Mexico
Associated Gas Utilization Study

Perrine Toledano, Belinda Archibong
Thanks to Tom Mitro for his thoughtful review
Mexico’s reform of the state-owned oil company, Petroleos Mexicanos (PEMEX) in 2013 along with the creation of the hydrocarbon regulatory agency, Comision National 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.
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

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

Source: Roldan and Pena, CNH, 2014
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.

Source: Estrada Estrada, CNH, 2011
The chart above depicts APG (blue), NAG (green) produced and gas flared (red) from 1960-2009 in mmcf/d. 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

Flaring – past, current and forecast

Statistics on APG flaring

On the companies involved

Source: Estrada Estrada, CNH, 2011
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 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?

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

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

- 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?

<table>
<thead>
<tr>
<th>Regulation/Policies on Gas Flaring/AG use</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td><strong>2008 Energy Reform/Ongoing reforms</strong></td>
<td>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. Energy reforms are currently in progress with improved, stricter gas flaring regulation expected.</td>
</tr>
<tr>
<td><strong>Resolution CNH.06.001/09</strong></td>
<td>CNH publishes technical specifications to reduce flaring and venting of gas in E&amp;P oil and gas operations. Non-compliance with those specifications trigger corrective procedures and possibly sanctions.</td>
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</table>
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%.

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.

In addition it stipulates the following measures to be adopted by the contractor (Fluenta, 2016):

- 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.

According to these guidelines, in cooperation with CNH Pemex will have to rework on all its plans for the use of APG.

The non-compliance with those specifications will be sanctioned according to the dispositions of the Hydrocarbons Laws or the specific contracts.
What is the legal and fiscal framework in place to stop flaring and incentivize APG use?

<table>
<thead>
<tr>
<th>Agencies</th>
<th>Fiscal Framework on Gas Flaring/AG use</th>
<th>Description</th>
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<tbody>
<tr>
<td></td>
<td>None listed</td>
<td>None listed</td>
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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.
Reinjection and Enhanced Oil Recovery (EOR)

Gas to Liquids

Power Generation (IPP)

Challenges

The CNH detects deviations and a negative trend in gas flaring at Cantarell

Second half of 2010, CNH started a review procedure to analyze the causes and set the necessary measures to reach the annual objective by the end of the year

A series of meetings took place. Additional information was required

Finally, PEMEX agreed to take measures to reduce the flaring and to revert the upward trend in 2010

However, PEMEX did not reach the goal by the end of the year

Then, CNH formally decreed non-compliance of PEMEX regarding this matter

First quarter of 2011, CNH started a non-compliance procedure against PEMEX

CNH, then, set additional measures that determined the goal to 2011 and 2012, taking into account the corrective plan proposed by PEMEX (additional activities and investment were included)

CNH also set a supervision mechanism

Source: Estrada Estrada, CNH (2011)
Improved technology at Cantarell

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

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<tr>
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<tbody>
<tr>
<td>Low pressure</td>
<td>High pressure</td>
<td>Injection Units</td>
<td>Low pressure</td>
</tr>
<tr>
<td>48</td>
<td>22</td>
<td>2</td>
<td>53</td>
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<table>
<thead>
<tr>
<th>Million dollars</th>
<th>Equipment and works</th>
<th>2005-2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>Total</th>
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<tbody>
<tr>
<td>High pressure compression units</td>
<td>188</td>
<td>59</td>
<td>299</td>
<td>235</td>
<td>28</td>
<td>433</td>
<td>1,242</td>
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<tr>
<td>Injection to the reservoir units</td>
<td>151</td>
<td>51</td>
<td>203</td>
<td></td>
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<tr>
<td>Low pressure units (Booster)</td>
<td>54</td>
<td>110</td>
<td>151</td>
<td>263</td>
<td>51</td>
<td>629</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vapor Recovery Units (VRU)</td>
<td>8</td>
<td>29</td>
<td>13</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Facilities and additional works</td>
<td>206</td>
<td>148</td>
<td>136</td>
<td>490</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>214</td>
<td>364</td>
<td>113</td>
<td>409</td>
<td>537</td>
<td>356</td>
<td>620</td>
<td>2,613</td>
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</tbody>
</table>

Source: Lozano, 2012
Rising gas utilization and improved capacity since 2008

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.
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?

- 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 county 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

- 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.


Greyrock ’s website: http://www.greyrock.com


“Publica CNH disposiciones técnicas para aprovechamiento de gas naturalOil and Gas.” *Oil and Gas Magazine*. 9 Jan. 2016

