resource and capacity limitation, confirmatory testing by the government cannot cover as many vehicles as in manufacturers' testing; thus, vehicle selection is an important element of any government testing program to increase the odds of identifying vehicles with compliance issues during testing.

Agencies may create and leverage various sources to monitor emissions of both new vehicles and in-use vehicles to identify vehicles that are candidates for further testing. One key source is the data that the manufacturer supplies through pre-, in-, and post-production testing (covered in Sections 4.1–4.3). Some agencies refer to information and data that come from programs that may be designed to discover emission issues attributable to manufacturers, but also can be used to screen in-use vehicles to uncover potential compliance issues. These sources include emission warranty reporting, defect reporting, I/M programs, OBD records, remote sensing or plume capture, and consumer or public service technician complaints. In some cases, information exchange from interagency collaboration and public information also provides valuable resources. For example, Canada and the United States have a long history of collaboration under the framework of the U.S.-Canada Air Quality Agreement toward the coordinated implementation of their vehicle and engine emission regulations. As most vehicles found in the United States can also be found in Canada, the two countries often coordinate the emissions testing. The U.S. EPA announcement of Volkswagen cheating on emissions tests with illegal defeat devices resulted in more surveillance testing on Volkswagen vehicles in other regions, including France, Germany, South Korea, and the UK.

Table 10 shows the channel of information that is available in each region and whether it is used for agency compliance programs. Note that most sources in this table provide support for emission compliance only. Only consumer reports sometimes provide information on vehicle fuel efficiency. The following section elaborates on the practices of each source.

Table 10. Data/information sources to support regulatory agency compliance activities.

	Laboratory testing data						Additional sources											
	Certification information		OEM COP test		OEM in-use test		Emission warranty		Defect report		I/M		OBD record		Remote sensing		Consumer reporting	
Brazil	o		o								*							
California	o	✔			o	✔	o	✔	o	✔	o	✔	o	✔	o	✔	o	✔
Canada	o	✔							o	✔	*						o	✔
Chile	o		o								o							
China	o	✔	o		o						o	✔	*		*		o	✔
France	o		o		o						o							
Germany	o		o		o						o							
India	o		o	✔							o							
Japan	o		o	✔					o	✔	o	✔					o	✔
Mexico	o										*							
South Korea	o	✔	o	✔	o	✔	o	✔	o	✔	o		o				o	✔
UK	o		o		o						o							
U.S.	o	✔			o	✔	o		o	✔	o	✔	o	✔	*		o	✔

*Notes: o Have the program nationally * Only in some regions/projects ✔ use the program for compliance*

Certification information. Some agencies refer to the certification documentation to make decisions about which vehicles to investigate. To receive certification to sell vehicles in certain markets, manufacturers in most regions must submit application materials that provide information on engine design, production volume, type of emission control equipment installed, as well as testing data to show that the vehicle or engine meets the emission and efficiency standards for its regulatory useful life. India is an exception; there, the certification test data are collected by the test agency, but the regulatory agency does not have access to it, so it becomes necessary to empower the agency to access and review the testing details and results whenever needed.

Canada, China, South Korea, and the United States are inclined to test vehicle models that have a higher potential of noncompliance based on certification and sales information. For example, in China, if the type-approval application of a vehicle has been returned for revision due to problematic data, unreasonable logic, or even a fake test, it may become a candidate for the agency's confirmatory testing. The United States pays attention to vehicles with small compliance margins[27] in relation to its applicable standard limit as well as to vehicles deployed with newly commercialized technologies. Canada verifies the compliance margin in certification documentation and sales volumes, sometimes targets specific technologies, and pays special attention to vehicles that are not certified in the United States for testing. South Korea may select vehicles with high sales volumes, new technologies (e.g., certified for Euro 5 emission standards), or special vehicle categories (e.g., SUV or mini car) for in-use testing (National Institute of Environment Research [NIER], 2013, 2014).

OEM COP test and in-use test. Information in the manufacturer's COP or in-use testing reports may provide evidence of design defects or emission control system durability

27 Determined by the regulators' best judgment.

issues. In the United States, two thirds of voluntary manufacturer recalls are due to issues discovered by manufacturer in-use testing. India, South Korea, and the United States also use the manufacturer's testing results to help select vehicles for confirmatory testing, if no voluntary action has been taken. However, not all regions that have manufacturer-run testing programs are able to use the test results as a guide for further compliance activities. China rarely refers to manufacturer testing results because they do not receive manufacturer COP or in-use testing reports that demonstrate any test failure.

Emission warranty. An emission warranty program requires a minimum period during which manufacturers must guarantee the performance of certain emission control components on vehicles and engines. These programs encourage vehicle owners to report and repair emission-related issues at no additional cost to the owner, while incentivizing manufacturers to build more durable emission control systems. The U.S. Clean Air Act, Korea Clean Air Conservation Act, and California state regulations set minimum emission-related warranty periods, based on vehicle age or cumulative miles, that manufacturers must provide to consumers. China added a minimum warranty requirement in its upcoming China 6 emission standards for gasoline vehicles and proposed China VI emission standards for diesel vehicles. South Korea and California require manufacturers to periodically review and report warranty claim records for each engine family or test group. In South Korea, it is common that the regulatory agency selects vehicles that are close to the emission warranty expiration year or mileage to conduct screening tests in the government laboratory (NIER, 2014). In principle, a warranty throughout the vehicle's full useful life that covers all emission-related parts will provide the most thorough information on part defects. As Table 11 shows, the warranty coverage is different across regions. The definition of "emission-related repair" may vary by region, but those differences are not discussed in this report.

Table 11. Warranty coverage in China, South Korea, California, and the rest of the United States for LDVs.

Region	Emission warranty coverage	Emission-related repair	Warranty for listed parts
China	Gasoline	3 years/60,000 km	
	Diesel LDV (proposed)	5 years/80,000 km	
	Diesel HDV (proposed)	5 years/160,000 km	
South Korea	Gasoline LDV	15 years/240,000 km	
	Diesel LDV[a]	10 years/160,000 km	
	Gasoline HDV	2 years/160,000 km	
California and 13 states[b]	LDV and medium-duty vehicle and engine	3 years/50,000 miles	7 years/70,000 miles[c] (cover a few dozen parts)
	Gasoline HDV	5 years/50,000 miles	
	Diesel HDV	5 years/100,000 miles	
Rest of the U.S.	LDV and medium-duty vehicle and engine	2 years/24,000 miles[d]	8 years/80,000 miles[c] (cover three parts)

Note. Data from CARB, 2017; MEP, 2016b; MEP, 2016c; Ministry of Environment (MOE), 2016a.

[a] *South Korea has a complicated warranty requirement for diesel HDVs that is not listed here (MOE, 2016a).*

[b] *Arizona, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New Mexico, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.*

[c] *Definition of major parts varies by regions. California's warranty covers any emission control parts above $600, including hardware and labor costs, and the list varies by manufacturer (the warranty typically covers a few dozen parts). U.S. EPA's warranty covers the catalyst, engine control computer, and OBD.*

[d] *2 years or 24,000 miles, whichever comes first.*

Defect report. An emission defect reporting program can also provide information on the frequency of emission control part failures and identify emission parts with abnormally high failure rates. South Korea requires manufacturers to report quarterly if they meet both of the following two conditions: (a) if they receive more than 40 defect repair requests for the same part of the same vehicle sold in the same year, and (b) if the defect repair demand ratio (ratio of number of requested repairs to annual sales) is more than 2% (MOE, 2016b). The manufacturers must also take corrective actions to bring the failed parts back into compliance. In the United States, manufacturers must submit a defect report once the manufacturer determines that an emission-related defect exists on 25 or more vehicles or engines[28] of the same model year. The approach in California is different from the U.S. national program. The California defect reporting program is based on the state's emissions warranty program. As mentioned earlier, California requires manufacturers to review warranty claim records for each engine family or test group on a quarterly basis and submit reports when the cumulative number of warranty claims reaches a certain threshold. Canada requires manufacturers to report emission-related defects that affect or are likely to affect compliance with applicable emission standards and to inform owners of the existence of the defect along with the corrective measure(s) if the manufacturer becomes aware that a problem is occurring. There is no prescribed threshold (number of occurrences) for reporting of a defect; the number need be only significant enough to raise the real possibility of a failure occurring. The ECCC may independently learn of potential defects through consumer complaints, recalls occurring in the United States, inspections, testing, or by examining technical service bulletins issued by manufacturers to their dealerships and bring the issue to the attention of the manufacturer, which may ultimately result in a notice of defect. In Japan, manufacturers collect defect information from the users' periodic maintenance, inspection, and service and investigate and study the cause of defects. Because the regulatory agency also collects defect information from users directly, manufacturers may receive notification from the regulatory agency to investigate the reported defects. According to the Road Vehicles Act, in cases where the manufacturer determines that defects of the vehicle or parts it manufactured or imported are resulting in potential noncompliance with the regulation due to the design or production process, the manufacturer must inform the regulatory agency (Ministry of Land, Infrastructure, Transport and Tourism [MLIT], 2016b). China's regulation requires manufacturers to investigate vehicles that they think have potential defects and report the investigation results (Administration of Quality Supervision, Inspection and Quarantine [AQSIQ], 2015). For LDVs certified with China 6 emission standards, manufacturers are required to record the maintenance of emission warranty parts and related OBD malfunctions and reasons. If the maintenance rate of an emission warranty part exceeds 4%, manufacturers must report it to authorities within 30 days (MEP, 2016b).

The defect reporting programs in Canada, Japan, and the United States allow the vehicle manufacturer to determine the existence of a defect with any method; thus, their programs lack transparency and are challenging to enforce. By comparison, the approach in South Korea is straightforward and easier to implement because it mandates that manufacturers take remedial actions once the defect threshold is reached. If allowed by law, this approach avoids extended negotiations between the

28 There are defect report requirements for other engines and equipment that are not installed on vehicles. The thresholds for reporting are different.

manufacturer and regulatory agency and reduces the need to conduct tests of in-use vehicles to demonstrate that the vehicle group is exceeding the emissions standard.

Inspection and maintenance. Inspection and maintenance programs established to ensure that in-use vehicles perform at or below given emission limits for their useful life are common in many regions. The primary purpose of establishing an I/M program is to identify maintenance and tampering issues that are the fault of the end user, not to support compliance surveillance work. However, agencies can use the data from I/M programs to discover differences between the performance of prototypes and in-use vehicles that may be the fault of the manufacturer. Typically, the I/M program is carried out at the local state, province, or city level to identify and reduce the prevalence of high-emitting vehicles that require maintenance. In addition to identifying vehicles with poor maintenance or with emission control systems that have been tampered with by users, some regions also use I/M data to identify certain in-use noncompliance issues caused by poor design, production issues, or deterioration of the emission control system. For example, the United States uses information from state I/M programs as one of the indirect data sources to help select vehicles for surveillance testing. In 1978, the U.S. EPA launched an investigation against Chrysler in connection with an issue discovered by analyzing I/M program data. Chrysler vehicles showed a very high failure rate (40%) of I/M testing in Chicago. U.S. EPA started its own laboratory test of Chrysler vehicles and eventually mandated that Chrysler recall the vehicles with the problematic part (He & Jin, 2017). The I/M data collected from local regulatory agencies in China can also show patterns of certain models with a noticeably high I/M failure rate, which helps MEP-VECC to select vehicles for confirmatory testing. Japan also confirmed, through our survey, the utilization of I/M information to identify potential noncompliant vehicles for testing. Canada has I/M programs in some provinces because the power to manage vehicle emissions at the hand of end users falls under provincial powers.

On-board diagnostic record. OBD systems monitor the performance of engine and aftertreatment components, especially those responsible for controlling harmful pollutant emissions. OBD systems monitor emissions components continuously and alert vehicle owners to necessary repairs by illuminating an “engine check” light—more formally the MIL, or malfunction indicator lamp—on the dashboard. OBD monitoring requirements vary across regions. Differences include the type of pollutant that is monitored, parts that are monitored for malfunction, and the minimum thresholds required for triggering an alert (Posada & German, 2016). Many regions require an OBD system on newly produced vehicles, but few integrate OBD systems into I/M programs. It is possible for I/M inspectors to use inspection equipment (e.g., a scan tool) to query the codes from the OBD and fail the vehicle if there are any fault codes.

The data provided by the OBD system frequently can pinpoint the specific component that has malfunctioned. The United States uses data from these types of OBD checks as an indirect data source to support its in-use surveillance program. Manufacturers in the United States are anxious to recall OBD-identified component failures quickly before other compliance programs pick up the issue or owners become annoyed with the MIL illumination (He & Jin, 2017). Since the introduction of the OBD requirements for LDVs, the number of voluntary recalls has increase partially because properly working OBD systems were effective in identifying failing emission components (He & Jin, 2017). Beijing, China, also collects OBD data at I/M test stations, but has not yet begun using the data for in-use compliance programs. For in-use compliance programs, the OBD records are only useful if the data are reported to the government agency—otherwise,

the information is just used to fix individual vehicles and is not used to identify systemic problems with a particular model.

Remote sensing. Remote sensing tests on-road vehicle emission levels during in-use operation. The remote sensing equipment is typically placed on the side of the road and scans exhaust emissions (e.g., CO_2, CO, HC, NO, and opacity) from passing vehicles. Remote sensing incorporates cameras that record the vehicle license plates, which link to vehicle registration information. Many countries, including China, Sweden, Switzerland, and the United States, are using remote sensing for various purposes, such as to cross-check on I/M performance, screen for high emitters, or monitor the in-use fleet emission level. China especially is increasing the use of remote sensing for in-use vehicle management at the city level. Remote sensing technology is not able to determine representative emission factors for individual vehicles because of the small amount of emissions data captured per vehicle, but it can be a good tool for screening the fleet for vehicles with higher than average on-road emissions. One benefit of remote sensing is that it can collect emissions from a large sample of vehicles in a short period of time. Remote sensing can scan exhaust emissions from thousands of vehicles in a single day. Setting up remote sensing stations at multiple locations can allow for the collection of a large volume of data. In several weeks, enough data could be collected to provide a reasonable representation of the in-use fleet. Variable driving conditions may influence the remote sensing results of individual vehicles, but the impact of the driving conditions on the fleet average decreases as the test sample increases. If different vehicles of the same model are found with significantly high emissions, the regulatory agency can categorize the vehicle as potentially noncompliant and pay special attention to the vehicle in its COP confirmatory and in-use surveillance program. So far, none of the regions we surveyed has used remote sensing data to support their compliance program.

Like remote sensing, plume capture is another noninvasive method to test on-road vehicles during operation. Plume capture can measure a broader range of pollutants than remote sensing, including testing particulate matter (PM), but the method cannot test as many vehicles per day. There are two types of plume capture being used to test vehicle tailpipe emissions. One is chase plume capture, where an instrumented mobile sampling platform follows a target vehicle and measures pollutant concentrations in the exhaust plume. The other is stationary plume capture, in which a portion of the exhaust plume of an individual vehicle passing a fixed sampling location is captured. Theoretically, plume capture can detect high emitters of certain models. To date, plume capture has only been used for research projects, in China and the United States, but it has the potential to provide information about potentially noncompliant vehicles to support in-use compliance programs.

Consumer reporting. Consumer reporting is another possible data source to inform potential noncompliance. U.S. EPA's Office of Enforcement and Compliance Assurance (OECA) handles complaints about environmental violations. In one documented case, OECA found an emissions violation case based on consumer complaints about a gasoline smell inside the car (He & Jin, 2017). Many U.S. states also have environmental complaint programs, such as those encouraging the public to report smoking vehicles on the roads. MLIT, the regulatory agency in Japan, has a website and hotline (Figure 3) that accepts vehicle safety and emission defect reports. From 2001 to 2015, MLIT received 6,000 reports annually, on average, from consumers. Of these, between 45% and 80% were considered by MLIT to be effective reports that provided complete and reasonable

information. MLIT publishes a statistical report every year summarizing consumer reported cases by issue, vehicle category, and manufacturer and pursues those issues as part of its compliance program. On average, emission-related cases accounted for 2% to 3% of effective reports. South Korea has a website and hotline for consumers to submit defect information related to automotive safety, although it is unclear whether emission-related defect information is collected through the same channel. In China, many cities have a public reporting program for "black smoke" vehicles. Citizens are encouraged to report the license plate numbers of vehicles visibly emitting smoke from their tailpipes (Yang, Qiu, & Muncrief, 2015). Canada[29] and Mexico[30] have opened email and phone lines for consumers to make emissions-related complaints.

Figure 3. Poster of vehicle defect report hotline in Japan.

Consumer reporting is one of the few sources of information on vehicle fuel efficiency in the real world. The vehicle fuel efficiency labeling programs in Brazil, Canada, Chile, UK, and the United States establish channels to collect consumers' comments and suggestions, such as through email, telephone, letter, and website forms. The United States also established a portal where consumers can report the actual fuel economy of their vehicles in real driving conditions[31] (Yang, Zhu, & Bandivadekar, 2016). However, it is unclear whether such information has been used to support vehicle fuel efficiency compliance activities.

29 As notified on the website: https://www.ec.gc.ca/default.asp?lang=En&n=DA294545-1 or https://www.ec.gc.ca/default.asp?lang=En&n=84AA050D-1

30 As notified on the website: https://www.gob.mx/profepa/articulos/como-realizar-una-denuncia-ante-profepa?idiom=es

31 See https://www.fueleconomy.gov/mpg/MPG.do?action=garag

5. ENFORCEMENT OF VEHICLE EMISSION STANDARDS

Strong enforcement is the key to bringing identified noncompliant vehicles back into compliance. Enforcement typically includes elements such as legally proving noncompliance, determining corrective actions against noncompliant vehicles, and making sure the corrective actions get implemented. Figure 4 reflects the general flow of the enforcement actions from manufacturers and agencies and the interactions among sides in most regions, although the detailed procedures in some regions may not be reflected accurately in the figure.

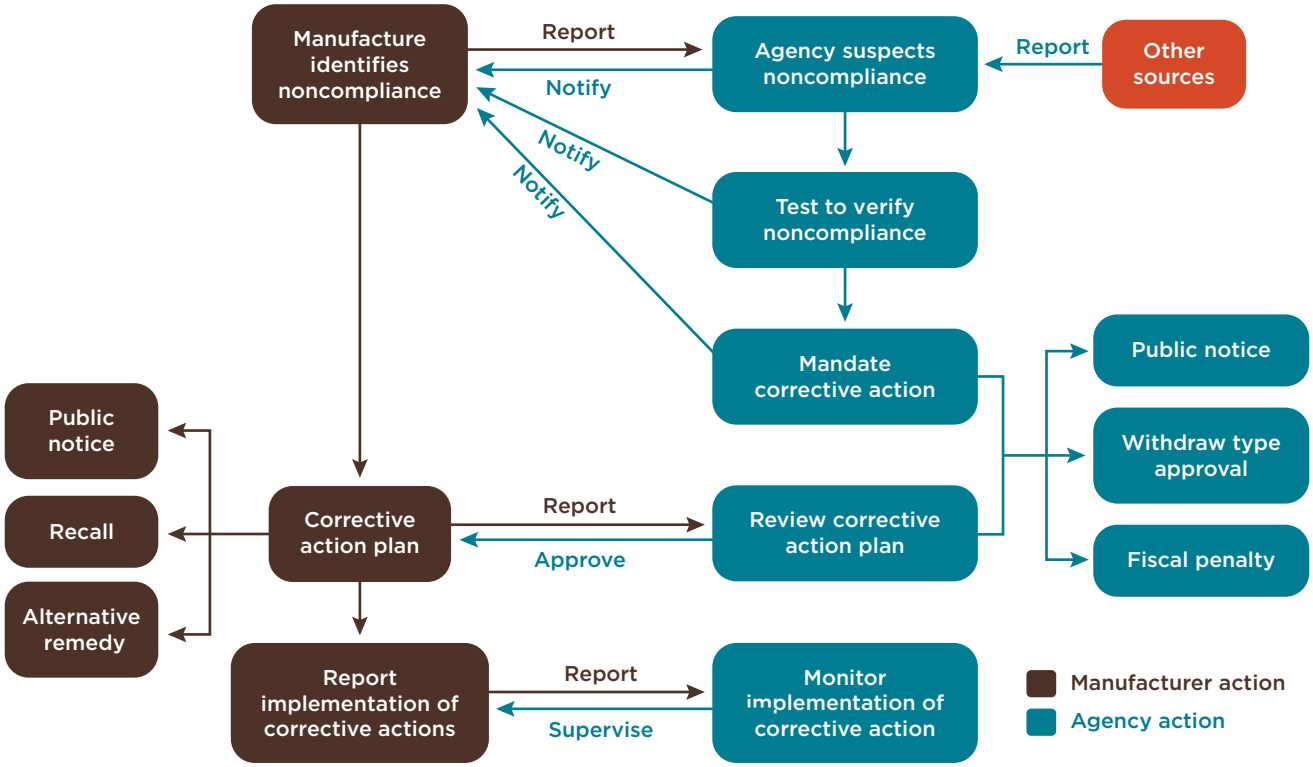

Figure 4. Potential enforcement procedures flowchart.

5.1 DETERMINE AND PROVE NONCOMPLIANCE

Both the manufacturer and the regulatory agency can determine noncompliance with the standards. For problems discovered by the manufacturer through self-monitoring or the government agency through surveillance testing, manufacturers will typically have the chance to investigate the issue, admit noncompliance, and take corrective actions voluntarily. If the regulatory agency is not satisfied with the manufacturer's voluntary actions, it must prove noncompliance with evidence as required by law to trigger any mandatory enforcement action.

As discussed in Section 4, manufacturers may discover emissions-related issues from voluntary internal monitoring or the required compliance testing program. If the problem discovered by the manufacturer is clear, manufacturers have the opportunity to voluntarily correct the issue.

The regulatory agency generally needs to conduct rigorous testing and provide sound evidence to amass an evidence base that proves the vehicle is violating the regulation. Each region sets its own approach and threshold to prove noncompliance. Table 12 provides examples of the testing required and thresholds to prove noncompliance in some regions during the confirmatory COP or in-use testing.

Table 12. Confirmatory testing required to determine noncompliance in different regions.

	Standards	Activities	Determine noncompliance
Conformity of production test			
Canada	LDV and HDV GHG and emission	Test 2–5 vehicles	A substantial* number of vehicles or engines in a category or class do not meet emission standards
China	LDV fuel consumption	Test 3–32 vehicles	Deviation from certified value statistically meets failure procedure
	HDV fuel consumption	Test or simulate individual vehicles	>1.06 times the certified value
	LDV and HDV emission (China 5)	Test 3–32 vehicles	Deviation from certified standards statistically meets failure procedure
	LDV emission (China 6)	Test 3 vehicles or engines	Individual result >1.1 times the certified value or average result > certified value
EU	LDV and HDV emission	Test 3–32 vehicles	Deviation from certified standards statistically meets failure procedure
In-use vehicle testing			
Canada	LDV and HDV GHG and emission	Test 2–5 properly maintained vehicles per test group	A substantial* number of vehicles or engines in a category or class exceeds certified value
China	LDV emission (China 5)	Test 3–20 vehicles	Number of vehicles that emit higher than pollutant limit fails statistical requirement, or two vehicles emit 1.5–2.5 times the pollutant limit because of the same cause (manufacturer/authority agree), or two vehicles emit >2.5 times of pollutant limit because of the same cause (determined by the regulatory authority)
EU	LDV emission		
China	LDV emission (China 6)	Test 3–10 vehicles	Number of vehicles that emit higher than pollutant limit fails statistical requirement
South Korea	LDV emission	Test 5–10 properly maintained vehicles per test group	On average, exceed emission standards
U.S.	LDV GHG	Test 5–10 properly maintained vehicles per test group	>1.1 times the certified value of individual vehicle
	LDV emission		A substantial* number of vehicles or engines in a category or class do not meet emission standards

** The determination of "substantial" depends on the agency's judgment and historical legal cases, which could be a high failure number of test vehicles or low failure number, but with a large noncompliance margin, or additional information that indicates that failures are systematic and not just isolated cases.*

In the United States, if the regulatory agency determines that a substantial number of vehicles or engines in one category or class do not meet emission standards in actual use, even though they are properly maintained and used, the category is determined

to be out of compliance and the agency can order the manufacturer to take actions. The determination of "substantial" depends on the regulatory agency's judgment and historical legal cases. Substantial could refer to a high failure rate of test vehicles or a low failure rate with large noncompliance margins for those vehicles that do fail, or additional information that indicates that failures are systematic and not just isolated cases. If the manufacturer challenges the accusation of noncompliance and refuses to take any corrective actions, U.S. EPA must inform the Department of Justice and take legal actions to prove noncompliance and force manufacturers to take action.

The threshold to determine noncompliance is more straightforward in South Korea. The regulatory agency will typically test five properly maintained vehicles per test group for in-use testing. If the average level of any pollutant emitted by the tested vehicles exceeds the applicable standards, the test group fails the test. If the manufacturer does not agree with the results, the regulatory agency will test 10 more properly maintained vehicles of the same test group and determine noncompliance if the average level of any emitted pollutant exceeds applicable standards for these 10 vehicles.

It is more difficult for some regulatory agencies in China and the EU to prove noncompliance through COP and in-use confirmatory testing. For COP testing, the authority may need to test up to 32 vehicles to make a pass or fail decision. For in-use testing, if more than two tested light-duty vehicles emit 1.5 to 2.5 times the applicable limit for any regulated pollutant, the agency can make a fail decision if the administrative department and the manufacturer both agree that the excess emission results from the same cause. If more than two vehicles emit more than 2.5 times the applicable limit for any regulated pollutant, the agency can determine that the excess emission results from the same cause and make a fail decision. If no agreement can be reached or there are other vehicles that do not meet emission standards, the authority may need to test up to 20 vehicles to demonstrate noncompliance of a vehicle type through a statistical procedure. Although this procedure is included in the formal regulation, no regulatory agency has completed such a process in practice. The introduction of China 6 gasoline vehicle emission standards significantly improved this verification process in China, as indicated in Table 12.

Manufacturers are more likely to admit noncompliance and take voluntary action if they regard doing so as the more cost-effective option and believe that the regulatory agency will be able to legally prove noncompliance and force the manufacturer to fix the problem. Since the late 1990s, nearly all corrective actions (e.g., recalls) in the United States have been voluntarily initiated by manufacturers. Most noncompliance in Japan is also voluntarily announced by manufacturers because they are concerned with being named publicly as noncompliant and thereby damaging their reputation.

5.2 CORRECTIVE ACTIONS AGAINST NONCOMPLIANCE

For problems discovered by manufacturers or regulatory agencies, manufacturers must submit a remedial plan that is subject to review and approval to ensure that the fix brings vehicles into compliance with the relevant standards. Based on previous cases in many countries, the regulatory agency should expect and be prepared for back-and-forth communication between the agency and manufacturers to agree on the details of the recall or other remedies for the noncompliant vehicles.

5.2.1. Suspend or withdraw certification

Suspending or withdrawing a manufacturer's sale certification prevents noncompliant vehicles from being sold on the market. The regulatory agencies in all regions surveyed for this study are authorized to assign/approve, suspend, and withdraw certification for sales of noncompliant vehicles.[32] As previously discussed, the EU is a special case where the type approval granted by a single member state enables the manufacturers to sell the vehicles in all EU member states. Only the authority that granted the original type approval of the vehicle can suspend or revoke the type-approval certification. However, a safeguard clause exists in Framework Directive 2007/46/EC that allows a member state to refuse to register a new vehicle type if the member state considers that those vehicles present a serious risk to road safety or that they seriously harm the environment or public health.

For vehicles that have already received the sale certification, regulatory agencies may suspend or withdraw the sale certification if the vehicle is determined to be noncompliant. The U.S. EPA and Brazil IBAMA can withhold certifications for other vehicles produced by the same manufacturer that produces noncompliant vehicles. After the U.S. EPA discovered in 2015 that Volkswagen used illegal defeat devices on some of its diesel models, the U.S. EPA revoked those models from certification and eventually held the certification of all Volkswagen models for 2016, including non-diesel models. The manufacturer may also voluntarily stop selling problematic vehicles if it identifies noncompliance through self-monitoring. After admitting cheating on fuel economy coastdown tests in Japan, Mitsubishi stopped production and sales of the affected cars (Mitsubishi Motors, 2016). In Japan, if the manufacturer does not take actions voluntarily, the regulatory agency will suspend type approval for vehicles if the agency determines that the manufacturer provided false information in applications and will revoke type approval for vehicles that fail to meet standards. Suspending vehicle certifications is an effective way to stop additional noncompliant vehicles from entering the market, but it does not address vehicles that have already been sold.

5.2.2. Recall

An emissions recall refers to a repair, adjustment, or modification program conducted by a manufacturer to remedy an emission-related problem on in-use vehicles collected from users free of charge. It is an important corrective action that helps ensure the problem gets fixed and thereby prevents excessive pollution from vehicles or engines that are already in service.

In general, there are two types of recalls: (1) a mandatory recall initiated by the regulatory agency, and (2) a voluntary recall initiated by the manufacturer. Depending on the level of engagement or intervention of regulatory agencies, the voluntary recall can be further categorized as a manufacturer voluntary recall or an influenced voluntary recall. As a rule of thumb, if a manufacturer initiates a voluntary recall in response to a regulator's intervention or to fix an issue discovered in a government surveillance program, it is more likely to be an influenced recall. Manufacturer voluntary recalls are independent manufacturer actions.

32 Canada does not issue certificates but rather accepts U.S. EPA certificates and conducts its own review of documents demonstrating compliance for vehicles not covered by a U.S. EPA certificate.

Countries use different procedures to determine if a mandatory recall is necessary. For instance, Japan's regulatory agency, MLIT, will recommend a recall if the manufacturer does not carry out a recall when the vehicles or engines are determined to be out of compliance with the regulation. If the manufacturer does not act as the agency recommends, MLIT will publicly announce noncompliance. If the manufacturer still refuses to act after the public announcement, MLIT will then order a recall through a legislative procedure (MLIT, 2016b). In the United States, the regulatory agency is more likely to involve the manufacturers in the investigative process and encourage manufacturers to initiate a recall voluntary. If the manufacturer disagrees with the agency's test results, the agency will take the case to the courts and order a mandatory recall if the agency wins the case. In recent years, all emission-related recalls in the U.S. and Japan were voluntary recalls, although many would be classified as influenced recalls.

To initiate a recall, manufacturers need to investigate and determine the cause of the emission issue, develop a remedial plan to notify owners and repair the vehicles, and inform the regulatory agency. In some countries, regulatory agencies need to review and approve the remedial plan before the manufacturers take any action. In the EU, the national authority that grants the type approval of the vehicle is responsible for assessing the remedial plan. Reviewing remedial plans, either on paper or in the laboratory, typically requires review by technical experts. The agency may require the manufacturer to carry out testing to demonstrate the effectiveness of the recall if the manufacturer proposes to change, repair, or modify the vehicles or components (Heinfellner et al., 2016). When necessary, some regulatory agencies will conduct technical verification in a laboratory to ensure that the plan will bring the vehicles into compliance. For example, Japan introduced technical verification of corrective measures by the national laboratory in 2006; thus, the regulatory agency can reject a remedial plan if the proposed corrective actions fail laboratory testing. If the regulatory agency determines that the contents of the corrective action are not adequate to fix the violation, the manufacturer must revise the plan under the agency's guidance. In a recent case, Volkswagen's remedial plan for its noncompliant diesel vehicles was rejected by the U.S. EPA twice due to insufficient remedial procedure details and technical evaluation to prove the effectiveness of the proposed action (California Air Resources Board [CARB], 2016a, 2016b; EPA, 2016b). South Korea's regulatory agency also rejected the plan submitted by Volkswagen three times for "insufficient information and data" to detail the problems and rectify the shortcomings of the affected vehicles (Dong-chan, 2016).

After the remedial plan is approved, the manufacturer should follow the plan to notify vehicle owners and provide instructions about how to have the vehicle repaired. To ensure the corrective action is effective, regulatory agencies require the manufacturers to recall a minimum percentage of the affected fleet and regularly report on the progress of the recall (see Section 5.3).

Table 13 summarizes the number of emission-related recall cases that we identified from 2011 to 2015. As shown in Table 13, not all regions in this study empower the regulatory agency to conduct a mandatory recall.

Table 13. Emission-related recall cases by country.

	Mandatory						Voluntary				
	Clear authority	Number of recall cases					Number of recall cases				
		2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Brazil	Yes	/					0	0	0	0	0
Canada	No	/					-	34	28	33	35
Chile	No	/					-	-	-	-	-
China	Yes[b]	0	0	0	0	0	0	0	0	0	2
EU	No	/					0	0	0	0	0
France	Partly	0	0	1	0	0	0	1	0	1	0
Germany	Partly	0	1	1	6	4	9	2	2	5	3
India[a]	No	/					-	-	-	-	1
Japan	Yes	0	0	0	0	0	13	20	11	14	11
Mexico	No	/					-	-	-	-	-
South Korea[a]	Yes	2	3	6	1	53	-	-	-	-	-
UK	Partly	-	-	-	-	-	1	0	0	4	5
U.S.	Yes	0	0	0	0	0	40	37	30	-	-

Note. "–" indicates data not available.

[a] Internal case-by-case data collection.

[b] China clarified the agency's authority to recall since 2016.

Emission recalls are a critical component of vehicle emission C&E programs. Emission recalls, especially mandatory recalls, can be quite costly to a manufacturer as a result of the high cost of implementation and potential civil penalties. A typical recall can cost millions of dollars plus damage the reputation of the automakers; therefore, a recall can be an effective deterrent against cheating and omission by manufacturers.

5.2.3. Other actions

In addition to emission recalls, manufacturers sometimes have the option—or are obligated—to take other corrective actions, such as warranty extensions, product buybacks, and environmental remediation.

Warranty extension is typically associated with a recall, but it also can be an alternative to a recall. It helps to minimize the cost to consumers by allowing them to repair the problematic part free of charge, even if the vehicle's original warranty expires. Manufacturers may propose a warranty extension when the identified issue is not salient and widespread or when more failures may occur as the vehicle ages. Ideally, the warranty should be extended to the vehicle's average life (e.g., 15 years/150,000 miles in the United States). Warranty extension on a defective part reduces the cost of the corrective action, as well as avoiding the inconvenience of recalling many vehicles on which the part may never fail. The warranty extension is effective only if the vehicle's OBD system is able to identify when the part has failed. A recall should be the only remedy if the failure of emission control parts already results in extremely high emissions. Such parts are typically critical emission control parts, such as the catalyst and evaporative emission control system (Cackette, 2016). U.S. manufacturers sometimes provide warranty extensions as part of their remedial plan.

Product buyback is another remedy when the manufacturer is incapable of repairing the vehicles through a recall. In the U.S. Volkswagen settlement, the manufacturer and all interested parties, including the U.S. EPA, agreed to offer a buyback option to have the manufacturer buy back vehicles and cancel relevant leases at no cost (EPA, 2016c). This is the first known vehicle buyback for an emissions violation. The cost per vehicle for a buyback is much higher than in a recall program, because the manufacturers must pay the full value of the affected vehicles rather than just the cost of the repairs (Kodjak, 2016). In the Volkswagen case, if U.S. EPA approves an emissions fix from the manufacturer, Volkswagen will be allowed to resell the vehicles; however, if Volkswagen does not obtain U.S. EPA approval by 2018, the vehicles will be required to be scrapped.

Environmental remediation helps to reduce the adverse environmental impact from operation of noncompliant vehicles through projects that mitigate the relevant environmental impacts. Excess pollution from problematic vehicles includes the amount emitted before the problem was discovered as well as after the implementation of corrective actions if the "fix ratio" (i.e., fraction of total affected vehicles that are actually fixed) is not satisfactory. Through discussions with the regulatory agency, the manufacturer can create an environmental remediation plan, such as launching its own relevant projects or investing in other projects that reduce pollutant emissions in the same regions that were elevated due to its faulty products (EPA, 2016c).

The regulatory agency typically determines or approves the most appropriate action to ensure that high-emitting vehicles are brought back into compliance and that manufacturers assume adequate responsibility at minimum cost to consumers.

Violation of fuel efficiency standards could lead to correcting the registered fuel efficiency value and grade, compensating vehicle owners, or paying fiscal penalties. If the manufacturer fails individual or fleet average fuel efficiency targets even with the corrected fuel efficiency value, it may trigger additional actions, such as submitting a compliance plan, trading compliance credits carried over from previous years, or paying fiscal penalties.

5.2.4. Civil and criminal penalties

Many regions have set fiscal penalties for violation of emission standards in addition to certification suspension, recall, and other actions. Regulatory agencies penalize manufactures that produce, sell, or import noncompliant vehicles/engines, tamper with engines or emission control devices, use illegal defeat devices, and fail to take corrective actions or follow other related regulations.

Legislation in the EU empowers member states to determine their own penalties applicable for infringement of emission standards. Although France, Germany, and the UK have some penalties for noncompliance (Heinfellner et al., 2016), no manufacturer has ever been penalized to date. The European Commission's proposed new framework for type approval and market surveillance lays out the types of infringements to which member states must apply penalties, including making false declarations during approval procedures or procedures leading to a recall, falsifying test results for type approval, and withholding data or technical specifications that could lead to a recall (European Commission, 2016a).

Penalty levels differ according to violation type and across regions. The regulators intend to put in place penalties that encourage compliance and discourage

manufacturers from violations of the regulation. For instance, in the new Air Pollution Control Law, China imposes a fine on manufacturers between 1 and 3 times the product value for violating the regulation and may confiscate any income made from illegally selling the noncompliant vehicles. South Korea increased the fiscal penalty cap per each compliance group in 2016 from 1 billion won to 10 billion won ($0.9 to $8.96 million), or 3% of the vehicle sales value. The maximum penalty for each noncompliant vehicle in the United States is $44,539,[33] which exceeds the average price of LDVs.[34] Canada imposes a maximum of $6 million Canadian ($4.5 million) for each offense for large corporations, which also may forfeit profits earned as a result of an offense.

Regulatory agencies typically determine the penalty amount based on multiple factors. The legislation determines a maximum civil or criminal penalty level. In the United States, the civil penalty amount is influenced by, among other things, the seriousness of the violation, how much the manufacturer benefited or saved, the manufacturer's history of compliance, and the manufacturer's remedial plan.[35] In South Korea, the penalty amount depends on the seriousness of the violation and other relevant elements (MOE, 2016b). For any technical agency that violates the European Commission's regulation, Germany may apply partial revocation or annulment of the technical agency, with additional possible criminal charges (European Commission, 2016b).

Table 14 lists a selection of penalties related to violation of emission standards in Brazil, Canada, China, Germany, Japan, and the United States. Some countries impose fiscal or criminal penalties on crimes that harm the environment and public health or behaviors that insult consumers' rights. Those types of provisions are not included in Table 14 because they are not vehicle specific penalties.

33 This penalty rate applies for violations that occurred after November 2, 2015, and will be adjusted based on inflation in the regulations (as set forth in 40 CFR part 19).

34 The estimated average transaction price of new LDVs in 2015 is $33,560. Source: http://www.usatoday.com/story/money/cars/2015/05/04/new-car-transaction-price-3-kbb-kelley-blue-book/26690191/

35 40 CFR §1068.125

Table 14. Selection of civil or criminal penalties related to violation of emission standards.

	Category	Description of manufacturer violation	Fiscal penalty
Brazil	Introduction to market	Sell or import vehicles that do not comply with the current emission limits during useful life.	R$100,000 to R$1,000,000 ($30,600 to $305,800)
Canada	Introduction to market	Apply a national emissions mark to, sell, or import vehicle, engine, or equipment that does not conform to the prescribed standards, for which evidence of conformity has not been obtained and produced, or that is not labeled in accordance with the regulations	Up to $6 million CAD ($4.5 million) for each offense (for large corporation). May forfeit profits earned as a result of an offense. Fines and possible imprisonment for involved individuals.
	Defeat device		
	Defect report	Fail to notify the responsible minister and owner of defect in the design, construction, or functioning of the vehicle, engine, or equipment in the manner prescribed in the regulations	
China	Introduction to market	Produce, sell, and import vehicles with excessive emissions due to design defects	100% of sales profit and a fine between 1 and 3 times the product value
	Defeat device	Intentionally cheat on emissions tests using an engine and emission control device	
	Tampering (owner or repair shop)	Illegally modify temporal pass of emissions test	5,000 CNY ($735) per vehicle (owner or repair shop)
France	Fraud to consumers	Make false declarations during the approval procedures or procedures leading to a recall; falsify test results for type approval or in-service conformity; withhold data or technical specifications, which could lead to recall or withdrawal of type approval; use prohibited defeat devices	€300,000 ($337,079)/2 years imprisonment or €750,000 ($842,697)/7 years imprisonment if human health is impacted; forfeit up to 10% of profits earned as a result of an offense
Japan	Noncompliance notification	Fail to notify MLIT recall or make a false notification on potential nonconforming or nonconforming vehicles/device due to construction or operation	Up to 1 year of penal servitude or/and fine up to 3 million yen ($27,273) for each person in addition to a fine up to 200 million yen ($1.82 million) for each group for each violation
	Corrective action failure	Refuse to take corrective actions ordered by the MLIT if manufacturer did not follow MLIT recommendation after first notification from MLIT without proper cause for making the nonconforming motor vehicles/device comply with safety regulations.	
	Failure to report and on-site inspection	Refuse to respond to the MLIT questionnaire, to accept on-site inspections, or to answer questions from an MLIT inspector, or to make a false report to the MLIT questionnaire and lie to the MLIT inspector	
South Korea	Introduction to market	Manufacture and sell automobiles without obtaining emission certification	Up to 3% of the sales value or 10 billion Won ($8.91 million) for each group
	Cheating	Manufacture and sell automobiles differing from the details of emission certification	
U.S.	Introduction to market	Sell, offer for sale, introduce or deliver into commerce, or import any new engine that is not covered by a valid certificate of conformity for its model year	Up to $37,500 for each engine/piece of equipment
	Tampering (manufacturer or dealer)	Remove or render inoperative any device or element of design installed on or in engines/equipment in compliance with the regulations prior to and after its sale and delivery to the ultimate purchaser	
	Warranty/recall / maintenance failure	Failure to meet obligations to honor the emission-related warranty, fulfill requirements related to defects and recalls, and provide emission-related installation and maintenance instructions	
	Defeat device	Knowingly manufacture, sell, offer to sell, or install any part that bypasses, impairs, defeats, or disables the control of emissions of any regulated pollutant, except as explicitly allowed by the standard-setting part	Up to $3,750 for each part

Notes. Sources: Canada: survey; China: Air Pollution Control Law and He (2016); France: Ordinance No. 2016-301; Japan: Road Vehicles Act; South Korea: Clean Air Conservation Act; United States: 40 CFR §1068.101. Exchange rates as of June 14, 2017: 1 USD = 3.27 BRL, 1.33 CAD, 6.8 CNY, 0.89 EUR, 110 Yen, 1122 Won.

5.3 IMPLEMENTATION OF CORRECTIVE ACTIONS

After noncompliance is identified, regulators first require manufacturers to lay out measures to implement corrective actions in the remedial plan, such as notifying vehicle owners and providing instructions for repairing the vehicle. To ensure that manufacturers fulfill their commitment in the remedial plan, regulators view tracking implementation of correct actions as another important part of enforcement. It is necessary to bring as many problematic vehicles as possible into compliance to reduce the environmental impact of those vehicles and equipment.

We find it effective to set a minimum recall capture rate, require manufacturers to periodically report the progress of corrective actions, and take actions if the recovery rate is low. Following are the approaches we found in some regions:

- California requires an 80% capture rate for emission recalls.[36]
- Although Canada does not set a minimum recovery rate, it requires manufacturers to report the measure(s) to be taken to correct the defect and how they will be implemented upfront and submit quarterly follow-up reports to include the revised number of defective units.
- China's recently revised Air Pollution Prevention Law enables the regulatory agencies to recall vehicles with emission defects. However, the detailed recall requirement has not yet been published. For recalls on safety issues in China, manufacturers are required to report recall progress quarterly until they fulfill the recall plan.
- The EU requires manufacturers to keep records of every vehicle recalled and repaired and the workshops that perform the repairs. The regulatory agencies have the authority to access these records (Heinfellner et al., 2016).
- In Japan, manufacturers are required to obtain information on the progress of the recall or any other corrective actions and periodically report to the regulatory agency. The regulatory agency also notifies users of uncorrected vehicles at the time of vehicle inspection in order to achieve a higher recovery rate. Japan found a 90% recovery rate 3 years after instituting this vehicle recall notification (MLIT, 2012).
- Manufacturers in the United States are required to report the progress of a recall on a quarterly basis for six consecutive quarters after the recall is initiated. If the number of owners having their cars repaired is too low, U.S. EPA can request the manufacturer to renotify owners of the availability of the free repair. In the case of vehicles with serious issues, the regulatory agency requires that a certain overall recall rate in the corrective plan be achieved by the manufacturer. If the manufacturer fails to achieve the recall rate, it must correct the issue through other means, such as paying additional sums for environmental remediation (EPA, 2016c).

36 13 CA ADC § 2112

6. DATA AND INFORMATION TRANSPARENCY

Compliance testing and related activities generate a significant amount of data and information on new and in-use vehicles. By making the data and information freely available to the public, manufacturers, test facilities, and regulatory agencies become more accountable for their activities in the C&E process. Data transparency gives the public better access to information on how governments and manufacturers test the vehicles and empowers citizens, especially third parties, to complement the government's efforts in validating vehicles' compliance with emission and efficiency standards.

In this report, we refer to C&E data and information on the following:

- Manufacturer compliance testing, such as the selection process of tested vehicles, maintenance records, numbers and types of vehicles tested, testing parameters, and results;
- Government compliance confirmatory testing, including the method for determining passage and failure of the tested group and communicating with manufacturers;
- Authorized test facilities, including test capacity, pricing, and compliance testing information; and
- Defects and recalls, including affected vehicles, possible impact of defects, type of recall (voluntary or mandatory), reason for recall, and remedial methods.

In many regions, manufacturers are required to report their compliance-related data and information to the responsible agency, although with varying levels of detail. If the regulatory agency assigns a laboratory to conduct a vehicle test, the testing institutions either report to the regulatory agency and/or keep the test records on file so that the regulatory agency may access them when necessary (e.g., as in some EU member states). However, this is not the case in India, where the authorized testing facilities hold all the testing data and the regulatory agency has no access to testing data besides receiving a pass or fail decision from the testing facilities. In some regions, regulatory agencies regularly publish approved vehicle and engine types that meet emission standards; however, only a few regions (e.g., Germany, Japan, and the United States) publish further details, such as vehicle specifications and the test results of key pollutants. Many more regions publish fuel economy/CO_2 emission data for certified vehicles, but only the United States publishes detailed vehicle specifications relevant to the test, such as the road load coefficient.

For regions that require manufacturers to conduct COP and in-use testing, the reported information is only reviewed by the agency without allowing for public access. For regions where the regulatory agency carries out its own testing, they treat their testing data and information differently.

Table 15 lists the availability of information on regulatory agency C&E activities.

Table 15. Public information regarding regulatory agency compliance and enforcement activities.[37]

	Type approval/ certification	Confirmatory certificate test	Confirmatory COP test	In-use surveillance test	Others
Brazil	Fuel economy	/	No public information	/	No public information
California	Emission certification	No public information	/	Report on test results (pre-2005)	No public information
Canada	Fuel economy	/	No public information	No public information	No public information
Chile	Fuel economy	Data for all vehicles pass agency test	Data from test results	/	No public information
China	Emission certification/ information; fuel economy	No public information	Information portal (in progress)	No public information	Recall
EU	No public information	/	/	/	Recall
France	CO_2 data; CO_2 and emissions test data	/	/	Report on test results (2016 only)	Recall
Germany	CO_2 and emissions test data	/	/	Report on test results (2016 only)	Recall
India	Fuel economy	/	No public information	/	Recall
Japan	Partial data on low-emission vehicles; fuel economy	/	No public information	No public information	Defect report Recall
Mexico	Fuel economy and partial emission	/	/	/	No public information
South Korea	Fuel economy	No public information	No public information	Report on test results	Recall (upon search)
UK	CO_2 data	/	/	Test results (upon request); Report on test results (2016 only)	Emission recall
U.S.	CO_2 and emissions test data; copy of Certificate of Conformity	Report on test results	/	Report on test results	Defect report; Recall (upon request)

For confirmatory tests of new vehicles that apply for certification, the United States publishes a list of the models that fail the emissions confirmatory test in a periodical report. All type-approval notifications in Japan and Chile reflect government test results because all vehicles are tested either by government laboratories or with sufficient government supervision. We did not find any publicly available information for China or South Korea regarding confirmatory certification test results.

Public information regarding COP tests to verify in-production compliance is limited. Although many regions carry out COP testing, only Chile publishes the test results and list explanations for vehicles that fail the COP test. China is building an information

37 For detailed reference information, please see Appendix C.

portal that will publish manufacturer COP test information. For in-use vehicle surveillance programs, some regions publish test results. For example, the United States periodically releases a report summarizing models that failed the test, including LDVs and HDVs. The information in these reports is not as detailed as those in the new vehicle certification database—no emissions data are provided other than failure rate and failed model type. By comparison, South Korea's annual in-use testing report provides more comprehensive information, including vehicles selected for in-use testing, reasons for the selection, and test results of vehicles. The UK does not publish its test results regularly, but there is a brief summary of in-use test results from 2007 to 2011 in the Q&A section of the UK parliament website. The summary provided a list of vehicles tested under the in-use project and indicated how many vehicles of each model failed the test. Since the dieselgate scandal in 2015, a number of member states in the EU, such as France, Germany, and the UK, have initiated—or reinstated—market surveillance testing (Muncrief, 2016). This has resulted in a large amount of publicly available data, which can be found in published government reports.

For transparency of C&E activities other than testing, the United States and Japan publish defect information every 1 or 2 years. In general, regions publish more information on safety-related recalls than on emission-related ones. The United States has an open web portal with a recall database for consumers to look up safety recalls, but the consumer would only know whether the vehicle is subject to an emission recall by sending a specific request to U.S. EPA via email. Japan and China have public websites that provide vehicle recall information for both safety- and emission-related issues. South Korea has a website with all emission-related recalls including recall of products other than vehicles. Germany's Automobile Association provides recall information on its website. The UK government categorizes an emissions recall as non-urgent and publishes reports summarizing non-urgent recalls twice per year. India's regulatory agency does not publish information on voluntary recalls, but does require manufacturers to announce recalls on their own websites.

7. C&E PROGRAMS IN MAJOR MARKETS

In this review, we found that C&E practices vary significantly among the major vehicle markets. The markets differ not only in their capacity to ensure compliance, but also in the willingness at the highest level of political leadership to prioritize C&E. These differences are the result of several factors:

(a) Disparity in legal authority and regulatory frameworks. The regulatory agencies in many regions have been constrained by the legal framework in one way or another, which has significantly weakened those regulatory agencies' power in C&E of vehicle emission and efficiency standards.

(b) Differing relationships among the regulatory agencies and the manufacturers. In regions where the C&E work is carried out by an agency that has the same mission as the regulation, the agencies have the incentive to push for more rigorous C&E programs. Otherwise, the agencies may prioritize the manufacturers' wants or other missions over the strong implementation of environmental or efficiency regulations.

(c) Varied enforcement history and culture of the region. In regions that rely heavily on the legislative system, a longstanding and strong C&E program with growing staff capacity and rich experience in the court is more likely to pressure manufacturers to actively ensure their vehicles or engines meet the standards. In regions where maintaining a good public image is critical, the "name and shame" approach is also appropriate.

Despite the differences in policy background, all regions are seeking to improve the effectiveness of C&E practices based on their or others' experience. Our investigation found the following trends and observations on the current C&E practices in major vehicle markets.

Not all regulatory agencies are sufficiently empowered to enforce compliance of the standards, including the authority to mandate recalls and impose punitive penalties. Although most legislative systems empower the authorities to establish standards and check for compliance, only some authorities have sufficient enforcement power to bring the identified noncompliant vehicles back into compliance. We observed this lack of recall and/or penalty authorizations in Brazil, Canada, Chile, India, and Mexico, along with a limitation on these authorizations in the EU. In Canada, the criminal proceedings required to prosecute vehicle emission infractions and the absence of a fine regime increase the burden on the regulatory agency to prove and correct noncompliance.

Regulators are fighting against budget and resource constraints by improving cost-effectiveness and sustainability of their C&E programs. Like many other government programs, budget and resources have been and will continue to be a constraint for effective implementation of a C&E program.[38] Although regions have shaped their C&E programs differently with different budgetary and resource levels, there are some similarities in program development. Many regulators attempt to improve the cost-effectiveness of identifying noncompliant vehicles by (1) reducing costs by conducting confirmatory tests while placing most of the test burden on the manufacturers; (2) testing in-use vehicles rather than new vehicles to cover wider compliance issues; and (3) using data from other programs, such as defect reporting and I/M programs, to

38 According to information collected from the survey.

identify potentially noncompliant vehicles, which increases the possibility of finding noncompliance during more expensive, in-depth testing. Some agencies have generated stable revenue to partly or fully support their C&E work. With fees collected from the manufacturers, India, South Korea, and U.S. agencies have fully covered the basic cost of operation of their C&E programs.

Regulators intend to test vehicles at different stages of their useful life and put the testing burden on manufacturers with sufficient independent audits. To confirm the compliance with standards, testing is not only conducted on new vehicles pre- or in-production, but also on in-use vehicles. Many C&E programs have evolved over the years to ensure compliance at all stages. Most regions put the testing burden on manufacturers. In some regions, the regulatory agencies play an oversight role by spot testing for the most critical issues (e.g., emission control device durability, defeat devices), whereas manufacturers are responsible for the bulk of the testing.

Cost of noncompliance varies significantly across regions. Rigorous enforcement will increase the cost of noncompliance, but not all regions have the authority or capacity to carry out rigorous enforcement. In many countries, noncompliance is not clearly subject to fiscal penalties or recalls. In regions where the regulators have the authority to initiate emission-related recalls and have ordered mandatory recalls, manufacturers are incentivized to proactively screen their fleet to identify potential compliance issues and are more likely to carry out voluntary corrective actions.

Transparency of C&E activities is extremely low. A C&E program generates abundant information that is of public interest, from vehicle testing results to remedial measures for noncompliance. We found that even for agencies with a well-structured C&E program, the publicly available information on C&E activities is limited. In some cases, the regulatory agency may not even have the information because of legislative constraints. Publishing testing information and data can effectively engage civil society, which plays a critical role in holding government and manufacturers accountable for vehicles' real-world emissions and efficiency. Currently, the possibility of third-party oversight is constrained because of the limitation of public information.

The C&E requirement and activities in most regions studied focuses more on the compliance with emission standards than GHG/fuel consumption standards, especially for vehicles in production and in use. As we learned from the C&E practices of emission standards across regions, it takes time and resources to build a mature C&E program. Compared to implementing standards of criteria pollution, GHG/fuel consumption requirements are relatively new. Although there are some countries that carry out compliance activities related to CO_2 emission/fuel economy standards, the extent of those activities has been relatively limited.

Policymakers in many markets consider C&E to be an important part of vehicle regulations and simultaneously acknowledge that enhancing their C&E programs is necessary. A number of regions have recently revised or are in the process of revising various elements of their C&E practices. For example, China has revised its Air Pollution Control Law, which strengthens the power of regulatory agencies to enforce vehicle emission standards. Japan added a road load confirmatory test for verification of vehicle fuel efficiency. The EU has proposed a plan to revise the regulatory framework to improve in-use vehicle surveillance and is considering incorporating the real-driving emissions (RDE) requirement into in-service conformity test for LDVs. South Korea has increased the penalty cap for noncompliance.

8. BEST PRACTICES OF C&E PROGRAMS

Based on existing practices, it is challenging to establish a one-size-fits-all ideal C&E system for all markets. Rather, while conducting this research, we observed the following best practices that are imperative based on experience in some markets.

1. **Establish clear legal authority** to hold manufacturers accountable for vehicle emission and efficiency performance throughout the useful life of vehicles. The regulatory agency or agencies in charge of ensuring C&E with the standards should be given the necessary legal authority to enforce them, including legal authority to force recalls and levy fines. The regulatory framework should include all the C&E provisions discussed in this report, such as vehicle testing at all stages of production, representative vehicles including proper road load and weight, representative test cycles, proper OBD operation, defeat device provisions including disclosure of AECDs, and defect reporting.
2. **Avoid conflicts of interest** that could undermine the program's effectiveness. Align the lead agency's mission with regulatory goals and break the financial link between testing agencies and manufacturers. Relationships among government agencies, manufacturers, and third-party testing laboratories should be established in such a way as to avoid any impropriety.
3. **Obtain the necessary resources** to continuously and properly enforce regulations. The enforcement agency/agencies should be given the financial and human resources necessary to develop expertise and properly enforce the regulations, and these should be sustained year to year. Ideally, some type of fee structure on vehicles or fuels that is not subject solely to government budgets should be put in place and designated to support C&E activities. Programmatic priorities should be established based on the level of funding available. Manufacturers should share the burden of the cost of testing.
4. **Conduct reliable testing and checks at all stages of production and use** on both emissions and efficiency, with the strongest focus on in-use testing. Vehicles and engines should be tested and checked—by manufacturers and the government agency—at pre-production, in-production, and post-production (i.e., in use) through the end of the vehicle's life, with the strongest focus on in-use testing. Existing data from other government programs or third-party stakeholders should be leveraged to help identify potential compliance issues that require further investigation. Supporting checks should also be established to ensure representative test vehicles, operational OBD systems, and an absence of defeat devices.
5. **Use corrective actions,** such as implementing mandatory recalls and fiscal penalties, to fix known issues and promote compliance. Government agencies should use effective corrective actions, such as mandatory recalls, fines, and other penalties, to correct and compensate for compliance problems. In a strong program, the cost of noncompliance should exceed the cost of compliance.
6. **Prioritize data and information transparency** to foster confidence in the program and facilitate third-party participation. Governments and industry should collect information and data relating to compliance activity and share information and data relating to compliance activity with other governments, as well as the general public.
7. **Create a roadmap for program development** that considers future regulations and technological advances. Governments should establish a vision and roadmap for their C&E programs that takes into account future regulations and advances in technology.

This report focuses primarily on the two key stakeholders in the C&E process—the government agency and the manufacturer. Table 16 outlines the general roles for each of these stakeholders, as well as the role third parties should play in each of the best practices described above.

Table 16. Roles of government agency, manufacturer, and third parties in implementing best practices of C&E programs.

	Government agency	Manufacturer	Third parties
1. Establish clear legal authority	• Have a clear understanding of the legal framework and their authority • If sufficient authority does not exist, work through available channels to obtain proper authority	• Have a strong understanding of the legal framework in which they are operating • Work constructively with relevant government agency to educate the agency thoroughly regarding appropriate elements of the manufacturer's business	• Make public any known gaps in the legal framework or any way in which the legal authority granted to the government agency is insufficient • Advocate for change when gaps are found
2. Avoid conflicts of interest	• The primary mission of the lead agency should be in line with the goal of the C&E program itself • Constantly work to identify and eliminate any potential conflicts of interest in the C&E program	• Avoid any improper business relationships with independent organizations involved in the C&E process • Alert authorities to potential conflicts • Develop an organizational mission that prioritizes and practices social and environmental responsibility	• Identify, document, and publicize any potential conflicts of interest • Propose regulatory solutions to identified conflicts of interest
3. Obtain the necessary resources	• Secure resources and long-term commitments of funding and support from appropriate government channels and manufacturers • Build internal technical capacity • Set programmatic priorities for resource-constrained programs	• Contribute fair share of resources to sustaining C&E programs • Share expertise with government agencies	• Contribute additional support and expertise to fill in gaps in the government's program
4. Conduct reliable testing and checks at all stages of production and use	• Continuously screen the fleet and conduct testing to determine causes of high in-use emissions • Work directly with manufacturers when testing their vehicles • Use third-party data to help target compliance issues • Implement procedures for representative test vehicles, OBD system operation, and defeat device detection	• Conduct extensive testing on products • Share data with government agencies • Let governments know about any issues found • Engage in honest back and forth when potential compliance issues are identified	• Conduct random independent testing of vehicles • Make testing results public • Hold governments and manufacturers accountable when potential compliance issues are found
5. Use corrective actions	• Ensure that cases of noncompliance are properly corrected • Use fines, recalls, and other tools to ensure the cost of compliance is less than the cost of noncompliance • Ensure the environmental harm caused by noncompliance is remediated	• Fix identified compliance issues voluntarily • React to government orders and cooperate with the agency to find solutions	• Act as watchdog to ensure corrective actions are effective and appropriate
6. Prioritize data and information transparency	• Share C&E program-related data in an accessible and timely manner • Regularly share compliance information with international counterparts	• Work with governments to facilitate data sharing and to ensure, when necessary, that confidential business information is not made public	• Call on governments for data transparency • Push for data to be made available to the extent that the legal framework allows • Use and analyze data as they are made available
7. Create a roadmap for program development	• Develop a comprehensive roadmap for the future • Ensure roadmap includes consideration of future technologies, long-term resources, and public health	• Work with government to develop and participate in the execution of the roadmap	• Work with government to develop and participate in the execution of the roadmap

Table 17 shows our evaluation of each country that we surveyed regarding how closely their C&E programs are currently meeting each best practice described above. Each best practice for each country is rated using the following scheme:[39]

● The country does not sufficiently meet any criteria for this practice

●+ The country meets some criteria for this practice

●++ The country meets all criteria for this practice

Table 17 shows that C&E programs in major global markets are at diverse stages of maturity, with no single program fully meeting all best practices. In general, the United States (including California), South Korea, and Japan have the most comprehensive programs, with better C&E schemes in legal framework, conflicts of interest prevention, resource sustainability, testing design, and enforcement. Mexico has the least comprehensive program, which can be improved in many ways. Among the identified best practices, poor data transparency and having an unclear vision for program development are two aspects that need be improved across all 14 vehicle markets.

Table 17. Evaluation of best practices for C&E activities in major vehicle markets.

Region/country		Best Practices						
		Establish clear legal authority	Avoid conflicts of interest	Obtain the necessary resources	Conduct reliable testing and checks at all stages of production and use	Use corrective actions	Prioritize data and information transparency	Create a roadmap for program development
Asia	China	●++	●+	●+	●++	●+	●	●+
	India	●+	●+	●+	●+	●	●	●+
	Japan	●++	●++	●+	●++	●++	●	●+
	South Korea	●++	●++	●++	●++	●++	●+	●+
Europe	EU	●	●+	●+	●	●+	●	●+
	France	●+	●	●+	●+	●+	●	●+
	Germany	●+	●	●+	●+	●+	●	●+
	UK	●+	●	●+	●+	●+	●+	●+
North America	California	●++	●++	●++	●++	●++	●+	●+
	Canada	●+	●++	●+	●++	●	●	●+
	Mexico	●+	●+	●	●	●	●	●
	U.S.	●++	●++	●++	●++	●++	●+	●+
South America	Brazil	●++	●+	●+	●	●+	●	●
	Chile	●+	●+	●+	●+	●	●+	●+

● *The country does not sufficiently meet any criteria for this practice.*

●+ *The country meets some criteria for this practice.*

●++ *The country meets all criteria for this practice.*

39 More information on how we filled in this table can be found in Appendix D.

Additional key findings from the various regions include the following:

- Asia: Government agencies in Japan and South Korea—home to major automotive manufacturers that sell their products worldwide—have better structured C&E programs with strong legislative support, clear governmental liability, and serious penalties—financial or reputational—and corrective methods in place for noncompliance. Both countries monitor compliance with necessary independent testing, although South Korea has shaped its program to be more financially sustainable. On the other hand, China and India do not have a lengthy history of compliance work; however, because of the need to address poor air quality in both countries, these governments are realizing the importance of C&E. This is most apparent in China, where the latest vehicle emission regulations include strengthened compliance and testing requirements, and where the legislative framework has recently been revamped to allow for stronger regulatory enforcement. While waiting for the enhanced emission regulatory system to take effect, boosting C&E of fuel efficiency standards becomes more imperative in China. India needs more powerful enforcement authority and better regulatory structure to break the financial link between testing agencies and manufacturers and conduct independent testing throughout a vehicle's useful life.
- Europe: The single market structure of the European Union combined with the independent administrative power of member states has led to a unique dynamic in Europe. Although it is the European Commission that sets up the framework for C&E of relevant standards, there is no centralized implementation authority. The cross-border compliance framework has an inherent potential for conflict of interest. The European system does little to incentivize member states to take compliance actions, especially with independent retesting absent from the framework. The enforcement authority of regulatory agencies in member states is also restricted. The extremely high levels of NO_x emissions from diesel cars that regulators are currently attempting to address in the European Union can be directly linked to the lack of a strong C&E procedure. The observed practices in France, Germany, and the UK also show insufficient resource sustainability. Ongoing negotiations among the European Commission, Parliament, and Council on the new motor vehicle type-approval framework in Europe create opportunity to improve the above-mentioned aspects.
- North America: The United States has a 5-decade history of developing and refining its C&E program, which is the oldest and most advanced in the world. The U.S. program today focuses heavily on testing in-use vehicles for compliance and has a history of implementing recalls and other corrective actions for enforcement. The program operates with the support of experienced experts and sustainable resources. This has created a level playing field among manufacturers and has fostered an environment where the cost of noncompliance is higher than the cost of compliance. Improving information transparency will help the United States further strengthen its program. Canada and Mexico tend to harmonize with U.S. emission standards, so both countries can leverage the U.S. compliance program to implement their own regulatory requirements. Canada and the United States have a long history of collaboration under the framework of the U.S.–Canada Air Quality Agreement toward the development of aligned vehicle and engine emission regulations and their coordinated implementation. While Canada runs its own compliance program, it has generally focused its testing effort on vehicles that are not sold in the United

States, with additional capabilities used to complement U.S.-certified vehicle testing as a result of the collaboration. That being said, Canada is now working to enhance its program sustainability in response to the defeat device situation. Mexico does not have a meaningful program in place to monitor new vehicles that are not covered by U.S. certification, nor do Mexican regulatory agencies have the legal authority to intervene regarding compliance of in-use vehicles.

- South America: Brazil is by far the largest automotive manufacturing market in South America, but the country's C&E capacity and activity are minimal. Most major manufacturers in Brazil have their headquarters in Europe, so Brazil typically follows the regulatory structure of the EU, where compliance protocols fall short. Brazil has relatively clear legislative system, but needs to build up regulatory capacity and start regular independent testing. In contrast to Brazil, Chile presents an interesting case study, because it is a country without its own automotive manufacturing and relies solely on imports. Yet, Chile has committed to developing a program designed for this specific market situation and has grown a strong technical capacity with some of the best government-run testing facilities in South America. Future priorities for improvement in Chile include strengthening legislative authority for enforcement, expanding test capacity and scope, and leveraging additional resources to support compliance checking.

There are currently insufficient data available to quantify the linkage between adherence to these best practices and lower real-world fleet emissions or fuel consumption. However, there is sufficient evidence that well-designed C&E programs are able to effectively lower real-world vehicle emissions (Franco et al., 2014; Miller & Franco, 2017; Muncrief, 2017; Tietge, Diaz, Yang, & Mock, 2017). It is important that policymakers deeply understand the importance of C&E programs, what a well-designed program looks like, and the status quo in their country or region. This will enable government agencies to set goals and work toward improving the effectiveness of their individual programs.

This paper is the first to take stock of C&E practices with regard to emission and efficiency standards in key vehicle markets. We found room for improvement, even in markets with mature regulatory systems, and we expect to see more efforts by stakeholders to support such improvements.

REFERENCES

Administration of Quality Supervision, Inspection and Quarantine. (2015). Implementation methods of provisions on defective vehicle product recall management (in Chinese). Retreived from http://www.aqsiq.gov.cn/xxgk_13386/jlgg_12538/zjl/2015/201512/t20151218_456879.htm

Cackette, T. (2016). *Improving emission standards compliance with a defect reporting system for in-use passenger vehicles*. Retrieved from http://www.theicct.org/compliance-defect-reporting-system-for-in-use-PVs

California Air Resources Board. (2016a). Air Resources Board rejects VW 2-liter diesel recall plan and issues Notice of Violation. Retrieved from http://www.arb.ca.gov/newsrel/newsrelease.php?id=780

California Air Resources Board. (2016b). Notice of rejection of Volkswagen Group of America Incorporated's diesel 3.0 liter TDI engine influenced emission recall plan submitted on behalf of VW and Audi. Retrieved from http://www.arb.ca.gov/msprog/vw_info/vw-diesel-info/2016_07_13_audi_vw_3l_recall_rejection_cover_letter.pdf

California Air Resources Board. (2017). California vehicle and engine emission warranty periods. Retrieved from https://www.arb.ca.gov/msprog/warranty.pdf

Dong-chan, J. (2016, July 14). Prosecution summons Volkswagen headquarters executives. *The Korea Times*. Retrieved from http://www.koreatimes.co.kr/www/news/biz/2016/07/388_209431.html

European Commission. (2016a). Regulation of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52016PC0031

European Commission. (2016b). Additional analysis to complement the impact assessment supporting the Review of the type-approval framework for motor vehicles. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_5712_2016_ADD_3&from=EN

Franco, V., Posada, F., German, J., & Mock, P. (2014). *Real-world exhaust emissions from modern diesel cars*. Retrieved from http://www.theicct.org/real-world-exhaust-emissions-modern-diesel-cars

He, H. (2016, July 11). "China's latest step forward on vehicle emissions regulation," The International Council on Clean Transportation staff blog. Retrieved from http://www.theicct.org/blogs/staff/latest-step-forward-on-china-vehicle-emissions-regulation

He, H., & Jin, L. (2017). *A historical review of the U.S. vehicle emission compliance program and emission recall cases*. Retrieved from http://www.theicct.org/sites/default/files/publications/EPA-Compliance-and-Recall_ICCT_White-Paper_12042017_vF.pdf

Heinfellner, H., Konrad, C., Lichtblau, G., Schodl, B., Stranner, G., & Winter, R. (2016). *Legal obligations relating to emission measurements in the EU automotive sector*. European Parliament. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/578996/IPOL_STU%282016%29578996_EN.pdf

Kodjak, D. (2016, July 15). "Taking stock of the VW settlement agreement," The International Council on Clean Transportation staff blog. Retrieved from http://www.theicct.org/blogs/staff/taking-stock-vw-settlement-agreement

Miller, J., & Franco, V. (2017). *Impact of improved regulation of real-world NO_x emissions from diesel passenger cars in the EU, 2015–2030*. Retrieved from http://www.theicct.org/rde-passenger-car-nox-impacts-eu

Ministry of Environment. (2016a). Enhancement of management of vehicle exhaust flaws correction (in Korean). Retrieved from http://www.me.go.kr/home/web/board/read.do?boardMasterId=1&boardId=639250&menuId=286

Ministry of Environment. (2016b). Clean Air Conservation Act (in Korean). Retrieved from http://www.law.go.kr/%EB%B2%95%EB%A0%B9/%EB%8C%80%EA%B8%B0%ED%99%98%EA%B2%BD%EB%B3%B4%EC%A0%84%EB%B2%95

Ministry of Environmental Protection. (2016a). Announcement about canceling the verification for new vehicle emission type approval testing agency (in Chinese). Retrieved from http://www.vecc-mep.org.cn/news/news_detail.jsp?newsid=69638

Ministry of Environmental Protection. (2016b). Limits and measurement methods for emissions from light-duty vehicles (China 6). (GB18352.6-2016) (in Chinese). Retrieved from http://kjs.mep.gov.cn/hjbhbz/bzwb/dqhjbh/dqydywrwpfbz/201612/t20161223_369476.shtml

Ministry of Environmental Protection. (2016c). Limits and measurement methods for exhaust pollutants from compression ignition and gas fuelled positive ignition engines of vehicles (China VI proposal) (in Chinese). Retrieved from http://www.mep.gov.cn/gkml/hbb/bgth/201610/W020161017543903508306.pdf

Ministry of Land, Infrastructure, Transport and Tourism. (2012). The automotive recall system of Japan (in Japanese). Retrieved from http://www.mlit.go.jp/jidosha/carinf/rcl/report.html

Ministry of Land, Infrastructure, Transport and Tourism. (2016a). About modification of the fuel consumption values and the like according to the current selling car eight models of Mitsubishi Motors Corporation (in Japanese). Retrieved from http://www.mlit.go.jp/report/press/jidosha08_hh_002377.html

Ministry of Land, Infrastructure, Transport and Tourism. (2016b). The automotive recall system of Japan (in Japanese). Retrieved from http://www.mlit.go.jp/jidosha/carinf/rcl/common/data/pamph_recall.pdf on 2016. 7.22

Mitsubishi Motors. (2016). Improper conduct in fuel consumption testing on products manufactured by Mitsubishi Motors Corporation (MMC). Retrieved from http://www.mitsubishi-motors.com/publish/pressrelease_en/corporate/2016/news/detailg420.html

Mock, P., & German, J. (2015). *The future of vehicle emissions testing and compliance*. Retrieved from http://www.theicct.org/sites/default/files/publications/ICCT_future-vehicle-testing_20151123.pdf

Muncrief, R. (2016, April 28). "Defeat device testing in the EU: So far, not so good," The International Council on Clean Transportation staff blog. Retrieved from http://www.theicct.org/blogs/staff/defeat-device-testing-eu-so-far-not-so-good

Muncrief, R., German, J., & Schultz, J. (2016). *Defeat devices under the U.S. and EU passenger vehicle emissions testing regulations*. Retrieved from http://www.theicct.org/briefing-defeat-devices-us-eu-vehicle-emissions-regulations

Muncrief, R. (2017). *NO_x emissions from heavy-duty and light-duty diesel vehicles in the EU: Comparison of real-world performance and current type-approval requirements*. Retrieved from http://www.theicct.org/nox-europe-hdv-ldv-comparison-jan2017

National Institute of Environment Research. (2013). Studies on in-use surveillance and confirmatory test in 2013 (in Korean). Retrieved from http://webbook.me.go.kr/DLi-File/NIER/06/020/5573152.pdf

National Institute of Environment Research. (2014). Studies on in-use surveillance and confirmatory test in 2014 (in Korean). Retrieved from http://webbook.me.go.kr/DLi-File/NIER/06/021/5590444.pdf

Posada, F., & German, J. (2016). *Review of LDV OBD requirements under the European, Korean and Californian emission programs*. Retrieved from http://www.theicct.org/review-ldv-obd-requirements-under-european-korean-and-californian-emission-programs

Tietge, U., Diaz, S., Yang, Z., & Mock, P. (in press). *From laboratory to road international—A comparison of official and real-world fuel consumption and CO_2 value for passenger cars in Europe, the United States, China, and Japan*.

U.S. Environmental Protection Agency. (2014). Hyundai and Kia Clean Air Act settlement. Retrieved from https://www.epa.gov/enforcement/hyundai-and-kia-clean-air-act-settlement

U.S. Environmental Protection Agency. (2015). *2012-2013 Progress report: Vehicle and engine compliance activities.* Retrieved from https://nepis.epa.gov/Exe/ZyPDF.cgi/P100NO1R.PDF?Dockey=P100NO1R.PDF

U.S. Environmental Protection Agency. (2016a). Vehicle emissions California waivers and authorizations. Retrieved from https://www.epa.gov/state-and-local-transportation/vehicle-emissions-california-waivers-and-authorizations

U.S. Environmental Protection Agency. (2016b). California Air Resources Board rejects VW 2-liter diesel recall plan and issues Notice of Violation. Retrieved from https://www.epa.gov/vw/california-air-resources-board-rejects-vw-2-liter-diesel-recall-plan-and-issues-notice-violation

U.S. Environmental Protection Agency. (2016c). Volkswagen to spend up to $14.7 billion to settle allegations of cheating emission tests and deceiving customers on 2.0 liter diesel vehicles. Retrieved from https://www.epa.gov/newsreleases/volkswagen-spend-147-billion-settle-allegations-cheating-emissions-tests-and-deceiving

Yang, Z., Qiu, Y., & Muncrief, R. (2015). *Review and comparative analysis of in-use vehicle emission control programs in Guangdong Province*. Retrieved from http://www.theicct.org/review-and-analysis-in-use-vehicle-emission-control-programs-guangdong-province

Yang, Z. Zhu, L., & Bandivadekar, A. (2016). *Review and evaluation of vehicle fuel efficiency labeling and consumer information programs*. Retrieved from http://www.theicct.org/apec-vehicle-fuel-economy-labeling

APPENDIX A: SURVEY

This online survey was sent to 86 contacts in 19 countries/regions. We collected responses from 28 contacts in 17 countries/regions through the online survey portal, email exchanges, and one-on-one interviews.

Global survey of compliance and enforcement activities

(Note: this version has some minor differences with the web version on SoGoSurvey. Some questions were triggered by certain answers to previous questions.)

Over the last 40 years, progressively tighter vehicle emission and fuel efficiency standards in the world's major markets have resulted in modern vehicles emitting a tiny fraction of the air pollution compared to uncontrolled vehicles. However, legally required standards can only fully deliver emissions reductions if combined with effective compliance and enforcement (C&E) activities.

Compliance activities ensure that the registered vehicles meet regulatory requirements and identify cases of noncompliance when they exist. Compliance monitoring activities such as pre- and post-production vehicle emissions testing under laboratory and real-world conditions are necessary to establish compliance status, and deter noncompliance. **Enforcement** activities are necessary when vehicles are found to be out of compliance with the standards and intervention is needed to hold responsible parties accountable and correct the situation. Enforcement activities such as noncompliant vehicle recalls and financial penalties are essential to achieving widespread compliance with standards.

Compliance and enforcement practices vary widely among the major vehicle markets. This survey aims to gather baseline information on the existing status of compliance and enforcement in these markets. The responses from the survey and information from other sources will be compiled in a baseline analysis report to be published later this year.

We expect that the survey should take between thirty and forty-five minutes to complete. Your individual response to this questionnaire will only be seen by ICCT staff. General comments may be quoted anonymously by the ICCT in its report, but any comments about specific programs, companies, or individuals will not be shared without explicit permission. We will provide you with an advance copy of the report in late summer.

Your input is important to ensure that we adequately capture the status and details of compliance and enforcement activities in your country/region. We greatly appreciate you taking the time to provide us with your insights. Please contact Zifei Yang at Zifei.yang@theicct.org if you have any questions or concerns.

1. Please tell us about yourself. (Your email address will only be used by the ICCT to ask follow-up questions, and will not be shared or used to send unsolicited email). **You can save the answers and come back to the survey at any point.**
   - Name _____
   - Organization or affiliation _____
   - Email address _____
   - Job title _____
   - Which country would you be answering questions about? _____

2. Which area of work are you familiar with?
   - Compliance
   - Enforcement
   - Passenger car/light commercial vehicle
   - Heavy-duty vehicle/engine
   - Fuel
   - Policy making
   - Vehicle testing
   - Other (explain)

3. In reference to the area of work you selected above, please explain your specific responsibilities in the text box below.

4. If you are from regulatory agency, what is the responsibility of your agency in vehicle emission related compliance and enforcement activities?

SECTION 1. BASIC INFORMATION ON COMPLIANCE AND ENFORCEMENT (C&E)

5. What types of vehicles are covered by the compliance and enforcement activities?
   - Passenger car
   - Light commercial vehicle
   - Heavy-duty vehicle/heavy-duty engine
   - Two- and three-wheelers
   - Nonroad engine and equipment
   - Other (for example: fuels, diesel generator sets etc.)

6. Are compliance and enforcement activities the same across different types of vehicles listed above?
   - Yes
   - No

7. Please use the text box below to specify which type(s) of vehicle(s) is/are different from others.

[Note] We are asking you to specifically answer these questions in the context of the C&E activities of light and heavy-duty vehicles. If you have additional comments regarding other vehicle types, we would appreciate additional information.

	8. Do the compliance and enforcement practices apply to	9. When did the compliance and enforcement activities start	10. Any additional comments?
Criteria pollutants (e.g. NO_X, CO, HC)	• Yes • No		
Greenhouse gases (e.g. CO_2, CH_4)/fuel economy	• Yes • No		
Others	• Yes • No		

SECTION 2. AGENCY AUTHORITY AND CAPACITY

11. Which regulatory text grants the authority for **compliance** activities? _____

12. Which regulatory text grants the authority for **enforcement** activities? _____

	13. Which authorities oversee the compliance activities?	14. Which authorities oversee the enforcement activities?
Criteria pollutants emission standards		
Greenhouse gas emission/fuel efficiency standards		
Others (if applicable)		

	15. Which authorities carry out the compliance activities?	16. Which authorities carry out the enforcement activities?
Criteria pollutants emission standards		
Greenhouse gas emission/fuel efficiency standards		
Others (if applicable)		

17. Does the ministry/agency have its own laboratories/facilities for compliance activities? (e.g. the facility is owned by the government and managed by government employees)
    - Yes
    - No

18. Please tell us more about the agency-owned laboratories/facilities?

Number of agency-owned facilities	Number of light-duty chassis dynamometers	Number of heavy-duty chassis dynamometers	Number of heavy-duty engine dynamometers	Number of Portable emissions monitoring equipment (PEMS) devices	Others (e.g. tire rolling resistance test facility, test track)

19. How many vehicles do you test each year with the agency-owned facilities for compliance purposes?

Light-duty chassis dynamometer	Heavy-duty chassis dynamometer testing	Heavy-duty engine dynamometer testing	PEMS testing	Others (e.g. tire rolling resistance, coastdown)

20. Does the agency authorize other laboratories/facilities to conduct test for compliance activities?

- Yes
- No

21. Who owns the laboratories/facilities?

22. How many authorized laboratories/facilities?

Number of authorized facilities	Number of light-duty chassis dynamometers	Number of heavy-duty chassis dynamometers	Number of heavy-duty engine dynamometers	Number of Portable emissions monitoring equipment (PEMS) devices	Others (e.g. tire rolling resistance test facility, test track)

23. How many vehicles are tested each year by the assigned facilities to determine compliance?

Light-duty chassis dynamometer	Heavy-duty chassis dynamometer testing	Heavy-duty engine dynamometer testing	PEMS testing	Others (e.g. tire rolling resistance test facility)

24. Please explain how compliance is determined if the agency doesn't own nor authorize laboratories/facilities to conduct test for compliance.

25. Which sector best represents you?
    - Regulatory agency
    - Industry
    - Others _____

	26. Compliance	27. Enforcement	28. Together (if the two programs are not separated)
How many staff/employees work on the compliance and enforcement program?			
What's the annual budget (please indicate currency)?			

29. What's the monetary source of the budget for compliance activities?
    - Fee paid by manufacturers
    - Fee paid by vehicle owners
    - Budget allocation from government
    - Others (Please specify) _____

30. Please explain your answer to the previous question in detail below:

31. How many employees work on emission-related compliance and enforcement? _____

32. What's the annual budget (in USD)? _____

SECTION 3. PRE-PRODUCTION (I.E. THE INITIAL TYPE APPROVAL, CERTIFICATION, OR HOMOLOGATION PROCESS)

33. What actions are the manufacturers required taking to prove that a vehicle can meet air pollutant emission standards?
    - Test at manufacturer's lab
    - Test at manufacturer's lab with witness from government
    - Test at manufacturer's lab with witness from certified third party
    - Test at agency authorized lab
    - Test at agency authorized lab with witness from government
    - Test at agency's lab
    - Submit test results
    - Provide materials to prove the vehicle meet all requirements in the standards with technical details
    - Provide materials to prove manufacture lab meet requirements
    - Other (please specify)

34. How is vehicle mass determined for the official tests?

- Manufacturer submitted value
- Testing facility determines reference mass as per type approval protocol
- Other (please specify)

35. How is the road load (for chassis dynamometer testing) determined for the official tests?

- Manufacturer submitted roadload coefficients without verification
- Manufacturer submitted roadload coefficients with validation by test facility
- Coastdown test validated by regulatory agency
- Values predefined by regulator based on vehicle specifications (e.g. inertia mass, power, load etc.)
- Other (please specify)

36. How do manufacturers choose the model for compliance testing?

- Every model and variant
- Every model
- Model with highest selling variant in the group or family
- Highest weight in the group or family
- Highest emissions in the group or family
- Vehicle with specific technology/engine in the group
- Others _____

37. Is the requirement the same for compliance with GHG emission standards?

- Yes
- No (Please specify the difference _____)

38. What actions does the agency take to check that a vehicle can meet air pollutant emission standards?

- Validate manufacturer application (paper work) without going through technical details
- Validate manufacturer application (paper work) by going through technical details
- Validate manufacturer application (paper work) by going through technical details and reserving the right the ask for more information from manufacturers
- Select model to conduct confirmatory test at agency's lab
- Select model to conduct confirmatory test at contracted lab
- Selectively check manufacturer's lab/facilities on site
- Selectively check testing work at contracted lab
- Select model to conduct onroad test
- No mandatory requirements
- Others (please specify) _____

39. How does the agency conduct confirmatory tests? (e.g. chassis dynamometer, PEMS)

40. How does the agency select the sample vehicle for confirmatory testing?
    - Randomly select
    - Targeted test
    - Others (Please specify) _____

41. How does the agency choose the target vehicle for confirmatory testing?

42. What's the sample size for confirmatory testing?

43. Is the requirement same for the compliance with GHG emission standards and/or fuel economy labels?
    - Yes
    - No

44. Please specify the difference _____

45. Who pays for the confirmatory test conducted by the agency for compliance?
    - Manufacturer
    - Agency
    - Other (please specify_____)

46. How does the agency confirm that the OBD system function properly?
    - Review manufacture's technical description of OBD system
    - Replace with broken parts and check OBD system reaction
    - No special test for OBD system
    - Others (please specify_____)

47. What action does your agency take during the pre-production process to verify that the on-road real world emissions from the vehicle are consistent with the test results?
    - Mandatory disclosure of the calibration of emission control technologies
    - Technical evaluation of descriptions of the calibration of emission control technologies
    - PEMS test
    - Test on supplementary test cycle (please explain the main characteristics of the test cycle)
    - Defeat device test
    - OBD test
    - No required actions
    - Others (please specify_____)

48. How do you ensure that the emission controls on the vehicle are durable (e.g. taking account of the deterioration of vehicle etc.)?

SECTION 4. PRODUCTION (CONFORMITY OF PRODUCTION)

49. What actions are the manufacturers required to take to prove that emissions from a production vehicle match the emissions from a certified vehicle?
    - Select vehicles from production line to conduct self-testing
    - Select vehicles from production line to test at government certified lab
    - Select vehicles from production line to test at government lab
    - Test entire vehicle
    - Test vehicle component (e.g. heavy-duty engine)
    - Submit test results to regulatory agency
    - No mandatory requirements for OEM
    - Others (please specify_____)

50. Is the requirement the same for the compliance with GHG emission standards/labeling?
    - Yes
    - No (Please specify the difference _____)

51. Does the agency perform conformity of production (COP) test to check the production vehicle or engine emissions match the certified vehicle criteria pollutant emission?
    - Yes
    - No, only review materials submitted by manufacturers of self-proving.
    - No, no action required

52. How does the agency conduct COP tests? (e.g. chassis dynamometer, PEMS)

53. How are the vehicles/engines selected?
    - Randomly selected by test agency from production line
    - Select by test agency from vehicles provide by manufacturers
    - Manufacturers provide vehicle for testing
    - Others (Please specify _____)

54. Are the manufacturers warned before conformity of production test?
    - Yes
    - No
    - Others (please explain _____)

55. What's the sample size for COP testing each year? _____

56. Where and how is the conformity of production test performed?
    - Test at manufacturer's lab
    - Test at manufacturer's lab with witness from government
    - Test at manufacturer's lab with witness from certified third party
    - Test at agency authorized lab
    - Test at agency authorized lab with witness from the agency
    - Test at agency's lab
    - Others (please specify)

57. How to verify the proper operation of OBD systems for COP test?
    - Same as OBD test during pre-production testing
    - No special test for OBD system for conformity of compliance testing
    - Others (Please specify _____)

58. Who pays for the conformity of production test conducted by the agency for compliance?
    - Manufacturer
    - Agency
    - Other (Please specify _____)

59. Is the requirement same for the compliance of GHG emission standards/labeling?
    - Yes
    - No (Please specify the difference _____)

SECTION 5. AFTER-PRODUCTION

60. What actions are the manufacturers required taking to prove that their vehicles conform to standards during in-use operation?
    - Select vehicle from consumers to conduct test at manufacturer's lab
    - Select vehicle from consumers to test at agency authorized lab
    - Select vehicle from consumers to test at agency's lab
    - Test vehicle within a required mileage range
    - Test vehicle within multiple mileage ranges for durability test
    - Submit test results to regulatory agency
    - No mandatory requirements for OEM
    - Other (please specify _____)

61. What action does the agency take to ensure that the vehicles conform to standards during in-use operation?
    - Review materials submitted by manufacturers
    - Select in-use vehicles directly from consumers to conduct test
    - Select in-use vehicles provided by manufacturers to conduct test
    - Test vehicle within a required mileage range
    - Test vehicle within multiple mileage ranges for durability test
    - Conduct confirmatory coastdown testing
    - Conduct testing or evaluation for defeat devices on in-use vehicles
    - Evaluate accuracy of manufacturers deterioration factors using data from in-use testing
    - Evaluate proper operation of OBD systems on in-use vehicles
    - No required actions
    - Other (please specify _____)

62. How does the agency conduct tests on in-use vehicles? (e.g. chassis dynamometer, PEMS)

63. What's the sample size for in-use testing each year? _____

64. Where and how is the in-use vehicle test performed?
    - Test at manufacturer's lab
    - Test at manufacturer's lab with witness from government
    - Test at manufacturer's lab with witness from certified third party
    - Test at agency authorized lab
    - Test at agency authorized lab with witness from the agency
    - Test at agency's lab
    - Other (please specify _____)

65. How to verify the OBD systems function properly for in-use test?
    - Malfunction light illumination check
    - Read and analyze historical OBD code record
    - Same as OBD function verification during pre-production test
    - No special test for OBD system for in-use confirmatory testing
    - Others (Please specify _____)

66. Is the requirement same for the compliance of GHG emission standards?
    - Yes
    - No (Please specify the difference _____)

67. Who pays for the in-use confirmatory test conducted by the agency for compliance?
    - Manufacturer
    - Agency
    - Other (Please specify _____)

68. Is there an inspection and maintenance (I/M) program in your country?
    - Yes
    - No
    - Other (Please specify _____)

69. Does legal authority address potential behavior from the aftermarket industry and consumers that would influence vehicle emissions?
    - Yes
    - No
    - Unsure

70. What tools are provided (e.g. prohibitions on tampering)? _____

SECTION 6. CROSSCUTTING ISSUES ON COMPLIANCE

	71. Pre-production	72. Production	73. After-production
What are manufactures required to do with the testing results?	• No testing • No need to report • Release results to agency • Release results to the public • Other	• No testing • No need to report • Release results to agency • Release results to the public • Other	• No testing • No need to report • Release results to agency • Release results to the public • Other
What does the agency do with the testing results?	• No testing • No need to report • Release results to agency • Release results to the public • Other	• No testing • No need to report • Release results to agency • Release results to the public • Other	• No testing • No need to report • Release results to agency • Release results to the public • Other

74. Please explain your answers if you choose “other” above. _____

75. Where does the regulatory agency announce compliance and enforcement related information (please provide link if there is a website or database)? _____

76. What are the other reporting requirements on manufacturers?
    - Manufacturer warranty report
    - Defect report
    - Others _____

77. What are the sources that agencies use to identify potential noncompliance?
    - Randomly select
    - I/M test results/record
    - Manufacture warranty report
    - Defect report
    - Individual consumer report
    - OBD data
    - Roadside remote sensing
    - Other (Please specify _____)

78. How does the agency collect sales data? _____

79. How does the agency verify the vehicle sales information? _____

80. How do you evaluate the effectiveness of the compliance program in your region/country?

    1 (Not effective) 2 3 4 5 6 7 (Very effective)

81. Please briefly explain your rating. _____

82. What are the major barriers to enhancing your current compliance and enforcement program?
    - Lack of authority for compliance
    - No agency-owned testing lab
    - Lack of trustworthy contracted testing lab
    - Lack of budget and staff
    - Lack of expertise among staff for compliance
    - Lack of political will
    - Other (Please specify _____)

83. Please briefly explain your answers given in the last question

84. Any improvement you would recommend to enhance the effectiveness of the compliance activities?

SECTION 7. ENFORCEMENT

85. What actions are the manufacturers required to take when a potential compliance issue is revealed during self-testing?
    - Report to the agency
    - Announce to the public
    - Submit a plan to fix the issue
    - Voluntary recall
    - Pay penalty
    - Other (Please specify _____)

86. What action can the agency take when the vehicles they test have failed the production or post-production test?
    - Test the vehicle again with exact same test procedure
    - Test the vehicle with a more detailed test procedure
    - Notify manufacturer
    - Identify as noncompliance
    - Other _____

87. What action can the agency take when vehicles are identified as being noncompliant?
    - Notify manufacturer
    - Negotiate with manufacturer to find solution
    - Announce to the public
    - Don't issue certification for production (pre-production)
    - Revoke or suspend certification (during production)
    - Halt production (during production)
    - Mandate recall (after production)
    - Apply fiscal penalty
    - Other (please specify)

88. How is the level of fiscal penalty decided (or provide the source that indicate the penalty rule)?
    - No fiscal penalty required
    - Fiscal penalty specified by the governing act/law
    - Higher than the level of the cost of compliance
    - The type of issue (e.g. design problem, defeat device, cheat during testing)
    - The number of incompliance vehicle sold
    - The level of emission that exceed standards
    - Determined by agency case by case
    - Other social cost (Please specify _____)
    - Other (Please specify _____)

89. Is there an emission related recall program?

- Yes, there is mandatory recall
- Yes, there is voluntary recall
- No
- Other (Please specify _____)

	90. Mandated recall by the government	91. Voluntary recall by manufacturers
2015		
2014		
2013		
2012		
2011 and earlier		

92. How do you evaluate the effectiveness of the enforcement program?

1 (Not effective) 2 3 4 5 6 7 (Very effective)

93. Please briefly explain your rating.

94. What are the major barriers to enhancing your current compliance and enforcement program?

- Lack of authority for enforcement
- Lack of budget and staff
- Lack of expertise among staff for compliance
- Lack of political will
- Others (Please specify)

95. Please briefly explain the answers you indicated above.

96. Any improvement you would recommend to enhance the effectiveness of the enforcement activities?

SECTION 8. OTHER

97. Are any new compliance and enforcement activities being currently developed in your region/country?

- Yes
- No

98. Please specify more details:

99. Please provide names and links to relevant regulatory documents or studies in the space below, or e-mail them directly to zifei.yang@theicct.org

100. We greatly appreciate your time and insights in responding to the above questions based on your experience. Please use the space below to make any final comments on compliance and enforcement that were not mentioned in the survey.

101. Would you be interested in participating with regular calls with other regulators or stakeholders to share knowledge and discuss compliance and enforcement related topics?
    - Yes
    - No

102. Can we follow up with you through email or a phone interview if necessary?
    - Yes
    - No

APPENDIX B: GLOSSARY

3CV Center	Vehicle Control and Certification Center (Chile)
AQSIQ	Administration of Quality Supervision, Inspection and Quarantine (China)
ARAI	Automotive Research Association of India
BMVI	Bundesminister für Verkehr, Ministry of Transport of Germany
C&E	Compliance and enforcement
CIRT	Central Institute of Road Transport
CNRV	Centre National de Réception des Véhicules of France
Compliance	The registered vehicles meet regulatory requirements and identify cases of noncompliance when they exist
CONAMA	National Environment Council of Brazil
COP	Conformity of production, which provides assurance that the production vehicles or engines meet the emission standards that their pre-production counterparts were certified to.
COP surveillance test	The testing of production line vehicles or engines by the regulatory agency
COP test	The testing of production line vehicles or engines by manufacturers and/or third parties
DGEC	Directorate General for Energy and Climate of France
DOJ	Department of Justice (United States)
DOT	Department of Transportation (United States)
Durability group	Vehicles in the group are identical in combustion cycle, engine type, fuel used, basic fuel metering system, catalyst construction, previous metal composition of the catalyst by the type of principal active material(s) used, and grouping statistic on relative precious metal loading rates.
DVSA	Driver and Vehicle Standards Agency (UK)
ECCC	Environment and Climate Change Canada
Enforcement	Actions taken when vehicles are found to be out of compliance with the standards and intervention is needed to hold responsible parties accountable and correct the situation
EPA	Environment Protection Agency (United States)
EU	European Union
Evaporative/refueling family	Vehicles in the family are similar in type of vapor storage device, basic canister design, fuel system, type of refueling emission control system, fillpipe seal mechanism, vapor control system, purge control system, vapor hose material, fuel tan material, and evaporative emission standards or family emission limit.
FTE	Full time equivalent
Fuel efficiency standards	Refer to all standards on fuel consumption, CO_2 or GHG emission standards for the purpose of this document
HD	Heavy-duty
HDV	Heavy-duty vehicle
IBAMA	Environment and Renewable Resources of Brazil
ICAT	International Center for Automotive Technology (India)
In-service surveillance test	The testing of in-use vehicles by the regulatory agency
In-service test	The testing of in-use vehicles by manufacturers and/or third parties

INMETRO	Federal Ministry of Environment & Natural Resources of Brazil
I/M	Inspection and maintenance
KBA	Kraftfahrt Bundesamt, Federal Motor Vehicle Office of Germany
LDV	Light-duty vehicle
MDIC	Ministry of Industry, Foreign Trade and Services (Brazil)
MDPV	Medium-duty passenger vehicle
MEP	Ministry of Environmental Protection (China)
METI	Ministry of Economy, Trade and Industry (Japan)
MIIT	Ministry of Industry, Information, and Technology (China)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
MOE	Ministry of Environment (Japan, Korea)
MOP	Ministry of Power (India)
MORTH	Ministry of Road Transport and Highway (India)
MTT	Ministry of Transport and Telecommunications of Chile
NALTEC	National Agency for Automobile and Land Transport Technology (Japan)
NHTSA	National Highway Traffic Safety Administration (United States)
NIER	National Institute of Environment Research (Korea)
NRCAN	Natural Resources Canada
NTSEL	National Traffic Safety and Environment Laboratory of NALTEC (Japan)
PPSC	Public Prosecution Service of Canada
PROFEPA	Federal Environmental Attorney (Mexico)
SMA	Superintendency of the Environment of Chile
Test group	Vehicles in the group are identical in durability group, engine displacement, cylinder/combustion chamber number and arrangement, and subjected to the same emission standards.
Type approval	The certification manufacturer must receive for its vehicles and engines to be sold to the market, commonly used in the EU, Japan, and China. This term is called “certificate of conformity” in the United States, Mexico, and Canada; “certification” in Korea; and “homologation” in India, Brazil, and Chile.
U.S.	United States
UK	United Kingdom
VCA	Vehicle Certification Agency (UK)
VECC	Vehicle Emission Control Center (China)

APPENDIX C: WEBSITE INFORMATION IN TABLE 15

Country	Public information of compliance and enforcement activities
Brazil	**Fuel economy** Programa Brasileriro de Etiquetagem. (2017). Light vehicle inquiry. Available at http://pbeveicular.petrobras.com.br/TabelaConsumo.aspx
California	**Emission certification** California Air Resources Board. (2017). On-Road New Vehicle & Engine Certification Program- executive orders listing. Available at https://www.arb.ca.gov/msprog/onroad/cert/cert.php **Report on test results (pre-2005)** California Air Resources Board. (2017). Annual Summary of In-Use Compliance Testing and Recall Activity. Available at https://www.arb.ca.gov/msprog/inusecom/rpt2004.pdf
Canada	**Fuel economy** Natural Resources Canda. (2017). Fuel Consumption Ratings Search Tool –conventional vehicles. Available at http://oee.nrcan.gc.ca/fcr-rcf/public/index-e.cfm
Chile	**Fuel economy** Ministerio de Energía. (2017). EIQUETA DE EFICIENCIA ENERGÉTICA. Available at http://www.consumovehicular.cl/ **Data for all vehicles pass agency test** Ministerio de Transportes y Telecomunicaciones. (2017). Homologación de Vehículos Livianos-Medianos y Motocicletas. Available at http://www.mtt.gob.cl/archivos/5609 **Data of test results** Ministerio de Transportes y Telecomunicaciones. (2017). Verification of Conformity. Available at http://www.mtt.gob.cl/archivos/5806
China	**Emission certification/information** Vehicle Emission Control Center. (2017). New vehicle compliance search. Available in Chinese at http://www.vecc-mep.org.cn/index.jsp **Fuel economy** 中国汽车燃料消耗量网站(The website of Automobile Fuel Consumption of China). (2017). Available in Chinese at http://chinaafc.miit.gov.cn/ **Information portal (in progress)** Vehicle Emission Control Center. (2017). Manufacturer COP test information search. Available at http://ids.vecc-mep.org.cn/Ids/op/index.jsp **Recall** AQSIQ. 召回信息(Recall information). (2017). Available in Chinese at http://www.aqsiq.gov.cn/zjsj/zhxx/
EU	**Recall** European Commission. (2017). Rapid Alert System- Search notifications. Available at https://ec.europa.eu/consumers/consumers_safety/safety_products/rapex/alerts/?event=main.search#searchResults

Country	Public information of compliance and enforcement activities
France	**CO_2 data** L'Agence de l'environnement et de la maîtrise de l'énergie (ADEME). (2017). Consommations de carburant et émissions de CO_2 des véhicules particuliers neufs vendus en France. Available at http://www.ademe.fr/consommations-carburant-emissions-co2-vehicules-particuliers-neufs-vendus-france **CO_2 and emissions test data** Open Data. (2017). Emissions de CO_2 et de polluants des véhicules commercialisés en France. Available in French at https://www.data.gouv.fr/fr/datasets/emissions-de-co2-et-de-polluants-des-vehicules-commercialises-en-france/ **Report on test results (2016 only)** Ministry of the Environment, Energy and the Sea. (2017). Rapport final de la commission indépendante mise en place par la Ministre Ségolène Royal après la révélation de l'affaire Volkswagen - Contrôle des émissions de polluants atmosphériques et de CO_2 mené sur 86 véhicules. Available in French at http://www.ladocumentationfrancaise.fr/rapports-publics/164000480/ **Recall** Ministry of Ecological and Solidarity Transition. (2017). Rappels de véhicules par les constructeurs. Available at http://www.ecologique-solidaire.gouv.fr/homologation-des-vehicules#e4
Germany	**CO_2 and emissions test data** Kraftfahrt-Bundesamt (KBA). (2017). Fuel Consumption and emission type test values. Available at http://www.kba.de/EN/Typgenehmigung_en/Fahrzeugtypdaten_amtlDaten_TGV_en/Auskuenfte_Informationen_en/Veroeffentlichungen_en/SV2_en.html?nn=644856 **Report on test results (2016 only)** BMVI. (2016). Bericht der Untersuchungskommission "Volkswagen". Available in German at http://www.bmvi.de/SharedDocs/DE/Publikationen/LA/bericht-untersuchungskommission-volkswagen.pdf?__blob=publicationFile **Recall** ADAC (2017). Recalls. Available in German at https://www.adac.de/infotestrat/reparatur-pflege-und-wartung/rueckrufe/
India	**Fuel economy** Society of Indian Automobile Manufacturers. (2017). SIAM Fuel Efficiency Data. Available at http://www.siamindia.com/cpage.aspx?mpgid=31&pgidtrail=82 **Recall** Society of India Automobile Manufacturers (2017). Vehicle recall information. Available at http://siamindia.com/siam-voluntary-recall.aspx?mpgid=31&pgidtrail=84
Japan	**Partial data on low-emission vehicles** MLIT. (2017). 低排出ガス認定自動車に関する公表. Available in Japanese at http://www.mlit.go.jp/jidosha/jidosha_tk10_000014.html **Fuel economy** MLIT. (2017). 自動車燃費一覧. Available in Japanese at http://www.mlit.go.jp/jidosha/jidosha_fr10_000019.html **Defect report** MLIT. (2017). 自動車不具合情報ホットラインについて. Available in Japanese at http://www.mlit.go.jp/jidosha/carinf/rcl/data.html **Recall** MLIT. (2017). リコール・改善対策の届出. Available in Japanese at http://www.mlit.go.jp/jidosha/recall.html
Mexico	**Fuel economy and partial emission** Portal de Indicadores de Eficiencia Energética y Emisiones Vehiculares. (2017). Available in Spanish at http://www.ecovehiculos.gob.mx/

Country	Public information of compliance and enforcement activities
South Korea	**Fuel economy** KEMCO. (2017). Vehicle Energy Efficiency. Available in Korean at http://bpms.kemco.or.kr/transport_2012/main/main.aspx **Report on test results** Ministry of Environment. (2017). Studies on In-use Surveillance and Confirmatory Testing. Available in Korean at http://library.me.go.kr/search/DetailView.ax?sid=12&cid=5590444 **Recall (upon search)** Ministry of Environment. (2017). E-environment news. Available in Korean at http://www.me.go.kr/home/web/index.do?menuId=284
UK	**CO_2 data** Vehicle Certification Agency. (2017). Car fuel data, CO_2 and vehicle tax tools. Available at http://carfueldata.direct.gov.uk/ **Test results (upon request)** Parliament. (2017). Written questions and answers. Available at http://www.parliament.uk/business/publications/written-questions-answers-statements/written-questions-answers/?page=1&max=20&questiontype=AllQuestions&house=commons%2Clords&use-dates=True&answered-from=2016-01-14&answered-to=2016-01-19&member=484 **Report on test results (2016 only)** Department for Transport. (2016). Vehicle Emission Testing Programme. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/548148/vehicle-emissions-testing-programme-web.pdf **Emission recall** Vehicle recalls and safety defects. (2017). Vehicle manufacturers' non-code actions. Available at https://www.gov.uk/government/collections/vehicle-defects-and-recalls-guides
U.S.	**CO_2 and emissions test data** EPA. (2017). Data on Cars used for Testing Fuel Economy. Available at https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy EPA. (2017). Annual Certification Test Data for Vehicles and Engines. Available at https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-test-data-vehicles-and-engines **Copy of Certificate of Conformity** EPA. (2017). How to Obtain a Copy of a Certificate of Conformity for a Light-duty Vehicle (car, truck, or motorcycle). Available at https://www.epa.gov/importing-vehicles-and-engines/how-obtain-copy-certificate-conformity-light-duty-vehicle-car-truck **Report on test results** EPA. (2017). Data on Cars used for Testing Fuel Economy. Available at https://www.epa.gov/compliance-and-fuel-economy-data/data-cars-used-testing-fuel-economy EPA. (2017). Compliance Activity Reports for Vehicles and Engines. Available at https://www.epa.gov/vehicle-and-engine-certification/compliance-activity-reports-vehicles-and-engines **Defect report** EPA. (2017). Compliance Activity Reports for Vehicles and Engines. Available at https://www.epa.gov/vehicle-and-engine-certification/compliance-activity-reports-vehicles-and-engines **Recall (upon request)** EPA. (2017). Recalls of Vehicles and Engines. Available at https://www.epa.gov/recalls/recalls-vehicles-and-engines

APPENDIX D: EVALUATION CRITERIA FOR C&E BEST PRACTICES IN TABLE 17

	●	●+	●++
Establish clear legal authority	The agencies are given 0~2 of the 5 authorities in Table 3	The agencies are given 3~4 of the 5 authorities in Table 3	The agencies are given all of the 5 authorities in Table 3
Avoid conflicts of interest	Clear conflict of interest without prevention on abuse of power	Some conflicts of interest with prevention on abuse of power	No known conflicts of interest with prevention on potential abuse of power
Obtain the necessary resources	Low resources, low sustainability	Medium resources, medium sustainability	High resources, high sustainability
Conduct reliable testing at all stages of production and use	Less than 4 "✔" in Table 2 ("o▲" are counted as o.5)	From 4–7 "✔" in Table 2	More than 8 "✔" in Table 2
Use corrective actions	No emission recall authority, no or some voluntary recalls	Agency has the right to mandate emission recall and fine	Agency has mandated emission recall or fined OEM and ensures the fix
Prioritize data and information transparency	No transparency or published emission recall and/or test results with no details	Publishes test results with some details and/or reports emission recall regularly that allows third-party duplication of test	Publishes test results with full details and reports emission recall and relevant activities regularly
Create a roadmap for program development	No plans for the future of the program	Some information and vision about plans for the future of the program	Publicized, feasible, compressive roadmap that has been developed with input from all relevant stakeholders

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