



Mexico

Associated Gas Utilization Study

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Thanks to Tom Mitro for his thoughtful review



Columbia Center
on Sustainable Investment

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Summary of findings

Energy sector reform and mandatory technical guidelines

Falling flaring figures

Growing domestic demand

Need for more investment in infrastructure and technology

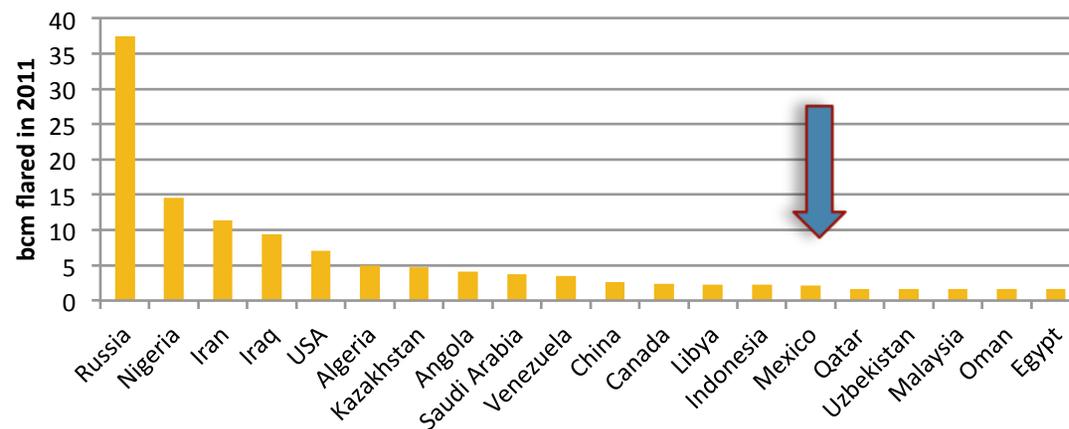
- Mexico's reform of the state-owned oil company, Petroleos Mexicanos (PEMEX) in 2013 along with the creation of the hydrocarbon regulatory agency, Comision Nacional de Hidrocarburos (CNH) in 2008 is a game changer for the oil and gas industry. The latest mandatory technical guidelines of January 2016 are addressing many of the challenges that CNH has encountered so far in regulating flaring and venting.
- Falling flaring and venting figures since 2008 have been lauded as a result of efforts from the Mexican government including the 2008 Energy Reform. Significant investments in gas handling and reinjection technology, particularly at the Cantarell field by Pemex, is also driving much of the flaring reduction since 2008.
- Growing domestic demand for gas for power generation could motivate an increase in Associated Petroleum Gas (APG) use in Mexico.
- However it will require the construction of more gathering facilities and gas transmission lines unless Greyryock's technologies of small scale gas to liquids are widely adopted. Failing this, more flaring is expected in the future since the gas reinjection programs won't absorb all the APG.



The statistics of APG flaring in Mexico

Statistics on APG flaring

Top 20 gas flarers in the world (2011)



Source: NOAA satellite data

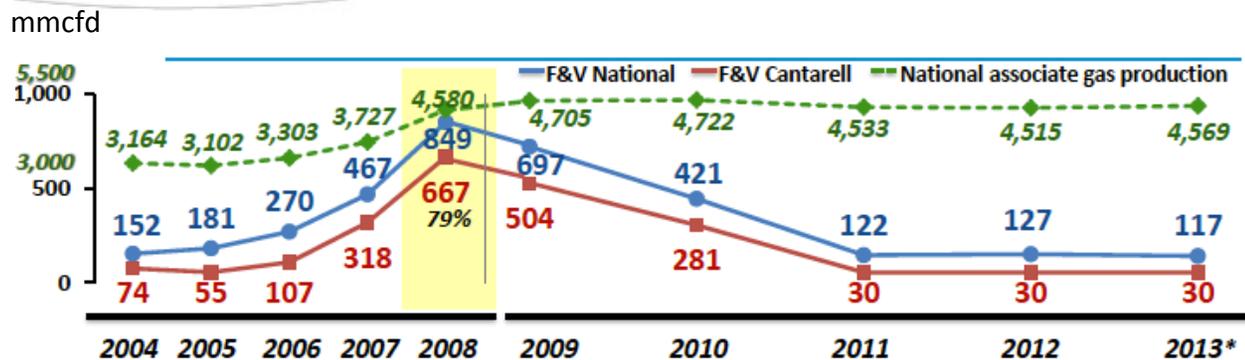
On the companies involved

- Gas flaring in Mexico has recently come to the forefront of the country's petroleum industry discourse, as the country holds the title of the 15th foremost gas flarer globally as of 2011.

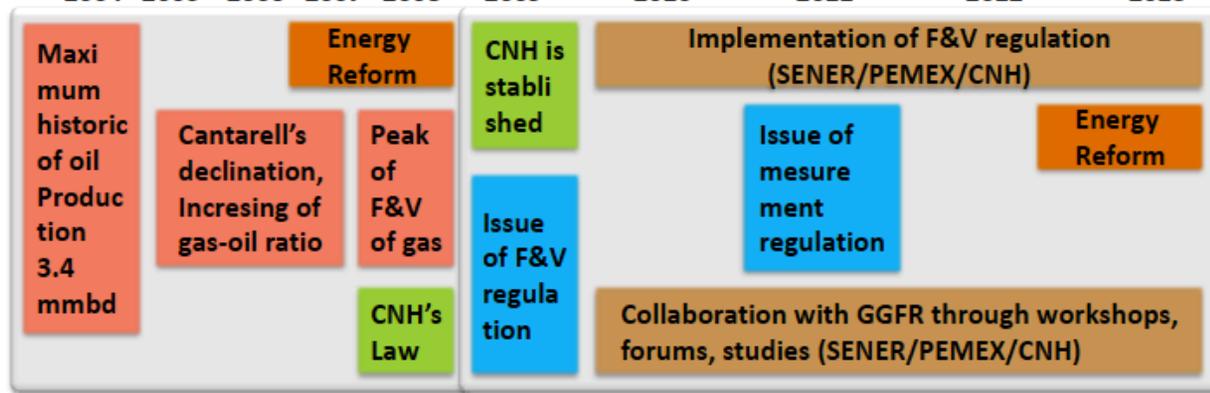


The statistics of APG flaring in Mexico

Statistics on APG flaring



On the companies involved



Source: Roldan and Pena, CNH, 2014

- Flaring and Venting (F&V) from 2004-2013
- Chart depicts rising gas flaring until the 2008 Energy reform, followed by declining flaring post reform years



The statistics of APG flaring in Mexico

Statistics on APG flaring

Con Cantarell

	(millones de pesos)										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Valor del Gas Venteado	3,018	5,079	4,304	2,479	4,370	3,154	4,999	6,163	12,897	41,650	14,050
% del valor del gas	60.8%	60.8%	60.8%	60.8%	60.8%	60.8%	60.8%	54.8%	57.1%	58.5%	45.8%

*Incluye Cantarell. ** El precio del gas es el promedio observado de I a VIII, 2009 *** La producción de gas es la pronosticada por PEP en su escenario central

Sin Cantarell

	(millones de pesos)										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Valor del Gas Venteado	1,117	1,792	1,848	849	1,273	1,523	3,419	3,737	3,435	5,740	3,819
% del valor del gas	60.8%	60.8%	60.8%	60.8%	60.8%	60.8%	60.8%	61.3%	57.1%	58.5%	45.8%

*Incluye Cantarell. ** El precio del gas es el promedio observado de I a VIII, 2009 *** La producción de gas es la pronosticada por PEP en su escenario central

Source: Estrada Estrada, CNH, 2011

On the companies involved

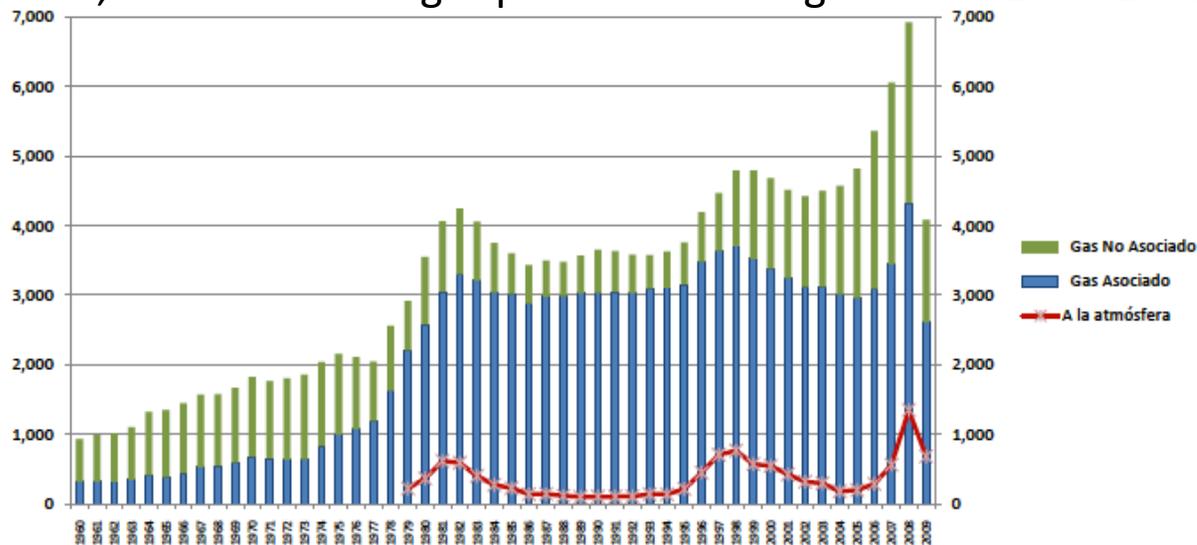
- The above figure shows value of flared gas from 1999 to 2009 with Pemex's Cantarell field (largest oil field in Mexico by overall production) (top) and without Cantarell (bottom): clearly Cantarell is the biggest field contributing to flaring.
- Value of gas flared and vented in 2009 stood at 14,050 million pesos (over US\$1 billion) which was about 46% of the value of overall APG produced.

The statistics of APG flaring in Mexico

Statistics on APG flaring

On the companies involved

Associated, NonAssociated gas production and gas flared 1960-2009



Source: Estrada Estrada, CNH, 2011

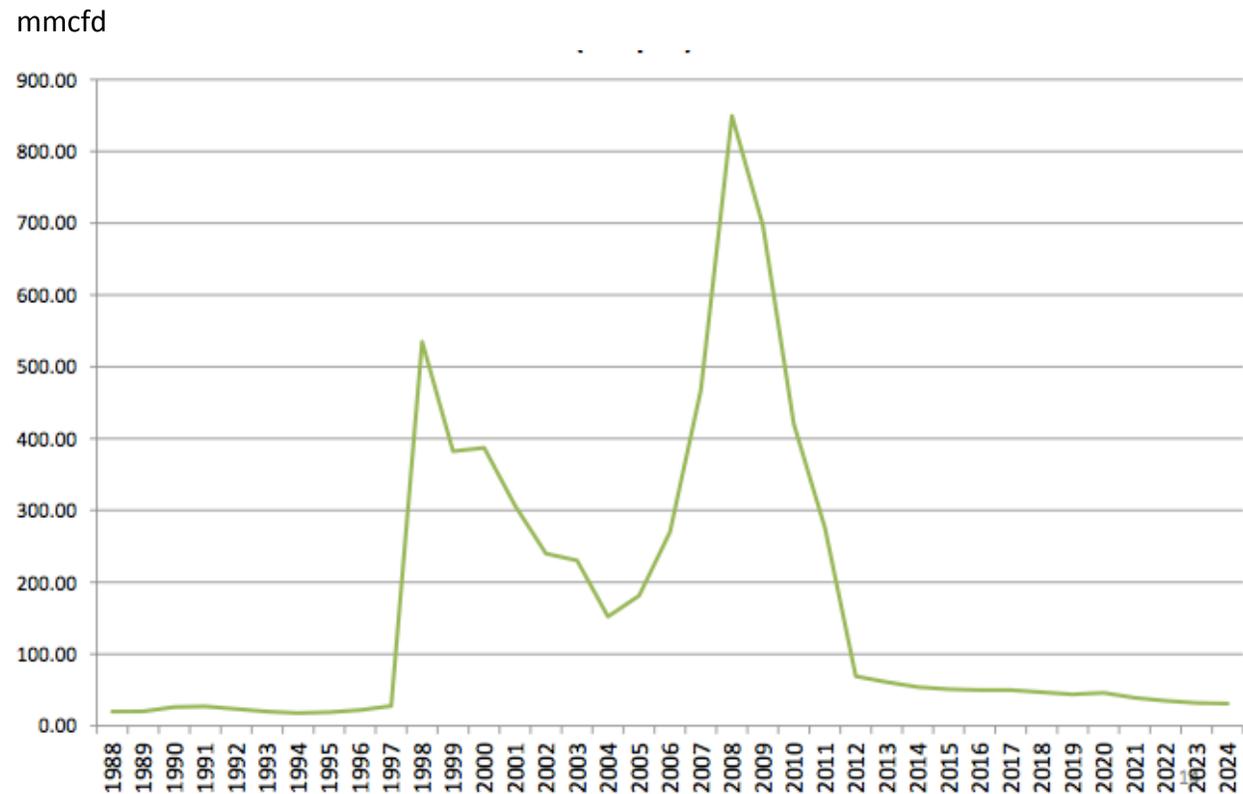
- ◆ The chart above depicts APG (blue), NAG (green) produced and gas flared (red) from 1960-2009 in mmcf. Note that most of the gas produced in the country since 1979 has been APG.
- ◆ As of 2009, gas flared made up 26% of APG produced, down from 31% in 2008 but significantly higher than single digit figures between 2004 and 2006.
- ◆ The chart in the next slide shows a net improvement post 2008.
- ◆ In fact, the curve of gas flared follows the life of the Cantarell oil field (with exploitation that started in 1979 and a decline of oil-to-gas ratio that started in 1997) and Pemex's efforts to reduce flaring. See slide 8 for further explanation.

The statistics of APG flaring in Mexico

Statistics on APG flaring

On the companies involved

Flaring – past, current and forecast



Source: Estrada Estrada, CNH, 2011



Flaring and use of APG at the Cantarell field

Statistics on APG flaring

On the companies involved

- Since 1979, one of the main reasons for Cantarell's prolific oil production rate was the existence of a giant natural gas cap that maintained pressure over the reservoir until about 1997. When the reservoir pressure started to fall, Pemex decided to use nitrogen to enhance the oil recovery – a program that started in 2000. That worked well until 2006. Then, injecting nitrogen was no longer enough and so Pemex had to increase the extraction of APG in the so-called, transition zone between gas and oil, in the field to maintain the level of oil production. However, the gas was polluted with nitrogen and could neither be sold nor re-injected so in 2004 PEMEX began the construction of a nitrogen plant that reached a capacity of 420 MMCFD in 2008. That capacity was still below the needs generated by the quantity of extracted APG so, in 2008, the flaring from the field drastically increased. To cope with the increasing trend in flaring, and under the pressure of CNH set up in 2008, Pemex invested in compression equipment to increase the re-injection (see further on).



The statistics of APG flaring in Mexico: Who is Involved?

Statistics on APG flaring



On the companies
involved

- ◆ The main player in the oil industry in Mexico is state-owned Petroleos Mexicanos (PEMEX).
- ◆ Pemex owns Mexico's largest field, Cantarell field, which is situated some 80 km offshore in the Bay of Campeche and consists of 4 main fields: Akai (the largest), Nohoch, Chac and Kutz.
- ◆ The national oil company, PEMEX, is the largest in Mexico, and by mandate of the late 2013 Energy Reform, it has ended its monopoly, allowing foreign investment, although it remains the state-owned company.



What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

Agencies

Legal framework

Fiscal framework

Government institutions involved in regulation of oil production/flaring	Description
Comision Nacional de Hidrocarburos (CNH)	Regulator in energy sector, newly established in 2008 to support regulatory mandate of SENER
Secretaria de Energia (SENER)	The Ministry of Energy, charged with managing and regulating all energy resources in the country
Secretaria de Hacienda y Credito Publico (SCHP)	The Secretariat of Finance and Public Credit, regulates fiscal matters with respect to hydrocarbon use, including APG



What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

Agencies

Legal framework

Fiscal framework

- Prior to the 2008 establishment of CNH, previous regulation considered gas flaring as a needed practice.
- There was a lack of specific regulation for tracking technical thresholds for gas flaring and venting issues.
- Any obligations assumed by Mexico were the consequence of international commitments and without any legal commitments.
- A 'Program to Reduce Greenhouse Gases Mexico (GEI Mexico)' was, in effect, promoted by a joint collaboration of the Ministry of Environmental Protection (SEMARNAT), the World Resources Institute (WRI), the World Business Council for Sustainable Development (WBCSD), and the Mexican Business Council (CCE).



What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

Agencies

Legal framework

Fiscal framework

Regulation/Policies on Gas Flaring/AG use	Description
2008 Energy Reform/ Ongoing reforms	<p>A series of policy changes in the energy sector occurred around 2008. The CNH has issued technical guidelines for the avoidance and reduction of natural gas flaring and venting. Although these guidelines are only mandatory for Pemex, Pemex includes the necessary provisions in its contracts with private contractors ensuring that they comply with these guidelines.</p> <p>Energy reforms are currently in progress with improved, stricter gas flaring regulation expected.</p>
Resolution CNH.06.001/09	<p>CNH publishes technical specifications to reduce flaring and venting of gas in E&P oil and gas operations.</p> <p>Non-compliance with those specifications trigger corrective procedures and possibly sanctions.</p>



What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

Agencies

Legal framework

Fiscal framework

Regulation/Policies on Gas Flaring/AG use	Description
<p>Technical provisions for the use of APG in the exploration and extraction of hydrocarbons – January 2016</p>	<p>In January 2016 CNH issued mandatory technical guidelines for the maximization of the use of APG. CNH requires from the operators to include a plan for the use of APG within the development plan for the exploitation of hydrocarbons. This plan will establish a yearly objective for the use of APG from exploration to closure to be calculated according to a prescribed formula and to be approved by CNH. Preferably within 3 years of exploitation, the use of APG needs to reach 98%.</p> <p>The guidelines explain that the operators must perform all actions and investments to put in place the technical and operational capacity necessary to obtain maximum utilization and conservation of the APG. The guidelines specify that the operator will be able to exploit the APG for auto-consumption, operations within the area of contractual assignment, fuel for turbines, compressors, motors, among others pneumatic devices or in any other way to generate power for the benefits of the operator. The solution for the use of APG will have to proceed from an economic and technical analysis taking into account the composition and volume of APG, the proximity of the processing, transportation and distribution infrastructure, the value of the gas and the value of the necessary investments to use the APG.</p> <p>In addition it stipulates the following measures to be adopted by the contractor (Fluenta, 2016):</p> <ul style="list-style-type: none"> • The capacity of flare and vent gas meters must be sized according to the expected amount of gas to be emitted or flared; • The maximum allowable measurement uncertainty for gas flaring / venting measurement systems cannot exceed plus or minus three per cent; • Indirect estimation of gas volumes must be made in accordance with gas oil ratio accounting or by using system balance or simulation. The installation of all gas and vent meters should be in compliance with manufacturer specifications; • Measurement and monitoring of flare and gas composition must be conducted either by sampling for laboratory analysis or with installed continuous analysers; • When there is a significant amount of liquid in the gases being vented, operators must install a separator alongside a liquid meter. <p>According to these guidelines, in cooperation with CNH Pemex will have to rework on all its plans for the use of APG.</p> <p>The non-compliance with those specifications will be sanctioned according to the dispositions of the Hydrocarbons Laws or the specific contracts.</p>

What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

Agencies

Fiscal Framework on Gas Flaring/AG use	Description
	None listed

Legal framework

Fiscal framework



APG-use case study: Cantarell

Reinjection and
Enhanced Oil
Recovery (EOR)

Gas to Liquids

Power Generation
(IPP)

Challenges



- ◆ In 2008, Pemex invested almost \$3bn in new well installation and desalination and dehydration plants designed to regulate its decreasing oil production. At the same time, gas flaring reduction turbocompressors, gas reinjection, and a nitrogen recovery unit were installed at the Ciudad Pemex, Tabasco Gas Processing Center, contributing to the reduction in flaring from the Cantarell site, in particular, post 2008 – an investment of more than \$1.6 billion from 2005 to 2012.
- ◆ APG use was accomplished through optimization of infrastructure and “distributing the gas stream for artificial lift, reservoir reinjection and delivery for industrial consumption” (Lozano, 2012).
- ◆ Reportedly, the company is currently investing an extra \$976 million towards its gas flaring reduction efforts.

CNH's strategy: the Cantarell Case Example

THE CANTARELL CASE

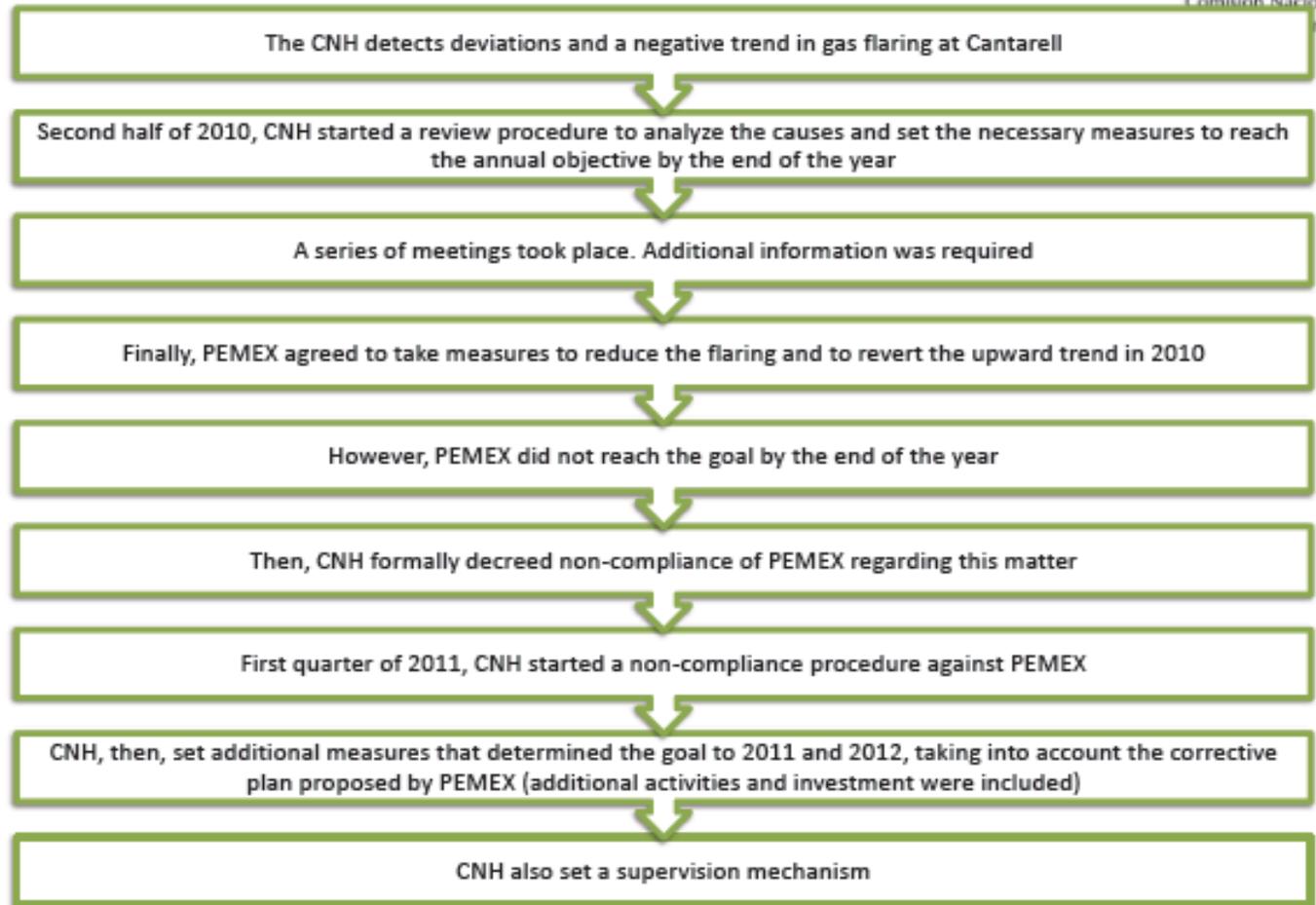


Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges



Source: Estrada Estrada, CNH (2011)



Improved technology at Cantarell



Infrastructure for gas handling

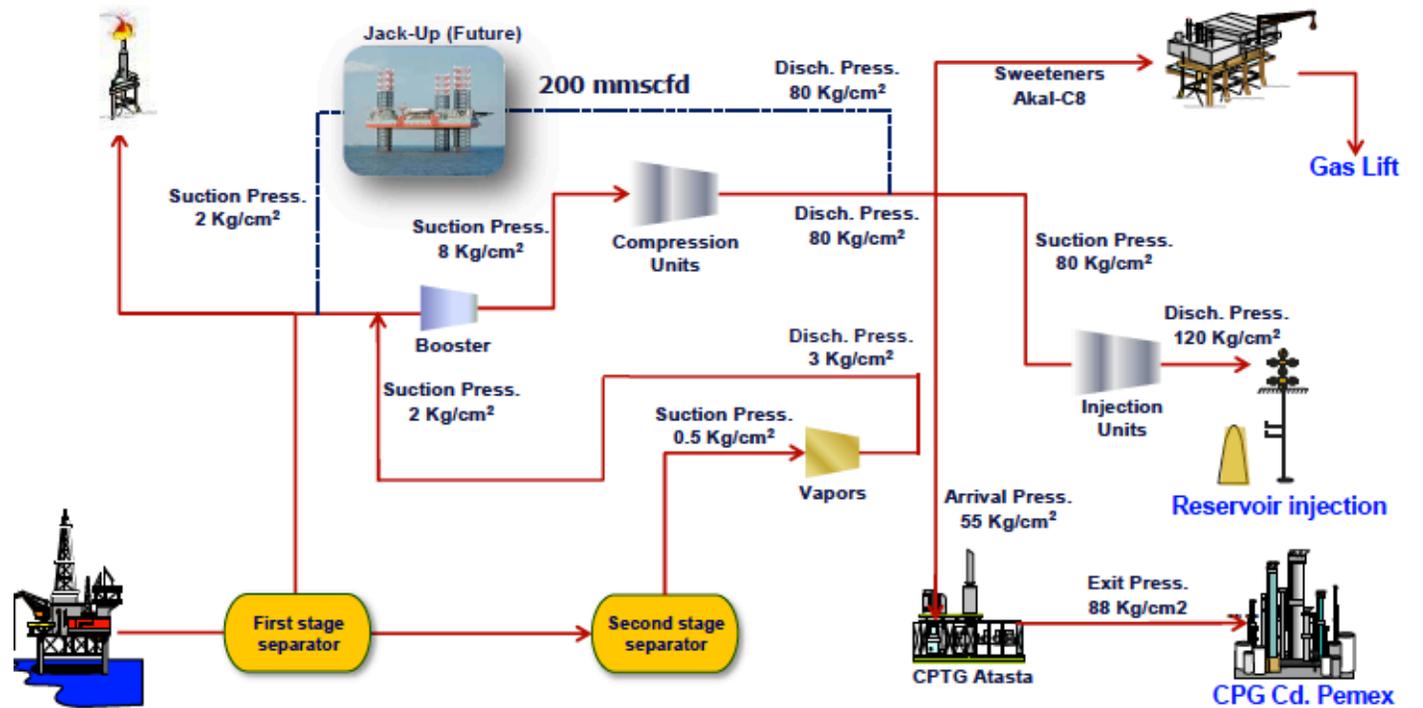


Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges



Source: Lozano, 2012



Pemex's investments for sustained gas utilization

Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges



Investments for sustainable gas utilization



Number

Before (2008)			Present (2012)			Future (2014)		
Low pressure	High pressure	Injection Units	Low pressure	High pressure	Injection Units	Low pressure	High pressure	Injection Units
48	22	2	53	29	9	65	38	10

Millions dollars

Equipment and works	2005-2008	2009	2010	2011	2012	2013	2014	Total
High pressure compression units		188	59	299	235	28	433	1,242
Injection to the reservoir units					151	51		203
Low pressure units (Booster)			54	110	151	263	51	629
Vapor Recovery Units (VRU)	8	29				13		50
Facilities and additional works	206	148					136	490
Total	214	364	113	409	537	356	620	2,613

Source: Lozano, 2012



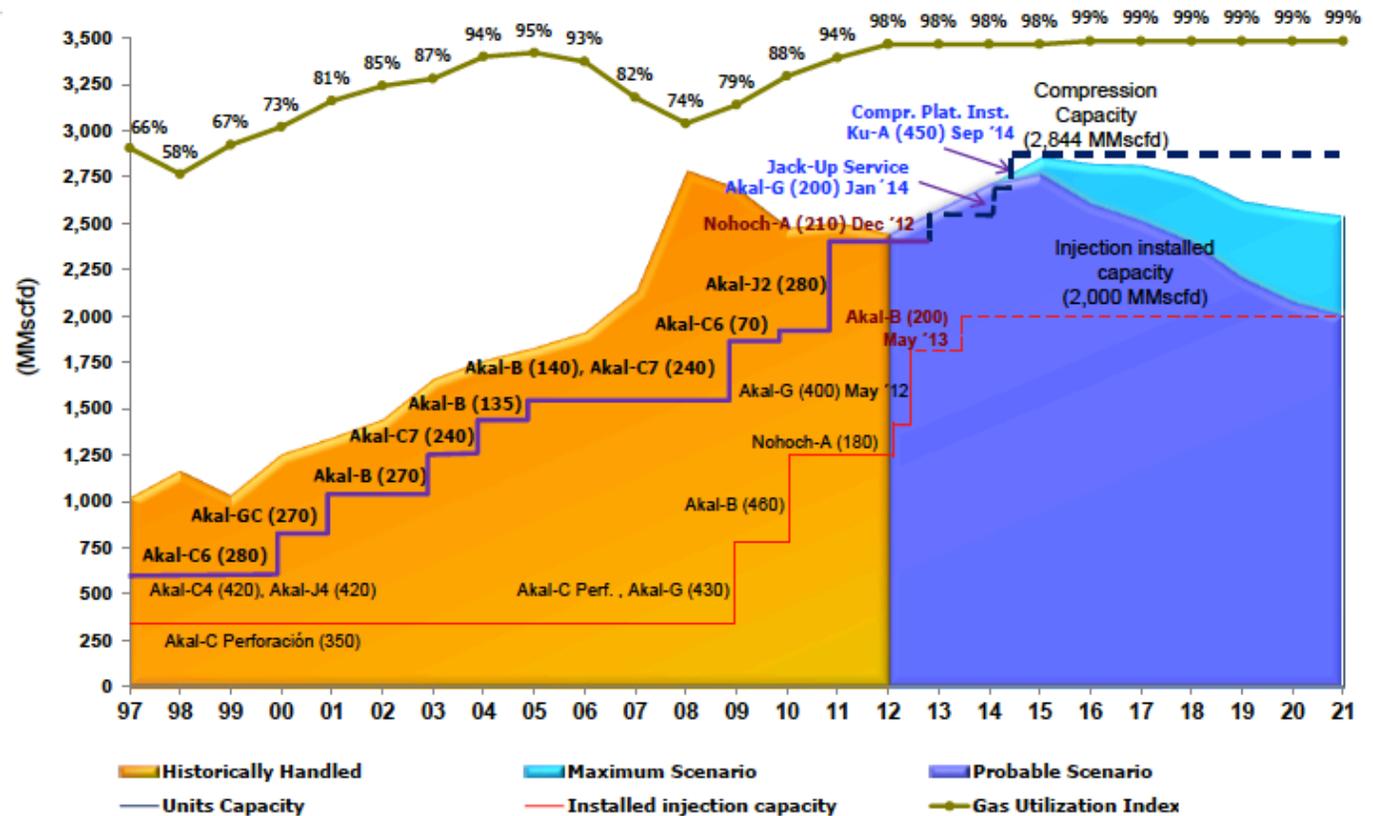
Rising gas utilization and improved capacity since 2008

Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges



Source: Lozano, 2012

Gas utilization increased by 24%, from 74% in 2008 to 98% in 2012, due to Pemex's significant investments in gas handling and reinjection capacity.

APG-use case study: Perseus/ Greyrock

Reinjection and
Enhanced Oil
Recovery (EOR)

Gas to Liquids

Power Generation
(IPP)

Challenges

◆ Project Participants

- Compañía Petrolera Perseus S.A. de C.V. (Perseus), an independent Mexican oil and gas exploration and production company, and Greyrock Energy, Inc., a specialist in transforming flare gas, bio-gas, natural gas or natural gas liquids into diesel fuel that can be used locally or can be easily transported to market.

◆ Project Description and Motivation

- In May 2016, Perseus and Greyrock signed a joint-venture to collaborate to provide solutions for flaring using Greyrock's Flare-to-Fuels™ systems.
- In July 2016 Greyrock was recognized by the World Bank's Global Gas Flare Reduction (GGFR) Partnership as "the top solution for elimination of flare gas worldwide" (Greyrock).

◆ Associated Gas Use

- Greyrock developed a system to convert flare gas into diesel fuel.
- "Greyrock systems are modular, easily transportable and remotely controlled for the production of 5 to 50 barrels per day of clean fuels from flare gas. Systems can be deployed in parallel as needed to process larger flare gas volumes" (Greyrock).
- According to Greyrock, this system reduces "the complexity and costs associated with traditional natural-gas-to-liquids processes by bypassing the intermediate hydrocarbon wax that normally needs to be refined into finished products" (Greyrock).
- These systems are to be located at the well pad. The fuels produced can either be blended with oil at the well pad or processed further. The diesel that is produced "features high cetane, no sulfur and good lubricity." According to Greyrock, these diesel fuels do not require further refining and upgrading as opposed to those coming from Fischer-Tropsch based technologies.



What energy needs could the flared gas satisfy?

Reinjection and
Enhanced Oil
Recovery (EOR)

Gas to Liquids

Power Generation
(IPP)

Challenges

- ♦ Mexico's use of APG has been mainly in reinjection but this might change.
- ♦ Driving domestic demand for gas is the demand for power generation in a country where fossil fueled power plants provide most of the generation capacity.
- ♦ And motivating gas-based power demand are private and independently operated power plants, whose gas consumption is anticipated to increase at a 7.9% average annual rate, from 1.6 Bcf/d in 2012 to 4.9 Bcf/d in 2027, according to a U.S. Energy Information Administration (EIA) report.
- ♦ In light of this growing demand (as Mexico has begun importing gas-importing 1.8Bcf/d as of 2013) and the Secretary of Energy Integral Fuel policy stressing the use of domestic gas, partly through the construction of gas fired combined cycle power plants, APG has the potential to meet a significant amount of Mexico's gas needs in coming years.
- ♦ However more investment in gas gathering facilities and gas transmission lines is needed to connect the South / Southeast fields to the far consumption centers in the North/ Northeast.



Challenges and opportunities: New challenges in currently producing oil fields and future challenges

Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges

- Project-related challenges for flaring and APG use identified by CNH:
 - Chicontpec Basin (petroleum system of fields scattered over a 3800 km² area in the states of Veracruz, Puebla and Hidalgo): Controlling the large amounts of flared gas at this group of sparsely distributed oil fields requires more gathering systems and solutions to use the APG in place or for the surrounding communities. Given the technical and geological challenges of this basin, the current oil production is however not at capacity.
 - With the 2016 technical guidelines, CNH is seeking to implement new methods of measuring the flaring and venting of APG, to improve the certainty and measurability for the handling of gas and to move towards preventive regulations promoting the utilization of gas beyond reinjection that cannot absorb all the APG generated by new fields.



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