Associated Gas Utilization : The Basics

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Outline of Presentation

- Definition of APG and gas flaring
- Impacts of gas flaring
- Barriers to effective APG utilization
- APG utilization options overview
- Potential fiscal and institutional frameworks for APG use
Associated petroleum gas (APG), also known as flare gas or associated gas, is a form of natural gas that is commonly dissolved in reservoirs of oil, and is a by-product in the process of extraction of oil.

APG can also be considered to be found in condensate or “wet gas” fields when the investor is only interested in the liquids of the field (with the APG being the dry gas that is not collected).

APG is composed mostly of light hydrocarbons like methane (up to 81%) and some heavier components including ethane ($C_2H_6$), propane ($C_3H_8$), butane ($C_4H_{10}$) and others.

APG is vented or flared (intentional burning) when it is not utilized for further processing. Flaring is preferable to venting gases, which can release larger quantities of methane and volatile organic compounds into the atmosphere. However, both processes are harmful to the environment.
The negative impacts of APG flaring

Definition of APG and gas flaring

Impacts of gas flaring

Barriers to effective APG utilization

- The negative environmental effects of gas flaring are well documented with the World Bank’s Global Gas Flaring Reduction Partnership (GGFR) stating that flaring produces about 400 million tons of greenhouse gas emissions globally each year.

- The negative health effects of exposure to hazardous air pollutants released during incomplete combustion of gas flare have also been well studied.

- Flaring can also be assessed in terms of foregone revenues, as high as $2.5bn/year between 1970-2006 for Nigeria alone.

Methane is a much more intensive greenhouse gas than carbon dioxide
Despite knowledge of the negative environmental, economic and health impacts of gas flaring, there remain some economic and institutional barriers to APG utilization.
Unlocking economic and institutional barriers opens a wealth of opportunity not only for APG use but also for Non-Associated Gas (NAG) use.

The case of the West Africa Region has demonstrated that APG use under the form of capital intensive projects such as LNG plants has been possible because they are backed by oil revenues. Therefore any such projects are, to a certain extent, incremental to the original development investment decision of exploiting oil.

In turn, those APG use projects can be supplemented by the development of NAG fields that will benefit from the facilities developed for APG use.

Simply put, in these regions, APG exploitation makes NAG exploitation cheaper.
There are a number of APG use strategies and options can broadly be classified into 4 main categories: reinjection, power generation, compression and liquefaction.
### APG utilization options: Reinjection

#### An Overview of APG utilization options

#### Comparing APG utilization options

#### Fiscal and Institutional frameworks

<table>
<thead>
<tr>
<th>Option</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinject for future use</td>
<td>Preserves value</td>
<td>Not all formations suited for reinjection; capital cost for local processing and compression</td>
</tr>
<tr>
<td>Reinject for Enhanced Oil Recovery (EOR)</td>
<td>Provides revenue through increased oil production, may allow future recovery of some reinjected gas</td>
<td>Not all oil formations suitable for gas EOR; capital cost for local processing and compression</td>
</tr>
</tbody>
</table>
An Overview of APG utilization options

**Regional** - Enables operators to transform wasted fuel into a resource, especially valuable in remote locations

**Local** - By generating power using gas already existing on-site, operators no longer need to truck in diesel to remote areas, resulting in lower operation costs

### Comparing APG utilization options

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<tr>
<th>Option</th>
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<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local electricity generation for needs of oil field</td>
<td>Savings in purchased electricity or purchased diesel to generate power</td>
<td>Capital cost; field typically requires only 30% of power that its APG could generate and other local markets may be limited or nonexistent</td>
</tr>
<tr>
<td>Regional electricity generation</td>
<td>Economic and environmental savings in purchased diesel to generate power – engine of regional integration</td>
<td>Capital cost of gathering and processing infrastructure; low domestic electricity prices limit price offered for gas</td>
</tr>
</tbody>
</table>
Liquefaction = Processing APG into:
- Liquefied Natural Gas (LNG),
- Liquefied Petroleum Gas (LPG)
- Gas-to-Liquids (GTL)

In the case of condensate/wet gas, the dry gas is considered as APG when only Natural Gas Liquids (NGL) are extracted.
**Definitions: LNG, LPG, GTL, NGL**

<table>
<thead>
<tr>
<th>LNG</th>
<th>LPG</th>
<th>GTL</th>
<th>NGL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas that has been cooled to a liquid state. Cooled at a temperature of approximately -256° F at atmospheric pressure; Consists primarily of methane</td>
<td>A mixture of propane and butane that exists in a liquid state at room temperature</td>
<td>Process of converting natural gas to liquid products like methanol, middle distillates (diesel and jet fuel), diethly ether (DME), specialty chemicals and waxes</td>
<td>Consists primarily of molecules heavier than methane like ethane, propane and butane. Separated from gas as liquids through methods like absorption, condensation in gas processing or cycling plants; Exists as condensate at low pressure, LPG at high pressure and natural gas at intermediate pressure</td>
</tr>
</tbody>
</table>

**CNG (Compressed Natural Gas) is often confused with LNG. CNG is stored as a gas at high pressure whereas LNG is stored as liquid at very low temperature. CNG’s cost of production is therefore lower than that of LNG, while requiring higher storage capacity. Thus, LNG is used for transporting gas over long distance, and is then converted to CNG for distribution.**
Different chemical compositions among the liquefaction options

An Overview of APG utilization options

Comparing APG utilization options

Fiscal and institutional frameworks

CNG is included for comparison purposes but is not a form of liquid gas (see slide before)

Source: University of Houston Institute for Energy, Law & Enterprise
For use at the local level, as compared to LNG, LPG presents the advantage of not necessitating a large demand and can serve small scale use in cooking, fertilizer plants and power generation. Its cost of production is lower than LNG and it is easy to use and transport.
The GTL technology is often called Fischer-Tropsch-Gas-to-Liquids (FT-GTL) technology because the Fischer-Tropsch chemical conversion is the process of converting the gas into liquid hydrocarbons. However, this technology is still in development. Since GTL has not been economically feasible and has involved a lot of technical risks, LNG technology has dominated the commercial markets for utilizing APG (Buzcu, 2010).
**Fiscal Stimuli** - Incentives and Penalties are two types of fiscal stimuli typically used by host governments to promote investment in flare and vent reduction projects. They can be introduced into production licenses or production sharing agreements as well as in the fiscal laws.

- **Penalties** are imposed uniquely on flaring and venting of APG that occur during upstream operations. They stimulate the effective utilization of APG by making flaring economically infeasible.

- **Incentives** are required for stimulating investment in utilization of APG, particularly in the conditions of an underdeveloped domestic gas market and limited export opportunities.
## Examples of fiscal incentives

The most common financial incentives used for APG use projects are:

1. lower royalty rates (e.g. Nigeria, Tunisia, Vietnam);
2. higher cost-recovery ceilings and/or profit shares (e.g. Egypt, Indonesia, Malaysia);
3. lower tax rates (e.g. Nigeria, Tunisia, Papua New Guinea);
4. reduction of existing oil taxes (e.g. Trinidad and Tobago (Supplementary Petroleum Tax))
5. Qualifying APG use project as Clean Development Mechanisms (CDM) enabling the company to gain carbon credits under a cap and trade system established in certain countries/regions upon the ratification of Kyoto’s protocols.

## Framework for Penalties

Penalties usually take the form of a fine imposed on a unit of gas flared or vented. There are 3 important conditions for penalizing policy to address flaring and venting effectively:

1. **High Level**: The level of penalties should be high enough to make the options of effective utilization more attractive than paying.
   - **Carbon tax** - sets a price for a unit of emission – easy to administer and flexible for the polluter (investing in flaring reduction to the point where the cost of reducing one more unit of emissions is just equal to the tax per unit of emissions)
2. **Established regulatory framework**: The presence of a strong, independent regulatory body is necessary to measure and report requirements, monitor flare and vent volumes, enforce the regulations and pursue the penalties.
3. **Combination of approaches**: The combination of the penalty approach with other fiscal incentives has proved to be the most effective fiscal policy.
Challenges of taxation of LPG

- Liquids can be sold on the same price terms as oil so on this basis policy makers often impose the same fiscal terms as oil. However, it generates disincentive for broader gas developments.

- High liquids content in a natural gas project significantly enhances its profitability and can enable producers to charge a lower price for gas. This can make the difference between a gas project being economically viable or not. When the liquids are liable to a high tax rate (e.g. oil tax rates), this economic benefit can be minimized for investors. Therefore, it is important to consider how condensate is treated under differentiated fiscal terms, as this can influence the pace of development of the gas industry.

- In the case of LPG produced out of APG present in oil fields, the facilities used for liquids separation and export can be those established for the production and export of oil. As a result it is more difficult for investors to argue for better fiscal terms for the liquids and differentiated profits are more difficult to establish. Applying the same fiscal terms for both oil and LPG represents an issue when LPG prices fall lower than oil prices.
Institutional reform to encourage APG utilization

**Legislation**
- Clear guidelines and rules on gas utilization targets;
- Fines and other penalties;
- Regulatory clarity;
- Support the state-private partnerships’ investments into APG reduction projects, with main focus on the regions with a high percentage of flaring;
- Assess direct subsidies to AG.

**Authorities**
- Clarity of roles and objectives;
- Autonomy;
- Participation;
- Accountability;
- Transparency;
- Predictability

**Enforcement**
- Enforcement based on step-wise penalties, including license revocation;
- Consistent and non-discriminatory enforcement.

Market mechanisms that create means and incentives for commercialization
(liberalized prices, regulated third-party network access, etc.)

Source: PFC, World Bank
### Annex: Energy conversion table

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Billion cubic meters gas BCM</th>
<th>Billion cubic feet gas Bcf</th>
<th>Million barrels of oil equivalent mmboe</th>
<th>Million tonnes oil equivalent mmtmoe</th>
<th>Trillion / million tonnes LNG</th>
<th>British Thermal units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion cubic meters gas BCM</td>
<td>1</td>
<td>35.51</td>
<td>6.10</td>
<td>0.83</td>
<td>0.7</td>
<td>36.7</td>
<td></td>
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<tr>
<td>Billion cubic feet gas Bcf</td>
<td>0.028</td>
<td>1</td>
<td>0.17</td>
<td>0.024</td>
<td>0.020</td>
<td>1.04</td>
<td></td>
</tr>
<tr>
<td>Million barrels oil equivalent mmboe</td>
<td>0.16</td>
<td>5.79 (one can use conversion factor of 6)</td>
<td>1</td>
<td>0.14</td>
<td>0.116</td>
<td>6.02</td>
<td></td>
</tr>
<tr>
<td>Million tonnes oil equivalent mmtmoe</td>
<td>1.20</td>
<td>42.55</td>
<td>7.35</td>
<td>1</td>
<td>0.86</td>
<td>44.21</td>
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<tr>
<td>Million tonnes LNG</td>
<td>1.41</td>
<td>49.74</td>
<td>8.59</td>
<td>1.17</td>
<td>1</td>
<td>51.69</td>
<td></td>
</tr>
<tr>
<td>Trillion British Thermal units</td>
<td>0.027</td>
<td>0.96</td>
<td>0.17</td>
<td>0.023</td>
<td>0.019</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

1 tbtu = 1 bcf
1 mscfd = 0.01 bcm
1 therm = 100,000 btu
1 therm = 0.1 mmmbtu
1 CF = 0.01 mmmbtu
1000 cubic meters to mmmbtu = divide 1000 by 35.315 to get price in mmmbtu
1 trillion = one thousand billion
If one had the price of natural gas in therm and one wants to convert it to the price per mmmbtu one needs to multiply by then (50 cents per therm = 55 mmmbtu)

Source: Energy dictionary
References

References


- "What is associated Petroleum Gas." Gazprom, Web. 04 May 2014


- Roberts, K. Modular design of smaller-scale gtl plants. *Oxford Catalysts, 1*(2013), 101-103


