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NAMA TRANSPORTE

MRV Blueprint for Road Freight Transport NAMA in Mexico

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On behalf of:

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for the Environment, Nature Conservation,
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of the Federal Republic of Germany

MRV-Blueprint
Road Freight Transport NAMA in Mexico

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Road Freight Transport NAMA

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Abstract

This paper describes the Road Freight Transport NAMA in Mexico and presents the MRV system for one of the three mitigation actions of the NAMA; the scrapping scheme.

The first section gives an overview of the NAMA and information on the Mexican context. The second section identifies the NAMA impacts and indicators and section three focuses on the calculation of GHG emissions and the MRV system for the scrapping scheme/ fleet modernization program. Chapter four briefly explains the most important points according to reporting and verification and the final chapter lines out some lessons learnt.

Content

List of Abbreviations

CONUEE	Comisión Nacional para el Uso Eficiente de la Energía National Commission for Efficient Energy Use
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
CMM	Centro Mario Molina
IMT	Instituto Mexicano del Transporte Mexican Institute of Transport
INECC	Instituto Nacional de Ecología y Cambio Climático National Institute for Environment and Climate Change
INEGI	Instituto Nacional de Estadística y Geografía National Institute of Statics and Geography
NAFIN	Nacional Financiera Federal Government 's Development Bank
NAMA	Nationally Appropriate Mitigation Actions
PECC	Programa Especial de Cambio Climático Special Program of Climate Change
SCT	Secretaría de Comunicaciones y Transportes Ministry of Communication and Transportation
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales Ministry of Environment and Natural Resources
SEPSA	Santaló Estudios y Proyectos, S.A. de C.V. Private Consultancy in Mexico
SHCP	Secretaría de Hacienda y Crédito Público Ministry of Finance

1. Scope and Objectives of Activity

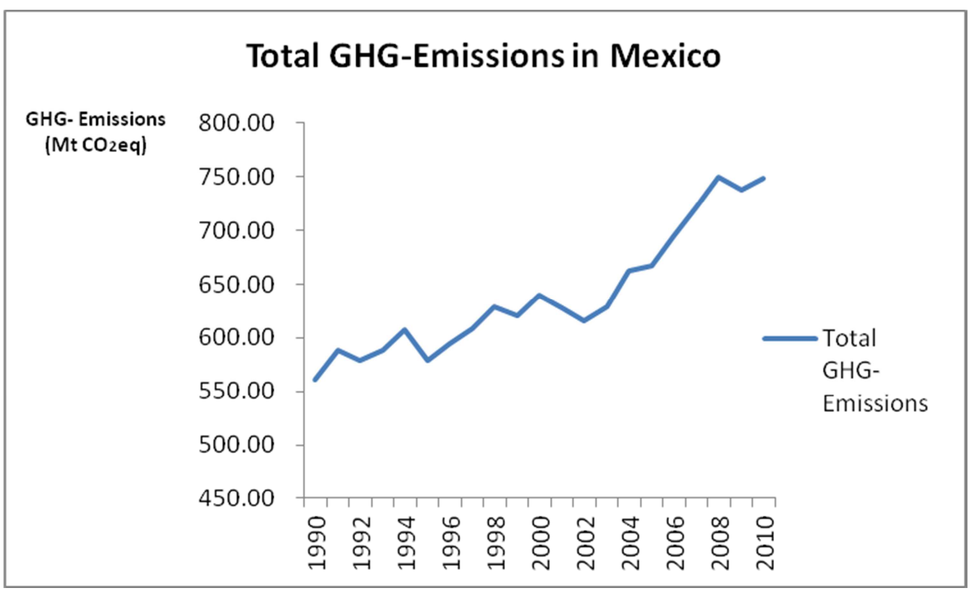
1.1 Road freight transport NAMA objective

The purpose of the Nationally Appropriate Mitigation Action (NAMA) is to reduce greenhouse gas (GHG) emissions in Mexico's road freight transport sector focusing on the "Man Truck" (owner operator, up to five vehicles) and smaller fleet carriers (up to 30 vehicles). These two groups make up about 60% of the total number of heavy duty vehicles (HDV) on Mexican roads. Many of them have old vehicles that fall below current average efficiency levels. Poor vehicle maintenance and inadequate driving reduce fuel efficiency further. Old vehicles have bad combustion processes and cause high GHG emissions and other criteria pollutants.

1.2 GHG Emissions in Mexico: an overview

Between 1990 and 2010, fossil fuel consumption grew by 53.1% while CO_2 emissions increased by 48.9%. In the same period, per capita GHG emissions grew by almost 2% in total.[1] Graph 1 shows national GHG emissions in megatons (Mt CO_2e) between 1990 and 2010 and highlights a significant increase between 2005 and 2010.

Graph 1: *Total Emissions of GHG in Mexico*



Source: INEGI with data from INECC, Inventario Nacional de Emisiones de Gases de Efecto Invernadero.

[1] Catálogo Nacional de Indicadores, INEGI. http://www3.inegi.org.mx/sistemas/cni/escenario.aspx?idOrden=1.1&ind=6200030182&gen=1370&d=n.

1.3 The transport sector in Mexico and its GHG emissions

In 2013, the transport industry represented 5.8% of total GDP, being the 6th most important economic activity in Mexico.[2] The transport sector accounts for approximately 50% of total energy consumption and 31% of total CO_2e emissions. Within this sector, the road freight transportation sector in Mexico is responsible for more than 40 million tons of CO_2e emission per year. This number represents more than 20% of total transport GHG-emissions.

According to national statistics, 381,250 heavy duty vehicles (HDV) were registered in 2013. These vehicles can be classified into different types (C2, C3, T2 and T3) as can be seen in Figure 1. The class "T2" has been introduced as a new class in 2010.

***Figure 1** Type of vehicles and fleet composition for 2013*[3]

Type of vehicle	Total (2013)	%
C2	75,293	19.74%
C3	64,582	16.93%
T2	2,276	0.59%
T3	238,390	62.52%
Others	709	0.18%
Total units of freight transport	381,250	

Source: SCT (2013): Estadística básica del Autotransporte Federal.

The companies in the road freight transport sector can be classified according to the number of vehicles per company. Table 1 shows the different types of companies and the corresponding total number of HDV. It also demonstrates that the focus group of the NAMA (Man Truck and Small Fleet Carriers) makes up about 60% of the fleet.

***Table 1** Classification by number of units and total of units for 2013*[4]

Classification	Number of units	Total of units	%
Man Truck	1 to 5 units	194,369	26.7%
Small Fleet Carriers	6 to 30 units	225,518	30.9%
Medium-Sized Business	31 to 100 units	122,750	16.8%
Large Company	More than 100 units	186,409	25.6%

Source: SCT (2013): Estadística básica del Autotransporte Federal.

[2] INEGI, Banco de Información Económica.
[3] SCT, Estadística Básica del Autotransporte Federal http://www.sct.gob.mx/transporte-y-medicina-preventiva/autotransporte-federal/estadistica-basica-del-autotransporte-federal/2013/.
[4] SCT, Estadística Básica del Autotransporte Federal http://www.sct.gob.mx/transporte-y-medicina-preventiva/autotransporte-federal/estadistica-basica-del-autotransporte-federal/2013/.

1.4 Policies

On June 6th 2012, the General Law for Climate Change was published and included rules to accomplish several objectives such as reducing GHG emissions and promoting the transition towards a competitive, sustainable and low carbon economy. The law also establishes a regulatory framework in order to develop ways to mitigate and adapt to climate change. Furthermore, it encourages the transport sector to foster different strategies and programs to reduce GHG emissions and to modernize the national fleet.[5]

The National Climate Change Strategy of 2013 integrates several rules to meet the objectives of mitigation and adaption to climate change established in the law. It has two different public policy objectives: the adaptation to climate change and the development of a low emissions economy. One of the objectives is to reduce the energy intensity with options of efficiency and responsible consumption.

In 2011, SCT and SEMARNAT requested support from the German government in the design of four NAMAs that would be developed between 2012 and 2015, in Mexico's major GHG emitting sectors. The project is part of the German Government's International Climate Change Initiative and was commissioned by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) acts as a technical advisor and promotes knowledge transfer at national, regional and international level.

Within this development cooperation framework, the road freight transport NAMA is aimed at reducing the sector's GHG emissions. SEMARNAT, SCT and GIZ make up the Steering Group and hold monthly meetings. The Steering Group receives additional support from the National Commission for Efficient Energy Use (CONUEE), the Mexican Institute of Transport (IMT), and the National Institute for Environment and Climate Change (INECC).

The NAMA is based on the following two existing government programs which are both aimed at modernizing the fleet and improving fuel efficiency:

1. "Transporte Limpio" (SEMARNAT): A voluntary market-driven partnership program which promotes eco-driving courses and fleet upgrades with various fuel saving technologies and by reducing idling time.
2. Scrapping Scheme and Financial Scheme (SCT): These schemes promote the replacement of old trucks with modern ones.

It is worth mentioning that the Special Program of Climate Change (PECC) in 2014 promoted the Transport NAMA as one of the national strategies for the reduction of short-lived pollutants.

1.5 NAMA scope

The scope of the NAMA is federal road freight transport (all trucks with a license to use highways) in Mexico. It addresses the modernization of the road freight sector, thereby reducing fuel

[5] SEMARNAT (2012), Ley General de Cambio Climático.

consumption and the sector´s GHG emissions in Mexico. The NAMA improves fuel efficiency of the truck fleet, enhancing existing programs without any elements of shift and avoid. The NAMA includes three greenhouse gases (GHG): CO_2, CH_4 and N_2O. The starting date of the NAMA was March 2012.

1.6 NAMA Actions

The NAMA includes three mitigation measures:

1. Eco-driving courses
2. Fuel-saving technologies
3. Modernization Program (including a scrapping and a financial scheme)

It is important to keep in mind that this document focuses mainly on the MRV system for the third mitigation measure: the modernization program. The impact of the other two mitigation actions on CO_2e emission is based on a different MRV approach and will only be briefly discussed.

Eco- Driving Courses: Eco-driving courses are being introduced as a mandatory part of the license process taken by road haulers every two years. Making these courses obligatory not only reduces GHG emissions significantly but also allows an important increase in entrepreneurs' income, because of fuel savings. The estimated GHG mitigation potential per participants is about 5 – 35%[6].

Fuel-saving technologies: This action refers to the massive implementation of fuel-saving technologies, such as aerodynamics (trailer tail, trailer boat tails, trailer gap and eco-skirt) and automatic inflation systems (AIS). Acquiring those technologies offer excellent cost-benefit conditions, the pay-back period usually lies within less than one year. The estimated GHG-emission mitigation potential per technology is between 0.6 and 5%[7].

The **Modernization Program** of the national freight transport is operated by "Nacional Financiera" (NAFIN)[8] under the guidelines of SCT. It was created in February 2004 with the objective to renew the national fleet by means of a financial and a scrapping scheme. To accomplish its purposes, the program grants credits and fiscal incentives for activities related to:

- The scrapping of eligible units.
- The provision of the initial payment to purchase new units.

On September 8th 2010, SCT and NAFIN agreed to establish the rules and procedures to work with associates in the design of financial schemes for the acquisition of freight vehicles. With this agreement, a new pool of 300 million MXN (approx. 15.5 million Euro) was raised to financially support program. In November 2011, a temporal credit line was created in order to provide

[6] GIZ (2014): Capacitación en conducción técnico-económica a Empresas Hombre-Camión y Pequeños Transportistas en México.
[7] SEMARNAT (2012): PECC 2012 - 2018.
[8] "Nacional Financiera (NAFIN)" is a Mexican Development Bank.

certainty to financial intermediaries that grant credits to the Man Truck and Small Fleet Carriers who usually do not fulfill the requirements to be eligible for a credit.

The two actions that the NAMA supports are divided into:

a) Scrapping Scheme

By providing grants – of up to 25% of the value of the new or semi-new unit - the scrapping scheme aims to promote the destruction of old trucks. The incentive for the scrapping scheme has been increased at the beginning of 2015. Before 2015, this incentive corresponded to only about 15% of the value of the new or semi-new unit. This incentive was too low to incentivize the scrapping of younger than 25-years-old trucks, because it did not cover their value. The result was that road haulers only scrapped very old units older than 25 years. The environmental effect was therefore very small. By increasing the former incentive by 55 - 85%, depending on the vehicle type (reaching up to 25% of the total value of the truck),[9] road haulers have, since the beginning of 2015, an incentive to also scrap younger units. This in turn leads to more significant GHG-emission reduction. The higher incentives enable the Man Truck and the Small Fleet Carriers to purchase a new or semi new unit (less than 6 years old) after scrapping their old vehicles. Figure 2 shows the different steps of the Scrapping Scheme.

Figure 2 *Process and paperwork of the Scrapping Scheme*

1. The enterprise (road hauler) decides to adquire a new or semi-new unit.
2. The distribution center offers the credit conditions to buy the new unit and checks the appropriate incentive.
3. Personal information of the enterprise is requested and reviewed.
4. The unit is taken to the scrapping center (the scrapping center must be registered in the Treasury Office).
5. The scrapping center delivers a destruction certificate of the unit.
6. The distribution center and the enterprise unregister the old unit.
7. The distribution center applies for the financial incentive.

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[9] Secretaria de Gobernanza: http://www.dof.gob.mx/nota_detalle.php?codigo=5386771&fecha=26/03/2015 (06.11.2015).

b) Financial Scheme

With the support of NAFIN, the objective of this scheme is to promote credits to buy new or semi new units with low interest rates. This scheme is not subject to the replacement of old units. The payment period is from 1 to 5 years depending on the type of credit, with a low interest rate that can be either fixed or flexible. In order to be eligible, the enterprise needs to be registered, have valid permissions and a bank account, give some financial references and have a financial endorsement. Transport enterprises of any size can participate in the program. A total of 3 million MXN (approx. 180,000 Euro) is given in credit to Man Trucks that acquire new or semi new trucks and up to 10 million MXN (approx. 600,000 Euro) to Small Fleet Carriers and Medium-sized business that acquire only new trucks.

Additionally to the existing financial incentive, a new credit guarantee has been implemented in November 2014, also called "Pari Passu". Pari Passu is a result of NAMA activities and is operated by the Transport Ministry (SCT) and NAFIN. It was designed to address the needs of Man Truck and Small Fleet Carriers. The objective of this credit guarantee is to ensure that the beneficiaries have a backup of possible losses for the financial intermediaries of up to 80% of the given credit.[10]

Figure 3 *Scrapping Plants in the State of Mexico*

In the framework of the NAMA, some scrapping plants have been visited and surveyed in order to know their opinion about the programs, to review their capacities for scrapping and to identify opportunities to improve the program.
Source: GIZ, 2014.

2. Identification of NAMA impacts and indicators

2.1 Causal chains from NAMA to emissions

As mentioned in section 1.6 this document focuses on the MRV system of the Modernization Program. The following therefore only describes the impact chain of the modernization component.

Through the political and economic framework, old truck units (in general less efficient, with less travel activity and higher emissions than newer units) are more likely to be replaced with newer ones. The technology improvement increases the fuel efficiency of the vehicle fleet, thereby

[10] RPM Informe Preliminar.

reducing emissions. With a newer vehicle, the driver now is able to make more trips with less fuel, potentially leading to additional indirect effects of increased kilometers travelled (summarized in Table 6).

2.2 Data availability

This section describes the available data used for the MRV system.

Several governmental institutions and private consultancies provide data about the Mexican truck fleet. These are the Ministry of Environment (SEMARNAT), Ministry of Transport (SCT), the National Statistic Authority (INEGI), the Statistic Authorities for each state (REPUVE) and the two consultancies with the name "MELGAR" and "TRAFALGAR". The available data refer to the total number of trucks and their age. Additionally, some sources offer information about different types (vehicle class) and fuel efficiency. Table 2 summarizes the different approaches of each source and provides information about the average age of the fleet and total number of trucks.

***Table 2** Different sources, methodology of information, total number and average age of the Mexican truck fleet*

Source	SEMARNAT	Melgar	INEGI	TRAFALGAR	SCT	REPUVE
Year	2008	2010	2011	2011	2012	2010
Characteristics	Sources are the Ministries of Finance of the federal states. These numbers are used to estimate the data of the National Emission Inventory	Different sources (methodology remains unclear)	Different sources (Federal and from states)	Just for HDV; based on new and second-hand sales	Just for HDV; own federal register	Own register for all vehicles Including type, model year and model
Total No. HDV	1,260,938	866,845	9,251,425	1,310,178	568,740	2,188,927
Average Age HDV	15.2	11.7	10.7	11.0	16.6	NA

As some of the sources do not provide yearly updates, it was not possible to compare the total number of HDV of the different sources for the same year. One should also consider that the different sources use different methodology when classifying truck types. For example, INEGI also includes Pick-ups and some SUVs, while SCT just considers trucks with a gross vehicle weight of more than 3,875 kg. Additionally, SCT just includes trucks with federal licenses, which is identical with the NAMA focus group. The SCT data base also provides information about the age of the truck (0 – 49 years).

Based on the existing information a study has been elaborated by SEPSA[11] for the NAMA to fill the data gaps. The aim was to elaborate a database with data on fuel efficiency and transport activity according to the four-truck-types classification used by SCT. INECC in cooperation with the "Centro Mario Molina (CMM)" developed an Emission Factor (EF) for the Mexican freight fleet using Diesel[12]. In order to calculate the period of the impact, information about the survival rate was needed. This has been developed by the Mexican Institute for Petroleum (IMP) in 2014.

The information and the sources of the parameters used for the MRV-System can be summarized as follows:

Table 3 *Information and sources used for the calculation of GHG emissions*

Type of information	**Specification**	***Source***
Number of units of each type and age of truck:	The total number of trucks registered in SCT in 2015 is categorized into four types: C2, C3, T2 and T3. This information is also categorized by vehicle age up to 49 years.	*Already existed before the NAMA and SCT provides a yearly update.*
Transport activity (tkm):	Total tkm per year of each type and age of truck.	*Taken from the study "Radiografía NAMA Transporte" developed in the framework of the NAMA.*
Fuel Efficiency:	Liters of diesel per kilometer of each type and age of truck.	*Taken from the study "Diagnóstico NAMA Transporte" developed in the framework of the NAMA.*
Fuel Efficiency for trucks complying with new emissions standard (EURO VI/EPA 2010):	For trucks complying with the new standard (starting with 2018) an average value of improvement of efficiency of 4% has been used on top of the value of a new truck[13].	*Developed by ICCT during the NAMA.*
Emission Factor (EF):	*GHG-emissions (CO_2, CH_4 and N_2O) per liter Diesel*	*Developed by INECC and CMM during the NAMA.*
Survival rate:	Survival rate for the Mexican truck fleet by vehicle age up to 49 years.	*Developed by IMP during the NAMA.*

[11] SEPSA, 2013: Diagnóstico sobre la Situación Actual del Autotransporte Federal de Carga, con un Enfoque Específico al Hombre-Camión y Pequeños Transportistas.
[12] About 99% of the Mexican federal road haulers use trucks, operated by Diesel.
[13] This value was taken from a study performed by ICCT, 2014a.

2.3 Potential sustainable development benefits

The NAMA has both direct and indirect social and economic co-benefits. Improving efficiency and reducing fuel consumption, leads to additional benefits, such as the introduction of more efficient units with less fuel consumption and reduced operating costs that translate into more competitiveness in the industry. Furthermore, the number of accidents is reduces because of the newer vehicles.

Additionally, some clients ask truck companies to use units with a maximum age of ten years. This translates into fewer criteria pollutant emissions and consequently better health.

In summary, all of the NAMA actions have a wide range of additional sustainable development benefits on health (through criteria pollutants), road safety (through the reduction in accidents), energy security (through fuel savings) and competitiveness (through the reduction of operating costs). Quantifying these benefits, however, proved to be a difficult and costly task. One benefit, which was quantified by the International Council on Clean Transportation (ICCT) is the pollutant emission reduction associated with the update of NOM-044[14] from EPA 2004 to EPA 2010. Through the implementation of the NOM-044 the following emission reductions are expected:

- 225 thousand tons of PM2.5
- 160 thousand tons of black carbon
- 4 million tons of NO_X

These would prevent 55,000 premature deaths as a result of lung cancer, cardiopulmonary diseases and acute respiratory diseases caused by emissions of diesel vehicle (ICCT, 2014a).

2.4 System boundaries

The NAMA is limited to the national road freight transport, considering only national trips, trucks having a gross vehicle weight of more than 3,875 kg and having a federal license. The MRV is made for the Mexican scrapping scheme and hence; uses the same criteria (e.g. minimum age for scrapping, maximum age for renewing) as the scrapping scheme.

The baseline and impact emissions calculation does not account for emissions resulting from fuel production, vehicle production and scrapping due to various reasons.

Emissions from fuel production are not included because these emissions are not considered as part of the transport sector emissions within the National Inventory of GHG-Emissions.

[14] NOM-044 is the Mexican emission standard for new HDV. During the NAMA process the standard has been updated similar to EURO VI/ EPA 2010 standards. The updated NOM-044 includes the following emissions: NH_3, HC, HCNM, HCNM+NOx, CO, NOx and PM. The standard is supposed to enter in force in 2018.

Vehicle production and scrapping related emissions are not included in the monitoring; due to minor relevance compared to the use-phase emissions (see ex-ante impact estimation in 3.3.d).

Table 4 summarizes the system boundaries of the MRV approach.

Table 4 *System boundaries of the MRV approach*

Boundary elements	Description
Temporal boundary	2010 – 2025 (after 2025 the input data for the calculator tool used to estimate emission reductions of the NAMA must be revised and renewed).
Sectoral boundary	Federal truck fleet (more than 3,875 kg).
Territorial boundary	Mexico: Only trucks with a federal license are included. Reason: to join the scrapping scheme a federal license is needed. The federal license also allows the road haulers to drive on federal highways.
GHG included	The focus is on direct, activity-based GHG emissions. The monitoring covers tank to wheel $CO_{2,}$ CH_4 and N_2O emissions. Other indirect upstream and construction emissions are not included in the monitoring, but have been estimated in an ex-ante process.
Sustainability effects included	No, only for the impact of the updated emissions standard (NOM-044) to EURO VI/EPA 2010 levels and cost-benefit analyses have been elaborated. This includes additional costs of vehicle production, health and environmental benefits, however those are not included in the regular monitoring of the MRV system.

3. MRV approach for the Mexican truck Modernization Program

3.1 Introduction

The MRV system for the Modernization Program is based on a scrapping calculator developed by a working group of the NAMA. The calculator allows estimating the reduction of GHG emissions achieved with the implementation of the Modernization Program. In the Mexican scrapping scheme three different scenarios are possible:

1. Scrapping (older than 10 years) and renewing (less than 6 years): this is the most usual way, which is promoted and the only possibility to receive a subsidy of up to 25% of the value of the new truck by the Mexican Fleet Modernization Program.
2. Only scrapping: in this case an old truck is scrapped but not renewed.
3. Only renewal: in this case no vehicle is scrapped. Only a new vehicle is added to the existing fleet. The road hauler has access to a special credit offered by NAFIN with lower interest rates compared to the ones offered by commercial banks in Mexico.

The first scenario is the most common one; hence the following description focuses mostly on it, but also includes the other two scenarios.

The ex-post evaluation is used by SCT and INECC to estimate the real GHG-emission mitigation. Essentially, the calculator compares emissions of the scrapped truck, which represents the baseline, to the emissions of the renewed truck (based on the fuel efficiency and total kilometers travelled with the truck).

The final scrapping calculator is the result of a stepwise methodological refinement. As a first step, an ex-ante evaluation was done, which also included and looked at rebound effects and analyzed the importance of tank to wheel emissions. Based on the findings from the ex-ante calculation it was decided to include the indirect effect of additional kilometers travelled by new trucks into the calculator (see 3.3.b), but to disregard emissions from vehicle production and scrapping (see 3.3.d).

Additionally, an ex-ante GHG-emission mitigation scenario has been developed to estimate the overall effect of the implementation of the Modernization Program. This scenario compared the situation with the "no-existence" of a modernization program with the existence of such a program (see 3.3.d).

3.2 The Baseline

a) Identification of the baseline scenario

The scrapped truck and its characteristics represent the baseline. The baseline is being calculated with the data described in Table 5. The proportion of types of trucks (C3, C3, T2 and T3) is assumed to stay equal over time just as performance and total yearly distance. Taking this into account, total liters per type of truck per year were calculated and translated into emissions via the emission factor developed by INECC: 2.69 kg of CO_2e per liter Diesel. The Emission Factor includes CO_2, CH_4 and N_2O, but not Black Carbon (BC) as a GHG-emission.

Table 5 *Information and sources used for the design of the baseline*

Type and age of truck:	Considering the four types of trucks: C2, C3, T2 and T3. This information is also categorized by vehicle age up to 49 years.
Transport Activity (tkm):	Total tones transported per year per type and age of truck.
Fuel Efficiency:	Liters of diesel per kilometer per type and age of truck.
Emission Factor (EF):	2.69 g of CO_2e per liter Diesel.

b) Calculation of baseline emissions

Given the information pointed out before, the baseline emissions are calculated as:

$$GHG - Emissions = \frac{km}{year} * \frac{liters}{km} * 2.69\ \mathrm{CO2e}\ kg\ per\ liter$$

c) Assessment of uncertainties in the baseline estimation

Although the baseline estimation is robust, some uncertainties exist due to limited data availability. The calculator uses average values for the types of trucks and ages which lead to results that are not precise for the unit. Additionally, the calculation does not account for the fact that some "old" vehicles may have newer engines and hence are more efficient and pollute less. Values such as the driving style (Eco-driving) and the percentage of urban versus inter-urban journeys are also not included because of information lack. Instead an average value for different vehicle type/age has been used, which combines urban and inter-urban journeys.

Additionally, the current categorization process of the Mexican truck fleet into only four types (C2, C3, T2 and T3) is too general. In particular, the last two types (T2 and T3) should be categorized into more groups. In the current classification, a truck transporting 30 tones on average and a truck transporting 60 tones on average could be included in the same category.

3.3 Assessment of the impact

a. Applicability

The MRV system, as already mentioned in previous sections, is limited to the federal road freight transport sector in Mexico, considering trucks with a gross vehicle weight of more than 3.875 tones.

b. Calculation of emissions savings through the NAMA

The calculator estimates the mitigation of CO_2e emissions with the scrapping scheme considering the three cases mentioned in 3.1. Table 6 shows the methodology for the calculation of the mitigation for case 1: scrapping and renewal. It indicates that the mitigation is calculated for the direct (new unit replaces old unit, calculated on tkm) and indirect effect (new unit is more efficient and replaces tkm of the average fleet).

Table 6 *Methodology implemented in the calculator*

Direct Effect	Indirect Effect
Direct Effect: the new unit transports the objects that the old one did, but with less CO_2e emissions. Direct Effect= tkm $_{old\_per\ year}$ x (EF $_{old}$ – EF $_{new}$) Where: tkm: tons per kilometer. EF: average emissions/tkm (old or new units) per vehicle class.	**Indirect Effect:** the new unit runs more tkm – because it is more efficient and costumers demand to use a new unit more than an old one. The new unit hence takes tkm away from the average of the fleet. Since the new unit is also more efficient than the average unit, there is an additional indirect effect. Indirect Effect= (tkm $_{new\_per\ year}$ – tkm $_{old\_per\ year}$) x (EF $_{fleet}$ – EF $_{new}$) Where: EF $_{new}$: average emissions/tkm of a new unit per vehicle class. EF $_{fleet}$: average emissions/tkm of a 17 year old unit per vehicle class.

Source: Authors and Jakob Graichen.

For case two (scrapping only), the mitigation was calculated in the following way:

$$Scrapping = \frac{tkm_{old\ per\ year}\ x\ (EF_{old} - EF_{fleet})}{1{,}000}$$

For case three (renewing only), the mitigation was calculated in the following way:

$$Renewal = \frac{(tkm_{new\ per\ year} -\ tkm_{fleet})(EF_{fleet} - EF_{new})}{1{,}000}$$

Where:

1,000 = Factor to convert kg into tons

These mitigation scenarios are calculated considering the “survival rate”, i.e. the probable age the old truck would have reached if it had not been scrapped. This value is taken from the Mexican Petroleum Institute (IMP 2014), which considers a survival rate of 100% in the first year until 35.6% after 49 years in use. This percentage corresponds to the percentage of new vehicles which reach the age of 49 year. Based on this information, the calculator estimates the probable age the old vehicle would have reached if it had not been scrapped (see Table 7).

Table 7 Survival Rate of Trucks in Mexico

Survival Rate Road Freight Transport in Mexico							
Vehicle Age	Loading	Survival rate (years)	Maximum Age	Vehicle Age	Loading	Survival rate (years)	Maximum Age
0	100.0%	17.425	17.425	25	55.3%	15.447	40.447
1	82.4%	20.707	21.707	26	53.9%	15.166	41.166
2	81.6%	20.493	22.493	27	52.6%	14.872	41.872
3	80.7%	20.281	23.281	28	51.3%	14.564	42.564
4	79.7%	20.071	24.071	29	49.9%	14.240	43.240
5	78.8%	19.863	24.863	30	48.6%	13.897	43.897
6	77.8%	19.656	25.656	31	47.3%	13.536	44.536
7	76.8%	19.450	26.450	32	46.0%	13.152	45.152
8	75.8%	19.246	27.246	33	44.6%	12.745	45.745
9	74.7%	19.042	28.042	34	43.3%	12.311	46.311
10	73.6%	18.840	28.840	35	42.0%	11.847	46.847
11	72.5%	18.640	29.640	36	41.5%	11.132	47.132
12	71.3%	18.448	30.448	37	41.0%	10.398	47.398
13	70.2%	18.245	31.245	38	40.6%	9.645	47.645
14	68.9%	18.074	32.074	39	40.1%	8.872	47.872
15	67.2%	17.983	32.983	40	39.6%	8.080	48.080
16	65.7%	17.867	33.867	41	39.1%	7.267	48.267
17	65.3%	17.414	34.414	42	38.7%	6.434	48.434
18	64.1%	17.193	35.193	43	38.2%	5.581	48.581
19	62.9%	16.966	35.966	44	37.8%	4.706	48.706
20	61.6%	16.732	36.732	45	37.3%	3.810	48.810
21	60.3%	16.503	37.503	46	36.9%	2.891	48.891
22	59.1%	16.253	38.253	47	36.5%	1.950	48.950
23	57.8%	15.994	38.994	48	36.0%	0.988	48.988
24	56.6%	15.717	39.717	49	35.6%	0.000	49.000[15]

Source: Own calculation based on the information of IMP: "Probabilidad de supervivencia. Proporcionado al INECC". México, 2014.

c. Calculation parameters

The calculator uses several parameters described below for the calculation of GHG-emissions.

a. Characteristics of the Mexican fleet.

[15] Maximum vehicle age for the calculator is 49 years. For older vehicles there are no data available in Mexico. This problem refers to: vehicle age, fuel efficiency, type of vehicle and survival rate.

The data concerning the performance and the total distance per year by type/age of truck were calculated with the data base of a survey study.[16] The database is representative of the federal road freight transport and integrates a significant amount of data useful for the analysis of the Man Truck and the Small Fleet Carriers characteristics. It is important to note that the data can be limited to the information that the drivers and owners gave, since the database was constructed with individual surveys. Nevertheless, an average performance has been calculated based on some control questions such as the capacity and number of the tanks and total kilometers per month. Additionally, the data has been compared with already existing data from SEMARNAT and INECC. Differences were very little.

Table 8 *Parameters used in the calculator (inputs)*

Performance by type and year:	Calculated with the data concerning the total kilometers achieved with full tank and the own tank capacity.
Total annual kilometers by year:	Annual average kilometers of the fleet by year model weighted by type and year of the unit.

b. Calculating Emission factors

The emission factors (EF) of CO_2e were calculated with the Emission Factors of Diesel: 2.69 $kgCO_2e$ per liter, used by INECC. It is divided by the type of truck, the year of the unit and the total weight carried.

$$\frac{EF_{Diesel} * l/km * 1000}{Tons\ Carried * 100} = \frac{\left(\frac{kgCO2}{l}\right) * \left(\frac{l}{100km}\right) * 1000}{(t) * 100} = EF_{Diesel}\left(\frac{gCO2}{tkm}\right)$$

Where: Emission Factor of Diesel ($kgCO_2e$/l)*l/km of vehicle class and age/ tons transported (t) by vehicle class and age.

d. Ex-ante assessment of the impact

a. Vehicle production

Based on the methodology used in the study “$C0_2$ -Einsparpotenziale für Verbraucher” by the Öko-Institut (2010), emissions resulting from vehicle production and scrapping have been calculated, but were not included since they represent an insignificant percentage of less than 2% of direct emissions of vehicles in the case of Mexico´s road freight transport.

As a result of the Modernization Program trucks will be taken out of the market before they would have if they were not scrapped, i.e. trucks do not reach the same vehicle age as before. Total kilometers traveled by the vehicles are therefore less and one has to consider whether this has a significant impact on the proportion of production emissions as part of total vehicle emissions. Table 9 shows the main values to be taken into account for the calculation of production and

[16] SEPSA, 2013.

scrapping emissions. All values except total kilometers traveled have been taken from the study by the Öko-Institut (2010) since they are assumed to be equal in Mexico. Total kilometers traveled, however, differ significantly. These values have been calculated with data from the Study "Diagnóstico sobre la Situación Actual del Sector del Autotransporte de Carga con un Enfoque Específico al Hombre-Camión y Pequeños Transportistas " by SEPSA (2013).

Table 9 *GHG-Emissions HDV Production*

Vehicle Type	CO_2e Production and Scrapping Emissions (kg/unit)	Total km (km)	Charge (tones)	Additional charge (g/tkm)
HDV	Production: 20,900.00 Scrapping: 834	**C2** 0-20: 1,133,580.00 0-35: 1,480,851.00 **C3** 0-20: 1,901,025.00 0-35: 2,796,471.00 **T2/T3** 0-20: 2,428,902.00 0-35: 3,701,403.00	2.6	**Production:** **C2** 0-20: 7.09 0-35: 5.43 **C3** 0-20: 4.23 0-35: 2.87 **T2/T3** 0-20: 3.31 0-35: 2.17 **Scrapping:** **C2** 0-20: 0.28 0-35: 0.22 **C3** 0-20: 0.17 0-35: 0.11 **T2/T3** 0-20: 0.13 0-35: 0.09

Source: Authors, based on information of Öko-Institut, 2010.

Based on these values, the following table shows the proportion (%) of the production and scrapping emissions as part of total direct emissions per vehicle type (C2, C3 and T3). The results show the shorter "life" of the trucks (20 years instead of 35 years), due to the Modernization Program, changes the proportion of production and scrapping emissions by less than 2% in the case of C2 HDV and less than 1% for C3 and T2/T3 HDV. Because of this insignificant change, production and scrapping emissions are not included in the emissions monitoring.

Table 10 *Proportion of production and scrapping emissions as part of direct emissions*

Vehicle Type	Direct Emissions CO_2e (g/tkm)	Proportion of production emissions as part of direct emissions (%)	Proportion of scrapping emissions as part of direct emissions (%)
C2			
0-20:	310.02	2%	0%
0-35:	331.24	2%	0%
C3			
0-20:	342.79	1%	0%
0-35:	383.79	1%	0%
T2/T3			
0-20:	468.79	1%	0%
0-35:	487.68	0%	0%

Source: Authors, based on information of Öko-Institut, 2010.

b. Scrapping process

Finally, a study elaborated by the consultancy TSTES also showed that the percentage of recycled material in the Mexican truck scrapping scheme is very high, because of the business interest of the owner of the scrapping plant. As it is his/her main source of income, the operator of the scrapping plant tries to sell as much materials as possible from the scrapped truck.[17]

c. Rebound Effect

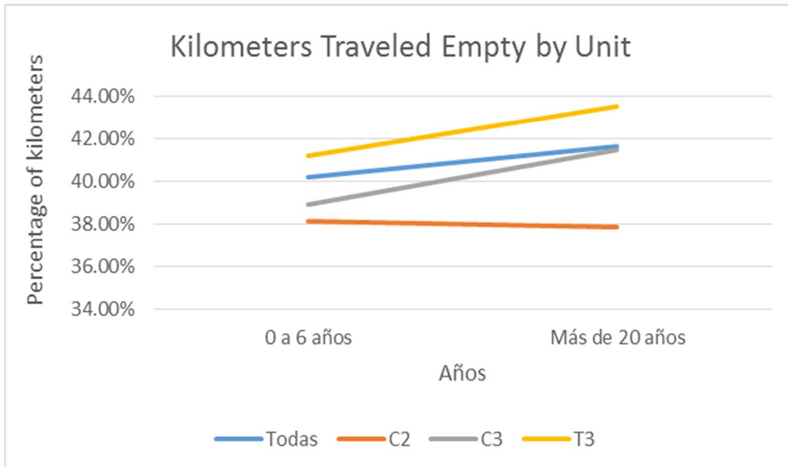
The Rebound Effect occurs when a motorist acquires one new unit and he/she uses it more than the old one for trips not related with transporting any products. The Rebound Effect also appears, when the new units are more cost effective than more sustainable modes of transport (e.g. train). This could lead to a shift away from the train towards road freight transport. If this occurred, the mitigation potential would be smaller. However, the rebound effect is not considered in any of the parameters of the calculator. There are a couple of reasons for it:

a) Other, more sustainable modes of transport in Mexico, such as train and ships, are just in very few cases an alternative. Moreover, the NAMA focuses on small haulers. According to the "Asociación Mexicana de Ferrocarriles, A.C. (Mexican train association) the Mexican railway sector is not competing with small haulers. Small haulers do not transport the amount of goods from A to B which are needed to run profitable for the Mexican railway sector. Additionally, in the current situation the Mexican railway service is operating close to their limits of capacity. This could be changed only due to significant investments in infrastructure and regulatory changes.[18]
b) The data for the Mexican freight fleet show that older units travel more kilometers empty than newer ones. The new unit is more efficient, hence the hauler is more likely to use the

[17] TSTES: Inventario de los centros de Chatarrización en México, 2014.
[18] Asociación Mexicana de Ferrocarriles: Comunicated during the "Foro de Eficiencia Energética en el Transporte" in Mexico City on 11th of December 2013.

new one than the old one and additionally, some big costumers such as Walmart or Coca-Cola (FEMSA) demand new units to transport their goods. If a motorist is willing to renew his/her 20 year old unit with a new one, on average he/she will not use it for empty trips but for trips with load. Therefore, the mitigation due to the indirect effect is not reduced as he/she is using his/her new unit to trips related to the freight industry. Graph 2 displays the evidence that new units are more effectively used to transport goods than old units.[19]

***Graph 2** Kilometers traveled empty by type of unit*



Source: Authors, based on information of SEPSA, 2013.

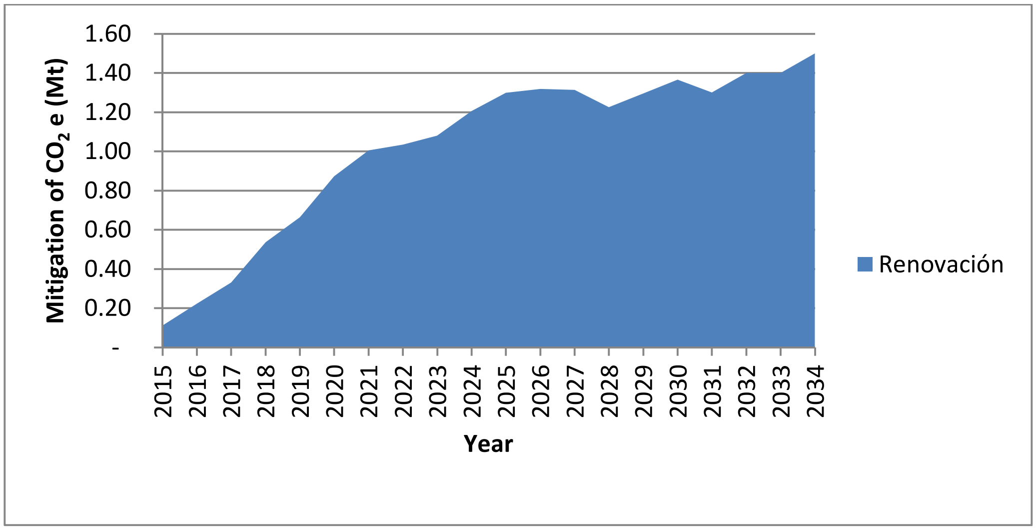
d. Ex-ante impact scenario

The following mitigation scenario has been studied:

Modernization fleet only scenario: Assumptions are: Program duration: 2015 – 2019. Scrapping (20 years old) and renovation (new ones) of 6,000 trucks/year (T3: 4000; C3 1500; and C2 1500[20]). The impact of the improved emissions standard for new HDV from EPA 2004/EUR III to EPA 2010/Euro VI (NOM-044) is reflected starting at the beginning of 2018 for all new entering HDV which have to comply with the new standard.

[19] A General Overview of the Transport Industry in Mexico requested by GIZ and performed by SEPSA.
[20] These numbers are calculated according to the modal split of the different types of trucks in Mexico.

__Graph 3__ Mitigation scenario for the Mexican Scrapping Scheme



Source: GIZ, 2015: Scrapping Calculator.

The graph shows a total GHG-emission mitigation of about 22 Mt between 2015 and 2034. Again, only between 2015 and 2019 trucks will be scrapped, but the impact of GHG-emission mitigation lasts longer: until 2034. In 2023, five years after the implementation of the updated emission standard (NOM-044), the impact of GHG-emission mitigation is already higher than the impact of the scrapping scheme, if it would be without the improved standard.

e. Ex-post assessment of the impact

The scrapping calculator[21] is a tool developed by the NAMA Working Group for SCT. Its aim is to facilitate the measurement of the mitigation of the CO_2e emissions for the Scrapping Scheme. To do so, the user firstly decides on whether he/she wants to: 1. Scrap and renew the vehicle, 2. Only scrap the vehicle or 3. Only renew the vehicle. Additionally, the user can also choose whether the results should appear considering the updated fuel standard of the NOM-044 (EURO VI/ EPA 2010) or an efficiency standard[22]. Table 11 summarizes all needed input data for the calculator from the user.

[21] To download the calculator: http://climate.blue/biblioteca-pronama/.

[22] Until 2016 is no fuel efficiency standard existing in Mexico for HDV. However, CONUEE started a process to develop such standard. Hence, the calculator offers already the possibility to include this standard, once it might be implemented.

Table 11 *Input data for the calculator*

User input data for the calculator	Specification	*Comment*
Year of scrapping and renewing	2010 – 2025. However, the impact will be calculated until 2043 (if scrapped a vehicle in 2025 with an expected remaining life time of 18 years.	*Only until 2025 possible.*
Age of scrapped truck	Possible from 10 to 49 years.	*If rules of scrapping scheme are changed, an update might be necessary.*
Type of scrapped truck	C2, C3, T2 and T3	*An update in more groups is recommendable, only if better information is available.*
Age of renewed truck	Possible from 0 (new) to 5 years (semi-new)	*If rules of scrapping scheme are changed, an update might be necessary.*
Type of renewed truck	C2, C3, T2 and T3	*An update in more groups is recommendable, only if better information is available.*
No. of scrapped and renewed truck	It is recommended to calculate only 1 (scrapped) to 1 (renewed). Just if exactly the same type and age of scrapped trucks is given it is possible to use more than 1 truck. The same counts for the renewed trucks.	

Table 12 shows all input data which is only accessible for the administrator (verifier) of the NAMA and at what point in time the different data needs to be updated.

Table 12 *Input data used by the calculator*

Input data for the calculation (only accessible for the verifier)	Specification	*Needs to be updated (Comment)*
Transport activity (tkm):	Total tkm per year of each type and age of truck.	*After 2025, or if better information is available.*
Fuel Efficiency:	Liters of diesel per kilometer of each type and age of truck.	*After 2025, or sooner if better information is available.*
Emission Factor (EF):	*GHG-emissions (CO_2, CH_4 and N_2O) per liter Diesel*	*After 2018 (in particular if there are changes with the new Ultra-low-sulfur diesel).*
Survival rate:	Survival rate for the Mexican truck	*After 2025, or sooner if*

	fleet by vehicle age up to 49 years.	*better information is available.*
Updated emission regulation (NOM-044) (only from 2018 – 2025 possible)	For trucks complying with the new standard (starting with 2018) an average value of improvement of efficiency of 4% has been used on top of the value of a new truck.	*After 2025, or sooner if better information is available.*
Fuel efficiency standard	No values.	*As soon as possible (divided by type and age).*

Introducing different input data shows that the mitigation potential is highest if scrapping is combined with renewing. The following screenshots show mitigation of the different cases (blue bars show annual emission reductions, the red line shows the accumulated emission reductions).

Entry data: Scrapping year: 2015

Vehicle Type: T3

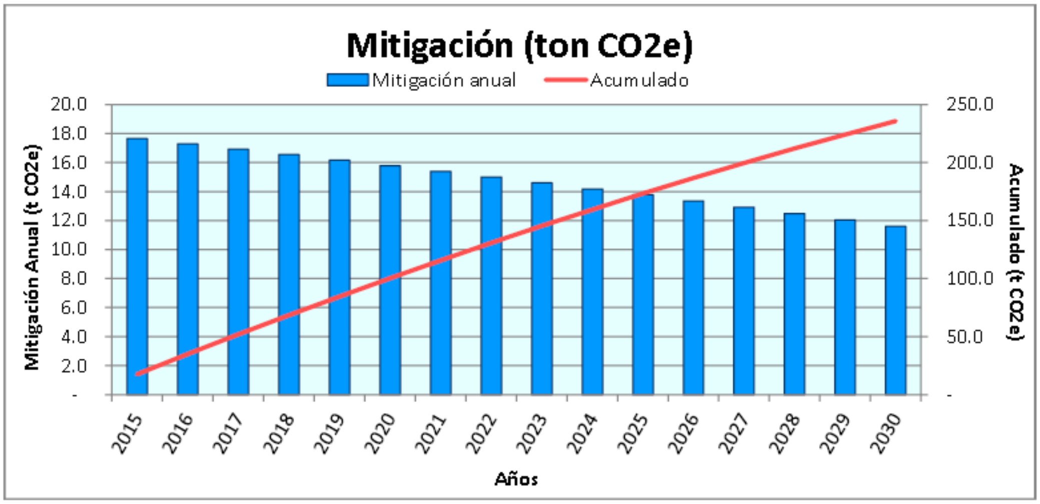
Age: 25

Quantity: 1

Age of new vehicle: 0

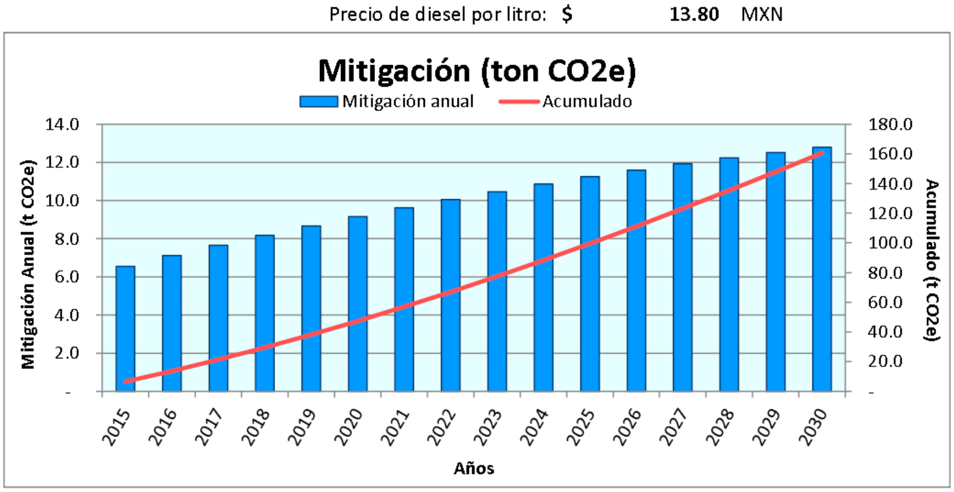
***Case 1:** Combining Scrapping with Renewing*

	Mitigación:		
Ambos:	**235.65**	t CO2e	
Total	**235.65**	t CO2e	
Periodo de mitigación:		**16**	Años
Ahorro anual en Pesos MX por chatarrizar y/o renovar:	$	**75,555.50**	MXN
Ahorro anual de combustible por chatarrizar y/o renovar:		**5,475.04**	Litros de diesel
Precio de diesel por litro:	$	**13.80**	MXN



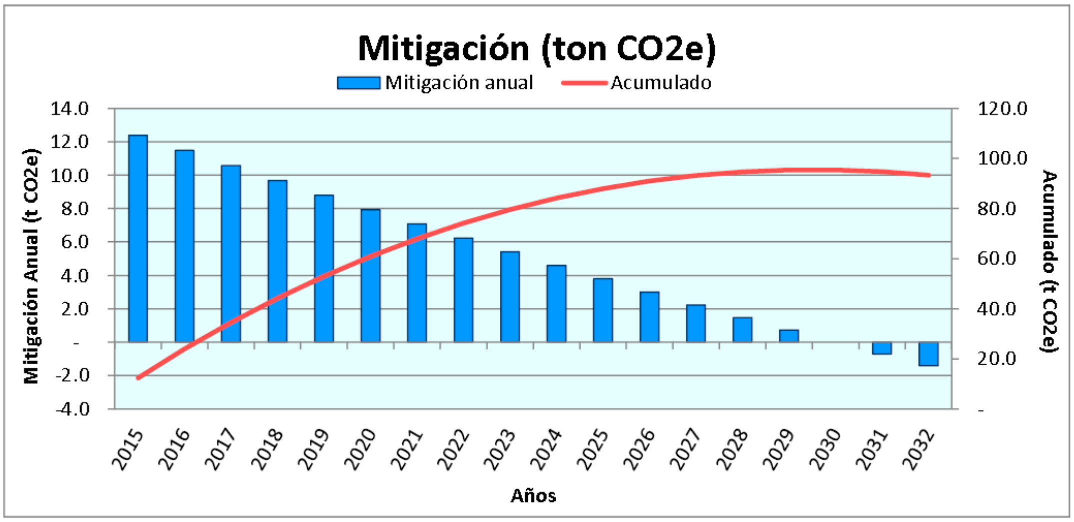
***Case 2:** Only Scrapping*

	Mitigación:		
Sólo chatarrización	**160.63**	t CO2e	
Total	**160.63**	t CO2e	
Periodo de mitigación:		**16**	Años
Ahorro anual en Pesos MX por chatarrizar y/o renovar:	$	**51,504.33**	MXN
Ahorro anual de combustible por chatarrizar y/o renovar:		**3,732.20**	Litros de diesel
Precio de diesel por litro:	$	**13.80**	MXN



Case 3: *Only Renewing*

	Mitigación:		
Sólo renovación:	93.30	t CO2e	
Total	93.30	t CO2e	
Periodo de mitigación:		18	Años
Ahorro anual en Pesos MX por chatarrizar y/o renovar:	$	26,590.74	MXN
Ahorro anual de combustible por chatarrizar y/o renovar:		1,926.87	Litros de diesel
Precio de diesel por litro:	$	13.80	MXN



4. Monitoring, Reporting and Verification Procedures

In order to calculate the CO_2e reduction of the mitigation action, the calculator needs a list of parameters. In order to see if the scrapping program achieves its mitigation objectives, the calculator needs certain input data. These parameters should be reported by the Ministry of Transport and Communication and NAFIN. Input data are:

1. Number of units that have been scrapped and renewed per year.
2. Age and type of the scrapped and renewed unit.

Tables 13 and 14, describe some of the parameters needed to calculate the mitigation as well as the responsible institution that collects the information.

Table 13 *Important parameters for the MRV*

Number of units scrapped	The number of units scrapped in a given year, divided by type and age of truck.
Description	Each type of truck has a different efficiency and corresponding potential mitigation. The calculator needs this information about all of the units that will be substituted to show the mitigation of CO_2e. The information about the age of the scrapped unit is also needed.
Source of data (report)	SCT reports how many units participate in the scrapping scheme.
Measurement Procedures	The Ministry of Treasury of the SAT[23] gives the information to the SCT of how many enterprises are subject to the fiscal incentive by scrapping.
Mitigation verification	INECC verifies the total mitigation calculated.

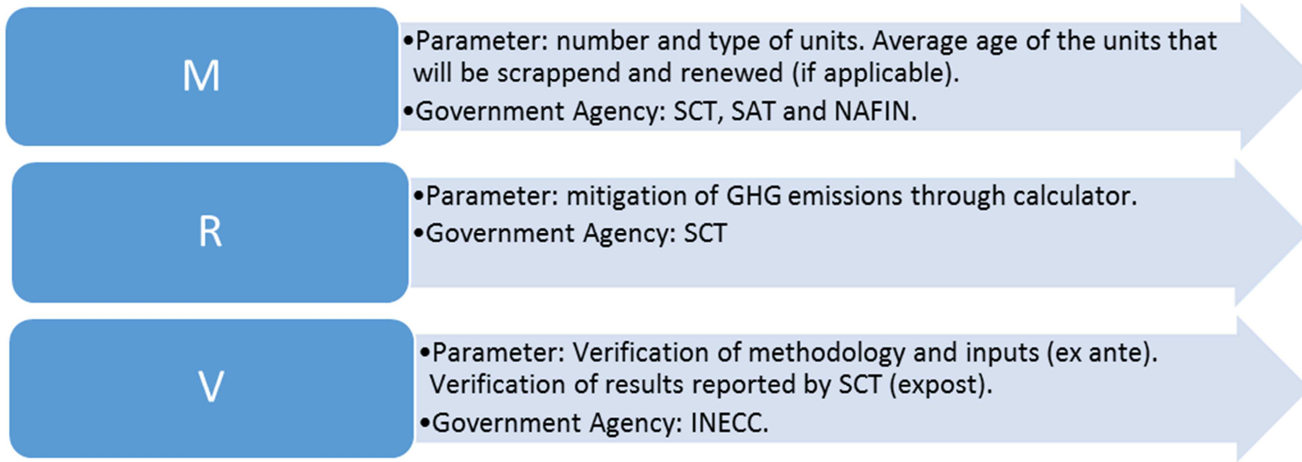
Table 14 *Important parameters for the MRV*

Number and characteristics of new units	Type and age of new/semi new units.
Description	The number of units that will be purchased as well as its characteristics can be used to calculate the mitigation of the substitution of the new units.
Source of data (report)	NAFIN informs SCT about the units that are obtained with the credit grant or only with the credit (only renewing).
Measurement Procedures	Interested enterprises who want to substitute their old units with new ones can use a credit provided by NAFIN. This information is collected by NAFIN.
Mitigation verification	INECC verifies the total mitigation calculated.

Figure 5 shows the MRV process and the entailment with government agencies for the NAMA. Given that the mitigation calculator requires various parameters, it is important to consider which agency is responsible for each part of the process.

[23] Sistema de Administración Tributaria.

Figure 5 *MRV process and entailment with government agencies for the NAMA*



5. Lessons learnt

The costs of creating the MRV system, including all expenses amounted to about 95,000 Euros. The time and resources required for the process of collecting data, developing a methodology, developing the mitigation tool and the process of verification have to be taken into consideration when choosing to develop a mitigation policy as a NAMA. On the other hand, the costs for a scrapping scheme or many other public policies are much higher. In the case of this NAMA the MRV costs are less than 0.5% of the total costs of the scrapping program. If a MRV system helps to improve the mitigation policy, the invested effort clearly outweighs the costs. Thanks to this MRV system it has been possible to identify the perfect vehicle scrapping age. This allowed government officials to identify the ideal incentive for the scheme. Additionally, many other questions and doubts about the impact and design of the program have been answered and clarified because of the MRV system.

Acknowledgements

The participation in several international workshops organized by the GIZ-TRANSfer program in the framework of a “MRV-Expert group” was very helpful. Many ideas for the MRV methodology have been influenced and improved because of the comments of those experts. In the same way, the early participation of INECC in developing the MRV system was crucial.

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