EMISSION REDUCTION ACTIONS PROGRAM (NAMA) IN NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEMS, THROUGH FUGITIVE EMISSION REDUCTION

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Embajada Británica en México

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ACRONYMS

API	American Petroleum Institute.
CDM	Clean Development Mechanism.
CE	Coordinating Entity.
CM	Calculation Memory for the Emission Reductions.
DE	Designated Entity.
DOE	Designated Operational Entity.
EMA	Mexican Accreditation Entity. EMA for its acronym in Spanish, *Entidad Mexicana de Acreditación*.
EPA	United States Environmental Protection Agency.
GHG	Greenhouse Gases.
IPCC	Intergovernmental Panel on Climate Change.
NAMA	Nationally Appropriated Mitigation Action.
PD	Project Document for the NAMA.
PEMEX	Petróleos Mexicanos.
PEP	PEMEX Exploration and Production, PEP for its acronym in Spanish, *PEMEX Exploración y Producción*.
PGPB	PEMEX Gas and Basic Petrochemicals, PGPB for its acronym in Spanish, *PEMEX Gas y Petroquímica Básica.*
PP	Project Participant.
PPQ	PEMEX Petrochemical, PPQ for its acronym in Spanish, *PEMEX Petroquímica*.
PR	PEMEX Refining, PR for its acronym in Spanish, *PEMEX Refinación*.
SCCP	Special Climate Change Program.
UNFCCC	United Nations Framework Convention on Climate Change.
VCS	Verified Carbon Standard.

1. EXECUTIVE SUMMARY

In 2011, the United Nations Framework Convention on Climate Change (UNFCCC) published the official positions and diverse mitigation actions identified by developing countries for Nationally Appropriate Mitigation Actions (NAMAs). On said document Mexico states the following:

> *"Mexico communicated that it aims to reduce its GHG emissions by up to 30 per cent compared with the 'business as usual' scenario by 2020. It added that the full implementation of its Special Climate Change Programme, adopted in 2009, which includes a set of NAMAs to be undertaken in all relevant sectors, would achieve a reduction in total annual emissions of 51 Mt CO_2 eq by 2012, compared with the 'business as usual' scenario [1]."*

With this Mexico establishes its interest to develop NAMAs, identifying mitigation actions originally established on the Special Climate Change Program[2]. In this program, which constitutes a public policy instrument that helps identify areas that are vulnerable to global warming and the costs associated to not acting, Mexico establishes and quantifies aims and fully identified goals to be meat by 2012. This seeks to ensure environmental sustainability through the responsible participation, care, protection, preservation and exploitation of natural resources of the country, in order to consolidate economic and social development without compromising our natural heritage and the quality of life of future generations.

Because of this, Petróleos Mexicanos (PEMEX) sponsored by the British Embassy in Mexico's Prosperity Fund asked the consulting firm CO2 Solutions their support to structure a NAMA initiative centred on the reduction of fugitive emissions on natural gas processing, transport and distribution systems in México, so that it will be possible to significantly reduce CO_2 equivalent emission that will help achieve the goals set in the country.

[1] UNFCCC, Ad Hoc Working Group on Long-term Cooperative Action under the Convention. "Compilation of information on nationally appropriate mitigation actions to be implemented by Parties not included in Annex I to the Convention". Page 31. Available at: http://unfccc.int/resource/docs/2011/awglca14/eng/inf01.pdf

[2] SECTUR webpage. "Programa Especial de Cambio Climático". Available at: http://www.sectur.gob.mx/es/sectur/Programa_Especial_de_Cambio_Climatico_PECC

Natural gas is the cleanest fossil fuel, and thanks to its competitive price (3.86 USD/MMBTU on average during 2011) and environmental benefits it is gaining relevance on international markets. Mexico's Natural gas process and transport system which belongs mostly to PEMEX and presents an area of opportunity that this NAMA seeks to translate into emission reductions, has 19 compression stations, 12,295.9 km of pipelines, 20 cryogenic plants and 20 liquefied gas production terminals.

The aim on this NAMA is to establish a platform that will allow emission reduction project activities on the different components of Mexico's Natural gas processing, transport and distribution systems to be incentivized.

Project activities registered under this NAMA must imply some kind of progress on the current industry practices, may be accompanied with technological advances and should imply emission reductions for Mexico on every case.

The emissions reduction potential estimated for this NAMA is of approximately 3 million tons of CO_2 equivalent per year, should this goal be met this would place the natural gas processing, transport and distribution system's efficiency on an equivalent level to the efficiency reached in countries like the United States of America and Canada, which have a lower fugitive emissions factor. The calculations made to estimate this amount are presented in the section "Emisison Reduction Goal".

Due to the difficulties that may arise when attempting to measure fugitive emissions on natural gas systems accurately, because of the wide variety of sources, several national and international practices for leak detection and repair as well as maintenance programs management aimed to minimize fugitive emissions in the natural gas industry will be reviewed throughout this document. Some technological alternatives recommended by the Natural Gas STAR EPA Program Participants are also reviewed.

With the development of this NAMA PEMEX, the British Embassy in Mexico and CO2 Solutions wish to contribute with Mexico's sustainable developed, as can be revised on the section "Benefits on the implementation of the NAMA".

2. GENERAL INFORMATION ON THE NAMA PROPONENTS

2.1 PETRÓLEOS MEXICANOS (PEMEX)

Petróleos Mexicanos (PEMEX) is the fourth largest producer of crude oil in the world and the eleventh globally integrated company. PEMEX is the only producer of oil, natural gas and oil products in Mexico and the government's most important income source which makes PEMEX the most important company in the country.

PEMEX's mission is to maximize the value of the oil reserves and its hydrocarbons, satisfying the national demand of petroleum products with the required quality and in a safe, reliable, cost effective and sustainable manner.

PEMEX was established on June 7, 1938 upon the expropriation, decreed by President Lázaro Cárdenas del Rio, of the movable and immovable property of 17 oil companies in favour of the nation.

In 1992, the new Organic Law of Petroleos Mexicanos and its subsidiary entities was issued in which PEMEX is defined as a decentralized body of the Federal Public Administration, responsible for the conduct of the national oil industry. This law determines the creation of one corporate Office and four Subsidiary entities, which is the organic structure under which it operates to date. Said subsidiary entities are:

- PEMEX Exploración y Producción (Exploration and Production), PEP
- PEMEX Refinación (Refining), PXR
- PEMEX Gas y Petroquímica Básica (Gas and Basic Petrochemicals), PGPB
- PEMEX Petroquímica (Petrochemical), PPQ

The Business Plan of Petroleos Mexicanos and its organisms in 2013-2017 defines the course of actions to be followed in order to accomplish the mandate of value creation and reaching operative and financial viability in the medium and long term. The Business plan has 15 strategic objectives that tend to the different aspects of PEMEX, such as the urgencies to maintain and increase the current levels of hydrocarbon production and its responsibility to guaranty sustainable operations for the long term, the need to replace reserves to insure the entities operations, efficiency on operations, administration and finance, the compromise to satisfy the energetic needs of the country and to strengthen relationships with society as well as to protect the environment, all this within a framework of value creation and accountability to society.

To reach its objectives, PEMEX has defined a series of specific strategies grouped in four lines of action:

- Growth, by which it seeks to incorporate and develop new reserves, develop optimum levels of production of hydrocarbons and petrochemicals, and guaranty efficient supply and less cost to the national demand on energetics;
- Operative Efficiency, this represents an improvement in the current performance of all operations, optimizing investment and operation expenses to gain a competitive performance in all of PEMEX's industrial activities;
- Corporate Responsibility, to improve the relationship with stakeholders and incorporate sustainable development into business decisions; and
- Modernization of Management, to acquire the required skills and with them operate and focus PEMEX though the results, business process efficiency promotion, human resources professionalization and the use of the regulatory framework to increase management autonomy and implement a results-oriented culture.

These strategies were defined considering the specific area of business lines, expressed in the actions of each Subsidiary Entity of PEMEX, as well as the transversal responsibilities that seek to serve the purposes with positive effect upon the whole organization.

For PEMEX the social responsibility is a permanent commitment that guides them on an ethic manner and helps contribute to the economic development of the country, at the same time as it improves the quality of life of its employees, their families, the communities and society as a whole. All of this within the framework of economic and environmental sustainability.

2.2 THE BRITISH EMBASSY IN MEXICO

The British Embassy in Mexico's aim is to represent the British Government in this country, playing an active role to strengthen and establish the bonds between the United Kingdom and Mexico on all of its levels.

The British embassy promotes the British interests and initiatives in Mexico, working together through different programs.

2.2.1 The Prosperity Fund of the British Embassy

Despite the fact that the fund has changed names throughout its history, the Prosperity Fund has been supporting for 10 years the implementation of the programs that are aligned with the Exterior Policy Priorities: "Build Britain's prosperity by increasing exports and investment, opening markets, ensuring access to resources, and promoting sustainable global growth".

The British government knows that an open economy is the best way to support the development and prosperity; this is why the Prosperity Fund seeks to support the establishment of stable and transparent regulatory regimes and promote public policies that encourage the sustainable and low carbon growth. Additionally, the fund intends to promote openness in trade and investment, discourage protectionism, increase competitiveness and strengthen the multilateral trading system, as well as promoting economic reforms and free trade. The Prosperity Fund seeks to promote transformational changes in policies and actions to help countries in particular and the world in general, to move to a world that has the tools to mitigate and cope with climate change, promoting green growth and sustainable. To achieve this in Mexico, the Fund has four main objectives:

1. Supporting the strong, stable and sustainable growth of the Mexican economy, supporting the recovery of the global economy and global prosperity.
2. Strengthen fair trade in Mexico.
3. Support Mexico to make a positive contribution in global economic governance.
4. Support Mexico in its policies and green actions and sustainable growth.

2.3 CO2 SOLUTIONS

CO2 Solutions operates in the carbon markets since 1998, thus being one of the pioneers in this field, having developed projects in Argentina, Brazil, Bulgaria, Chile, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Spain, United States, Guatemala, England, India, Mexico, Morocco, Nicaragua, Panama, Peru, Dominican Republic, Switzerland, among others.

CO2 Solutions provides comprehensive carbon related services to numerous corporations, banks, developers and funds, to whom it supports from the project conceptualization, through the validation stage and the verification of their emissions and unto the issuance of the carbon credits.

Strategic Consulting projects developed by CO2 Solutions allow businesses, corporations and institutions to develop a global strategy seeking to adapt to market challenges, taking a competitive advantage. Through the strategic consulting protocols may be custom-made for each entity, establishing a work plan to develop an optimal strategy that minimizes the impact of a new carbon economy restrictive to the company and at the same time identify areas of opportunity that allow a company to position itself as a leader in combating climate change in its sector.

2.4 JOINT DEVELOPMENT OF A NAMA AS AN EMISSIONS REDUCTION PROGRAM

After the emergence of Nationally Appropriate Mitigation Actions (NAMAs) PEMEX Carbon Finance Office and CO2 Solutions, decided to work together to explore their potential in the oil and gas industry. Thanks to the experience of both entities on greenhouse gases mitigation related subjects it was possible to estimate the potential of mitigation in natural gas processing, transport and distribution systems, focusing on the reduction of fugitive emissions.

On August 2012, the project was presented before several internal organisms of PEMEX as well as the Secretariat of Environment and Natural Resources of Mexico (SEMARNAT), and after receiving the approval and support of all the parties the project caught the attention of the United Kingdom’s Prosperity Fund working team. The

Prosperity Fund provided not only a strategic ally but also provided the budget required for the development of this executive project.

The present document strives to incentivize the participation of every organism, public or private, involved in the natural gas sector in Mexico to reduce the environmental impact off this sector through the reduction and/or elimination of fugitive emissions in the processing, transport and distribution of natural gas, thus contributing to reach the national goals on emission reductions. Furthermore, this NAMA seeks that the mitigation actions have the backing of the United Nations Framework Convention on Climate Change (UNFCCC) through the Designated National Authority (Interministerial Commission on Climate Change, headed by SEMARNAT). For this, an adjustment was made on the requirements of the UNFCCC to the particular conditions of the natural gas sector in Mexico, seeking with this that the NAMA has national and international recognition.

3. GOALS AND DESCRIPTION OF THE NAMA

The central goal of this NAMA is the creation of a framework program that allows project activities consisting of the reduction of methane emission by means of the minimization and/or elimination of fugitive emissions in the components of the process, transport and distribution system to be incentivized.

In Chapter 4 of the IPCC Guidelines for National Inventories of Greenhouse Gases ("fugitive emissions")[3], fugitive emissions are defined as: *"Intentional or unintentional release of greenhouse gases may occur during the extraction, processing and delivery of fossil fuels to the point of final use."* This type of emissions can be classified as degree 3 leaks according to the Mexican norm NOM-009-SECRE-2002 "Monitoring, detection and classification of natural gas and L.P. gas leaks", this is: "*This class of leaks are not dangerous when detected and are not likely to represent a risk for the future, so it is only necessary to periodically reevaluate them until they are repaired*". For the purpose of this NAMA, fugitive emissions will be considered as: "the intentional or unintentional liberation of methane, which is not dangerous when it is detected and does not represent a probable risk to the future, and that may occur during the extraction, processing and delivery of natural gas until its final destination."

Fugitive emissions from petroleum and natural gas systems tend to be difficult to quantify with accuracy, this is due to the diversity of the sector, the great amount and the wide variety of sources of the potential emission sources, the wide variations on the emissions' control levels, and the limited availability of data about emission sources. The main difficulties related to the evaluation of emissions are:

- The use of simple production-based emission factors introduces large uncertainty;
- The application of rigorous bottom-up approaches requires expert knowledge and detailed data that may be difficult and costly to obtain;

[3] Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories: "Fugitive Emissions". Volume 2, chapter 4, page 4.6. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf [Access 07/02/2013]

Measurement programs are time consuming and very costly to perform [4].

PEMEX carries out the entire production chain of the sector, from the exploitation and processing to the distribution and commercialization of final products, while the private industry has a participation, in accordance with the amendments made in 1995 to the Regulatory Law on Constitutional Article 27, regarding Oil and the publication of the Regulations on Natural Gas, transport, distribution, storage, import and commerce of natural gas.

In Mexico, natural gas transport is done through a system consisting of pipelines, pigging traps, sectioning valves, stem valves, air steps and crossings of rivers, highways and trains. The gasoduct grid of Mexico is composed of two systems: The National Gasoduct System (SNG for its acronym in Spanish), and the Naco-Hermosillo, both of which belong to PGPB. Besides these, there are also some pipelines interconnected to the south of the United States, other connected to the SNG and some isolated lines. While PGPB is in charge of transporting natural gas to the big consumers and the entries to the cities, most part of the interior distribution is done by private companies. By the end of 2011, PEMEX administered two of the 22 Open Access Transport (TRA for its acronym in Spanish) permits given by the CRE to transport gas and that continue in force; this permits include the SNG and the Naco-Hermosillo system as well as 20 permits administered by private carriers. The open access permits form, as a whole, a pipeline grid of 12,295.9 km, of which PEMEX owns 11,296 km.

In terms of distribution, Mexico has a network of 46.312 km, which is comprised by 22 permits authorized by the CRE until April 2012.

The compression capacity in the national territory is delivered by 19 compression stations, 11 of which belong to PEMEX (10 belong to PGPB subsidiary and 1 to PEP), resulting on an installed capacity of de 508,158 HP; 328,310 HP correspond to PEMEX, while the remaining 179,848 HP of installed capacity belong to private parties.

The main goal of this NAMA is to establish a framework program that allows the sum of actions in the public and private sector to reduce

[4] Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories: "Fugitive Emissions". Volume 2, chapter 4, page 4.36 Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf [Access 07/02/2013].

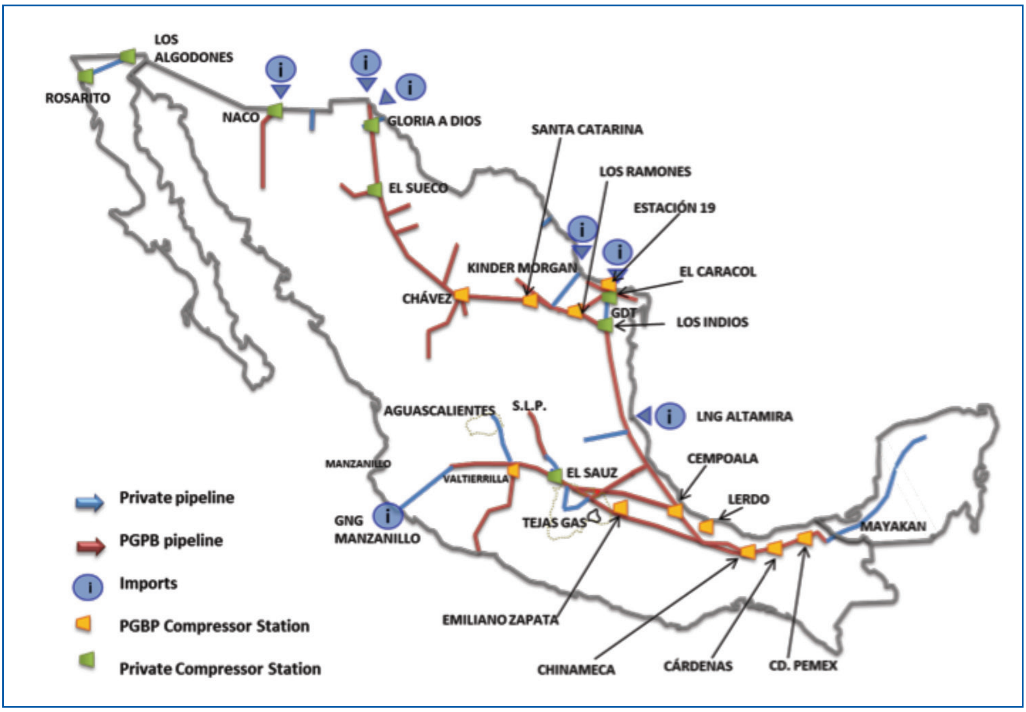


Figure 1. Natural Gas transport infrastructure Map[5]

and/or eliminate the fugitive emissions in the natural gas process, transport and distribution system of Mexico. Some of the fugitive emission sources have already been identified, however, they are presented as part of the operations of components that are part of the natural gas system, being part of the current sectorial practices of the sector, at national or international level, and do not represent any risk; however they do represent an important area of opportunity to reduce GHG emissions to the environment.

[5] Prospectiva del Mercado de gas natural 2012-2026, SENER page 68. Available at: http://www.sener.gob.mx/res/PE_y_DT/pub/2012/PGN_2012_2026.pdf [Access 07/02/2013].

4. NATURAL GAS AND MARKET STATISTICS

4.1 NATURAL GAS AND THE ENVIRONMENT

Natural gas is the cleanest fossil fuel, and because it is composed mainly of methane the chief products of its combustion are carbon dioxide and water vapour, with small traces of sulphur dioxide, nitrogen oxides, carbon monoxide and other hydrocarbons.

Pollutants emitted to the atmosphere, particularly those originated from fossil fuels combustion, have collaborated with the increase of many environmental problems. By emitting less polluting chemicals to the atmosphere than other fossil fuels, natural gas can contribute to mitigate problems such as emissions of greenhouse gases and other atmospheric pollutants and acid rain by reducing emissions due to combustion in the industrial, electric, transport, domestic and services sector.

Natural gas is a gaseous mix of simple hydrocarbons, mainly methane (CH_4) but containing also parts of molecules of up to 4 carbons, and on occasion small traces of nitrogen, carbon dioxide, hydrogen sulphide and water. Depending on the gas's origin this can be classified as associated gas or non-associated gas, where associated gas is that which is extracted along with oil and has important parts of other hydrocarbons such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}), while non-associated gas is found in gas deposits containing no oil. To eliminate impurities and obtain a gas that is mostly composed of methane, the gas will pass by gas treatment plants with sweetening processes and cryogenic plants before being sold.

It is important to point out how essential a proper natural gas management is since the Global Warming Potential of methane is of 21 while carbon dioxide's is 1 and it is a product of natural gas combustion.

4.2 NATURAL GAS PROCESSING

In the industry natural gas that is extracted from the ground is processed to obtained dry gas or commercial natural gas (NG) which is transported by pipelines. Liquid petroleum gas (LPG) is also produced and it is transported in tanks and ships.

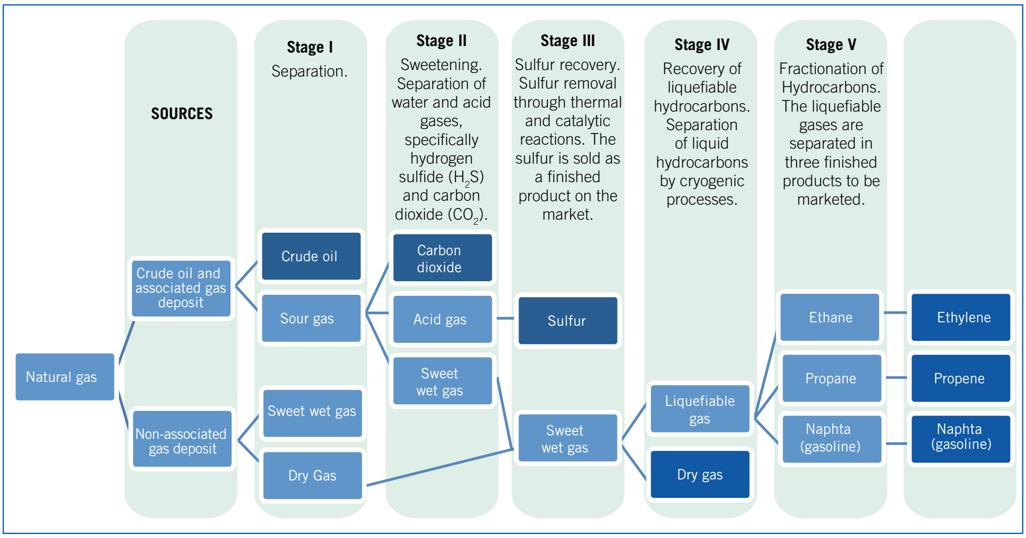


Figure 2. Natural Gas processing stages[6]

Commercial natural gas is used as:

- Fuel: in the transport sector (in taxis and buses); in the domestic sector for water heaters, stoves and heating systems; in the commercial sector for water heaters, furnaces and air conditioners; and industrial heating systems, drying, steam generation and kilns.
- Electric energy generation source: in combined cycle plants.
- Raw material: in the petrochemical industry where it is transformed relatively easily into hydrogen, ethylene or methanol for the production of plastics and fertilizers.

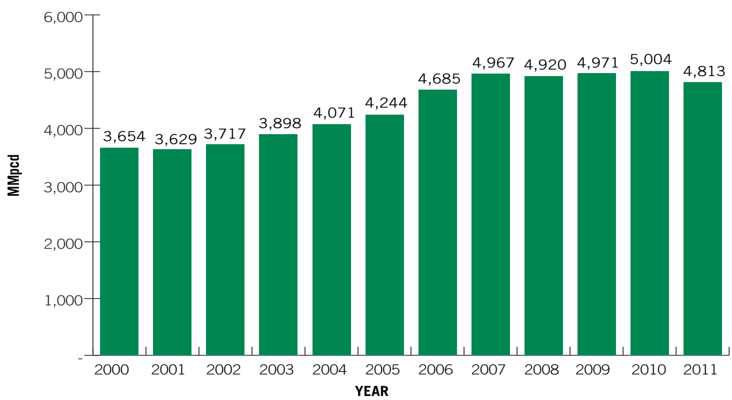
4.3 NATIONAL SCENARIO OF PRODUCTION, STORAGE AND DISTRIBUTION OF NATURAL GAS

4.3.1 National Natural Gas Market

Even though the national production of natural has registered a growth in the years between 2000 and 2010 thanks to the supply of non-associated gas from PEMEX PEP linked to an increase in the utiliza-

[6] SENER. Procesamiento, almacenamiento y transporte de Gas. Page 2. Available at: http://www.sener.gob.mx/res/403/Elaboraci%C3%B3n%20de%20Gas.pdf [Access 07/02/2013].

tion and processing capacities, in 2011 the primary production of associated and non-associated natural gas decreased 191 million cubic feet per day compared to the production in year 2010 (refer to figure 3).



‣ Includes dry gas production in plants and direct fields, ethane inyected to pipelines and other streams.

Figure 3. Natural gas production[7]

In the past year important changes have occurred in the natural gas market, factors such as the growing international supply thanks to shale gas, the growing demand of natural gas in the electric, industrial and transport sector, along with the environmental advantages of gas in comparison to coal and oil have contributed in turning natural gas in the fastest growing fuel in the years to come. This is how, thanks to the low prices and a growing production, it is to be expected that natural gas will be the fastest growing fuel in the next 15 years and Mexico must be ready for this changes.

In Mexico, the electric sector will continue growing and, being the mayor natural gas consumer of the country, it is expected that in the period of 2012-2017 the electric sector will represent 70% of the internal demand (excluding the oil sector). It is also expected for the industrial sector to have a participation of 26%, the domestic sector a participation of 2%, the services sector a participation of 0.5% and the auto-transportation industry will contribute only with a 0.02%.

[7] PEMEX. Principales elementos del Plan de Negocios de Petróleos Mexicanos y sus Organismos Subsidiarios: 2013-2017. Page 13. Available at: http://www.pemex.com/files/content/pn_13-17_121107.pdf [Access 07/02/2013].

On the other hand, the internal sales volume of natural has in PEMEX PGPB in 2011 was of 3,385 MMCFD, which represents an increase of 4% to the volumes reached the year before. The increase can be attributed to lower levels of water in some hydroelectric stations which caused an increase in the consumption of natural gas in the electrical sector as well as to the competitive price of natural gas in comparison to other fuels, which was on average 3.86 USD/MMBTU during 2011. This price is on average 29% lower than the average price of the past ten years.[8]

4.3.2 The National Distribution Grid of Natural Gas in Mexico

The natural gas transport system of PEMEX has 8,385 km of transport pipelines operating, 322 km of pipelines out of service and 507 km of branching pipelines, the transport capacity is of 5,102 MMCFD, covering 19 states of the country.

The growing demand of natural gas, which has increased on average 1.4% annually since 2008, represents a need to increase in the requirements of the pipelines' infrastructure and compression stations of the National Pipelines System and the Naco-Hermosillo System. In 2011 the transport capacity was raised from 1,014 to 1,270 MMCFD of natural gas in the Cempoala-Santa Ana pipeline as a result of the works done in the Emiliano Zapata compression station.

4.3.3 Efficiency in the Exploitation of Natural Gas

Between the years 2007 and 2008 gas venting and flaring were observed to be above those of previews years, because of this since 2009 actions have been taken to reduce the emissions from this sources in the Northwest Marine Region in particular. In December 2009, in order to align these efforts, the Resolution of the National Hydrocarbons Commission (CNH) was published on the Official Federal Gazette, making known the technical dispositions to reduce and avoid the venting and flaring of gas in the exploration and production of hydrocarbons (Resolution CNH.06.001/09).

In 2011 gas utilization reached 96.2%, which is above the world average utilization of 95%. This was achieved thanks to the actions

[8] PEMEX. Principales elementos del Plan de Negocios de Petróleos Mexicanos y sus Organismos Subsidiarios: 2013-2017. Pages 15-16. Available at: http://www.pemex.com/files/content/pn_13-17_121107.pdf [Access 07/02/2013].

implemented to: increase operational reliability and the availability of the compression equipment, the efficiency of gas sweetening processes, the increase in the capacity of sour gas injection to reservoirs, the improvement in high pressure gas operation and compression with Booster equipment, and to the closing of oil wells with a high oil-gas ration.

In November 2012 PEP received recognition from the Directors Board of the World Bank's Global Gas Flaring Reduction (GGFR) Partnership for achieving a decrease in gas flaring at the Cantarell Field. The gas utilization of 97% was reached as a result of the efforts made in the project to reinject sour gas in the reservoir, initiated in 2008.

Thanks to this project, in which 600 MMUSD have been invested, in the last 3 years it has been possible to decrease the quantity of polluting gases released to the atmosphere from 13.6 to 2.1 trillion cubic meters. PEP will continue investing an additional billion dollars in the period of 2013-2014 on the Integral Project for the Management and Use of Gas in the Northwest Marine Region in order to achieve a rate of utilization of 99%.

It should be noted that Mexico, through PEMEX and SENER, has joined the Global Gas Flaring Reduction (GGFR) partnership led by the World Bank.

4.4 NATURAL GAS INDUSTRY IN THE WORLD

In 2005, PEMEX was placed as the thirteenth dry gas producer in the world according to the Energy Intelligence Group. This position reflects the importance of PEMEX as an international oil company and the economic importance of it for the development of Mexico (Table 1).

The world's natural gas reserves have increased slightly over the years, reaching 6.405 trillion cubic feet (TCF) in 2006. The global distribution of natural gas reserves is somewhat irregular, with the highest concentration in Middle Eastern countries and Russia (66.7%), however natural gas reserves exist in all continents. On the other hand, the major natural gas producers are Russia and the United States. In addition, Canada, Iran, Norway, Algeria, United Kingdom, Indonesia and Saudi Arabia also showed significant levels of dry gas production, and together with the United States and Russia accounted for 63.8% of global production of dry gas in 2006 by drawing more than 7,000

Table 1. Major petroleum companies by dry gas production levels in 2005[9]

POSITION	COMPANY	COUNTRY	STATE OWNED (%)	PRIVATLY OWNED (%)	GAS PRODUCTION (MMCFD)
1	Gazprom	Russia	50	50	53,135
2	Exxon Mobil	United States	-	100	9,251
3	BP	United Kingdom	-	100	8,424
4	NIOC	Iran	100	-	8,414
5	Royal Dutch/Shell	United Kingdom / Netherlands	-	100	8,263
6	Sonatrach	Algeria	100	-	8,152
7	Saudi Aramco	Saudi Arabia	100	-	6,721
8	Petronas	Malaysia	100	-	5,113
9	Total Fina Elf	France	-	100	4,780
10	Chevron Texaco	United States	-	100	4,233
11	ENI	Italy	-	100	3,762
12	PetroChina	China	90	10	3,681
13	**Pemex**	**Mexico**	**100**	**-**	**3,575**
14	Repsol YPF	Spain	-	100	3,415
15	Conoco Philllips	United States	-	100	3,337

MMCFD. Meanwhile, Gazprom was presented as the first dry gas producer with a production volume of 53.794 MMCFD, which represents 90.8% of Russia's production, and 19.4% of the total volume produced worldwide. That same year, Mexico ranked 19th place with a production of 4,195 MMCFD, at the end of 2012 the national production of natural gas had reached a volume of 5.665 million cubic feet according to the report of the National Hydrocarbons Commission, November 2012[10].

Due to its clean and efficient combustion, natural gas is gaining importance in the international market, diversifying its uses and increasing production rates to meet demand. This increase in the rates

[9] SENER. Procesamiento, almacenamiento y transporte de Gas. Page 8. Available at: http://www.sener.gob.mx/res/403/Elaboraci%C3%B3n%20de%20Gas.pdf

[10] Reporte de Producción de Gas Natural en México (Noviembre de 2012) CNH. http://www.cnh.gob.mx/_docs/Reportes_IH/Reporte_de_Gas_Nov_12.pdf

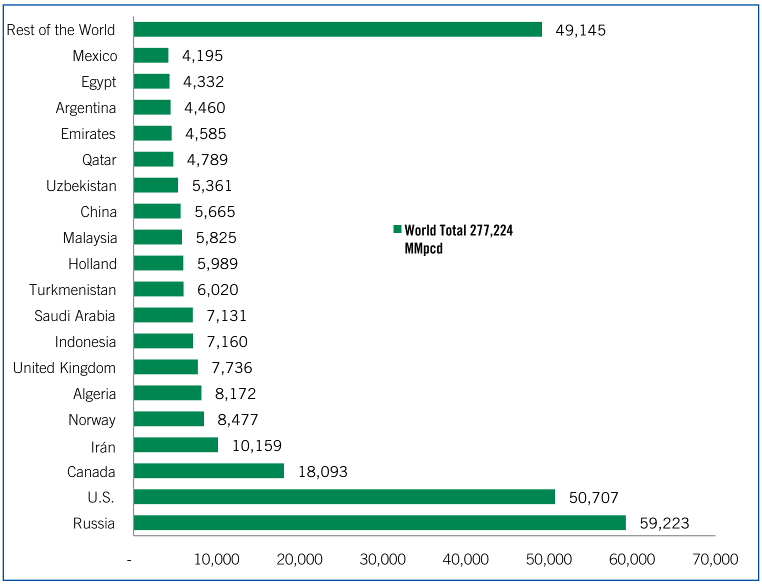


Figure 4. Worldwide dry gas production, 2006[11]

of extraction has led to the incorporation of reservoirs in different countries. As a result of this, the rate of R / P (reservoirs / production) has fallen in recent years to levels lower than programmed; thereby while in 2003 the rate was of 70.4 years, in 2006 it had dropped to 63.3 years in spite of the increase in global proved reserves.

4.5 NATIONAL AND INTERNATIONAL REGULATIONS ON NATURAL GAS TRANSPORT

In Mexico, the Official Mexican Standards regarding the transmission, distribution, processing, storage or natural gas specifications are the following:

- Natural gas specifications, NOM-001-SECRE-2010: Establishes the specifications to be met by the natural gas to be handled in the transport, store and distribution systems, in order to preserve people's safety, environment and facilities of the owners and users.

[11] SENER. Procesamiento, almacenamiento y transporte de Gas. Page 7. Available at: http://www.sener.gob.mx/res/403/Elaboraci%C3%B3n%20de%20Gas.pdf

- Natural gas utilization facilities, NOM-002-SECRE-2010: Establishes the minimum safety requirements that must be met in the design, materials, construction, installation, leakage tests, operation, maintenance and safety of the natural gas utilization facilities.
- Natural gas and liquefied petroleum gas pipeline distribution, NOM-003-SECRE-2002: This regulation establishes the minimum safety requirements that must be met by the natural gas and liquefied petroleum gas pipeline distribution systems.
- Natural gas transport, NOM-007-SECRE-2010: This regulation establishes the minimum safety requirements that must be met by the natural gas pipeline transport systems.
- Monitoring, detection and sorting of natural gas and liquefied petroleum gas leaks in pipelines, NOM-009-SECRE-2002: This Mexican official standard establishes the minimum requirements to be met by the owners of the transport and distribution pipelines system in Mexico for the monitoring, detection and sorting of leaks of natural gas and liquefied petroleum gas.

The NOM-009-SECRE-2002 applies to natural gas and liquefied petroleum gas transport and distribution pipelines systems operating in Mexico. This regulation defines a leak as follows:

> "Any gas emission in a pipeline, due to a fracture, rupture, defective weld, corrosion, imperfect sealing and accessory or device malfunction used on it."

Likewise monitoring is defined as follows:

> "The set of activities to be performed periodically to detect and classify gas leaks from the streams moved through the pipelines of the transport and distribution systems."

This Official Mexican Standard establishes that a owner (Title holder of a transport or distribution permit through pipelines for natural gas or liquefied petroleum gas) should have the necessary resources to perform an inspection:

> "Human resources. Must have enough personnel, that have the required qualification and experience to apply the chosen inspection method.

Material resources: For the leaks inspection in a pipeline system, the following material resources must be available:

a) Current distribution network or transport line layout with the appropriate scale and detail level,
b) Appropriate leak detection equipment for the location and quantification of leaks according to the facilities characteristics and the applicable inspection methods, and
c) Transport equipment for leaks repair."

The regulation also establishes that the owner can apply the following methods for leaks detection, individually or combined, in his facilities:

"a) Fuel gas indicators;
  i. Above ground surface
  ii. Below ground surface
b) Visual vegetation inspection;
c) Pressure drop;
d) Ultrasound;
e) Optical fibre;
f) Ground or aerial infrared thermography, and
g) Trained dogs."

According to the regulation NOM-009-SECRE-2002, the owner can use other methods as long as they are used along with procedures that prove that such methods are as efficient as the ones included in the previous list. The use of the appropriate method is responsibility of the owner, who has to determine that there is not a leak, or in case there is, it must be detected, localized, sorted and immediately controlled.

- Detection with fuel gas indicators. The equipment to perform this inspection can be portable or mobile. The indicator must be of the adequate type and have adequate sensibility, according to manufacturer's instructions, for the natural gas and liquefied petroleum gas detection method applicable to the inspected facility.
- Above ground detection. For underground facilities ground level continuous monitoring must be performed as close to the facili-

ties as possible. For above ground facilities, continuous monitoring from the adjacent environment to the facilities must be taken.

a) For underground facilities, samples from the atmosphere must be taken at a distance no longer than 5 cm from above ground, whenever it is possible, and in all those land irregularities that allow the gas to come to the surface. In areas where the pipeline is below finished floor, for example: sidewalks and paved streets, air samples close to discontinuities and irregularities of the floor must be taken; examples of the latest could be openings, grooves, breaks and cracks that let the gas come to the surface. Likewise, the air within enclosures located in floor openings below its level, closed to the pipelines, manholes, sewer register, electrical installations, telephone installations and installation for other services, must be analysed.
b) The monitoring of the superficial atmosphere with a gas indicator must be performed at appropriated speed and conditions in order for it to be correct. The gas indicator operation must be performed according to the manufacturer's instructions. Samples must be analysed in the places specified in the last paragraph.

- Detection below surface. The monitoring of the underground atmosphere must be performed in existing openings and/or upper section soundings and/or next to the pipelines. The sampling wells must be drilled as close to the pipelines as possible and laterally with a distance no longer than 5 meters from its axis. Along the pipeline the monitoring points must be located at a distance no longer than the double of the distance between the pipeline and the closest building wall or 10 meters, the closest, but on every circumstance the distance must be shorter than 3 meters. The sampling pattern must include testing points adjacent to the connections to the service lines, electric connection to the building, crossing streets and branch connections.

Under this regulation, fugitive emissions included as part of this NAMA will be classified as Degree 3:

> "These types of leaks are not dangerous when detected nor do they represent any possible risk for the future, thus, it is only necessary to assess them periodically until they are fixed"[12].

As mentioned in the previous definition, these type of leaks are not dangerous and do not represent any risk, although it is necessary to assess them periodically. It should be emphasized that in the Official Mexican Standard a time limit for its repair is not stated, and subsequently, the current practice for PEMEX is to repair natural gas leaks that are considered dangerous in the present or that could represent a risk in the future.

4.6 EMISSION SOURCES IN THE NATURAL GAS SYSTEM

Methane emissions may occur on along all the processes of oil and gas systems around the world; be it exploration, production, transport and distribution. Throughout the system, the gas passes by hundreds of valves, processing mechanisms, compressors, pipes, pressure-regulating stations and other equipment.

Emissions sources may be:

1. Emission during the exploration stage (drilling and well testing).

   In the exploration stage some methane emissions may occur as a result of the explosions that take place in exploration drilling process, when wells are being tested and during the well cleaning processes.
2. Emission related to unused associated gas (vented of flared).

   During the production of oil and natural gas, some gases which cannot be sold at that time are generated. This problem occurs primarily in the case of associated gas from oil production. Part of the associated gas can be used for energy generation in situ, but the remaining gases are used. Occasionally, the gas is re-injected into the oil field to enhance oil recovery, however in some cases it is vented or flared, which results in emission of methane and carbon dioxide.

[12] NOM-009-SECRE-2002. Monitoreo, detección y clasificación de fugas de gas natural y gas LP, en ductos. Page 8. Available at: http://www.sener.gob.mx/res/Acerca_de/nom009secre2002.pdf

3. Emissions due to venting or flaring of off-gasses form gas treatment facilities (associated and non-associated gases).

    - Residual Gases: occur when methane is dissolved in various fluid phases and subsequently released into the atmosphere after reducing the pressure of said fluid.
    - Purge Gas: purge gases are traditionally used in flaring and venting systems to prevent air from entering the system.
    - Blanket gas emissions of storage vessels: when filling the tanks with liquid condensate, the gas content of the container is replaced with liquid, and removed through an atmospheric venting or flaring systems. Many times the storage tanks are blanketed with nitrogen, resulting in reduced emissions.
    - Vessel breathing: as a result of fluctuations in the atmospheric temperatures gases and liquids constantly change their volume in the containers.
    - Passing valves emissions: when as a result of wear or fouling, flow valves (pressure relief valves, and check valves) do not close completely, a certain amount of natural gas leaks. These passing valve emissions tend to end up in high pressure flaring and venting systems.

    The process emissions may be calculated as the sum of process off-gas, purge gas, blanket gases and passing-valve emissions. It is important to clarify the amount of high pressure steam which is used on site or is re-compressed, to which extent gas streams are flared instead of vented, how much gas is purged and signal out the amount of emissions avoided in valves when doing this estimations.

4. Emission related to maintenance of the natural gas systems.

    During routine maintenance, some amounts of methane can be released. This occurs, for example, when processing equipment or pipelines are depressurized and flushed with air, before maintenance.
5. Emission related to energy requirements.

    Methane emissions related to the oil and gas systems energy requirements are part of the exhaust emissions but may also take place during engines and turbines start up and shut down.

- Exhaust emissions: a series of incineration processes are used for various purposes such as heaters and reciprocating engines and turbines used to supply the energy required to operate the compressors and generate electricity. In many occasions said incineration processes use natural gas as combustion fuel and can be a considerable source of methane emissions as a result of incomplete combustion.
- Non-exhaust engine-emissions: when reciprocating engines are shut down they must be cleaned for security reasons, this is done by flushing them with air, likewise before starting up they must be slushed several times with natural gas, thus causing large amounts of natural gas to be released to the atmosphere. Therefore, both in start-up and shutdown engines have methane emissions.

6. Emission from compressors.

   Gas compression is an essential part of gas transmission systems as a compression station is necessary every 100-150 km, causing a series of methane emissions to the atmosphere.

- Seal losses: the compressor axis rotates inside of the compressor casing and the connections between these parts cannot be made airtight and as a result the seals between the axis and the casing present fugitive emissions continuously.
- Passing-valves emissions: Other contributors to the emissions of a compressing station are open-end valves, pressure-safety valves and block-valves, none the less, with a good maintenance and proper control systems the amount of emissions can be reduced.
- Start-up / shut-down: Methane emissions may also arise during start-up and shut-down. During start up compressors are flushed with natural gas, while on shut-downs they are flushed with air, both practices result in methane emissions. However, after short term shut-downs, in order to enable a quick start up compressors are left filled with gas instead of being flushed with air.

7. Emission from pneumatic devices.

   Pneumatic devices are commonly used all throughout the natural gas system, from well-sites to pipelines. Transmission and production system valves and actuators may be operated using hydraulic pressure of natural gas to adjust the valves, and other components, after which it is vented to the environment.

8. Emission during system upsets.

   When there is a system upset, safety systems come into action. When this happens the pressure relief valves are opened, depressurizing the system, the off-streams of liberated gases are normally flared or be vented.

9. Fugitive emissions from process equipment, transportation, storage facilities and from the distribution grid.

   It is common to have chronic fugitive emissions in natural gas systems; said fugitive emissions originate in joints, flanges and valves, among other sources, and are usually between 6 and 10 m^3 per day. Nevertheless, when adding the total amount of these fugitive emissions for the entire system it may become a significant contribution.

   - Exploitation and transport: although larger fugitive emissions can be easily detected due to abrupt changes in pressure, causing the formation of ice on the flanges, chronic smaller fugitive emissions are more difficult to handle and can occur throughout the system.
   - Distribution: fugitive emissions throughout the distribution system are difficult to estimate. Emissions can be estimated by calculating the difference between the inputs and outputs of the system, however this method is not very reliable because of the inaccuracies on metering equipment.

Many studies on natural gas distribution systems have been carried out in the past years and they all agree upon the same conclusion: most of the natural gas emissions are caused by old cast iron distribution lines, accentuating on the hemp-joints, and new systems tend to have fewer fugitive emissions. Approximately 90% of the fugitive emissions take place on the distribution systems, other sources of fugitive emissions may be storage facilities.

4.7 DETECTION AND REPAIR OF SOURCES THAT GENERATE FUGITIVE EMISSIONS

To evaluate the economic feasibility of repairing or replacing a component it should be enough to quantify, by estimation or measurement, the rates of fugitive emissions. Quantitative methods may be by modelling the process, material balances, capture and measurement systems, sampling techniques in ducts, screening tests and some remote sensing methods, the method used will depend on the information available at the time (some methods are listed in Table 2 and Table 3).

Table 2. Leak detection and measurement methods[13]

QUALITATIVE METHODS	QUANTITATIVE METHODS
Bubble Tests	Portable Organic Vapour Analysers
Optical emissions detection (Leak imaging)	Quantitative remote sensing techniques
Ultrasonic Leak Detectors	Engineered estimates

Table 3. Summary of Screening and Measurement Techniques[14]

INSTRUMENT/TECHNIQUE	EFFECTIVENESS	APPROXIMATE CAPITAL COST
Soap Solution	**	$
Electronic Gas Detectors	*	$$
Acoustic Detection / Ultrasound Detection	**	$$$
Toxic vapour analyser / Flame ionization Detector	*	$$$
Bagging	*	$$$
High Volume Sampler	***	$$$
Rotameter	**	$$
Leak Imaging	***	$$$

* Least effective at screening/measurement *** Most effective at screening/measurement $ Smallest capital cost $$$ Largest capital cost

[13] Canadian Association of Petroleum Producers (CAPP). Best management practice: Management of Fugitive Emissions at Upstream Oil and Gas Facilities. January 2007. Page 6.

[14] Canadian Association of Petroleum Producers (CAPP). Best management practice: Management of Fugitive Emissions at Upstream Oil and Gas Facilities. January 2007. Page 7.

A component that is leaking does not necessarily need to be changed if this is too expensive to replace, if it poses no threat to safety, health or the environment, in such cases it shall be marked so that the component may be screened in the next scheduled survey of fugitive emissions.

To evaluate the economic benefits of repairing a leak or repair the component that is leaking the following factors should be considered: market value of natural gas, the cost of repair and replacement of equipment and the life of the chosen solution.

The instruments used in the detection and measurement must be calibrated regularly according to the manufacturer's recommendations and when problems arise, they must also be serviced by the manufacturer or technicians authorized by the manufacturer. To ensure that fugitive emissions components are identified and repaired adequate records must be kept, this will help the appropriate follow-up for each case are taken[15].

4.7.1 Fugitive Emissions detection and estimation applicable EPA Methods

There are internationally recognized methods to identify leaks in components and estimate leakage flow in the same components in land, offshore and in the processing of gas, examples of these are those developed by the Environmental Protection Agency (EPA) of the United States: "EPA Method 21" and "EPA protocol for estimating equipment leak emissions." These methods are presented in this NAMA as an alternative for project proponents to identify sources and estimate fugitive emissions flow generated in these.

EPA Method 21 is used to determine the leak (or fugitive emissions for purposes of this NAMA) of volatile organic compounds (VOCs) in processing equipment. These sources may include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

[15] Canadian Association of Petroleum Producers (CAPP). Best management practice: Management of Fugitive Emissions at Upstream Oil and Gas Facilities. January 2007. Pages 9-12.

For its part, the EPA Protocol target is to present a standard procedure for estimating emissions from equipment leaks. This protocol has four approaches for estimating leakage equipment:

- Average emission factors;
- Select by concentration ranges;
- EPA Correlations; and
- Unit-specific leak-rate correlations.

A more accurate approach would require further information for the component being analyzed. Under the approximations of average facto and of concentration ranges selection, emission factors are combined with the accounting of equipment to estimate total emissions. Due to the correlations approximations of the EPA, more concentration specific measurements are required of all equipment to be used in general correlations developed by EPA. Meanwhile, for the specific correlation approximation unit is required concentration measurement and quantification of the leakage flow of a set of components and the information is then used to develop specific correlations unit. Subsequently, the concentration values for all components are introduced in these specific correlations for estimation of emissions.

4.7.2 Practices and Technologies Recommended by the Natural Gas STAR Program

The Natural Gas STAR Program of EPA provides information of cost-effective opportunities to reduce methane emissions in a number of documents about Lessons Learned Studies, data sheets with Partner Reported Opportunities, Technical Presentations and articles Partner Updates on the program projects. Some of the lessons learned under the Natural Gas STAR program are projects with a great potential for application on processing, transmission and distribution systems of natural gas in Mexico. A list of some of these practical cases are shown on Table 4, (Natural Gas STAR Program: Recommended Technologies and Practices. Available at: http://www.epa.gov/gasstar/tools/recommended.html) for further information refer to Annex II:

Table 4. Case studies of improved efficiency of components to reduce fugitive emissions

Replacement of wet seals by dry seals in centrifugal compressors	The rate of methane emissions in a compressor with wet seals ranges from 40-200 cubic feet per minute. In dry seals the maximum emission rate is 6 cubic feet per minute.
Replacement of Gas-Assisted Glycol Pumps with Electric Pumps	Methane emissions in energy exchange pumps are usually of 1,000 cubic feet per million cubic feet of gas treated. With electric pumps emissions can be reduced so that a dehydrator with 10 million cubic feet per day will save up to 3,000 cubic feet of gas per year.
Options to reduce methane emissions from pneumatic devices in the natural gas industry	Automatic control of valves, pressure controllers, flow, temperature or fluid levels in production systems, processing and transportation of natural gas tends to be pneumatic, which use the energy of pressurized natural gas that is released to the atmosphere. However control mechanisms can also be electric or by compressed air.
Installation of BASO® Valves	Use of BASO ® valves on oil heaters and processors avoids natural gas losses since the valves have temperature sensors and they can detect the temperature of the pilot flame of such equipment, closing the flow of natural gas when it detects that the flame is off.
Change pneumatic controllers to mechanical	With the change to mechanical control systems, which use mechanical linkages to transmit the position of the liquid with the use of float valves for drainage, losses of gas to the atmosphere typical of pneumatic systems can be avoided.
Installation of Flares	Avoids the release of gases containing methane, volatile organic compounds, hydrogen sulphide and other pollutants into the atmosphere by burning the gas flow. There are no savings by reducing emissions but manages to turn the leaked gas into gases with a lower environmental impact.
Install Electronic Flare Ignition Devices	Consists on the replacement of pilot flames to electric sparks, similar to those on modern stoves, which require little electrical power. According to EPA studies, the amount of methane lost with conventional pilots would be of 1.68M cubic feet per year.

5. METHODOLOGY FOR THE CALCULATION OF THE EMISSIONS REDUCTION CORRESPONDENT TO EACH PROJECT ACTIVITY

A key part in the development of this stage of the NAMA is the proposal of a methodology through which is established the criteria and formulas for calculating emission reductions estimated for each Project Activity.

The methodology used for determining the CO_2 equivalent emissions reduction related to the Project Activity reasonably minimizes the calculated uncertainty and generates accurate, coherent and reproducible results, following what is established by the standard NMX-SAA-14064-1-IMNC-2007.

In order to guarantee that the emissions reduction calculation be performed in the most successful and conservative way, the methodology AM0023 ("Leak detection and repair in gas production, processing, transmission, storage and distribution systems and in refinery facilities"[16]) has been used as reference, which has been approved by the United Nations Framework Convention on Climate Change (UNFCCC) for the validation of projects under the Clean Development Mechanism (CDM).

The development of this methodology includes the additionality assessment of each Project Activity, namely, to conclude if a certain Project Activity truly requires an incentive in order to be implemented and in consequence, obtain the emissions reduction calculated by the Project Proponent.

The emissions reduced by a Project Activity will be determined in function of the correspondent fugitive emissions reduction. Without limitation it is defined as follows:

Project Activity emissions reduction = Baseline emissions – Project Activity emissions

This can be observed in a schematic way in the following graphic:

[16] Available at: http://cdm.unfccc.int/methodologies/DB/PZN9ZCTGF3KHFH0W21NY0NYL6X5CIR

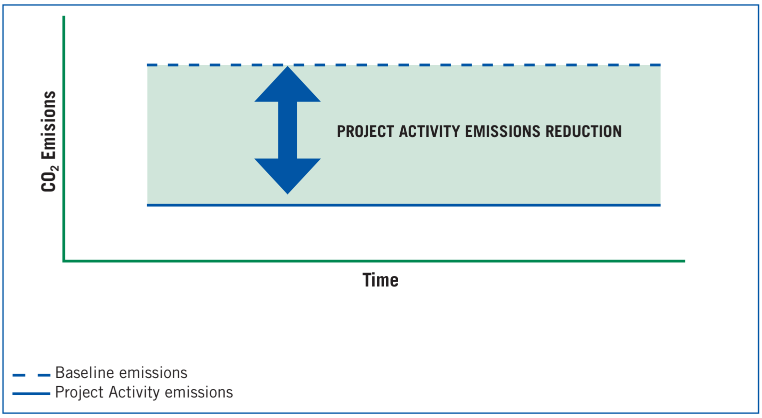


Figure 5. Emission reduction scheme

5.1 BASELINE

The baseline is defined as the Greenhouse Emissions that would be generated in absence of the proposed emissions reduction Project Activity. For the baseline identification is first necessary to identify the current situation and assess it for the lifetime of the Project Activity.

5.2 PROJECT ACTIVITY

A Project Activity is defined as a specific action or set of actions oriented to the Greenhouse Gas emissions reduction in relation with the baseline. At the same time, each Project Activity implementation can generate GHG emissions reduction that would have not existed in its absence, these emissions will be categorized as project emissions.

5.3 PROJECT BOUNDARIES

Project boundaries correspond to the geographical location in which the components included in the Project Activity can be found.

A component is defined as: any process equipment in the production, processing, storage, and distribution systems, as well as in refineries. This can include valves, flanges and other connectors, pump seals, compressors seals, diaphragms, drains, meters, vents, among others.

5.4 ADVANCED FUGITIVE EMISSIONS DETECTION AND REPAIR PROGRAM

The methodology structured for this NAMA intends to focus in the reduction or elimination of the component's fugitive emissions through the introduction of an advanced fugitive emissions detection and repair program.

A conventional fugitive emissions detection and repair program corresponds to a program structured by the Project Proponent with the objective of identifying and repairing components that generate fugitive emissions. A conventional fugitive emissions detection and repair program also comprehends any measure of detections and repair that the Project Proponent follows due to the applicable national regulations.

Meanwhile, an advanced leak detection and repair program is one that exceeds a conventional program followed by each particular Project Proponent prior to the execution of a Project Activity. A differentiating document for a fugitive emissions detection and repair program can be qualified as advanced will be the creation of a database required to concentrate all the resulting information for each Project Activity, which at the same time will help to determine the emissions reduction resulting from it (direct to step 1 of the section "Methodology: Additionality and Emissions Reduction Calculation" for more details about the database contain).

An advanced fugitive emissions detection and repair program may also include:

- Adopting a more rigorous monitoring system, for instance: an increment in the components maintenance frequency of the component's in which fugitive emissions have been identify, resulting in a better monitoring and ultimately in a reduction of fugitive emissions.
- Use of a more advanced technology for the detection and quantification of fugitive emissions.

However, for these latest measures to be considered as part of an advanced fugitive emissions detections and repair program under this NAMA, the will have to be implemented including the reduction of fugitive emissions from the included components to the environment.

5.5 METHODOLOGY APPLICABILITY

This methodology is applicable to project activities that reduce fugitive emissions in components using as tool an advanced fugitive emissions detection and repair program.

This methodology is applicable to the following scenarios, while not being limited to them:

- Substitution of installed and operational components by others more advanced that represents a fugitive emissions reduction or complete elimination.
- Use of more efficient technology (that reduces or eliminates the fugitive emissions) as a replacement of components with an almost ending lifetime, and the considered replacements are components with the same or similar efficiency level.
- Use of a more efficient technology (that generates a lower quantity of fugitive emissions or none at all) in the construction of new projects, taking as reference the technology initially considered for them.
- Implementation of a more advanced component monitoring system where the generation of fugitive emissions had been identified. For instance, the increase of the frequency of the preventive maintenance, beyond the minimum specified by the supplier, meaning an additional effort from the Project Proponent.
- Use of a more advance technology for the detection and repair of fugitive emission sources. This should go beyond the one used by the Project Proponent in the past, therefore meaning an additional effort by the Project Proponent.

Some practical cases can be included as part of the scenarios explained in further detail in section 4.7.2 “Practices and Technologies Recommended by the Natural Gas STAR Program”. Additionally, rich methane streams projects and methane recovery projects in Nitrogen Rejection Units (NRUs) could be considered.

Methane emissions produced from process venting or pigging for pipelines maintenance can reach significant levels, for this reason the recovery of this methane streams for its later use can mean a considerable opportunity for the reduction of fugitive emissions. Moreover, despite the low percentage of methane in the nitrogen streams removed through the NRUs, the impact of this source of fugitive emissions is high due to the considerable volume involved in the phase of natural gas processing.

5.6 METHODOLOGY: ADDITIONALITY AND EMISSION REDUCTIONS CALCULATION

Baseline emissions, according to the previous definition, refer to the quantity of methane released as fugitive emissions from the components included in a specific Project Activity.

The methodology comprises the six following steps:

1. Description of the Project Activity advanced fugitive emissions detection and repair program.
2. Project Activity additionality assessment.
3. Project Activity lifetime determination.
4. Baseline emissions calculation.
5. Project Activity emissions calculation.
6. Project Activity emissions reduction calculation.

5.6.1 Step 1: *Description of the Project Activity advanced fugitive emissions detection and repair program*

First, the Project Proponent will have to describe the current fugitive emissions detection and repair practices performed before the implementation of the Project Activity that looks for its registration as part of this NAMA.

The following criteria can be taken into account to be included in such description:

- Safety aspects: Some physical leaks need to be repaired for safety reasons. An assessment of the safety regulations, local industry safety standards and their implementation may help in identifying what types of physical leaks are detected and repaired under the current safety regulations or other legislation of the country and local industry safety practices.
- Accessibility: Some physical leaks may not get detected by a conventional fugitive emissions detection and repair program because

they are inaccessible (e.g. they occur in crowded areas, are unsafe to access due to hot surfaces, etc.).

- Visibility, audibility and/or smell: Some companies may detect and repair fugitive emission sources only if staff see, smell or hear it.
- Leak detection technologies: The types of physical leaks that are identified may depend on the technology used to detect physical leaks. The introduction of new advanced technologies as part of the Project Activity may help to identify physical leaks that would otherwise be ignored.

The following information can be used:

- Written protocols and registries for the repair of fugitive emission sources of previous years.
- Specifications and design standards of the equipment.
- Internal procedures of personnel training for the detection and repair of fugitive emissions.
- Documentation of the technology and equipment used to detect fugitive emissions and available material to perform the correspondent repairs.

Afterwards, the advanced fugitive emissions detection and repair program that will be incorporated as part of the Project Activity will have to be described.

As was mentioned before, the main characteristic of an advanced fugitive emissions detection and repair program under this NAMA will be the establishment of a database for the gathering of the information that will be used for the calculation of the emission reductions of the Project Activity. In general, it is recommended that the database includes the following information by each component where fugitive emissions are identified:

1. Data to clearly identify the component: ID number, component type, component size, service, area, processing unit, component location, installation type.
2. Fugitive emission source relevant information: Detection date, applied method, the responsible of the fugitive emission detection, detection reading (if applicable e.g. screening value or leak image, etc.).

3. In case measurements of the flow from the physical leak are undertaken, relevant information on the measurement: date of measurement, the measurement method applied, the measured leak rate and the uncertainty of the measurement.
4. Hours during which the component is in pressurized natural gas or refinery gas service since the last leak survey.
5. Information regarding the eligibility of the physical leak to be included in the Project Activity (information that is required to distinguish between leaks detected by the conventional fugitive emissions detection and repair program and the advanced program).
6. Relevant information about the component repairing attempts.

The database will be continuously updated during the Project Activity lifetime with information of the repaired or replaced components that originally produced fugitive emissions.

5.6.2 Step 2: Project Activity additionality assessment

For the Project Activity to be registered as under this NAMA will have to meet the following criteria, known as additionality criteria.

Additionality criteria: For a Project Activity to be additional it will have to meet the following requirements:

a) Adopt an advanced fugitive emissions detection and repair program.
b) The measures to be implemented as part of this Project Activity in order to reduce fugitive emissions within the project boundaries will have to meet the applicable Mexican regulations with the purpose of guaranteeing that the minimum operational requirements of the country are met.
c) The Project Proponent must prove that it has implemented at least one of the following options:

- A more efficient component (that based on technical specifications generates a lower quantity of fugitive emissions) than the one that would be used in the baseline.
- A more rigorous monitoring system in relation to the installed previously to the Project Activity.

- A more advanced technology for the detection and monitoring of fugitive emissions.

5.6.3 Step 3: *Project Activity lifetime determination*

When calculating the baseline emissions, it is presumed that the fugitive emissions are generated as part of the normal operation of a certain component and that additional actions should be performed in order to reduce or stop said fugitive emissions' source.

Baseline emissions will be considered until the repair, substitution or improvement of a component is performed or a certain detection and repair system or equipment is implemented in scheduled basis. This can be evidenced through any of the following:

- Current sectorial practices.
- Maintenance program followed by the Project Proponent.
- Lifetime of the component specified by the manufacturer.
- Public information specific for the component of the Project Activity.

5.6.4 Step 4: *Baseline emissions calculation*

There are two options for the baseline emissions calculation:

Option 1: Use any tool listed in the "monitoring equipment" section (refer to the Annex IV of this document) to detect (not to quantify) the fugitive emissions and apply default emission factors developed by the American Petroleum Institute), using methods of EPA as base, information from the manufacturer, or any equivalent source.

The emissions will have to be calculated multiplying the methane fraction in the natural gas or refinery gas with the appropriate emission factors and adding all the components at the end, as shown below:

$$BE_y = \frac{1}{1000} \times GWP_{CH_4} \times w_{CH_4,Y} \times \sum_i \sum_r \left[EF_i \times T_{i,r} \right] \qquad \textbf{(1)}$$

Where:

BE_y	=	Baseline emissions for the year *"y"* (t CO_2e).
GWP_{CH_4}	=	Global warming potential of methane (t CO_2e/t CH_4).
$w_{CH_4,y}$	=	Average mass fraction of methane in the natural gas/ refinery gas for crediting year *"y"* (kg CH_4/kg gas).
EF_i	=	Emission factor for the component type i (kg/hour/ component type).
$T_{i,r}$	=	The time the component r of component type i would leak in the baseline scenario and would be eligible for crediting during the crediting year y (hours).
i	=	Component types as classified by the "*API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry*" 2009, tables 6-17, 18, 19, 21 (or any similar standard).
r	=	Components of component type i for which physical leaks were detected during initial survey and repaired and which would leak in the baseline scenario during the crediting year *y*.

Option 2: Measure of the flow rates of the fugitive emissions through the use of appropriate technology for measurement as described in section of *"Monitoring Equipment"* (please direct to Annex IV of this document).

The baseline emissions are calculated as follows:

$$BE_y = ConvFactor \times \sum_j \left[F_{CH_4,J} \times T_{j,y} \times (1\text{-}UR_j) \right] \times GWP_{CH_4} \qquad \textbf{(2)}$$

Where:

BE_y	=	Baseline emissions for year "*y*" (t CO_2e).
ConvFactor	=	Conversion factor to convert Nm_3 CH_4 to t CH_4.
j	=	All physical leaks that are included in the Project Activity for which physical leaks were detected and repaired and which would leak in the baseline scenario during the crediting year *"y"*.
$F_{CH_4 j}$	=	Measured flow rate of methane for the physical leak *j* from the leaking component (m³ CH_4/h).

UR_j	=	Uncertainty range for the flow rate measurement method applied to physical leak *j*.
$T_{j,r}$	=	The time the relevant component, in which physical leak j occurred, would leak in the baseline scenario and would be eligible for crediting during the crediting year *"y"*.
GWP_{CH_4}	=	The global warming potential of methane (t CO_2e/t CH_4).

The uncertainty of the measurement is taken into account conservatively by using the flow rate at the lower end of the uncertainty range of the measurement at a 95% confidence interval for baseline emissions from leaks. For example, if the measured flow rate is 1 m³/h and the uncertainty range of the measurement method is ±10%, emissions reductions shall be calculated based on a flow rate of 0.9 m³/h. Given the large quantity of measurements potentially involved in the baseline study, calculation methods provided in the IPCC Guidelines to calculate uncertainty range using the combined uncertainties of all measurements can be used.

The following assumptions will have to be applied to the baseline emissions calculation:

- For the components in which no fugitive emissions have been detected in a first inspection and where fugitive emissions have been identify in subsequent inspections, baseline emissions will have to be accounted from the detection of the fugitive emissions source.
- Fugitive emissions of a specific component will be included in the calculation until the end of the lifetime determined in step 3.

5.6.5 Step 5: *Project Activity emissions calculation*

Project emissions account those emissions occurring in the components included within the Project Activity boundaries in case a repair stops working, while this fugitive emissions source lasts without being repaired again.

Project emissions are calculated as follows:

Option 1:

$$PE_y = \frac{1}{1000} \times GWP_{CH_4} \times w_{CH_4,Y} \times \sum_i \sum_x \left[EF_i \times T_{i,x} \right] \quad \textbf{(3)}$$

Where:

PE_y	=	Project emissions in crediting year *"y"* (t CO_2e).
GWP_{CH_4}	=	Global warming potential of methane (t CO_2e/t CH_4).
i	=	Component types as classified by the API Compendium[17] (see Annex III) or equivalent standards.
$w_{CH_4,y}$	=	Average mass fraction of methane in the natural gas/ refinery gas for crediting year *y* (kg CH_4/kg gas).
EF_i	=	Emission factor for the component type *i* (kg/hour/ component type).
$T_{i,x}$	=	The time the component *x* of component type *i* was leaking during the crediting year *y* (hours).
x	=	All components of component type *i* that are accounted for as project emissions during the crediting year *y*.

For Option 2:

$$PE_Y = ConvFactor \times \sum_2 \left[F_{CH_4,Z} \times T_Z \times (1\text{-}UR_Z) \right] \times GWP_{CH_4} \quad \textbf{(4)}$$

Where:

PE_Y	=	Project emissions in crediting year *y* (t CO_2e).
ConvFactor	=	Conversion factor to convert Nm_3 CH_4 into t CH_4.
Z	=	All fugitive emission sources that are accounted for as project emissions during the crediting year *y*.
$F_{CH_4 j}$	=	The fugitive emissions flow rate of methane for the physical leak *z* from the component that releases fugitive emissions (Nm_3CH_4/h).

[17] American Petroleum Institute (API). "Compendium of greenhouse gas emissions estimation methodologies for the oil and natural gas industry". 2009, tables 6-17, 18, 19, 21. Available in: http://www.api.org/ehs/climate/new/upload/2009_ghg_compendium.pdf

UR_z	=	The uncertainty range for the measurement method applied to fugitive emission source *z*.
T_z	=	The time the relevant component has been releasing fugitive emissions during the crediting year *y* (hours).
GWP_{CH_4}	=	Global warming potential of methane (t CO_2e/t CH_4).

The uncertainty of the measurement is taken into account conservatively by using the flow rate at the upper end of the uncertainty range of the measurement at a 95% confidence interval for project emissions from leaks. For example, if the measured flow rate is 1 m^3/h and the uncertainty range of a measurement is ±10%, emissions reductions will be calculated at an effective flow rate of 1.1 m^3/h. Given the large quantity of measurements potentially involved, calculation methods provided in the IPCC Guidelines to calculate uncertainty range using the combined uncertainties of all measurements can be used.

If a repair of a fugitive emissions source ceases to function, the following assumptions must be made when calculating the project emissions:

a. At the same flow rate that was measured prior to its repair when using only fugitive emissions detection equipment.
b. At the newly measured rate if the fugitive emission source is re-measured at the time of monitoring.
c. At the flow rate specified by the 2009 API Compendium, the determined based on the methods from EPA, the component's manufacturer information, or any equivalent source (in case of Option 1).

It is further assumed that the component produced fugitive emissions from the last survey it was subjected without any fugitive emission being perceived. Therefore, the fugitive emissions produced where the repair has failed will have to be included in the project emissions until one of the followings occurs (the first one occurring):

a. The source of fugitive emissions is repaired and does not stop working.
b. The replacement of the component where fugitive emissions were being produced.

5.6.6 Step 6: *Project Activity emissions reduction calculation*

As it was established at the beginning of this section, the emissions reduction calculation as part of a Project Activity must be performed based on the following formula:

Project Activity emissions reduction = Baseline emissions – Project Activity emissions

5.7 PROJECT ACTIVITY MONITORING

According to the parameters established in the UNFCCC approved methodology, below are presented the monitoring procedures and the variables that will have to be taken into account during this stage.

5.7.1 Establishment of a database

Refer to step 1 of the previous section, *Methodology: Additionality and Emission Reductions Calculation.*

5.7.2 Data gathering during implementation phase

The project implementation includes an initial monitoring check followed by regular subsequent monitoring checks of each component within the project boundaries. Increasing the frequency of the monitoring check will increase the control level over the fugitive emission sources.

5.8 MONITORING REQUIREMENTS

The following information will have to be collected for each component that generates fugitive emissions for each regular monitoring check:

- Date of monitoring.
- The number of hours during which the component is in pressurized natural gas or refinery gas service.
- An assessment whether the repair, the replacement or improve-

ment of the component, or the implementation of an improved fugitive emissions detection and repair system or equipment, as applicable, operates appropriately.

All of the previous information, as well as the parameters to be monitored (refer to Annex V), must be added to the database created as part of the advanced fugitive emissions detection and repair program.

This NAMA does not establish a maximum or minimum monitoring period, being open to the Project Proponent's consideration. The verifications must be performed by a Designated Entity (DE) authorized by the Coordinating Entity (CE) and hired by the Project Proponent (PP)[18].

[18] The function of these entities will be explained in further detail in the Validation and Registration Mechanisms section.

6. VALIDATION MECHANISM AND REGISTRATION

The validation of a Project Activity (PA) is a rigorous process in order to determine if the applicability conditions and additionality criteria are met. This stage also seeks to ensure that the benefits of each Project Activity are real, measurable and enduring, having as a final result the registration of a Project Activity to the NAMA. The following explains the options for validation:

- Validation mechanism similar to that followed under the CDM or VCS.
- Mechanism established by the financing source obtained by a specific Project Activity.

The validation and registration process requires the interaction of the following participants:

- Coordinating Entity (CE): This institution focuses the information from the different project activities registered in the NAMA. Evaluates and authorizes third parties to perform functions as Designated Entity, keeps track of emissions reduction as a result of the NAMA and produces statistical results.

  There can only be one Coordinating Entity, this may be a government agency or private entity that is not a Project Proponent, it shall act impartially being alien to the interests of Project Proponents and will be chosen by the various funders of this NAMA together with at least one entity of the Mexican government. Operating expenses of the Coordinating Entity will be covered by the funds jointly sponsoring activities that integrate the NAMA project.
- Project Proponent (PP): entity responsible for the Project Activity. The Project Proponent is the responsible for all the activities related to the conceptual development of the Project Activity and the execution of it. Among others, the activities that it must perform are the following:
  1. Develop the Project Document (PD).
  2. Calculate the emissions reduction resulting from the Project Activity.
  3. Establish a procedure for monitoring, collecting and storing the information.

4. Provide all information necessary Project Activity to be validated by the Designated Entity. This information must be supported by reliable documentation.
5. Organize and coordinate the validation and verification of their respective Project Activity.
6. Transmit to the Coordinating Entity the primary documentation that supports its registration as Project Activity within this NAMA and, at the conclusion of each stage of verification, documentation certifying emission reductions for each verification period.

- Designated Entity (ED): Independent entity that acts as auditor of each Project Activity that wants to participate in the NAMA. Its obligation is to verify compliance with the applicability conditions and additionality criteria, and validate the emissions reduction calculation achieved by each Project Proponent.

  This entity may be a Designated Operational Entity (DOE) accredited by the UNFCCC, a body recognized by the Mexican Accreditation Entity (EMA) or a third party with proven experience in projects that reduce emissions GHGs. The ED must be approved by the Coordinating Entity of the NAMA.

The projects that wish to be a part of this NAMA must elaborate a Project Document (PD)[19] that contains the information presented in the Annex VI “Project Document Template”.

6.1 ANALOG VALIDATION MECHANISM TO THAT FOLLOWED BY THE CDM AND VCS

The validation process of this option must be coordinated by the Project Proponent and must be endorsed by a Designated Entity unrelated to the Project Proponent. The validation process is the following:

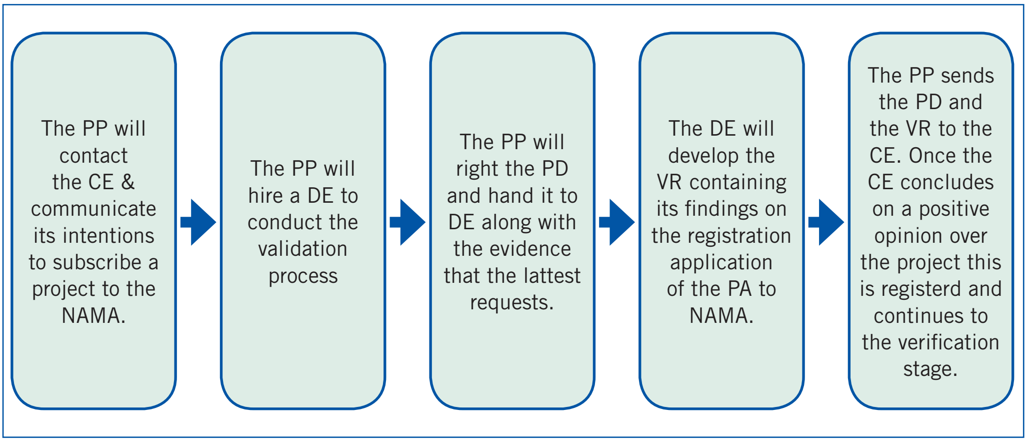
1. The Project Proponent should contact the Coordinating Entity in order to inform their interest in participating in the NAMA.

[19] This document can be found in the Annexes.

2. The Project Proponent establishes contact with a Designated Entity to coordinate and begin the validation process. The Designated Entity must be hired by the Project Proponent.
3. The Project Proponent will present the documentation required by the Designated Entity to conduct the validation process to reach the registration of the Project Activity.
4. The Project Activity on validation is subject to an eligibility process conducted by the Coordinating Entity to determine the need for a site visit as a requirement for registration. If a visit is necessary, it will be organized and coordinated by the Project Proponent, otherwise the Coordinating Entity shall make a notification to the Designated Entity who will then proceed with the preparation of the Validation Report (VR)[20].
5. The Designated Entity must deliver the Project Proponent a Validation Report containing an analysis of the Project Activity, a description of the validation process and a conclusion on the eligibility of the correspondent Project Activity as part of the NAMA described in this document (refer to Annex VIII "Validation Report Template").

Upon completion of the validation, the Project Proponent shall send a copy to the Coordinating Entity of the Project Document and the Validation Report. A project will be registered in this NAMA when obtaining a positive opinion by the Coordinating Entity, which must be in the Validation Report.

Figure 6. Validation Process



[20] This document can be found in the Annexes.

6.2 MECHANISM ESTABLISHED BY THE FINANCING SOURCE OBTAINED BY A SPECIFIC AP

The fund or project sponsor may define its own validation mechanism. At the end of the validation process, the Project Proponent must deliver the Project Document, the calculation memory for the emission reductions (CM) and a document issued by the funding body that contains the description of the validation process followed by the Project Activity to the Coordinating Entity. Once the Coordinating Entity receives such documentation the project will be registered.

7. VERIFICATION

The verification process is carried out between the Project Proponent and the coordinating entity. This process can use one of the two mechanisms presented as options for the validation stage: audit by a Designated Entity or mechanism defined by the financing entity. This activity is very important because it defines whether the reductions are granted or not Project Proponent.

Once a Project Activity has been registered or is in operation, Project Proponents must implement the monitoring plan outlined in this document and specifically stated in the Project Document.

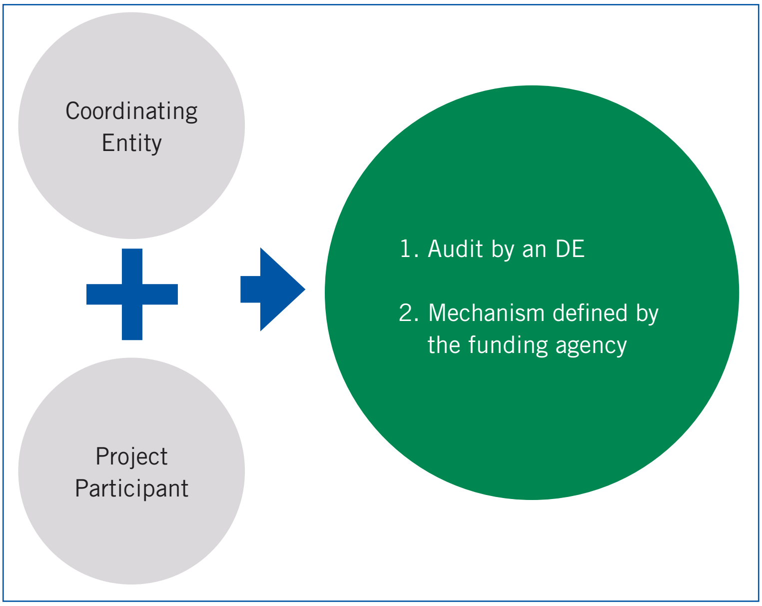


Figure 7. Verification Process

In the event that the Project Proponent wishes to hire a Designated Entity to this stage, it must present to the Coordinating Entity the Monitoring Report (prepared by the Project Proponent, see Annex VII "Monitoring Report Template") and Verification Report (prepared by the Designated Entity, see Annex IX: " Verification Report Template "), the latter will contain the resolution in relation to the emission reductions from the Project Activity and serve as an endorsement of the outcome of the stage verification. If a visit to the site is required, the Project Proponent shall submit to the Designated Entity the documentation for the first monitoring period within no less than 30 calendar days prior to the site visit to initiate the review.

In case the verification is done following the mechanism established by the funding body, the Project Proponent shall submit to the Coordinating Entity the Monitoring Report and a document issued by the funding body containing a description of the verification process followed by the activity of project.

Once the Project Proponent has delivered the corresponding documentation for the selected verification mechanism to the Coordinating Entity, the Coordinating Entity will certify the emission reductions corresponding to the Project Proponent for the monitoring period assessed.

8. EMISSION REDUCTION GOAL

8.1 ESTIMATED REDUCTION

Based on default emission factors of methane from natural gas systems in industrialized countries, which can be found in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual*, we can estimate the maximum potential CO_2 equivalent reduction in Mexico. The reference emission factors are:

Table 5. Predetermined CH_4 fugitive emissions factors for the processing, transport and distribution of natural gas

	UNITS	PREDETERMINED EMISSIONS FACTORS
United States and Canada	tCH_4/PJ	57*
Western Europe	tCH_4/PJ	72*
Other oil exporting countries / Rest of the world	tCH_4/PJ	118*

** Conservatively, the lower limits of emission factors were taken.*

Drawing on information from the previous table, the corresponding emission factor for tCH_4/PJ Mexico is 118, while for Western Europe it is 72 tCH_4/PJ and for the United States and Canada it is 57 tCH_4/PJ, being the processing, transportation and distribution systems of natural gas from these last two countries the one that generate the least amount of fugitive emissions by PJ of natural gas produced worldwide.

According to the most recent public information (see Table 6), Mexico has produced a total of 6706.18 PJ of natural gas in the period 2009-2011, this is, an average of 2235.39 PJ / year.

According to the above data the processing, transmission and distribution system of natural gas in Mexico may set as an aspirational goal to reach the levels of fugitive emissions from developed countries such as the U.S. and Canada, these being the most efficient international systems. Below is the calculation of the potential for reducing fugitive emissions:

Table 6. Primary energy production 2009-2011 (Peta Joules)

Description	Primary energy production (PJ)		
	2009	2010	2011
Total	**9,474.71**	**9,250.71**	**9,190.76**
Coal	***222.18***	***241.28***	***290.96***
Hydrocarbons	***8,530.08***	***8,304.34***	***8,151.63***
Crude oil	6,058.73	6,008.64	5,933.53
Condensed oil	86.08	92.51	100.38
Natural gas	2,385.27	2,203.19	2,117.72
Nuclear energy	***112.75***	***63.94***	***106.39***
Renewable	***609.71***	***641.14***	***641.78***
Hydropower	95.20	132.26	130.56
Geothermal	152.69	149.94	149.29
Solar energy	4.06	4.91	5.86
Wind energy	7.24	4.46	5.93
Biogas	1.12	1.30	1.47
Biomass	349.40	348.28	348.67
Bagasse	*88.73*	*88.97*	*90.58*
Firewood	260.68	259.31	258.09

Table 7. Fugitive emissions reduction potential (tCO_2e)

Parameter	Value
Emission Factor for United States and Canada (tCH_4/PJ)	57
Emission Factor for Mexico (tCH_4/PJ)	118
CH4 Global Warming Potential (tCO_2e/tCH_4)	21
Annual production of natural gas (PJ)	2,235
Emissions reduction potential (tCO_2e)	2,863,035

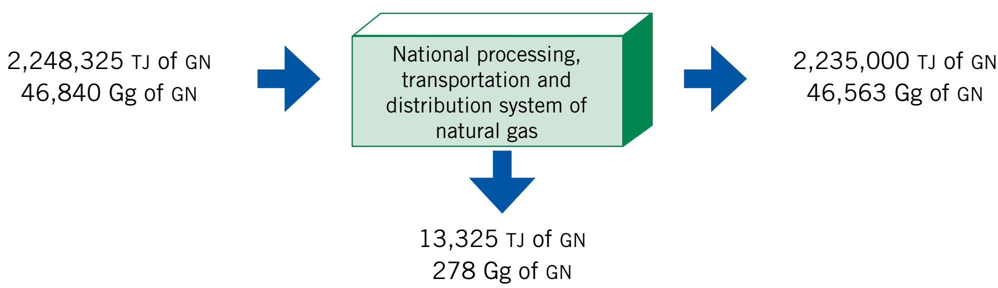
When evaluating the results of Table 7, we find that the maximum emission reduction potential for this NAMA is 2,863,035 tCO_2 equivalent per year. Reaching this goal would represent an upgrade and optimization of the national natural gas system to a more advanced level on a global scale, specifically for the stages of processing, distribution and transmission of natural gas. Being that the comparison is to a high efficiency system, but one that still presents fugitive emissions from the operations of the natural gas system, this potential represents a realistic and achievable goal through this NAMA.

8.2 MASS AND ENERGY BALANCE FOR THE NATIONAL PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEM OF NATURAL GAS

Using as a reference the national production of natural gas in 2011 which amount to 2,235,000 TJ according to the information contained in Table 6, and methane fugitive emissions estimated as the maximum potential for the present NAMA (2,863,035 tCO2 equivalent per year, equal to tCH_4 263.730 per year), it is possible to set the following mass balance for the current national processing, transportation and distribution system of natural gas:

According to the above, this NAMA aims to become a platform for small projects that together allow the recuperation of 278 Gg of GN, which translates to 0.6% of national production.

Figure 8. Mass and Energy Balance for the National Processing, Transport and Distribution System of Natural Gas*



** For the above calculations data from the IPCC[21] and the official PEMEX[22] webpage have been used.*

[21] 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. Chapter 1, page 1.18. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf

[22] Official PGPB webpage. Gas Natural. Available at: http://www.gas.pemex.com/PGPB/Productos+y+servicios/Gas+natural/


ENTRADA A DESHIDRATADORAS
CABEZAL 20" SALIDA DE DESHIDRATADORAS

9. PROJECT FINANCING

The funding required for a particular Project Activity to be economically feasible, should be clearly defined by the Project Proponent in Section A.2 of the Project Document Template (refer to Annex VI). Such an assessment should have been carried out based on supporting documents that allow each data support.

Due to the large scope of the NAMA and the wide range of project activities that may be presented, evaluation methods of capital costs will not be limited for the calculation of the funding requested for the Project Activity, including alternatives such as calculating the rate Internal Rate of Return (IRR) and Net Present Value (NPV).

The estimated funding for each Project Activity will come from funds, through carbon credits and any equivalent provided by a third party so that as a whole it sums up the amount requested by the Project Proponent.

A couple case studies that may be used to determine funding are presented.

9.1 EMISSION REDUCTIONS CDM PROJECT "REDUCTION OF METHANE EMISSIONS IN THE GAS DISTRIBUTION NETWORK OF ARMENIA REPUBLIC"[23]

This project is presented under conditions similar to those in Mexico. The distribution network of natural gas included in its Project Activity has, as baseline scenario, with a conventional system leak repair, focusing primarily on compliance with the laws of the country, focused on the safety of operating personnel and society.

The Project Activity presented suggests the acquisition and use of advanced technologies for the detection, measurement and repair of fugitive emissions, as part of an advanced system as it is described in the proposed methodology. It is expected that project activity, which is focused on the repair of 15,282 valves included in the network, can prevent the drain of 1.98 liters of methane per part, which corresponds to 222, 657 tons CO_2 equivalent.

[23] Information available at: http://cdm.unfccc.int/Projects/DB/BVQI1314039132.28/view

The funding through carbon credits, will enable defray the high costs of:

- Leak detection and measurement equipment
- Sealing systems of different dimensions
- Staff training for installation and maintenance of sealing systems
- Systematic collection of information
- Monitoring of loss prevention systems efficiency.

The project was approved on November 29, 2012 to receive carbon credits under the Clean Development Mechanism of the Convention of the United Nations Framework on Climate Change. This funding of about 1.8 million euros for the entire length of the project[24], amounting to approximately 26% of total investment (EUR 7 million of total investment) is a determining factor for the Project Activity to be carried out.

Although the project described above corresponds to only one of the possible activities in this NAMA, it is useful as a reference of how international financing activities have allowed similar benefits can be implemented.

9.2 EMISSION REDUCTIONS CDM PROJECT "LEAK REDUCTION IN ABOVE GROUND GAS DISTRIBUTION EQUIPMENT IN THE GAS DISTRIBUTION NETWORK UZTRANSGAZ- MARKAZGAZ (UZTG)"[25]

This project, based in Uzbekistan, aims to reduce leakage on gate stations, pressure regulating stations, valves and fittings, as well as interconnection points with industries and residential buildings.

The project was registered on November 27, 2010, which allows it to receive carbon credits under the Clean Development Mechanism of the Convention of the United Nations Framework on Climate Change.

The project estimates an annual reduction of 1,021,137 tons of CO_2 equivalent over a crediting period of 10 years, which translates to

[24] Carbon credit price on November 30, 2012. Source: http://www.eex.com/en/Market%20Data/Trading%20Data/Emission%20Rights/Certified%20Emission%20Reductions%20Futures%20I%20Derivatives/Certified%20Emission%20Reductions%20Futures%20History%20I%20Derivatives/futures-historic/2012-12/F2CR/2013.12

[25] Information available at: http://cdm.unfccc.int/Projects/DB/SGS-UKL1265038490.73/view

approximately 13 million euros as incentive, which represents a financial aid of 64% of the total project cost (just over 20 million euros).

9.3 ESTIMATED FINANCING FOR THE NAMA

Based on the previous cases reviewed in this section (see sub sections 9.1 and 9.2), the following information about investment and financing required for the implementation of the project activities can be summarized as follows:

Based on the above information and as an estimation, the information on Table 8 (which includes some of the activities considered for this NAMA, though not entirely) was used as reference to estimate an approximate value of the costs that the NAMA would have if it were to reach its maximum potential, as well as the approximate amount required as funding to make this a feasible project.

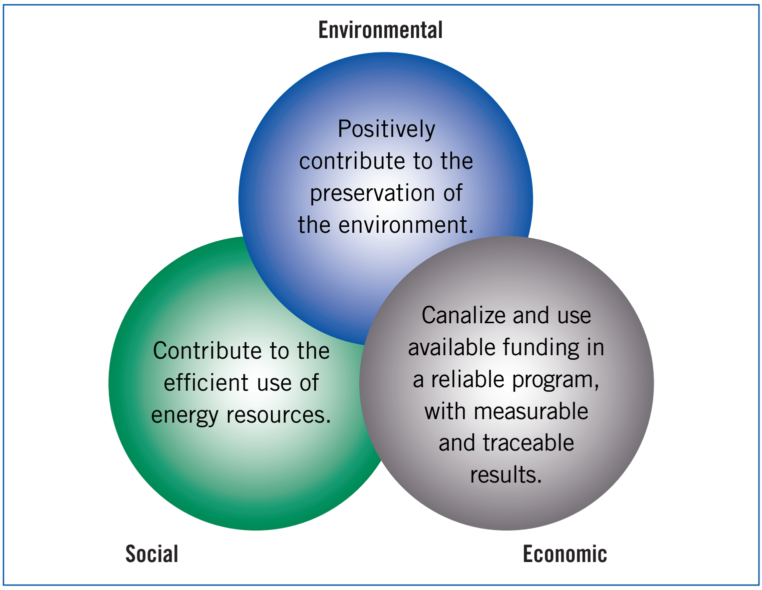
Thus it is considered that to achieve emission reductions estimated at 2,863,035 tonnes of CO_2 equivalent per year would require about 35 million euros for the implementation of the various project activities; for it would be expected to require funding of about 54% through any of the mechanisms previously described.

Table 8. Summary of economic incentives for international cases similar to the NAMA

Project Name	Total Project cost (Euros)	Project emission reductions per year (tCO2 eq/ year)	Economic incentive by carbon credits (Euros)	Financing %
Reduction of methane emissions in the gas distribution network of Armenia Republic	7,007,000.00 €	222,657	1,803,521.70 €	26%
Leak Reduction in Above Ground Gas Distribution Equipment in the Gas Distribution Network UzTransgaz- Markazgaz (UzTG)	20,392,630.00 €	1,021,137	13,037,121.19 €	64%
Average	**13,699,815.00 €**	**621,897**	**7,420,321.45 €**	**54%**

10. BENEFITS ON THE IMPLEMENTATION OF THE NAMA

This NAMA seeks to deliver environmental, social and economic benefits, which are presented as axes of the sustainable development.



Moreover, this NAMA is built upon the objectives of the Prosperity Fund in Mexico sponsored by the British Embassy in Mexico (FCO)[26]:

- The main beneficiary is Mexico.
- The project promotes global sustainable growth.
- The project encompasses a set of specific and measurable actions.
- The project may be developed on a regional or state level within Mexico.
- The fate of the funds received in support of project activities under the framework of this NAMA is clearly established.

[26] British Embassy in Mexico. Prosperity Fund guidance 2012-2013. Pages 2 y 3. Available at: http://uk.sitestat.com/fcoweb/ukingov/s?was.mex.resources.en.press-release.712765482.712767382.concept-bidding-round.p.pdf.prosperity-fund-guidance-jan-2012&ns_type=pdf&ns_url=http://ukinmexico.fco.gov.uk/resources/en/word/doc1/prosperity-fund-guidance-jan-2012

Finally, the tripartite collaboration between PEMEX-FCO-CO2 Solutions, seeks to aid reach the emission reductions goals that Mexico proposed as part of the Climate Change Law (published in the Official Journal of the Federation on June 6, 2012), which establishes the following:

> *"The country assumes the indicative goal or aspirational aim to reduce by 2020 thirty per cent of the emissions compared to the baseline; as well as a fifty per cent emissions reduction by 2050 compared to those issued in 2000".*

This NAMA seeks to capitalize the total 2,863,035 tonnes of CO_2 equivalent per annum that are presented as maximum potential, and for this joint efforts (here called project activities), through the appropriate channelling of national or international resources will be imperative.

10.1 OTHER BENEFITS

According what was detailed in the section of objectives and project description, current practices in leak detection and repair in Mexico are governed under the content of the NOM-009-SECRE-2002, in which security issues have a predominant role. Thus, the development of this NAMA will focus on the "fugitive emissions", which should not pose any risk to workers and to society; however it is important to stress that the application of an advanced leak detection and repair program, as is proposed for this NAMA, may be one more effort contributing to the current efforts on risk reduction and therefore minimize the chances of accidents by any improper handling of natural gas.

This is how, the proposed efforts, as well as collaborating on environmental, economic and social development in the country are also a useful tool in the prevention of risks.

ANNEXES

ANNEX I: GAS LEAK CLASSIFICATION ACCORDING TO MEXICAN LAW NOM-009-SECRE-2002 "NATURAL GAS AND LPG MONITORING, DETECTION AND CLASSIFICATION, IN DUCTS"

- Degree 1. Are those leaks that represent an imminent danger to people or properties, for this reason, once they are detected they must be immediately repaired and/or continuous actions must be carried out until it can be guaranteed that conditions are no longer dangerous. All situations where there is a possibility of asphyxia, fire or explosion at the area where the leakage occurs, are considered dangerous.
- Degree 2. Are those leaks that are not dangerous when they are detected but could represent a risk in the future. Their reparation must be programmed to prevent that they become dangerous.
- Degree 3: Are those leaks that are not dangerous when they are detected and do not represent a possible risk in the future, for this reason, they need to be re-evaluated periodically until they are repaired.

ANNEX II: NATURAL GAS STAR PROGRAM RECOMMENDED PRACTICES AND TECHNOLOGIES

Replacing Wet Seals with Dry Seals in Centrifugal Compressors[27]

Centrifugal compressors are widely used in production and transmission of natural gas. Seals on the rotating shafts prevent the high-pressure natural gas from escaping the compressor casing. Traditionally, these seals used high pressure oil as a barrier against escaping gas. Natural Gas STAR partners have found that replacing these "wet" (oil) seals with dry seals significantly reduces operating costs and methane emissions.

Methane emissions from wet seals typically range from 40 to 200 standard cubic feet per minute (scfm). Most of these emissions occur when the circulating oil is stripped of the gas it absorbs at the high-pressure seal face. Dry seals, which use high-pressure gas to seal the compressor, emit less natural gas (up to 6 scfm for a two seal system), have lower power requirements, improve compressor and pipeline operating efficiency and performance, enhance compressor reliability, and require significantly less maintenance.

An alternative to the traditional wet (oil) seal system is the mechanical dry seal system. This seal system does not use any circulating seal oil. Dry seals operate mechanically under the opposing force created by hydrodynamic grooves and static pressure.

[27] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Replacing Wet Seals with Dry Seals in Centrifugal Compressors. Available at: http://www.epa.gov/gasstar/documents/ll_wetseals.pdf

Replacing Gas-Assisted Glycol Pumps with Electric Pumps[28]

Approximately 36,000 glycol dehydrators in the natural gas production sector are used to remove water from the gas. Most glycol dehydration systems use triethylene glycol (TEG) as the absorbent fluid and rely on pumps to circulate TEG through the dehydrator. Operators use two types of circulation pumps: gas-assisted glycol pumps, also referred to as "energy-exchange pumps," and electric pumps.

Gas-assisted pumps are the most common circulation pumps in remote areas that do not have an electrical power supply. They are basically pneumatic gas driven pumps, specially designed to take advantage of the energy of high-pressure natural gas entrained in the rich (wet) TEG leaving the gas contactor. Additional high-pressure wet production gas is necessary for mechanical advantage, and therefore more methane rich gas is carried to the TEG regenerator, where it is vented with water boiled off of the rich TEG. The mechanical design of these pumps places wet, high-pressure TEG opposed to dry, low pressure TEG, separated only by rubber seals. Worn seals result in contamination of the lean (dry) TEG making it less efficient in dehydrating the gas, requiring higher glycol circulation rates. Typical methane emissions are about 1,000 cubic feet (Mcf) for each million cubic feet (MMcf) of gas treated.

Replacing gas-assisted pumps with electric pumps increases system efficiency and significantly reduces emissions. For example, a 10 MMcf per day dehydrator could save up to 3,000 Mcf of gas a year.

Options for Reducing Methane Emissions from Pneumatic Devices in the Natural Gas Industry[29]

The natural gas industry uses a variety of control devices to automatically operate valves and control pressure, flow, temperature or liquid levels. Control devices can be powered by electricity or compressed air, when available and economic. In the vast majority of applications, however, the gas industry uses pneumatic devices that employ energy from pressurized natural gas.

As part of normal operation, pneumatic devices release or bleed natural gas to the atmosphere and, consequently, are a major source of methane emissions from the natural gas industry. The actual bleed rate or emissions level largely depends on the design of the device.

To reduce emissions from pneumatic devices the following options can be pursued, either alone or in combination:

1. Replacement of high-bleed devices with low-bleed devices having similar performance capabilities.
2. Installation of low-bleed retrofit kits on operating devices.

[28] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Replacing Gas-Assisted Glycol Pumps with Electric Pumps. Available at: http://www.epa.gov/gasstar/documents/ll_glycol_pumps3.pdf

[29] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Options For Reducing Methane Emissions From Pneumatic Devices In The Natural Gas Industry. Available at: http://www.epa.gov/gasstar/documents/ll_pneumatics.pdf

3. Enhanced maintenance, cleaning and tuning, repairing/replacing leaking gaskets, tubing fittings, and seals.

Install BASO® Valves[30]

Crude oil heater-treaters, gas dehydrators, and gas heaters burn natural gas in air-aspirated burners to provide processing heat. Strong wind gusts can blow out the pilot flame resulting in methane emissions.

Gas leaks will persist until the pilot is relit. Partners have reported using BASO® valves to prevent this gas loss and methane emissions. BASO® valves are snap-action valves activated by a thermocouple that senses the pilot flame temperature. When the flame is extinguished, the valve automatically shuts off the fuel gas flow, preventing continued fuel loss and methane emissions. These valves are particularly effective at remote, unmanned production sites.

Convert Pneumatics to Mechanical Controls[31]

Remote, non-electrified sites often use natural gas powered pneumatic controllers for process control. The controllers are designed to continuously bleed natural gas resulting in significant methane emissions to the atmosphere.

The most common mechanical control device is a level controller, which uses mechanical linkages to translate the position of a liquid-level float to the position of a drain valve. No gas is used in the measurement of liquid level or in the valve actuation, and reliability is very high.

Install Flares[32]

Remote, unmanned production sites and compressor stations may vent low pressure natural gas and vapors from storage tanks and other onsite equipment to the atmosphere. These gases, which contain methane and often volatile organic compounds (VOC), hydrogen sulfide, and hazardous air pollutants (HAP), can pose an environmental, health, and safety hazard. In order to reduce these emissions, Partners have reported installing flares to combust these gases instead of venting them to the atmosphere.

Flares can be applied to all point source vented emissions of combustible gas with minimal sulfur content.

The methane emissions reduction is uniquely dependent on the types and sizes of sources and the methane content of the flared gas. Wellhead gas may range from 70 to 90 percent methane while crude oil production tank vapors may be as low as 50 percent methane. Partners have reported production site application for tank vents, relief valves, and compressor blow-down at 2,000 Mcf per year, low-pressure separators at 4,000 Mcf per year, and condensate tanks at 36,000 Mcf per year.

[30] Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Install BASO® Valves. Available at: http://www.epa.gov/gasstar/documents/installbaso.pdf

[31] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Convert Pneumatics to Mechanical Controls. Available at: http://www.epa.gov/gasstar/documents/convertpneumaticstomechanicalcontrols.pdf

[32] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Convert Pneumatics to Mechanical Controls. Available at: http://www.epa.gov/gasstar/documents/installflares.pdf

Flares are commonly installed on higher-pressure blowdown or emergency pressure relief valves for safety reasons. Low-pressure gas installations have been justified by environmental emissions control. There are no revenues from the gas as it is destroyed through combustion.

Install Electronic Flare Ignition Devices[33]

Some flares have one or more continuously burning pilot flames, while others save gas by only igniting pilot flames in preparation for use. Pilots can be blown out by wind and gas leakage and/or waste gas is occasionally released to an unlit flare. Both of these situations result in methane, volatile organic compounds (VOC) and hazardous air pollutant (HAP) emissions to the atmosphere.

This technology replaces the intermittently or continuously burning flare pilots with electrical sparking pilots similar to a modern gas stove. These sparking pilots require low electrical power that can be supplied from a battery with solar recharge in remote sites. In addition to using electronic flare ignition devices for pilots, facilities may also install sensors to detect the pilot flame and shut off fuel gas if the pilot is extinguished.

Methane emissions occur from leaking or venting uncombusted natural gas through an unlit flare. Leakage may occur through emergency relief valves and blowdown valves connected to a flare. Venting occurs when flare pilot flames are occasionally blown out by high winds, causing release of methane at 70 scf per hour per pilot until they are relit or shut off. In order to model methane savings, it was assumed that a pilot would be blown out for 24 hours in a year, leading to 1.68 Mcf of methane being vented. In addition to the volume of methane that is vented when the pilot is blown out, there are emissions from incomplete combustion of the fuel gas used for the pilot. To be conservative, these emissions are not included in this analysis.

[33] Environmental Protection Agency (EPA). Natural Gas STAR Program: Recommended Technologies and Practices. Convert Pneumatics to Mechanical Controls. Available at: http://www.epa.gov/gasstar/documents/installelectronicflareignitiondevices.pdf

ANNEX III: EMISSION FACTORS FOR EMISSION REDUCTION CALCULATIONS

1. **Parameter:** Methane Global Warming Potential
   Value: 21 t CO_2 e/ t CH_4
   Source: IPCC Guidelines
2. **Parameter:** Conversion factor
   Value: 0.00067 t CH_4 / Nm_3 CH_4 (at 20°C and 101.3 kPa, references must be found for different conditions)
   Source: IPCC Guidelines
3. **Parameter:** Components emission factors
   Value: N kg/ hour/ component (See table below)
   Source: API Compendium 2009

COMPONENTS EMISSION FACTORS[34]

a) Natural Gas Transmission Compressor Station

Component	ON COMPRESSOR	OFF COMPRESSOR
	Emission Factor, kg/hr/component	
MAIN LINE PRESSURE (3447.4 a 6894.8 kPa)		
Ball/Plug Valves	1.31E-03	1.09E-02
Blowdown Valves	--	4.24E-01
Compressor Cylinder Joints	2.02E-02	--
Packing Seals - Running	1.77	--
Packing Seals – Idle	2.59	--
Compressor Valves	8.39E-03	--
Control Valves	--	8.71E-03
Flanges	1.66E-03	6.54E-04
Gate Valves	--	1.25E-03
Loader Valves	3.52E-02	--
Open-Ended Lines (OEL)	--	1.67E-01

[34] American Petroleum Institute (API). "Compendium of greenhouse gas emissions estimation methodologies for the oil and natural gas industry". 2009, tables 6-17, 18, 19, 21. Available at: http://www.api.org/ehs/climate/new/upload/2009_ghg_compendium.pdf

Pressure Relief Valves (PRV)	--	1.18E-01
Regulators	--	4.09E-04
Starter Gas Vents	--	8.34E-02
Threaded Connectors	1.51E-03	1.23E-03
Centrifugal Seals - Dry	--	1.28E-01
Centrifugal Seals - Wet	--	5.69E-01
Unit Valves	--	7.29E-03
FUEL GAS PRESSURE (482.6 a 689.5 kPa)		
Ball/Plug Valves	2.05E-04	1.04E-03
Control Valves	--	5.03E-03
Flanges	--	4.09E-04
Fuel Valves	5.64E-02	--
Gate Valves	--	8.79E-04
Open-Ended Lines (OEL)	--	5.17E-03
Pneumatic Vents	--	1.57E-01
Regulators	--	8.24E-03
Threaded Connectors	2.47E-03	6.54E-04

b) Natural Gas Transmission and Storage

Component	Emission factor, kg/hr/component
Block valves	0.002140
Control valves	0.01969
Connectors	0.0002732
Compressor seals – reciprocating	0.6616
Compressor seals – centrifugal	0.8139
Pressure relief valves	0.2795
Open-ended lines (OEL)	0.08355
OEL - station or pressurized compressor blowdown system	0.9369
OEL – depressurized reciprocating (comp. blowdown system)	2.347
OEL – depressurized centrifugal (comp. blowdown system)	0.7334

OEL – overall pressurized/ depressurized reciprocating (comp. blowdown system)	1.232
OEL – overall pressurized/ depressurized centrifugal (comp. blowdown system)	0.7945
Orifice meter	0.003333
Other gas meter	0.000009060

c) Natural Gas Distribution Meter/Regulator Stations

Component	Emission factor, kg/hr/component
Valves	0.00111
Control valves	0.01969
Connectors	0.00011
Pressure relief valves	0.01665
Open-ended lines (OEL)	0.08355
OEL – station blowdown	0.9369
Orifice meter	0.00333
Other gas meter	0.00001

d) Other systems (refinery, etc.)

Component – Service	Emission factor, kg/hr/component
Valves	2.81E-03
Connectors	8.18E-04
Control valves	1.62E-02
Pressure relief valves	1.70E-02
Pressure regulators	8.11E-03
Open ended lines	4.67E-01
Chemical injection pumps	1.62E-01
Compressor seals	7.13E-01
Compressor starts	6.34E-03
Controllers	2.38E-01

ANNEX IV: MONITORING EQUIPMENT

Project Proponents may use the following equipment to detect, not to quantify, physical leaks in the components:

- Electronic gas detectors using small hand-held gas detectors or "sniffing" devices to detect accessible physical leaks. Electronic gas detectors are equipped with catalytic oxidation and thermal conductivity sensors designed to detect the presence of specific gases. Electronic gas detectors can be used on larger openings that cannot be screened by soaping.
- Organic Vapour Analysers (OVAs) And Toxic Vapour Analysers (TVAs): are portable hydrocarbon detectors capable of detecting a physical leak. An OVA is a flame ionization detector that measures organic gas concentration at a range of 0.5 a 500,000 parts per million (ppm). TVAs and OVAs measure the methane concentration at the area around the physical leak.
- Acoustic leak detection using portable devices designed to detect the acoustic signal produced when a pressurized gas escapes throughout an orifice. When a gas moves from a high pressure condition to a lower pressure condition across a leak orifice, the turbulent flow produces an acoustic signal that is detected by a portable sensor or probe which indicates an augmentation on the signal intensity when approaching to the source. Although acoustic detectors are incapable of determining the physical leak rate, they may indicate the size of the physical leak given that a greater leak rate will result in a more intense signal.
- Optical Gas Imaging Instruments. There are two general classes of such instruments, active and passive instruments. The active type uses a laser beam that is reflected by the background. The attenuation of the beam passing through a hydrocarbon cloud provides the optical image. The passive type uses ambient illumination to detect the difference in heat radiance of the hydrocarbon cloud. Optical gas imaging instruments do not measure leak rates, but allows faster screening of components than FID detectors.
- Gas leak detection fluids.

One of the following technologies can be used to measure the leak flow rates:

- Bagging techniques are regularly used to measure physical leak flow rates. The component that presents a leak is enclosed into a bag or tent. An inert carrier gas like nitrogen is transmitted through the bag at a known rate. When the carrier gas reaches equilibrium a gas sample is obtained from the bag and the methane concentration of the sample is measured. The flow rate of the component's leak source is calculated from the purge flow rate through the enclosure and the concentration of methane in the outlet stream as shown below:

$$F_{CH_4} = F_{purge,i} \times w_{CH_4} \quad \textbf{(5)}$$

Where:

$F_{CH_{4},i}$	=	Leak flow rate of methane for leak i from the leaking component (m^3CH_4/h)
$F_{purge,i}$	=	The purge flow rate of the clean air or nitrogen at leak i (m^3/h)
$w_{CH_{4},i}\ i$	=	The measured mass fraction of methane in the natural or refinery gas during year y (kg CH_4 / kg gas).

- High volume/Hi-Flow Samplers™ capture all the emissions from a component to quantify the leak flow rate. Leak emissions, plus a large volume sample of the air around the leaking component, are pulled into the instrument through a vacuum sampling hose. High volume samplers are equipped with dual hydrocarbon detectors that measure hydrocarbon gas concentration from the captured sample, as well as the hydrocarbon proportion from ambient air. Sample measurements are corrected with the hydrocarbon gas concentration from the ambient and the leak flow rate is obtained by multiplying the flow rate of the measured sample and the difference between the ambient and sample gas proportions.

Methane emissions are obtained by calibrating the hydrocarbon detectors to a range of concentrations of methane-in-air. High volume samplers are equipped with special attachments designed to promote complete emissions capture and to prevent interference from other nearby emissions sources. The hydrocarbon sensors are used to measure the exit concentration in the air stream of the system. The sampler essentially makes rapid vacuum enclosure measurements.

- Calibrated bag measurements use anti-static bags of known volume (e.g. 0.085 m^3 or 0.227 m^3) with a neck shaped for easy sealing around the vent. Measurement is made by timing the bag expansion to full capacity while also employing a technique to completely capture the leak while the inflation is being timed.

The measurement is repeated on the same leak source numerous times (at least 7, typically 7 to 10 times) to ensure a representative average for the fill times (outliers or problem times should be omitted and the tests rerun until a representative average rate is established). The temperature of the gas is measured to allow correction of volume to standard conditions. Additionally, the gas composition is measured to verify the proportion of methane in the vented gas, since in some cases air may also be vented, resulting in a mixture of natural gas and air. Calibrated bags allow for reliable measurement of leak flow rates of more than 250m^3/h. The leak flow rate of methane is calculated as shown below:

$$F_{CH_{4,i}} = V_{bag} \times w_{sampleCH_{4,i}} \times 3600/\, t_{aver,i} \qquad \textbf{(6)}$$

Where:

$F_{CH_{4},i}$	=	Leak flow rate of methane for leak i from the leaking component. (m^3CH_4/h).
V_{bag}	=	Volume of calibrated bag used for measurement (m^3).
$w_{sampleCH_{4},i}$	=	The concentration of methane in the sample flow from leak i (volume percent).
$t_{aver,i}$	=	Average bag fill time for leak i (seconds).

ANNEX V: MONITORED PARAMETERS

Data/ Parameter:	$T_{i,x}$
Data units:	Hours
Data description:	The time the component x of component type i was leaking during year y (hours)
Source of data used:	Plant records
Measurement procedures:	Any outages will be recorded
Recording frequency:	Constant
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	Any outages resulting from system repairs will be documented and logged in the project database in the form of a reduction in the time of operation
Comments:	-

Data/ Parameter:	T_z
Data units:	Hours
Data description:	The time the relevant component has been leaking during year *y*
Source of data used:	Plant records
Measurement procedures:	Any outages will be recorded
Recording frequency:	Constant
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	Any outages resulting from system repairs will be documented and logged in the project database in the form of a reduction in the time of operation. If an unrelated activity requires the shut-down of an already repaired piece of equipment, the hours of operation for every piece of affected equipment will be reduced in the database for the entire duration of the shut-down. Any other unscheduled shutdown will also be timed and accounted for through a reduction of operating hours
Comments:	-

Data/ Parameter:	**Temperature and pressure of natural gas**
Data units:	°C and bar
Data description:	Conditions observed at the point and time of the leak rate measurement
Source of data used:	-
Measurement procedures:	At the time of each leak measurement
Recording frequency:	100%
Proportion of data to be monitored:	Data measurement equipment will be calibrated and double checked on a regular basis. The manufacturer's recommended calibration procedures shall be applied
Comments:	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected

Data/ Parameter:	$T_{i,r}$
Data units:	Hours
Data description:	The time the component r of component type i would leak in the baseline scenario and would be eligible for crediting during year *y*
Source of data used:	Plant records
Measurement procedures:	Any outages will be recorded
Recording frequency:	Constant
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	Any outages resulting from system repairs will be documented and logged in the project database in the form of a reduction in the time of operation. If an unrelated activity requires the shut-down of an already repaired piece of equipment, the hours of operation for every piece of affected equipment with be reduced in the database for the entire duration of the shut-down. Any other unscheduled shutdown will also be timed and accounted for through a reduction of operating hours
Comments	-

Data/ Parameter:	$T_{j,y}$
Data units:	Hours
Data description:	The time the relevant component, in which physical leak *j*, occurred, would leak in the baseline scenario and would be eligible for crediting during year *y* (hours)
Source of data used:	Plant records
Measurement procedures:	Any outages will be recorded
Recording frequency:	Constant
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	Any outages resulting from system repairs will be documented and logged in the project database in the form of a reduction in the time of operation. If an unrelated activity requires the shut-down of an already repaired piece of equipment, the hours of operation for every piece of affected equipment with be reduced in the database for the entire duration of the shut-down. Any other unscheduled shutdown will also be timed and accounted for through a reduction of operating hours
Comments:	-

Data/ Parameter:	UR_j
Data units:	Fraction
Data description:	The uncertainty range for the measurement method applied to leak *j*
Source of data used:	Manufacturer data and/or 2000 IPCC Good Practice Guidance
Measurement procedures:	Estimated, where possible, at a 95% confidence interval, consulting the guidance provided in Chapter 6 of the 2000 IPCC Good Practice Guidance. If leak measurement equipment manufacturers report an uncertainty range without specifying a confidence interval, a confidence interval of 95% may be assumed
Recording frequency:	Periodically
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments:	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected

Data/ Parameter:	UR_z
Data units:	Fraction
Data description:	The uncertainty range for the measurement method applied to leak *z*
Source of data used:	Manufacturer data and/or 2000 IPCC Good Practice Guidance
Measurement procedures:	Estimated, where possible, at a 95% confidence interval, consulting the guidance provided in Chapter 6 of the 2000 IPCC Good Practice Guidance. If leak measurement equipment manufacturers report an uncertainty range without specifying a confidence interval, a confidence interval of 95% may be assumed
Recording frequency:	Periodically
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments:	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected

Data/ Parameter:	$w_{CH_{4,y}}$, $w_{CH_{4,l,}}$
Data units:	kg CH_4/kg gas
Data description:	Average mass fraction of methane in the natural gas/refinery gas for crediting year *y*
Source of data used:	Direct measurement
Measurement procedures:	
Recording frequency:	Periodically
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	For the purpose of determining average mass fraction of methane, a natural gas or refinery gas sample should be collected and chemical analysis should be made in the laboratory
Comments:	-

Data/ Parameter:	$w_{sample\ CH_{4,i}}$
Data units:	Volume percent
Data description:	The concentration of methane in the sample flow from leak *i*
Source of data used:	Direct measurement
Measurement procedures:	-
Recording frequency:	Periodically
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected

Data/ Parameter:	$F_{CH4,\ i}$ /$F_{CH4,\ z}$ /
Data units:	m^3CH_4/h
Data description:	The leak flow rate of methane for leak (*i, z*) from the leaking component
Source of data used:	On-site measurements
Measurement procedures:	Procedures requires by manufactures of the equipment used to measure leak flow rates should be followed
Recording frequency:	Annual
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments:	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected. The leak flow rate (FCH4,j) and conversion factor (ConvFactor) should be corrected to the same reference temperature and pressure conditions. For example if value of 0.00067 (IPCC 2006 Vol.2, p. 4.12) is used to convert from m³ CH4 into t CH4, then the flow rate should corrected to reference conditions of 20 degree Celsius and 101.3 kPa

Data/ Parameter:	$F_{purge, i}$
Data units:	m³/h
Data description:	The purge flow rate of the clean air or nitrogen at leak *i*
Source of data used:	On-site measurements
Measurement procedures:	Procedures requires by manufactures of the equipment used to measure leak flow rates should be followed
Recording frequency:	Annual
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments:	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected. The purge flow rate and leak flow rate should be corrected to the same reference temperature and pressure conditions

Data/ Parameter:	$t_{aver, i}$
Data units:	Sec
Data description:	Average bag fill time for leak *i*
Source of data used:	On-site measurements
Measurement procedures:	Procedures requires by manufactures of the equipment used to measure leak flow rates should be followed
Recording frequency:	Annual
Proportion of data to be monitored:	100%
QA/QC procedures to be applied:	-
Comments	Applicable only in the case that option 2 for the calculation of baseline and project emissions is selected

ANNEX VI: PROJECT DOCUMENT TEMPLATE

EMISSION REDUCTION ACTIONS PROGRAM (NAMA) IN NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEMS, THROUGH FUGITIVE EMISSION REDUCTION

Version 01.0

PROJECT DOCUMENT (PD)

Project Activity proponent
PD Version
PD Issue Date
Project Activity participants
Project Activity location
Estimated emissions reduction

SECTION A. PROJECT ACTIVITY DESCRIPTION

Sections A1 and A2: Please include a brief summary describing the Project Activity, including a description of the scenario previous to its implementation, the technology to be adopted by the proposed Project Activity, the estimated emissions reduction and the fund required to accomplish this goal.

In case the scenario previous to the Project Activity implementation is the same as the baseline scenario it is not necessary to repeat this description, it will only be necessary to indicate that both scenarios are equal.

Sections A.3, A.4 y A.5: Please define the Project Activity location(s) including its specific geographic coordinates, state and municipality.

A.1.Purpose and description of the Project Activity ______________________________

A.2. Characteristics of the measures(s) to be implemented as part of the Project Activity ______________________________

A.3. Location ______________________________

A.4. State ______________________________

A.5. City/ Municipality ______________________________

SECTION B. BASELINE AND EMISSIONS REDUCTION

Please include a brief description of:

- *Section B.1: Establishment of the baseline scenario taking as reference the methodology that has been elaborated for this NAMA.*
- *Section B.2: Advanced leak detection program established for the Project Activity.*
- *Section B.3: Applicability assessment and demonstration of additionality.*
- *Section B.4: Values of the parameters that have been defined (not to be monitored) previous to the Project Activity implementation.*
- *Section B.5: Summary of the emissions reduction expected for the Project Activity*

B.1. Baseline establishment and description ______________________________

B.2. Description of the advanced leak detection and repair program to be implemented ______________________________

B.3. Project Activity applicability and additionality assessment ______________________________

B.4. Fixed data and parameters ______________________________

Data/ Parameter
Units
Description
Source
Value applied
Measurement method
Purpose of the data
Comments

(This table can be replicated as many times as needed).

B.5.Emissions reduction summary ____

____

____

Please describe the steps taken for the emissions reduction calculation.

Year	Baseline emissions (t CO2e)	Project emissions (t CO2e)	Emissions reduction (t CO2e)
Year A			
Year B			
Year C			
Year...			
Total			
Annual average			

SECTION C. MONITORING PLAN

Section C.1: By using the table that has been provided in this section, please include for each parameter the following information:

1. *Value of the parameter to be monitored for emissions reduction calculation purposes.*
2. *Description of the equipment to be used for monitoring each parameter, including accuracy class and calibration information (frequency, validity) in case it is available.*
3. *Measuring method and data archive, specifying measurements and archive frequency.*
4. *Data source (Logs, data system, etc.).*
5. *Calculation method, if relevant.*
6. *QA/QC procedures (as monitoring plan).*
7. *Information about emission factors, IPCC default values and other referenced values used for emissions reduction calculation.*

C.1. Data and parameters monitored ______________________________

____

Data/ Parameter	
Units	
Description	
Source	
Value applied	
Measurement method	
Monitoring frequency	
QA/QC procedure	
Comments	

(This table can be replicated as many times as needed in order to include all parameters).

SECTION D. ENVIRONMENTAL IMPACTS

Section D.1: Describe the environmental impacts of the Project Activity implementation.

D.1. Environmental impacts assessment ______________________________

____

ANNEX VII: MONITORING REPORT TEMPLATE

EMISSION REDUCTION ACTIONS PROGRAM (NAMA) IN NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEMS, THROUGH FUGITIVE EMISSION REDUCTION

Version 01.0

MONITORING REPORT (MR)

Contents

MONITORING REPORT
INSERT version and date dd/mm/yyyy
INSERT Project Activity title
INSERT reference number
INSERT monitoring period number and dates
First and last day included (dd/mm/yyyy - dd/mm/yyyy)

SECCTION A. DESCRIPTION OF THE PROJECT ACTIVITY

- *Please add in section A.1 a description of the Project Activity including:*
  1. *Purpose of the Project Activity and measures taken to reduce GHG emissions;*
  2. *Brief description of the technology used;*
  3. *Relevant dates of the Project Activity (e.g.: construction, installation, commissioning, operating periods, etc.);*
  4. *Emissions reduction generated during the period.*
- *Section A.2 must include Project Proponents information (entity name, address, authorized representative, e-mail, fax, phone number).*
- *Please add in section A.3 the Project Activity location, using corresponding coordinates and including images (this last requisite is optional).*
- *Section A.4 must include a description of the technology used for the Project Activity implementation.*
- *In section A.5 please mention the Registration date (day, month and year).*
- *Please add in section A.6 the Project Activity lifetime, its starting date and if it has been modified and in section A.7 all contact information about the people/ entities responsible of elaborating the Monitoring report.*

A.1. Description of the Project Activity ______________________________

____

A.2. Project Proponents ______________________________

____

Name of Project Proponent	
Address	
Authorized representative	
E-mail	
Fax	
Phone number	

(Please replicate this table as many times as needed depending on the number of Project Proponents).

Project Activity lifetime

A.3. Project Activity location(s)____

____

A.4. Project Activity technical description _______________________________

____

A.5. Registration date____

____

A.6. Project Activity lifetime ____

____

A.7. People/ entities responsible of elaborating the Monitoring report__________

____

SECTION B. IMPLEMENTATION STATUS

Section B.1 must include a description of the implementation status of the Project Activity and its operation during the monitoring period. This description shall include the following information:

1. *The date when the Project Activity started operations.*
2. *Information regarding the current operation of the Project Activity.*
3. *Information regarding the operation of the Project Activity(s) during this monitoring period, including any information on events that may impact the GHG emission reductions or removals and monitoring.*

B.1. Implementation status of the Project Activity ________________________

____

SECTION C. DESCRIPTION OF THE MONITORING PLAN

This section must incorporate of a description the monitoring plan, including the organizational structure, responsibilities and competences, the methods for generating, recording, storing, aggregating, collating and reporting data on monitored parameters and the procedures for handling internal auditing and non-conformities.

C. Data and parameters

- C.1. Data and parameters determined at Registration stage and not monitored, including default values and factors.
- C.2. Data and parameters monitored

SECTION D. DATA AND PARAMETERS

This section shall include all the parameters used to calculate the baseline and Project emissions as well as other parameters required by the approved methodology and monitoring plan and specific information about the manner these parameters have been monitored during the current period. Data that has only been determined once, at the project registration, and that are used during all monitoring periods shall be included.

For each parameter, the next information shall be provided:

1. *Value of the parameter monitored for the purpose of calculating the emissions reduction. For reporting multiple values a table or a reference to a spreadsheet can be used. For default values (including IPCC Guidelines default values), the most recent value shall be applied.*
2. *Description of the equipment used for monitoring each parameter, including as accuracy class data and calibration information, (calibration date, frequency and validity), according what has been established in the monitoring plan.*
3. *Measuring method and data archive: A description of how each parameter is measured/ calculated specifying its frequency must be included.*
4. *Data source: Logs, data system, etc.*
5. *Calculation method for each parameter, if relevant.*
6. *QA/QC procedures (as monitoring plan).*
7. *Information about emission factors, IPCC default values and other referenced values used for emissions reduction calculation.*

D.1. Data and parameters determined at Registration stage and not monitored, including default values and factors ______________________________

____

Data/ Parameter:
Units:
Description:
Source:
Value :
Comments:

(Please replicate this table as many times as needed depending on the number of parameters).

D.1. Data and parameters monitored ____

____

Data/ Parameter:
Units:
Description:
Measured/Calculated/Default:
Source
Value of the monitored parameter:
Frequency of Measurement/ reading/archive:
Calculation method (if applies):
QA/QC procedures:

(Please replicate this table as many times as needed depending on the number of parameters).

SECTION E. EMISSIONS REDUCTION CALCULATION

Section E.1 includes all the formulae that have been used and the description of the baseline emissions calculations using real values. For multiple values a table and references to a spreadsheet may be incorporated.

Section E.2 includes all the formulae that have been used and the description of the project emissions calculations using real values. For multiple values a table and references to a spreadsheet may be incorporated.

Section E.3 shall include all the formulae that have been and the description of the emissions reduction achieved during monitoring the period.

E.1. Baseline emissions calculation ____________________

E.2. Project emissions calculation ____________________

E.3. Emissions reduction calculation/ table ____________________

Baseline emissions (tCO_2):
Project emissions (tCO_2):
Emissions reduction tCO_2):

ANNEX I. PROJECT PROPONENTS' INFORMATION

Project Proponent	
Street and number	
Building	
City	
State/ region	

ZIP Code	
Country	
Phone Number	
Fax	
E-mail	
Website	
Authorized representative's name	
Title	
Last name	
First name	
Primer nombre	
Departamento	
Móvil	
Fax directo	
Tel. directo	
E-mail personal	

(Please replicate this table as many times as needed depending on the number of Project Proponents).

ANNEX II. ADDITIONAL INFORMATION

This section is available for any additional information regarding the monitoring plan.

ANNEX VIII: VALIDATION REPORT TEMPLATE

EMISSION REDUCTION ACTIONS PROGRAM (NAMA) IN NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEMS, THROUGH FUGITIVE EMISSION REDUCTION

Version 01.0

VALIDATION REPORT (VR)

Document prepared by:

Representative's contact information:

The present document may be used by Designated Entities for the validation of Project activities wanting to be included in this NAMA. Each designated entity may develop its own template for a validation, as long as all the requisites included in this template and the applicable methodology are covered.

Project Activity title	
Version	

Project Proponent	
Pages in report	
Elaboration date	

Contents

SECTION A. SUMMARY

A.1. Objectives of the report ______________________________

____

A.2. Summary and Project Activity description ______________________________

____

Please write a brief description of the Project Activity, including the next information:
- *Brief description of the Project Activity.*
- *Description of any questioning, restriction or irregularity during validation process.*
- *Summary of validation conclusions.*

SECTION B. VALIDATION PROCESS

B.1. Methodology and criteria ____

____

Describe the methodology and criteria used during validation.

B.2. Documents reviewed ____

____

List the documents used as references for the validation process.

B.3. Interviews____

____

List the people that were interviewed during validation and the most relevant information obtained from these interviews.

B.4. Site visit results ____

____

Description of the activities carried out during site visit.

B.5. Answer to any discrepancy ____

____

Describe the process followed for any discrepancy found and the conclusion.

SECTION C. QUESTIONS DURING VALIDATION

C.1. Project document ____

____

- *Identify, discuss and justify your conclusions regarding:*
- *Description of the Project Activity*
- *Technology to be used*
- *Start date of the Project Activity*
- *Emissions reduction estimation*
- *Project Activity location*
- *Additional information*

C.2. Methodology applicability

C.2.1. Applicability

Identify, discuss and justify your conclusions regarding how the Project complies with methodology's applicability conditions.

C.2.2. Baseline scenario

Identify, discuss and justify your conclusions regarding the baseline scenario described in the Project document.

C.2.3. Additionality demonstration

Identify, discuss and justify your conclusions regarding the additionality demonstration according methodology criteria.

C.2.4. Emissions reduction quantification

Identify, discuss and justify your conclusions regarding:

- *Baseline emissions quantification.*
- *Project emissions quantification.*
- *Total emissions reduction.*

C.2.5. Implementation plan

Describe and assess the Implementation plan.

C.2.6. Monitoring plan

Identify, discuss and justify your conclusions regarding:

- Data and parameters available during validation.
- Data and parameters monitored.

C.3. Environmental impact

Identify, discuss and justify the environmental implications of the Project Activity implementation.

SECTION D. VALIDATION CONCLUSIONS

Clearly describe if the Project Activity accomplishes with all requisites to be registered.

ANNEX I

List all corrective action requests (CAR), clarifications (CL) and forward action requests (FAR) required by the DE during validation process, and the actions carried out by the Project Proponent.

FINDING # 1

CLASSIFICATION OF FINDING : (CAR, CL, FAR)

Finding description (1st evaluation)	*Complete description from the DE.*
Clarification or corrective action (1st evaluation)	*Project Proponent must describe the corrective actions carried out in the deliverable reports or explain why no change is necessary.*
1st evaluation	*DE must evaluate if the answers received are enough to close out the finding. In case a conclusion cannot be reached, this table may be continued with "n" number of evaluation until a conclusive result is reached.*
Finding description (2nd evaluation)	*Just in case it is necessary*
Clarification or corrective action (2nd evaluation)	*Just in case it is necessary*
2nd evaluation	*Just in case it is necessary*
Date when finding was closed	*DD/MM/YYYY*

(Please replicate this table as many times as needed depending on the number of Project Proponents).

ANNEX IX: VERIFICATION REPORT TEMPLATE

EMISSION REDUCTION ACTIONS PROGRAM (NAMA) IN NATURAL GAS PROCESSING, TRANSPORT AND DISTRIBUTION SYSTEMS, THROUGH FUGITIVE EMISSION REDUCTION

Version 01.0

VERIFICATION REPORT (VERR)

Report title

Document prepared by (organization):

Contact information:

The present document may be used by Designated Entities for the verification of a registered activity for a specific monitored period. Each designated entity may develop its own template for verification, as long as all the requisites included in this template and the applicable methodology are covered.

Document version:	
Date when document was finished:	
Monitored period:	

Content

SECTION A. PROJECT SUMMARY

A.1. Objective of the report ____________________

____

A.2. Project Activity summary ____________________

____

Include a summary with the most relevant information of the Project Activity.

A.3. Project Proponent ____________________

____

Complete name of the people and/or entities in charge of the Project Activity development.

A.4. Other entities involved in the Project Activity ______________________________

____

Complete name of other people and/or entities involved in the Project Activity development and documentation.

SECTION B. VERIFICATION PROCESS

B.1. Documentation review ____

____

List the documents that have been used as references during the verification process.

B.2. Interviews____

____

Describe the interview process and list the people that have been interviewed and their relation with the Project Activity.

SECTION C. VERIFICATION FINDINGS

C.1. Exactitude of emissions reduction calculation______________________________

____

Identify and comment the methods used for the emissions reduction calculation, determine if they have been done complying with all requisites established in the existing methodology. Confirm that the conversions, formulae, default values and uncertainty ranges have been determined adequately.

C.2. Quality of evidences used for emissions reduction calculation ______________

____

Justify conclusions regarding quality and quantity, nature and source of evidences used as support for the emissions reduction calculation Describe why these sources are considered appropriated.

C.3.Description of information system_____________________________________

____

Identify the organizational structure, responsibilities and competences for the information handling and review.

SECTION D. VERIFICATION CONCLUSIONS

Clearly determine if the Project accomplishes with all the requisites that have been established for this NAMA and if the emissions reduction calculation has been carried out correctly.

GHG emissions reduction	tCO_2
Baseline emissions	
Project emissions	
Leakage	
Emissions reduction	

SECTION E. ANNEXES

ANNEX I. LIST OF REQUESTS

List all corrective action requests (CAR), clarifications (CL) and forward action requests (FAR) required by the DE during the verification process, and the actions carried out by the Project Proponent.

FINDING # 1

CLASSIFICATION OF FINDING : (CAR, CL, FAR)

Finding description (1st evaluation)	*Complete description from the DE.*
Clarification or corrective action (1st evaluation)	*Project Proponent must describe the corrective actions carried out in the deliverable reports or explain why no change is necessary.*
1st evaluation	*DE must evaluate if the answers received are enough to close out the finding. In case a conclusion cannot be reached, this table may be continued with "n" number of evaluation until a conclusive result is reached.*
Finding description (2nd evaluation)	*Just in case it is necessary*
Clarification or corrective action (2nd evaluation)	*Just in case it is necessary*
2nd evaluation	*Just in case it is necessary*
Date when finding was closed	*DD/MM/YYYY*

(Please replicate this table as many times as needed depending on the number of Project Proponents).


ALIMENTACION A SEPARADO 7-06
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DESFOGUE DE SEPARADOR

REFERENCES

UNFCCC, Ad Hoc Working Group on Long-term Co-operative Action under the Convention. "Compilation of information on nationally appropriate mitigation actions to be implemented by Parties not included in Annex I to the Convention". Page 31.Available at: http://unfccc.int/resource/docs/2011/awglca14/eng/inf01.pdf

IPCC. 1996 Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy. Chapter 1, page 1.18. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf [Accessed 07/02/2013].

American Petroleum Institute (API). *Compendium of greenhouse gas emissions estimation methodologies for the oil and natural gas industry.* 2009. Tables 6-17, 18, 19, 21. Available at: http://www.api.org/ehs/climate/new/upload/2009_ghg_compendium.pdf [Accessed 07/02/2013].

British Embassy in Mexico. *Prosperity Fund guidance 2012-2013.* Pages 2-3. Available at: http://uk.sitestat.com/fcoweb/ukingov/s?was.mex.resources.en.press-release.712765482.712767382.concept-bidding-round.p.pdf.prosperity-fund-guidance-jan-2012&ns_type=pdf&ns_url=http://ukinmexico.fco.gov.uk/resources/en/word/doc1/prosperity-fund-guidance-jan-2012 [Accessed 07/02/2013].

Canadian Association of Petroleum Producers (CAPP). *Best management practice: Management of Fugitive Emissions at Upstream Oil and Gas Facilities.* January 2007. Pages 3-12, 25-33. Available at: http://www.capp.ca/getdoc.aspx?DocId=116116&DT=PDF [Accessed 02/07/2013].

CNH. *Reporte de Producción de Gas Natural en México (Noviembre de 2012).* http://www.cnh.gob.mx/_docs/Reportes_IH/Reporte_de_Gas_Nov_12.pdf [Accessed 07/02/2013].

Diario Oficial de la Federación. DOF 06/06/2012: Ley General de Cambio Climático. Artículo transitorio segundo, Page 42. Available at: http://dof.gob.mx/nota_detalle.php?codigo=5249899&fecha=06/06/2012 [Accessed 07/02/2013].

Ecofys. *Economic Evaluation of Methane Emission Reduction in the Extraction, Transport and Distribution of Fossil Fuels in the EU: Bottom up analysis.* January 2001. Pages 6 -11. Available at: http://ec.europa.eu/environment/enveco/climate_change/pdf/fossilfuel.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program, Recommended Technologies and Practices.* Available at: http://www.epa.gov/gasstar/tools/recommended.html [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Convert Pneumatics to Mechanical Controls.* Available at: http://www.epa.gov/gasstar/documents/convertpneumaticstomechanicalcontrols.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Install Electronic Flare Ignition Devices.* Available at: http://www.epa.gov/gasstar/documents/installelectronicflareignitiondevices.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Install BASO® Valves.* Available at: http://www.epa.gov/gasstar/documents/installbaso.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Install Flares.* Available at: http://www.epa.gov/gasstar/documents/installflares.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Replacing Gas-Assisted Glycol*

Pumps with Electric Pumps. Available at: http://www.epa.gov/gasstar/documents/ll_glycol_pumps3.pdf [Accessed 02/07/2013].

Environmental Protection Agency (EPA). *Natural Gas STAR Program: Recommended Technologies and Practices. Replacing Wet Seals with Dry Seals in Centrifugal Compressors.* Available at: http://www.epa.gov/gasstar/documents/ll_wetseals.pdf [Accessed 02/07/2013].

Intergovernmental Panel on Climate Change (IPCC). 2006 IPCC Guidelines for National Greenhouse Gas Inventories: "Fugitive Emissions". Volume 2, Chapter 4, Pages 4.6 and 4.36. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf [Accessed 07/02/2013].

IPCC. *Revised 1996 IPCC Guide lines for National Greenhouse Gas Inventories: Reference Manual.* Page 1.121, Table 1-58. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6a.html [Accessed 07/02/2013].

Natural Gas. *Natural Gas and the Environment.* Available at: http://www.naturalgas.org/environment/naturalgas.asp [Accessed 07/02/2013].

NOM-001-SECRE-2010 Especificaciones del gas natural. Available at http://www.sener.gob.mx/res/Acerca_de/NOM-001-SECRE-2010.pdf [Accessed 07/02/2013].

NOM-002-SECRE-2010 Instalaciones de aprovechamiento de gas natural. Available at: http://dof.gob.mx/nota_detalle.php?codigo=5177014&fecha=04/02/2011 [Accessed 7/02/2013].

NOM-003-SECRE-2002 Distribución de gas natural y gas licuado de petróleo por ductos. Available at http://www.sener.gob.mx/res/Acerca_de/nom003secre2002.pdf [Accessed 07/02/2013].

NOM-007-SECRE-2010 Transporte de gas natural. Available at: http://www.cre.gob.mx/documento/1970.pdf [Accessed 07/02/2013].

NOM-009-SECRE-2002 Monitoreo, detección y clasificación de fugas de gas natural y gas LP, en ductos. Available at: http://www.sener.gob.mx/res/Acerca_de/nom009secre2002.pdf [Accessed 02/07/2013].

Options for Reducing Methane Emissions from Pneumatic Devices in teh Natural Gas Industry. Available at: http://www.epa.gov/gasstar/documents/ ll_pneumatics.pdf [Accessed 02/07/2013].

PEMEX Web Page. *Acerca de PEMEX.* Available at: http://www.pemex.com/index.cfm?action=content&sectionID=1 [Accessed 07/02/2013].

PEMEX Web Page. *Relación con inversionistas.* Available at: http://www.ri.pemex.com/index.cfm [Accessed 07/02/2013].

PEMEX. *Informe de Responsabilidad Social 2011.* Available at: http://www.pemex.com/files/content/irs_2011.pdf [Accessed 02/07/2013].

PEMEX. *Principales elementos del Plan de Negocios de Petróleos Mexicanos y sus Organismos Subsidiarios: 2012-2016.* Page 1. Available at: http://www.pemex.com/files/content/principales_elementos_del_pn_2012-2016-.pdf [Accessed 02/07/2013].

PEMEX. *Principales elementos del Plan de Negocios de Petróleos Mexicanos y sus Organismos Subsidiarios: 2013-2017.* Pages 1, 11, 13 and14. Available at: http://www.pemex.com/files/content/pn_13-17_121107.pdf [Accessed 07/02/2013].

Secretaría de Energía. *Prospectiva del mercado de gas natural 2012-2026.* Pages 67-74. Available at: http://www.sener.gob.mx/res/PE_y_DT/pub/ 2012/PGN_2012_2026.pdf [Accessed 07/02/2013].

SENER. *Balance nacional de energía 2011.* Cuadro 38, page 104. Available at: http://www.energia.gob.mx/res/PE_y_DT/pub/2012/BNE_2011.pdf [Accessed 07/02/2013].

SENER. *Procesamiento, almacenamiento y transporte de gas.* Pages 1-8. Available at: http://www.sener.gob.mx/res/403/Elaboraci%C3%B3n%20de%20Gas.pdf [Accessed 07/02/2013].

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