Petrobras’ Gas Utilization Optimization Program
(POAG-2015)

Denis Krambeck Dinelli
Petrobras’ Domestic E&P Gas Production Planning

2nd WOC1/PGCA Meeting
Rio de Janeiro, Brazil
18-21 February 2013
Summary

1. INTRODUCTION: PETROBRAS’ E&P HIGHLIGHTS

2. GAS FLARING: PROBLEM DIAGNOSIS

3. POAG 2015 – GAS UTILIZATION OPTIMIZATION PROGRAM

4. RESULTS

5. NEXT STEPS

6. CONCLUSIONS
1. INTRODUCTION: PETROBRAS’ E&P HIGHLIGHTS
Petrobras’ E&P Highlights (2011)

PROVEN RESERVES (31/12/2011)
- SPE
  - 15.7 billion boe
  - 395 bcm natural gas
  - R/P 19.5 years
  - Reposition index 153%
- SEC
  - 12.2 billion boe
  - 293 bcm natural gas
  - R/P 15.2 years
  - Reposition index 115%

PRODUCTION (2011)
- 2.376 Mboepd
- 2.022 Mbpd oil
- 64 Mm³/day natural gas
Proven Reserves (2011)

Proven reserves 31/12/2011 (SPE)

(15.7 billion boe)

- Proven reserves developed: 60%
- Proven reserves undeveloped: 40%

- Oil and NGL: 84%
  - Non-associated gas: 4%
  - Associated gas: 12%

- Gas:
  - > 31 °API (light): 5%
  - 22 - 31 °API (intermediate): 36%
  - < 22 °API (heavy): 43%
Natural Gas Production

ASSOCIATED  NON-ASSOCIATED

5.7% p.y.

million m³/d

2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 (Jan-Oct)

38.3 42.5 43.1 45.6 48.0 48.0 49.3 58.5 57.3 61.3 64.0 69.3

6.6 7.3 7.9 9.3 9.0 8.8 10.8 17.4 11.4 15.3 19.1 22.8
Domestic E&P Supply

10.1% p.y.

million m³/d


16.4 20.3 21.9 24.3 24.5 24.8 24.7 32.2 25.8 32.1 37.0 43.1
2. GAS FLARING: PROBLEM DIAGNOSIS
Production, Flaring and Utilization Index: 2004

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

- Percentages:
  - 90.8%
  - 45.6%
  - 41.4%
  - 4.2%

- Units:
  - Million m³/day

Legend:
- Gas flared, old platforms
- Gas utilized
Production, Flaring and Utilization Index: Evolution 2004 - 2009

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

- 26% increase in natural gas production
- 121% increase in flaring
Production, Flaring and Utilization Index Evolution 2004 - 2009

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

- 2004:
  - Production: 41,4 million m³/day
  - Flaring: 4,2 million m³/day
  - Utilization: 37,2 million m³/day
  - Flaring Index: 10,0%

- 2009:
  - Production: 48,0 million m³/day
  - Flaring: 9,3 million m³/day
  - Utilization: 38,7 million m³/day
  - Flaring Index: 19,3%

Why?
Production, Flaring and Utilization Index
2009 Diagnosis

Petrobras' Natural Gas Production, Flaring and Utilization Index in Brazil

HOW TO IMPROVE?

COMISSIONING OF NEW PLATFORMS

“OLD” PLATFORMS

Gas flared, old platforms
Gas flared, platforms in commissioning
Gas utilized
Gas Utilization Optimization Program: The Beginning

• A multi-disciplinary study group was formed to:
  – study the causes;
  – make a diagnosis;

• Case studies were classified into three groups:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Facilities already under construction that could be modified without major changes in their startup time</td>
</tr>
<tr>
<td>2</td>
<td>Facilities already under construction in which modifications could strongly impact their startup time</td>
</tr>
<tr>
<td>3</td>
<td>Operating facilities with high flaring rates and low gas utilization ratio</td>
</tr>
</tbody>
</table>

• Focus should be on Campos Basin.
Campos Basin Infrastructure
3. POAG 2015 – GAS UTILIZATION OPTIMIZATION PROGRAM
POAG 2015: Gas Utilization Optimization Program

- Program planned during 2009, based on the Action Plan developed by the multi-disciplinary Study Group;

- Approval and patronage of E&P’s Executive Managers:
  - E&P Corporate
  - E&P Engineering
  - E&P S-SE

- Implemented from January 2010;

- Basic contents:
  - Directives for the approval of new production facilities;
  - Retrofits and actions to reduce gas flaring in operating platforms;
  - Flare monitoring on a weekly basis;
  - Monitoring of facilities under design or construction on a monthly basis;
  - Gas flaring reduction goals from 2010 to 2015.
POAG 2015 - Initial Goals

Gas utilization index

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
<td>88.0%</td>
<td>90.0%</td>
<td>90.0%</td>
<td>92.0%</td>
<td>93.0%</td>
<td>95.0%</td>
</tr>
</tbody>
</table>
POAG 2015: Strategic Directives

RAISE GAS UTILIZATION TO INTERNATIONAL BENCHMARK LEVELS

GROUP 1
- Secure a minimum utilization ratio of 97% in new production facilities

GROUP 2
- Secure a minimum utilization ratio of 95% in new production facilities

GROUP 3
- Secure a minimum utilization ratio of 95% in production facilities that flare more than 80,000 m³/d

At startup new platforms must abide to the strategic directives set for gas utilization and exportation.

GAS UTILIZATION AND OIL PRODUCTION CANNOT BE AFFECTED BY DEMAND FLUCTUATIONS

NEW PROJECTS SHOULD NOT REDUCE THE UTILIZATION RATIO OF OPERATING FACILITIES (e.g. platforms, collection stations)
POAG 2015: Analytical Structure of the Program

- POAG directives for new platforms (commissioning, critical equipments, design, etc.)
- Directives for process operation and machine maintenance
- Dissemination of best practices
- Communication plan for the workforce

UO-BC Sub-program
- P-35
- P-18
- P-26
- PCE-1
- P-15
- P-20
- PGU-1
- PNA-1
- P-19
- PCE-1
- North-South Pipeline

UO-RIO Sub-program
- P-40
- P-50
- P-51
- P-53
- P-54
- FPSO Cid. Niteroi

UO-BS Sub-program
- FPSO Cid. Angra dos Reis
- FPSO Cid Santos

E&P-PDP Sub-program
- FPSO Cid. Itajai
- FPSO Cid. Santos
- FPSO Cid. Paraíba
Objectives: Assure transparency and periodicity in the distribution of information concerning the evolution of the program; support decision makers of all levels with real time monitoring of the physical progress achieved in the projects, in a structured and organized manner.

**Strategic Vision I**

- Director Monitoring
  - Resp: Director

**Strategic Vision II**

- Corporative Monitoring
  - Resp: Executive Manager I
- Technical Monitoring
  - Resp: Executive Manager II

**Program Vision**

- Blocking and Corrective Actions
  - Resp: Technical Manager
- Operation Monitoring
  - Deviations
- Level 3 Monitoring
  - Resp: POAG Coordinator
- Risk Management

**Project and Case Study Vision**

- Internal Meetings at Operating Units
  - Level 4
  - Resp: Sub-Program Coordinators
POAG 2015: Implementation Monitoring

• Structured monitoring of the projects development was essential;
• Web-based tool used on the monthly meetings:
  – Baseline vs. Projected completion date for each project;
  – Projects’ activities and chronogram;
  – Projected impact on the initial goals;
  – Updated Action Plan, with root cause analysis for deviations;
<table>
<thead>
<tr>
<th>SUBPROGRAMA</th>
<th>PROJETO</th>
<th>PENDÊNCIAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>UO-BS - Novos Sistemas</td>
<td>Atividades Complementares (POAG UO-BS)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sist. Comp. Esc. Cid. Angra dos Reis</td>
<td></td>
</tr>
<tr>
<td>UO-BS - Sistemas Implantados</td>
<td>Sist. Comp. Esc. Und. Afretada (FPSO Cid Santo...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sist. Comp. Esc. Und. Próprias (P-56)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redução de Queima da P-50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redução de Queima da P-51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redução de Queima da P-52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Redução de Queima da P-53</td>
<td></td>
</tr>
</tbody>
</table>

**Legenda**

- **Verde**: No prazo
- **Amarelo**: Atraso sem impacto na data
- **Laranja**: Atraso com impacto na data
- **Turquesa**: Marco sem tendência
- **Vermelho**: Total de marcos em edição
- **Fundo**: Total de marcos finalizados
- **Fundo e Verde**: Total de marcos em edição e finalizados

Localizar: queima
### Fase de Seleção (Projeto Conceitual)

2.6 Aprovação do EVTE Conceitual (Portão 2)

- **Planejada EVTE:** AGO/07
- **Planejada Implantação:** AGO/07
- **Prevista/Alcançada:** AGO/07
- **Tendência ATUAL:** Concluído

### Fase de Definição (Projeto Básico)

3.5 Aprovação do EVTE Básico (Portão 3)

- **Planejada EVTE:** AGO/08
- **Planejada Implantação:** NOV/08
- **Prevista/Alcançada:** NOV/08
- **Concluído**

3.5.1 Conclusão do projeto para fabricação do ICS

- **Planejada EVTE:** FEV/08
- **Planejada Implantação:** FEV/08
- **Prevista/Alcançada:** FEV/08
- **Concluído**

3.5.2 Conclusão do projeto detalhado das obras de adequação da P-18

- **Planejada EVTE:** MAI/08
- **Planejada Implantação:** JUL/08
- **Prevista/Alcançada:** JUL/08
- **Concluído**

### Fase de Execução / Implantação

4.4 Conclusão do Recebimento dos Materiais e Equipamentos

- **Planejada EVTE:** OUT/10
- **Planejada Implantação:** OUT/10
- **Prevista/Alcançada:** NOV/10
- **Concluído**

4.4.1 Testes do Conjunto Principal / Teste de Resistência

- **Planejada EVTE:** JUL/10
- **Planejada Implantação:** JUL/10
- **Prevista/Alcançada:** JUL/10
- **Concluído**

4.4.2 Liberação do Equipamento na Fábrica.

- **Planejada EVTE:** AGO/10
- **Planejada Implantação:** JUL/10
- **Prevista/Alcançada:** JUL/10
- **Concluído**

4.4.3 Transporte para o Brasil e Desembaraço Algandégario

- **Planejada EVTE:** OUT/10
- **Planejada Implantação:** OUT/10
- **Prevista/Alcançada:** NOV/10
- **Concluído**

4.4.4 Recebimento de Materiais para Sistema de Captura de Condensado (Cooling Loop Trap)

- **Planejada EVTE:** OUT/10
- **Planejada Implantação:** OUT/10
- **Prevista/Alcançada:** NOV/10
- **Concluído**
POAG 2015: Results Monitoring

- Weekly reports of the flared volumes and the projections for the month and year for the High Management, summarizing the biggest deviations from the goals:

- Corrective actions monitoring;

- Critical factor for the success: the discipline in keeping the Program governance running as proposed was vital to communicate the importance of POAG to all involved workforce.

It is for real!
4. RESULTS
POAG 2015: Production, Flaring and Utilization Index Results 2009-2012

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

- 2009: 48.0 million m³/day
- 2012 Jan-Oct: 57.3 million m³/day
- Flaring, old platforms: 5.0 million m³/day
- Flaring, commissioning platforms: 4.3 million m³/day
- Gas utilized: 83.7%
POAG 2015: Production, Flaring and Utilization Index Results 2009-2012

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

- 19% increase in natural gas production
- 58% decrease in flaring
POAG 2015: Production, Flaring and Utilization Index Results 2009-2012

Petrobras’ Natural Gas Production, Flaring and Utilization Index in Brazil

Previous record: 90,8% (2004)

Flaring, old platforms | Flaring, commissioning platforms | Gas utilized

<table>
<thead>
<tr>
<th>Year</th>
<th>Flaring, old platforms</th>
<th>Flaring, commissioning platforms</th>
<th>Gas utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>4,3</td>
<td>5,0</td>
<td>83,7%</td>
</tr>
<tr>
<td>2012 Jan-Oct</td>
<td>3,5</td>
<td>0,4</td>
<td>64,6</td>
</tr>
</tbody>
</table>

% utilization:
- 57,3% in 2009
- 94,3% in 2012 Jan-Oct

Million m³/day:
- 48,0 in 2009
- 64,6 in 2012 Jan-Oct
POAG 2015:
Flaring and G.H.G. Avoided 2010-2012

GAS FLARING REDUCTION

If 2009’s 83.7% utilization Index had been kept, flaring would have been...
POAG 2015:
Flaring and G.H.G. Avoided 2010-2012

Gas Flaring avoided: 5.9 billion m³
G.H.G emissions avoided: 16 million tons CO₂

3 million passenger cars (15% Brazilian fleet)

References:
- Global Gas Flaring Reduction partners make progress, UNIDO, June 2012
- Estudo de Baixo Carbono para o Brasil, World Bank, 2010

GAS FLARING REDUCTION

Gas Flaring avoided: 5.9 billion m³
G.H.G emissions avoided: 16 million tons CO₂

3 million passenger cars (15% Brazilian fleet)

References:
- Global Gas Flaring Reduction partners make progress, UNIDO, June 2012
- Estudo de Baixo Carbono para o Brasil, World Bank, 2010

GAS FLARING REDUCTION

Gas Flaring avoided: 5.9 billion m³
G.H.G emissions avoided: 16 million tons CO₂

3 million passenger cars (15% Brazilian fleet)

References:
- Global Gas Flaring Reduction partners make progress, UNIDO, June 2012
- Estudo de Baixo Carbono para o Brasil, World Bank, 2010
5. NEXT STEPS
The Brazilian Pre-Salt

- The Pre-Salt in Brazil was the result of efforts to find new exploratory horizons in the Brazilian sedimentary basins;
- Total area of 149,000 km², comprising the Santos and Campos sedimentary basins;
- The Pre-Salt reservoirs are, as is characteristic of carbonate reservoirs, heterogeneous, with highly variable petrophysical properties;
- Basically associated gas, in a gas-oil ratio between 200 and 300 m³/m³.
The Brazilian Pre-Salt

- Challenges:
  - reservoirs depths between 5,000 and 6,000 m below the sea level;
  - extensive salt layer, with thickness up to 2,000 m;
  - high contents of CO2;
  - H2S in high concentrations;
  - flow assurance in ultra-deep waters, with low fluid temperature.

- Extended Well Tests (EWT) – 6 to 12 months
  - reducing technical and geological risks;
  - powerful tool for reservoir characterization:
    ✓ Checking Damage mechanisms and reservoir hydraulic communications;
    ✓ Sampling rocks and fluids;
    ✓ Flow assurance;
    ✓ Economic potential.

HOW TO TEST WITHOUT FLARING?
Modular Offshore Gas-to-Liquids (GTL)

- Technological solution for transporting and monetizing associated and stranded gas reserves during EWT phase;
- The compact reactors applied in GTL process represent a breakthrough in GTL technology, because of their small footprint, lower weight, modular design and high efficiency per unit of reactor volume which meet the requirements for offshore applications.

Gas-to-Flare  →  Gas-to-Liquid
Petrobras’ FGTL R&D 2006-2012

~ US$ 90 MM

Human Resources: ~ US$ 15 MM
(200,000 h)

Infra-structure + OPEX + others:
~ US$ 75 MM
Petrobras’ FGTL: Pilot Projects

- Operating since November/2011;
- Technology has been qualified, and enhancing the efficiency is under analysis;
- Processing 10 th m3/d of gas, producing up to 20 bbl of synthetic oil.

- Operating since December/2011;
- Project under revision, with new startup on March/2013;
- Processing 3 to 4 th m3/d of gas, producing up to 10 bbl of synthetic oil.
6. CONCLUSIONS
Conclusions

• Petrobras’ Gas Utilization Optimization Program allowed a growth in our Gas Utilization from 83.7% in 2009 to 94.3% in 2012;

• Key factors for POAG’s success were:
  – a correct diagnosis of the causes for flaring;
  – focused Action Plan and Strategic Directives;
  – High Management sponsorship for the Program;
  – dissemination of all the initiatives to all involved workforce;
  – structured and constant monitoring of gas flaring by all management levels;

• Petrobras is still searching for better and improved means of raising its production altogether with minimum gas flaring, through the use of modular GTL units in the EWT platforms.
Coordination Committee 2012-2015

Merci!