POLICY UPDATE

FEBRUARY 2018

MEXICO HEAVY-DUTY VEHICLE EMISSION STANDARDS

ICCT **POLICY UPDATES** SUMMARIZE REGULATORY AND OTHER DEVELOPMENTS RELATED TO CLEAN TRANSPORTATION WORLDWIDE.

On February 19, 2018, the Mexican government published a modification to standards regulating particulate matter (PM), nitrogen oxide (NO_X), hydrocarbon (HC), carbon monoxide (CO), and ammonia (NH_3) emissions from heavy-duty diesel engines and vehicles, including trucks, buses, and large pickups and vans. The new final standard is NOM-044-SEMARNAT-2017.[1] When fully implemented, this regulation will require new trucks sold in Mexico to meet best-in-class, filter-based standards, equivalent to those in place in the rest of North America, the European Union, Japan, South Korea, Turkey, and India. Full implementation of NOM-044 will achieve substantial air quality, health and climate benefits.

The regulation applies to diesel vehicles and diesel engines for use in vehicles with a gross vehicle weight rating (GVWR) above 3,857 kg. It sets three stages of regulatory limits aligned with prior and current standards in the United States and the European Union. The first stage matches the emissions limits currently in place, equivalent to U.S. 2004 or Euro IV, and expires on June 30, 2019. The regulation introduces the other two stages, including both transitional standards with a stated end date and final standards for which no end date is specified, on January 1, 2019. The transitional standards are equivalent to U.S. 2007[2] or Euro V and expire on December 31, 2020. The final standards are equivalent to U.S. 2010 or Euro VI and have no end date in the current regulation. On January 1, 2021, the more stringent U.S. 2010 and Euro VI limits become the sole mandatory standard for all heavy-duty diesel motors and vehicles sold in Mexico.

This regulation is an important step forward for Mexico in meeting the country's nationally determined contribution (NDC) to the Paris Accord of the United Nations Framework Convention on Climate Change (UNFCCC). Mexico is the only country that committed to black carbon reductions as part of its NDC,[3] and is pledging to reduce

1 Norma Oficial Mexicana NOM-044-SEMARNAT-2017, Que establece los límites máximos permisibles de emisión de monóxido de carbono, óxidos de nitrógeno, hidrocarburos no metano, hidrocarburos no metano más óxidos de nitrógeno, partículas y amoniaco, provenientes del escape de motores nuevos que utilizan diésel como combustible y que se utilizarán para la propulsión de vehículos automotores con peso bruto vehicular mayor a 3,857 kilogramos, así como del escape de vehículos automotores nuevos con peso bruto vehicular mayor a 3,857 kilogramos equipados con este tipo de motores. Diario Oficial de la Federación (2017). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5513626&fecha=19/02/2018

2 U.S. 2007 is not a separate standard, but a phase in for the 2010 standard. We use U.S. 2007 for clarity.

3 Borgford-Parnell, N., Kuyenstierna, J., Kallbekken, S., Van Asselt, H., Hicks, K., and Shindell, D. 2016. How to better align climate goals with sustainable development. Climate and Clean Air Coalition. Retrieved from http://ccacoalition.org/en/blog/how-better-align-climate-goals-sustainable-development

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black carbon emissions by 51% by 2030. The adoption of NOM-044-SEMARNAT-2017 is the single-most critical policy needed to achieve this ambitious climate goal.[4]

Enacting this policy will also reduce air pollution, improve health, and save lives within Mexico. The regulatory impact assessment accompanying the proposal found that implementation would eliminate 6,800 premature deaths per year once the standard has affected most of the in-use vehicles (the year 2037 in this analysis). The net economic benefits derived from the reduced impacts on climate and premature mortality are assessed at $123 billion (U.S.).

BACKGROUND

The Secretariat of Environment and Natural Resources (SEMARNAT) is the sole agency responsible for emission standards for new vehicles. Emission standards for heavy-duty diesel vehicles were first established in Mexico in 1993, aligning Mexican regulation with the U.S. standards at the time. The 2006 update to heavy-duty diesel emission standards, NOM-044-SEMARNAT-2006,[5] introduced the option for compliance with either U.S.- or Euro-based regulations and set standards through June 2011. An extension[6] of that standard was adopted in June 2014, and a second extension[7] was granted when that one expired, extending the 2006 emission limits until the publication of a replacement. A proposal for replacement of that standard was published in December 2014,[8] and was then modified and adopted as a final standard in February 2018.

The availability of ultralow-sulfur diesel (maximum of 15-ppm sulfur) is required for implementation of the final filter-based standards that will become mandatory in 2021 under NOM-044-SEMARNAT-2017. The use of these cleaner fuels will reduce particulate and sulfur oxides emissions for all diesel vehicles in the fleet. When NOM-044-SEMARNAT-2006 was adopted, SEMARNAT was also the lead regulator for fuel quality in Mexico. NOM-086-SEMARNAT-SENER-SCFI-2005,[9] adopted prior to NOM-044-SEMARNAT-2006, required PEMEX, the national fuel company and only provider at that time, to supply 15-ppm sulfur diesel nationwide in 2009, a requirement that was never met. The Energy Reform of 2014 opened consumer fuel sales to commercial providers and also transferred the authority for fuel quality standards to the Energy Regulatory Commission (CRE). In 2015, CRE adopted a 6-month emergency fuel quality standard (NOM-EM-005-CRE-2015) that required: 1) immediate

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4 Intended Nationally Determined Contribution Mexico. México, Gobierno de la República (2015). Retrieved from https://www.gob.mx/cms/uploads/attachment/file/162973/2015_indc_ing.pdf

5 NORMA Oficial Mexicana NOM-044-SEMARNAT-2006, Que establece los límites máximos permisibles de emisión de hidrocarburos totales, hidrocarburos no metano, monóxido de carbono, óxidos de nitrógeno, partículas y opacidad de humo provenientes del escape de motores nuevos que usan diesel como combustible y que se utilizarán para la propulsión de vehículos automotores nuevos con peso bruto vehicular mayor de 3,857 kilogramos, así como para unidades nuevas con peso bruto vehicular mayor a 3,857 kilogramos equipadas con este tipo de motores. Diario Oficial de la Federación (2006). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=4934189&fecha=12/10/2006

6 ACUERDO por el que se modifican las notas al pie de las tablas 1 y 2 de los numerales 5.1 y 5.2 de la Norma Oficial Mexicana NOM-044-SEMARNAT-2006, …. Diario Oficial de la Federación (2011). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5198696&fecha=30/06/2011

7 ACUERDO por el que se modifica la vigencia del periodo establecido en las notas al pie de las tablas 1 y 2 de los numerales 5.1 y 5.2, únicamente en lo que se refiere al estándar B, de la Norma Oficial Mexicana NOM-044-SEMARNAT-2006, …. Diario Oficial de la Federación (2014). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5350536&fecha=30/06/2014

8 PROYECTO de Modificación a la Norma Oficial Mexicana NOM-044-SEMARNAT-2006, …. Diario Oficial de la Federación (2014). Retrieved from http://www.dof.gob.mx/nota_detalle.php?codigo=5376263&fecha=17/12/2014

9 NORMA Oficial Mexicana NOM-086-SEMARNAT-SENER-SCFI-2005, Especificaciones de los combustibles fósiles para la protección ambiental. Diario Oficial de la Federación (2006). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=2107972&fecha=30/01/2006

implementation of 15-ppm sulfur diesel in the northern border region of Mexico and the major metropolitan areas of Mexico City, Guadalajara, and Monterrey; and 2) further expansion of 15-ppm sulfur diesel supply along 11 major freight corridors by December 1, 2015.[10] The reauthorization of another six months of the emergency standard in 2016 set a July 1, 2018 date for nationwide implementation of 15-ppm sulfur diesel.[11] Permanent fuel quality standards finalized in 2016 (NOM-016-CRE-2016) delayed nationwide implementation of 15-ppm sulfur diesel until December 31, 2018.[12]

Figure 1 provides a history of emission standards in the United States, the European Union, and Mexico. While the blue, filter-based, U.S. 2010 and Euro VI standards are closely aligned and functionally equivalent, previous standards that share color schemes are not necessarily closely matched. The United States aligned fuel quality with the emission standards that required it, mandating 15-ppm sulfur diesel nationwide by 2007. The European Union phased in 10-ppm sulfur diesel, requiring availability in the market in 2005 and making it mandatory in 2009. 10-ppm sulfur diesel preceded filter-based Euro VI standards for heavy-duty vehicles, aligning instead with light-duty Euro 5 standards, which introduced filters on diesel passenger cars.

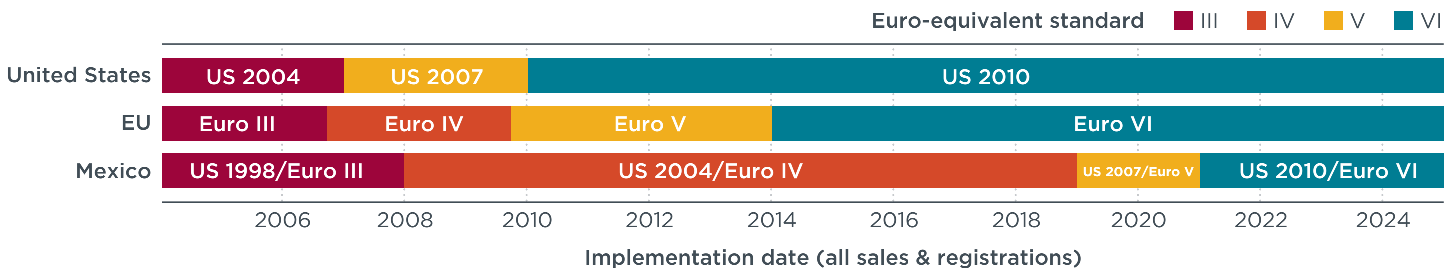

Figure 1. Heavy-duty diesel emission standards in the United States, European Union, and Mexico

KEY ELEMENTS OF THE PROPOSED REGULATION

When fully implemented, NOM-044-SEMARNAT-2017 will require diesel particulate filter (DPF) and selective catalytic reduction (SCR) technology to be incorporated into all new medium- and heavy-duty diesel vehicles sold in Mexico. This will dramatically reduce the most dangerous pollutant emissions, as these vehicles are the primary source of black carbon and particulate matter from the on-road transport sector and are responsible for about half of the sector's NO_x emissions.[13] Black carbon is estimated to be the pollutant with the second highest climate impact and is a critical component of ambient $PM_{2.5}$, or fine particulate matter, the pollutant responsible for

10 NORMA Oficial Mexicana de Emergencia NOM-EM-005-CRE-2015, Especificaciones de calidad de los petrolíferos. Diario Oficial de la Federación (2015). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5413788&fecha=30/10/2015

11 ACUERDO por el que la Comisión Reguladora de Energía expide por segunda vez consecutiva la Norma Oficial Mexicana de Emergencia NOM-EM-005-CRE-2015, Especificaciones de calidad de los petrolíferos. Diario Oficial de la Federación (2015). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5435482&fecha=29/04/2016

12 ACUERDO de la Comisión Reguladora de Energía que modifica la Norma Oficial Mexicana NOM-016-CRE-2016, Especificaciones de calidad de los petrolíferos, con fundamento en el artículo 51 de la Ley Federal sobre Metrología y Normalización. Diario Oficial de la Federación (2017). Retrieved from http://dof.gob.mx/nota_detalle.php?codigo=5488031&fecha=26/06/2017

13 Pineda, L., Blumberg, K., Schade, M., Koupal, J., Perez, I., Zirath, S., ...Hernandez, U. (2018), Air quality and health benefits of improved fuel and vehicle emissions standards in Mexico. International Council on Clean Transportation. Retrieved from https://www.theicct.org/publications/mexico-emissions-review

more than 67% of the global health burden from air pollution.[14, 15] Particle number is also critical to consider: when mass is reduced but not particle number (see Table 2 below) each particle emitted will be smaller, making it longer-lived in the atmosphere and potentially more dangerous for human health.[16] DPFs typically eliminate more than 95% of black carbon and $PM_{2.5}$ and more than 99% of the number of particles, resulting in particle emissions that are similar to ambient conditions. Effective use of SCR technology will reduce NO_x emissions by approximately 90%.[17]

Compared to the proposal published in December 2014, the final regulation delays initial implementation of the new standards by one year and allows for two additional years of compliance with an interim standard. These actions serve to delay full implementation of mandatory requirements for best-in-class, filter-based standards by three years and are the most relevant changes from the proposal to the final standard. Table 1 shows the timing of implementation of NOM-044-SEMARNAT-2017, indicating the aligned standards in the United States and the European Union for each regulatory option. Standard A, allowed through June 30, 2019, is essentially the same as the previous NOM-044 standard. An interim (AA) and permanent (B) standard will both begin implementation on January 1, 2019. The AA standard expires on December 31, 2020, at which point the B standard becomes mandatory nationwide.

Table 1. Timing and alignment of NOM-044-SEMARNAT-2017

	Heavy-duty engines		Complete vehicles	
Implementation	NOM-044	Aligned standard	NOM-044	Aligned standard
Until June 30, 2019	1A	U.S. 2004	3A	California LEV I[18]
	2A	Euro IV	4A	Euro 4
January 1, 2019— December 31, 2020	1 AA	U.S. 2007	—	—
	2 AA	Euro V	4AA	Euro 5
From January 1, 2019	1 B	U.S. 2010	3B	U.S. 2010
	2 B	Euro VI	4B	Euro 6

Table 2 provides the approximate levels of emission reductions from each option available under A, AA, and B standards. Throughout the current implementation of NOM-044, 1A has been the de facto standard in the market, due to the lower cost

14 Bond, T. C., Doherty, S. J., Fahey, D. W., Forster, P. M., Bernsten, T., DeAngelo, B. J., ... Zender, C. S. (2013). Bounding the role of black carbon in the climate system: A scientific assessment. *Journal of Geophysical Research*, 118, 5380-5552. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50171/abstract

15 GBD 2016 Risk Factors Collaborators. (2017). Global, regional, and national comparative risk assessment of 84 behavioral, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet*, 390, 1345-1422. Retrieved from http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(17)32366-8.pdf

16 Baldauf, R. W., Devlin, R. B., Gehr, P., Giannelli, R., Hassett-Sipple, B., Jung, H., ... Walker, K. (2016). Ultrafine particle metrics and research considerations: Review of the 2015 UFP Workshop. *Int J Environ Res Public Health,* 13, 1054. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5129264/

17 Anenberg, S. C., Miller, J., Minjares, R., Du, L., Henze, D. K., Lacey, F., ... Heyes, C. (2017). Impacts and mitigation of excess diesel-related NO_x emissions in 11 major vehicle markets. *Nature*, 545, 467. doi:10.1038/nature22086

18 Previous U.S. federal standards regulated vehicles in this weight category exclusively as heavy-duty engines. To offer a certification option, the regulation draws upon the California Low Emission Vehicle programs, discussed in more detail below.

of compliance, and thus it is considered as the baseline.[19] While options 2A and 2AA offer reductions in PM mass compared with 1A, without a filter there are no expected reductions in the number of particles emitted. Under ideal compliance conditions, 2AA should provide modest reductions in NO_x emissions compared with A standards. Standard 1AA would offer similar NO_x reductions, along with full reductions in both PM mass and number. As there is no current off-the-shelf commercial availability of engines complying with 1AA standards, 2AA is expected to be the de facto standard in the market during the transition period.

Table 2. Approximate real-world emissions reductions from current baseline for heavy-duty engine standards

NOM-044	Aligned standard	Approximate real-world emissions reductions			Filter
		NO_x	PM mass & black carbon	PM number	
1A	U.S. 2004	baseline			No
2A	Euro IV	None	75%	None	No
1 AA	U.S. 2007	25%	>95%	>99%	Yes
2 AA	Euro V	20%	75%	None	No
1 B	U.S. 2010	90%	>95%	>99%	Yes
2 B	Euro VI	90%	>95%	>99%	Yes

The final and permanent 1B and 2B standards, aligned with U.S. 2010 and Euro VI, are functionally equivalent, with very similar limit values, compliance costs, and expected reductions for NO_x and PM emissions—including PM mass, number, and black carbon. Both compliance options require strong and complete on-board diagnostic (OBD) systems and both require warnings and driver inducements to ensure proper use of diesel exhaust fluid (DEF) in SCR systems.

LIMIT VALUES

The limit values for standards and options for certification of heavy-duty engines are included in Table 3, along with identification of the matching standard in the United States and the European Union. Limits for opacity have been eliminated in this update. In many cases, pollutants regulated vary depending on the aligned regulatory path:

» Particle number and ammonia (NH_3) limits are set as part of the Euro VI standards but have not been defined as limit values under U.S. standards.

» The U.S. 2004 standards set limits for NO_x plus non-methane hydrocarbons (NMHC), while all of the other standards set limits for each pollutant separately.

» Euro VI standards set limits for HC rather than NMHC, whereas U.S. 2010 standards continue to set limits for NMHC.

19 Blumberg, K., Posada, F., and Miller, J. 2014. Revising Mexico's NOM 044 standards: Considerations for decision-making. International Council on Clean Transportation. Retrieved from http://www.theicct.org/publications/revising-mexicos-nom-044-standards-considerations-decision-making

The U.S. regulatory pathway measures pollutant emissions in grams per brake horsepower-hour on the heavy-duty Federal Test Procedure (FTP) and the Supplemental Emissions Test (SET). The Euro pathway measures pollutants in grams per kilowatt-hour. Euro IV and Euro V standards use the European Stationary Cycle (ESC) and European Transient Cycle (ETC), while the Euro VI standard measures emissions on the World Harmonized Stationary and Transient Cycles (WHSC and WHTC), which are more closely matched to the U.S. SET and FTP cycles.

Table 3. Emissions limits for heavy-duty engines

Aligned standard	Standard	Test Cycle	CO	NO_x	NMHC	NMHC + NO_x	PM	Particle number	NH_3
			g/bhp-hr						
U.S. 2004	1A	SET & FTP	15.5	—	—	2.4	0.10	—	—
					0.5	2.5		—	—
U.S. 2007	1AA	SET & FTP	15.5	1.2	0.14	—	0.01		
U.S. 2010	1B	SET & FTP	15.5	0.20	0.14	—	0.01	—	—

Aligned standard	Standard	Test Cycle	CO	NO_x	NMHC	HC	PM	Particle number	NH_3
			g/kWh						
Euro IV	2A	ESC	1.5	3.5	—	0.46	0.02	—	—
		ETC	4.0	3.5	0.55	—	0.03	—	—
Euro V	2AA	ESC	1.5	2.0	—	0.46	0.02	—	—
		ETC	4.0	2.0	0.55	—	0.03	—	—
Euro VI	2B	WHSC	1.5	0.4	—	0.13	0.01	8.0 x 10^{11}	10
		WHTC	4.0	0.46	—	0.16	0.01	6.0 x 10^{11}	10

Source: ICCT & DieselNet. 2017. TransportPolicy.Net (United States, European Union)

Standards 1A, 2A, 1B, and 2B are unchanged from the original proposal, while standards 1AA and 2AA were added in the final standard. The implications of this addition are discussed below.

Table 4 provides useful life requirements for each engine standard. Requirements have not changed under U.S. regulations but Euro VI standards have increased the distance requirements to more closely match U.S. standards. Useful life is defined as the reference values used in durability tests as part of new engine or vehicle certification for design and testing of emission control systems. Useful life does not refer to, nor is it equivalent to, the manufacturer warranty or in-use vehicle emissions.

Table 4. Useful life requirements for heavy-duty engines

Aligned standard	Standard	Gross vehicle weight (kg)	Useful life	
			Distance (km)	Time (years)
U.S. 2004, U.S. 2007, and U.S. 2010	1A, 1AA, and 1B	3,857 – 8,845	177,023	10
		8,846 – 14,970	297,721	
		14,971 and greater	700,046	
Euro IV and Euro V	2A and 2AA	3,857 – 15,999	200,000	6
		16,000 and greater	500,000	7
Euro VI	2B	3,857 – 15,999	300,000	6
		16,000 and greater	700,000	7

The standard also includes certification limits for complete vehicles in the medium-duty size categories. Table 5 describes the limit values, weight restrictions, and useful life requirements for the certification pathway for complete vehicles, as well as the aligned standard in the United States and the European Union. Both the U.S. Federal Test Procedure (FTP-75) and the New European Drive Cycle (NEDC) include multiple drive cycle segments and specified test conditions.

Table 5. Emissions limits and useful life requirements for complete vehicles

Aligned standard	Standard	Gross vehicle weight (kg)	Test cycle	CO	NO_x	NMHC	PM	Particle Number (#/km)	Useful Life	
				g/km					km	years
California LEV I	3A	3,857 – 4,539	FTP 75	—	0.311	0.121	0.037	—	193,121	11
		4,540 – 6,350		—	0.435	0.143	0.037	—		
U.S. 2010	3B	3,857 – 4,539	FTP 75	—	0.124	0.121	0.012	—	193,121	11
		4,540 – 6,350		—	0.249	0.143	0.012	—		

Aligned standard	Standard	Reference weight (kg)	Test cycle	CO	NO_x	$HC+NO_x$	PM	Particle Number (#/km)	Useful Life	
				g/km					km	years
Euro 4	4A	≤2,840	NEDC	0.74	0.39	0.46	0.06	—	160,000	5
Euro 5	4AA	≤2,840	NEDC	0.74	0.28	0.35	0.005	—	160,000	5
Euro 6	4B	≤2,840	NEDC	0.74	0.125	0.215	0.005	$6.0x10^{11}$	160,000	5

Source: ICCT & DieselNet. 2017. TransportPolicy.Net (California, United States, European Union)

These limits can be used for medium-duty vehicles that are certified as complete vehicles, with testing done on a chassis dynamometer, rather than certified as an engine, with testing on an engine dynamometer. The 3B and 4B pathways for certification of complete vehicles were included in the original proposal, while 3A, 4A, and 4AA were added in the final standard. The implications of these expanded options are discussed further below.

ON-BOARD DIAGNOSTICS AND SCR COMPLIANCE INDUCEMENTS

The final standards require full OBD systems to be installed and operating on new vehicles meeting B standards. The type of OBD system must be listed in the certification documentation. Appendix A includes general OBD system requirements and a detailed description of the requirements—including monitoring thresholds and the systems and metrics to monitor—for OBD systems meeting the Euro VI and U.S. 2010 standards. As both U.S. and Euro standards require the full phase-in of OBD systems implementation of B standards, certification documentation under U.S. and Euro standards is used as the primary proof of compliance with OBD requirements.

The regulation requires that all vehicles meeting AA and B standards that are equipped with SCR systems (which require use of DEF for proper control of NO_x) are equipped with the full suite of operating systems of alerts and driver inducements to ensure the correct functioning of these systems. These fail-safes include lights, auditory alarms, and requirements to safely limit vehicle operation in all cases of improper use, including lack of DEF, poor-quality DEF, and insufficient consumption or dosing of DEF. Both European and U.S. systems described in Appendix B also include anti-tampering mechanisms to ensure that users do not evade these requirements.

RELEVANT CHANGES IN THE FINAL RULE

The regulatory end goal of alignment with filter-based, best-in-class standards in the United States and Europe is not changed in the final rule, however full implementation is delayed by three years, from 2018 to 2021. The introduction of filter-based standards, delayed by one year to January 2019, was revised to align with the revised timeline for nationwide implementation of 15-ppm sulfur diesel. However, it is the introduction of much weaker transitional standards that delays full implementation by an additional two years. Early and transitional standards were also introduced for complete vehicles in the final standard. The final regulation is strengthened by removal of a contingency plan that would have suspended implementation of the B standard by one year in case of delays in fuel quality implementation.

TIMELINE

To coordinate vehicle standards with 15-ppm sulfur diesel availability, the final NOM-044 regulation delays the introduction of 1B and 2B standards, harmonized with U.S. 2010 and Euro VI, to January 2019. This timeline aligns with the mandatory requirement for all diesel fuel sold in Mexico to meet 15-ppm sulfur limits by December 31, 2018.

TRANSITIONAL HEAVY-DUTY ENGINE STANDARDS

The addition of transitional 1AA and 2AA standards for heavy-duty engines delays mandatory implementation of filter-based 1B and 2B standards by another two years. The 1AA and 2AA standards introduced in the final regulation are aligned with U.S. 2007 and Euro V standards. While the final 1B and 2B standards are functionally equivalent, requiring the same technology investments and achieving approximately the same emissions in the real world, the transitional 1AA and 2AA standards have very different emission profiles and require different technologies and levels of investment.

The 1AA standard is based on the phase in of the technology-forcing U.S. heavy-duty emission standards, which required the use of DPFs for full compliance with PM standards but allowed for higher NO_x emissions between the years 2007 and 2009. Full NO_x control, primarily achieved with SCR technology, was not required until 2010. The vehicles sold in those phase-in years were less efficient and less reliable and had higher overall emissions than vehicles meeting the final standard. While manufacturers could potentially supply U.S. 2007 vehicles upon request, there is no current commercial availability of engines complying with this standard and it is unlikely to be a common option for compliance.

The 2AA standard is based on the Euro V standard. The Euro V standard is largely unchanged from the Euro IV standard that is the basis for the 2A standard. Particulate filters are not required for either standard and the same SCR technology is used for compliance with NO_x limits, with somewhat lower NO_x certification limits for Euro V. Unfortunately, due to an unrepresentative test cycle and weaker in-use requirements—two problems that were solved with Euro VI—the real-world NO_x emissions significantly exceed certification levels for Euro IV and Euro V.[20,21] As Euro V vehicles are widely produced and sold throughout the world, the 2AA standard is expected to be the default compliance option prior to mandatory implementation of the B standards in 2021.

PRIOR AND TRANSITIONAL STANDARDS FOR COMPLETE VEHICLES

The 3B and 4B standards in the final NOM-044 are unchanged from the original proposal, while 3A, 4A, and 4AA standards for complete vehicle certification have been added. These additions are expected to have less of an overall impact on emissions than the inclusion of transitional standard options for engine certification. The option to allow for certification as complete vehicles fills regulatory gaps opened by recent changes in how vehicles are classified or regulated in the United States and Europe—these gaps are explained in further detail below.

Mexico and the United States both use GVWR to categorize vehicles. However, the United States has recently adjusted the coverage of light-duty emission standards to include complete vehicles that fall under the heavy-duty weight categorization in Mexico. While California has had standards for complete vehicles in these weight classes for many years, U.S. federal regulations only introduced complete vehicle standards for these weight categories with the U.S. 2010 standards, which matches the 3B standard. Since that time, U.S. 2010 heavy-duty standards for complete vehicles with a GVWR of less than 6,350 kg have been superseded by the much more stringent light-duty Tier 3 standards, which extend coverage for light-duty vehicles into the 3,857 to 6,350 kg GVWR range.

The 3A standard was not included in the 2014 proposal and is provided as an option only until June 30, 2019. The NO_x and PM limit values come from California's light-duty emission standard, which has covered vehicles in this weight rating since the low emission vehicle (LEV) standards were adopted in 1990. As the limit values for NMHC

20 Chambliss, S., and Bandivadekar, A. 2015. Accelerating progress from Euro 5/V to Euro 6/VI vehicle emissions standards. International Council on Clean Transportation. Retrieved from http://www.theicct.org/publications/accelerating-progress-euro-4iv-euro-6vi-vehicle-emissions-standards

21 Muncrief, R. 2015. Comparing real-world off-cycle NO_x emissions control in Euro IV, V, and VI. International Council on Clean Transportation. Retrieved from https://www.theicct.org/publications/comparing-real-world-cycle-nox-emissions-control-euro-iv-v-and-vi

that would have matched these values under LEV I standards are lower than the 3B standard allows, the 3B limit values are also adopted for 3A.

European regulations formerly categorized vehicles using the metric of maximum laden mass,[22] which is similar to GVWR, and also defined heavy-duty vehicles as having a laden mass of greater than 3.5 tons. The heavy-duty Euro VI standards and light-duty Euro 5 and 6 standards changed the metric to reference mass, which does not consider loaded vehicle weight, opening the potential that some vehicles could be categorized as light-duty in Europe and heavy-duty in Mexico. Given this disconnect, the 4B standard, which was aligned with Euro 6 and included in the original proposal, was necessary to ensure a certification pathway was available for all vehicles. The 4AA standard, which is aligned with Euro 5, meets the same purpose, but was added only when the interim Euro V-based option was added for engine certification.

The 4A standard, which will be an option for complete vehicle certification only until June 30, 2019, is aligned with Euro 4 emission standards for light-duty vehicles. As Euro 4 regulations were in effect prior to the change in methodology for categorization of vehicles, in the European Union this standard applies exclusively to vehicles of less than 3.5 tons, which by definition would not be covered by the NOM-044 standard.

EXPECTED EFFECTS OF THE REGULATION

Full implementation of the filter-based standards will bring significant air quality, health, and climate benefits, along with multiple co-benefits for industry and consumers. The cost-benefit analysis for the proposal was done in part using the ICCT Roadmap Model Health Module.[23] The assessment took into consideration the difference in emissions that would be expected in 2037, approximately 20 years after implementation began. By that time, most of the existing fleet would have been replaced with vehicles meeting the filter-based standards. While the final standard delays full implementation by three years, the majority of vehicles in the 2037 fleet would still be expected to be in compliance with B standards.

The original analysis found that when fully implemented the new standards will result in annual reductions of:

- 6,800 premature deaths from exposure to $PM_{2.5}$ emissions in urban areas;
- 24,000 tons of $PM_{2.5}$;
- 17,000 tons of black carbon; and
- 410,000 tons of NO_X.

The annual operating and technology cost will be $1.8 billion, with annual social benefits from reduced deaths and reduced climate impacts of $22 billion to $30 billion (U.S.).

22 Maximum laden mass is defined in a very similar manner as GVWR, as the total curb weight of the vehicle plus its maximum recommended load of passengers and cargo.

23 MIR de impacto moderado con analisis de impacto en la competencia y analisis de impacto en el comercio exterior. COFEMER (2017). Documents available in Anexos: http://www.cofemersimir.gob.mx/mirs/43430

The cumulative benefits over the years 2018 to 2037 include:

- Climate benefits amounting to the equivalent of 54 million tons of CO_2 (using a 20-year global warming potential), and
- Net economic benefits of to $123 billion (U.S.).

The figures do not take into account the savings in fuel consumption expected from new and more efficient engines nor the significant but unquantified health benefits, such as reductions in asthma, bronchitis, stroke, heart attack, and other cardiopulmonary disorders.

The ICCT has recently completed an additional air quality and health analysis, which estimated 6,200 avoided deaths annually (using 2035 in this analysis) associated with NOM-044, in line with the estimates used in the regulatory impact analysis for the proposed and final standard.[24] Delaying full implementation to 2021 will delay the achievement of air quality and health benefits.

INTERNATIONAL CONTEXT

This regulation places Mexico at the forefront of clean vehicle policy in Latin America and other rapidly growing vehicle markets worldwide. This update of NOM-044 will virtually eliminate fine particle and black carbon emissions from all new diesel trucks beginning in 2021. Mexico is the second medium-income country in the world to adopt best-in-class, filter-based standards for all new heavy-duty vehicles: India finalized Euro VI standards in 2016, with a 2020 implementation date; and China has proposed 2020 implementation but has not yet finalized the proposal.

As can be seen in Figure 2, full implementation of NOM-044 will bring Mexico in line with standards in the United States, Canada, Japan, the European Union, South Korea, Turkey, and India. NOM-044 also responds to the commitments made during the 2016 North American Leaders' Summit by President Peña, President Obama, and Prime Minister Trudeau to align emission standards for light- and heavy-duty vehicles by 2018, although full implementation of U.S.-aligned heavy-duty standards in Mexico will not occur until 2021.

24 Pineda, L., Blumberg, K., Schade, M., Koupal, J., Perez, I., Zirath, S., ...Hernandez, U. (2018), Air quality and health benefits of improved fuel and vehicle emissions standards in Mexico. International Council on Clean Transportation. Retrieved from https://www.theicct.org/publications/mexico-emissions-review

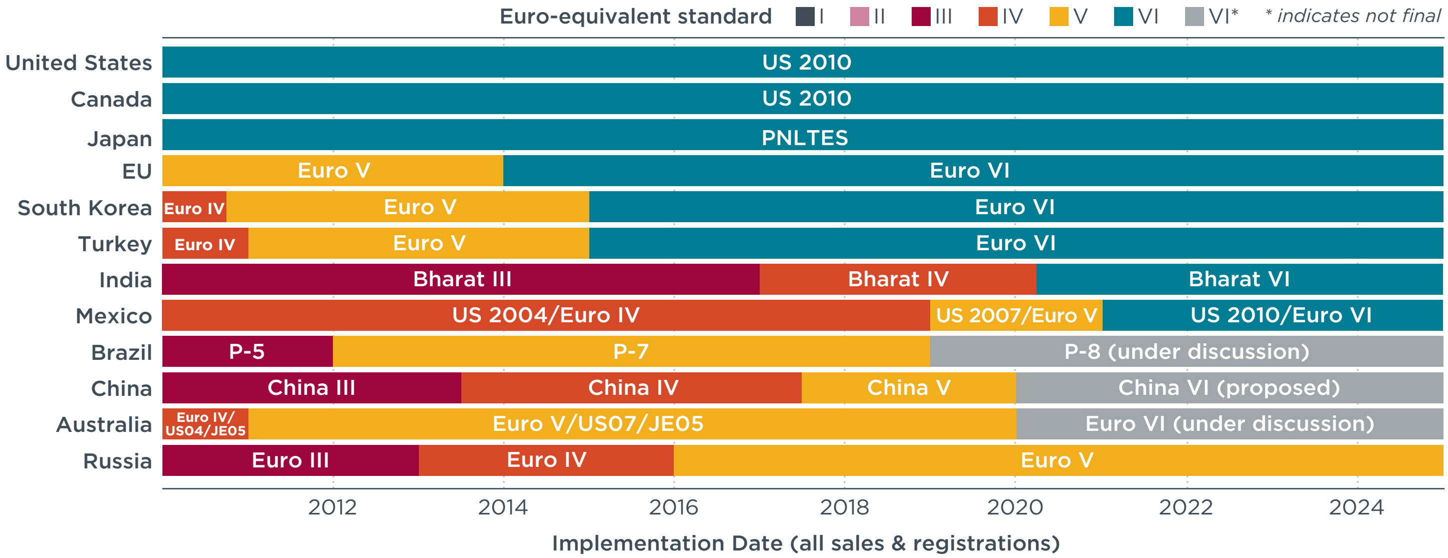

Figure 2. Regulatory timeline in major markets

Mexico is the first country in Latin America to adopt filter-based, best-in-class standards at the national level. Brazil has nationwide access to 10-ppm sulfur diesel and has Euro V-based standards in place, and alignment with Euro VI standards is under discussion, with timelines ranging from 2019 to 2023.[25, 26] At the same time, accelerated progress has been made in cities, especially in urban bus fleets. In Santiago, Chile, new buses entering the Transantiago fleet will be required to meet Euro VI standards by January 2019.[27] Mexico City has committed to a Euro VI or U.S. 2010 standard for all new buses in the publicly owned fleet by 2017.[28] The adoption of the federal NOM-044 standard, finalizing filter-based standards, could facilitate the adoption of more ambitious implementation timelines for local or specific fleets and other efforts to accelerate the introduction of the cleanest technologies and to remove older vehicles. Such actions could potentially offset the delay in mandatory implementation of filter-based standards, allowing Mexico to realize the full air quality, climate, and health benefits estimated for the original proposal.

25 CETESB. 2017. Cetesb apresenta propostas para novas fases do Proconve e Promot. Retrieved from http://cetesb.sp.gov.br/blog/2017/02/02/cetesb-apresenta-propostas-para-novas-fases-de-controle-de-poluicao-veicular/

26 IBAMA. 2017. Proposta CONAMA. Retrieved from http://www.ibama.gov.br/phocadownload/proconve-promot/2017/consulta-publica/2017-10-proposta-conama-P8-%20final-mbv-v3.pdf

27 ICCT and DieselNet. 2017. Chile: Heavy-duty: Emissions. Retrieved from http://www.transportpolicy.net/standard/chile-heavy-duty-emissions/

28 García, Tanya Müller. 2016. Letter from SEDEMA. Retrieved from http://www.theicct.org/sites/default/files/Letter%20from%20SEDEMA_06302016_esp.pdf