Policy and regulatory review of international experiences in reducing non-road mobile machinery (NRMM) emissions

Document prepared for CALAC+ by:

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Policy and regulatory review of international experiences in reducing non-road mobile machinery (NRMM) emissions.

This document has been prepared under the Climate and Clean Air project in Latin American Cities Programme - CALAC+ (Phase 1) financed by the Swiss Agency for Development and Cooperation - SDC and implemented by the Swiss Foundation for Technical Cooperation - Swisscontact.

The document is for informative purposes only and does not necessarily reflect the views or opinions of the organisations and governments mentioned. Nor does it seek to contain all the regulations related to NRMM, but only those considered to be of most relevance for use in strategies to reduce pollutant emissions from NRMM. The experiences gathered were based on the most recent policy developments for machinery with internal combustion engines.

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Cover image: CALAC+
Edition: November 2021 version

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1. Introduction

The study presented in this document was developed under the Climate and Clean Air project in Latin American Cities (CALAC+), implemented by Swisscontact and funded by the Swiss Agency for Development and Cooperation (SDC). The study aims to contribute to the work stream "Urban policy incubators for off-road machinery".

The study identified the main regulatory aspects used in different regions globally to control local pollutant emissions generated by machinery. This information will provide criteria for the technical discussions that are being held in Latin American countries to define the regulatory bases for reducing local pollutant emissions from this type of sources.

The document is structured as follows. Section 2 presents an executive summary of the study; Section 3 explains the methodology used to develop the study and lists the case studies included.

Sections 4 to 10 present the results of the case studies in areas including, among others:

- Definitions of Non-Road Mobile Machinery (NRMM).
- Identification of local pollutant reduction tools for non-road mobile machinery.
- Air pollutant emission standards
- Import requirements and type-approval processes
- Labelling processes
- Regulation on machinery useful life, repowering, overhaul and scrapping practices
- Operational and road circulation requirements
- Procedures for NRMM control and inspection during the operational phase
- Stakeholders involved in the import, manufacturing, registration, sale, inspection and end-of-life practices of NRMM

For terminology purposes, the international term “non-road mobile machinery” (non-road) is used in this document. However, in those cases where the regulation of a country or region uses the term “off-road”, this term is maintained in accordance with the terminology used in those cases.

Table 1. 1. Terminology used to refer to machinery in the different case studies.

Country	Original name	English name
Canada	Off-road machinery	-
United States	Nonroad engines (in California the term Off-road engines/vehicles is more commonly used).	-
Brazil	*Máquinas agrícolas e rodoviárias (construção)*	Agricultural and road machinery (construction)
Colombia	*Fuentes móviles de uso fuera de carretera*	Mobile non-road sources
Mexico	*Vehículos fuera de carretera*	Non-road vehicles
Peru	*Máquinas amarillas y verdes*	Yellow and green machines

Country	Original name	English name
Chile	*Maquinaria fuera de ruta*	Non-road machinery
China	Non-road mobile machinery	-
South Korea	Construction machinery	Construction machinery
India	Construction equipment vehicles and agricultural tractors	Agricultural and construction machinery
Japan	Non-road vehicles	-
European Union	Non-road mobile machinery	-
Switzerland	Non-road mobile machinery	-
United Kingdom	Non-road mobile machinery	-
South Africa	Non-road mobile machinery	-

Source: Own elaboration.

2. Executive summary

Introduction

This information gathering and analysis aims to strengthen the knowledge on existing practices for regulating non-road mobile machinery (NRMM) emissions. The experience of the European Union and 14 other countries was compiled in order to provide examples of strategies that can be useful for developing instruments that can significantly reduce pollutant and greenhouse gas emissions in the Region.

The formulation of policies and other regulatory instruments to reduce NRMM emissions is a relatively new issue in several regions of the world. This review, in addition to presenting the emission standards that apply in different countries, includes aspects of machinery regulation throughout its life cycle, such as import/manufacture, registration, sale, operation, scrapping, etc. Through this holistic information gathering approach it is also possible to identify potential inter-institutional synergies within the countries in terms of verification, inspection and control of machinery emissions.

The information gathering methodology focused on existing regulations for each case study, covering environmental, transport and trade sector regulations, among others. Previous studies from indexed literature and the community of practice were also reviewed, as well as interviews with independent public and private sector stakeholders.

Information structure

Information compilation and analysis was divided into 10 (ten) sections gathering the information found for each of the geographic areas under study, as shown below:

Table 2.1. Case studies.

North America	South America	Asia-Pacific	Europe	Africa
United States	Brazil	China	European Union	South Africa
Canada	Colombia	South Korea	London[1]	
Mexico	Peru	India	United Kingdom	
	Chile	Japan	Switzerland	

Source: own elaboration.

Among the countries selected for analysis are those with the most advanced policies for internal combustion engine machinery.

For terminology purposes, the international term “non-road mobile machinery” (non-road) is used in this document. However, in those cases where the regulation of a country or region uses the term “off-road”, this term is maintained in accordance with the terminology used in those cases.

[1] This city was included because it is a special case study in the implementation of low-emission areas and machinery labeling.

Table 2. 2. Terminology used to refer to machinery in the different case studies.

Country	Original name	English name
Canada	Off-road machinery	-
United States	Nonroad engines (in California the term Off-road engines/vehicles is more commonly used).	-
Brazil	*Máquinas agrícolas e rodoviárias (construção)*	Agricultural and road machinery (construction)
Colombia	*Fuentes móviles de uso fuera de carretera*	Mobile non-road sources
Mexico	*Vehículos fuera de carretera*	Non-road vehicles
Peru	*Máquinas amarillas y verdes*	Yellow and green machines
Chile	*Maquinaria fuera de ruta*	Non-road machinery
China	Non-road mobile machinery	-
South Korea	Construction machinery	-
India	Construction equipment vehicles and agricultural tractors	-
Japan	Non-road vehicles	-
European Union	Non-road mobile machinery	-
Switzerland	Non-road mobile machinery	-
United Kingdom	Non-road mobile machinery	-
South Africa	Non-road mobile machinery	-

Source: Own elaboration.

For each of the countries, the information was analysed in the following areas.

- Definitions of Non-Road Mobile Machinery (NRMM).
- Identification of local pollutant reduction tools for non-road mobile machinery.
- Air pollutant emission standards
- Import requirements and type-approval processes
- Labelling processes
- Regulation on machinery useful life, repowering, overhaul and scrapping practices
- Operational and road circulation requirements
- Procedures for NRMM control and inspection in the operation stage

- Stakeholders involved in the import, manufacturing, registration, sale, inspection and end-of-life practices of NRMM

The definition of NRMM, especially in a legal context, is important as it outlines the nature of the sources to be regulated. It is also important to identify whether the subject of emission regulation is non-road mobile machinery and/or specifically the machinery engines. In terms of air emissions, it is primarily the engines contained in the machinery that are regulated according to their power. However, the definitions of NRMM must be known and considered.

Eight predominant criteria were identified, the most common being: (i) portability and mobility, which refer to whether the vehicle or machinery in question is part of self-propelled equipment, is handheld or portable; (ii) end-use sector, which refers to inclusion or exclusion in the NRMM category depending on the sector where the vehicle or machine is used; iii) functionality, which means that the vehicle and machine´s main use is different from the transport of persons or goods; and iv) specific function, which are cases where a list of machinery and vehicles with their functions is provided and it is specified that they are part of the NRMM category (see Table 2.3).

Table 2.3. Criteria used to define NRMM in the case studies.

Case study → Criterion ↓	United States	Canada	Brazil	Colombia	Mexico	Peru	Chile	China	India	Japan	South Korea	European Union	United Kingdom	London	Switzerland	South Africa
Portability and mobility	✓	✓		✓	✓		✓	✓		✓		✓	✓	✓	✓	✓
Functionality	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Specific function	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓
Time spent at one location	✓	✓														
Power range							✓	✓								
End-use sector			✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
Circulation permit										✓						
Registration										✓						

Source: own elaboration.

A review was carried out of different instruments used to control NRMM emissions and other processes associated with the life cycles of machinery, such as transport, safety and other areas. The latter, as instruments of potential indirect utility to reduce emissions by facilitating the surveillance, control and inspection of emission sources.

The instruments were classified into three groups, according to the methodology employed by Huang et al., (2021): 1) Mandatory Administrative Instruments, 2) Economic Incentive Instruments and 3) Voluntary Participation

Instruments. The regulatory instruments cited in the information review document were kept on file for consultation by any interested party. As a result of this grouping, it became evident that most of the instruments belong to the mandatory administrative group, followed by the voluntary participation instruments and in last place are the economic incentives.

Following Huang et al., (2021) and several other authors, it is recognised that the most effective strategies for regulating pollutant emissions are those that combine different types of instruments (mandatory, economic incentives and voluntary). However, in practice, it is evident that there is a predominant reliance on mandatory instruments to achieve emission reductions.

Table 2. 4. Number of emission reduction instruments identified per case study.

Instrument	Code	United States	Canada	Brazil	Chile	Colombia	Peru	Mexico	China	India	Japan	South Korea	European Union	Switzerland	United Kingdom	London	South Africa
Total		**40**				**10**	**8**	**10**		**5**			**5**				**5**
Mandatory administrative	**PI-A**	**30**				**8**	**8**			**5**			**5**				**5**
Law	PI-AL		1	1										1			1
Regulation	PI-AR	21	5	1	1	5											
Pilot programme	PI-APP																
Emission standard	PI-AES			1	1	1			5	1		1	1	1	1	1	1
Economic incentives	**PI-B**		**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Subsidy	PI-BS																
Tax	PI-BT					1											
Reimbursement	PI-BR																
Loans	PI-BLI																
Capital and subsidies	PI-BGS																
Voluntary participation	**PI-C**	**8**	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Voluntary emission standards	PI-CVS					1		1			1						
Official service	PI-CGS																
Certifications and stamps	PI-CCL																
Voluntary pilot programme	PI-CVPP		1														
Dissemination of information	PI-CID																

Source: own elaboration.

In terms of regulation of emission levels, it was found that of the countries with such standards, all have emission limits for particulate matter, nitrogen oxides, hydrocarbons and carbon monoxide. Countries such as China, India and the European Union also have regulations that are beginning to incorporate particle number (PN) standards. The regulatory schemes identified contain mostly emission standards for new emission sources to be imported, manufactured and sold in the countries and, to a lesser extent, instruments for machinery in use. For the latter sources, it was found that the most widely implemented aftertreatment system for the reduction of particulate matter from in-use machinery is the diesel particulate filter (DPF).

For the group of countries that have emission level limits, the gradual adoption of the standards for the period 1996-2021 was reviewed (see Table 2. 65). The emission levels mentioned below are those that the community of practice has largely adopted in the different countries of the world, which are primarily based on the regulations of the European Community and the United States[2]. For practical purposes and given their similarities, it is possible to establish equivalence between these emission standards:

Table 2.5. Emission Standard Equivalences

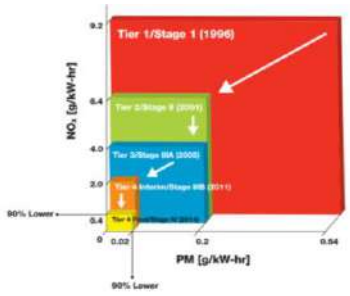
US EPA	Stage (EU)
Tier 1	Stage I
Tier 2	Stage II
Tier 3	Stage IIIA
Tier 4 Interim	Stage IIIB
Tier 4 Final	Stage IV
Tier 4* Final (With DPF and SCR)	Stage V

**There is no standard equivalent for Stage V, but could be considered emissions equivalent in terms of control systems if Tier 4 Final is met by implementing DPF and SCR filters.*

Source: CALAC+ 2021

The United States was the first country to implement emission limits for NRMM, and this case also stands out because from the outset it implemented limits covering all power ranges of machinery. The countries with the most advanced and currently implemented emission standards are the EU countries with Stage V standards, followed by the USA with Tier 4 Final and Korea, Japan and India with Stage IV.

Overall Evolution of Machinery Emission Reductions for US and European Standards



Source: Cited by Tampere University of Technology [3] .

In terms of standards in the pipeline, China has recently enacted regulations that will apply highly stringent emission standards in the coming years. The standards applicable to machinery were updated in 2020, requiring that from December 2022 Stage IIIB emission standards will come into force with some requirements of the European Stage V standard such as particle number (PN) limit. For the latter, the installation of GPS in machinery is anticipated, as

[2] India is an exception where some Bharat standards differ from US and European standards.

[3] Presentation by Professor Seppo Tikkanen from Tampere University of Technology, Faculty of Engineering Sciences at CASCADES 2017 https://www.cimac.com/cms/upload/events/cascades/CASCADES_2017_Finland/12_Seppo_Tikkanen_cimaccascades_final.pdf

well as control with on-board emission monitoring systems (PEMS), among others, to evaluate compliance with the permitted standards (ICCT, 2021).

In Latin America, so far Brazil has Stage IIIA emission standards; in the case of Chile, on 21 October 2021 a Supreme Decree was published that establishes the emissions standard equivalent to Stage IV or V standard for machinery to be brought into the country, applicable 24 months from the entry into force of the standard; agricultural tractors have 36 months to comply with this requirement[6]. At the local level, the *Plan de prevención y descontaminación atmosférica para la región metropolitana de Santiago* (Air Pollution Prevention and Decontamination Plan for the Metropolitan Region of Santiago) includes requirements for the implementation of DPF particulate filters for machinery with power ranges between 56 kW and 560 kW.

Colombia is working on a bill[7] for machinery emission standards that calls for the implementation of Stage IIIB standards for units to be imported into the country in the coming years. Locally, the city of Bogota has developed the *Plan estratégico para la gestión integral de la calidad del aire a 2030 (Strategic Plan for the integrated management of air quality to 2030)*, which includes measures aimed at promoting the technological upgrading of construction machinery operating in the city. In Mexico, the Metropolitan Area of the Valley of Mexico (including Mexico City) has published the *Programa de gestión para mejorar la calidad del aire PROAIRE 2021 – 2030 (Management Programme to Improve Air Quality PROAIRE 2021 – 2030),* which includes machinery emissions and highlights the need for a standard to regulate emissions from these sources. In Peru, actions related to the quantification of machinery engine emissions in inventories and the need to set regulations on emission limits were included in the *Plan de acción para el mejoramiento de la calidad del aire de Lima-Callao 2021-2025 (Action Plan for the Improvement of Air Quality in Lima-Callao 2021-2025)*[8].

The comprehensive analysis of policy and regulatory instruments also identified experiences with machinery labelling, operation and road circulation requirements, control and inspection procedures and the main stakeholders involved in these processes. According to the case review, emission control and inspection processes are generally focused on the production, import and type-approval stages of NRMM. Switzerland is a special case as the control of the machinery distributed in the country is carried out based on the market information of the machinery, i.e., an internal control mechanism in which the authority checks this information with the private counterparts. On the other hand, when searching for information in the countries consulted, the machinery registration processes were highlighted as important, as they play a strategic role in the inspection of NRMM.

A wide variety of aspects were identified in the operation and road circulation requirements of NRMM that are included in the regulation. These may be broadly classified into environmental requirements, related to emission levels of air pollutants and noise; and safety requirements, which are the most common and include aspects such as speed of circulation, zones where NRMM is allowed to circulate, hours of circulation, ways to move machinery between sites, licensing and training requirements for operators.

In the United States, Canada, Brazil, the European Union, China and the United States of America, guidelines are provided in the NRMM regulation covering at least one of the aspects of machinery end-of-life (NRMM useful life, repowering, overhaul and scrapping practices). In cases such as the United States, the European Union, Canada and China, regulation is associated with the control of air pollutant emission levels and the emission assessment considers the deterioration of the emission control systems of machinery over its lifetime.

It should be noted that there are mechanisms to control emissions during the NRMM operation. For example, in the European Union, starting with Stage V, through an in-service compliance mechanism for certain power ranges

that considers testing pollutant emissions of a sample of machines during the first years of their useful life (Directive 2017/0655).

Emission verification mechanisms for in-use machinery focus on opacity measurements; particle number measurements are also carried out in cases where the machinery is fitted with a diesel particulate filter (DPF). Regarding the latter control system, it is found to be the preferred and most effective emission control strategy for reducing particulate matter emissions from in-use machinery, with Switzerland being one of the first countries to establish regulations in this respect, applicable since the 1990s.

Table 2. 6. Comparison of emission standards for non-road mobile machinery around the world [4] .

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V

Region	Net Power (kW)*		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Canada	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										
	P ≥ 560																										
United States	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P < 225																										
	225 ≤ P < 450																										
	450 ≤ P < 560																										
	P ≥ 560																										
Brazil	19 ≤ P < 37																										
	37 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P ≤ 560																										

*Equivalence between kW and HP: 1.34 HP = 1 kW.

[4] Note: The years of entry into force indicated here correspond to the most representative dates for the power ranges. However, for some categories, e.g., agricultural machinery, the dates of entry into force may be later than those indicated here as they have had a special deadline. Therefore, this table should be used only as a general indicator and for details of the exact dates (year and month) of entry into force of a particular machine it is important to refer to the original standard, power range, category and other characteristics to identify the corresponding table.

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V

Region	Net power (kW)			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
China	0 ≤ P < 8																										
	8 ≤ Pmax < 18																										
	18 ≤ Pmax < 37																										
	37 ≤ Pmax < 75																										
	75 ≤ Pmax < 130																										
	130 ≤ Pmax ≤ 560																										
	Pmax >560																										
Korea	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P < 225																										
	225 ≤ P < 450																										
	450 ≤ P < 560																										
India**	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										

Note: The maximum net power used in China refers to the maximum value of the net power on the full-load rated power curve for the engine type, unlike in Europe, where emission limits are reported according to a reference power that may correspond to the maximum net power or the manufacturer's declared net rated power of an engine at rated speed, as specified for each category of non-road mobile machinery engine. Rated speed refers to the maximum engine speed at full load allowed by an engine´s governor, as designed by the manufacturer or, in the absence of a governor, the speed at which the maximum net power output is attained by the engine, as specified by the manufacturer. (REGULATION (EU) 2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on Requirements Relating to Gaseous and Particulate Pollutant Emission Limits and Type-Approval for Internal Combustion Engines for Non-Road Mobile Machinery, Ame, 2016).

**Broad equivalence Bharat (CEV) Stage IV and Bharat (Trem) Stage IV. For India, the entries into force and some maximum permissible levels vary depending on the industry in which the machinery operates. Some Bharat standards are not related to US standards, nor to European standards; in these cases, they are represented in the table with the colour of the standard that the machine would meet. For example, machines below 19 kW rated under Bharat (Trem) Stage III meet the Tier 1 standard, but not Tier 2.

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V

Region	Net power (kW)			1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Japan	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P ≤ 560																										
European Union, Switzerland, United Kingdom	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										
	P > 560																										
South Africa	18 ≤ P ≤560																										

Source: Elaborated by CALAC+, 2020a

In 2020, the Chinese government updated the emission standards for NRMM. The new standards, to be implemented in December 2022, will be equivalent to Stage IIIB limits but upgraded to meet some requirements of the Euro Stage V standards (ICCT, 2021). This analysis is available at: https://theicct.org/publications/china-iv-non-road-emission-standards-jul2021.

Based on the characterisation of the NRMM regulation from different case studies, some practices are identified that could be used as a reference for NRMM emissions control in Latin America. Some of these practices are mentioned below:

- The US, EU, Switzerland and UK have established engine-based regulations which favours the development of concise and practical instruments for classifying types of NRMM. This perspective reduces the risk of loopholes compared to an emission regulation based on machinery typologies. For Latin America, these strategies can be taken in combination with some of the criteria for defining NRMMs, in order to establish effective control and follow-up mechanisms for the standards to be proposed.

- In Switzerland, at the federal level, the control and inspection of machinery is carried out on the basis of commercial information that the private sector is able to provide at the request of the Federal Office for the Environment. In addition, the cantons (states that make up the Swiss Federation) have the power to establish their own complementary control mechanisms. These can be varied and include site visits, emission measurements, among others.

- Emission regulation for NRMM is mostly focused on the implementation of emission standards for new machinery fleets; however, natural machinery replacements are slow processes that can take several decades and for this reason, it is advisable to implement short-term machinery emission control strategies on existing fleets. The Swiss experience is highlighted here as a global pioneer since the 1990s in implementing DPF filter policies for the reduction of particulate matter in in-use machinery.

- The guidance of the European Union and the United States towards emission controls at the manufacturing stage of engines and certification tests that guarantee emission levels that comply with the regulation during their useful life is highlighted. In this regard, manufacturers –and not only the user of the machinery– are responsible for emissions. This approach poses the challenge of guaranteeing emission standards during the time of use for which the emission certificate was issued (useful life).

- The State of California has implemented the DOORS platform for machinery owners to register the equipment purchased and scrapped each year, allowing them to monitor the operation time of the machinery. This is a model with defined roles and responsibilities to track machinery from its manufacture, usage time and its final disposal or need for overhaul.

- There is synergy between NRMM pollution reduction and other environmental programmes. This can be achieved by linking NRMM regulation with established national or local air quality programmes (e.g., Asia-Pacific and India), as well as with greenhouse gas emission mitigation programmes.

As a complementary aspect to the documentary reviews, interviews were carried out with government stakeholders, private sector consultants and machinery importing companies in the countries targeted by the CALAC+ programme, and the main aspects were identified as follows:

- Effective regulation of NRMM emission limits must be accompanied by programmes on best practices in machinery operation and maintenance.
- Other instruments that can also contribute to reducing NRMM pollution include local decontamination plans, implementation of sustainable building standards, private sector sustainability plans and greenhouse gas emission reduction targets.
- The operation and inspection of machinery could be more efficient if linked to construction permits issued by local or state authorities for their works.
- The specifics of each sector that uses machinery (construction, mining, industry, agriculture, forestry) should be considered in order to establish the regulatory framework for NRMM according to its context and impact. There are sectors in which regulatory prioritization is necessary due to the high levels of exposure for the operating personnel or for the population around the area of influence of NRMM emissions. For example, it is possible to make exclusions for social and/or economic reasons, as is the case for the agricultural sector in several of the cases analysed.
- The private sector has a key role in reducing air pollution generated by NRMM. It can be a leader in the implementation of socially and environmentally responsible practices, by anticipating and cooperating with the public sector. These practices can in turn be encouraged and recognised by the public sector as they are currently being implemented.

Finally, the potential for collaboration in Latin America to develop instruments for the control of NRMM emissions is highlighted. Joint working schemes allow to take advantage of lessons learned in different countries. In addition, joining the efforts of the community of practice in the region is an effective way to overcome some of the limitations of individual countries.

3. Methodology

A review of 16 selected case studies was carried out based on the identification of the countries with the most advanced emission standards for combustion engines. Consideration was also given to incorporating the experiences of countries importing machinery to Latin America. The case studies include the European Union, one city (London), and other countries listed in the Table 3. 1

The review focused on regulatory documents for each case study, covering environmental, transport and trade sector regulations, among others, which are the sectors where standards associated with NRMM were identified. Previous studies from indexed literature and the community of practice were also reviewed.

Table 3. 1. Case studies.

North America	South America	Asia-Pacific	Europe	Africa
United States	Brazil Chile	China	European Union	South Africa
Canada	Colombia	South Korea	London	
Mexico	Peru	India	United Kingdom	
		Japan	Switzerland	

Source: own elaboration.

In addition, interviews were conducted with people working with machinery in the countries where the CALAC+ Programme operates, in order to better understand the context and identify key aspects for the control of NRMM emissions that are not necessarily reflected in the current regulations. The interviews identified points of view on the application of regulations in the countries of the region.

4. Definitions of non-road mobile machinery

This section presents a compilation of the definitions given to the term NRMM in each of the case studies.

From the review, different characteristics were identified that are used to define what is included in the NRMM category. The most common characteristics and some examples are presented in the table below.

Table 4. 1. Characteristics used to define NRMM.

Criterion	Definition
Equipment portability and mobility	The definition states whether the vehicle or machinery in question is part of self-propelled, handheld or portable equipment.
Functionality	In some cases, the classification of NRMM is made according to the main function of the vehicle or machinery, and refers to those that are not primarily intended to transport passengers or goods. NRMM is also referred to when it is part of equipment intended to propel itself while performing some function (e.g., lawn mower).

Criterion	Definition
Specific function	There are cases where rather than giving a general definition, a number of specific equipment are listed that make up the NRMM group. E.g., China: machinery for excavation, earthmoving, lifting machinery, forklifts, compactors, road construction and maintenance, machinery used for concrete, tunnel manufacturing, rock drilling machinery; agricultural machinery; airport ground handling equipment; loading and unloading equipment; snow ploughing equipment and industrial drilling equipment. This criterion is also used in India.
Time spent at one location	Some definitions include this criterion to define a vehicle or machinery as an NRMM. For example, in the United States, they are excluded if the equipment remains in one place for more than 12 consecutive months.
Power rating	One of the most common criteria is to use the power rating for classifying a vehicle or machinery within the NRMM category.
End-use sector	In some cases, the definition of NRMM is made according to the end-use sector of the vehicle or machinery in question. For example, only those used for the construction and mining sectors. In some cases, the agricultural sector is included in the NRMM category, in others it is excluded.
Circulation permit	In cases such as Japan and Peru, the definition is explicit in that NRMM does not have a circulation permit.
Registration	Registration is another criterion considered in the definitions. In cases such as Japan, the definition specifies that the NRMM has no registration.

Source: own elaboration.

Taking into account the aforementioned criteria, it was identified in which case studies these criteria are used to define the NRMM (see Table 4. 2).

Table 4. 2. Criteria used to define NRMM in the case studies.

Case study → Criterion ↓	United States	Canada	Brazil	Colombia	Mexico	Peru	Chile	China	India	Japan	South Korea	European Union	United Kingdom	London	Switzerland	South Africa
Portability and mobility	✓	✓		✓	✓		✓	✓		✓		✓	✓	✓	✓	✓
Functionality	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Specific function	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓	✓
Time spent at one location	✓	✓														
Power range							✓	✓								
End-use sector			✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓

Circulation permit										✓						
Registration										✓						

Source: own elaboration.

North America

4.1. Canada

According to the Government of Canada's Guidance Document on Off-Road Compression-ignition Engine Regulations (2012), for an internal combustion engine to be classified as an off-road machinery engine, it must meet the following criteria:

i) It is (or will be) used in or on a piece of equipment that is self-propelled or serves a dual purpose by both propelling itself and performing another function (such as garden tractors, bulldozers, etc.).

ii) It is (or will be) used in or on a piece of equipment that is intended to be propelled while performing its function (such as lawnmowers).

iii) By itself or in or on a piece of equipment, it is handheld or portable, meaning designed to be and capable of being carried or moved from one location to another. Indicia of transportability include, but are not limited to, wheels, skids, carrying handles, dolly, trailer, or platform.

Most of the regulated engines are diesel-fuelled engines and are used in the construction, agricultural, forestry and mining sectors. This includes among others: tractors, excavators, log skidders, heavy haulers, bulldozers, handheld generators, as well as engines that supply electricity to a machine (e.g., refrigeration units).

According to the Government of Canada's Guidance Document on Off-Road Compression-ignition Engine Regulations (2012), the excluded engines are:

- Engines designed to propel an aircraft (e.g., an airplane)
- Engines designed to propel rolling stock (e.g., a locomotive).
- Compression-ignition marine engines rated at 27 kW and above and designed to propel a vessel.
- Engines that are used by on-road vehicles (e.g., a diesel-fuelled passenger car).
- Engines designed for competition and bearing a label to that effect.
- Engines designed exclusively for use in underground mining and open pit mining and which are certified by the Canadian Centre for Mineral and Energy Technology (CANMET) and the Mine Safety and Health Administration (MSHA).
- Engines that have a per cylinder displacement of less than 50 cm^3.
- Engines designed exclusively in military machines designed for combat or combat support and bearing the combat use label.
- Engines being exported and accompanied by a written statement indicating that they will not be sold for use in Canada.
- Marine inboard engines.
- Stationary engines that bear a label.

- Engines used exclusively to provide electricity for small communities[5] in remote areas and bearing a label to that effect.
- Engines mounted on electric generators used in back-up or emergency service.

4.2. United States

The definition and regulation related to non-road mobile machinery is mainly based on the criteria of portability and mobility of the equipment on which the engines are installed. The regulation set forth in Chapter 40 of the Code of Federal Regulations (CFR) states, in different parts of it, that a non-road engine[6] corresponds to any type of internal combustion engine that meets any of the following three characteristics:

- It is (or will be) used in or on a piece of equipment that is self-propelled or serves a dual purpose by both propelling itself and performing another function (such as garden tractors, bulldozers, etc.).
- It is (or will be) used in or on a piece of equipment that is intended to be propelled while performing its function (such as lawnmowers).
- By itself or in or on a piece of equipment, it is handheld or portable, meaning designed to be and capable of being carried or moved from one location to another.

An internal combustion engine is not a non-road engine if it meets any of the following criteria:

- The engine is used to propel a motor vehicle, an aircraft, or equipment used solely for competition.
- The engine is a stationary power source and is regulated under 40 CFR 60.
- The equipment remains at a location for more than 12 consecutive months, or a shorter period for an engine located at a seasonal source. A seasonal source is a stationary source that remains in a single location on a permanent basis and that operates at that single location approximately three months each year.

The following equipment is categorically outside the definition of the aforementioned regulations:

- Aircraft equipment.
- Mining equipment. Mining machinery is regulated by the *Mining Safety and Health Administration* in 30 CFR Mineral Resources. 40 CFR § 1039.5 states that this equipment is excluded.
- Locomotives, which are regulated by 40 CFR 92.
- Navigation equipment, regulated by 40 CFR 94.
- Hobby equipment[7] : Small-scale models not suitable for transporting a person.

The definitions and regulations are further subdivided on the basis of the following properties:

[5] Communities that are not connected to an electricity grid (an interconnected system that distributes electricity over a wide area, usually through a network of high-voltage cables and power plants).
[6] Non-road engine.
[7] Hobby engine.

- Compression ignition combustion engines are classified according to the rated power in units of kilowatts (kW).
- Spark-ignition combustion engines are classified by class according to the displacement volume of the pistons in units of cubic centimetres (cc) (see Table 4. 3).

Table 4. 3. Engine classes according to piston displacement volume.

Phase[8]	Non-handheld				Handheld		
Phase 1	Class I < 225 cc		Class II ≥ 225 cc		Class III < 20 cc	20 cc ≤ Class IV < 50 cc	Class V ≥ 50 cc
Phase 2	Class IA < 66 cc	66 cc ≤ Class IB < 100 cc	100 cc ≤ Class I < 225cc	Class II ≥ 225 cc			
Phase 3	Class I < 225 cc		Class II ≥ 225 cc				

Source: own elaboration.

4.3. Mexico

At the moment, the draft standards that seek to regulate emissions from non-road vehicles in Mexico are under discussion, so there is still no binding regulatory document that classifies the types of machinery to be regulated and defines the emission standards that they must adhere to.

The *Instituto Nacional de Ecología y Cambio Climático* (INECC) (National Institute of Ecology and Climate Change), together with institutions such as the *LTME Center for Energy and Environment*, developed the study "*Caracterización de las emisiones de fuentes móviles fuera de carretera con motor diésel en México con y sin filtro de partículas"* (Characterisation of emissions from off-road mobile sources with diesel engines in Mexico with and without particulate filters), based on the following technical definition for non-road vehicles:

> **Non-road vehicles:** those sources such as handheld generators, forklifts, special vehicles and a wide range of other equipment used in agriculture, construction and industry, which do not have a road permit to travel on streets or highways due to their weight, size, design or low speed. One of the characteristics of this type of equipment is that due to their power requirements they use diesel as fuel and generally do not have technology to control their emissions, so they can become large emitters of polluting gases, black carbon, organic matter and other particulate matter components**.** (INECC, 2014)

With regard to the definitions of agricultural machinery provided for in the technical standards for tractors, the standard NMX-O-153 (1981) of the *Secretaría de Comercio y Fomento Industrial* (Ministry of Commerce and Industrial Development), defines agricultural machinery as follows:

> **Agricultural machinery:** "is a set of mechanisms, intended to supply, transform, transfer, apply or regulate any type of energy, in order to carry out or assist agricultural work and which is permanently intended for such work."

[8] No categorical definition of the term "Phase" was found. According to its usage it seems to be a term of a lower level than "Tier". It would appear to be the name of the compliance level for spark ignition and handheld engines.

South America

4.4. Brazil

In Brazil, Resolution 433 (2011) of the National Environmental Council was the first to establish emission and noise limits for agricultural and construction machinery. This regulation establishes emission limits equivalent to Tier 3 technologies in the United States and Stage III in the European Union (DieselNet, 2019). Generally, Brazilian regulations classify its off-road machinery as agricultural and construction machinery which are defined as follows:

- **Agricultural machine:** self-propelled machine with wheels or tracks, which has equipment or attachments designed primarily for soil preparation, sowing, cultural treatments, harvesting of agricultural and forestry products.
- **Construction machine:** self-propelled machine with wheels, tracks or legs, which has equipment or attachments designed primarily for trenching, digging, loading, carrying, transporting, spreading or compacting earth and similar materials.

Note: It is important to note that no explicit definition was identified for non-road mobile machinery but for machinery in certain categories.

4.5. Chile

On 21 October 2021, the emission standard for mobile machinery, which applies to non-road mobile machinery, was published in the official gazette, in which all imported machinery with a power between 19 and 560 kW will be required to meet the Stage IV or V regulatory standard 24 months after publication of the standard, with the exception of tractors, which will have a period of 30 months.

The Decree defines mobile machinery and engine types or engine families as follows:

> **Mobile machinery:** machinery not intended for the carriage of passengers or goods by road, capable of travelling on the ground, with or without a road, and powered by compression-ignition internal combustion engines with a net installed power of 19 kW or above but not exceeding 560 kW. Excluded are engines intended for the propulsion of railcars, locomotives or other railway or rail-borne equipment, ships, aircraft and recreational vehicles.
>
> **Engine type or engine family:** manufacturer's grouping of engine types which, by design, have similar exhaust emission characteristics and comply with the applicable emission limit values.

4.6. Colombia

In Law 769 (2002) of the Congress of the Republic, whereby the *Código Nacional de Tránsito Terrestre* (National Land Traffic Code) is issued, and other provisions are enacted, Article 2 includes the following definitions:

> "**Agricultural vehicle**": A motor vehicle with a special configuration, intended exclusively for agricultural work.
>
> (...)
>
> **Construction or mining rolling stock:** A self-propelled vehicle intended exclusively for industrial works, including mining, construction and maintenance works, which due to its technical and physical characteristics cannot travel on public or private roads open to the public.

On the other hand, in August 2022, Resolution 762 of 2022 came into force: *By which the maximum permissible pollutant emission limits to be met by land mobile sources are regulated, articles 2.2.5.1.1.6.1, 2.2.5.1.8. 2 and 2.2.5.5.1.8.3 of Decree 1076 of 2015* are regulated and other provisions of the Ministry of Environment and Sustainable Development of Colombia are adopted, which defines off-road mobile land sources and the engines that are intended for these as follows:

> "Off-road land mobile source: A mobile machine, portable equipment or vehicle with or without bodywork or with or without wheels, powered by an internal combustion engine, which is not designed for the carriage of passengers or goods by road. This category does not include constant speed engines, railway equipment, electric generators and recreational vehicles.
>
> (...)
>
> Electric off-road land mobile source: A mobile machine powered exclusively by one or more electric engines, drawing current from a rechargeable energy storage system, such as batteries or other handheld electric energy storage devices, including hydrogen fuel cells or drawing current through catenaries. These machines do not have internal combustion engines or on-board electrical generation systems as a means of supplying electrical power. "

4.7. Peru

In accordance with the National Vehicle Regulations approved by Supreme Decree No. 058-2003-MTC, they are considered as Yellow Machine and Green Machine, and their definition was included through the amendment of Supreme Decree No. 019-2018-MTC.

Yellow machine: machine or equipment designed and manufactured to be used exclusively in the construction or mining industry, which is not considered a special vehicle or for special use. It is not intended to circulate within the *Sistema Nacional de Transporte Terrestre* (SNTT) (National Land Transport System).

Green machine: machine or equipment designed and manufactured to be used exclusively in the agricultural or forestry industry, which is not considered a special vehicle or for special use. It is not intended to circulate within the *Sistema Nacional de Transporte Terrestre* (SNTT) (National Land Transport System).

In this regard, it is also important to note the definitions of special vehicle and vehicle of specific operation or use in the National Vehicle Regulation approved by Supreme Decree No. 058-2003-MTC:

Amendment introduced by Supreme Decree No. 002-2005-MTC, published on 22 January 2005, which reads as follows:

Special vehicles: These are self-propelled or towed vehicles, including their combinations, which, due to their particular design features and because they are intended to carry out specific works or services, do not comply with the weights, dimensions, emissions or other provisions established in the Regulation.

Machines and equipment designed and manufactured exclusively for use outside the SNTT, in the construction, mining and agricultural industries (yellow machines and green machines) are not considered special vehicles.

Special combinations listed in Annex I: Vehicle Classification, which comply with the weights, measures, emissions or other provisions laid down in this Regulation are not considered as special vehicles.

Amendment introduced by Supreme Decree No. 019-2018-MTC, published on 10 December 2018, which reads as follows:

Specific operation or use vehicle: A vehicle which by virtue of its particular design features (construction or modification) is specially equipped with devices or machinery which serve to perform specific operational functions or services other than transport as such. These vehicles are not essentially designed or intended for the carriage of persons or goods. Their nature is determined by their specific or special use, depending on the type of bodywork fitted.

Likewise, it should be noted that the *Texto Único Ordenado del Reglamento Nacional de Tránsito - Código de Tránsito* (Single Ordered Text of the National Traffic Regulation - Traffic Code) (2009) approved by Supreme Decree No. 016-2009-MTC, includes a definition of special machinery in its article 2 under definitions:

Special machinery: motor vehicle whose purpose is not the transport of persons or cargo and which occasionally uses public roads.

Asia-Pacific

4.8. China

Regulations in China cover the model year inspection, manufacturing, air pollutant emission, in-use inspection and durability of non-road mobile machinery (equipment or engines) (Ministry of Ecology and Environment of the People's Republic of China, 2020).

The type of machinery regulated includes machinery used in construction covering excavation, earthmoving, lifting machinery, forklifts, compactors, road construction and maintenance, machinery used for concrete, tunnelling, piling, aerial lift machinery, rock drilling machinery; agricultural machinery; airport ground handling equipment; loading and unloading equipment; snow ploughing equipment and industrial drilling equipment.

Within stationary machines or engines, the regulations cover air compressor equipment, generators, machinery used in fishing (aerators, pond diggers, etc.) and water pumps.

The definitions of NRMM can be found in the GB20891 (2014) regulation of the Ministry of Ecology and Environment of the People's Republic of China, which states:

> **Non-road mobile machinery**: "self-driven or double function; machinery self-driven and operating other functions; machinery which fails to be self-driven but is designed to be capable of moving or being moved from one place to another place. ".

Likewise, the same regulation GB20891 (2014b) of the Ministry of Ecology and Environment of the People's Republic of China classifies non-road mobile machinery according to its power into:

> **Diesel engine:** "engine with a power range below or equal to 560 kW".
>
> **Gasoline engine:** "engine with a power range below or equal to 19 kW".

On the other hand, according to the mandatory regulation GB 19756 (2005) of the Ministry of Ecology and Environment of the People's Republic of China, off-road machinery that is classified as a low-speed three-wheeled or four-wheeled vehicle is defined as:

> **Three-wheeled vehicle**: "vehicles whose maximum speed is less than or equal to 50 km/h".
>
> **Low-speed vehicles**: "four-wheeled vehicles with a maximum speed of 70 km/h or less".

In addition to the previously mentioned definitions of off-road machinery, regulation GB 20891 of the Ministry of Ecology and Environment of the People's Republic of China sets out definitions for secondary engines as follows:

> **Secondary engine:** "Diesel engine, which is mounted for road vehicle, does not provide driving force for vehicles but provides power for vehicle-mounted special facilities ".

4.9. South Korea

In South Korea, emission limit values are set based on the ruling of the Clean Air Conservation Act of 2007, currently Ministry of Environment Ordinance No. 17797 of December 29, 2020, where they are defined in Article 2:

- Motor vehicles means any of the following:
    a) Motor vehicles prescribed by Ordinance of the Ministry of Environment among those defined in subparagraph 1 of Article 2 of the Motor Vehicle Management Act; and
    b) Construction machinery prescribed by Ordinance of the Ministry of Environment, the driving characteristics of which are similar to those of motor vehicles referred to in item (a) among the construction machinery defined in Article 2, paragraph 1 of the Construction Machinery Management Act.

- The term "motor" means any of the following:
    c) Devices which generate electric power for construction machinery prescribed by Ordinance of the Ministry of Environment, other than construction machinery defined in subparagraph 13 (b), among the construction machinery defined in Article 2(1) 1 of the Construction Machinery Management Act; and
    d) Devices which generate electric power for machinery prescribed by ordinance of the Ministry of Environment and used for agricultural, forestry or marine purposes.

Vehicle classifications are prescribed by the Motor Vehicle Management Act of the Ministry of Land Infrastructure and Transport, which defines in its article 3, numeral 4, among other categories:

- *Special motor vehicle*: A motor vehicle suitably manufactured to perform towing other motor vehicles, rescue work, or other special tasks and that is neither a passenger motor vehicle, a motor vehicle for passengers and freight, nor a freight motor vehicle (corresponding definitions in Article 3(1) and 3(2) of the Motor Vehicle Management Act, 2017).

According to the Construction Machinery Management Act, this is defined in Article 2, paragraph 13:

- *Construction machinery*: machinery that can be used for construction works, which is prescribed by Presidential Decree (Clean Air Conservation Act, Laws and Regulations, 2008).

4.10. India

According to notification S.O.1248(E) (Government of India, 2004) Table 1, in exercise of the powers conferred by sub-section (4) of section 41 of the Motor Vehicles Act, 1988, the Government of India defines two types of motor vehicles:

(1) Transport vehicles; and

2) Non-transport vehicles, or vehicles for purposes other than transport.

Vehicles for purposes other than transport are defined in Chapter 1 of the Central Motor Vehicles Rules 1989, paragraph 2 (h) as motor vehicles whose primary function is other than the transport of goods or passengers (Ministry of Road Transport & Highways, 1989).

The category of non-transport vehicles includes fleet such as agricultural vehicles or construction machinery and others, as made explicit in the first table of the notification S.O.1248(E):

- Motorcycle with or without side car for personal use, mopeds with engine capacity exceeding 25 cc, invalid carriage, three-wheeled vehicles for personal use.
- Forklifts, vehicles or trailers fitted with equipment such as rig, generator and compressor, crane-mounted vehicles.
- Agricultural tractors or power tillers.
- Private service vehicles registered in the name of an individual and declared to be used by the individual solely for personal purposes, camper van or trailer for private use.
- Tow trucks, breakdown vans, recovery vehicles, tower wagons and tree-trimming vehicles owned by central, state or local authorities.
- Construction equipment vehicles whose use on public roads is incidental to the main off-road function. However, when the public road is being used regularly for carrying on commercial activities, then Construction Equipment Vehicles such as dumpers and excavators being used for such activities, shall be deemed as transport vehicles.

In addition, according to the Central Motor Vehicles Rules 1989, Chapter 1, the terms are defined in its numeral 2:

- **Agricultural tractor**: any mechanically propelled four-wheeled vehicle designed to work with suitable implements for various field operations and/or trailers to transport agricultural products or materials. Agricultural tractor is a non-transport motor vehicle;
- **Combine harvester:** agricultural equipment vehicle, self-propelled or agricultural tractor powered type (either coupled to the trailer for header assembly or any other attachment of the machine) designed to perform more than one of the following tasks namely:
  i. Picking, harvesting, threshing, separating, cleaning, chopping, collecting and unloading crop or agricultural produce, such as a grain, sugarcane, cotton, fodder, straw or stalk, while moving through the standing crop or agricultural produce;
  ii. Agreement of bagging with a pick-up attachment to use it for handling crop that has been swathed.
  A combine harvester shall be a non-transport motor vehicle, the driving on the road of which is incidental to the main intended use in the fields and for travelling from one field to another, for short durations, at a speed not exceeding thirty kilometre per hour (Ministry of Road Transport & Highways, 1989).

- **Construction equipment vehicles:** it refers to rubber tyred (including pneumatic tyred), rubber padded or steel drum wheel mounted, self-propelled, excavator, loader, backhoe, compactor roller, dumper, motor grader, mobile crane, dozer, fork lift truck, self-loading concrete mixer or any other construction equipment vehicle or combination thereof designed for off-highway operations in mining, industrial undertaking, irrigation and general construction but modified and manufactured with "on or off" or "on and off" highway capabilities. A construction equipment vehicle shall be a non-transport vehicle the driving on the road of which is incidental to the main off-highway function and for a short duration at a speed not exceeding 50 kms per hour. This category does not include other purely off-road construction equipment designed and adopted for use in enclosed premises, factories or mines, or sites other than a road network, not equipped to travel on public roads by its own means (Ministry of Road Transport & Highways, 1989)

Finally, according to the Motor Vehicles Act (Ministry of Road Transport & Highways, 1988) in its numeral 2, although definitions for off-road vehicles are not properly identified, classifications are provided in which some of these may be included, specifying:

- **Tractor:** a motor vehicle which is not itself constructed to carry any load (other than equipment used for the purpose of propulsion); but excludes a road-roller.
- **Motor vehicle**: any mechanically propelled vehicle adapted for use upon roads whether the power of propulsion is transmitted thereto from an external or internal source and includes a chassis to which a body has not been attached and a trailer; but does not include a vehicle running upon fixed rails or a vehicle of a special type adapted for use only in a factory or in any other enclosed premises or a vehicle having less than four wheels fitted with engine capacity of not exceeding 1 [twenty-five cubic centimetres];.
- **Heavy goods vehicle:** any goods carriage the gross vehicle weight of which, or a tractor or a road-roller the unladen weight of either of which, exceeds 12,000 kilograms.
- **Light motor vehicle**: a transport vehicle or omnibus the gross vehicle weight of either of which or a motor car or tractor or road-roller the unladen weight of any of which, does not exceed 1 [7500] kilograms.

4.11. Japan

The term **non-road vehicles** as used in the definitions provided from Article 2 of Chapter 1 in Law No. 51 of May 25, 2005 of the Japanese Ministry of the Environment refers to those motor vehicles, as defined in Article 2, Paragraph 2 of the Road Vehicles Act (Law No. 185 of 1951) except for equipment for towing other vehicles and other equipment specified by order of the Cabinet of Japan (2005):

1. Large-sized special motor vehicles and special small-sized special motor vehicles provided for in Article 3 of the Road Vehicles Act; and
2. Motor vehicles that fall under the category of construction machinery provided for in Article 2 of the Construction Machinery Hypothecation Act (Act No.97 of 1954) (except those enumerated in the preceding item) and other motor vehicles which have special structures and which shall be specified by Japanese Cabinet order.

The term **non-road engine** as used in this Act means an engine which is installed in a non-road vehicle and a device which is installed in a unibody therewith which is specified by order of the competent ministry (Act on Regulations for Emissions from Non-Road Vehicles (Act No. 51 of May 25, 2005).

The term **emissions from non-road vehicles** as used in this Act refers to substances such as carbon monoxide, hydrocarbons and lead[9] generated by the use of non-road special motor vehicles which may possibly cause damage to the human health or living environments and which shall be specified by the Japanese Cabinet order. (Act on Regulations for Emissions from Non-Road Vehicles (Act No. 51 of May 25, 2005).

[9] Regarding other pollutants, the Ministry of Environment has continuously revised and regulated its emission standards for PM and NOx as well as HC and CO according to the successive reports of CEC recommendations, with the eleventh report in 2012 being the latest one in force as of 2019. Regarding particulate matter, Japan has set ambient standards for $PM_{2.5}$ in September 2009 and since then has been developing a national measurement system for this pollutant, which, following the eleventh report, has updated its measurement method to the use of opacimeters. (CEC, 2012).

Emission standards for so-called special motor vehicles (all intended for off-road operation) apply to vehicles with engines rated between 19-560 kW categorised into two types:

i. **Special motor vehicles:** "self-propelled non-road vehicles as well as machinery that are registered for operation on public roads (fitted with license plates)" (Dieselnet, 2016). "This is a type of motor vehicle that could be operated on public roads such as an agricultural tractor or a forklift" (Act on Regulations for Emissions from Non-Road Vehicles (Act No. 51 of May 25, 2005). Special motor vehicles can be specified as motor vehicles other than ordinary sized motor vehicles, small-sized motor vehicles and mini-sized motor vehicles and other than passenger vehicles, trucks or buses. These vehicles have registration plates and could possibly be used on the road even though this is not their place of operation (LEMA, 2019)

ii. **Non-road special motor vehicles:** "self-propelled and non-registered non-road vehicles and machinery" (Dieselnet, 2016). "These are a type of motor vehicle that never travels on a public road such as a bulldozer or a construction crane tower" (Act on Regulations for Emissions from Non-Road Vehicles (Act No. 51 of May 25, 2005). Non-road special motor vehicles are those mobile machines for non-road operation that are propelled on the ground by the engine installed in the vehicles just like special-purpose vehicles, but differ from these in that non-road special motor vehicles never travel on public roads, do not have license plates and are used in other non-road locations (LEMA, 2019)

"Engines installed in either special motor vehicles or non-road special motor vehicles are intended to use for propelling its vehicles, as well as for promoting work on construction sites where they are used". (LEMA, 2019)

For special motor vehicles and non-road special motor vehicles with an engine installed capacity between 19 and 560 kW, emission limits have been specified under the provision of the Air Pollution Control Act (Act No. 97 of 1968) and legislative control is to be performed by the Non-road Vehicle Emission Regulation Act (Act No. 51 of 25 May 2005). (Dieselnet, 2016)

Europe

4.12. European Union

For the European Union and the United Kingdom, the same provisions apply as those presented for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

4.13. Switzerland

The emission regulations for non-road mobile machinery in Switzerland are based on the Ordinance on Air Pollution Control (OAPC) issued by the Swiss Federal Council in 1985 (Ordinance of 16 December 1985 on Air Pollution Control (OAPC), 2020) where it is stated in its annex 4, section 4, that internal combustion engines of machinery and equipment must comply with the requirements set out in Regulation (EU) No. 2016/1628 (2016) which defines:

- **Non-road mobile machinery:** any mobile machine, portable equipment or vehicle with or without bodywork or wheels, not intended for the transport of passengers or goods on roads, and includes machinery installed on the chassis of vehicles intended for the transport of passengers or goods on roads.
- **Mobile crane:** a self-powered jib crane capable of travelling on-road or off-road or both, and relying on gravity for stability and operating on tires, crawlers or with other mobile arrangements.
- **Generating set:** an independent non-road mobile machine that is not part of a power train, primarily intended to produce electric power.
- **All-terrain vehicle (ATV):** a motorized vehicle, propelled by an engine, intended primarily to travel on unpaved surfaces on four or more wheels with low-pressure tires, having a seat designed to be straddled by the driver only, or a seat designed to be straddled by the driver and a seat for no more than one passenger, and handlebars for steering.
- **Side-by-side (SbS) vehicle:** a self-propelled, operator-controlled, non-articulated vehicle intended primarily to travel on unpaved surfaces on four or more wheels, having a minimum unladen mass, in running order, of 300 kg (including standard equipment, coolant, lubricants, fuel and tools but excluding optional accessories and the driver) and a maximum design speed of 25 km/h or more; such a vehicle is also designed to transport persons and/or goods, and/or to pull and push equipment, is steered by a control other than a handlebar, is designed for recreational or utility purposes and carries no more than six people including the driver, sitting side by side on one or more non-straddle seats.
- **Railway vehicle:** a non-road mobile machinery that operates exclusively on railway track.
- **Auxiliary railway vehicle:** a railway vehicle that is not a railcar or locomotive, including but not limited to a railway vehicle specifically designed to perform maintenance or construction work or lifting operations associated with the track or other infrastructure of the railway.
- **Locomotive:** a railway vehicle designed to provide, either directly through its own wheels or indirectly through the wheels of other railway vehicles, the motive power for propelling itself and for propelling other railway vehicles that are designed to carry freight, passengers and other equipment, itself being designed or intended not to carry freight or passengers, other than those operating it.

- **Railcar:** a railway vehicle designed to provide, either directly through its own wheels or indirectly through the wheels of other railway vehicles, the motive power for propelling itself, and is specifically designed to carry goods or passengers, or both goods and passengers, and is not a locomotive.
- **Snowmobile:** a self-propelled machine that is intended for off-road travel primarily on snow, is driven by tracks in contact with snow and steered by a ski or skis in contact with the snow, and has a maximum unladen mass, in running order, of 454 kg (including standard equipment, coolant, lubricants, fuel and tools but excluding optional accessories and the driver).
- **Snow thrower:** a self-powered machine that is exclusively designed for clearing snow from a paved surface by collecting a quantity of snow and projecting it forcefully through a chute.
- **Tractor:** Motorised, wheeled or tracked agricultural or forestry vehicle having at least two axles and a maximum design speed of not less than 6 km/h, the main function of which lies in its tractive power and which has been especially designed to pull, push, carry and actuate certain interchangeable equipment designed to perform agricultural or forestry work, or to tow agricultural or forestry trailers or equipment; it may be adapted to carry a load in the context of agricultural or forestry work and/or may be equipped with one or more passenger seats'.

In addition to the above, the categorisation of engines according to the mobile source for which they are intended is important to understand the definition and distinction of non-road mobile machinery from other types of mobile sources. This categorisation is found in Article 4 of the aforementioned regulation:

- Category NRE (Non-Road Engines):
    a) engines for non-road mobile machinery intended and suited to move, or to be moved, by road or otherwise, that are not excluded under Article 2(2) and are not included in any other category set out in points 2 to 10 of Article 4; and
    b) engines having a reference power of less than 560 kW used in the place of Stage V engines of categories IWP, IWA, RLL or RLR.

Table 4. 4. Subcategories for NRE engines.

Category	Ignition type	Speed operation	Power range (kW)	Subcategory	Reference power
NRE	CI[10]	Variable	0 < P < 8	NRE-v-1	Maximum net power
	CI		8 ≤ P < 19	NRE-v-2	
	CI		19 ≤ P < 37	NRE-v-3	
	CI		37 ≤ P < 56	NRE-v-4	
	All		56 ≤ P < 130	NRE-v-5	
			130 ≤ P ≤ 560	NRE-v-6	
			P > 560	NRE-v-7	
	CI	Constant	0 < P < 8	NRE-c-1	Net rated power
	CI		8 ≤ P < 19	NRE-c-2	
	CI		19 ≤ P < 37	NRE-c-3	

[10] *Compression Ignition*

Category	Ignition type	Speed operation	Power range (kW)	Subcategory	Reference power
	CI		37 ≤ P < 56	NRE-c-4	
	All		56 ≤ P < 130	NRE-c-5	
			130 ≤ P ≤ 560	NRE-c-6	
			P > 560	NRE-c-7	

Source: European Parliament and Council (2016).

- Category NRG (non-road generators): engines having a reference power that is greater than 560 kW, exclusively for use in generating sets; engines for generating sets other than those having those characteristics are included in the categories NRE or NRS, according to their characteristics.

Table 4. 5. Subcategories for NRG engines.

Category	Ignition type	Speed operation	Power range (kW)	Subcategory	Reference power
NRG	All	Variable	P > 560	NRG-v-1	Maximum net power
		Constant	P > 560	NRG-c-1	Net rated power

Source: European Parliament and Council (2016).

- Category NRSh (non-road SI handheld engines): handheld SI engines having a reference power that is less than 19 kW, exclusively for use in handheld machinery.

Table 4. 6. Subcategories for NRSh engines.

Category	Ignition type	Speed operation	Power range (kW)	Swept volume (cm^3)	Subcategory	Reference power
NRSh	SI[11]	Variable or constant	0 < P < 19	SV < 50	NRSh-ª-1a	Maximum net power
				SV ≥ 50	NRSh-v-1b	

Source: European Parliament and Council (2016).

- Category NRS (non-road spark ignition engines): SI engines having a reference power that is less than 56 kW and not included in the category NRSh.

Table 4. 7. Subcategories for NRS engines.

Category	Engine type	Speed operation	Power range (kW)	Swept volume (cm^3)	Subcategory	Reference power
NRS	YES	Variable ≥ 3600 rpm or constant	0 < P < 19	80 ≤ SV < 225	NRS-vª-1a	Maximum net power
				SV ≥ 225	NRS-vr-1b	
		Variable < 3600 rpm		80 ≤ SV < 225	NRS-vª-1a	

[11] *Spark Ignition*

Category	Engine type	Speed operation	Power range (kW)	Swept volume (cm^3)	Subcategory	Reference power
				SV ≥ 225	NRS-vi-1b	
		Variable or constant	19 ≤ P < 30	SV ≤ 1 000	NRS-ª-2a	Maximum net power
				SV > 1 000	NRS-v-2b	
			30 ≤ P < 56	Anyone	NRS-v-3	Maximum net power

For engines < 19 kW with swept volume < 80 cm^3 in machinery other than handheld machinery, engines of the category NRSh shall be used.

Source: European Parliament and Council (2016).

Additionally, Regulation (EU) 1628 of 2016 defines other categories of non-road engines such as IWP and IWA (inland waterway vessels and auxiliary engines), RLL (locomotive engines), RLR (railcars) and SMB (snowmobile engines) which are not presented in this document given their scope; however, in case you want to know the classifications for these categories, see European Parliament and Council (2016).

Africa

4.14. South Africa

According to Report No. GRPE-50-20 of 2005 on Vehicle Emission Legislation for Agricultural Tractors, published in the Gazette of the Republic of South Africa, paragraph 4.2, the exhaust emission from the engine of an agricultural tractor shall be such that it complies with the applicable regulations in force promulgated under the Atmospheric Pollution Prevention Act of 1965 (Act 45 of 1965). In addition, the exhaust emissions from the engine of an agricultural tractor shall comply with SANS 20096/ECE R96: *Uniform provisions concerning the approval of compression-ignition (C.I.) engines to be installed in agricultural and forestry tractors and in non-road mobile machinery with regard to the emissions of pollutants by the engine*, equivalent to ECE Regulation R96 up to and including the 01 series of amendments which entered into force on 16 September 2001 (Republic of South Africa: Recently Gazetted and Imminent Vehicle Emission Legislation: GRPE June 2005, 2005).

According to the above and as stated in the aforementioned SANS 20096/ECE R96 document known as United Nations Economic Commission for Europe (UN/ECE) Regulation No. 96, effective since 2001, the emission standard for non-road mobile machinery will have a scope for the emission of gaseous and particulate pollutants from compression ignition (CI) engines in the following cases:

- Used in T-category vehicles with a net installed power greater than 18 kW but less than 560 kW;
- Used in non-road mobile machinery with a net installed power greater than 18 kW but less than 560 kW, operating at variable speed; and
- Used in non-road mobile machinery with a net installed power greater than 18 kW but less than 560 kW, operating at constant speed.

In order to understand these regulations, reference is made in the aforementioned standard to the definitions presented by the Consolidated Resolution on the Construction of Vehicles (R.E.3) ECE/ TRANS/WP.29/78/Rev.2 (2017) in paragraph 2:

- Non-road mobile machinery: Any mobile machine, portable industrial equipment or vehicle with or without body work, not intended for the use of passenger- or goods-transport on the road, in which an internal combustion engine is installed;
- Categories T, R and S: agricultural vehicles;
- Category T: A power-driven vehicle, either wheeled or forestry vehicle, which has at least two-axles and a maximum design speed of not less than 6 km/h, whose function depends essentially on its tractive power, and which is specially designed to pull, push, carry or power certain implements, machines or trailers designed to perform agricultural or forestry work, or to tow agricultural or forestry equipment. Such a tractor may be arranged to carry a load and attendants.
- Category-R - Agricultural trailer: any agricultural or forestry vehicle intended mainly to be towed by a tractor and intended primarily to carry loads or process materials and where the ratio of the technically permissible maximum laden mass to the unladen mass of that vehicle is equal to or greater than 3.0; and
- Category-S - Interchangeable towed equipment: means any vehicle used in agriculture or forestry which is designed to be towed by a tractor, changes or adds to its functions, permanently incorporates an implement or is designed to process materials, which may include a load platform designed and constructed to receive all tools and appliances needed for those purposes and to store temporarily any

materials produced or needed during work and where the ratio of the technically permissible maximum laden mass to the unladen mass of that vehicle is less than 3.0.

5. Main regulatory instruments for NRMM emissions reduction

In the regulatory review, different instruments to reduce local pollutant emissions from machinery were identified. The study developed by Huang et al. (2021) proposes the classification of policy instruments into three main groups:

i. Mandatory administration (PI-A, according to the nomenclature used in the original study), by definition, command and control mechanisms belong to this group.

ii. Economic incentives (PI-B), options such as financial assistance programmes, subsidies and tax exemptions are part of this group.

iii. Voluntary participation (PI-C).

These three groups are made up of the subgroups as presented in Table 5. 1.

Table 5. 1. Classification of environmental emission reduction instruments.

PI-A	Mandatory administration	PI-B	Economic incentives	PI-C	Voluntary participation
PI-AL	Law	PI-BT	Tax	PI-CVS	Voluntary emission standards
PI-AR	Regulation	PI-BR	Reimbursement	PI-CGS	Official service
PI-APP	Pilot programme	PI-BLI	Loans	PI-CCL	Certifications and labels
PI-AES	Emission standard	PI-BGS	Grants and subsidies	PI-CVPP	Voluntary pilot programme
				PI-CID	Information dissemination

Source: own elaboration based on (Huang, Chen, et al., 2021; Huang, Fan, et al., 2021).

According to the authors, the most widely used instruments globally, both in developed and undeveloped countries, are of the PI-A type. International evidence on emission control shows that better results are achieved when different types of instruments are combined, and this applies both to mobile sources in general (Santos et al., 2010) as well as machinery (Huang, Fan, et al., 2021). For example, the imposition of emission limits on new machinery, which is of the PI-A type, has a limited effect on total machinery, given the weight of old machinery in the stock, and implies high costs for those acquiring the machinery (Huang, Chen, et al., 2021). It is advisable to have PI-B and PI-C instruments that can complement each other to accelerate the replacement of the older fleet, with economic impacts that are better distributed among the stakeholders involved in this type of program.

The effectiveness of instruments is determined by the design of the instrument for a specific context, and therein lies the difficulty of adapting an instrument created for one context to a particular one. Different criteria are relevant in the design of instruments: changes in the total welfare of society (social effect in addition to the purely environmental effect), transaction costs for applying the instruments, capacities for monitoring, as well as the identification of losers and winners, among other aspects.

In addition to the instruments mentioned above, certain elements are identified as necessary to achieve effective control of emissions from machinery throughout its useful life, including among others: **i)** regulation of emission levels for the fleet in use; **ii)** registration systems for non-road machinery or vehicles; **iii)** programmes and mechanisms for monitoring emissions compliance (Kubsh, 2017).

In this section we focus on identifying regulatory instruments that have been used in the case studies. In the first part, we present a synthesis according to the classification proposed in the Huang et.al. (2021) study and then present the instruments organised in tables for each case study.

The following table shows how many instruments of each type were identified in the case studies. The following messages are highlighted from this analysis:

- Most of the instruments identified belong to the mandatory administration group, followed by voluntary participation and lastly by economic incentives.
- In both the developed and developing country groups, there is a predominance of mandatory administration instruments over the other two groups of instruments.
- According to the studies referenced in the introduction to this section, the recommendation based on previous international experience is to have different types of instruments that act in a complementary manner. For the reduction of NRMM emissions, the United States is the only case that has instruments from all three groups, and countries such as Canada, Colombia and Japan have at least two types of instruments. The rest of the countries concentrate their instruments in the mandatory administration group.

A complementary analysis that could be considered for future studies is the identification of the key aspects for these instruments to fulfil the objective for which they were created, in particular identifying the differences between contexts, in order to have more elements on the possibility of using them in Latin America.

Table 5. 2. Number of emission reduction instruments identified per case study.

Instrument	Code	United States	Canada	Brazil	Chile	Colombia	Peru	Mexico	China	India	Japan	South Korea	European Union	Switzerland	United Kingdom	London	South Africa
Total			**5**				**0**	**0**		**5**			**5**				**5**
Mandatory administrative	**PI-A**	**30**				**1**	**0**	**0**		**5**			**5**				
Law	PI-AL													1			
Regulation	PI-AR	21		1	1							1				1	1
Pilot programme	PI-APP																
Emission standard	PI-AES			1	1	1			5	1		1	1	1	1	1	1
Economic incentives	**PI-B**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Subsidy	PI-BS																
Tax	PI-BT																
Reimbursement	PI-BR																
Loans	PI-BLI																
Grants and subsidies	PI-BGS																
Voluntary participation	**PI-C**	**8**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
Voluntary emission standards	PI-CVS					1					1						
Official service	PI-CGS																
Certifications and labels	PI-CCL																
Voluntary pilot programme	PI-CVPP		1														
Information dissemination	PI-CID																

Source: own elaboration.

North America

5.1. Canada

Regulations for off-road machinery in Canada are created under the authority of the Canadian Environmental Protection Act 1999 (CEPA) which, while not directly regulating NRMM, sets out the pathways and procedures in terms of stakeholders and responsible parties regarding the formulation and publication of laws and standards (CEPA, 1999; Government of Canada, 2012). Prior to the enactment of the CEPA, the Canadian government signed in 1991 a commitment with the United States to limit the transport of transboundary air pollutants in a document called the Air Quality Convention (AQC) (Government of Canada and United States of America, 1991) where measures were taken concerning the implementation of technologies aimed at reducing air emissions from industrial and mobile sources. This agreement served as the basis for the enactment of the CEPA and consequently for the generation of regulations aimed at the environmental control of off-road machinery in Canada.

Prior to the definition of specific standards for non-road machinery, Canada signed commitments called Memoranda of Understanding (MOUs) with 13 engine manufacturers in 2000. In these commitments, the manufacturers agreed to supply machinery with engines complying with the Tier 1 technology standard (Government of Canada, 2000).

Canadian environmental regulations for off-road machinery incorporate the following guidelines as defined by the United States Federal Code:

- 40 CFR § 89, Control of emissions from new and in-use nonroad compression-ignition engines (Tier 1, 2 and 3 emission standards).
- 40 CFR § 1039, Control of emission from new and in-use nonroad compression-ignition engines (Tier 4 interim emission standards and Tier 4 emission standards).
- 40 CFR § 1068, General compliance provisions for engine programs (rule covering general compliance provisions).

A compilation of different types of instruments identified in Canada for the control of air pollution generated by NRMM is presented in Table 5. 3.

Table 5. 3. Regulatory framework and identification of NRMM emission reduction tools - Canada.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	SOR/2020-258	Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations	The standards set out in the CFR referred to in this Regulation are the certification, in-use and field-testing standards and the test procedures, fuels and calculation methods referred to in CFR 60, CFR 89, CFR 94, CFR 1039, CFR 1042, CFR 1048, CFR 1051, CFR 1054, CFR 1060 or CFR 1068, as applicable, for the model year in question.	Minister of Justice	(Minister of Justice of Canada, 2021)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	SOR/2011-10	Marine Spark-Ignition Engine, Vessel and Off-road Recreational Vehicle Emission Regulations.	Reduce emissions of hydrocarbons, nitrogen oxides and carbon monoxide from engines, vessels and vehicles by establishing emission limits for these substances or combinations of these substances. Reduce emissions of the toxic substances formaldehyde, 1,3-butadiene, acetaldehyde, acrolein and benzene by establishing emission limits for hydrocarbons from engines, boats and vehicles. Establish emission standards and test procedures for engines, vessels and vehicles that are aligned with those of the EPA.	Minister of Justice	(Minister of Justice of Canada, 2011)
PI-AR	SOR/2005-32	Off-Road Compression-Ignition Engine Emission Regulations	Regulation applicable to NRMM to reduce emissions of hydrocarbons, nitrogen oxides, particulates and carbon monoxide from engines by establishing emission limits for these substances or combinations of these substances. Reduce emissions of the toxic substances formaldehyde, 1,3-butadiene, acetaldehyde, acrolein and benzene by establishing emission limits for hydrocarbons from engines; and Establish emission standards and test procedures for engines aligned with those of the EPA.	Minister of Justice	(Minister of Justice of Canada, 2012)
PI-AR	SOR/2003-355	Off-Road Small Spark-Ignition Engine Emission Regulations	Regulation applicable to NRMM to reduce emissions of hydrocarbons, nitrogen oxides and carbon monoxide from engines by establishing emission limits for these substances or combinations of these substances. Reduce emissions of the toxic substances formaldehyde, 1,3-butadiene, acetaldehyde, acrolein and benzene by establishing emission limits for hydrocarbons from engines; and Establish emission standards and test procedures for engines that are aligned with those of the EPA.	Minister of Justice	(Minister of Justice of Canada, 2009)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-CVPP	N/A (2000)	Memorandum of Understanding (MOU) on vehicle compatibility.	Set out the general terms and conditions with regard to sale in Canada of vehicles designed in accordance with the performance criteria contained in Attachment A[12], as amended.	Government of Canada.	(Government of Canada, 2000)

Source: own elaboration.

5.2. United States

A compilation of different types of instruments identified in the United States for the control of air pollution generated by NRMM is presented in Table 5. 4.

Table 5. 4. Regulatory framework and identification of NRMM emission reduction tools - United States.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	40 CFR § 89	Control of emissions from new and in-use nonroad compression-ignition engines (CI)[13] .	Macro chapter containing emission control guidelines for new and in-use non-road compression ignition engines; emission limits, tests and procedures, import and recall regulations, offset programs, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2009)
PI-AR	40 CFR § - 89 - 104	Useful life, recall and warranty periods (CI).	Sets the useful life category and warranty times of engines in terms of hours of operation or years of use, whichever comes first. Note: The concept of useful life is directly linked to the certificate of compliance with emission standards considering the deterioration factors of the engines during use.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 1998c)
PI-AES PI-CVS	40 CFR § - 89 - 112	Emission standards for NO_x, CO, THC, PM. Tier 1 and 2 (CI).	Tier 1 and 2 (Tier 1 and 2) emission limits for non-road compression ignition engines with rated power greater than 8 kW. Units expressed in grams of pollutant per kWh. Other provisions such as emission limits per engine family and voluntary standards of the *Blue-Sky Engines* programme.	Environmental Protection Agency (EPA)	(Environmental Protection Agency, 2005)

[12] Attachment A defines the vehicle performance criteria to improve crashworthiness, as well as the anticipated timeframe in which the "COMPANY" commits to implement these criteria for the vehicles it markets in Canada.
[13] Internal Nomenclature: Compression-ignition engines.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	40 CFR § 89 - 113	Smoke emission standard (CI).	Opacity level limits. Three states of operation are considered for testing. Excluded are single cylinder engines, engines used in navigation equipment, and engines operating at constant rpm.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 1998b)
PI-CVPP	40 CFR § - 9 - Subpart C	Certification Averaging, Banking and Trading Provisions (ABT) (CI).	Guidelines for the eligibility and certification of engine families for access to emissions trading and offsetting schemes.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2006)
PI-AR	40 CFR § - 9 - Subpart D	Emission test equipment provisions (CI).	Equipment guidelines and equipment calibration methods for the direct measurement of pollutants.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2005a)
PI-AR	40 CFR § - 9 - Subpart E	Emission test procedures (CI).	Guidelines for direct pollutant measurement tests; test preparation, data and recording times, fuel flow parameters, air, exhaust gas, dilution parameters, data analysis, engine operating cycles, data treatment, etc.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 1998a)
PI-AR	40 CFR § 90	Control of emissions from new and in-use nonroad spark ignition engines < 19 kW (SI)[14]	Macro chapter containing emission control guidelines for new and in-use nonroad spark ignition engines with power ratings of 19 kWh and below; emission limits, tests and procedures, import and recall regulations, offset programs, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008g)
PI-AES	40 CFR § - 0 - 103	Emission standards for NO_x, CO, THC. Phases 1 and 2 (SI).	Phase 1 and Phase 2 emission limits for non-road spark ignition engines with a rated power of less than 19 kW. Units expressed in grams of pollutant per kWh.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2002)
PI-AR	40 CFR § - 0 - 105	Useful life periods for Phase 2 engines (SI).	Sets the useful life category for non-road spark ignition engines with a rated power of less than 19 kW differentiating between handheld and non-handheld engines in hours of use.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2000a).
PI-CVPP	40 CFR § - 0 - 1203	Voluntary manufacturer in-use testing programme (SI).	Guidelines for the voluntary in-use engine testing programme.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2000b)
PI-CVPP	40 CFR § - 0 - Subpart C	Certification Averaging, Banking and Trading Provisions (ABT) (SI).	Guidelines for the eligibility and certification of engine families for access to emissions trading and offsetting schemes.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008f)

[14] Internal Nomenclature: Non-road spark ignition engines with rated power less than 19 kW, compliance phases I and II.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	40 CFR § - 0 - Subpart D	Emission test equipment provisions (SI).	Equipment guidelines and equipment calibration methods for the direct measurement of pollutants.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2005b)
PI-AR	40 CFR § - 0 - Subpart E	Gaseous exhaust test procedures (SI).	Guidelines for direct pollutant measurement tests; test preparation, data and recording times, fuel flow parameters, air, exhaust gas, dilution parameters, data analysis, engine operating cycles, data processing, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2005c)
PI-AR	40 CFR § 94	Control of emissions from marine compression-ignition engines.	Macro chapter containing guidelines for the control of emissions from engines and turbines used by compression ignition navigation equipment; emission limits, tests and procedures, import and recall regulations, compensation programmes, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2010e)
PI-AR	40 CFR § 1039	Control of emissions from new and in-use nonroad compression ignition engines. Tier 4 (CI. T4)[15].	Macro chapter containing emission control guidelines for new and in-use non-road compression ignition Tier 4 or Tier 4 engines; emission limits, tests and procedures, import and recall regulations, offset programs, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016f)
PI-AES PI-CVS	40 CFR § 1039-101	Control of emissions from new and in-use nonroad compression ignition engines > 2014. Tier 4. (CI. T4).	Tier 4 emission limits for non-road compression ignition engines with a power rating greater than 8 kW and a model year greater than 2014. Units expressed in grams of pollutant per kWh. Other provisions such as emission limits per engine family and voluntary standards of the *Blue-Sky Engines* programme are proposed.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016c)
PI-AES PI-CVS	40 CFR § 1039-102	Control of emissions for new and in-use nonroad compression ignition engines < 2014. Tier 4- (CI. T4).	Tier 4 (Tier 4) emission limits for non-road compression ignition engines with rated power greater than 8 kW and model year less than 2014. Units expressed in grams of pollutant per kWh. Other provisions such as emission limits per engine family and voluntary standards of the *Blue-Sky Engines* programme are proposed.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016d)
PI-AES	40 CFR § 1039-105	Smoke emission standard (CI. T4).	Opacity level limits. Three states of operation are considered for testing. Excluded are single-cylinder engines, constant-speed engines, and engines certified to a PM emission standard of 0.07 g/kWh or lower.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016e).

[15] Internal Nomenclature: Non-road compression ignition engines, Tier 4 compliance.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	40 CFR § 10-9 - Subpart F	Emission test procedures (CI T4).	Guidelines for direct pollutant measurement tests; test preparation, data and recording times, fuel flow parameters, air, exhaust gas, dilution parameters, data analysis, engine operating cycles, data processing. Among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016a)
PI-CVPP	40 CFR § 1042 - Subpart H	Averaging, Banking and Trading (ABT) for certification (CI T4).	Guidelines for the eligibility and certification of engine families for access to emissions trading and offsetting.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2016b)
PI-AR	40 CFR § 1048	Control of emissions from new, large, non-road spark ignition engines >19 kW (SI >19 kW).	Macro chapter containing emission control guidelines for new and in-use non-road spark ignition engines with power above 19 kWh; emission limits, tests and procedures, import and recall regulations, offset programs, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008d)
PI-AES	40 CFR § 10-8 - 101	Emission standards for NO_X, CO and useful life (SI >19 kW).	Tier 1 and 2 (Tier 1 and 2) emission limits for non-road spark ignition engines with rated power greater than 19 kW. Units expressed in grams of pollutant per kWh. The Tier limit corresponds to the model year of the engine, no further divisions by engine size or power ranges are presented.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008c)
PI-AR	40 CFR § 1048 - Subpart D	Testing production-line engines.	Guidelines for direct measurement testing of pollutants for manufacturers exceeding 150 engines per model year. Supplemented by 40 CFR 1065.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008a)
PI-AR	40 CFR § 1048 - Subpart E	Testing in-use engines (SI >19 kW).	Guidelines for direct pollutant measurement tests; test preparation, data and recording times, fuel flow parameters, air, exhaust gas, dilution parameters, data analysis, engine operating cycles, data processing, among others. Supplemented by 40 CFR 1065.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008b)
PI-AR	40 CFR § 1051	Control of emissions from recreational engines and vehicles.	Macro chapter containing emission control guidelines for Phase 1, Phase 2 non-road spark ignition compression ignition engines; emission limits, tests and procedures, offset programs, exemptions and prohibitions, among others.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2008e)
PI-AR	40 CFR § 1054	Control of emissions from new, small, nonroad spark ignition engines and equipment (SI <19 kW).[16]	Macro chapter containing emission control guidelines for Phase 3 non-road spark ignition engines with rated power greater than 19 kW; emission limits, tests and procedures, offset	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2010d)

[16] Internal Nomenclature: Non-road spark ignition engine with a power rating of less than 19 kW, Phase III of compliance.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
			programs, exemptions and prohibitions, among others.		
PI-AES	40 CFR § 1054 - 103	Phase 3 emission standards for NO_x, THC, CO, from new handheld engines (SI <19 kW).	Phase 3 emission limits for nonroad engines used in handheld spark ignition engines with a rated power of less than 19 kW. Units expressed in grams of pollutant per kWh.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2010a)
PI-AES	40 CFR § 1054 – 105	Phase 3 emission standards for non-handheld engines (SI <19 kW)	Phase 3 emission limits for nonroad engines used in non-handheld spark ignition engines rated at less than 19 kW. Units expressed in grams of pollutant per kWh.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2010b)
PI-AR	40 CFR § 1054 - 107	Useful life of Phase III engines (SI <19 kW).	Sets the useful life category for non-road spark ignition engines with rated power less than 19 kW differentiating between handheld (residential and commercial use) and non-handheld (light-duty, medium-duty, heavy-duty) engines in hours of use.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2010c)
PI-AR	40 CFR § 10-4 - Subpart E	Testing in-use engines (SI <19 kW)	It refers to the authority's ability to request information from the manufacturer.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2015a)
PI-AR	40 CFR § 10-4 - Subpart F	Test procedures (SI < 19 kW).	It refers to CFR 1065 to perform these tests.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2015b)
PI-AR	40 CFR § 1060	Control of evaporative emissions from new and in-use nonroad and stationary equipment.	Macro chapter containing guidelines for the control of evaporative emissions from fuel lines and fuel tanks, couplings and fittings, fuel caps, used in non-road engines and stationary sources.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2020)
PI-AR	40 CFR § 1065	Engine-testing procedures	Macro chapter defining the procedures for direct emissions testing of different engine types. These include non-road engines covered by CFR 1039, 1048, 1054. This chapter contains 12 subparts in which measurement and calibration instruments, testing cycles, fuel quality and data to be collected are specified.	Environmental Protection Agency (EPA)	(U.S. Environmental Protection Agency, 2014).
PI-BS	N/A	Carl Moyer Memorial Air Quality Standards Attainment Program	This program helps finance the incremental cost of cleaner than required engines, equipment and other sources of air pollution. The Moyer programme complements California's regulatory programmes by providing incentives to achieve emission reductions earlier or beyond what is required by regulation.	California Air Resources Board (CARB)	(U.S. Environmental Protection Agency, 2021a)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
			The implementation of the Moyer programme is a partnership between CARB and California's 35 local air districts. Throughout the history of the Moyer programme, more than half of the funding has gone to off-road projects. Funding is available for vehicle replacements, retrofits, zero-emission technologies and infrastructure.		
PI-BS	N/A	Funding Agricultural Replacement Measures for Emission Reductions (FARMER)	In September 2017, US $135 million was provided for cleaner heavy-duty trucks, tractors, harvesting equipment, agricultural pump engines, terrain utility vehicles and other equipment used in agricultural operations. FARMER Program incentive funding is available for participants to purchase cleaner farm equipment to help reduce their exposure to harmful diesel emissions, improve local air quality and reduce greenhouse gas emissions.	California Air Resources Board (CARB)	(U.S. Environmental Protection Agency, 2021a)

Source: own elaboration.

There is an initiative supported by the cities of Los Angeles and San Francisco known as the C40 Clean Construction Declaration (C40, 2020), in which Mexico City commits to require zero-emission construction equipment in municipal projects from 2025 and zero-emission construction sites throughout the city by 2030, when available.

5.3. Mexico

There are no regulations governing emissions generated by NRMM. There is an initiative supported by Mexico City called Clean Construction Declaration through Dr. Marina Robles García, in which Mexico City commits to require zero-emission construction machinery in municipal projects from 2025 and zero-emission construction sites throughout the city by 2030, when available.

South America

5.4. Brazil

Table 5. 5 presents a compilation of different types of instruments identified in Brazil for the control of air pollution generated by NRMM.

Table 5. 5. Regulatory framework and identification of NRMM emission reduction tools - Brazil.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	Resolution 433 of 2011	Provides for inclusion in the Air Pollution Control Programme by Motor Vehicles (PROCONVE) and establishes maximum noise emission limits for agricultural and new construction machinery.	Define emission limits for CO, NOx + HC and PM and noise levels.	National Environment Council	(National Environment Council, 2011)
PI-AR	Resolution 418 of 25 November 2009	It establishes criteria for the preparation of Vehicle Pollution Control Plans (VPCPs) and for the implementation of In-Use Vehicle Inspection and Maintenance (I/M) Programs by state and municipal environmental agencies and determines new emission limits and procedures for the assessment of the maintenance condition of in-use vehicles.	This Resolution establishes criteria for the development of Vehicle Pollution Control Plans (VPCPs), for the implementation of In-Use Vehicle Inspection and Maintenance (I/M) Programs by state and municipal environmental agencies, for determining new emission limits, and procedures for assessing the maintenance status of in-use vehicles. (*Note: The resolution gives discretion to the authority to exempt non-road machinery from such a requirement, but could apply in principle*).	Ministry of the Environment and National Environment Council	(MMA and CONAMA, 2009)

Source: own elaboration.

5.5. Chile

Table 5. 6. Regulatory framework and identification of NRMM emission reduction tools - Chile.

Instrument	Regulation number	Regulation name	Object	Issuing entity	Reference
PI-AES	Decree 39 of 2020	Emission Standard for Mobile Machinery	It establishes the requirement of maximum emission limits equivalent to Stage IV or V for machinery with a power between 19 and 560 kW, starting 24 months after the publication of the standard for all machinery except tractors, which have a deadline of 30 months.	Ministry of Environment	(Chilean Ministry of Environment, 202121).

Instrument	Regulation number	Regulation name	Object	Issuing entity	Reference
PI-AR	Decree 31 (Effective 24 November 2017)	Establishes an Atmospheric Prevention and Decontamination Plan for the Metropolitan Region of Santiago.	To comply with the primary environmental air quality standards in force, associated with pollutants such as Respirable Particulate Matter (PM10), Respirable Fine Particulate Matter (PM2.5) and Ozone within 10 years.	Ministry of Environment	(Chilean Ministry of Environment, 2017).

5.6. Colombia

Table 5. 7 presents a compilation of different types of instruments identified in Colombia for the control of air pollution generated by NRMM.

Table 5. 7. Regulatory framework and identification of NRMM emission reduction tools - Colombia[17] .

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR/PI-AES	Resolution 762 of 2022	By which the maximum permissible pollutant emission limits to be complied with by land mobile sources are regulated, article 2.2.5.5.1.8.2 of Decree 1076 of 2015 is regulated and other provisions are adopted.	This resolution establishes the maximum permissible pollutant emission limits that land mobile sources must comply with, regulates the requirements and certifications to which they are subject, whether imported, assembled or of national manufacture, and adopts other provisions, with the aim of protecting the environment, health, the right to a healthy environment and human life from the risks generated by land mobile source pollutants.	Colombian Ministry of Environment and Sustainable Development	Colombian Ministry of Environment and Sustainable Development, 2022

[17] The following instruments are not directly related to emissions reduction, but can help the authority to strengthen the control and surveillance mechanisms of these emission sources: Resolution 1068 of 2015, which regulates the National Registry of Industrial Agricultural and Construction Machinery. Decree Number 723 of 2014, Incorporation of a GPS system, prior to registration in the RUNT. Resolution 2086 of 2014, by which the technical conditions of the equipment, installation, identification, operation and monitoring of the Global Positioning System (GPS) or other electronic security and monitoring device and the control mechanism for the change of the device are set, as well as the parameters for the authorization of service providers and the respective registration. Decision 774 of 2012, Andean Policy to Combat Illegal Mining.
Law 769 (2002) of the Congress of the Republic, by which the National Land Traffic Code is issued, defines the obligation of the Ministry of Transport to implement the National Traffic Registry (RUNT), which by Article 207 of Law 019 of 2012, which amended Article 10 of Law 1005 of 2006, must have the registry of agricultural, industrial and self-propelled construction machinery. It is important to note that, in the same year, Colombia signed a regional agreement between Andean countries against illegal mining, which was reaffirmed in Decision 774 (2012) of the Andean Council of Ministers of Foreign Affairs, which defines the "Andean Policy to Combat Illegal Mining". The procedure for registering machinery was regulated by the Ministry of Transport through the issuance of Resolution 1068 of 2015 and technical provisions were set forth for the installation of GPS devices for machinery tracking and provisions on the machinery circulation on roads (Ministry of Transport, 2015).

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-CVS	Not applicable	CASA Colombia certification system	Certification system for sustainable construction housing. One of the assessment categories of this system is "on-site sustainability", in which one of the relevant aspects is "air quality management during construction".	Colombia Green Building Council	(Colombia Green Building Council, 2021).

Source: own elaboration.

The local authority of Bogota issued Decree 332 of 2021 of the Mayor's Office of Bogota, "Whereby the Strategic Plan for the Integral Management of Air Quality in Bogotá 2030 - Air Plan is adopted", which includes a line of action for the reduction of construction machinery emissions.

5.7. Peru

There are no regulations governing the emissions generated by NRMM. However, the local authorities of Lima and Callao are drafting a work plan for quantifying and reducing NRMM emissions through the "*Plan de Acción para el Mejoramiento de la Calidad de Aire de Lima y Callao 2021 – 2025*" (Action Plan for the Improvement of Air Quality in Lima and Callao 2021 – 2025) approved by Ministerial Resolution No. 142-2021-MINAM. It includes three measures related to NRMM:

- Socialisation, validation and approval of the first non-road mobile machinery (NRMM) emissions inventory.
- Periodic preparation of the non-road mobile machinery (NRMM) emissions inventory.
- Drafting of regulations establishing maximum permissible limits for emissions from mobile machinery entering the country.

Asia-Pacific

5.8. China

A compilation of different types of instruments identified in China for monitoring air pollution generated by NRMM is presented in Table 5. 8

Table 5. 8. Regulatory framework and identification of NRMM emission reduction tools - China

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	HJ-1014-2020	Emissions control technical requirements of non-road diesel mobile machinery.	Specifies the technical requirements for pollutant emission control for Stage IV non-road diesel mobile machinery, diesel engines and secondary diesel engines installed in	Ministry of Ecology and Environment of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2020)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
			vehicles used to transport persons (freight) on roads.		
PI-AR	GB/T 28239-2020	Limits and measurement methods for non-road diesel engine specific fuel consumption.	This standard specifies the limits and measurement methods for non-road diesel engines, is applicable to those engines whose rated power is not greater than 560 kW and that use light diesel fuel, but is not applicable to marine diesel engines that use heavy diesel fuel.	State Administration for Market Regulation of the People's Republic of China and Standardisation Administration of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2020)
PI-AES	GB 36886-2018	Limits and measurement methods for exhaust smoke from non-road mobile machinery equipped with diesel engines.	This standard specifies the exhaust smoke limit and measurement method for on-site measurements of non-road diesel mobile machinery and equipment. It applies to domestically manufactured and imported machinery.	Ministry of Ecology and Environment of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2018).
PI-AES	GB 20981-2014	Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (China III and IV).	The standard stipulates the limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery for Phase III and puts forward the predictive requirements for Phase IV.	National Standards of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2014a).
PI-AES	GB 26133-2010	Limits and measurement methods for exhaust pollutants from small spark ignition engines of non-road mobile machinery.	This standard provides the limits and measurement methods for exhaust pollutants from small spark ignition engines of non-road mobile machinery. It applies to (but is not limited to) the following non-road mobile machinery with a net power of less than 19 kW and 1 litre working volume: lawnmowers, chainsaws, generators, pumps and bush cutters. This standard does not apply to engines used for the following purposes: engines for propelling ships, engines used for underground mining, spare engines for emergency rescue, vehicles for recreational purposes such as sleds, off-road motorcycles, all-terrain vehicles and engines for export.	Ministry of Environmental Protection	(Ministry of Ecology and Environment of the People's Republic of China, 2010).

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	GB 20891-2007	Limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (China stage I and II).	This Standard is formulated for the purpose of implementing the Environmental Protection Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution, preventing and controlling the pollution by exhaust pollutants from diesel engines of non-road mobile machinery and improving ambient air quality. The current Standard specifies the limits and measurement methods for exhaust pollutants from diesel engines of non-road mobile machinery (I and II) that are used for approval and examination of production consistency. It is legally binding in accordance with the relevant legal regulations.	National Standards of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2007).
PI-AES	GB 1832-2002	Limits and measurement methods for smoke at free acceleration from agricultural vehicles.	Specifies the limits and measurement methods for smoke emissions at free acceleration from agricultural vehicles. This standard applies to agricultural vehicles.	Ministry of Ecology and Environment of the People's Republic of China	(Ministry of Ecology and Environment of the People's Republic of China, 2002).

Source: own elaboration.

In 2020, the Chinese government updated the regulations for NRMM emissions. The new standards, scheduled for implementation in December 2022, will be equivalent to Stage IIIB limits but enhanced to meet some requirements of the Euro Stage V standards (ICCT, 2021). Analysis available at: https://theicct.org/publications/china-iv-non-road-emission-standards-jul2021.

5.9. South Korea

A compilation of different types of instruments identified in South Korea for the control of air pollution generated by NRMM is presented in Table 5. 9. Regulatory framework and identification of NRMM emission reduction tools - South Korea.

Table 5. 9. Regulatory framework and identification of NRMM emission reduction tools - South Korea.

Political instrument	Regulation number	Instrument name	Object	Issuing entity	Reference

PI-AL	Law No. 17453 of June 09, 2020	Construction Machinery Management Act	The purpose of this Act is to promote the mechanization of construction works by efficiently managing construction machinery and securing the safety of construction machinery by prescribing matters concerning the registration, inspection, and type-approval of construction machinery, construction machinery business, construction machinery operator's license, etc.	Korean Ministry of Land and Transport Infrastructure (MOLIT) [18]	(Construction Machinery Management Act, 2020)
PI-AR	Law No. 17453 of June 09, 2020	Decree implementing the law on the management of construction machinery	The purpose of this Decree is to regulate the matters delegated by the Construction Machinery Management Act and the matters necessary for the implementation of the said Act.	Korean Ministry of Land and Transport Infrastructure (MOLIT)[19]	(Enforcement decree of the construction machinery management act, 2020)
PI-AL	Ordinance of the Ministry of Environment No. 17797 of Dec. 29, 2020	Clean Air Conservation Act	The purpose of this Act is to enable all people to live in a healthy and comfortable environment, by preventing air pollution which causes harm to people and the environment, and by managing and conserving the atmospheric environment in a proper and sustainable manner.	Ministry of Environment (MoE)[20]	(Clean Air Conservation Act, Laws and Regulations, 2020)
PI-AES	Ordinance of the Ministry of Environment No. 14532 of January 17, 2017	Clean Air Conservation Act	The emission standards for South Korea are set in the Clean Air Conservation Act for construction and agricultural machinery, which in both cases correspond to US Tier 4 standards with the application of the ISO 8178 C1 or NRSC test cycles (known as KC1-8 in Korea) and the NRTC cycle.	Ministry of Environment (MoE)[21]	(Clean Air Conservation Act, Laws and Regulations, 2008; Transport Policy, 2015).

[18] Note: Although laws are issued by the National Assembly, the translation of the original title as "Law" is maintained even if issued by the administrative branch.
[19] Note: Although laws are issued by the National Assembly, the translation of the original title as "Law" is maintained even if issued by the administrative branch.
[20] Note: Although laws are issued by the National Assembly, the translation of the original title as "Law" is maintained even if issued by the administrative branch.
[21] Note: Although laws are issued by the National Assembly, the translation of the original title as "Law" is maintained even if issued by the administrative branch.

Source: own elaboration.

5.10. India

Table 5. presents a compilation of different types of instruments identified in India for the control of air pollution generated by NRMM.

Table 5. 10. Regulatory framework and identification of NRMM emission reduction tools - India.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	Notification No. G.S.R. (201) (E) of 2018	Notification No. G.S.R. (201) (E) of 2018 on emission standards for construction equipment vehicles and agricultural tractors.	On 5 March 2018, the Ministry of Road Transport and Highways published the final regulation for Bharat Stage (CEV/Trem) IV and V tractor and construction equipment emission standards, including stricter emission limits for particulate matter (PM), particle number (PN) (BS V only), nitrogen oxide (NOx), hydrocarbons (HC) and carbon monoxide (CO). The emission limits are analysed for the non-road steady cycle (NRSC) and non-road transient cycle (NRTC).	Ministry of Road Transport and Highways.	(Ministry of Road Transport and Hghways, 2018) (ICCT, 2018)
PI-AR	S.O. Notification 1248 (E) of 5 November 2004	Notifications under the Motor Vehicles Act: specification of types of motor vehicles.	In exercise of the powers conferred by sub-section (4) of section 41 of the Motor Vehicles Act, 1988, the Government of India defines two types of motor vehicles: transport and non-transport vehicles, the latter including agricultural machinery and construction machinery with some examples and definitions.	Ministry of Road Transport and Highways.	(Government of India, 2004)
PI-AR	Central Motor Vehicle Rules, 1989	Central Motor Vehicle Rules, 1989.	In pursuance of the legislative provisions of Act No. 59 of 1988, the Government of India enacted the Central Motor Vehicles Rules, 1989 which clarifies definitions for types of non-road mobile machinery in the agricultural and construction sector, definitions regarding actors in manufacturing, type-approval, regulatory bodies, registration and sale of machinery, as well as standards for operation.	Ministry of Road Transport and Highways.	(Ministry of Road Transport & Highways, 1989).
PI-AL	Act No 59 of 1988	Motor Vehicles Act, 1988.	Transport sector law regulating all aspects of road transport vehicles, setting out in detail the legislative provisions on driver licensing, vehicle registration, control of motor vehicles by permits, special provisions for state transport undertakings, traffic regulation, insurance,	Ministry of Road Transport and Highways.	(Ministry of Road Transport & Highways, 1988).

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
			liability, offences and penalties. It establishes some definitions for road motor vehicles and non-road mobile machinery, as well as import requirements for new and used machinery other than railways and trams.		
PI-AL	Law No. 14 of 1981	Air (Prevention and Control of Pollution) Act 1981.	The Air Pollution Prevention and Control Act of 1981 establishes the right of the Government of India to set vehicular and industrial emission standards (except for aircraft or ships), for which state agencies known as Central Pollution Control Boards (CPCBs) are responsible. India's emission standards known as Bharat Stage are set since 2000 by the Government of India to regulate air pollutant emissions by compression ignition engines, which currently distinguish differentiated standards for machinery in the construction and agricultural sectors, formulated by the CPCB under the administration of the Ministry of Environment, Forests and Climate Change.	Parliament of India	(Government of India, 1981)

Source: own elaboration.

5.11. Japan

A compilation of different types of instruments identified in Japan for the control of air pollution generated by NRMM is presented in Table 5.

Table 5. 11. Regulatory framework and identification of NRMM emission reduction tools - Japan.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	Eleventh CEC report to the Ministry of Environment	Future policy for the motor vehicle exhaust emission reduction (eleventh report).	For the transport and non-road machinery sector, in August 2012 the CEC has reported recommendations in its eleventh report (draft legislation passed), where the RMC (Ramped Modal Cycle) cycle will be added as an ESC (Steady Test Cycle) cycle option to the existing discrete test cycle, as well as a review to update the emission standards for diesel non-road mobile machinery.	Japanese Central Environment Council (CEC)	(CEC, 2012)
PI-AES	Ninth CEC report to the	Future policy for motor vehicle emission reduction (ninth report).	For the transport and non-road machinery sector, the Stage 4 regulation has been introduced from 2014 to 2016 recommended	Japanese Central Environment Council (CEC)	(CEC, 2008)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
	Ministry of Environment		by the Central Environmental Council (CEC) in its ninth report (bill passed) to introduce new emission limits for special motor vehicles and non-road gasoline-powered special motor vehicles. The document was submitted to the Minister of Environment in January 2008.		
PI-AL	Law No. 51 of 2005	Act on regulations for emissions from non-road vehicles.	With application in the industrial and construction sectors, the purpose of this act is to control exhaust emissions from non-road vehicles, establish technical standards for these vehicles and their engines, as well as regulations on their use, among other measures.	Japanese Ministry of Environment (MoE)	(Act on Regulations for Emissions from Non-Road Vehicles (Act No. 51 of May 25, 2005), 2005)
PI-AES	Sixth CEC report to the Ministry of the Environment	Future policy for motor vehicle exhaust emission reduction (sixth report).	Emission regulations for special vehicles that use gasoline or LPG for fuel have been introduced from 2007 onwards after being recommended by the CEC as emission regulations for those special motor vehicles and special non-road motor vehicles that use these fuels according to its sixth report (bill passed) to the Minister of Environment in June 2005.	Japanese Central Environment Council (CEC)	(CEC, 2003)
PI-AL	Law No. 97 of 1968	Air Pollution Control Act.	With application in the construction, transport and industry sectors, this law seeks to control emissions of soot and smoke, volatile organic compounds and particulates associated with the business activities of factories, workplaces and with the demolition of buildings, by promoting the implementation of measures against hazardous air pollutants and by setting maximum permissible limits for automobile exhaust. It also aims to protect victims where air pollution has caused harm to human health by providing for the liability of business operators for damages.	Japanese Ministry of Environment (MoE)	(Air Pollution Control Act (Act No. 97 of June 10, 1968), 1968)
PI-AL	Act No. 185 of 1952	Road Traffic Act.	With application in the transport and construction sectors, this law seeks to certify the ownership of road transport vehicles, improve technology to ensure safety and maintenance, and contribute to the sound development of the automobile maintenance business, with the aim of promoting public welfare. It defines for the first time the category of motor vehicles, within which non-	Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT)	(Road Transport Vehicle Act (Act No. 185 of 1952), 1952)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
			road mobile machinery of special character with or without license plates is distinguished.		
PI-CVS	-	Voluntary emission regulations for non-road engines by LEMA.	Voluntary emission regulation for SI and CI non-road engines below 19 kW, applicable to on-road and non-road vehicles, with emission standards endorsed by the CEC and machinery labelling.	Land Engine Manufacturers Association of Japan (LEMA)	(LEMA, 2020)

Source: own elaboration.

Europe

5.12. European Union

Table 5. 12 presents a compilation of different types of instruments identified in the European Union for the control of air pollution generated by NRMM.

Table 5. 12. Regulatory framework and identification of NRMM emission reduction tools - European Union.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR/AES	Regulation (EU) 2016/1628	Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016	Regulation on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012, (EU) No 167/2013 and amending Directive 97/68/EC. It defines and details the categories and subcategories of non-road vehicles and machinery.	European Parliament Council of the European Union	(European Parliament and Council, 2016)
PI-AR	Regulation (EU) 2017/654	COMMISSION DELEGATED REGULATION (EU) 2017/654 of 19 December 2016	To set out the technical and general requirements and test methods relating to emission limits, EU type-approval procedures for internal combustion engines for non-road mobile machinery, arrangements with regard to conformity of production and the requirements and procedures relating to technical services to those engines.	European Commission	(European Commission, 2017a)
PI-AR	Regulation (EU) 2017/655	COMMISSION DELEGATED REGULATION (EU) 2017/655 of 19 December 2016	To adopt detailed arrangements with regard to the selection of engines, test procedures and reporting of results relating to the monitoring of gaseous pollutant emissions by testing in-service engines installed in non-road mobile machinery using handheld emission measurement systems.	European Commission	(European Commission, 2017b)
PI-AR	Regulation (EU) 2017/656	COMMISSION IMPLEMENTING REGULATION (EU)	To lay down administrative requirements relating to emission limits and type-approval of internal combustion engines for non-road mobile machinery.	European Commission	(European Commission, 2017c)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
		2017/656 of 19 December 2016			

Source: own elaboration.

5.13. United Kingdom

A compilation of different types of instruments identified in the UK for the control of air pollution generated by NRMM is presented in Table 5.13.

Table 5. 13. Regulatory framework and identification of NRMM emission reduction tools - UK.

Policy instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	764 - 2018	The Non-Road Mobile Machinery (type-approval and emission of gaseous and particulate pollutants) Regulation 2018.	Statutory instrument adopting Regulation 1628 of 2016 of the Parliament of the European Council.	Secretary of State for Transport.	(Secretary of State for Transport, 2018)
PI-AES	1891 - 2002	Agricultural or Forestry Tractors (Emission of Gaseous and Particulate Pollutants) Regulations. 2002.	Statutory instrument presenting the definitions, classification by categories of tractors and maximum permissible emission limits for the pollutants CO, THC, NO_x, PM.	Secretary of State for Transport.	(Secretary of State for Transport, 2002)
PI-AR	3171 – 2013	Agricultural or Forestry Tractors (Emission of Gaseous and Particulate Pollutants) Regulations. 2013.	Amendments to statute 1891 - 2002		(Secretary for State for Transport, 2014).

5.14. London

In addition to the instruments that apply to the UK, the following table presents an additional regulatory instrument identified in London for the control of air pollution generated by NRMM.

Table 5. 14. Regulatory framework and identification of NRMM emission reduction tools - London.

Policy instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR/AES	Not applicable	London's 'Low Emission Zone' for Non-Road Mobile Machinery	Stricter emission standards are required in the central London area compared to the rest of the city: - Central area: Stage IV for machinery between 37 and 560 kW. - Rest of the city: Stage IIIB for machinery between 37 and 560 kW. It establishes a gradual schedule of higher emission levels from 2025 onwards.	Mayor of London	(Mayor of London, 2020)

5.15. Switzerland

In Switzerland, the Ordinance on Air Pollution Control (OAPC), issued by the Swiss Federal Council in 1985 (Ordinance of 16 December 1985 on Air Pollution Control (OAPC), 2020) states in its annex 4, section 4, that internal combustion engines of machines and equipment must comply with the requirements set out in Regulation (EU) No. 2016/1628 (2016), i.e. European Union regulations apply.

Africa

5.16. South Africa

A compilation of different types of instruments identified in South Africa for the control of air pollution generated by NRMM is presented in Table 5. 15.

Table 5. 15. Regulatory framework and identification of NRMM emission reduction tools - South Africa.

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AR	Report No. GRPE-50-20 of 2005	Vehicle emissions legislation for agricultural tractors: GRPE 2005.	Report No. GRPE-50-20 of 2005 states and communicates on the requirement that emissions by agricultural tractors shall comply with the United Nations Economic Commission for Europe (UNECE) Regulation No. 96 of 2014 and at the same time with the provisions laid down in the Air Pollution Prevention Act of 1965 (Act No. 45 of 1965).	Ministry of Forestry, Fisheries and Environment	(Republic of South Africa: Recently Gazetted and Imminent Vehicle Emission Legislation: GRPE June 2005, 2005)

Instrument	Regulation number	Instrument name	Object	Issuing entity	Reference
PI-AES	Directive 97/68/EC Directive 2002/88/EC Directive 2004/26/EC Directive 2006/105/EC Directive 2010/26/EU Directive 2011/88/EU Directive 2012/46/EU Directive 2012/46/EU	European Directives on NRMM emissions.	Measures on the emission of gaseous pollutants and particulate matter from internal combustion engines to be installed in NRMM. In the case of South Africa, the standards implemented for machinery of this type continue to be Tier 2/Stage II (Putzmeister, 2018), as well as for heavy-duty vehicles the emissions legislation in South Africa is equivalent to Euro II (known in South Africa as Euro 2). Plans to implement Euro IV levels (omitting Euro III) have not been realised due to problems with the supply of Euro IV fuels. Plans have been formulated that will involve moving directly from Euro II standards to Euro V equivalents. However, the move is expected to take place by 2020 at the latest (Ricardo EMLEG, 2016).	European Commission	(Dieselnet, 2004) (Ricardo EMLEG, 2016).

Source: own elaboration.

6. Emission standards for air pollutants

This section provides a description of the local pollutant emission level regulations that apply to NRMM.

Table 6. 1 shows the pollutants regulated by case studies in the current legislation. According to this, all the countries presented in the table have emission limits for particulate matter (fine and respirable), nitrogen oxides, hydrocarbons and carbon monoxide. Countries such as China, India, Chile and the European Union also have regulations on particulate matter concentration. China, India, the European Union, the United Kingdom and Switzerland have standards for ammonia.

Table 6. 1. Pollutants regulated in the case studies.

Case / Pollutant	United States	Canada	Brazil	Chile	Colombia	China	South Korea	India	Japan	European Union	United Kingdom	Switzerland	South Africa
PM PM_{10} or $PM_{2.5}$	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PN Particle number				✓		✓		✓		✓	✓	✓	
NO_x	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
HC	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CO	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NH_3						✓		✓		✓	✓	✓	

Source: Own elaboration.

Chile: Entry into force of standards in 2023.
China: Entry into force of PN standards in 2022.

The regulatory schemes identified contain mostly emission standards for new emission sources to be imported, manufactured and marketed in the countries and, to a lesser extent, instruments for machinery in use. For the latter sources, it was found that the most widely implemented aftertreatment system for the reduction of particulate matter from in-use machinery is the diesel particulate filter (DPF).

For the group of countries that have emission level limits, the gradual adoption of the standards for the period 1996 - 2021 was reviewed. The emission levels mentioned below are those that the community of practice in the different countries has adopted for the most part, which are based primarily on the regulations of the European Community

and the United States[22]. For practical purposes and given their similarities, it is possible to establish equivalence between these emission standards:

Table 6. 2. Emission standard equivalences.

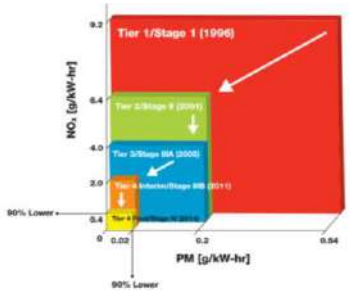
US EPA	Stage (EU)
Tier 1	Stage I
Tier 2	Stage II
Tier 3	Stage IIIA
Tier 4 Interim	Stage IIIB
Tier 4 Final	Stage IV
Tier 4* Final (With DPF and SCR)	Stage V

**There is no standard equivalent for Stage V, but could be considered emissions equivalent in terms of control systems if Tier 4 Final is met by implementing DPF filters and SCR.*

Source: CALAC+ 2021

The United States was the first country to implement emission limits for NRMM, and this case also stands out because from the outset it implemented limits covering all power ranges of machinery. The countries with the most advanced and currently implemented emission standards are the EU countries with Stage V standards, followed by the USA with Tier 4 Final and Korea, Japan and India with Stage IV.

Overall Evolution of Machinery Emission Reductions for US and European Standards



Source: Cited by Tampere University of Technology [23] .

In terms of standards in the pipeline, China has recently enacted regulations that will apply highly stringent emission standards in the coming years. The standards applicable to machinery were updated in 2020, requiring that from December 2022 Stage IIIB emission standards come into force with some requirements of the European Stage V standard such as particle number (PN) limit. For the latter, the installation of GPS in the machinery is anticipated, as well as control with on-board emission monitoring systems (PEMS), among others, to evaluate compliance with the permitted standards (ICCT, 2021).

[22] India is an exception where some Bharat standards differ from US and European standards.

[23] Presentation by Professor Seppo Tikkanen from Tampere University of Technology, Faculty of Engineering Sciences at CASCADES 2017 https://www.cimac.com/cms/upload/events/cascades/CASCADES_2017_Finland/12_Seppo_Tikkanen_cimaccascades_final.pdf

In Latin America, so far Brazil has Stage IIIA emission standards. In the case of Chile, on 21 October 2021, the Supreme Decree was published which establishes the emission standard equivalent to Stage IV or V standard for machinery to be brought into the country, applicable 24 months from the entry into force of the standard; agricultural tractors have 36 months to comply with this requirement. At the local level, the *Plan de prevención y descontaminación atmosférica para la región metropolitana de Santiago* (Air Pollution Prevention and Decontamination Plan for the Metropolitan Region of Santiago) includes requirements for the implementation of DPF particulate filters for machinery with power ranges between 56 kW and 560 kW.

Colombia is working on a bill[7] for machinery emission standards that calls for the implementation of Stage IIIB standards for units to be imported into the country in the coming years. Locally, the city of Bogota has developed the *Plan estratégico para la gestión integral de la calidad del aire a 2030* (Strategic Plan for the integrated management of air quality to 2030), which includes measures aimed at promoting the technological upgrading of construction machinery operating in the city. In Mexico, the Metropolitan Area of the Valley of Mexico (including Mexico City) has published the *Programa de gestión para mejorar la calidad del aire PROAIRE 2021 – 2030* (Management Programme to Improve Air Quality PROAIRE 2021 – 2030), which includes machinery emissions and highlights the need for a standard to regulate emissions from these sources. In Peru, actions related to the quantification of machinery engine emissions in inventories and the need to set regulations on emission limits were included in the *Plan de acción para el mejoramiento de la calidad del aire de Lima-Callao 2021-2025* (Action Plan for the Improvement of Air Quality in Lima-Callao 2021-2025)[8].

The comprehensive analysis of policy and regulatory instruments also identified experiences with machinery labelling, operation and road circulation requirements, control and inspection procedures and the main stakeholders involved in these processes. According to the case review, emission control and inspection processes are generally focused on the production, import and type-approval stages of NRMM. Switzerland is a special case as the control of the machinery distributed in the country is carried out based on the market information of the machinery, i.e., an internal control mechanism in which the authority checks this information with private counterparts. On the other hand, when searching for information in the countries consulted, the machinery registration processes were highlighted as important because they play a strategic role in the inspection of NRMM.

A wide variety of aspects were identified in the operation and road circulation requirements of the NRMM that are included in the regulation. These may be broadly classified into environmental requirements, related to emission levels of air pollutants and noise; and safety requirements, which are the most common and include aspects such as speed of circulation, zones where NRMM is allowed to circulate, hours of circulation, ways to move machinery between sites, licensing and training requirements for operators.

In the United States, Canada, Brazil, the European Union, China and the United States of America, guidelines are provided in the NRMM regulation covering at least one of the aspects of machinery end-of-life (NRMM useful life, repowering, overhaul and scrapping practices). In the USA, EU, Canada and China, regulation is associated with the control of air pollutant emission levels and the emission assessment covers the deterioration of the emission control systems of machinery over its lifetime.

It should be noted that there are mechanisms to control emissions during the NRMM operation. For example, in the European Union, starting with Stage V, there is an in-service compliance mechanism for certain power ranges that considers testing pollutant emissions of a sample of machines during their first years of life (Directive 2017/0655).

Emission verification mechanisms for in-use machinery focus on opacity measurements; particle number measurements are also carried out in cases where the machinery is fitted with DPFs. Regarding the latter control system, it is found to be the preferred and most effective emission control strategy for reducing particulate matter emissions from in-use machinery, with Switzerland being one of the first countries to establish regulations in this respect, applicable since the 1990s.

Table 6. 3. Comparison of emission standards for non-road mobile machinery around the world[24] .

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V[25]

Region	Net Power (kW)*		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Canada	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										
	P ≥ 560																										
United States	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P < 225																										
	225 ≤ P < 450																										
	450 ≤ P < 560																										
	P ≥ 560																										
Brazil	19 ≤ P < 37																										
	37 ≤ P < 75																										
	75 ≤ P < 130																										

[24] Note: The years of entry into force indicated here correspond to the most representative dates for the power ranges. However, for some categories, e.g., agricultural machinery, the dates of entry into force may be later than those indicated here as they have had a special deadline. Therefore, this table should be used only as a general indicator and for details of the exact dates (year and month) of entry into force of a particular machine it is important to refer to the original standard, power range, category and other characteristics to identify the table.

[25] Note: The years of entry into force indicated here correspond to the most representative dates for the power ranges. However, for some categories, e.g., agricultural machinery, the dates of entry into force may be later than those indicated here as they have had a special deadline. Therefore, this table should be used only as a general indicator and for details of the exact dates (year and month) of entry into force of a particular machine it is important to refer to the original standard, power range, category and other characteristics to identify the table.

	130 ≤ P ≤ 560																									

*Equivalence between kW and HP: 1.34 HP = 1 kW.

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V

Region	Net power (kW)		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
China	0 ≤ P < 8																										
	8 ≤ Pmax < 18																										
	18 ≤ Pmax < 37																										
	37 ≤ Pmax < 75																										
	75 ≤ Pmax < 130																										
	130 ≤ Pmax ≤ 560																										
	Pmax >560																										
Korea	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P < 225																										
	225 ≤ P < 450																										
	450 ≤ P < 560																										
India**	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										

Note: The maximum net power used in China refers to the maximum value of the net power on the full load rated power curve for the engine type, unlike in Europe, where emission limits are reported according to a reference power which may correspond to the maximum net power or the manufacturer's declared net rated power of an engine at rated speed, as specified for each category of non-road machinery engine. Rated speed means the maximum full load speed allowed by an engine´s governor, as designed by the manufacturer, or, if a governor is not present, the speed at which the maximum net power is attained by the engine, as specified by the manufacturer (REGULATION (EU) 2016/1628 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 September 2016 on Requirements Relating to Gaseous and Particulate Pollutant Emission Limits and Type-Approval for Internal Combustion Engines for Non-Road Mobile Machinery, Ame, 2016)..

** Broad equivalence Bharat (CEV) Stage IV and Bharat (Trem) Stage IV. For India, the entries into force and some maximum permissible levels vary depending on the industry in which the machinery operates. Some Bharat standards are not related to US standards, nor to European standards; in these cases, they are represented in the table with the colour of the standard that the machine would meet. For example, machines below 19 kW rated under Bharat (Trem) Stage III meet the Tier 1 standard, but not Tier 2.

Stage I / Tier 1	Stage II / Tier 2	Stage IIIA / Tier 3	Stage IIIB / Tier 4 Interim	Stage IV / Tier 4 Final	Stage V

Region	Net power (kW)		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Japan	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130 ≤ P ≤ 560																										
European Union, Switzerland, United Kingdom	P < 8																										
	8 ≤ P <19																										
	19 ≤ P < 37																										
	37 ≤ P < 56																										
	56 ≤ P < 75																										
	75 ≤ P < 130																										
	130≤ P ≤560																										
	P > 560																										
South Africa	18 ≤ P ≤560																										

Source: Elaborated by CALAC+,2020a

North America

6.1. Canada

Initially the air pollutant emission level regulation was defined in the Canadian Environmental Protection Act 1999 (CEPA, 1999) and subsequently reinforced through the Canada-United States Air Quality Agreement (Government of Canada and United States of America, 1991).

Prior to the definition of specific standards for NRMM or off-road machinery as the term is used in Canadian regulations, Canada signed Memoranda of Understanding (MOUs) with 13 engine manufacturers in 2000 (Government of Canada, 2000). In these commitments, the manufacturers agreed to supply off-road machinery with engines complying with the Tier 1 technology standard.

According to the Transport Policy portal, there are different standards and adoption schedules for different types of engines. While compression-ignition off-road engines are aligned with US Tier 4 technologies, small spark-ignition engines[26] operate to their own standard. Engines used in underground mining fall under provincial jurisdiction and marine engines comply with EPA regulations (Transport Policy, 2021).

Emission standards for off-road diesel engines were introduced in 2006. The measurement methods for Canadian off-road diesel engines are in line with the regulations defined by the EPA for the United States.

The regulated pollutants mentioned in section 10 of regulation SOR/2005-32 include carbon monoxide (CO), particulate matter (PM), non-methane hydrocarbons (NMHC) and nitrogen oxides (NOx). The emission standards are divided into classes according to engine power. The standards are defined in terms of mass of pollutant per unit of engine work, expressed in kilowatt hours.

The standards are aligned with those set by the EPA for the United States, and the regulations incorporate the following references:

- 40 CFR §89.112; 40 CFR §89.120; and
- 40 CFR §1039.101; 40 CFR §1039.102; 40 CFR §1039.105 and 40 CFR §1039.107

The regulation sets different emission standards and provisions for different types and power categories of engines. The following list presents a summary the various emission standards and provisions, as well as the corresponding sections of Regulation SOR/2005-32 (Minister of Justice of Canada, 2012) where these can be found:

1. Emission control systems and defeat devices (section 9 of the Regulation);
2. Exhaust emission standards (section 10 of the Regulation);
3. Crankcase and smoke emission standards (section 10 of the Regulation);
4. Adjustable parameters (section 11 of the Regulation);
5. Transportation refrigeration unit alternate emission standards (section 11.1 of the Regulation);
6. Replacement engines (section 12 of the Regulation); and
7. Transition engine emission standards (section 13 of the Regulation).

[26] Including handheld machines

The following tables summarise the emission standards adopted by Canada for the regulation of emissions from off-road engines for compression ignition engines.

Table 6. 4. Emission standards for Tier 2 engines.

Power (Kw)	Model years	PM (g/kW hr)	NOx (g/kW hr)	NMHC (g/kW hr)	**NOx+NMHC (g/kW hr)**
<8	2006-2011	0.80	-	-	7.5
≥8<19	2006-2011	0.80	-	-	7.5
≥19<37	2006-2011	0.60	-	-	7.5
≥37<75	2006-2007	0.40	-	-	7.5
≥75<130	2006	0.30	-	-	6.6
>560	2006-2011	0.20	-	-	6.4

Source: (Government of Canada, 2012).

Table 6. 5. Emission standards for Tier 3 engines.

Power (Kw)	Model years	PM (g/kW hr)	NOx (g/kW hr)	NMHC (g/kW hr)	**NOx+NMHC (g/kW hr)**
≥37<75	2008-2011	0.40	-	-	4.7
≥75<130	2007-2011	0.30	-	-	4.0
≥130<560	2006-2011	0.20	-	-	4.0

Source: (Government of Canada, 2012).

Table 6. 6. Emission standards for interim Tier 4 engines.

Power (Kw)	Model years	PM (g/kW hr)	NOx (g/kW hr)	NMHC (g/kW hr)	**NOx+NMHC (g/kW hr)**	CO (g/kW hr)
<8 (1)(5)	2012+	0.40	-	-	7.5	8.0
<8 (2)(5)	2012+	0.60	-	-	7.5	8.0
≥8<19(5)	2012+	0.40	-	-	7.5	6.6
≥19<37(5)	2012	0.30	-	-	7.5	5.5
≥37<56(5) (option 1)	2012	0.3	-	-	4.7	5.0
≥37<56(5) (option 2)	2012	0.03	-	-	4.7	5.0
≥56<75[1]	2012-2013	0.02	-	-	4.7	5.0
≥75<130[1]	2012-2013	0.02	-	-	4.0	5.0
≥130≤560	2012-2013	0.02	-	-	4.0	3.5
>560≤900	2012-2014	0.10	-	-	-	3.5
>900 (3)	2012-2014	0.10	-	-	-	3.5
>900 (4)	2012-2014	0.10	-	-	-	3.5

Source: (Government of Canada, 2012).

Table 6. 7. Emission standards for Tier 4 engines.

Power (Kw)	Model years	PM (g/kW hr)	NOx (g/kW hr)	NMHC (g/kW hr)	**NOx+NMHC (g/kW hr)**	CO (g/kW hr)
<8 (1)(5)	2012+	0.40	-	-	7.5	8.0
<8 (2)(5)	2012+	0.60	-	-	7.5	8.0
≥8<19(5)	2012+	0.40	-	-	7.5	6.6
≥19<37	2012+	0.30	-	-	4.7	5.5
≥37<56	2013+	0.03	-	-	4.7	5.0
≥56<130	2014+	0.02	0.40	0.19	-	5.0
≥130≤560	2014+	0.02	0.40	0.19	-	3.5
>560 (3)	2015+	0.04	3.5	0.19	-	3.5

Power (Kw)	Model years	PM (g/kW hr)	NOx (g/kW hr)	NMHC (g/kW hr)	**NOx+NMHC (g/kW hr)**	CO (g/kW hr)
>560 (4)	2015+	0.03	0.67	0.19	-	3.5
<8 (1)(5)	2012+	0.40	-	-	7.5	8.0
<8 (2)(5)	2012+	0.60	-	-	7.5	8.0
≥8<19(5)	2012+	0.40	-	-	7.5	6.6

Source: (Government of Canada, 2012).

(1) All engines except hand-start, air-cooled, direct injection engines.
(2) Hand-start, air-cooled direct injection engines.
(3) All except gen-set drive engines.
(4) Gen-set drive engines.
(5) Transient testing and NTE provisions for engines below 56 kW are delayed until 2013 in accordance with 40 CFR §1039.102 (a) (1) (i) and §1039.102 (g) (1).
[1] For the 2011 model year, the Tier 3 standards apply.
(*) Some of the Tier 4 standards apply for the interim Tier 4 standards.

6.2. United States

The first regulation related to emission limits (Tier 1) for non-road engines was published in 1994, which would come into force between 1996 and 2000 and covered compression ignition engines with a rated power above 37 kW (Reference Standard: 40 CFR 89). In 1995, emission standards were formulated for non-road spark ignition engines with a rated power below 19 kW at the Tier 1, which were to become effective from 1997. For the same engines, Tier 2 standards were formulated in 1999 and became effective between 2001 and 2007. Tier 2 has a 59% reduction in HC and NO_X emissions compared to Tier 1 (United States Department of Agriculture, 2002). Tier 3 standards were formulated in 2008 and come into force between 2011 and 2012.

In 1998, Tier 1 emission limits were defined for compression ignition engines below 37 kW and Tier 2 and Tier 3 emission limits were proposed[27] to be implemented between 2001 and 2006 (Tier 2) and between 2006 and 2008 (Tier 3). The fuel used to certify these standards was diesel with a maximum sulphur content of 2,000 parts per million (ppm) (TransportPolicy.net, 2021). One of the objectives of the Tier 2 and 3 standards was to promote compliance by advancing engine design rather than emission control or gas treatment systems. These standards were primarily aimed at controlling nitrogen oxides and hydrocarbons, not particulate matter (PM); even for various engine categories, Tier 1 had no limits for PM and Tier 2 and 3 have the same values.

In 2004, Tier 4 emission limits for non-road engines were adopted and came into effect between 2008 and 2015. These focused on PM and were up to 90% stricter than the values presented in the Tier 2 and 3 standards. These standards were accompanied by regulations on diesel quality, setting a maximum sulphur content of 15 parts per million (ppm) for 80% of sales in June 2006, and 100% in 2010 (MECA, 2021).

The tables below present the emission standards and useful life periods for the different classifications of engines regulated by the United States. The useful life of engines is established by the length of time the engine has been in operation, either in hours of use or years of age, whichever comes first.

[27] Applicable only to engines in the power range between 37kW and 560 kW.

Table 6. 8. Emission standards for compression ignition engines.

Power range (kW)	Tier	Year - model	Limit (g / kWh)					Useful life (hh /aa)
			NMHC	NMHC + NO_x	NO_x	PM	CO	
P <8	1	2000 - 2004	-	10.5	-	1.0	8.0	3,000 / 5
		2005 - 2007	-	7.5	-	0.80	8.0	
		2008 +	-	7.5	-	0.40	8.0	
8 ≤ P <19	1	2000 - 2004	-	9.5	-	0.80	6.6	3,000 / 5
		2005 - 2007	-	7.5	-	0.80	6.6	
		2008 +	-	7.5	-	0.80	6.6	
19 ≤ P <37	1	1999 - 2003	-	9.5	-	0.80	5.5	5,000 / 7
		2004 - 2007	-	7.5	-	0.60	5.5	
		2008 - 2012	-	7.5	-	0.30	5.5	
		2013 +	-	4.7	-	0.03	5.5	
37 ≤ P <56	1	1998 - 2003	-	-	9.2	-	-	8.000 / 10
		2004 - 2007	-	7.5	-	0.40	5.0	
		2008 - 2011	-	4.7	-	0.40	5.0	
	(Op 1)	2008 - 2012	-	4.7	-	0.40	5.0	
	(Op 2)	2012	-	4.7	-	0.03	5.0	
		2013 +	-	4.7	-	0.03	5.0	
56 ≤ P <75	1	1998 - 2003	-	-	9.2	-	-	8.000 / 10
		2004 - 2007	-	7.5	-	0.40	5.0	
		2008 - 2011	-	4.7	-	0.40	5.0	
		2012 - 2013	-	4.7	-	0.02	5.0	
		2014 +	0.19	-	0.40	0.02	5.0	
75 ≤ P <130	1	1997 - 2002	-	-	9.2	-	-	8.000 / 10
		2003 - 2006	-	6.6	-	0.30	5.0	
		2007 - 2011	-	4.0	-	0.30	5.0	
		2012 - 2013	-	4.0	-	0.02	5.0	
		2014 +	0.19	-	4.0	0.02	5.0	
130 ≤ P <225	1	1996 - 2002	1.3	-	9.2	0.54	11.4	8.000 / 10
		2003 - 2005	-	6.6	-	0.20	3.5	
		2006 - 2010	-	4.0	-	0.20	3.5	
		2011 - 2013	-	4.0	-	0.02	3.5	
		2014 +	0.19	-	0.40	0.02	3.5	
225 ≤ P <450	1	1996 - 2000	1.3	-	9.2	0.54	11.4	8.000 / 10
		2001 - 2005	-	6.4	-	0.20	3.5	
		2006 - 2010	-	4.0	-	0.20	3.5	
		2011 - 2013	-	4.0	-	0.02	3.5	
		2014 +	0.19	-	0.40	0.02	3.5	

Power range (kW)	Tier	Year - model	Limit (g / kWh)					Useful life (hh /aa)
			NMHC	NMHC + NO_x	NO_x	PM	CO	
450 ≤ P <560	1	2000 - 2005	1.3	-	9.2	0.54	11.4	8.000 / 10
		2006 - 2010	-	6.4	-	0.20	3.5	
		2011 - 2014	0.40	-	3.5	0.10	3.5	
		2015 +	0.19	-	3.5	0.04	3.5	
560≤ P <900	1	2000 - 2005	1.3	-	9.2	0.54	11.4	8.000 / 10
		2006 - 2010	-	6.4	-	0.20	3.5	
		2011 - 2014	0.40	-	3.5	0.10	3.5	
		2015 +	0.19	-	3.5	0.04	3.5	
P>900	1	2000 - 2005	1.3	-	9.2	0.54	11.4	8.000 / 10
		2006 - 2010	-	6.4	-	0.20	3.5	
		2011 - 2014	0.40	-	3.5	0.10	3.5	
		2015 +	0.19	-	3.5	0.04	3.5	

Source: own elaboration.

Table 6. 9. Emission standards for spark ignition engines and reference power ≤ 19 kW. ABT: Averaging, banking, trading.

Corresponds to emission offsetting programmes between different engine families or lines, or manufacturers. Averaging refers to the exchange of emission credits between engine families within a given manufacturer´s product line. Banking means the retention of emission credits in a given engine family for use in future models or for the purpose of trading. Trading refers to the exchange of emission credits between engine manufacturers. Emission credits represent the amount of emission reductions or exceedance, by an engine family below or above the applicable emission standard.

Phase	Class	Year - model	Limit (g/kWh)					Useful life (hh)
			THC	HC+NO_x	NMHC + NO_x	NO_x	CO	
1	I	1997 +	-	16.1	-	-	519	Engines are not obliged to comply with emission standards for their entire useful life.
	II	1997 +	-	13.4	-	-	519	
	III	1997 +	295	-	-	5.36	805	
	IV	1997 +	241	-	-	5.36	805	
	V	1998 +		-	-	5.36	603	
	I	2003 +	-	46.1 (ABT)	14.8 (ABT)	-	610	125 / 250 / 500
	IA	2001 +	-	50 (ABT)	-	-		50 / 125 / 300
	IB	2001 +	-	40 (ABT)	37 (ABT)	-		125 / 250 / 500
	II	2001	-	18.0 (ABT)	16.7 (ABT)	-	610	250 / 500 /1000
		2002	-	16.6 (ABT)	15.3 (ABT)	-		
		2003	-	15.0 (ABT)	14.0 (ABT)	-		
		2004	-	13.6 (ABT)	12.7 (ABT)	-		
		2005 +	-	12.1 (ABT)	11.3 (ABT)	-		
	III	2002	-	230.0 (ABT)	-	-	805	50 /125 / 300
		2003	-	175.0 (ABT)	-	-		
		2004	-	113.0 (ABT)	-	-		

Phase	Class	Year - model	Limit (g/kWh)					Useful life (hh)		
			THC	HC+NOx	NMHC + NOx	NOx	CO			
		2005 +	-	50.0 (ABT)	-	-				
	IV	2002	-	196.0 (ABT)	-	-	805	50 /125 / 300		
		2003	-	148.0 (ABT)	-	-				
		2004	-	99.0 (ABT)	-	-				
		2005 +	-	50.0 (ABT)	-	-				
	V	2004	-	143.0 (ABT)	-	-	603	50 /125 / 300		
		2005	-	119.0 (ABT)	-	-				
		2006	-	96.0 (ABT)	-	-				
		2007	-	72.0 (ABT)	-	-				
	I	2012	-	10.0 (ABT)	-	-	610	**Residential**	**Residential extended life**	**Commercial**
								125		
	II	2011	-	8.0 (ABT)	-	-	610		500	1,000
	III	2010	-	50.0 (ABT)	-	-	805	**Light use**	**Medium use**	**Intensive use**
	IV	2010		50.0 (ABT)	-	-	805	50	125	
	V	2010		72.0 (ABT)	-	-	603			

Source: own elaboration.

Table 6. 10. Emission standards for spark ignition engines and reference power > 19 kW.

Tier	Year - model	General standard for engines using general cycle		Alternative standard for heavy duty engines		Field test standards		Useful life (yy/hh)
		HCT + NOx (g/kWh)	CO (g/kWh)	HCT + NOx (g/kWh)	CO (g/kWh)	HCT + NOx (g/kWh)	CO (g/kWh)	
1	2004 - 2006	4.0	50.0	4.0	130	-	-	7 / 5,000
	2007 +	2.7	4.4	2.7	130	3.8	6.5	

Source: own elaboration

6.3. Mexico

According to information gathered through interviews with local experts[28] , Mexico City technical staff are working on measures to reduce emissions from construction machinery that will be published in the *Programa de Gestión*

[28] (P.C. Rodriguez, personal communication, 18 June 2021).

para Mejorar la Calidad del Aire de la Ciudad de México (ProAire) (Management Programme to Improve Air Quality in Mexico City)[29] .

There are no emission standards for new or used machinery imported or existing in the country.

[29] The creation of a regulation for new machinery will be proposed, defining pollutant emission limits and emission control systems.

South America

6.4. Brazil

For construction and agricultural machinery in Brazil, the PROCONVE MAR-1 regulation sets the emission standards with which they must comply to operate in the national territory. The regulation established emission limits equivalent to North American Tier 3 and European Stage IIIA standards. The following table specifies them for each type according to their engine power.

Table 6. 11. Maximum emission limits for agricultural and construction machinery engines.

Engine power (kW)	Date of implementation		Emission limit (g/kWh)		
	Construction	Agricultural	CO	NOx + HC	PM
130 ≤ P ≤ 560	January 2015	January 2017	3.5	4.0	0.2
75 ≤ P < 130	January 2015	January 2017	5.0	4.0	0.3
37 ≤ P < 75	January 2015	January 2019	5.0	4.7	0.4
19 ≤ P < 37	January 2017	January 2019	5.5	7.5	0.6

**Maximum power according to ISO Standard 14396: 2002, which, at the discretion of the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), may adopt the equivalent ABNT standard.*

Source: own elaboration based on (National Environment Council, 2021).

Resolution 433 of 2011 (National Environment Council, 2011) also states generally that:

- Emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and particulate matter (PM) must comply with ISO 8178-1.
- The sound power level shall be measured under the conditions established in accordance with NBR-NM-ISO 6395, and shall not exceed the permissible level Lwa in dB (A) / 1 pW specified in the Annex to Resolution 433 of 2011 in relation to the net installed power in kW.
- The net installed power shall be determined as defined in ISO 14396: 2002.
- The reference fuel for the type-approval test shall be, for MAR-I Stage, regulated by the National Agency for Oil, Gas and Biofuels (ANP).

6.5. Chile

The Supreme Decree N°39/2020 of the Ministry of Environment establishes the emission standard for mobile machinery which will come into force 24 months after the publication of the standard, with the exception of tractors which have a period of 30 months. The regulation sets emission limits equivalent to the European Stage IV or V standard as indicated in Tables 6.11 and 6.12 respectively.

Table 6. 12. Maximum emission limits from the exhaust system.

Power kW	CO		NMHC		NOx		NMHC + NOx		PM	
	(g/kWh)	(g/bhp-h)	(g/kWh)	(g/bhp-h)	(g/kWh)	(g/bhp-h)	(g/kWh)	(g/bhp-h)	(g/kWh)	(g/bhp-h)
130 ≤ P ≤ 560	3.5	2.6	0.19	0.14	0.40	0.30	-	-	0.02	0.015
56 ≤ P < 130	5	3.7	0.19	0.14	0.40	0.30	-	-	0.02	0.015
37 ≤ P < 56	5	3.7	-	-	-	-	4.7	3.5	0.03	0.022
19 ≤ P < 37	5.5	4.1	-	-	-	-	4.7	3.5	0.03	0.022

Source: (Ministry of Environment, 2021).

Table 6. 13. Maximum emission limits from the exhaust system.

Power kW	CO	HC	NOx	HC + NOx	PM	PN
	g/kWh	g/kWh	g/kWh	g/kWh	g/kWh	1/kWh
130 ≤ P ≤ 560	3.5	0.19	0.40	-	0.015	$1x10^{12}$
75 ≤ P < 130	5	0.19	0.40	-	0.015	$1x10^{12}$
56 ≤ P < 75	5	0.19	0.40	-	0.015	$1x10^{12}$
37 ≤ P < 56	5	-	-	4.7	0.015	$1x10^{12}$
19 ≤ P < 37	5	-	-	4.7	0.015	$1x10^{12}$

Source: (Ministry of Environment, 2021).

The aforementioned regulation indicates that the *Superintendencia del Medio Ambiente* (SMA) (Superintendency of the Environment) is in charge of establishing protocols and procedures to determine compliance with the regulation. On the other hand, it is mentioned that:

> "The manufacturers or their legal representatives in Chile, distributors or importers, of mobile machinery affected by the emission limits required in Tables 6.11 or 6.12, shall submit a certificate to the *Superintendencia del Medio Ambiente*, which shall verify, the emissions compliance of the type or engine family of the mobile machinery, prior to its importation, according to the procedures established by Regulation (EU) 2016/1628 of the European Parliament and of the Council, or by the United States Code of Federal Regulations (CFR), title 40, part 1039, as applicable."

6.6. Colombia

Resolution 762 of 2022 sets maximum levels for carbon monoxide (CO), particulate matter (PM), hydrocarbons (HC) or non-methane hydrocarbons (NMHC) and nitrogen oxides (NOx). The emission standards are categorised by ranges of net rated engine power in kW and defined in terms of mass of pollutant per unit of engine work in g/kW-h.

Tables 6.11 and 6.12 present the emission limits for off-road mobile sources according to the Draft Resolution, which would apply to compression ignition engines under dynamic test that are assembled, manufactured or imported into the country from 1 January 2023. For approval of the *Certificado de Emisiones en Prueba Dinámica y Visto Bueno del Protocolo de Montreal* (CEPD) (Emissions Test Cycle and Montreal Protocol Approval), compliance with European or US standards must be demonstrated. Exemptions from compliance are made for non-road land mobile sources used exclusively for agricultural work, those that operate with fuel other than diesel and those that,

regardless of their fuel and work, have a rated power below 19 kW or above 560 kW (Colombian Ministry of Environment and Sustainable Development, 2020).

Table 6. 14. Maximum permissible emission limits for non-road land mobile sources in dynamic testing, assessed under the steady-state cycle (NRSC) and the transient cycle (NRTC), according to European standards.

Net rated engine power - P (kW)	CO (g/kW-h)	HC (g/kW-h)	NOx (g/kW-h)	HC+NOx (g/kW-h)	PM (g/kW-h)
130≤P≤560	3.50	0.19	2.00	-	0.025
75≤P< 130	5.00	0.19	3.30	-	0.025
56≤P<75	5.00	0.19	3.30	-	0.025
37≤P<56	5.00	-	-	4.70	0.025
19≤P<37	5.50	-	-	7.50	0.600

Source: own elaboration based on Ministry of Environment and Sustainable Development of Colombia (2020).

Table 6. 15. Maximum permissible emission limits for non-road land mobile sources in dynamic testing, assessed under the steady-state cycle (NRSC) and the transient cycle (NRTC), according to US standards.

Net rated engine power - P (kw)	CO (g/kW-h)	HCNM (g/kW-h)	NOx (g/kW-h)	NMHC+NOx (g/kW-h)	PM (g/kW-h)
130≤P≤560	3.50	0.19	2.00	-	0.02
56≤P< 130	5.00	0.19	3.40	-	0.02
37≤P<56	5.00	-	-	4.70	0.03
19≤P<37	5.00	-	-	7.50	0.30

Source: own elaboration based on Ministry of Environment and Sustainable Development of Colombia (2020).

Regulatory standards for the conformity measurement of gaseous and particulate emissions for non-road land mobile sources were adopted by Colombia from the European Union Directive 97/68/EC as amended by 2012/46/EU (Directive 2012/46/EU, 2012) of the European Union and the United States Code of Federal Regulations (CFR) title 40, part 1039 in Ministry of Environment and Sustainable Development of Colombia (2020).

6.7. Peru

The country currently has no air pollutant emission standards for green machinery or yellow machinery.

Asia-Pacific

6.8. India

Diesel-powered agricultural and construction vehicles and machinery

On 5 March 2018, the Ministry of Road Transport and Highways published the final regulation for Bharat Stage non-road emission standards (called BS Stage CEV/Trem IV and V), including stricter emission limits for particulate matter (PM), particle number (PN) (for BS V only), nitrogen oxide (NOx), hydrocarbons (HC) and carbon monoxide (CO), which will be applicable for diesel-powered equipment, including agricultural tractors, construction vehicles and harvesters. According to ICCT (2018), this is the first time that India has adopted a consistent set of standards for both agricultural and construction machinery, assigned distinctive terminology for each type of machinery (Trem

and CEV, respectively) and set maximum levels that are equivalent to EU Stage V emission standards. The deterioration factors for durability periods and test cycles of the current Bharat standards are also consistent with those of the European Stage IV and V standards (Dieselnet, 2018; ICCT, 2018).

According to the definition of the regulations as can be seen in Table 6. 16, the BS (CEV and Trem) IV standards set requirements for diesel engines between 37 and 560 kW. Although their implementation start date was initially set for 1 October 2020, due to a delay it has been updated for the same months in 2021. The BS (CEV and Trem) V standards will be effective from 1 April 2024 and will cover a wider range of engines, including those with power ratings below 8 kW and above 560 kW, as well as introducing PN limits for engines with power ratings between 19 and 560 kW. It has also been decreed that from April 2026, all engines manufactured and approved to the BS V standard and in operation will be required to undergo compliance testing by Portable Emission Measurement Systems (PEMS), which is a necessary and important regulatory component to verify that emissions from actual vehicle operation remain within the limits of the new Bharat standards, as recommended by the ICCT to the Ministry of Road Transport and Highways (Dieselnet, 2018; ICCT, 2017b, 2018).

Despite the benefits that the implementation of such emission limits in India may bring, some authors have highlighted the fact that the BS IV standard does not specify limit values for engines with a power rating below 37 kW (which account for about 90% of agricultural tractors in India), nor are limits covered for engines above 560 kW, at least until the implementation of the BS V standard by 2024, when all power ratings will be covered. According to the ICCT, by not specifying standards for engines below 37 kW in the BS IV standard, it will substantially delay the introduction of emission standards for engines used in most agricultural tractors and similar sized non-road equipment, for which one recommendation is the formulation of amendments to the standards that set stringent limits equivalent to Tier 4 standards for that range (Dieselnet, 2018; ICCT, 2018).

Table 6. 16. Bharat Trem Stage IV and V standards for agricultural equipment and Bharat CEV Stage IV and V standards for construction machinery.

Power rating (kW)	Date	Emission limit (g/kWh)					Test cycle
		CO	HC	NOx	PM	PN (1/kWh)	
Bharat Trem Stage IV and Bharat CEV Stage IV							
37 ≤ P < 56	April 2021 (CEV)	5.0	4.7*		0.025	-	NRSC and NRTC
56 ≤ P < 130	October 2021 (Trem)	5.0	0.19	0.4	0.025	-	
130 ≤ P < 560		3.5	0.19	0.4	0.025	-	
Bharat Trem Stage V and Bharat CEV Stage V							
P < 8	April 2024	8.0	7.5*		0.4	-	NRSC
8 ≤ P < 19		6.6	7.5*		0.4	-	
19 ≤ P < 37		5.0	4.7*		0.015	1×10^{12}	NRSC and NRTC
37 ≤ P < 56		5.0	4.7*		0.015	1×10^{12}	
56 ≤ P < 130		5.0	0.19	0.4	0.015	1×10^{12}	
130 ≤ P < 560		3.5	0.19	0.4	0.015	1×10^{12}	
P ≥ 560		3.5	0.19	3.5	0.045	-	NRSC
Engines equipped with selective catalytic reduction (SCR) must meet an ammonia emission limit of 25 ppm for engines ≤ 56 kW and 10 ppm for engines above 56 kW. The limits are defined as a mean value over the NRTC and NRSC cycles.							

*NOx + HC

Source: own elaboration based on (Dieselnet, 2018).

According to ICCT, the stricter PM and PN limits are set at a level that will ensure the implementation of diesel particulate filters, the key technology needed to effectively control particulate matter emissions from diesel engines, adopted as expected in the European Stage V standards. (ICCT, 2018).

Locomotives

Locomotive operation in India is an important component of non-road mobile machinery; it is regulated by the Ministry of Railways and carries up to 13 million passengers per day in 2018. In March 2017, India's Central Pollution Control Board (CPCB) submitted proposed emission standards for diesel locomotives to the Ministry of Environment, Forest and Climate Change, whose limit values are based on emission measurements conducted by the CPCB on Indian railways of the two categories operating in the country: ALCO-type locomotives and heavy-duty EMD-type locomotives. The standards would be applicable through the useful life of the locomotive and the proposal provides for defining a compliance protocol, including certification, production line testing and in-use testing, based on the practice followed by US railroads (Dieselnet, 2018; Indian Ministry of Railways, 2018).

Table 6. 17. Proposed emission limits for locomotives.

Type of locomotive	Emission limits (g/bhp-hr)			
	CO	HC	NOx	PM
ALCO	3.0	1.00	17.0	0.45
EMD (HHP locomotives)	1.4	1.00	9.0	0.35

Source: own elaboration based on (Dieselnet, 2018).

6.9. China

China's 13th Five-Year Plan for Protecting Ecological Environment showed China's intention to accelerate the design, review and implementation of emission standards for non-road vehicles (ICCT, 2017a), pushing for the incorporation of the China IV standard by 2020, which would present an opportunity to align Chinese standards with US Tier 4 standards, as well as to incorporate DPF (Diesel Particle Filter) emission after-treatment technologies.

China has historically followed the implementations of European standards for NRMM emissions, starting with the China I and II standards, implemented since October 2007 and October 2009 respectively, as stipulated in regulation GB20891-2007 which included the description of pollutant measurement methods for NRMM diesel engines and which at the time were generally aligned with the EU Stage I and II standards determinations (ICCT, 2021).

Subsequently, in 2014 the Ministry of Ecology and Environment of the People's Republic of China defined the limits and measurement methods for pollutants from NRMM diesel engines for the China III and IV standards (equivalent to the European Stage IIIA and Stage IIIB, respectively) according to the GB 20891-2014 regulation. However, although the gradual implementation of the China III standards would start from October 2014, the implementation date for the China IV standards had not been defined until the amendment or update of their regulation that occurred in 2020, where these China IV standards are scheduled to be required from December 2022 and will be equivalent to the European Stage IIIB but with updates that include, in addition to emission limits for NH3 and PN, the use of portable emission measurement systems (PEMS) during engine operation, NOx and particulate control

diagnostic systems (NCD and PCD respectively), installation of GPS systems, remote emission monitoring for equipment between 37 and 560 kW and labelling requirements for NRMM as described in the ICCT report *The updated China IV non-road emission standards* (ICCT, 2021), so as to meet some of the requirements that characterise the Stage V standards currently being implemented for the European Union.

The emission limits for criteria pollutants for non-road mobile machinery according to the regulations GB 36886-2018, GB 20891-2014, GB 26133-2010, GB 20891-2007 and GB 19756-2005 are given in the tables below (Ministry of Ecology and Environment of the People's Republic of China, 2005, 2007, 2010, 2014b, 2018)..

Emission limits for Stage I, II, III and IV non-road mobile machinery engines:

The limits reported by the GB 20891-2014 and GB 20891-2007 regulations are shown in the table below.

Table 6. 18. Emission limits for NRMM diesel engine exhaust pollutants.

Stage	Net power rating (Pmax)(Kw)	Date of implementation	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	HC+NOx (g/kWh)	PM (g/kWh)
China I	130 ≤ Pmax ≤ 560	October 2007	5.0	1.3	9.2	-	0.54
	75 ≤ Pmax < 130		5.0	1.3	9.2	-	0.7
	37 ≤ Pmax < 75		6.5	1.3	9.2	-	0.85
	18 ≤ Pmax < 37		8.4	2.1	10.8	-	1.0
	8 ≤ Pmax < 18		8.4	-	-	12.9	-
	0 ≤ Pmax < 8		12.3	-	-	18.4	-
China II	130 ≤ Pmax ≤ 560	October 2009	3.5	1.0	6.0	-	0.2
	75 ≤ Pmax < 130		5.0	1.0	6.0	-	0.3
	37 ≤ Pmax < 75		5.0	1.3	7.0	-	0.5
	18 ≤ Pmax < 37		5.5	1.5	8.0	-	0.8
	8 ≤ Pmax < 18		6.6	-	-	9.5	0.8
	0 ≤ Pmax < 8		8.0	-	-	10.5	1.0
China III	Pmax > 560	October 2014	3.5	-	-	6.4	0.2
	130 ≤ Pmax ≤ 560		3.5	-	-	4.0	0.2
	75 ≤ Pmax < 130		5.0	-	-	4.0	0.3
	37 ≤ Pmax < 75		5.0	-	-	4.7	0.4
	Pmax < 37		5.5	-	-	7.5	0.6
China IV	Pmax > 560	No definite date until 2020 update	3.5	0.40	3.5, 0.67[1]	-	0.10
	130 ≤ Pmax ≤ 560		3.5	0.19	2.0	-	0.025
	75 ≤ Pmax < 130		5.0	0.19	3.3	-	0.025
	56 ≤ Pmax < 75		5.0	0.19	3.3	-	0.025
	37 ≤ Pmax < 56		5.0	-	-	4.7	0.025
	Pmax < 37		5.5	-	-	7.5	0.6
	(1) Applicable to mobile generator sets with Pmax > 900 kW diesel engines.						

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2007, 2014b).

Table 6. 19. New exhaust pollutant emission limits for NRMM diesel engines according to China IV standard updated in 2020 for implementation as of 2022.

Stage	Net power rating (Pmax)(Kw)	Date of implementation	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	HC+NOx (g/kWh)	PM (g/kWh)	NH_3 (g/kWh)	PN (#/kWh)

China IV	Pmax>560	December 2022	3.5	0.40	3.5, 0.67 [1]	-	0.10	25[2]	-
	130 ≤ Pmax < 560		3.5	0.19	2.0	-	0.025		5x10[12]
	75 ≤ Pmax < 130		5.0	0.19	3.3	-	0.025		
	56 ≤ Pmax < 75		5.0	0.19	3.3	-	0.025		
	37 ≤ Pmax < 56		5.0	-	-	4.7	0.025		
	Pmax		5.5	-	-	7.5	0.60		
▪ Applicable to mobile generator sets with Pmax > 900 kW diesel engines ▪ Applies to diesel engines using reagents									-

Source: (ICCT, 2021)

Exhaust emission limits for non-road mobile machinery:

The limits of regulation GB 36886-2018 are presented below:

Table 6. 20. Limits and methods for measuring exhaust fumes from non-road mobile machinery fitted with diesel engines.

Category	Pmax (kW)	Light absorption coefficient/m-1	Ringelmann Blackness series
Class I	Pmax < 19	3.00	1
	19 ≤ Pmax ≤ 37	2.00	
	37 ≤ Pmax ≤ 560	1.61	
Class II	Pmax < 19	2.00	1
	19 ≤ Pmax ≤ 37	1.00	1
	Pmax ≥ 37	0.80	
Class III	Pmax ≥ 37	0.50	1
	Pmax < 37	0.80	

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2018).

Table 6. 21. Engine category.

Engine category code	Working volume (V/cm^3)
SH1	V < 20
SH2	20 ≤ V < 50
SH3	V ≥ 50
FSH1	V < 66
FSH2	66 ≤ V < 100
FSH3	100 ≤ V < 225
FSH4	V ≥ 225

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2018).

Stage I and II emission limits for small SI engines:

The emission limits of the GB 26133-2010 regulation are presented in the following tables.

Table 6. 22. Emission limits for engine exhaust pollutants (Stage I).

Engine category code	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	HC+NOx (g/kWh)
SH1	805	195	5.36	-
SH2	805	241	5.36	-
SH3	603		5.36	-

FSH1	519	-	-	50
FSH2	519	-	-	40
FSH3	519	-	-	16.1
FSH4	519	-	-	13.4

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2018).

Table 6. 23. Emission limits for engine exhaust pollutants (Stage II)

Engine category code	CO (g/kWh)	HC+NOx (g/kWh)	NOx (g/kWh)
SH1	805	50	10
SH2	805	50	
SH3	603		
FSH1	610	50	
FSH2	610	40	
FSH3	610	16.1	
FSH4	610	12.1	

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2018).

Criteria for defining emission limits

The Air Law (Law on the Prevention and Control of Air Pollution, 2000) mentions the need to improve air quality by emphasising the treatment of emissions from a prevention perspective and mentioning non-road mobile sources as sources of concern. The law promotes efforts to reduce pollutants such as particulate matter (PM), sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC), ammonia (NH_3) and greenhouse gases. Furthermore, due to the country's economic growth in the construction sector[30] and the agricultural sector[31] , the relevance of incorporating emission standards for the equipment used by these sectors was noted.

According to the *Environmental Protection Tax Law of the People's Republic of* China (Standing Commite of the National People's Congress, 2016), Article 12 of Chapter III entitled "Tax Reduction and Exemption", in sub-index ii, states that pollutants discharged by mobile sources such as railway locomotives, ships and aircrafts shall be exempted.

[30] Construction machinery in China recorded an average annual growth rate of 10% during 2010-2015 (Borscon,2018).
[31] Diesel engines for agricultural machinery are growing by 3.8% each year, and are expected to reach RMB 600 billion in gross industrial output value by 2020 (Borscon,2018).

Europe

6.10. European Union

For the European Union and the United Kingdom, the same provisions apply as those presented for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

6.11. Switzerland

The Swiss OAPC Ordinance adopts the EU regulation. The following table shows the current emission standards.

Table 6. 24. Stage V emission standards by engine category.

Engine category	Equipment type	Power range (kW)	Engine type	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	PN (#/kWh)	A*
NRE-v-1 NRE-c-1	Non-road mobile machinery with NRE engines	0<P<8	CI	8.00	HC + NOx ≤ 7.50		0.40	-	1.1
NRE-v-2 NRE-c-2		8≤P<19	CI	6.60	HC + NOx ≤ 7.50		0.40	-	1.1
NRE-v-3 NRE-c-3		19≤P<37	CI	5.00	HC + NOx ≤ 4.70		0.015	1×10^{12}	1.1
NRE-v-4 NRE-c-4		37≤P<56	CI	5.00	HC + NOx ≤ 4.70		0.015	1×10^{12}	1.1
NRE-v-5 NRE-c-5		56≤P<130	All	5.00	0.19	0.40	0.015	1×10^{12}	1.1
NRE-v-6 NRE-c-6		130≤P≤560	All	3.50	0.19	0.40	0.015	1×10^{12}	1.1
NRE-v-7 NRE-c-7		P>560	All	3.50	0.19	3.50	0.045	-	6.0
NRG-v-1 NRG-c-1	Generating sets	P>560	All	3.50	0.19	0.67	0.035	-	6.0
NRSh-v-1a	Equipment with SI engines	0<P<19	YES	805	HC + NOx ≤ 50		-	-	-
NRSh-v-1b		0<P<19	YES	603	HC + NOx ≤ 72		-	-	-
NRS-vr-1a NRS-vi-1a		0<P<19	YES	610	HC + NOx ≤ 10		-	-	-
NRS-vr-1b NRS-vr-1b NRS-vi-1b		0<P<19	YES	610	HC + NOx ≤ 8		-	-	-
NRS-v-2a		19<P<30	YES	610	HC + NOx ≤ 8		-	-	-
NRS-v-2b NRS-v-3		19≤P< 56	YES	4.40¥	HC + NOx ≤ 2.70¥		-	-	-
IWP-v-1 IWP-c-1 IWA-v-1 IWA-c-1	Inland waterway vessels	37≤P<75	All	5.00	HC + NOx ≤ 4.70		0.30	-	6.0
IWP-v-2 IWP-c-2		75≤P<130	All	5.00	HC + NOx ≤ 5.40		0.14	-	6.0

Engine category	Equipment type	Power range (kW)	Engine type	CO (g/kWh)	HC (g/kWh)	NOx (g/kWh)	PM (g/kWh)	PN (#/kWh)	A*
IWA-v-2 IWA-c-2									
IWP-v-3 IWP-c-3 IWA-v-3 IWA-c-3		130≤P<300	All	3.50	1.00	2.10	0.10	-	6.0
IWP-v-4 IWP-c-4 IWA-v-4 IWA-c-4		300≤P	All	3.50	0.19	1.20	0.22	1×10^{12}	6.0
RLL-c-1 RLL-v-1	Railway	P>0	All	3.50	HC + NOx ≤ 4.00		0.025	-	6.0
RLR-c-1 RLR-v-1		P>0	All	3.50	0.19	2.00	0.015	1×10^{12}	6.0
SMB-v-1	Snowmobiles	P>0	YES	275	75	-	-	-	-
ATS-v-1	All-terrain vehicles (ATVs) and four-wheeled side-by-side vehicles (SbS)	P>0	YES		HC + NOx ≤ 8		-	-	-

*Where an "A" factor is defined, the HC emission limits for fully and partially gaseous fueled engines will be calculated with the following formula: HC = 0.19 + (1.5 × A × GER), where the GER is the average gas energy ratio over the appropriate cycle. The average GER is determined by the hot-start transient test cycle in both the non-road steady cycle (NRSC) and the transient cycle (NRTC). If the calculated HC limits exceed the value of 0.19 + A, the limits should be set to 0.19 + A.

¥Alternatively, any combination of values satisfying the equation $(HC+NOx)*CO^{0.784} \leq 8.57$, as well as the following conditions: CO≤20.6g/kWh and (HC+NOx)≤2.7g/kWh.

Source: (ICCT, 2016).

Africa

6.12. South Africa

The following table presents the emission standards for local pollutants, with their date of adoption.

Table 6. 25. EU Stage II emission standards for diesel engines in non-road motor vehicles.

Engine category	Power range (kW)	Start of the implementation	Emission limit (g/kWh)			
			CO	HC	NOx	PM
E	130 ≤ P ≤ 560	January 2002	3.5	1.0	6.0	0.2
F	75 ≤ P < 130	January 2003	5.0	1.0	6.0	0.3
G	37 ≤ P < 75	January 2004	5.0	1.3	7.0	0.4
D	18 ≤ P < 37	January 2001	5.5	1.5	8.0	0.8

* Stage II also applies to constant speed engines from January 2007.

Source: (Dieselnet, 2004).

7. Import requirements and type-approval processes

The following sections show the import requirements and type-approval processes for NRMM in the different case studies.

North America

7.1. Canada

7.1.1. Import requirements

The importation procedures for an engine are described in the Canadian Environmental Protection Act (CEPA, 1999) in paragraphs 153(1) (a), (b), (d) and (e), "Vehicles, engines and equipment standards"; "Compliance by companies", 154 "Compliance on importation", 155(1) (a), (b), (c) "Exceptions for certain importations", 155(2) (a), (b) "Vehicle from United States and Mexico"; 155(3) (a), (b) "Change in standard since manufacture" and 155(4) "Imported vehicle or engine".

Importers, whether individuals or companies, must generate an import declaration if 50 or more engines (in the case of companies) or 9 or more engines (in the case of individuals) enter Canadian territory. The declarations must be submitted to the Minister of National Revenue, which is the entity responsible for reviewing engine import declarations. (Minister of Justice of Canada, 2009, 2012, 2021).

These procedures apply to the following regulations:

- Emission regulations for off-road compression-ignition engines (mobile and stationary).
- Emission regulations for large off-road spark ignition engines (mobile and stationary).
- Emission regulations for small, spark ignition, off-road engines.
- Emission regulations for off-road compression-ignition engines.

In the case of importations of engines for use in vessels under the "Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations", importation declarations must be made only for companies importing at least 500 engines (subsection 37(3)) and exempts individuals importing fewer than 10 engines (subsection 37(2)) (Minister of Justice of Canada, 2011).

It is the importer's responsibility to complete the importation declaration. The tables below show the information required for engines and machinery.

Table 7. 1. Importation declaration form for engines.

Manufacturer	Brand	Model	Model year	Power category	Emission standard	Expected date of importation	Quantity	Applicable declaration

Source: (Minister of Justice of Canada, 2011).

Table 7. 2. Importation declaration form for machinery.

Manufacturer	Brand	Model	Type

Source: (Minister of Justice of Canada, 2011).

Once the importation declaration forms are completed, they should be sent to the Regulatory Administration Section of the Transportation Division (Government of Canada, 2012).

The importation declaration covers engines installed in machinery and single engines in:

- Construction: bulldozers, backhoe loaders, tractors (loaders).
- Forestry sector: skidders, forwarders, and harvesters.
- Mining: drilling machines, crushers and grinders.
- Agricultural sector: tractors and sprayers.

For example, in the specific guidelines for the importation of engines to be used in off-road applications by both individuals and companies, the document "Off-Road Compression Ignition (Mobile and Stationary) and Large Spark-Ignition Road Engine Emission Regulations" sets out the steps and procedures for import declarations in the following sections: subsection 44 (1) "Declarations prior to importation"; 44(2) "Submission", 44(3) "Importation of 50 engines or more"; 44(4) "Submission on time"; 44(5) "Replacement engines". For individuals the procedures are set out in the following sections: subsection 45(1) "Declaration for person that is not a company"; 45(2) "Submission" and 45(3) "Exception". (Minister of Justice of Canada, 2021)

7.1.2.Type-approval processes

Type-approval tests are conducted in laboratories equipped with dynamometers and flue gas measuring devices. The type-approval methods used in Canada are in accordance with 40 CFR Subpart E - Exhaust Emission Test Procedures[32]. A summary of the laboratory procedures used can be found in 40 CFR § 89.404 - Test procedure overview[33] .

7.2. United States

7.2.1. Import requirements

The EPA establishes detailed regulatory and admission requirements for stationary and off-road engines (19 CFR§ 12.74) (40 CFR§ 1068.Subpart D).

Importers must file Form 3520-21 and submit the information to EPA's Office of Transportation and Air Quality (EPA-OTAQ) and keep these documents and media for at least five years after the date of importation. There are 10 categories of engines that can be selected in this format. Engines may be imported as certified engines from the

[32] https://www.law.cornell.edu/cfr/text/40/part-89/subpart-E
[33] https://www.law.cornell.edu/cfr/text/40/89.404

United States, or engines installed in certified vehicles. In general, engines that are imported must be covered by a Certificate of Conformity, unless it was built before the effective date of the regulations.

There are two important definitions as to the type of engine being imported and different formalities and procedures depend on this.

- U.S. version engines: These are engines that are manufactured in accordance with federal emission requirements. The manufacturer affixes a label in the engine compartment that indicates, in English, that the vehicle complies with all EPA regulations. A vehicle that lacks the EPA emissions compliance label is considered non-compliant.
- Non-US version engines: These are engines generally sold in foreign countries that do not meet the emission standards set by the EPA.

If the engine in question does not comply with the emissions regulations, it may be imported under certain circumstances on a temporary (40 CFR § 1068.325) or permanent (40 CFR § 1068.315) basis, as explained below.

Temporary: this modality requires the payment of a bond that will remain in the custody of the U.S. Customs and Border Protection until the engine leaves the country again or its destruction is demonstrated.

- Repairs: this modality applies to engines that are temporarily imported for the purpose of being repaired and must be re-exported or shown to have been destroyed. This figure requires the payment of a temporary bond.
- Testing: temporary importation modality for engine testing.
- Display: temporary importation modality for exhibition and sales purposes.
- Export: This modality can be used if the country of export has different emission standards to those stipulated by the United States, in which case it must have a Certificate of Conformity. Otherwise, the engines may be operated only in preparation for the export process.
- Diplomatic or military use: it is possible to import a non-compliant engine if the applicant is a military or governmental entity.
- Delegated assembly: it is possible to import engines that do not comply with the emission standards if it is demonstrated that the missing parts to comply with the standards (e.g., emission control systems) are to be installed by the manufacturer.
- Partially complete engine: this corresponds to the import of an engine that is not finalised and will be modified.

Permanent:

- National security: engines for use in military and national defence equipment. They must include a label presenting their emission standard.
- Manufacturer-owned engine: is applicable if the manufacturer (OEM) has at least one Certificate of Conformity. This engine must be used only for manufacturing products, evaluating production methods, and promoting engines in the market. It may not be sold or exchanged.
- Replacement engine: it is permitted to import an engine that is outside the emission standard approval date to replace one that has already been put into service.

- Extraordinary circumstances.
- Hardship for small-volume manufacturers: depending on the circumstances, it is possible to extend the date of compliance with the emission standards for small companies that demonstrate that not importing the engines will put the company's solvency at risk. Balance sheets and supporting documents must be submitted, as well as action plans to ensure that this does not happen again.

7.2.2. Type-approval processes

The following definitions are relevant to machinery type-approval processes:

Certificate of Conformity (COC) - A document that EPA issues to an engine manufacturer (OEM), or importer (ICI), to certify that an engine family meets EPA requirements. All classes of non-road engines sold in the U.S. are required to have a Certificate of Conformity and are valid for only one model year of production (U.S. Environmental Protection Agency, 2021b).

Engine family: A manufacturer's (OEM) product line is divided into engine families that are composed of engines expected to have similar emission characteristics during their useful life (40 CFR § 89.116).

Engines and Vehicles Compliance Information System (EV-CIS): is a comprehensive data management system that allows vehicle and engine manufacturers to securely submit required emissions data and other compliance information to EPA. It also contains a subsystem, the Engine and Vehicle Exemption System (EV-ES), which collects basic contact information (name, address, email address, vehicle identification number (VIN) and phone number) from individuals seeking to temporarily import nonconforming vehicles or engines into the US (Regulations.gov, 2021). The Manufacturer must be registered with a unique three-digit alphanumeric code, regardless of whether it produces equipment for different industries.

South America

7.3. Brazil

7.3.1. Import requirements

According to Resolution No. 433 of the National Environmental Council (2011), Articles 3 to 8 establish the requirements for the importation of agricultural and construction machinery, which are:

- Establishment of maximum pollutant emission limits for diesel cycle engines, provided for in Table I of Annex A of this Resolution for agricultural and new construction machinery, of national and imported origin, defined through the Mercosur Common Nomenclature (NCM) codes according to Annex B of this Resolution.
- Engines with power equal to or greater than 19 kW for domestic and imported agricultural and construction machinery, sold in Brazil, must comply with the maximum emission limits defined in Table I of Annex A of this resolution and the dates established in Article 4.
- According to article 7 of the Resolution, only models of agricultural and construction machinery, national or imported, that have the LCVM - *Licença para Uso da Configuração de Veículo ou Motor*, issued by IBAMA, may be sold.
- Road machinery shall comply with the maximum permissible noise limits set out in Annex A of the resolution.

On the other hand, the *Licença para Uso da Configuração de Veículo ou Motor* (LCVM) is a mandatory document that certifies compliance with vehicle emissions legislation (pollutants and noise) and allows the sale of engines, light vehicles, heavy vehicles and machines in Brazil (2021). To qualify for this licence, it is necessary to:

1. Apply for the LCVM on IBAMA's website through the PROCONVE / Promot Computerised System (INFOSERV) according to the following steps:
    a. Access the Services Login with CPF / CNPJ and password, or Digital Certificate. Access the INFOSERV system.
    b. Apply for the licence in the system, according to the modalities: limited quantities or unlimited quantities.
    c. Complete the information requested, according to the type of licence required, and submit the request. INFOSERV can also follow the progress of the analysis of the request.
2. When the licence is granted, the system will generate the Payment Guide in PDF: fee of R$721.77 for issuing a statement of conformity with noise limits and R$721.77 for issuing the LCVM by application (as per Interministerial Order No. 812/2015).
3. After payment, the user must click on "Progress of open requests" and click on the "Details" icon to generate the licence PDF.

IBAMA may exempt the importer or manufacturer from the obligation to obtain the LCVM, in the following cases, in accordance with IBAMA Ordinance 86/1996 and CONAMA Resolution No. 15/1995:

a) Prototypes for emissions tests and adaptation tests.

b) For economic feasibility tests.

c) Adapted for use by disabled people.

d) Donation to philanthropic entities.

e) For diplomatic use.

f) Older collecting vehicles (over 30 years old).

g) For special applications (not suitable for urban and/or road transport).

7.4. Chile

All mobile machinery entering Chilean territory 24 months after the entry into force of the regulation must comply with the emission standards reported in Decree 39/2020 of the MMA, with the exception of tractors which have a period of 36 months. Likewise, importers or distributors, manufacturers or their legal representatives in Chile must submit a certificate of compliance to the SMA, of the emission standards of the engine type or family of the mobile machinery, prior to its importation.

The National Customs Service will have to report monthly to the SMA on the machinery imported in the month prior to the one being reported, once the rule comes into force. In addition, after 6 months from the entry into force of the rule, they will have to issue an official notice giving instructions regarding the importation of mobile machinery.

7.5. Colombia

7.5.1. Import requirements

Article five of Chapter II of Resolution 1068 of 2015 specifies that manufacturers, assemblers and importers of self-propelled agricultural, industrial and construction machinery that has been manufactured, imported or assembled in the country as of the date of entry into force of Decree 019 of 2012, are required to upload the detailed information of the machinery to the RUNT system prior to registration (Ministry of Transport, 2015). Additionally, it shall be noted that in order to upload the detail of the machinery, the owners, holders and/or lessees, manufacturers, assemblers and importers of machinery pertaining to tariff subheadings 8429.11.00.00.00, 8429.19.00.00, 8429.51.00.00, 8429.52.00.00, 8429.59.00.00 and 8905.10.00. 00, must carry out the procedure described in article six of chapter II of the aforementioned resolution, which specifies the obligation to previously have a Global Positioning System (GPS) and the submission of the *Formulario de Declaración de Propiedad* (Declaration of Machinery Ownership Form) available as an annex to the aforementioned resolution.

On the other hand, Resolution 762 of 2022 of the Ministry of Environment and Sustainable Development, as of 2023, establishes as a requirement for the importation, assembly or manufacture of machinery that is within the scope of the standard, the approval of a certificate called *Certificado de Emisiones en Prueba Dinámica (CEPD) y Visto Bueno por Protocolo de Montreal* (Certificate of Emissions in Dynamic Test (CEPD) and Montreal Protocol Approval). The Montreal Protocol Approval follows the guidelines established in Resolution 1652 (Colombian Ministry of Commerce, Industry and Tourism, 2007).

Manufacturers, assemblers or importers must submit the format in Annex 3 of the Draft Resolution to the National Environmental Licensing Authority (ANLA), together with the technical test report and other applicable documents

and certifications from the manufacturer that are required for processing. The Draft Resolution, in Part II, Article 4, also states that:

- In order to obtain the Montreal Protocol Approval, the manufacturer, importer or assembler must comply with Resolution 1652 of 2007[34] or the regulation that modifies, adds or substitutes it, in which it is stated that it did not require for its production or operation any of the ozone-depleting substances listed in said resolution.

Regarding used agricultural machinery, the Colombian Agricultural Institute (ICA), through Resolution No. 24690 of 2018, has established sanitary inspection procedures for this type of machinery entering the national territory. The import requirements include the internal and external cleanliness of the machinery, in the absence of pests, vegetation and soil present. These controls aim to protect the national agricultural sector from pests and invasive vegetation (Colombian Agricultural Institute, 2018).

Other import requirements imposed by the ICA under this resolution are:

- Before importing, it is necessary to complete the application for the *Documento de Requisitos Fitosanitarios para Importación* (DRFI) (Phytosanitary Requirements Document for Importation), through the virtual platform SISPAP (Sanitary Information System for the Importation and Exportation of Agricultural and Livestock Products);
- In order for the machinery to be inspected by the ICA, the importer must submit the following documentation:
    - Application for Phytosanitary Inspection of Agricultural Imports.
    - Import licence.
    - Document certifying the pre-enlistment of used machinery, equipment and/or vehicles certifying cleanliness.

Once all documentation requirements have been fulfilled and provided that the sanitary inspection is favourable, the ICA will issue the *Certificado Fitosanitario para la Nacionalización* (CFN) (Phytosanitary Certificate for Nationalisation) that will allow the entry of the machine, equipment or vehicle.

7.5.2. Type-approval requirements

The type-approval processes defined in Resolution 762 of 2022 of the Ministry of Environment and Sustainable Development are based on the emissions tests or dynamic test evaluation procedures[35] defined by article 5 of the same document, which must be carried out by manufacturers, assemblers or importers wishing to bring machinery into Colombian territory.

According to the Resolution, such tests must comply with the regulatory guidelines described by the United States and the European Union. If importers, assemblers or manufacturers of non-road machinery wanted to use other types of tests, these would have to be agreed by the EPA or the European Union and would have to be more stringent.

[34] Prohibiting the manufacture and import of equipment and products containing or requiring for their production or operation the ozone-depleting substances listed in Annexes A and B of the Montreal Protocol, and making other determinations.
[35] Test on an engine dynamometer for engines that would be installed in mobile sources for non-road use.

According to Article 6 of Resolution 762 of 2022, the technical test report for obtaining the Certificate of Emissions in Dynamic Test (CEPD) must be issued by a testing laboratory accredited by the National Accreditation Body of Colombia (ONAC) under the ISO/IEC 17025 standard or by a testing laboratory accredited by an accreditation body within the multilateral recognition agreements to which ONAC is a signatory.

According to article 11 of Resolution 762 of 2022, in case the previously certified machinery is going to have any modification in the specifications described in the CEPD, the importer, assembler or manufacturer must request the approval of a new CEPD that provides for these modifications. Likewise, in the event that the Ministry of Environment and Sustainable Development establishes new maximum permissible pollutant emission limits, and in the event that the previously certified machinery does not comply with them, the importer, assembler or manufacturer must request the approval of a new CEPD, in which compliance is supported.

According to the Resolution, the test cycles to be used for dynamic testing for non-road land mobile sources are NRSC and NRTC as used in the European Union and the United States.

7.6. Peru

Although not currently applicable for machinery, according to Supreme Decree 019-2018-MTC, the then General Directorate of Land Transport (DGTT) was in charge of designing a computer system for storage and management of information related to vehicle type-approval, which should be interconnected and available to the DGAT, SUNARP and SUNAT, with the purpose of verifying that the makes and models of new vehicles that are imported, manufactured or assembled in the country comply with the technical requirements established by this regulation and the Maximum Permissible Pollutant Emission Limits standard for new vehicles that are incorporated (imported or produced) into the vehicle fleet *(Decreto Supremo No. 019-2018-MTC: Decreto Que Modifica El Reglamento Nacional de Vehículos, El Texto Único Ordenado Del Reglamento Nacional de Tránsito - Código de Tránsito y Dicta Otras Disposiciones, 2018*) (Supreme Decree No. 019-2018-MTC: Decree Amending the National Vehicle Regulation, the Single Ordered Text of the National Traffic Regulation - Traffic Code and Other Provisions, 2018). According to the Integrated Text of the Regulation of the Organisation and Functions of the Ministry of Transport and Communications (2021b) at present, the General Directorate of Transport Authorisations is responsible for maintaining a standard system of motor vehicle driving licences, type-approval, certification, verification and technical vehicle inspections within the framework of the regulations in force, and the Directorate of Road Traffic, as a dependency of the former, is responsible for managing the system of vehicle identification and type-approval, certification and technical inspections at national level, as well as for issuing number plates and administering the system for issuing driving licences for motor vehicles and rail vehicles.

Although there is currently an attempt to implement type-approval for light-duty vehicles in Peru, there is still no standard regulation that can match quality and safety with respect to the NRMM for this process, meaning that machinery of an undetermined age may be imported, as well as a cabbed chassis disassembled from its machinery components.

Regarding the legislation for the import of machinery, Legislative Decree No. 1053 or General Customs Law defines capital goods as machines and equipment subject to depreciation that are directly involved in a productive activity without this process modifying their nature and are subject to the application of the procedures, obligations, import and export regimes, goods controls and sanctions defined by this Legislative Decree (Legislative Decree No. 1053: General Customs Law, 2008).

Regarding the importation of used vehicles, whose regulation is set out in Legislative Decree 843 and its amendments (SUNAT, 2021), the only regulated importation of used vehicles is the import of vehicles transiting in the SNTT, therefore it is not applicable to machinery, although this is currently under consideration, since the import of machinery has no restrictions whatsoever and is subject to the general import law.

Asia-Pacific

7.7. India

7.7.1. Import requirements

According to Chapter 87 of the ITC HS Code (2017) of the Directorate General of Foreign Trade (DGFT), import requirements for mobile machinery other than railway and tramway rolling stock are set out as specified below:

Import requirements for used vehicles and machinery

(I) A second-hand or used vehicle (including all vehicles other than railway or tramway) for the purposes of this Chapter shall mean a vehicle which:

- (a) Has been sold, leased or loaned prior to importation into India; or
- (b) Has been registered for use in any country according to the laws of that country, prior to importation into India.

(II) The importation of second-hand or used vehicles shall be subject to the following conditions:

- (a) The second-hand or used vehicle shall not be older than three years old from the date of manufacture.
- (b) The second-hand or used vehicle shall:
  - (i) Have right-hand steering and controls (applicable on vehicles other than two- and three-wheelers).
  - (ii) Have a speedometer indicating the speed in kilometres.
  - (iii) Have photometry of the headlamps to suit “keep left traffic”.
- (c) In addition to the conditions specified in (a) and (b) above, the second-hand or used vehicle shall conform to the provisions of the Motor Vehicles Act 1988 and the rules made thereunder.

(III) Whoever being an importer or dealer in motor vehicles who imports or offers to import a second-hand or used vehicle into India shall:

- (a) At the time of importation, submit a certificate issued by a testing agency, which the Central Government may notify in this regard, that the second hand or used vehicle being imported into India has been tested immediately before shipment for export to India and the said vehicle conforms to all the regulations specified in the Motor Vehicles Act, 1988 of India and the rules made thereunder.
- (b) At the time of importation, submit a certificate issued by a testing agency, which the Central Government may notify in this regard, that the second hand or used vehicle being imported into India has been tested immediately before shipment for export to India and the said vehicle conforms to the original homologation certificate issued at the time of manufacture.

(c) On arrival at the Indian port but before clearance for home consumption, submit the vehicle for testing by the Vehicle Research and Development Establishment, Ahmednagar of the Ministry of Defence of the Government of India or Automotive research Association of India, Pune or Central Farm Machinery Training and Testing Institute, Budni, Madhya Pradesh for tractors, and such other agencies as may be specified by the Central Government, for granting a certificate by that agency as to the compliance of the provisions of the Motor Vehicles Act, 1988 and any rules made thereunder.

(d) Import of these vehicles shall be allowed only through the customs port at Mumbai.

(IV) The second hand or used vehicles imported into India should have a minimum roadworthiness for a period of 5 years from the date of importation. For this purpose, the importer shall, at the time of importation, submit a declaration indicating the period of roadworthiness in respect of every individual vehicle being imported, supported by a certificate issued by any of the testing agencies, which the Central Government may notify in this regard.

Import requirements for new vehicles

(I) A new imported vehicle (including all the vehicles other than Railway or Tramway) for the purposes of this Chapter shall mean a vehicle that:

(a) has not been manufactured/assembled in India.

(b) has not been sold, leased or loaned prior to importation into India.

(c) has not been registered for use in any country according to the laws of that country, prior to importation into India.

(II) The import of new vehicles shall be subject to the following conditions:

The new vehicle shall:

(a) have a speedometer indicating the speed in kilometres per hour.

(b) have right hand steering, and controls (applicable on vehicles other than two and three wheelers).

(c) have photometry of the headlamps to suit continuous traffic.

(d) be imported from the country of manufacture.

The country of manufacture will also mean a Single Market like the European Union (EU).

In addition to the conditions specified in (a) above, the new vehicle shall conform to the provisions of the Motor Vehicles Act, 1988 and the rules made thereunder, as applicable, on the date of import.

Whoever being an importer or dealer in motor vehicles who imports or offers to import a new vehicle into India shall:

i) at the time of importation, have valid certificate of compliance as per the provisions of rule 126 of Central Motor Vehicle Rules (CMVR), 1989, for the vehicle model being imported, issued by any of the testing agencies, specified in the said rule.

ii) be responsible for all the provisions assigned to the manufacturer as per Rules 122 and 138 of CMVR, 1989 and for issuing Form 22, as per provisions of CMVR, 1989.

iii) give an undertaking in writing that the proof of compliance to conformity of production as per rule 126A of CMVR shall be submitted within six months of the imports. In case of failure to do so, no further import of new vehicle of that model shall be allowed thereafter.

(III) The import of new vehicles shall be permitted only through the following Customs port at Nhava Sheva, Kolkata, Chennai and Chennai Airport, Cochin, ICD-Tughlakabad and Delhi Air Cargo, Mumbai Port and Mumbai Air Cargo Complex, Vishakhapatnam Port, ICD Talegaon Pune, ICD Faridabad, Ennore port, Kattupalli Port, APM Terminals, Pipavav Port and Krishnapatnam Port. In addition, import of new motorcycles is also permitted through LCS Benapole / Petrapole and LCS Agartala.

(IV) The provisions of this notification will not apply to the imports of new vehicles:

i) for the purpose of certification as per para (i) above; and

ii) for the purpose of defence requirements.

(V) The above-mentioned provisions will also not apply to the import of new vehicles for R and D purpose by vehicle manufacturers and auto component manufacturers. However, the vehicles imported by both these categories for R and D will not be registered under the CMVR Rules in the country and will not apply on Indian roads. The customs will make necessary endorsement at the time of clearance of these vehicles. g. In case the country of manufacture is a land locked country and the shipment takes place from another country, the vehicles would have deemed to have been exported from the country of manufacture provided there are supporting documents to track the vehicles from the country of manufacture to the Port of Landing and from there, to the Port of Destination.

7.7.2.Certification requirements

The Automotive Research Association of India (ARAI) sets out in its document Procedure for Type-approval and Certification of Agricultural Tractors for Compliance to Central Motor Vehicle Rules, Annex E, guidelines for the selection of agricultural tractors for verification under CMRV requirements (AIS-017), which can be accessed on the association's website. (ARAI, 2016).

On the other hand, the following table presents the tests required for construction machinery vehicles or equipment according to the CMVR vehicle type-approval regulation.

Table 7. 3. Tests for construction machinery according to the Central Motor Vehicle Rules (CMVR).

Test	CMVR Rule	Reference standard
Photographs	---	ARAI procedure
CMVR physical verifications	93 to 125	CMVR, 1989
Vehicle weighing	95	IS: 11825
Brake test	96(4)	IS: 11852
Turning circle diameter test	98(2)	IS: 12222

Test	CMVR Rule	Reference standard
Steering effort test	98(3)	IS: 11948
Maximum speed	---	IS: 11877
Speedometer calibration	117(1)(2)	IS: 11827
Vehicle dimensions	93 (1A), (3A), (4A), (6A) & (7A)	CMVR, 1989
Safety glass windscreen laminated (if applicable)	100(2)	IS:2553 Part-2 & AIS: 037
Side window/door glass (if applicable)	100(2)	IS:2553 Part-2 & AIS: 037
Reflector	104(4)	AIS:057 & AIS: 037
Horn	119(1)	IS:1884 & AIS: 037
Automotive lamps	124(1)	AIS: 034 & AIS: 037
Hydraulic brake hose (if applicable)	124(2)	IS:7079 & AIS: 037
Hydraulic brake fluid (if applicable)	124(3)	IS:8654-1986
Performance requirements for lighting and signalling devices	124 (20)	SS 15.1 & AIS: 037
Headlamp head assembly (glass lens) / (with plastic lens)	124 (20)	AIS: 034 & AIS: 037
Front parking light assembly	124 (20)	AIS: 034 & AIS: 037
Front/rear direction indicator lamp assembly	124 (20)	AIS: 034 & AIS: 037
Rear registration plate lamp assembly	124 (20)	AIS: 034 & AIS: 037
Rear combination lamp assembly	124 (20)	AIS: 034 & AIS: 037
Tell-tales and indicators	124 (18)	AIS-071(Part-1,2)
Warning triangle	138(4) (c)	AIS 022-2001
Engine mass emission with particulate	115	TAP-115/116

Source: ARAI, 2012.

Conformity of Production (COP) period for agricultural tractor, power tiller, construction equipment vehicle (CEV) and combine harvester engines with annual import up to 200 units will be once every two years per family/model. For agricultural tractor, power tiller, construction equipment vehicle (CEV) and combine harvester engines with annual production / import exceeding 200 units it shall be once a year per family/model. Other requirements concerning the details of conducting the COP test can be found in paragraphs 3.2 to 3.11 of the Automotive Research Association of India (ARAI) document AIS-137 (Part 6) of 2019, as well as exceptional cases, conduct of

extended tests, forms required for completion and consequences of failure or incompleteness of the test (ARAI, 2019a).

If the vehicle/engine complies with the COP requirements, the testing agency shall issue a COP certificate to the manufacturer. The COP certificate will cover the vehicle/engine model and its variants produced/planned to be produced during the COP interval. The test agency shall also send copies of the COP certificate to other test agencies and nodal agencies. In the Automotive Research Association of India (ARAI) document AIS-137 (Part 6) of 2019, the format of the COP certificate is given in Annex 3 for vehicles with gross vehicle weight up to 3,500 kg and in Annex 4 for vehicles with gross vehicle weight above 3,500 kg, agricultural tractor, construction machinery and power tillers. (ARAI, 2019a).

On the other hand, in the ARAI AIS-137 (Part 7) of 2019, the specific emission tests for COP approval of construction (CEV) and agricultural (TREM) machinery in accordance with the CMRV rules number 115 and 126 as per the current Bharat Stage (CEV or TREM) IV and V emission standards are laid down. As in other countries, the NRTC and NRSC test cycles are implemented for CEV and TREM non-road mobile machinery as per the Table 6. 16 (ARAI, 2019b).

According to AIS-137 (part 7) standard (ARAI, 2019b), Clause 3 specifies the application for engine type-approval, as a separate technical unit, which shall comply with the following points:

1. The application for approval of an engine or an engine family with regard to the level of emission of gaseous and particulate pollutants shall be submitted by the engine manufacturer or by a duly accredited representative;
2. The application shall be accompanied by the following information: a description of the engine type comprising the particulars referred to in AIS-007 and, if applicable, particulars of the engine family as referred to in the same standard;
3. An engine conforming to the engine type characteristics described in AIS-007 shall be submitted to the Test Agency responsible for conducting the approval tests defined in clause 5 of AIS-137 (Part 7). If the Test Agency determines that the submitted engine does not fully represent the engine family described in AIS-007, an alternative and, if necessary, an additional engine shall be submitted for test according to clause 5 below (p. 10/778).

According to AIS-137 (Part 7) (2019b), clause 4 specifies the engine type-approval process, as a separate technical unit, which shall comply with the following points:

1. For the purposes of type-approval and conformity of production certification, manufacturer's engine range shall be divided into model families, consisting of parent engine model and its variant, and application for Type-approval shall be made in the proforma prescribed in AIS-007 as amended by time to time;
2. The determination of an engine family and the decision regarding parent engine shall be based on AIS-007. For the purpose of identification, the manufacturer shall designate families as F1, F2, F3, ..., Fn;
3. The Test Agency shall decide the family, the parent model and its variants depending on the information provided by the manufacturer;
4. Testing of the parent model, shall, normally, be sufficient for type-approval of the family. The Test Agency has the option to carry out the testing of more than one model in the family to satisfy itself, subject to parent engine-concept as per Annex 1B of AIS-137 (Part 7);

5. At a later stage, if the manufacturer submits an application for type-approval of a model, the Test Agency shall ascertain whether the model can be classified as belonging to a family of model(s) already certified. If the model does not belong to family already certified, the Test Agency shall proceed with the testing of the model for type-approval. If the model belongs to a family already certified, the Test Agency shall decide whether the specific testing of the model is not required. In case the specific testing of the model is not required, the type-approval certificate for the family may be extended to include the model (pp. 10/778 - 11/778).

Finally, all details concerning the performance of specific emission tests for the current non-road mobile machinery emission standards can be found in clause 5 of AIS-137 (part 7) (ARAI, 2019b). In addition to the requirements for installation on the vehicle (clause 6), conformity of production (clause 7), production definitively discontinued or penalties for non-conformity of production (clauses 8 and 9) as well as all technical annexes accompanying the information of all mentioned clauses can be found in this standard document.

7.8. China

7.8.1. Manufacturing and import requirements

The NRMM manufactured or imported shall report the information set out in the GB 20891-2014 regulation (Ministry of Ecology and Environment of the People's Republic of China, 2014b), specifically in Annex A of the standard. Likewise, manufacturers and importers of machinery with power ratings less than or equal to 560 kW shall comply with the requirements of regulation HJ 1014-2020.

In general terms, manufacturers will have to comply with the emission standards defined in the current regulation, as well as provide precise information on how to operate the engines that will be destined for NRMM, either through manuals containing information related to the installation of emission control systems, global positioning systems, as well as obligations regarding preventive measures for the dismantling of engine parts (Ministry of Ecology and Environment of the People's Republic of China, 2020). In that regard, the general obligations of manufacturers are summarised as follows:

- Type of fuel to be used by the engine[36] .
- Reporting of emissions to environmental authorities when machinery is fitted with control systems, as well as NOx emissions when not fitted with such systems (HJ 1014-2020 section 5.1.6).
- Emission control systems (reactants) (HJ 1014-2020 section 5.6.1).
- Manuals for operating emission control systems (HJ 1014-2020 section 5.6.5).
- Maintenance instructions.
- Preventive measures (HJ 1014-2020 section 5.7.3).
- Use and reporting of engine global positioning system failures (HJ 1014-2020 section 5.7.4 and 5.7.7).
- Warranty periods (HJ 1014-2020 section 5.8.3).
- Voluntary self-inspections (HJ 1014-2020 section 7.2.2).

[36] HJ 1014-2020 section 5.1.5

- Report which types of engines belong to the same family.

According to HJ 1014-2020, section 5.7.4: The NRMM with a rated net power of 37 kW or higher shall be equipped with satellite navigation precision positioning systems before leaving the factory, and shall meet the requirements of section 5.7.7. (Ministry of Ecology and Environment of the People's Republic of China, 2020).

With regard to the warranty periods, as specified in Annex B of GB 36886-2019, the manufacturer shall provide the emission-related components in accordance with HJ 1014-2020, section 5.8.3. (Ministry of Ecology and Environment of the People's Republic of China, 2020). This period shall not be less than the periods specified in table 6.26 below.

Table 7. 4. Requirements for key environmental protection components during the emission warranty period.

Diesel engine power segment (kW)	Rotational speed	Quality period	
		Time (hours)	Years
Pmax ≥ 37	Any speed	3000	5
19≤Pmax<37	Non-constant speed		
	Constant speed <3000		
	Constant speed >3000		
Pmax<19	Any speed		

* Warranty period is calculated from the date of sale.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

7.8.2. Type-approval processes

According to the regulation HJ 1014-2020 and GB20891-2014 (Ministry of Ecology and Environment of the People's Republic of China, 2014b, 2020), the definitions of the test and type-approval cycles are:

Test cycle: "Procedures that diesel engines are tested according to, with defined speed and torque under steady state or transient state (NRTC, Non-road transient cycle) conditions".

Non-road steady cycle: "Test cycles comprising 5, 6 and 8 cycles for the measurement of combustion emissions for Stage III and Stage IV diesel engines".

NRTC test: "Test cycle consisting of 1238 gradual changes of working conditions".

The NRMM equipped with diesel engines, with rated net power from 37 kW to 560 kW, shall be equipped with diesel particulate filter (DPF) or more efficient particulate removal control system. When testing according to the procedures defined in regulation GB 20891-2014 and HJ 1014-2020 (Annex B in both regulations), the particle number results obtained shall be multiplied by the deterioration factor. The final results shall not exceed the limits set by GB 10891-2104 and shall not show visible smoke during the test (Ministry of Ecology and Environment of the People's Republic of China, 2014b, 2020).

The deterioration factors according to the 2020 update for the China IV standards that would come into effect from 2022 were generated based on tests of diesel engines in actual operation and will correspond to 1.3 for CO, 1.3 for HC, 1.15 for NOx, 1.05 for PM, 1.0 for PN and 1.0 for NH3. The proposal of these deterioration factors is intended

to potentially reduce manufacturers' testing costs, so that manufacturers would make use of their application directly rather than determining equipment durability test values, which would normally require them to test their engines over a representative duty cycle (under actual operating conditions that would include driving and performing work such as lifting) of a quarter or more of the full service life (ICCT, 2021).

According to HJ 1014.2020 (2020) type-approval tests are performed on dynamometers with steady state[37] and transient state[38] cycles. The variables to be considered during the tests include absolute temperature (Ta) of the diesel engine at the inlet expressed in Kelvin (K); dry atmospheric pressure (Ps), expressed in kPa and the laboratory atmospheric pressure factor to be calculated following the formulae in Annex B, section B.2.2.1. Other types of tests performed are durability tests, NO_x control and PM control. A summary of the type of tests performed is described in the table below.

Table 7. 5. Types of tests performed in type-approval processes.

Standard cycle	Non-road steady cycle (NRSC)	Gaseous pollutants
		Particulate matter (PM) Particle Number (PN1)
		Ammonia (NH_3) concentration[2]
		Carbon dioxide (CO_2)
	Non-road transient cycle (NRTC)	Gaseous pollutants
		Particulate matter (PM) Particle Number (PN)
		Ammonia concentration
		CO_2
Non-standard cycle[6]	Steady single point test	Gaseous pollutants
		Particulate matter (PM)
Durability		
NO_x control[2,3]		
PM control[4]		
Precious metal detection		

[1] PN measurements suited to 37kW<Pmax<560kW diesel engines.
[2] Test items requiring use of reactant aftertreatment system.
[3] Test items requiring use of EGR system.
[4] Test items requiring use of particulate matter aftertreatment system.
[5] Does not apply to Pmax< 19 kW single-cylinder diesel engine.
[6] Applies to diesel engines with electronic fuel injection systems.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

[37] It includes five working condition, six working condition and eight working condition cycles, shall apply to the measurement of stage IV diesel engine exhaust pollutants.
[38] It consists of 1238 transient modes for measurement of exhaust pollutants from 19 kW - 560 kW non-constant speed diesel engines. Companies may also use this cycle for Stage III diesel engines.

Europe

7.9. European Union

The same provisions apply for the type-approval process in the European Union and in the United Kingdom as for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

7.10. Switzerland

7.10.1. Import requirements

According to the Swiss Air Pollution Control Ordinance (OAPC) (2020) in its Article 19b, paragraph b: the proof of conformity comprises a declaration by the manufacturer or importer that the construction machines or particle filter systems to be placed on the market conform to the tested types (declaration of conformity), including the following details:

1. Name and address of the manufacturer or importer;
2. Designation of the type of construction machine, engine and particulate reduction system;
3. Year of manufacture and serial numbers of the construction machine, engine and particle filter system;
4. Name and address of the conformity assessment body and number of the certificate of conformity;
5. Name and position of the person signing the declaration of conformity for the manufacturer or the importer; and
6. The precise location of the markings on the construction machine and markings as specified in Annex 4, paragraph 33 of the 1985 OAPC.

The conformity assessment bodies shall send certificates of conformity, together with the relevant test reports, to the Federal Office for the Environment (FOEN). The FOEN shall publish lists of compliant particle filter system and engine types. The manufacturer or importer shall retain the declaration of conformity for ten years after placing the construction machine or particle filter system on the market (Ordinance of 16 december 1985 on air pollution control (OAPC), 2020).

7.10.2. Acceptance of equivalent engine type-approvals

Regulation (EU) 2016/1628 (2016) in its Article 42, states:

1. The Union may, in the framework of multilateral or bilateral agreements between the Union and third countries, acknowledge the equivalence between the conditions and provisions for EU type-approval of engines established by this Regulation and the procedures established by international regulations or regulations of third countries;
2. Type-approvals granted and statutory markings that are in conformity with UNECE regulations, or amendments thereto, which the Union has voted in favour of or to which the Union has acceded as set out in the delegated act referred to in point (a) of paragraph 4, shall be recognised as being equivalent to the EU type-approvals granted and statutory marking required in accordance with this Regulation;

3. EU type-approvals granted on the basis of Union acts as listed in the delegated act referred to in point (b) of paragraph 4 shall be recognised as being equivalent to the EU type-approvals granted in accordance with this Regulation; and
4. The Commission is empowered to adopt delegated acts in accordance with Article 55 supplementing this Regulation by setting out:
    a) the list of UNECE regulations, or amendments thereto, including any requirements set out therein which relate to their application, which the Union has voted in favour of or to which the Union has acceded, and which are to apply to EU type-approval of engine types and engine families to be installed in non-road mobile machinery; and
    b) the list of Union acts pursuant to which EU type-approvals are granted, including any requirements set out therein which relate to their application. Those delegated acts shall be adopted by 31 December 2016.

Regulation (EU) 2016/1628 (2016) in its Article 3, states:

Technical service: an organisation or body designated by the approval authority as a testing laboratory, or as a conformity assessment body to carry out initial assessment and other tests or inspections, on behalf of the approval authority, or of the authority itself when carryng out those functions. In order to ensure that the conformity of production control procedure, which is one of the cornerstones of the EU type-approval system, has been implemented and is functioning properly, manufacturers should be assessed regularly by the designated competent authority or by an appropriately qualified technical service designated for that purpose.

7.10.3. Tests required for EU type-approvals

Regulation (EU) 2016/1628 (2016) in Article 24 sets out the obligations that manufacturers must comply with in terms of environmental requirements for the type-approval of engines to be installed in mobile machinery:

1. Compliance with the technical prescriptions laid down in the Regulation in question shall be demonstrated by means of appropriate tests performed by designated technical services
2. The manufacturer shall make available to the approval authority as many engines as are required under the relevant delegated acts for the performance of the required tests.
3. The required tests shall be conducted on engines that are representative of the engine type or, where applicable, of the parent engine of the engine family to be approved. However, the manufacturer may, in agreement with the approval authority, select an engine which, although not representative of the engine type or, where applicable, of the parent engine of the engine family to be approved, combines a number of the most unfavourable features with regard to the required level of performance.
4. For the purposes of conducting the EU type-approval tests, the applicable test cycles are those set out in Annex IV. The test cycles applicable to each engine type included in the EU type-approval shall be indicated in the information document.
5. An engine that is representative of the engine type or, where applicable, of the parent engine of the engine family, or an engine selected in accordance with the second subparagraph of paragraph 3, shall be tested on a dynamometer using the applicable non-road steady-state test cycle identified in Tables IV-1 to IV-10 of Annex IV. The manufacturer may choose whether to conduct that test using the discrete-mode or the

ramped-modal test method. Except in the cases referred to in paragraphs 7 and 8, a variable-speed engine of a particular category used in a constant-speed operation of the same category need not be tested using the applicable constant-speed steady-state test cycle.

6. In the case of a constant-speed engine with a governor that can be set to an alternative speed, the requirements of paragraph 5 shall be fulfilled at each applicable constant speed and the information document shall indicate the speeds that apply for each engine type.
7. In the case of an engine of category IWP intended to be used for both variable-speed and constant-speed operation, the requirements of paragraph 5 shall be fulfilled for each applicable steady-state test cycle separately and the information document shall indicate each steady-state test cycle in respect of which those requirements were fulfilled.
8. In the case of an engine of category IWP that is intended for use in the place of an engine of category IWA in accordance with Article 4(2), the requirements of paragraph 5 of this Article shall be fulfilled for each applicable steady-state test cycle set out in Tables IV-5 and IV-6 of Annex IV, and the information document shall indicate each steady-state test cycle in respect of which those requirements were fulfilled.
9. Except for engines type-approved pursuant to Article 34(5) and (6), variable-speed engines of category NRE having a net power that is greater than or equal to 19 kW but not more than 560 kW shall, in addition to fulfilling the requirements of paragraph 5 of this Article, also be tested on a dynamometer using the transient test cycle identified in Table IV-11 of Annex IV.
10. Engines of sub-categories NRS-v-2b and NRS-v-3 having a maximum speed of less than or equal to 3 400 rpm shall, in addition to fulfilling the requirements of paragraph 5, also be tested on a dynamometer using the transient test cycle identified in Table IV-12 of Annex IV.

7.10.4. Measurements and tests for EU type-approvals

Regulation (EU) 2016/1628 (2016) in Article 25 sets out the obligations to be fulfilled when measuring pollutant emissions during the tests required for type-approval:

1. The final exhaust emission test results for engines subject to this Regulation shall be calculated by applying all of the following to the laboratory test results:
   a) The emissions of crankcase gases, where required by Article 25(3) of said regulation and where not already included in the laboratory measurement;
   b) Any necessary adjustment factor, where required by Article 25(3) and where the engine includes a regenerating exhaust after-treatment system.
   c) In respect of all engines, deterioration factors appropriate to the emission durability periods specified in Annex V.
2. The testing of an engine type or engine family to determine whether it meets the emission limits set out in this Regulation shall be carried out by using the reference fuels or fuel combinations described in European regulations. The engine type or engine family shall, in addition, meet the exhaust emission limits set out in this Regulation in respect of any other specified fuels, fuel mixtures or fuel emulsions included by a manufacturer in an application for EU type-approval.
3. As regards the conduct of measurements and tests, the technical requirements shall be met in respect of:

a) Apparatus and procedures for the conduct of tests.

b) Apparatus and procedures for emission measurement and sampling.

c) Methods for data evaluation and calculations.

d) Methods for establashing deterioration factors.

e) In relation to engines in categories NRE, NRG, IWP, IWA, RLR, NRS, NRSh, SMB and ATS complying with the Stage V emission limits set out in Annex II:

   i. Methods for taking account of crankcase gases.

   ii. Methods for determining and taking account of continuous or infrequent regeneration of exhaust aftertreatment systems.

f) In relation to electronically controlled engines of categories NRE, NRG, IWP, IWA, RLL and RLR complying with Stage V emission limits set out in Annex II and using electronic control to determine both the quantity and timing of injecting fuel or using electronic control to activate, de-activate or modulate the emission control system used to reduce NOx:

   i. Emission control strategies, and shall include the documentation required to demonstrate those strategies.

   ii. NO_x control measures, and shall include the method used to demonstrate those control measures.

   iii. The area associated with the relevant non-road steady-state test cycle, within which the amount by which the emissions are permitted to exceed the emission limits set out in Annex II is controlled.

   iv. The selection by the technical service of additional measurement points within the control area during the emission bench test.

Africa

7.11. South Africa

7.11.1. Import and type-approval requirements

According to SAAMA (2008), any manufacturer, importer or builder (MIBs) who manufactures, builds, imports or modifies motor vehicles for the purpose of his or her business of selling motor vehicles or modifications of motor vehicles shall register by following the steps below.

1. Application for registration
   - Contact the local Department of Transport (PDoT), the following will be required:
     - Complete application and notice form in respect of manufacturer, importer and builder of motor vehicles (MIB) form which can be found at https://www.gauteng.gov.za/Services/GetServices?serviceId=CPM-001666. (Gauteng Provincial Government, 2021), as well as contact information of the PDoT officer per province in the 'Information Document for the Registration of Manufacturers, Builders and Importers of Motor Vehicles and Related Processes' of the Automotive NRCS. (NRCS, 2020).
     - Certified copy of applicant's identity document (ID).

- Certified copy of the proxy´s identification (if the applicant is a body of persons).
- Certified copy of the business certificate (if the applicant is a body of persons).
- Letter of proxy if you represent a company.
- Custom code number from SARS (South African Revenue Service), in the case of application for registration of importer.
- Proof of VAT registration from SARS.
- The appropriate fees as determined by the Member of the Executive Council (MEC) of the province concerned, and.
- Any other requirements by the PDoT.

2. Request for evaluation of the applicant

On receipt of an application the PDoT will ensure the application is in order, require the NRCS Automotive to evaluate the application and make a recommendation and require the South African Police Service (SAPS) to submit a report.

3. Evaluation of the applicant by NRCS Automotive

The NRCS Automotive will contact the applicant to verify all details as per the application form and to inform the applicant about the evaluation requirements. The process covers the evaluation of:

- Management system.
- Technical competency of personnel involved.
- Understanding of the relevant legislation, specification and code of practice in relation to the type and category of vehicle involved, and
- Compliance of products with the relevant legislation.

4. Registration certificate

if the PDoT is satisfied that the applicant is suitable to be registered based on the evaluation of the NRCS automotive and the saps, it registers the applicant, record the particulars on the register of MIB's and issue the applicant with a certificate. The registration certificate gives permission to:

- Apply for the world manufacturer identifier code (WMI) for use in compiling a vehicle identification number (VIN) – manufacturers only.
- Apply for the homologation/approval of the motor vehicle models.
- Importers to apply for LOA3/exemption in terms of NRTA for approval samples.
- Apply for model numbers on notification of vehicle model form (NVM form), and
- Register vehicles on the national traffic information system (NaTIS).

Additionally, for processes between South Africa and the United States, according to the US International Trade Administration, all import and export trade transactions related to agricultural machinery and commodities in this sector require that the products in the customs declarations are classified according to an appropriate tariff heading. The tariff classification code is directly related to the rate of duty payable on that product and can be

found in Act No. 91 of 1964 for all agricultural and construction machinery. The classification operates as part of the International Harmonised Commodity Coding System under the Harmonised System Convention of the World Customs Organisation (WCO). The import of all second-hand goods is subject to import control and an import permit issued by the International Trade Administration Commission (ITAC) is required (South African Government, 2021b; The Customs and Excise Act 91 of 1964, 1964a; US International Trade Administration, 2020)..

8. Labelling processes

For the case studies in which the use of labels[39] was identified in the NRMM, different objectives for this practice are defined:

- The identification of general technical aspects of the NRMM.
- The unique emission level identification of the NRMM.

Despite this difference, information on emission levels is included in all cases.

Within the cases with an exclusive environmental label, China and Canada are identified:

- In China, the main function of the label is to provide information on the environmental performance of the NRMM.
- Although Canada follows the same guidelines as the United States, it has an additional label (NEM), the use of which is exempted if the NRMM is EPA certified.

In the cases with a more general label, which also includes information on emissions, the United States, the European Union, India and the regulatory proposal for Colombia are identified.

- In the United States, the European Union, India and in Colombia, the label features a unique engine identification number, and specifies the technical characteristics of the NRMM including information on the level of emissions. The emission level is specified through information on the use of emission control systems, through the emission standard it meets, or through information on type-approval processes.

In the different cases, the labelling regulation provides guidelines on the format of labels, their content, coding rules and rules for placement in the NRMM.

Specific information is presented below for the case studies for which labelling practices were identified.

North America

8.1. Canada

Canada adheres to the labelling requirements of the United States Code of Federal Regulations 40 CFR § 89.110 and 40 CFR § 1048.135 (see section 8.2). In addition, they have a national label, as explained in this section.

Off-road machinery that is manufactured and transported on Canadian territory must have the National Emission Mark (NEM) (see Figure 8.1). Some provinces do not require the use of the mark as long as the machinery is EPA certified (Government of Canada, 2012).

[39] Different terms are used in the case studies, including labels, seals and markings.

Figure 8. 1. Label used on engines in off-road machinery in Canada.

Source: (Government of Canada, 2012).

According to the Canadian government's guidance document on emissions regulations for compression-ignition engines in off-road machinery (2012), the considerations for obtaining the NEM label are**:**

- Imported machinery may use the NEM mark as long as the new holder complies with the requirements to apply for the mark.
- For engines imported and assembled in Canada, if they meet EPA certifications, and if the emission control filter is installed in Canada in accordance with EPA guidelines, then the NEM mark is not required. However, if the emission control system is installed in a manner different from that indicated on the EPA certificate, then the company installing the emission control system must apply for an NEM mark.
- If a company receives an engine that is not EPA certified and is assembled in Canada, it must apply for NEM mark.

Characteristics of the mark

- The national emissions mark shall be at least 7 mm in height and 10 mm in width. The company authorization number assigned by the Minister to the company shall be in figures at least 2 mm in height and be located immediately below or to the right of the national emission mark.
- The national emissions mark shall be placed next to the EPA engine information label or, if there is no such label, in a visible, readily accessible location.
- The national emission mark must be on a permanently applied, weather resistant label that is readable.

Procedure for applying the national emissions mark

A company must submit an application to get the Minister’s authorization to use the national emissions mark. The following information must be included in the application:

- The name and street address of the head office of the company and, if different, its mailing address.
- A statement that the company is seeking to obtain the authorisation to apply the national emissions mark under these regulations.
- The street address of the location where the NEM will be applied.
- Information to show that the company is capable of verifying compliance with the standards in these regulations.

A company's application must be signed by a person who is authorised to act on behalf of the company. When the Minister authorises a company to use the national emission mark, a company authorisation number will be assigned to the company. The company authorisation number is not to be confused with the unique identification number that must be engraved on every engine.

8.2. United States

The manufacturer must affix at the time of manufacture a permanent label and eligible label identifying each non-road engine that is manufactured. Guidelines for engine labelling can be found in 40 CFR § 89.110 and 40 CFR § 1048.135. The label must meet the following requirements:

Assign a unique identification number[40] to each engine that is manufactured. This must be permanently stamped on the engine.

- Be attached in such a manner that it cannot be removed without destroying or defacing the label.
- Be durable and legible for the entire engine life.
- Be secured to an engine part necessary for normal engine operation and not normally requiring replacement during engine life.
- Be written in English.
- Be located so as to be readily visible to the average person.

The label must contain the following information:

- The heading “Important Engine Information”.[41]
- The full corporate name and trademark of the manufacturer.
- EPA standardised engine family designation.
- Engine displacement.
- Advertised power.
- Emission control system.
- Engine tune-up specifications and adjustments: these should indicate the proper transmission position during tune-up, and accessories (for example, air conditioner), if any, that should be in operation.
- Fuel requirements.
- Date of manufacture (month and year).
- Family emission limits, if applicable.
- The statement "This engine conforms to (model year) U.S. EPA regulations for large non-road compression-ignition engines"[42] .
- Engines belonging to an engine family that have been certified as a constant-speed engine must contain the statement on the label: "constant-speed only".[43]
- Engines belonging to an engine family that have been certified as a variable-speed engine must contain the statement on the label "variable-speed use".[44]

[40] Engine identification number.
[41] "Emission control information".
[42] "This engine complies with U.S. EPA regulations for [model year] nonroad engines."
[43] "Use in constant-speed applications only".
[44] "Use in variable-speed applications only".

- Engines meeting the voluntary standards to be designated as Blue-Sky Series engine must contain the statement.

South America

8.3. Chile

Regarding the use of labelling on machinery, this aspect has not yet been regulated.

8.4. Colombia

According to Resolution 762 of 2022, all mobile non-road sources must carry a visible label on the engine. According to Article 28, the label shall comply with the following specifications.

"(...)

a) Be attached in such a manner that it cannot be removed without destroying or defacing the label;

b) Be durable and legible for the entire engine life.

c) Be secured to an engine part necessary for normal engine operation and not normally requiring replacement during engine life.

d) Be located in a visible place after the engine has been installed in the machinery. A supplementary label may be affixed to a part other than the engine which complies with the specifications set out in this Article if the label required on the engine is hidden after the engine is installed in the machinery; and

e) A supplementary label in the Spanish language shall be affixed on a part other than the engine when the engine has a label which complies with the specifications set out in this Article and is in a language other than the official language of the Republic of Colombia.

The labelling shall contain the following information:

a) Title: "Important engine information";

b) Name of the manufacturing company;

c) Engine designation (code, usually numeric or alphanumeric, identifying the engine family);

d) Engine type;

e) Engine displacement;

f) Net rated engine power;

g) Fuel type;

h) Date of manufacture (month and year);

i) Expressly state the emission standard the engine meets (e.g., Tier 3, Stage IV, etc.); and

j) Emission measurement cycle.

Additional information such as maintenance conditions or compliance or non-compliance with other legal provisions may be included on the required label.

(...)"

8.5. Peru

Regarding the use of labelling on machinery, this aspect has not yet been regulated.

Asia-Pacific

8.6. India

Labelling and registration of machinery

According to amendment No. 1 of 2017 to AIS-136: Product identification and numbering system for construction machinery and earthmoving vehicles / machinery, paragraph 2, product labelling is defined as the means of displaying the PIN and vehicle / machine details. (2017)No. 2, product labelling is defined as the means of displaying the PIN and characteristics of the machine.

The PIN is the primary marking on the vehicle or machine and the product label or plate and shall consist of 17 characters on a single horizontal line without breaks or separations between the characters. There shall be no additional signs, letters or characters before or after the preceding and ensuing symbols specified in paragraph 3.2 of the above standard. Zero (0) shall be used in the first positions of a field whenever fewer than the required number of characters is used, e.g., for model 'AF3' write 00AF3.

An acceptable symbol must immediately precede the first numeral or letter of the PIN and immediately follow the last numeral of the PIN.

The acceptable symbol shall be:

- An asterisk (*),
- Greater-than and less-than signs (> <),
- a corporate symbol, or
- a company logo.

Instead of greater-than and less-than signs, angle brackets or similar "vee" symbols horizontally pointing inwards may be placed on either side of the PIN.

The following characters only shall be used in the PIN:

- 1234567890
- ABCDEFGHJKLMNPRSTUVWXYZ
- Characters I, O and Q shall not be used.

Other codes that make up the PIN are defined according to AIS-136 Amendment No. 1 of 2017 (2017) as listed below:

1. World Manufacturer Code (WMC)

WMC shall consist of three alphanumeric (alpha or numeric) characters in positions 1, 2 and 3. The manufacturer shall follow the procedure in Annex A to secure a WMC listing. The registration process will require sufficient information to identify a manufacturer.

2. Vehicle / Machine Descriptor Section (MDS)

The MDS shall consist of five alphanumeric characters in positions 4, 5, 6, 7 and 8. The manufacturer is to determine the coding and sequence of the information. This field may be comprised of general descriptive attributes of the vehicle or machine. It is recommended that this field makes use of information that is readily easily on the vehicle / machine. For example, for a 493C model, a suitable character sequence would be 00493 or 0493C.

3. Vehicle or Machine Indicator Section (MIS)

The MIS shall designate a unique manufacturing number and consist of eight alphanumeric characters in positions 10, 11, 12, 13, 14, 15, 16 and 17. Alpha or numeric characters may be used in positions 10, 11, 12 and 13. Only numerals shall be used in positions 14, 15, 16 and 17. The content of the MIS is at the discretion of the manufacturer. The manufacturer may choose to designate the year of manufacture. It is recommended that the year be indicated by the first character of the MIS (position 10). The recommended code to be used to identify the year is given in Table 1 of 2017 Amendment No. 1 to AIS-136.

4. Check Letter (CL)

The calculation to determine the CL shall be based on a formula provided by the website manager to the manufacturer (see Annex A of the 2017 Amendment No. 1 to AIS-136). As an alternative, the website manager may provide a non-calculated letter that the manufacturer may use in this position for vehicle/machine models having a volume of less than 100 units per year.

5. Duplication

The manufacturer shall ensure that the same 17-character PIN number shall not be reissued for 30 years. The manufacturer is responsible for maintaining a complete file of PIN records for all vehicles or machines using the assigned WMC.

The following example shows a PIN meeting the requirements of the AIS-136 standard.

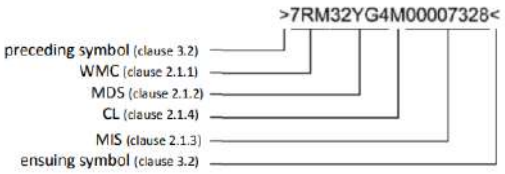


Figure 8. 2. Label used on non-road machinery engines in India according to AIS-136.

Source: (Government of India, 2017).

Within the label the approval code associated with the certificate of compliance (*CMRV type-approval number*) is specified in accordance with the provisions of rule 126 of the Central Motor Vehicle Rules (CMVR). In this respect the label also reflects information on the emission level of the mobile machinery.

8.7. China

According to the regulation HJ 1014-2020 (2020) all diesel engines must carry a label which must comply with the following parameters:

a) The label shall not be removed from the engine, unless due to engine deterioration the label is not visible.

b) The label shall remain legible during the entire life of the diesel engine.

c) It shall be located in a place that does not interfere with the free operation of the engine.

d) The location of the label shall be clearly visible.

If the label cannot be positioned in a visible place for any reason, the manufacturer shall provide an additional label which cannot be removed from the machinery and which does not interfere with the operation of the machinery.

The information on the label must comply with the following specifications:

- The label shall display the words "*environmental information label*".
- Power section corresponding to the standard defined in Article 5.2.3 and approval number described in Annex F.
- Type, engine family and power.
- Date of engine manufacture: year, month and day[45]. If the engine already contains the date of manufacture, the label may discard this information.
- Full name of manufacturer.
- Technical information on control systems: ECU, NCD, PCD, EGR turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filters, intake muffler, exhaust muffler, etc.
- Basic information: machine manufacturer's name, machine name, trademark, machine type, model, engine manufacturer's name, engine model, fuel injection system type, etc.

Each machine shall have a 17-digit alphanumeric environmental identification. For machines used in earthmoving tasks, the product identification number (PIN) shall be reported in accordance with GV/T25606-2010 and ISO 10261:2002 (Ministry of Ecology and Environment of the People's Republic of China, 2020).

The rules for the definition of the numerical environmental identification shall be as follows: manufacturer identification part + machinery description part + check digit + machinery identification part (Figure 8. 3).

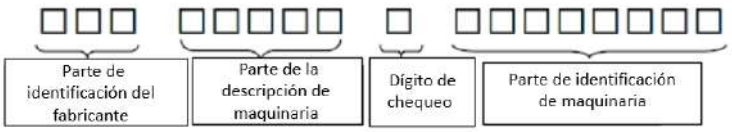


Figure 8. 3. Schematic diagram for machine environmental identification numbers.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

Comentado [MFT1]: Añadir traducción al inglés (de izquierda a derecha):
Manufacturer identification // Machine description // Check code // Machine identification

Machine Environmental Identification Number: <88811233QH3123446>.

Figure 8. 4. Machine environmental identification number format.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

A detailed description of the content of each of the alphanumeric digits can be found in Annex K of HJ 1014-2020.

The size of the label can be 130 mm x 60 mm. The content of the label must be legible. Some label examples are shown in the following tables.

[45] Day is optional

Table 8. 1. Example 1: Format of NRMM environmental information label in China.

Environmental information label Compliant with GB 20891-2014; *Stage X* Emission Standard Manufacture; Date: mm/yyyy Environmental information disclosure number.	
Basic information	Machine manufacturer's name, machine name, trademark, machine type, model, engine manufacturer's name, engine model, fuel injection system type, etc.
Critical environmental parts	ECU, NCDM PCDM EGRM turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filters, intake muffler, exhaust muffler, etc.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

Table 8. 2. Example 2: Format of NRMM environmental information label in China.

Machinery environmental information label	Environmental information label Compliant with GB 20891-2014; *Stage X* Emission Standard. Date: mm/yyyy Environmental Information Disclosure Number.	
	Basic information	Machine model, name, trademark, machine type, manufacturer name, importer name (if applicable), engine model and manufacturer name, fuel injection system type, etc.
	Environmentally critical parts	ECU, ECR, turbocharger, intercooler, fuel injection pump, fuel injector, DOC, DPF, SCR, air filters, intake muffler, exhaust muffler, etc.

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

Europe

8.8. European Union

For the European Union and the United Kingdom, the same provisions apply as those presented for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

8.9. Switzerland

Regulatory marking of engines

Regulation 2017/656, in its first appendix of Annex III, specifies the content of the marking or "approval plates" which shall comply with the following characteristics:

1. Registered trade name or registered trade mark of manufacturer;
2. Engine type designation or engine family;
3. Unique engine identification number;
4. EU type-approval number;
5. Engine production date;
6. Markings in accordance with applicable legislation; and
7. EC type-approval number.

In addition, the following guidelines from Article 32 of Regulation (EU) No. 2016/1628 should be taken into account (2016)**:**

"(...)

1. The manufacturer shall affix a marking on each engine manufactured in conformity with the approved type (hereinafter referred to as the 'statutory marking');
2. In respect of the following engines, the statutory marking shall include supplementary information indicating that the engine is subject to the relevant exemption or transitional provision:
    a) engines intended for export to third countries referred to in Article 34(1) that are manufactured either in the Union or outside the Union and subsequently installed in non-road mobile machinery in the Union;
    b) engines placed on the market in accordance with Article 34(2), (5), (6) or (8);
    c) engines temporarily placed on the market in accordance with Article 34(4);
    d) transition engines placed on the market in accordance with Article 58(5);
    e) replacement engines placed on the market in accordance with Article 34(7) and Article 58(10) or (11).
3. The Commission may adopt implementing acts laying down the format for the statutory marking, including the mandatory essential information required when the engine leaves the production line, the mandatory essential information required before the engine is placed on the market and, where applicable, the supplementary information referred to in paragraph 2 of this Article. Those implementing acts shall be adopted, by 31 December 2016, in accordance with the examination procedure referred to in Article 56(2).

(...)"

According to Article 33 of the above-mentioned EU regulation, it may be the case that a temporary marking of engines may be implemented under the following characteristics:

"(...)

1. The manufacturer shall affix a temporary marking to each engine manufactured in conformity with the approved type and that is placed on the market on the basis of Article 34(3).
2. An engine that is not yet in conformity with the approved type and that is being delivered to the manufacturer of that engine shall only bear a temporary marking.
3. The Commission may adopt implementing acts laying down the template for the temporary markings referred to in paragraphs 1 and 2 of this Article, including the mandatory essential information that is to be indicated thereon. Those implementing acts shall be adopted, by 31 December 2016, in accordance with the examination procedure referred to in Article 56(2).

(...)"

9. Regulation on machinery useful life, repowering, overhaul and scrapping practices

With regard to the NRMM useful life, repowering, overhaul and scrapping practices, some specific regulatory guidelines for this category were identified in the United States, Canada, Brazil, the European Union and China.

In cases such as the United States, Canada and China, regulation is associated with the control of air pollutant emission levels.

From this review, it can be noted that in countries where emission levels are controlled during the entire operation stage of the NRMM, the useful life of the NRMM is indirectly controlled. This is the case in the European Union. In India, this criterion applies to mobile sources in general, but agricultural machinery is excluded.

North America

9.1. United States

The useful life of the engines is established by the time in operation of the engines, either in hours of use or years of age, whichever comes first. In the section on emission standards (see section 6.2), the useful life periods for the different classifications of engines regulated by the United States are presented.

9.2. Canada

The useful life for NRMM is defined in subsection 1(1) of the Off-Road Compression Ignition Engine Emission Regulations as "the period of time or use in respect of which an emission standard applies to an engine, as set out in 40 CFR §1039.104-Subpart B." (Government of Canada, 2012).

The following table summarises the useful lives for different engine categories applicable to the Canadian regulation.

Table 9. 1. Useful life for different engine categories.

Scenario	Useful life
All engines rated under 19 kW	3000 hours or 5 years, whichever occurs first
Constant speed engines rated under 37 kW with rated speeds greater than or equal to 3000 rpm	3000 hours or 5 years, whichever occurs first
All other engines rated at or above 19 kW and under 37 kW	5000 hours or 7 years, whichever occurs first
All other engines rated at or above 37 kW	5,000 hours or 10 years, whichever occurs first.

Source: (Government of Canada, 2012).

South America

9.3. Brazil

Regarding final disposal, Brazil enacted Resolution 530 that regulates Law No. 12.977 aimed at defining the guidelines for the scrapping of land motor vehicles (National Traffic Council of Brazil, 2015; Presidency of the Republic of Brazil, 2014). The Resolution defines the main stakeholders in the inspection processes of the sites where motor vehicles are scrapped. The main objective of Law 12.977 is to combat the clandestine trade of spare parts (Silva, 2016), as well as to define the guidelines and specifications regarding the scrapping of vehicles. The waste generated during the scrapping of vehicles must comply with the requirements defined in the National Solid Waste Policy established in Law No. 12.305 of August 2, 2010.

It should be noted that it is not specified whether this general rule also covers NRMM.

9.4. Chile

For Chile, no maximum fleet age requirements for operation were identified.

9.5. Colombia

For Colombia, no requirements were identified regarding the maximum age of the NRMM for its operation. No information has been identified on repowering, overhaul and end-of-life scrapping practices.

9.6. Peru

Similar to the machinery import and operation regulation, there is also no regulation in Peru regarding the machinery useful life or repowering. However, this practice is known to be common and is used to extend their useful life.

It is worth noting the contrast with the vehicles circulating in the SNTT, since in this case, regulations have been generated to promote the renewal of the on-road vehicle fleet. Thus, in 2021, the Supreme Decree approving the National Regulation for the Promotion of Scrap Vehicles was issued. (Decreto Supremo No. 005-2021-MTC: Decreto Que Aprueba El Reglamento Nacional Para El Fomento Del Chatarreo, 2021).

On the other hand, in terms of machinery repowering, the private sector has implemented practices such as those promoted by the company Ferreycorp under the Certified Collision Repair (CCR) program. Under this mechanism, the CATERPILLAR brand provides the repair guidelines to be followed, which, once carried out by Ferreycorp, CATERPILLAR evaluates and issues a certificate of the repair process. This allows users to opt for new equipment or repower used machinery through Ferreycorp, in addition to having after-sales support.

Another type of repair programmes is the Certified Power Train (CPT) where the major components and final drives are rebuilt; and the Certified Power Train Plus (CPT Plus) where the above is complemented with the repowering of the electrical system, hydraulics and structures, providing a life expectancy similar to that of a new machine.

Finally, local experts mentioned that overhaul practices (changing engines, parts and attachments) are common in the NRMM segment in Peru; and that used machinery is also often imported to take its parts and repower other machinery without any restrictions (G.N. Castillo, personal communication, 5 July 2021).

Asia-Pacific

9.7. India

In March 2021, the Ministry of Road Transport and Highways presented the policy of mandatory vehicle scrapping for commercial vehicles older than 15 years and passenger vehicles older than 20 years, if they fail to pass their corresponding emission and operational tests. However, the proposal is explicit in that it does not include agricultural machinery such as tractors, ploughs and harvesters to date (IBEF, 2021). The milestones set out in the draft policy require the rules for operational and scrapping tests to be in place by 1 October 2021. As for NRMM, it is only known that there will be a mandatory roadworthiness testing requirement for heavy-duty vehicles scheduled for October 2023; the same will be done for other types of vehicles by 1 October 2024 (DownToEarth, 2021).

Useful life periods

Compliance with emission standards must take into account the deterioration of emission control systems that occurs over the lifetime of the machines. In the case of India, this useful life is defined according to the power range and operating regime, as shown below:

Table 9. 2. Useful life periods for vehicles and machinery under Trem Stage IV - V and CEV Stage IV - V standards.

Rated power		Useful life (h)
≤ 37 kW	Constant speed	3,000
	Variable speed	5,000
> 37 kW		8,000

Source: (Dieselnet, 2018).

Alternatively, to demonstrate emissions compliance, instead of performing ageing tests with the useful lives described above, manufacturers may use fixed emissions deterioration factors of 1.3 for CO, 1.3 for HC, 1.15 for NOx and 1.05 for PM (NRSC and NRTC) (Dieselnet, 2018).

9.8. China

The maximum useful life of machinery is specified in Article 5.2.2 of GB 20891-2014. It ensures the normal operation of NRMM diesel engines and their emission control systems (if any) to comply with the emission limits for gaseous and particulate pollutants and has been confirmed in the type-approval (Ministry of Ecology and Environment of the People's Republic of China, 2014b).

The durability tests of diesel engines are performed according to the parameters set out in Annex BD of GB 20891-2014 where the respective deterioration factor or coefficient, generated on the basis of tests of diesel engines in actual operation, is determined. The tests shall be performed according to the test cycle defined in Annex BD.2.1. (Ministry of Ecology and Environment of the People's Republic of China, 2014b)..

The engine durability test times according to GB 20891-2014 regulation shall not be lower than 25% of the diesel engine useful life time specified in Table 9. 3 (Ministry of Ecology and Environment of the People's Republic of China, 2014b). On the other hand, the entity performing the durability tests may randomly choose the type of test that fits the times defined in the table below.

Table 9. 3. Durability time requirements.

Engine power range (kW)	Speed (r/min)	Useful life (h)	Allowable minimum test duration (h)
Pmax ≥ 37	Any speed	8000	2000
19 ≤ Pmax < 37	Non-constant speed		1250
	Constant speed <3000		
	Constant speed≥3000	3000	
Pmax < 19	Any speed		

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2014b).

Table 9. 4. Specified deterioration factor or coefficient for each pollutant.

Pollutant	CO	HC	Nox	PM	PN	NH_3
Specific deterioration factor or coefficient	1.3	1.3	1.15	1.05	1	1

Source: (Ministry of Ecology and Environment of the People's Republic of China, 2020).

Diesel engine manufacturers shall be permitted to choose the deterioration coefficient specified in the above table as a substitute durability deterioration coefficient. The specific emissions of various pollutants shall be multiplied by the determined deterioration coefficients, and the results shall not exceed the limits specified in regulation GB 20891-2014.

Regulation HJ 1014-2020 adds criteria for determining the deterioration coefficients for diesel engines:

> The use of one of the two test cycles of GB 20891-2014 No. B.3.8.1 and B.3.8.2 (hot start cycle only) shall be permitted at each time node to determine the deterioration coefficient or deterioration correction value, and the other test cycle shall require that an emission test be conducted at the beginning and end of the durability test. The determined deterioration coefficient or degradation correction value shall apply to the two cycles, and no pollutant emission at any node in the durability test shall exceed the limit specified in GB 20891- 2014 (Ministry of Ecology and Environment of the People's Republic of China, 2020).

Europe

9.9. European Union

For the European Union and the United Kingdom, the same provisions apply as those presented for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

9.10. Switzerland

As regards the final disposal of vehicles for the European Union, Directive 2000/53/EC of the European Parliament and of the Council was issued, which aims to stipulate measures to prevent and limit waste from end-of-life vehicles (ELVs) and their components by ensuring that they are reused, recycled or recovered, and to improve the effectiveness of environmental protection for all economic operators involved in the life cycle of vehicles. This legislation applies to passenger cars and vans, but not to large trucks, vintage vehicles, special purpose vehicles and motorbikes (Summary of Directive 2000/53/EC on End-of-Life Vehicles, 2000) and is applicable to non-road mobile machinery.

In other legislation such as Directive 2012/19/EU on waste electrical and electronic equipment, paragraph 4(e) makes it explicit that the disposal measures laid down are not applicable to machinery (European Commission, 2012).

Africa

9.11. South Africa

In order to deregister a motor vehicle, the ADV form provided by the registration authority through the eNATIS portal of the National Traffic Information System must be completed. The vehicle in question must comply with the South African Government's requirements for this process (2021a) (although it is not explicitly stated that they apply to off-road machinery):

- has been declared permanently unfit to be on a public road;
- has been stolen;
- has been permanently demolished;
- becomes exempt from registration.

The registering authority will then issue a deregistration certificate. A motor vehicle that has not been licensed for four years shall be deregistered automatically.

The application instructions are to go to the nearest registering authority and submit the following:

- a certified copy of the identity document;
- a certified copy of the proof of ownership of the motor vehicle;
- supporting documentation if required;
- the vehicle´s registration certificate; and
- complete the application for deregistration of vehicle (ADV) form.

In this case the legislation does not specify whether its application is general, and whether it covers NRMM or not.

10. Operational and road circulation requirements

This section describes the practices related to operation, circulation, transit, and licensing requirements for NRMM[46] in the different case studies.

A wide range of operational aspects were identified as being regulated for NRMM in the different cases, including the following:

- Environmental requirements: in cases such as Canada and Mexico, there are requirements related to air pollutant and noise emission levels. In specific cases such as Mexico City, environmental restrictions are identified for the operation of NRMM as a response to high pollution contingencies.
- Safety requirements: These are the most common among the case studies. They include mechanical criteria for NRMM and NRMM operating conditions such as, for example, speed of circulation, zones where NRMM is allowed to circulate, hours of circulation, ways to move machinery between sites, licensing and training requirements for operators
- Additional operational requirements are specified in the cases of Peru and Colombia, related to the monitoring and control of illegal mining.

North America

10.1. Canada

10.1.1. Operational requirements

The operating requirements for engines or machinery used in off-road applications are described in the Canadian Environmental Protection Act and in the general regulation for off-road compression-ignition engines. In general terms, all equipment and vehicles must be EPA certified or carry an NEM label certifying that they meet the emission standards defined by the regulation.

Provinces may independently mandate certain off-road machinery operation requirements. For example, the provinces of New Brunswick[47] and Ontario[48] require that machinery meet certain mechanical criteria and that users of such machinery meet certain safety conditions (Government of Ontario, 2021; Government of New Brunswick, 2021).

10.2. Mexico

According to the Mexico City Traffic Law (Official Gazette of Mexico City, 2015), Article 41, section v states the following:

Article 41: - The following vehicles shall be fitted with amber flashing lights on the upper part, subject to authorisation by the Secretariat:

[46] Practices are specified if these differ from the entry requirements, which are presented in the section on import requirements and type-approval processes (see section 7).
[47] https://www2.gnb.ca/content/gnb/en/services/services_renderer.200660.Off-Road_Vehicle_Requirements.html
[48] https://www.ontario.ca/document/official-mto-drivers-handbook/off-road-vehicles-snowmobiles

Fraction v: oversized vehicles, agricultural or construction machinery and vehicles used for flagging.

Article 49: "Agricultural or construction machinery is only allowed to circulate on Mexico City roads when authorised by the Secretariat. Their circulation shall be limited to the transfer of the vehicle to the place where it will be used".

> When travelling on the road, agricultural or construction machinery must have the necessary safety measures, such as reflective or luminous warning signs. When its speed of circulation is less than 20 kilometres per hour or it has excessive dimensions, it must be supported by a vehicle that accompanies it to warn other drivers of its presence.
>
> Infringement of the prohibitions set out in this Article shall be punishable by a fine equivalent to 20, 25 or 30 times the *Unidad de Medida y Actualizacion* in force.

Likewise, agricultural or construction machinery must carry reflective material on their vehicles as specified in the Traffic Law "*Material Reflejante para Vehículos de Transporte de Pasajeros o Carga; I. Objeto"* (Reflective Material for Passenger or Freight Transportation Vehicles; I. Object) and according to what is specified in the standard NMX-D-225-IMNC-2013 or in force. (Official Gazette of Mexico City, 2015)..

In Jalisco, there is a procedure called *Permiso para Circulación de Maquinaria* (Machinery Circulation Permit), issued by the Ministry of Transport (Government of Jalisco, 2021). "The machinery circulation permit allows the transport of heavy machinery (prior authorised route) in the Metropolitan Zone of Guadalajara and is granted indicating the point of origin and destination of the machinery". The legal grounds supporting this requirement are:

- Law of Mobility and Transport of the State of Jalisco (Article 70, Section v).
- Regulation of the Law of Mobility and Transport of the State of Jalisco (Article 103 and 136, section II-VII, clause d).
- Revenue Law of the State of Jalisco, for the fiscal year 2019 (Article 23, section iv, clause f).

On the other hand, the press report entitled "*Maquinaria pesada incumple reglamento*"[49] (El Imparcial, 2016) specifies the following:

- All heavy machinery vehicles such as backhoes, motor graders and others of similar type, must have permission from the Municipal Transit to circulate within the cities, moving from one side to the other being towed on platforms to avoid damaging the roads.
- Drivers must have a driver's licence.
- The traffic law specifies that they cannot drive at very low speeds or exceed the speed limit.
- The units must have a municipal traffic permit to operate at appropriate hours, either at night or in the early hours of the morning.

In information obtained through interviews with experts in Mexico[50], the following was found regarding the operation of machinery in Mexico City:

[49] https://www.elimparcial.com/sonora/nogales/Maquinaria-pesada-incumple-reglamento-20160825-0162.html
[50] P.C. Rodriguez, personal communication, 18 June 2021.

In case of high pollution contingencies in the Metropolitan Zone of the Valley of Mexico, restrictive measures for the operation of machinery are implemented in order to reduce emissions of ozone precursors[51] and particulate matter[52]. However, depending on the event that triggers the contingency, the measures may vary and sometimes, despite a contingency being active, there may be an exception so that the NRMM can operate on a regular basis.

[51] In case of an environmental contingency declared for high concentrations of ground-level ozone. Limited precursors are volatile organic compounds and nitrogen oxides.
[52] Limiting the circulation of vehicles and the activities of machinery used in construction.

South America

10.3. Chile

10.3.1. General road circulation requirements

It should be clarified that the road circulation requirements defined in the regulations described below apply to all types of vehicles and their application on NRMM is not specified.

Citing the Decree with Force of Law 1 Fixing the Consolidated, Coordinated and Systematised Text of the Traffic Law (2014), in numeral 35, the definition of *padrón* or vehicle registration certificate is as follows:

Registration or registration certificate: "document issued by the authority, intended to identify the vehicle and its owner so that it can transit on public roads".

Likewise, Title 1 of the aforementioned decree "On drivers and licences" in its articles 5 and 6, states:

> **Article 5**: No person may drive a motorised or animal-drawn vehicle, without a licence issued by the Director of the Municipal Traffic and Public Transport Department of a Municipality authorised for this purpose; or a provisional permit which the Courts may grant only to drivers who have their licence withheld due to pending proceedings; or a court summons, issued by the officials referred to in Article 4 in replacement of the aforementioned licence or permit; or a valid international licence or permit to drive motor vehicles, granted under international treaties or agreements to which Chile is a party.
>
> **Article 6**: Drivers of motorised or animal-drawn vehicles, with the exception of the previous article, must carry their licence, permit or citation slip with them and, when required by the competent authority, prove their identity and hand over the documents that entitle them to drive.

On the other hand, §2 "On the single licence plate, the registration certificate and the certificate of compulsory motor vehicle accident insurance" states in Article 51 (2014):

> **Article 51:** Motor vehicles may not be driven without a single number plate, a vehicle registration certificate issued by the municipality and a compulsory motor vehicle accident insurance certificate (Subsection 1).
>
> Trailers and semi-trailers that must be registered in the Special Register of Trailers and Semi-trailers must have a unique number plate, without which they are not authorised to transit (Subsection 2).
>
> The unique number plate must be obtained at the Office of the Civil Registry and Identification Service where the registration is requested (Subsection 3).
>
> The compulsory motor vehicle accident insurance certificate must always be carried in the vehicle and be valid (Subsection 4).

10.3.2. Environmental operating requirements for NRMM

In terms of environmental requirements for the operation of machinery, the emission standard for mobile machinery must be complied with by October 2023, with the exception of tractors, which will have a 36-month deadline.

On the other hand, for the Metropolitan Region of Santiago de Chile, it was identified that according to Article 18 of Decree 31 (Ministry of Environment of Chile, 2017), the Ministries of Public Works, Housing and Urbanism, and

Health when executing construction works must use closed particulate filters for their own and third-party machinery.

10.4. Colombia

10.4.1. General operational requirements

Article 28 of Law 769 of 2002, which establishes the National Land Traffic Code and other provisions, states:

> **Article 28. Technical-mechanical, gas and operating conditions:** in order for a vehicle to be able to travel through the national territory, it must guarantee at least the perfect functioning of the brakes, the steering system, the suspension system, the visual and audible signals system and the exhaust system; and demonstrate an adequate condition of the tires, the safety glass and the mirrors and comply with the gas emission standards established by the environmental authorities.

The National Traffic Code does not specify whether the application of Article 28 covers NRMM. This is an aspect that needs to be clarified in the regulations.

10.4.2. Operational requirements for NRMM

According to Resolution 1068 of 2015, once self-propelled agricultural, industrial and construction machinery is registered in the RUNT system, machinery classifiable under subheadings 8429.11.00.00, 8429.19.00.00, 8429.51.00.00, 8429.52.00.00, 8429.59.00.00, 8431.41.00.00, 8431.42.00.00.00 and 8905.10.00.00 of the customs tariff, shall have a global positioning system or other electronic security and monitoring device, permanently installed in accordance with the requirements established by the Colombian National Police (Ministry of Transport, 2015a).

The same Resolution defines the waybill as a document that authorises the movement or transit of machinery under subheadings 8429.11.00.00.00, 8429.19.00.00, 8429.51.00.00, 8429.52.00.00, 8429.59.00.00 and 8905.10.00.00, by public or private land (road and rail), river and sea routes in the country (Ministry of Transport, 2015a).

10.4.3. General road circulation requirements

According to Articles 28 and 50 of Law 769 of 2002 (Colombian Ministry of Transport, 2002) in order for the vehicle fleet to circulate in the national territory, it must comply with the pollutant emission standards set out in the regulations, and it must be guaranteed that the vehicles are in optimal mechanical and safety conditions.

The National Traffic Code does not specify whether the application of these requirements covers NRMM[53] .

[53] However, when the Draft Resolution entitled "*Proyecto de Resolución por el cual se reglamentan los límites máximos permisibles de emisión de contaminantes que deberán cumplir las fuentes móviles terrestres, se reglamenta el artículo 2.2.5.1.8.2 del Decreto 1076 de 2015 y se adoptan otras disposiciones*" (Draft Resolution regulating the maximum permissible emission limits for pollutants to be met by land mobile sources, regulating Article 2.2.5.5.1.8.2 of Decree 1076 of 2015 and adopting other provisions) comes into force, it might specify whether there are similar requirements for machinery.

10.4.4. Road circulation requirements for NRMM

With regard to road transit requirements, Resolution 1068 of 2015, which regulates the National Register of Self-propelled Industrial Agricultural and Construction Machinery and establishes other provisions, sets forth the following (2015b):

Circulation: According to Chapter VI, Article 29, in order for machinery to circulate on public or private roads open to the public, it cannot exceed the dimensional limits (size and weight) established in Resolution 4100 of 2004 and must have tires for its movement as per manufacturer's configuration. Likewise, machinery circulating on public or private roads open to the public between 06:00 and 16:59 must have a lighting system that allows it to be easily seen by other vehicles, people and obstacles, as well as being visible to other road users. For the hours between 17:00 and 05:59, the machinery shall have an amber-coloured device on the front and rear of the equipment.

In this same section, a fluorescent lemon-yellow tape on high intensity retro-reflective paper must be attached to the machinery, perimetrically on the upper and lower part of the equipment or trailer being pulled. This same section establishes the requirements for the following aspects:

Transit: In paragraph f, it mentions that machinery shall travel on the shoulder of the road, in the event that there is no shoulder, the machinery shall circulate on the far-right side of the road, at a distance of no more than one metre from the edge of the carriageway.

Speed: the travel speed shall be 20 km/h as minimum speed and 50 km/h as maximum speed.

Parking: Machinery shall not be parked within the strip that forms the carriageway, including the shoulder of the road.

Driving licence: persons driving self-propelled agricultural, industrial and construction machinery must have an operator's certificate for driving the type of machinery mobilised and have a category B1 driving licence in accordance with the provisions of Resolution 1500 of 2006.

Identification number: according to Resolution 1068 of 2015, once the information on self-propelled agricultural and construction machinery has been uploaded to the RUNT, the system will assign a consecutive alphanumeric code of 8 characters corresponding to the type and registration and identification number of the self-propelled agricultural, industrial and construction machinery in the system, being Agricultural Machinery (MA) followed by 6 digits; Industrial Machinery (MI) followed by 6 digits and Construction or Mining Machinery (MC) followed by 6 digits.

10.4.5. NRMM in illegal mining

With regard to controls on illegal mining activities in Colombia, due to the environmental impact and the problems of violence caused by the unregulated extraction of minerals such as gold, the Ministry of Foreign Affairs, together with the Andean Council, promoted Decision 774 of 2012, which aimed to generate prevention and control measures for illegal mining activities (The Commission of the Andean Community, 2012). The main objective of

Decision 774 was to optimise the control and surveillance of the import, export, transport, processing and sale of minerals in the Andean Region.

For all of the above reasons and thanks to Decision 774 of 2012, the Government of Colombia promoted the creation of regulations focused on obtaining statistics on the machinery used in the country and registered with the RUNT (for example, Resolution 1068 of 2015 regulating the National Register of Industrial Agricultural and Self-propelled Construction Machinery) and, additionally, contributing to the formalisation and regulation of mining.

Likewise, the National Government, through the Ministry of National Defence, issued Decree 2235 of 2012, which aims at destroying machinery used in mineral exploration or exploitation activities without an environmental licence or mining title (Ministry of National Defence, 2012). The background to this Decree is found in the National Development Plan 2010-2014, which in its Article 106, prohibited the use of dredges, mini-dredges, backhoes and other equipment used in mining activities without a mining title registered in the National Mining Registry (Congress of the Republic of Colombia, 2011). Likewise, failure to comply with this prohibition would result in penalties such as the seizure of goods used in the illegal activity, and the application of a fine of up to one thousand legal monthly minimum wages in force.

10.5. Peru

According to Article 155 of the National Traffic Regulation, as amended by Supreme Decree No. 019-2018-MTC (2018), machines (yellow or green), defined in Annex II of the National Vehicle Regulation, are prohibited to travel by their own means on public land transport roads. They must be transported on a vehicle designed and built for the transport of goods. Such machines may only circulate on the roads on which they are operating. Circulating, driving or operating yellow or green machines on public roads is a very serious offence according to code M.33 of the National Traffic Regulations.

NRMM in illegal mining

There is currently no register of machinery, nor is there an information system in place. One step forward in this regard was the holding of an extraordinary multisectoral commission to map the machinery used illegally for mining in the Department of Madre de Dios.

The national regulations issued related to machinery and its use in the context of illegal mining are listed below:

- Legislative Decree No. 1126: Legislative Decree that establishes control measures on chemical inputs and controlled products, machinery and equipment used for the production of illicit drugs.

  This Decree refers to machinery and equipment as controlled goods that may be used in the manufacture of illicit drugs, defines the powers of registration, control and inspection by SUNAT, as well as the granting of authorisation for the international trade of goods and the control of the means and services for their transport. The decree also establishes the implementation of special regimes for the monitoring of controlled goods in geographical areas where illicit drugs are produced, the destination of the controlled goods and means of transport seized, the responsibilities of the user requesting orders of goods and the infractions and their seriousness in case of non-compliance with the provisions of this Legislative Decree (*Decreto Legislativo No. 1126: Decreto Legislativo Que Establece Medidas de Control En Los Insumos Químicos y Productos Fiscalizados, Maquinarias y Equipos Utilizados Para La Elaboración de Drogas Ilícitas, 2012*).

- Legislative Decree No. 1107: Legislative Decree that establishes control and inspection measures for the distribution, transport and sale of machinery and equipment that may be used in illegal mining, as well as the mining product obtained in this activity.

  This Decree defines the competences in control, inspection and seizure of machinery by SUNAT, establishes the mandatory use of GPS for units transporting machinery and other obligations regarding the sale of mining products and responsibilities of actors involved in the aforementioned activities *(Decreto Legislativo No. 1107: Decreto Legislativo Que Establece Medidas de Control y Fiscalización En La Distribución, Transporte y Comercialización de Maquinarias y Equipos Que Puedan Ser Utilizados En La Minería Ilegal Así Como Del Producto Minero, 2012)*.

- Legislative Decree No. 1100: Legislative Decree that regulates the interdiction of illegal mining throughout the Republic and establishes complementary measures.

  This Decree establishes the prohibition of machinery for the development of illegal mining activities exemplifying some of the equipment that can be used for these purposes and information for the execution of interdiction actions against mining activities that incur in prohibitions involving the use of machinery, which can result in the confiscation of equipment, destruction or demolition of goods among other aspects. *(Decreto Legislativo No. 1100: Decreto Legislativo Que Regula La Interdicción de La Minería Ilegal En Toda La República y Establece Medidas Complementarias, 2012)*.

- Legislative Decree No. 1102: Legislative Decree incorporating illegal mining offences into the Penal Code.

  This Decree defines the acts that involve the acquisition of machinery and constitute illegal mining offences, as well as the disqualification, responsibilities of public officials and related criminal actions. *(Decreto Legislativo Legislativo No. 1102: Decreto Legislativo Que Incorpora Al Código Penal Los Delitos de Minería Ilegal, 2012)*.

- Legislative Decree No. 1099: Legislative Decree approving actions to interdict illegal mining in the department of Puno and environmental remediation in the Ramis and Suches River Basins.

  This Decree provides information for the execution of interdiction actions against mining activities that incur in prohibitions involving the use of machinery, as well as the possible confiscation and destruction or demolition of assets. *(Decreto Legislativo No. 1099: Decreto Legislativo Que Aprueba Acciones de Interdicción de La Minería Ilegal En El Departamento de Puno y Remediación Ambiental En Las Cuencas de Los Ríos Ramis y Suches, 2012).*

Asia-Pacific

10.6. India

No regulation has been identified that specifies operating and road circulation requirements for NRMM that are additional to those presented in the other sections of this document.

As explained in earlier sections of this document (see section 4.10), according to notification S.O.1248(E) (Government of India, 2004):

- use of public road by Construction Equipment Vehicles is incidental to its main off-road function. However, when the public road is being used regularly for carrying on commercial activities, then Construction Equipment Vehicles such as dumpers and excavators being used for such activities, shall be deemed as transport vehicles. Their driving on the road is allowed only for a short period of time at a speed not exceeding 50 km/h (Ministry of Road Transport & Highways, 1989).
- movement of power tillers on the road is incidental to its main function on the field and should only be used to travel from one cultivation area to another for a short period at a speed not exceeding 30 km/h (Ministry of Road Transport & Highways, 1989).

10.7. China

10.7.1. Fuel quality operational requirements

The country independently regulated the sulphur content of diesel used in road and non-road machinery (Yang, 2021). Generally, fuel for non-road machinery contained high sulphur levels, low cetane number and lower lubricity[54]. In 2018, China's State Council published the National Blue-Sky Plan standardising the quality of diesel used in both machinery sectors. In this regard, as of January 2019, only diesel engines that meet the China IV fuel quality standard can be sold in the territory.

10.7.2. Safety operational requirements

The Safety Standard of Machinery and Equipment (Safety Standard of Machinery and Equipment, 2014) states the following:

With regard to the operating requirements for forklift, ram and other machinery intended for loading goods, the following guidelines shall be met:

- There should be no significant damage or corrosion to machinery.
- The stress in the fork shall be below one third of the yield strength of steel used in the fork, when the maximum load is put in the base-load centre.
- When the forklift truck is equipped with a driver seat in a lifting manner, an armrest and a fall prevention device shall be provided.
- The seat cushion shall be made of shock-absorbing materials to prevent significant vibration of the body of the driver when the truck is moving.

[54] Lubricity is the measure of the reduction in friction or wear by a lubricant. The study of lubrication and wear mechanisms is called tribology.

- The type of forklift truck shall be equipped with safety belts, guard rails or other protective devices that prevent the driver from crushing when the truck falls.

Other requirements identified are as follows:

- The vehicle shall be explosion-proof.
- The vehicle shall comply with the requirements of CNS 4782.

Europe

10.8. European Union

For the European Union and the United Kingdom, the same provisions apply as those presented for Switzerland. The Swiss regulation is based on Regulation (EU) 2016/1628.

10.9. Switzerland

10.9.1. Operational requirements

According to the Swiss Air Pollution Control Ordinance (OAPC) (2020) in its Article 20b, the requirements for non-road mobile machinery are specified:

1. Mobile machines and equipment with internal combustion engines that are not intended for use on the roads (machines and equipment with internal combustion engines) must satisfy the requirements specified in Annex 4, number 4.
2. New machines and equipment with internal combustion engines may only be placed on the market if the conformity of the engines with the requirements specified in Annex 4, number 4 has been demonstrated (Article 20c).

In its Annex 4, Article 20c defines the requirement for proof of conformity, which consists of:

A. Type-approval granted by an EU Member State for an engine type or engine family in accordance with Regulation (EU) No 2016/162833.

B. Engine markings as specified in Article 32 of Regulation (EU) No 2016/1628.

Conformity may also be proven by means of a certificate issued by a conformity assessment body as specified in Article 18, to the effect that the type of machine or equipment with internal combustion engine meets the requirements of Annex 4, Number 4 (certificate of conformity). In this case, the engine must bear the trademark or trade name of the manufacturer of the engine and the name of the conformity assessment body (Ordinance of 16 December 1985 on Air Pollution Control (OAPC), 2020).

Annex 4 specifies for internal combustion machinery and equipment that:

1. Internal combustion engines in machinery and equipment must comply with the relevant requirements of Regulation (EU) 2016/1628.
2. The emission limit requirements specified in Annex 1 do not apply.

11. Procedures for NRMM control and inspection in the operation phase

According to the regulations identified for the different case studies, it can be noted that the control and inspection processes are generally concentrated in the production, import and type-approval stages.

In the operation stage, the most common practice identified is the development of random tests to verify the emission levels of the NRMM. In India it is proposed by PEMS and in the Colombian regulatory proposal by opacity testing. In Switzerland, the review is based on the results of maintenance and tailpipe emissions.

North America

11.1. United States

In the United States, no off-road engine inspection practices are identified during the operation of non-road engines. The purpose of the regulations is to ensure that engines leave the factory in compliance with emission limits during their useful operating life. The Certificate of Conformity is issued to the manufacturer and not to the purchaser or user of the machinery.

Regulation 40 CFR § 1068.20 specifies that the Environmental Protection Agency (EPA) may conduct inspections of emissions testing and equipment and their calibration certificates, manufacturing processes, storage warehouses (including seaports), and available documents or records.

South America

11.2. Chile

The emission standard for mobile machinery states that the Superintendency of the Environment will be the agency in charge of establishing protocols and procedures to ensure compliance with the standard.

11.3. Colombia

In the Draft Resolution regulating the maximum permissible limits of pollutant emissions to be met by land mobile sources, two schemes are mentioned for the inspection and control of non-road sources. The first consists of verifying the emissions of combustion gases generated through the opacity test where, if the machinery inspected exceeds the No. 2 pattern of the Ringelmann scale, the authority may exercise some type of sanction. On the other hand, all machinery must carry a label that must be visible on the engine[55] (Colombian Ministry of Environment and Sustainable Development, 2020).

Issues related to inspection and control of NRMMs for illegal mining are described in the previous section of this document (see section 10.4.5).

[55] See labelling specifications on section 10.4.

11.4. Peru

Currently, the control and inspection procedures for non-road mobile machinery in operation in Peru are related to illegal mining activities. According to Legislative Decree No. 1107, which establishes control and inspection measures for the distribution, transport and sale of machinery and equipment that may be used in illegal mining as well as the mining product obtained from such activity, the following provisions related to control and inspection actions are enacted (2012d):

- According to Article 3, SUNAT shall control and inspect the entry, permanence, transport or transfer and exit of machinery and equipment used in the mining activity, and of mining products, as well as their distribution to and from the customs territory and within the national territory, without prejudice to the competences of other State entities, in accordance with the legislation in force.
- According to Article 4, the transport or transfer of machinery, equipment and mining products shall be carried out through the established Tax Routes and shall have the corresponding documentation, as provided for in the Payment Voucher Regulations and other applicable regulations, with SUNAT being empowered to verify the documents and goods at the checkpoints implemented for such purposes, at the time and place required, without prejudice to the other obligations established by the corresponding regulations.
- According to Article 5, SUNAT will proceed to seize the machinery, equipment and mining products that constitute the object of the crime of clandestine trade, as well as the means of transport used for their transportation, when in the exercise of its administrative actions it detects the presumed commission of the crimes foreseen in numbers 4) and 5) of Article 272 of the Penal Code, and must inform the Public Prosecutor's Office for the corresponding actions. Mining products and means of transport seized or confiscated whose sale, circulation, use or possession is prohibited in accordance with national regulations, shall be destroyed and in no case shall the value of such products be refunded, unless a court order orders their return. SUNAT may order the storage of seized mining products and means of transport, as well as their sale, donation, destination to public entities and delivery to the competent sector and, in the case of means of transport, the sale will proceed once the corresponding judicial process has been completed. The disposal of the mining products will be carried out even when the fiscal investigation or judicial process is in progress, informing the prosecutor or criminal judge hearing the case.
- According to Article 6, the Public Prosecutor's Office, the Peruvian National Police and the Directorate General of Coast Guard and Coast Guard - DICAPI, within the scope of their competences, will provide support and collaborate with SUNAT in the control and inspection of mining machinery, equipment and products. In places of difficult access that also imply the absence of sufficient members of the National Police of Peru or without the necessary logistics or infrastructure, SUNAT may exceptionally request the intervention of the Armed Forces for actions that ensure the effectiveness of this Legislative Decree, and the intervention of the Armed Forces does not imply in any way the restriction, suspension, or affectation of the fundamental rights enshrined in the Political Constitution of Peru.
- According to Article 7, the use of the global positioning system (GPS) is compulsory in units transporting machinery and equipment controlled by this regulation, which must be registered with the MTC. Those responsible for the transport units mentioned in the preceding paragraph shall provide the MTC with the information from the GPS. Likewise, such information shall be available to SUNAT, the Ministry of the Interior and the Ministry of Energy and Mines - MINEM, as well as to any other authority of the Public

Administration that may require it. The MTC shall establish the type and minimum characteristics of GPS systems, as well as the mandatory use of security seals, and shall be empowered to establish their gradual implementation. Also, the Superintendency of Terrestrial Transport of People, Load and Goods - SUTRAN, will supervise the fulfilment of the present Article, being empowered to apply the sanctions that correspond. The MTC shall approve such provisions as may be necessary for the effective implementation of this Article.

Additionally, Legislative Decree No. 1100 will regulate the interdiction of illegal mining throughout the Republic and establishes complementary measures (*Decreto Legislativo No. 1100: Decreto Legislativo Que Regula La Interdicción de La Minería Ilegal En Toda La República y Establece Medidas Complementarias, 2012*).

On the other hand, according to the criteria of local experts (C. Ramos, personal communication, July 5, 2021) the sanctions that deter misconduct by machinery operators should be based on vehicle identification (in addition to the driver), which is not currently available, so that effective control can be exercised for machinery, which could be implemented at the municipal level in accordance with the permits granted for construction work, so that the amount of machinery in operation is identified, and the National Police of Peru (PNP) can have access to this registry to monitor them and effectively control and fine them. According to the same expert interviewed (C. Ramos, personal communication, 5 July 2021), if the machinery is not properly identified, it will be difficult to carry out adequate preventive and control measures, and they cannot be the same as for vehicles on the road.

Note: Issues related to inspection and control of NRMM for illegal mining in Peru are described in Section 10 of this document.

Asia-Pacific

11.5. India

India has a conformity of production scheme described in AIS-137 (ARAI, 2019A), which aims to periodically verify that units being produced for use in the country are in conformity with the type-approval granted to the engine model. Details of this scheme can be found in the referenced standard and in summary form in chapter 7 of this document for this country.

However, according to ICCT (2018), while the BS (CEV/Trem) IV and V standards are based on the European Stage IV and Stage V standards, the Indian standard does not cover some aspects related to the control and inspection of mobile machinery that are specified in the equivalent European regulations. These include, among others, operational compliance testing using portable emission measurement systems (PEMS), off-cycle emission testing, production compliance procedures and technical requirements for NOx and particulate matter control measures.

Europe

11.6. Switzerland

According to the Swiss Air Pollution Control Ordinance (OAPC) (2020) in its Article 20b, the requirements for non-road mobile machinery are specified. In terms of inspection it is stated that:

1. The holder or operator of a construction machine must carry out exhaust emission maintenance or have such maintenance carried out at least every 24 months. It must retain the results of the exhaust emission maintenance for at least two years and present it to the authorities on request. The FOEN shall issue recommendations.
2. Machines and equipment with internal combustion engines need not be inspected periodically in accordance with Article 13(3). The authority shall carry out random checks on the results of the exhaust emission maintenance. If there is any suspicion of excessive solid particle emissions, it may order further exhaust emission maintenance.

12. Stakeholders involved in the import, manufacturing, registration, sale, inspection and end-of-life practices of NRMM

The main stakeholders involved in the different processes associated with the life cycle of NRMM were identified in the aspects most related to the emission levels of air pollutants. The main source of this stakeholder identification was the NRMM regulation.

For each case study, a table summarising the stakeholders involved and their main functions is presented. In addition, some of the processes are explained according to the information available.

North America

12.1. Canada

The following table presents the main stakeholders involved in the NRMM processes in Canada.

Table 12. 1. Stakeholders and roles - Canada.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Environment and Climate Change Canada – ECCC	In addition to establishing guidelines and regulations for companies, individuals and legal representatives, this agency has the function of preserving and enhancing the natural heritage, as well as providing guarantees for a clean, safe and sustainable environment for future generations[56] .	(Government of Canada, 2012)
Import	Canada Border Services Agency – CBSA	Agency in charge of facilitating the free flow of people and goods that comply with all regulatory requirements. In terms of importing NRMM, the agency requests the completion of import forms.	(Government of Canada, 2012)
Import	Canada Centre for Mineral and Energy Technology (CANMET)	Certification body for equipment used in underground mining.	(Minister of Justice of Canada, 2012)
Import	Minister of National Revenue	According to the guidance document on off-road compression-ignition engine regulations, the Minister is responsible for receiving import declarations from companies and individuals.	(Government of Canada, 2012)
Type-approval	Minister of Justice	Agency in charge of establishing test methods for engines.	(Minister of Justice of Canada, 2012)
Registration	Ministry of Transport	Agency in charge of receiving registrations of new and used snowmobiles used in the Ontario Region.	(Government of Ontario, 2021)
Registration	Quebec Transport Commission	Agency where off-road machinery with a gross weight of 4,500 kg or more must be registered.	(Commission des Transports du Québec)
Control at manufacturing and import stage	Environment Canada	It will oversee the regulations for transition engines through annual reports and compare the use of the provisions with those in the United States. If there is over-regulation in Canada, the agency will have the power to amend the regulations. Environment Canada will also monitor through	(Government of Canada, 2012)

[56] https://www.canada.ca/en/environment-climate-change.html

Stage	Stakeholders/Entities involved	Main roles	Sources
		its programmes the use of the national emissions marks, compliance with evidence of conformity, registration of defects in emission control systems, test engines and emission control components and laboratory testing.	
Control at manufacturing and import stage	Vehicle and Engine Testing and Emissions Verification Section	Environment Canada section whose function is to receive complaints regarding evidence of conformity.	(Government of Canada, 2012)
Control at manufacturing and import stage	Regulatory Administration Section, Transportation Division	Environment Canada section with functions related to NRMM administrative requirements.	(Government of Canada, 2012)
Regulation of emission limits	Minister of Justice	Agency in charge of setting emission standards and test procedures for engines that are aligned with the EPA.	(Minister of Justice of Canada, 2012)

Source: own elaboration.

The following part of this section provides additional information on NRMM-related processes and the stakeholders involved in each process.

Import

According to the Canadian Environmental Protection Act (1999), the main stakeholders in the process of importing off-road engines and machinery are, primarily, companies, individuals and legal representatives.

- Companies: in section 149 of the Act, a company is defined as a "person" who:
    a. Is engaged in the business of manufacturing vehicles, engines or equipment in Canada.
    b. Is engaged in the business of selling to other persons, for the purpose of resale by those persons, vehicles, engines or equipment obtained directly from a person or the agent of such a person.
    c. Imports of any vehicle, engine or equipment into Canada for the purpose of sale (includes importing equipment for lease).
- Persons: Natural persons importing at least 9 engines intended for off-road applications on land must submit a declaration to the Minister of National Revenue. Exceptions are made for persons importing more than 10 engines intended for vessels.
- Legal representative: Person with the power to sign import declarations, whether for a company or an individual.

These stakeholders are regulated by national institutions such as the Environment and Climate Change Canada Institute, the Canada Border Services Agency and the Minister of National Revenue (Government of Canada, 2012; Minister of Justice of Canada, 2012). The roles of each institution are explained below.

- Environment and Climate Change Canada (ECCC): An institution charged with preserving and enhancing the natural heritage and providing assurance of a clean, safe and sustainable environment for present and future generations[57] .
- Canada Border Services Agency (CBSA): Agency responsible for providing integrated border services that support national security and public safety priorities. It facilitates the free flow of people and goods, including animals and plants, that meet all legislative requirements[58] .
- Minister of National Revenue**:** Agency in charge of receiving import declarations from companies and individuals.

Manufacturing and distribution

Manufacturer: is a person or company in Canada who, before selling the engine to a customer, performs one of the following activities (Government of Canada, 2012):

a. Internal modifications to the engine (e.g., by adding or modifying emission control systems).
b. Builds an engine in parts.
c. Modifies an engine (e.g., retrofitting a diesel engine to run on natural gas).

Manufacturers' obligations in terms of emissions are as follows:

a. All Canadian manufacturers must use the national emissions mark on their engines.
b. It must first determine whether the engine will be used in a stationary application and if so, apply the appropriate label for such use.

If the engine manufacturer produces a transient engine[59] that will be used independently or within machinery, it must submit an annual report to Environment and Climate Change Canada, following the guidelines defined in subsection 13.1 (1) of SOR/2005-32 (Minister of Justice of Canada, 2012).

Distributor: a person who is engaged in the business of selling to others, engines obtained directly from a Canadian engine manufacturer or its agent.

Registration

In Canada, there is an Off-Road Vehicle Act for each of the provinces such as Ontario, New Brunswick, Manitoba, Alberta, Nova Scotia[60], among others (Government of Alberta, 2020; Government of Ontario, 2019; Legislative Assembly of Manitoba, 2021; Legislative Assembly of New Brunswick, 2003). This Act establishes guidelines for registration, insurance and identification through licensing, among other NRMM provisions.

[57] https://www.canada.ca/en/environment-climate-change.html
[58] https://www.cbsa-asfc.gc.ca/agency-agence/menu-eng.html
[59] Refers to engines with older technologies (e.g. Tier 4) and which do not meet current technology standards at the time of manufacture (Environment and Climate Change Canada, 2019).
[60] https://novascotia.ca/sns/rmv/registration/roadveh.asp

A common feature found for each of the provincial laws is that the requirements in terms of off-road vehicle registration only cover vehicles such as snowmobiles, off-road motorbikes, road maintenance vehicles and ATVs, excluding agricultural and construction machinery.

Some characteristics of the standards[61] are explained below at the provincial level, for Ontario, New Brunswick and Quebec.

Registration process in Ontario:

New and used snowmobiles must be registered with the Ministry of Transportation through the Ontario Service Centre (Government of Ontario, 2021).

The following vehicles do not need to be registered as off-road vehicles: road construction machines, agricultural vehicles, golf carts and motorised wheelchairs. In addition, off-road vehicles participating in a competition sponsored by a motorbike association with more than 25 members do not need to be registered for the event[62].

New Brunswick:

All off-road vehicles must be registered annually and display a valid registration plate.

The registration serves as a unique identifier and is mandatory for all types of off-road vehicles according to the provincial Off-Road Vehicle Act of New Brunswick.

Quebec:

According to the Quebec Automobile Insurance Corporation (*Société de l'assurance automobile du Québec*), off-road vehicle registration processes consider:

- Vehicles that have been designed to operate on public roads, but will be used on private roads, must be registered under a "V" type licence at an SAAQ service point[63] .
- Vehicles registered for off-road use include cars, motorcycles, mopeds and scooters, trucks[64] , motor homes[65] , buses and minibuses, snowmobiles, tool vehicles[66] , trailers[67] , camping trailers, motor home trailers, snow ploughs[68] and military vehicles.

  On the other hand, owners of off-road machinery with a gross weight of 4,500 kg or more must register with the Quebec Transport Commission (Commission des Transports du Québec).

[61] Off-Road Vehicle Act.
[62] https://www.ontario.ca/document/official-mto-drivers-handbook/off-road-vehicles-snowmobiles
[63] Société de l'assurance automobile du Québec.
[64] Road vehicle with a net weight of more than 3,000 kg, designed and equipped primarily for the carriage of goods or for carrying equipment permanently attached to the vehicle.
[65] A motor vehicle permanently converted into a dwelling.
[66] A road vehicle, other than a vehicle mounted on a truck chassis, designed to perform a task and having an integrated workstation in the cab. A truck chassis is a frame equipped with the mechanical components found in a vehicle built to transport passengers, cargo or equipment.
[67] A road vehicle that is designed to be pulled by another vehicle, whether or not it maintains a horizontal position without external support.
[68] A road vehicle with a net weight of more than 900 kg, equipped with a mechanical snow blower.

Sale

In order for a company or person to sell an engine in Canada, it must comply with certain obligations within the parameters defined by the Canadian Environmental Protection Act (CEPA) (Government of Canada, 2012), as well as regulations for engines used in off-road machinery (Minister of Justice of Canada, 2012).

Among the general requirements to fulfil the obligations are providing invoices or proof of payment for the engine sold to the customer who purchases the engine for resale purposes, such as receipts and invoices from the customer whose business activity is leasing or selling engines to third parties.

Any engine marketed in Canada must have a National Emissions Mark (NEM) or EPA certificate.

The requirements for selling off-road engines are described below:

- **Engines covered by an EPA certificate and sold concurrently in Canada and in the United States**

  Section 16 of SOR/2005-32 (Minister of Justice of Canada, 2012) identifies the evidence of conformity for an engine that is covered by a valid EPA certificate sold concurrently in Canada and the United States.

- **Engines sold in the United States**

  An engine in addition to having a National Emissions Mark (NEM) and complying with section 153(2) must:

  1. If the engine sold in the United States belongs to the same family, you must provide the retail customer or lessee with the following:
     a. Copy of dated invoice to the first retail U.S. purchaser/leaser.
     b. Copy of dated invoice to a U.S. party who sells or leases at the U.S. retail level.
     c. Copy of dated purchase order between a U.S. party and the first U.S. retail purchaser/leaser.
  2. A dated advertisement of engine or engine family targeted at U.S. consumers (this could be sales brochure, printed ad, magazine, price list, etc.) demonstrating that the product was actively marketed and available for delivery in the U.S.
  3. A dated U.S. manufacturer/importer/dealer list for the machine model demonstrating that the product was actively marketed and available for delivery in the U.S. (Minister of Justice of Canada, 2009).

  If the above evidence of conformity pertains to a machine within which an engine is installed, then the evidence must include supporting documentation matching the engine to the machine (Minister of Justice of Canada, 2009):

  Before the import of an engine, before applying the NEM mark or, in the case of 153 (2), before the engine leaves the possession or control of the company, a company must ensure that it has the complete evidence of conformity available (including EPA Certification) and at least one of the above-listed concurrent sale documents that is appropriately dated. The evidence of conformity must be available prior to any of the above action taking place.

  If the above is not done, the company shall provide evidence of conformity compliance in accordance with section G.4.2 of the Off-Road Compression-Ignition Engine Emission Regulation.

- **Type 1 – Specifically listed on an EPA certificate and sold in Canada but not in the United States**

Evidence of conformity must be submitted to Environment and Climate Change Canada, according to paragraph 17 (1) (b) of regulation SOR/2005-32[69] because the engine is not sold concurrently in both countries.

- **Type 3 – Neither specifically listed on an EPA certificate nor sold concurrently in Canada and the United States**

  Evidence of conformity must be submitted to Environment and Climate Change Canada in accordance with paragraph 17 (1) (b) of regulation SOR/2005-32, if there is no valid EPA certificate covering the engine.

- **Sale of transition engines**

  A transition engine sold in Canada in accordance with the Government of Canada must comply with the following conditions (Government of Canada, 2012):

  1. A machine of the same model is sold to the first retail buyer or leaser in the United States. This must be substantiated by any of the following:
     a. Copy of dated invoice to the first U.S. retail purchaser or leaser.
     b. Copy of dated invoice to a U.S. party who sells or leases at the U.S. retail level.
     c. Copy of dated purchase order between a U.S. party and the first U.S. retailer purchaser/leaser in the same country.
  2. A dated advertisement of the machine model targeted at US consumers (this could include sales brochure, printed ad, magazine, price list, etc.) demonstrating that the product was actively marketed and available for delivery in the United States.
  3. A dated U.S. manufacturers/importers/dealer list for the machine model demonstrating that the product was actively marketed and available for delivery in the United States.

  All engines marketed within the provinces must have a national emissions mark unless the engines already have an EPA certificate.

Before the import of a transition engine and before applying the NEM, the company or individual must ensure that it has the complete evidence of conformity that the engine was manufactured as per the guidelines set forth in 40 CFR §1039.625.

Control and inspection

Minister of National Revenue: responsible for the administration of tax law and revenue collection; it is the agency in charge of issuing authorisations and labelling numbers (Minister of Justice of Canada, 2009, 2012, 2021).

Canada Centre for Mineral and Energy Technology (CANMET): certification body for underground mining equipment (Minister of Justice of Canada, 2012).

[69] 17 (1) (b) in respect of an engine other than an engine referred to in paragraph (a), a company shall obtain and submit evidence of conformity in a form and manner satisfactory to the Minister and shall include a copy of the mark referred to in subsection 10.1, 11.1, 12 or 13, as the case may be.

Environment Canada will oversee the regulations for transition engines through annual reports and compare the use of the provisions with those in the United States. If there is over-regulation in Canada, the agency will have the power to amend the regulations. Environment Canada will also oversee the following through its programmes:

- Use of the national emissions mark
- Evidence of conformity
- Recording of defects in emission control systems
- Test engines and emission control components
- Laboratory emission tests

Vehicle and Engine Testing and Emissions Verification Section: part of Environment Canada whose function is to receive complaints regarding evidence of conformity.

Regulatory Administration Section, Transportation Division: part of Environment Canada whose function is to deal with administrative requirements related to NRMM.

12.2. United States

The table below presents the main stakeholders involved in the NRMM processes in the United States.

Table 12. 2. Stakeholders and roles - United States.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Environmental Protection Agency EPA	Issuance of the EPA 3520-21 format, which is the main document in the process of importing non-road engines. It is the agency that validates that the engines being imported comply with the established requirements.	(U.S. Environmental Protection Agency, 2011)
	U.S. Customs and Border Protection (CBP)	Responsible for validating the importer's documentation in the first instance. The EPA 3520-21 form must be submitted to this agency.	(U.S. Environmental Protection Agency, 2011)
	Independent Commercial Importer (ICI)	It is the agency that carries out the import process of the engines. It holds a Certificate of Conformity and is based in the United States.	(U.S. Environmental Protection Agency, 2011)
Type-approval	Environmental Protection Agency EPA, Office of Transportation and Air Quality.	It is responsible for verifying the emission test performance, the equipment calibration, the results, and for issuing the Certificate of Conformity of the engines.	(U.S. Environmental Protection Agency, 2011)
Registration	EV-CIS. Engines and Vehicles Compliance Information System	System where information related to the certification and compliance of vehicle and engine emissions and fuel consumption is stored. All engines in use must be registered in this system.	(Overview of Certification and Compliance for Vehicles and Engines | US EPA n.a.)
	DOORS System	California State Vehicle and Motor Vehicle Registration.	(U.S. Environmental Protection Agency, 2021a)

Stage	Stakeholders/Entities involved	Main roles	Sources
Control at operation stage	Environmental Protection Agency EPA, Office of Transportation and Air Quality.	The Agency may carry out an emissions test on engines in operation, subject to prior notice to the engine owner.	40 CFR §1039.401
Regulation of emission limits	Environmental Protection Agency EPA, Office of Transportation and Air Quality.	It sets pollutant emission limits for different types of engines.	(U.S. Environmental Protection Agency, 2011)

Source: own elaboration.

Additional information on the stakeholders involved in each process is presented in the following part.

Import

Customs and Border Protection[70] .

Independent Commercial Importer (ICI): an entity, other than an OEM, located in the United States, on whose name a Certificate of Conformity for a class of non-road engines has been issued, allowing it to import and modify certain nonconforming road engines to meet EPA requirements (U.S. Environmental Protection Agency, 2011). The ICI is not associated with the EPA or the original vehicle manufacturer.

Final purchaser: a person who in good faith buys a non-road engine for an ultimate purpose other than resale.

EPA Administrator: representative of the United States Environmental Protection Agency (US-EPA).

Manufacturing

Original Engine Manufacturer (OEM): the entity which originally manufactured the non-road engine (40 CFR § 89.602).

Secondary Engine Manufacturer: the entity that produces a new engine by modifying a complete or partially complete engine that was made by a different company (40 CFR §1068.30).

Registration

EPA-OTAQ: US-EPA Office of Transportation and Air Quality.

DOORS system: In the state of California, owners must report the fleet acquired within 30 days after purchasing it through the DOORS system. Also, not only new vehicles must be registered through this platform, but also those that have been sold and decommissioned. The owner companies must submit an annual report every March.

[70] *U.S. Customs and Border Protection.*

South America

12.3. Brazil

The following table presents the main stakeholders identified in Brazil's NRMM processes. Following the table, some complementary aspects are presented.

Table 12. 3. Stakeholders and roles - Brazil.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	National Environmental Council - CONAMA	Regulates the requirements to be met by machinery vehicles imported and manufactured in Brazil in accordance with Resolution No. 433 of 2011.	(National Environment Council, 2011)
Import	Importer of vehicles for own use	According to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), importers are natural persons who import engines, light-duty vehicles, heavy-duty vehicles and construction and agricultural machinery subject to pollutant emission controls.	(IBAMA, 2021b)
Import	Importer of vehicles for sale	According to IBAMA, they are individuals who import engines, light-duty vehicles, heavy-duty vehicles and construction and agricultural machinery subject to pollutant emission controls.	(IBAMA, 2021b)
Import	Retailer	Importer of motor vehicles for commercial purposes, under the INFOSERV category of Transportation, Terminals, Depots, Warehouses and Commerce (code 18-78), which must be registered in the Federal Technical Registry (CTF) to hold an LCVM license.	(IBAMA, 2021b)
Type-approval	Associated Technical Agents (ACT) of PRONCOVE	Entity responsible for carrying out the necessary tests and checks to verify that the vehicle or machine complies with the emission limits laid down in the legislation.	(IBAMA, 2021b)
Type-approval	National Environmental Council - CONAMA	Together with IBAMA, they are the competent bodies to establish procedures for testing, measuring, certifying, licensing and evaluating vehicle emission levels, as well as all complementary measures related to the control of pollutants from motor vehicles. Both institutions shall follow the National Motor Vehicle Pollution Control Programme (PROCONVE), respecting the metrological system in force in the country.	(IBAMA, 2021b)
Registration	IBAMA	Entity that grants the licence for vehicles, engines or machines referred to as LCVM to allow the sale of engines, light-duty vehicles, heavy-duty vehicles and machines in Brazil.	(IBAMA, 2021a)
Registration	Machine manufacturer	The manufacturer shall register with the CTF/APP under activity 4-1: Mechanical engineering - Manufacture of machines, appliances, parts, tools and accessories with and without heat or surface treatment, and shall have a duly issued and up to date certificate of regularity.	(IBAMA, 2021b)
Control at operation stage	Deputy Head of Legal Affairs	By Decree No. 6,514 of July 22, 2008, the Deputy Office of Legal Affairs provides for environmental administrative offenses and penalties and establishes the federal administrative authority process for the investigation of these offenses, which are applicable to NRMM.	(National Environment Council, 1993)
Regulation of emission limits	National Environmental Council - CONAMA	Together with IBAMA, they are the competent bodies to establish procedures for testing, measuring, certifying, licensing and evaluating vehicle emission levels, as well as	(IBAMA, 2021b)

		all complementary measures related to the control of pollutants from motor vehicles. Both institutions shall follow the National Motor Vehicle Pollution Control Programme (PROCONVE), respecting the metrological system in force in the country.	
Regulation of emission limits	IBAMA and DENETRAN	Entity that grants the license for vehicles, engines or machines known as LCVM, which is the document that certifies compliance with the vehicle emissions legislation (pollutants and noise) and authorizes the sale of engines, light-duty vehicles, heavy-duty vehicles and machines in Brazil. The procedures for obtaining the license were established by IBAMA Ordinances No. 86/1996 and IBAMA No. 167/1997 and updated by subsequent regulations. The license is a requirement for the registration of these same vehicles with the National Traffic Department (DENATRAN).	(IBAMA, 2021b)

Source: own elaboration.

Import

National Environmental Council: regulates the requirements to be met by machinery vehicles imported and manufactured in Brazil in accordance with Resolution No. 433 of 2011 (National Environmental Council, 2011).

Importer of vehicles for own use: according to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), importers are natural persons who import engines, light-duty vehicles, heavy-duty vehicles and construction and agricultural machinery subject to pollutant emission controls. After issuing the first authorisation, the company must register with the CTF/APP under activity 21-43: Activities subject to environmental control and inspection not listed in Annex VIII of Law No. 6.938 / 1981: Importation of motor vehicles for own use and Law No. 8723/1993. From the second authorization, upon request, the company must already be registered in the CTF / APP with the Certificate of Validity Standing in good standing (IBAMA, 2021b).

Importer of vehicles for sale: according to IBAMA, they are individuals who import engines, light-duty vehicles, heavy-duty vehicles and construction and agricultural machinery subject to pollutant emission controls. After issuing the first authorisation, the company must register with the CTF / APP in activity 21-44: Activities subject to environmental control and inspection not listed in Annex VIII of Law No. 6.938 / 1981: Importation of motor vehicles for sale and Law No. 8723/1993. From the second authorisation, upon request, the company must already be registered in the CTF / APP with the Certificate of Validity in good standing. (IBAMA, 2021b).

Manufacturing

Machine manufacturer: according to IBAMA, individuals who produce engines, light-duty vehicles, heavy-duty vehicles and construction and agricultural machinery subject to pollutant emission controls. The manufacturer must register in the CTF/APP in activity 4-1: Mechanical industry - Manufacture of machines, equipment, parts, tools and accessories with and without heat or surface treatment, in addition to having the regularity certificate duly issued and up to date (IBAMA, 2021b).

Associated Technical Agents of PROCONVE (ACT): the associated technical agents (ATC) are those who carry out the tests and verifications necessary to validate that the vehicle or machine complies with the limits set out in the legislation. The ATCs charge for the service provided directly by the user and correspond to the following entities:

the vehicle type-approval sector of the Environmental Company of the State of Sao Paulo (CESETB) and the Technological Institute of Mauá (IMT) (IBAMA, 2021b).

Registration

IBAMA and DENATRAN: The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) is the entity that grants the license for vehicles, engines or machines known as LCVM, which is the document that certifies compliance with the vehicle emissions legislation (pollutants and noise) and authorizes the sale of engines, light-duty vehicles, heavy-duty vehicles and machines in Brazil. The procedures for obtaining the license were established by IBAMA Ordinances No. 86/1996 and IBAMA No. 167/1997 and updated by subsequent regulations. The license is a requirement for the registration of these same vehicles with the National Traffic Department (DENATRAN) (IBAMA, 2021b).

National Environmental Council - CONAMA: Together with IBAMA, they are the competent bodies to establish procedures for testing, measuring, certifying, licensing and evaluating vehicle emission levels, as well as all complementary measures related to the control of pollutants from motor vehicles. Both institutions shall follow the National Motor Vehicle Pollution Control Programme (PROCONVE), respecting the metrological system in force in the country.

Sale

IBAMA: Entity that grants the license for vehicles, engines or machines referred to as LCVM to allow the sale of engines, light-duty vehicles, heavy-duty vehicles and machines in Brazil (IBAMA, 2021b).

Retailer: Importer of motor vehicles for commercial purposes, under the INFOSERV category of Transportation, Terminals, Depots, Warehouses and Commerce (code 18-78), which must be registered in the Federal Technical Registry (CTF) to hold an LCVM license (IBAMA, 2021a).

Control and inspection

Deputy Head of Legal Affairs: by Decree No. 6,514 of July 22, 2008, the Deputy Office of Legal Affairs provides for environmental administrative offenses and penalties and establishes the federal administrative authority process for the investigation of these offenses, which are applicable to NRMM. According to Article 4 of Law No. 8,723 of October 28, 1993, imported vehicles must comply with the same emission limits and other requirements established for all their sales in the domestic market (National Environmental Council, 1993).

Associated Technical Agents of PROCONVE: entity responsible for carrying out the necessary tests and checks to verify that the vehicle or machine complies with the emission limits laid down in the legislation. The ATCs charge for the service provided directly by the user and correspond to the entities of the vehicle type-approval sector of the Environmental Company of the State of Sao Paulo (CESETB) and the Technological Institute of Mauá (IMT) (IBAMA, 2021b).

12.4. Chile

The following table presents the main stakeholders involved in the different NRMM processes. Subsequently, some complementary aspects of these processes are shown.

Table 12. 4. Stakeholders and roles - Chile.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Superintendence of the Environment	Entity that verifies the emissions compliance of the mobile machinery´s engine type or family, prior to importation, on the basis of the certificates provided by the importers.	(Chilean Ministry of Environment, 2020).
Import	National Customs Service	Entity that reports monthly to the SMA on the importation of mobile machinery in the month preceding the reporting month.	(Chilean Ministry of Environment, 2020).
Type-approval	Not stated in the standard		
Registration	National Customs Service	Entity that reports monthly to the SMA on the importation of mobile machinery in the month preceding the reporting month.	(Chilean Ministry of Environment, 2020).
Control at operation stage	Superintendence of the Environment	Entity in charge of establishing procedures and protocols to determine compliance with the emission standard.	(Chilean Ministry of Environment, 2020).
Regulation of emission limits	Chilean Ministry of Environment	Entity that establishes emission limits for mobile machinery, through supreme decree 39/2020.	(Chilean Ministry of Environment, 2020).

Import

All mobile machinery entering Chilean territory 24 months after the entry into force of the regulation must comply with the emission standards reported in Decree 39/2020 of the MMA, with the exception of tractors which have a period of 36 months. Likewise, importers or dealers, manufacturers or their legal representatives in Chile must submit a certificate of compliance to the SMA, of the emission standards of the mobile machinery's engine type or family, prior to importation.

Manufacturing and distribution

According to Article 19 of Decree 31 Establishing the Plan of Prevention and Atmospheric Decontamination for the Metropolitan Region of Santiago, the relevant stakeholders involved in the manufacturing, distribution and import processes of non-road machinery shall comply with the following:

Manufacturers of new non-road mobile machinery or their legal representatives in Chile, distributors or importers, shall certify by means of a certificate of origin to the Superintendence of the Environment, that the engine type or engine family of the new machinery complies with the requirements of Table III-8, Table III-9 or Table III-10 as appropriate, in accordance with the ISO 8178 laboratory test method (Internal combustion engines and exhaust emission measurement. Part 1: Test-bed measurement systems of gaseous and particulate emissions). The Superintendence of the Environment shall establish the certification protocol.

Registration

The registration of vehicles in Chile according to Law N°18.290, Traffic Law, Title II (Ministry of Justice of Chile, 2009) is done through the office of the Civil Registry Service, which is the entity in charge of managing the databases of registered motor vehicles and their owners. The registration of a vehicle is done when it receives the number plate, which is the distinctive sign that allows the vehicle to be identified. Article 33 of Law No. 18.290 states the following:

"The establishment of ownership, transfer, conveyance and encumbrances on motor vehicles shall be subject to the rules established by ordinary law for movable property".

Article 34 of the same body of law states:

The Civil Registry and Identification Service will keep a Motor Vehicle Registry in the central database of its mechanized system, in which the vehicles and their owners will be registered and the unique patents granted by the Civil Registry and Identification Service will be recorded (Subsection 1).

The registration of a vehicle shall be made when the single license plate is granted. The documents authorizing such registration shall be incorporated in the National Archive of the Civil Registry and Identification Service (Section 3). Any alterations to the vehicles that cause them to change their nature, their essential characteristics, or their identification, as well as their abandonment, destruction or total or partial scrapping, or the cancellation of the registration at the owner's request, shall also be recorded therein. Where appropriate, the registration shall be cancelled and the vehicle's licence plates withdrawn.

Likewise, the report of the theft of a motor vehicle at the request of a police or judicial authority, or of its owner in certain cases, must be recorded in accordance with the form and conditions set forth in the regulations (Number 4°).

On the other hand, Decree 111, which approves the Regulation on Motor Vehicle Registration, in Title 1, "General Provisions", Articles 1 and 2, mentions that (Ministry of Justice of Chile, 2021):

The Civil Registry and Identification Service shall keep a Register of Motor Vehicles in the central base of its mechanised system, in which all vehicles referred to in Law No. 18.290, circulating on roads, streets and other public, rural or urban roads, country roads or private roads intended for public use, throughout the territory of the Republic, shall be registered, with the identification of their owners and the single licence plate granted to them.

Article 2. In addition, changes of ownership of registered vehicles shall be entered in the Register of Motor Vehicles. It may also be required that encumbrances, prohibitions, liens and precautionary measures affecting them be recorded in said Register, which is not a requirement for their incorporation.

The mobile machinery emission standard indicates that the National Customs Service will have to report monthly to the SMA on the machinery imported in the month prior to the one being reported, once the standard comes into force. In addition, after 6 months from the entry into force of the rule, they will have to issue an official notice giving instructions regarding the importation of mobile machinery.

Control and inspection

The mobile machinery emission standard states that the Superintendency of the Environment will be the entity in charge of establishing protocols and procedures to ensure compliance with the standard.

12.5. Colombia

The table below presents the main stakeholders involved in NRMM processes in Colombia. Subsequently, some complementary aspects of the processes are presented.

Table 12. 5. Stakeholders and roles - Colombia.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Directorate of Taxes and Customs of Colombia (DIAN) Ministry of Industry and Trade	The Ministry of Industry and Commerce and DIAN are the entities responsible for establishing and verifying the import requirements and nationalisation processes for non-road mobile machinery. Depending on the end-use sector, other entities such as the Ministry of Transport, Ministry of Mines and Energy, Superintendence of Industry and Commerce, among others, may have additional import and nationalisation requirements.	(Ministry of Trade, 2021)
Import	National Authority for Environmental Licensing (ANLA)	The ANLA approves the Certificate of Emissions on Dynamic Test (CEPD) and subsequently, the importer with the CEPD files an import registration.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Import	Manufacturers, assemblers, importers or distributors	They are responsible for complying with all import requirements in accordance with the guidelines set by entities such as the Ministry of Industry and Commerce, Customs and DIAN. According to Article 18 of the Draft Resolution of the Ministry of Environment and Sustainable Development, distributors shall demonstrate compliance with the emission limits of the machinery they sell.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Type-approval	Testing laboratories	According to the Draft Resolution of the Ministry of Environment and Sustainable Development, the Certificate of Emissions on Dynamic Test (CEPD) must be obtained through a testing laboratory accredited by the National Accreditation Body of Colombia (ONAC) under the ISO/IEC 17025 standard or by a testing laboratory accredited by an accreditation body within the multilateral recognition agreements to which ONAC is a signatory.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Type-approval	National Accreditation Body (ONAC) and other accredited bodies or competent environmental authority	ONAC is the body in charge of the accreditation of testing laboratories, and for this it must follow the requirements set forth in Article 6 of the Draft Resolution.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Registration	Ministry of Transport	The machinery must be registered in the *Registro Único Nacional de Transporte* (National Traffic Registry) of the Ministry of Transport according to resolution 1068 of 2015 of the Ministry of Transport.	(Ministry of Transport, 2015b)
Operation	Ministry of Mines and Energy	According to Article 3 of Law 1972 of 18 July 2019, the Ministry of Mines and Energy will develop the relevant actions to guarantee the production, importation, storage, addition and quality in the distribution of fuels necessary to meet the defined emission standards.	(Act No. 1972 of July 18, 2019, 2019)
Control at operation stage	Local environmental authorities and local traffic authorities	Environmental authorities are responsible for verifying visible emissions from off-road land mobile sources, as stipulated in Article 26 of the Draft Resolution.	(Colombian Ministry of Environment and Sustainable Development, 2020).

Stage	Stakeholders/Entities involved	Main roles	Sources
		The competent environmental authority is also in charge of verifying the emission control labels of non-road land mobile sources, as set forth in Article 27 of the Draft Resolution.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Control at operation stage	Ministry of Transport	Article 1 of Law 769 of 2002 states that the Ministry of Transport is responsible for defining, guiding, monitoring and inspecting the implementation of national traffic policy.	(Ministry of Transport, 2015a)
Regulation of emission limits	Ministry of Environment and Sustainable Development (MADS)	It is the entity in charge of setting regulations on emission limits for criteria pollutants.	(Colombian Ministry of Environment and Sustainable Development, 2020).
Regulation of emission limits	World Trade Organisation	According to the third page of the Draft Resolution, the MADS notifies the World Trade Organisation of the new environmental standards regulations, in order to carry out the international consultation process in compliance with the Agreement on Technical Barriers to Trade of the World Trade Organisation (WTO) and other trade agreements in force, so that third countries can submit their observations and respond to them before issuing the final draft.	(Colombian Ministry of Environment and Sustainable Development, 2020).

Source: own elaboration.

Import

According to Resolution 762 of 2022, which regulates the maximum permissible emission limits of pollutants to be met by land mobile sources, Article 2.2.5.5.1.8.2 of Decree 1076 of 2015 is regulated and other provisions are adopted (Colombian Ministry of Environment and Sustainable Development, 2020). According to the definitions in its Annex 1, an importer is defined as:

Unrelated importer: A natural or legal person importing land mobile sources that does not have the brand representation of the manufacturer.

Manufacturing and distribution

In line with the other definitions included in the Draft Resolution, manufacturer certification is defined as follows:

Manufacturer's certification: Document issued by the manufacturer of a motor vehicle certifying the technical specifications of a mobile source.

Registration

The Draft Resolution cites Law 769 of 2002, as a regulation that defines the procedures for the registration of NRMM in the National Traffic Registry (RUNT). By means of this law, all vehicles circulating in Colombian territory must be registered in the RUNT, including construction and agricultural machinery (Colombian Ministry of Transport, 2002)

According to Law 769 of 2002, in Chapter VII, National Traffic Registry, Article 46 on registration states:

Registration: Every motor vehicle, registered and authorised to circulate in the national territory, including machinery capable of moving, must be registered by the competent authority in the National Traffic Registry (RUNT) kept by the Ministry of Transport. Trailers and semi-trailers must also be registered. All registered and authorised motor vehicles must present the current technical-mechanical inspection certificate, which complies with the terms provided for in this Code.

On the other hand, according to Article 49 of the same Law, "*if modifications are made to the characteristics that identify a motor vehicle, the modifications shall be subject to authorisation by the traffic authority and shall be registered in the National Registry of Motor Vehicles*":

Prior authorisation for change of characteristics: Any modification or change in the characteristics that identify a motor vehicle shall be subject to prior authorisation by the competent traffic authority and must be registered in the National Traffic Registry (RUNT). In no case may the identification numbers of the engine, chassis or serial number of a vehicle be changed, modified or tampered with, nor may the license plates of the vehicle be defaced or altered, under penalty of being subject to the sanction provided in this Code for those who drive without license plates.

Resolution 1068 of 2015, which regulates the National Register of Self-propelled Agricultural, Industrial and Construction Machinery and establishes other provisions, assigns the Ministry of Transport, or whoever it delegates, the responsibility of registering and issuing the respective registration card of the NRMM, according to the provisions of Decree 019 of 2012.

12.6. Peru

The following table shows the role of the Ministry of Transport and Communications according to the existing regulation in Peru. Subsequently, some complementary aspects are presented.

Table 12. 6. Stakeholders and roles - Peru.

Stage	Stakeholders/ Entities involved	Main roles	Sources
Control at operation stage	Ministry of Transport and Communications (MTC)	According to Article 155 of the National Traffic Regulations, as amended by Supreme Decree No. 019-2018-MTC, it is prohibited for machines (yellow or green), as defined in Annex II of the National Vehicle Regulations, to circulate on their own means on public land transport roads. They must be transported on a vehicle designed and built for the transport of goods. Such machines may only travel on the roads on which they are operating. Circulating, driving or operating yellow or green machines on public roads is a very serious offence according to code M.33 of the National Traffic Regulations.	(Decreto Supremo No. 019-2018-MTC: Decreto Que Modifica El Reglamento Nacional de Vehículos, El Texto Único Ordenado Del Reglamento Nacional de Tránsito - Código de Tránsito y Dicta Otras Disposiciones, 2018).

Source: own elaboration.

Import, manufacturing and registration

Although there are currently no regulations governing or controlling the importation of NRMM into Peru, the following can be identified as the main stakeholders (currently) involved in the import process

National Superintendence of Customs and Tax Administration (SUNAT) and National Superintendence of Public Registries (SUNARP): According to the definition in the General Law on Imports, the customs administration is the body of the National Superintendence of Customs and Tax Administration competent to apply customs legislation, collect customs duties and other taxes applicable to imports for consumption, as well as the corresponding surcharges, apply other laws and regulations related to customs regimes, and exercise customs authority.

Control and inspection

There are no specific requirements for machinery.

End of life

There are no specific requirements for machinery.

Asia-Pacific

12.7. China

The table below presents the main stakeholders involved in NRMM processes in China. Complementary aspects of these processes are presented below.

Table 12. 7. Stakeholders and roles - China.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Department of Ecology and Environment	Entity in charge of receiving the necessary documentation for the import of non-road mobile machinery in accordance with regulation HJ 1014-2020.	(Ministry of Ecology and Environment of the People's Republic of China, 2020)
Type-approval	Ministry of Ecology and Environment of the People's Republic of China	Entity empowered to establish type-approval test guidelines (steady-state and transient-test cycles and single-point steady state test) in accordance with HJ 1014-2020.	(Ministry of Ecology and Environment of the People's Republic of China, 2020)
Registration	Ministry of Ecology and Environment of the People's Republic of China	Entity in charge of keeping the inventory of non-road mobile machinery at national level by tracking it through GPS systems.	(Shao, 2021)
Control at operation stage	Ministry of Labour	Entity that establishes requirements regarding the operation of forklift, ram and other machinery intended for loading goods.	(Safety Standard of Machinery and Equipment, 2014).,
Regulation of emission limits	Ministry of Ecology and Environment of the People's Republic of China	Entity in charge of setting emission limits for pollutants emitted by NRMM through regulations GB 36886-2018, GB 20891-2014, GB 26133-2010, GB 20891-2007, GB 19756-2005.	(Ministry of Ecology and Environment of the People's Republic of China, 2020)

Source: own elaboration.

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Import

Machinery manufactured or imported shall report the information set out in GB 20891-2014 (Ministry of Ecology and Environment of the People's Republic of China, 2014), specifically Annex A of the standard. Manufacturers and importers of machinery with a net rated power of 560 kW or below shall comply with the requirements of regulation HJ 1014-2020.

Type-approval

The Ministry of Ecology and Environment of the People's Republic of China, in regulation HJ 1014-2020 and GB20891-2014) defines the testing and type-approval cycles.

Registration

The Ministry of Ecology and Environment is the entity where emission standards inspection processes are registered.

Control and inspection

On a general level, the Ministry of Ecology and Environment of the People's Republic of China is the entity in charge of formulating and implementing national ecological and environmental policies, as well as responsible for drafting laws and regulations. Together with other departments, it supervises the implementation of ecological and environmental plans, organises and formulates ecological standards, as well as elaborates environmental technical specifications. According to the Environmental Protection Law of the People's Republic of China, governments at or above the provincial level shall perform management and supervision tasks related to environmental protection management (Standing Committee of the National People's Congress, 2016).

12.8. India

The following table presents the main stakeholders involved in NRMM processes in India. Complementary aspects of these processes are presented below.

Table 12. 8. Stakeholders and roles - India.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Importer	Any natural or legal person established in the country placing on the market a vehicle, system, component, separate technical unit, part or equipment from a third country.	(ARAI, 2016)
Import	Directorate General of Foreign Trade (DGFT)	The DGFT, through the Indian Trade Classification System (ITC), also known as the Indian Trade Code, defines in Chapter 27 of the ITC HS Code 2017 the import policy for vehicles other than railways and tramway rolling-stock, which includes tractors whether or not capable of transport use.	(ITC (HS), 2017 : Schedule 1- Import Policy, Chapter 87, Vehicles Other Than Railway Or Tramway Rolling-Stock, And Parts And Accessories Thereof. Notification, 2017)
Type-approval	- Vehicle Research and Development Establishment - Ministry of Defence - Automotive Research Association - Central Farm Machinery Training & Testing Institute	After an import and on arrival at a port in India, but before clearance for operation, the motor vehicle, including machinery, must be sent to one of the agencies designated by the Central Government to issue a certificate of compliance with the provisions of the Motor Vehicles Act, 1988 and any regulations made thereafter.	
Type-approval	Testing agency	Organisation specified under Rule 126 of the CMVR Rules for compliance certification or any other testing agency approved by the CMVR Technical Committee for the purpose of testing parts, components, systems or vehicles. The testing agencies specified under Rule 126-A of the CMVR Rules 1989 will be responsible for carrying out the conformity of production (COP) tests in conjunction with the vehicle type-approval tests. Initially, the vehicle/engine manufacturer has the option to choose the Type-approval Testing Agency for his specific model from those listed in Rule 126-A of CMVR 1989.	(ARAI, 2012016, 2012019a)
Registration	Registration Authority and State Government	As per rule 47 of Chapter III of the Central Motor Vehicles Rules, 1989, an application for registration of a motor vehicle shall be made in Form #20 to the registering authority within a period of 70 days from the date of taking delivery of such vehicle, excluding the period of journey and shall be accompanied by the documents specified in this rule. As per rule 48, after verification and acceptance of the above documents, the registering authority shall issue a certificate of registration in Form #23 or #23-A as may be specified in a Notification issued by the concerned State Government or the Union Territory Administration	(Ministry of Road Transport & Highways, 1989).

Stage	Stakeholders/Entities involved	Main roles	Sources
		within the period of 30 days from the receipt of such an application. Each registering authority shall, after registration of a vehicle, including agricultural traction vehicles, power tillers and construction equipment, upload the registration details of the vehicle on the portal https://www.vahan.nic.in/makermodel/.	
Control at operation stage	Automotive Industry Standards Committee (AISC)	The Automotive Industry Standards Committee (AISC), following its establishment by the Ministry of Road Transport and Highways, is the agency in charge of verifying safety in the design, construction, operation and maintenance of motor vehicles, as well as issuing the publication of standards and implementing testing facilities for these, including the procedures for vehicle type-approval and certification for agricultural tractors in accordance with the CMVR rules.	(ARAI, 1997, 2016)
Regulation of emission limits	Automotive Industry Standards Committee (AISC)	The Automotive Industry Standards Committee (AISC), following its establishment by the Ministry of Road Transport and Highways, is the agency in charge of verifying safety in the design, construction, operation and maintenance of motor vehicles, as well as issuing the publication of standards and implementing testing facilities for these, including the procedures for vehicle type-approval and certification for agricultural tractors in accordance with the CMVR rules.	(ARAI, 1997, 2016)

Source: own elaboration.

Import

Regulatory entity: Directorate General of Foreign Trade (DGFT), through the Indian Trade Classification System (ITC), also known as Indian Trade Code, defines in Chapter 27 of the ITC HS Code 2017 the import policy for vehicles other than railways and tramway rolling stock, which includes tractors whether or not capable of being used for transportation (ITC (HS), 2017: Schedule 1- Import Policy, Chapter 87, Vehicles Other Than Railway Or Tramway Rolling-Stock, And Parts And Accessories Thereof. Notification, 2017).

Importer: "any natural or legal person established in the country who places on the market a vehicle, system, component, separate technical unit, part or equipment from a third country" (ARAI, 2016).

Manufacturing and distribution

Manufacturer: a person or body responsible to the approval authority for all aspects of vehicle type-approval and who must ensure conformity of production. It is not essential that the person or body is directly involved in all stages of the construction of the vehicle, system, component or separate technical unit which is the subject of the type-approval process. (ARAI, 2016). According to Act 126 of the Central Motor Vehicles Rules, 1989, every manufacturer of motor vehicles other than trailers and semi-trailers is required to submit the prototype of the

vehicle he wishes to manufacture for approval by the Vehicle Research Development Establishment, Ministry of Defence, Government of India or the Automotive Research Association of India (ARAI), Pune, Central Farm Machinery Training and Testing Institute, Budni (MP), Indian Institute of Petroleum, Dehradun, and such other agencies, as may be specified by the Central Government, to be granted a certificate by the said agency against compliance with the provisions of these regulations (Ministry of Road Transport & Highways, 1989).

Testing Agency: organisation specified under Rule 126 of the CMVR Rules for compliance certification or any other testing agency approved by the CMVR Technical Committee for the purpose of testing parts, components, systems or vehicles. The testing agencies specified under Rule 126-A of the CMVR Rules 1989 will be responsible for carrying out the conformity of production (COP) tests in conjunction with the vehicle type-approval tests. Initially, the vehicle/engine manufacturer has the option to choose the Type-approval Testing Agency for his specific model from those listed in Rule 126-A of CMVR 1989. (ARAI, 2016).

Regulatory body: Ministry of Road Transport & Highways, through Chapter V of the Central Motor Vehicles Rules, 1989 sets standards for manufacture, equipment and maintenance of motor vehicles including construction machinery, such as dimension of vehicles, condition of tyres, brakes, steering gears, safety glass, reflectors, location of exhaust pipes, emission standards in operation and idling according to Bharat Stage IV standards (for agricultural and construction machinery from 2020) and their respective measurement tests, speed meters, noise reducers, number of chassis and engine, safety devices and other special provisions regarding the driver, the load being transported among others (Ministry of Road Transport & Highways, 1989). This ministry is also categorised as the nodal agency for the implementation of emission legislation in both aspects such as Conformity of Production (COP) and vehicle type-approval (ARAI, 2019a).

Registration

Registering authority: as per rule 47 of Chapter III of the Central Motor Vehicles Rules 1989, an application for registration of a motor vehicle shall be made in form #20 of these rules to the registering authority within a period of 70 days from the date of taking delivery of such vehicle, excluding the period of journey and shall be accompanied by the documents specified in this rule. As per rule 48, after verification and acceptance of the above documents, the registering authority shall issue a certificate of registration in Form #23 or #23-A, as may be specified in the Notification issued by the concerned State Government or Union Territory Administration within a period of 30 days from the receipt of such an application. Every registering authority shall, after registration of a vehicle including agricultural tractor vehicles, power tillers and construction equipment, upload the registration details of the vehicle on the portal https://www.vahan.nic.in/makermodel/ (Ministry of Road Transport & Highways, 1989).

Sale

Registering authority: as per rule 34 of Chapter III of the Central Motor Vehicles Rules 1989, an application for renewal of a trade certificate shall be made in Form #16 and shall be accompanied by the appropriate fee as specified in rule 81. Under regulation 35, on receipt of an application for the grant or renewal of a trade certificate in respect of a vehicle, the registering authority may, if satisfied that the applicant is *bona fide* dealer (or manufacturer of motor vehicles or a testing agency specified by regulation 126) and requires the certificates specified in the application, issue to the applicant one or more certificates, as the case may be, in Form #17 (within thirty days from the date of receipt of such application) and shall assign in respect of each certificate a trade registration mark (Ministry of Road Transport & Highways, 1989).

Distributor: "any natural or legal person in the supply chain, other than the manufacturer or importer, that makes a vehicle, system, component, separate technical unit, part or equipment available on the market" (ARAI, 2016).

Control and inspection

Standard setting and verification authority: the Automotive Industry Standards Committee (AISC), following its establishment by the Ministry of Road Transport and Highways, is the agency in charge of verifying safety in the design, construction, operation and maintenance of motor vehicles, as well as issuing the publication of standards and implementing testing facilities for these, including the procedures for vehicle type-approval and certification for agricultural tractors in accordance with the CMVR rules (ARAI, 2016).

End of life

Ministry of Road Transport and Highways: on March 18, 2021, Nitin Gadkari, Minister of Road Transport and Highways, announced the vehicle scrapping scheme which for now is planned to be applicable to commercial vehicles older than 15 years and passenger vehicles older than 20 years, on a mandatory basis, in case they fail to pass their corresponding emission and operational tests. Although the overall objective of the announced policy is to counteract high levels of urban air pollution and to stimulate the sale of new cars (as it continues to be affected during the post-COVID-19 revival phase), this policy will currently not apply to agricultural machinery such as tractors, power tillers and combine harvesters (IBEF, 2021).

Europe

12.9. European Union, Switzerland and the United Kingdom

For the European Union, Switzerland and the United Kingdom, the stakeholders listed in the table below apply. In some cases where only one applies, it is explicitly mentioned. Further aspects of these processes are presented below.

Table 12. 9. Stakeholders and roles - European Union, Switzerland and United Kingdom.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Importer	Any natural or legal person established in the Union who places on the market an engine from a third country, whether or not the engine is already installed in non-road mobile machinery. An importer that makes an engine available on the market under its name or trade mark, or that modifies such an engine in such a way that its compliance with the applicable requirements may be affected, shall be considered as a manufacturer for the purposes of Regulation (EU) 2016/1628 and shall, in particular, be subject to the obligations laid down in Articles 8 and 9 thereof. A list of the importer's obligations is detailed in Articles 11 and 12 of Regulation (EU) 2016/1628.	(European Parliament and Council, 2016)
Type-approval	Approval authority	Authority of a Member State established, designated or notified by it to the European Commission which has competence for all aspects of the EU type-approval of an engine type or of an engine family, the authorisation process, granting and, where appropriate, withdrawing or refusing EU type-approval and issuing EU type-approval certificates, acting as the contact point for the approval authorities of other Member States, designating the technical services and ensuring that the manufacturer meets its obligations regarding conformity of production.	(European Parliament and Council, 2016)
Type-approval	Vehicle Certification Agency (VCA)[71] (in the case of the UK)	Executive Agency of the UK Department for Transport to improve vehicle safety and environmental protection by providing certification testing to internationally recognised standards. Agency appointed by the Secretary of State to fulfil its statutory responsibility to operate national and UNECE type-approval schemes, approving most categories of new vehicles from locations in the UK and abroad. In the case of NRMMs, the VCA provides type-approval guidelines under EU Regulation 2016/1628 for manufacturers (OEMs) charged with bringing such vehicles to the UK or EU market.	
Registration	Approval authority	Approval authorities in their role as registering authority shall make public, through the Internal Market Information System (IMI) established by Regulation (EU) No 1024/2012, a register of all engine types and engine families for which EU type-approvals have been granted, extended or withdrawn, or in respect of which an application for EU type-approval has been rejected.	(European Parliament and Council, 2016)

[71] Vehicle Certification Agency.

Stage	Stakeholders/Entities involved	Main roles	Sources
Control at operation stage	Technical service	A technical service entity means an organisation or body designated by the approval authority as a testing laboratory to carry out tests, or as a conformity assessment body to carry out the initial assessment and other tests or inspections, on behalf of the approval authority, or the authority itself when carrying out those functions. In order to ensure that the procedure for monitoring conformity of production, which is one of the cornerstones of the EU type-approval system, has been correctly implemented and functions properly, manufacturers should be regularly checked by the appointed competent authority or by an appropriately qualified technical service designated for that purpose.	
Regulation of emission limits	Swiss Federal Council (in the case of Switzerland)	Issuing authority of the Air Pollution Control Ordinance (OAPC) 1985, regulating the preventive limiting of emissions from installations as defined in its article 7, requirements for thermal and motor fuels, maximum permitted ambient air pollution levels (ambient limit values) and the procedure in the event of excessive ambient air pollution levels. It also mandates the monitoring of the current European emission standards for non-road mobile machinery as set out in Regulation (EU) 2016/1628.	(Ordinance of 16 December 1985 on Air Pollution Control (OAPC), 2020)
Regulation of emission limits	European Commission	Establishes Regulation (EU) 2016/1628 setting forth requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No. 1024/2012, (EU) No 167/2013 and amending Directive 97/68/EC. It defines and details the categories and subcategories of vehicles and non-road machinery.	(European Parliament and Council, 2016)

Source: own elaboration.

The EU regulation defines the stakeholders as follows.

Import

Importer: any natural or legal person established in the Union who places on the market an engine from a third country, whether or not the engine is already installed in non-road mobile machinery. An importer that makes an engine available on the market under its name or trade mark, or that modifies such an engine in such a way that its compliance with the applicable requirements may be affected, shall be considered as a manufacturer for the purposes of Regulation (EU) 2016/1628 and shall, in particular, be subject to the obligations laid down in Articles 8 and 9 thereof. A list of the importer's obligations is detailed in Articles 11 and 12 of Regulation (EU) 2016/1628.

Manufacturing and distribution

Manufacturer: the person or body who is responsible to the approval authority for all aspects of the type-approval or authorisation process of the EU engine type and for ensuring conformity of production of the engine, and who is also responsible for market surveillance issues of the engines produced, whether or not they are directly involved

in all stages of the design and construction of the engine that is the subject of the EU type-approval process. A list of their obligations is detailed in Articles 8 and 9 of Regulation (EU) 2016/1628.

Manufacturer´s representative or 'representative': any natural or legal person established within the Union who has received a written mandate from a manufacturer to act on its behalf in relation to specified tasks with regard to the manufacturer´s obligation under the relevant Union harmonisation legislation or under the requirements on the Regulation. A list of their duties is set out in Article 10 of Regulation (EU) 2016/1628.

Economic operator: means the manufacturer, the authorised representative, the importer or the distributor. Economic operators and OEMs shall, upon request, notify the following to the approval and market surveillance authorities for a period of five years after the date of placing on the market:

a) Any economic operator who has supplied them with an engine; and

b) Any economic operator or, where identifiable, any OEM to whom they have supplied an engine.

Original equipment manufacturer or "OEM": any natural or legal person that manufactures NRMM. A list of their obligations is detailed in Articles 15 and 17 of Regulation (EU) 2016/1628.

National authority: approval authority or any other authority involved in and responsible for the engines to be installed in the NRMM or for these vehicles in which the engines are installed, market surveillance, border control or placing on the market in a Member State of the European Union.

Approval authority: the authority of a Member State established, designated or notified by it to the European Commission and having competence for:

a) All aspects of EU type-approval of an engine type or engine family;

b) The authorisation process;

c) Issuing and, if appropriate, withdrawing or refusing of EU type-approval certificates;

d) Acting as the point of contact point for the approval authorities of other Member States;

e) Designating technical services; and

f) Ensuring that the manufacturer meets his obligations regarding conformity of production.

In compliance with the obligations of the member states of the European Union, as stipulated in Article 5(1) and (2) of Regulation (EU) 2016/1628, member states shall establish or appoint approval authorities and market surveillance authorities in accordance with the provisions of that Regulation, specifying their names, postal and electronic addresses, as well as their areas of responsibility (European Parliament and Council, 2016). Updated as of 8 April 2021, the European Commission makes public on its website the list and details of the approval authorities for non-road mobile machinery in document Ref. Ares (2021)2410631 - 08/04/2021 (NRMM Emissions - Approval Authorities in the Member States, 2021), where it is noted that:

- in countries such as Greece, Italy, Slovakia and the Czech Republic correspond to their transport ministries;
- in Bulgaria, Denmark and France correspond to their ministries of environment or agriculture;
- in Hungary and Austria correspond to their ministries of innovation and technology;
- and in the case of Spain it is the Ministry of Industry, Trade and Tourism (NRMM Emissions - Approval Authorities in the Member States, 2021).

Registration and type-approval

Approval authority (registering authority): approval authorities shall make public, by means of the Internal Market Information System (IMI) established by Regulation (EU) No 1024/2012, a register of all engine types and engine families for which EU type-approvals have been granted, extended or withdrawn, or in respect of or which an application has been rejected. That register shall contain at least the following information:

a) Name and address of manufacturer and name of the company name, if different;

b) Trade name(s) or trade mark(s), as appropriate, belonging to the manufacturer;

c) Designation of the engine types covered by the EU type-approval of the engine type or, where applicable, the EU type-approval of the engine family;

d) Engine category;

e) Number of the EU type-approval, including the number of any extensions;

f) Date of granting, extension, refusal or withdrawal of the EU type-approval; and

g) The contents of the sections 'General engine information' and 'Final emission result' of the test report referred to in Article 24(12) of Regulation (EU) 2016/1628.

Sale

Distributor: any natural or legal person in the supply chain, other than the manufacturer or the importer, who makes an engine available on the market. A distributor that makes an engine available on the market under its name or trade mark, or that modifies an engine in such a way that its compliance with the applicable requirements may be affected, shall be considered to be a manufacturer for the purposes of Regulation (EU) 2016/1628 and shall, in particular, be subject to the obligations laid down in Articles 8 and 9 thereof. A list of the distributor's obligations is detailed in Articles 13 and 14 of Regulation (EU) 2016/1628.

Market surveillance authority: an authority of a Member State that is responsible for carrying out market surveillance in its territory, which refers to the activities carried out and the measures taken by national authorities to ensure that engines placed on the market comply with the relevant EU harmonisation legislation. The list of market surveillance authorities by sector and their contact information, updated as of September 2021 and published on the European Commission's website, shows in paragraph 28 that in countries such as France and Germany their environment ministries are responsible, in Greece, Italy and Slovakia their transport ministries, in Hungary their Ministry of Innovation and Technology, while in Spain their Ministry of Industry, Trade and Tourism is responsible (European Commission, 2021).

End-user: any natural or legal person, other than the manufacturer, OEM, importer or distributor, that is responsible for operating the engine installed in NRMM.

End of life

As far as the disposal of vehicles is concerned, the measures established by the European Union do not make explicit their applicability to non-road mobile machinery. The European Union issued Directive 2000/53/EC of the European

Parliament and of the Council, which aims to set forth measures to prevent and limit waste from end-of-life vehicles (ELVs) and their components by ensuring that they are reused, recycled or recovered, and to improve the effectiveness of environmental protection for all economic operators involved in the life cycle of vehicles. However, this legislation only applies to passenger cars and vans, but not to large trucks, vintage vehicles, special-purpose vehicles and motorbikes (Summary of Directive 2000/53/EC on End-of-Life Vehicles, 2000).

Other legislation such as Directive 2012/19/EU on waste electrical and electronic equipment, in its paragraph 4, point (e) also makes it explicit that the disposal measures laid down are not applicable to non-road mobile machinery (European Commission, 2012).

12.10. South Africa

The table below presents the main stakeholders involved in NRMM processes in South Africa. Further details of these processes are presented below.

Table 12. 10. Stakeholders and roles - South Africa.

Stage	Stakeholders/Entities involved	Main roles	Sources
Import	Ministry of Industry and Trade	Authority in charge of issuing the legislation corresponding to the National Regulator for Compulsory Specifications for imported goods, from which the regulation of automotive regulatory specifications is derived by the authority known as the Automotive NRCS.	(Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008)
Import	National Regulator for Compulsory Specifications	Public entity or legal person that must operate and exercise its functions in accordance with Law No. 5 of 2008. It is the entity in charge of issuing the importer a letter of authority certificate which permits commodities or products to be sold.	(Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008)
Import	Chief Executive Officer	Employee of the National Regulator for Compulsory Specifications, member of the Board, responsible for the efficient administration of the National Regulator and who must perform any function delegated by the National Regulator or the Board.	(Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008)
Import	Board of National Regulator for Compulsory Specifications	Board consisting of 7 to 9 members, representative of the demographics of the country and with sufficient knowledge, experience or qualifications relating to the 15 functions of the National Regulator and the responsibilities of the Board, as defined in the said Act, whose members include the Chief Executive Officer of the National Regulator by virtue of his office and the remaining members, who are not executive members and are delegated by the Minister of Trade and Industry.	(Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008)
Import	Importer	An importer shall mean an agent as defined in section 1(1) of Act No. 91 of 1964, known as the Customs and Excise Act (1964) who is a person who at the time of importation owns any imported goods, carries the risk for any goods imported, represents that or acts as if he is the importer or owner of any goods imported, actually brings any goods into the Republic of South Africa, is beneficially interested in any way whatever in any goods imported or acts on behalf of any person referred to in paragraph (a), (b), (c), (d) or (e) of the said Customs and Excise Act.	(The Customs and Excise Act 91 of 1964, 1964b)
Type-approval	Local Department of Transport (PDoT)	Registering authority designated by the respective laws of each province as set out in the NRTA (1996), which manufacturers and importers must contact to initiate the registration process that will allow them to access the type-approval process for their vehicles or motorised machinery.	(Information Document for the Registration of Manufacturers, Builders and Importers of Motor Vehicles and

Stage	Stakeholders/Entities involved	Main roles	Sources
			Related Processes, 2008a).
Registration	Local Department of Transport (PDoT)	Registering authority designated by the respective laws of each province as set out in the NRTA (1996), which manufacturers and importers must contact to initiate the registration process that will allow them to access the type-approval process for their vehicles or motorised machinery.	(Information Document for the Registration of Manufacturers, Builders and Importers of Motor Vehicles and Related Processes, 2008a).
Registration	Automotive NRCS	Assessment body of the PDoT registration application with regard to operational requirements, technical capability and compliance with the relevant regulations concerning the manufacturer or importer for its vehicle categories.	(Information Document for the Registration of Manufacturers, Builders and Importers of Motor Vehicles and Related Processes, 2008a).
Registration	South African Police Service (SAPS)	Entity in charge of generating an official registration report as a requirement together with the evaluation by the Automotive NRCS.	(Information Document for the Registration of Manufacturers, Builders and Importers of Motor Vehicles and Related Processes, 2008a).
Control at operation stage	Inspector	In order to comply with Act No. 5 of 2008, the Chief Executive Officer may, either generally or for a specific purpose, appoint qualified and certified employees of the National Regulator as inspectors for the purposes set out in the said National Regulator for Compulsory Specifications Act (Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008).	(Act No. 5 of 2008: National Regulator for Compulsory Specifications Act, 2008)
Regulation of emission limits	European Commission	It sets out the measures on the emission of gaseous pollutants and particulate matter from internal combustion engines to be installed in non-road mobile machinery, which South Africa is required to comply with according to SANS 20096/ECE R96, equivalent to the European regulation ECE R96 up to and including the 01 series of amendments that came into force on 16 September 2001.	(Republic of South Africa: Recently Gazetted and Imminent Vehicle Emission Legislation: GRPE June 2005, 2005).

Source: own elaboration.

The South African Agricultural Machinery Association (SAAMA) states in its information document for the registration of manufacturers, builders and importers of motor vehicles and related processes (2008) that the National Regulator for Compulsory Specifications (Automotive NRCS) is mandated to enforce compliance of the automotive products with the relevant national legislation. The mandate is derived from two acts of parliament being:

1. Act No. 5 of 2008, known as the National Regulation for Compulsory Specifications (NRCS).
2. Act No. 93 of 1996, known as the National Road Traffic Act (NRTA).

The Automotive NRCS then covers several mandatory specifications for all products in this class, as well as mandatory inspection of manufacturers, importers and builders (MIBs) of motor vehicles.

The NRCS (2008), in its first section, establishes the following definitions related to the process of importation, manufacture, registration, sale and operation.

Import

Minister: the minister responsible for trade and industry.

National Regulator: National Regulator for Compulsory Specifications of South Africa, established as a public entity or legal person that must operate and exercise its functions in accordance with Law No. 5 of 2008. It is the entity in charge of issuing the importer a letter of authority certificate which allows commodities or products to be sold.

Chief Executive Officer: employee of the National Regulator for Compulsory Specifications, member of the Board, responsible for the efficient administration of the National Regulator and who must perform any function delegated by the National Regulator or the Board.

Regulatory Board: Board of National Regulator for Compulsory Specifications, consisting of 7 to 9 members, representative of the demographics of the country and with sufficient knowledge, experience or qualifications relating to the 15 functions of the National Regulator and the responsibilities of the Board, as defined in the said Act, whose members include:

- The Chief Executive Officer of the National Regulator by virtue of his office.
- The remaining members, who are not executive members and are delegated by the Minister.

Importer: according to the NRCS, an importer shall mean an agent as defined in section 1(1) of Act No. 91 of 1964, known as the Customs and Excise Act (1964) who is a person who at the time of importation:

- Owns any imported goods.
- Carries the risk for any goods imported.
- Represents that or acts as if he is the importer or owner of any goods imported.
- Brings any goods into the Republic of South Africa.
- Is beneficially interested in any way whatever in any goods imported or acts on behalf of any person referred to in subparagraphs (a), (b), (c), (d) or (e).

Manufacturing and distribution

From the NRCS (2008), in its first section, the following stakeholders are identified:

Manufacturer: in terms of the NRTA, a person who, for the purpose of carrying on a business of selling motor vehicles, manufactures or assembles new vehicles. In general terms of the NRCS, it is a person who produces, assembles, alters, modifies, adapts, converts, processes or treats products or goods.

National Regulator: in terms of manufacturing, the National Regulator is in charge of issuing the importer a letter of authority certificate which permits commodities or products to be sold, as well as services to be provided.

Registration

According to SAAMA (2008), the following stakeholders will be involved in the registration process:

Local Department of Transport (PDoT): registering authority designated by the respective laws of each province as set out in the NRTA. (1996), which manufacturers and importers must contact to initiate the registration process that will allow them to access the type-approval process for their vehicles or motorised machinery.

Automotive NRCS: assesses the PDoT registration application with regard to operational requirements, technical capability and compliance with the relevant regulations concerning the manufacturer or importer for its vehicle categories.

South African Police Service (SAPS): entity in charge of generating an official registration report as a requirement together with the evaluation by the Automotive NRCS.

Sale

From the NRCS (2008), in its first section, the following stakeholders are defined in terms of sales activity:

Seller: A person who:

(i) Displays, offers or advertises for sale.

(ii) Exports from the Republic of South Africa for or in pursuance of a sale.

(iii) Has in its possession goods for the purpose of sale, trade, manufacture or export from the Republic.

(iv) Exchanges, donates, rents or offers goods.

National Regulator: the National Regulator shall issue a permit for sale to the seller upon compliance with section 14(4) of the aforementioned Act.

Control and inspection

Automotive NRCS: according to the SAAMA (2008), the Automotive NRCS is the entity in charge of the inspection of vehicle manufacturers and importers.

Inspector: in order to ensure compliance with Act No. 5 of 2008, the Chief Executive Officer may, in general or for a specific purpose appoint suitably qualified employees of the National Regulator as inspectors for the purposes set out in the said National Regulator for Compulsory Specifications Act (National Regulator for Compulsory Specifications Act, 2008 (Act No. 5 of 2008), 2008).

End of life

Registering authority: Corresponding to the Local Department of Transport, it will be the local entity in charge of administering the process of deregistration of a motor vehicle depending on its jurisdiction and will be responsible for generating a certificate for this process when it meets the requirements specified by the South African Government, as well as when it has not been renewed for more than 4 years. Although it is not specified that the procedure is applicable for non-road mobile machinery, the requirements are currently stipulated generally for motor vehicles (South African Government, 2021a).

13. Final messages

Lessons learned on the NRMM regulation

- Most of the countries reviewed adopt the power criterion to classify engine or machinery types. However, not all of them comprise the same categories in their regulation, which may result in some types of engines or machinery being left out of the regulation. The United States and the European Union are a good example in terms of categories included, as they cover all existing power ranges in the market, and combustion ignition types (spark and compression ignition), while countries such as Colombia and Chile, for example, do not include heavy machinery (above 560 kW) or spark ignition.
- Most of the instruments identified for the control of NRMM emissions in the case review belong to the mandatory administrative group, followed by voluntary participation instruments and lastly by economic incentives. The command-and-control instruments pose a great challenge to the inspection capacity. Based on previous international experience, the recommendation is to have different types of instruments that complement each other.
- Of the countries reviewed that have emission standards, all have emission limits for particulate matter (fine and respirable), nitrogen oxides, hydrocarbons and carbon monoxide. Countries such as China, India, Chile (to come into force in 2023) and the EU countries also have regulations on particulate matter concentration. China and India have standards for ammonia.
- By 2021, 13 countries and regions among those reviewed already had emission standards in place, the most advanced being the European Union countries with the implementation of Stage V standards, followed by Korea, Japan and India with Stage IV, and the United States with Tier 4 Final. Of the Latin American countries analysed, only Brazil has emission limits in place, while Chile and Colombia have emission standards that will come into force in 2023 and 2024, respectively.
- According to the regulations identified for the different case studies, it can be observed that the control and inspection processes are generally concentrated in the production, import and type-approval stages of NRMM. Under this approach, registration processes become fundamental for the control and inspection mechanisms of NRMM. The importance of having a registry of machinery as one of the first steps for the control of machinery and its emissions was a common recommendation among different experts from the region interviewed during the development of the study.
- In the operation stage, the most common practice identified for control and inspection is the development of random tests to verify the emission levels of NRMM.
- Two different objectives were found in the NRMM labelling practices: i) the identification of general technical aspects of NRMM; ii) the unique identification of the NRMM emissions level. Despite this difference, information on the level of emissions is always included.
- In the NRMM regulation of the United States, Canada, Brazil, the European Union and China, guidelines are issued that cover at least one of the following aspects of machinery end-of-life: NRMM useful life, repowering, overhaul and scrapping practices. In cases such as the United States, Canada, Chile and China, regulation is associated with the control of air pollutant emission levels. In Brazil and the European Union, the guidelines focus on solid waste management.
- An indirect way to monitor the useful life of machinery is the one proposed by the European Union, which requires frequent maintenance and emissions testing throughout the NRMM operation.

- In terms of NRMM operation and road circulation requirements, a wide range of aspects were identified as being covered by the regulation in the case studies. Overall, these can be classified into environmental requirements, related to emission levels of air pollutants and noise; and safety requirements, which are the most common, and include aspects such as speed of circulation, zones where NRMM is allowed to circulate, hours of circulation, ways to move machinery between sites, licensing and training requirements for operators.
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Opportunities for countries in the Latin American region and the NRMM regulation

- Although the definition of emission limits is fundamental for the control of NRMM emissions, in contexts such as those of Latin American countries, where difficulties in the control and compliance with environmental regulations are evident, other complementary instruments should be considered. The review of international cases shows examples of voluntary instruments and incentives that could be taken into consideration in Latin America.
- Effective regulation of NRMM emission limits must be accompanied by programmes on best practices in machinery operation and maintenance.
- Other instruments that can also contribute to the reduction of NRMM pollution include local decontamination plans, implementation of sustainable building standards, private sector sustainability plans and greenhouse gas emission reduction targets.
- There is synergy between NRMM pollution reduction and other environmental programmes. This can be achieved by linking NRMM regulation with national or local air quality programmes already in place (e.g., Asia Pacific and India), as well as with greenhouse gas emission mitigation programmes. It highlights the contribution that the C40 Clean Construction Declaration seeks to make, which calls for commitment at the highest political level in cities to move towards the elimination of fossil fuel use in machinery. The operation and inspection of machinery could be more efficient if linked to the construction permits issued by local or state authorities for their works.
- The specificities of each sector that uses machinery (construction, mining, industry, agriculture, forestry) should be considered to establish the regulatory approach for NRMM according to its context and impact. There are sectors where regulation must be prioritized due to the high levels of exposure for the operators or for the population around the area of influence of the NRMM emissions. For example, it is possible to make exclusions for social and/or economic reasons, as is the case with the agricultural sector in several of the cases analysed.
- A review of international case studies shows that the control of NRMM requires coordinated work between different sectors of national governments. The most common at the national level are the environmental, transport, finance and trade sectors. In turn, coordination with regional and local level institutions is required.
- The private sector has a key role to play in reducing air pollution generated by NRMM. It can be a leader in the implementation of socially and environmentally responsible practices, by anticipating and cooperating with the public sector. These practices can in turn be encouraged and recognised by the government sector as they are currently being implemented.
- Working together in the countries of the region to develop instruments for the control of NRMM emissions makes it possible to take advantage of the lessons learned in the different countries at the regional level. In addition, joining the efforts of the community of practice in the region is an effective way to overcome some of the limitations of individual countries, such as those related to the verification of engine emission limits.

Leading practices in the control of NRMM

- It highlights the US focus on emissions control with emphasis on the manufacturing stages of engines and on the certification of engines after passing tests to ensure that they will maintain desirable emission levels throughout their useful life. In this respect, manufacturers are largely responsible for emissions and not only the user of the machinery. This approach poses the challenge of monitoring the time of use for which the emissions certificate was issued. The state of California has implemented the DOORS platform for machinery owners to register the equipment purchased and scrapped each year, which also allows them to monitor the operating time of the machinery. This is a model with defined roles and responsibilities that allows the traceability of the machinery from its manufacture, the time of use and the time of its final disposal or need for repowering.
- From the private sector, the case presented by Ferreycorp Peru, shows new service schemes for NRMM that include preventive maintenance, repair and repowering, with certification through joint work between manufacturers and a team of technical experts in the region. These schemes provide advantages for users in the form of competitive costs for purchasing NRMM and maintenance services, and also offer advantages in technical and environmental terms through the development of services certified by the manufacturer in terms of machine performance.
- Regulation in the EU, Switzerland and the UK shows the advantages of establishing regulations that summarise in a concise and practical way the classification of NRMM types, reducing the risk of loopholes.
- Japan's regulation is notable for its clarity in terms of penalties for non-compliance.

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