Brazil Gas to Power

High Costs of Imported LNG

&

Challenges to Secure Supply of Domestic Gas

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LNG to Power in Brazil
Expensive Gas = Expensive Power

- Requirement for 20 year firm gas contracts for PPPs (with flexibility for Dispatch)
  - Petrobras exited from this market
  - No other producers with reserves and production to meet 20 year requirement
  - Created dependency on LNG Suppliers
- Lack of Gas Storage Capacity in Brazil meant Flexible Imported LNG Only Solution
- Long-term contract with Firm Supply Obligation and Downward Flexibility leads to these costs:
  - Gas Cost – Source? HH or Brent-Based – ANEEL/EPE bid parameters decide base gas cost
  - PLUS LNG Liquefaction – c. US$2.25 to US$3.25 per mmbtu (opex and capex)
  - PLUS Shipping - c. US$1.15 to US$2.50 per mmbtu to Rio
  - PLUS Cost of 50 percent Take flexibility – c. US$3 to US$5 per mmbtu
  - PLUS Cost of Regasification – c. US$0.75 to $1.25 per mmbtu

What is Required to Supply Domestic Gas?

- Balancing Associated Gas Supply & Demand
- Meeting requirements of Oil Producers to commit to supply gas
- Installation of T&P/Consumption Infrastructure
- Meeting requirements of Natural Gas Liquids
- Increasing Demand – including in Power Sector
- Increasing Storage – creating flexibility for developments in market

Balancing Associated Gas Supply & Demand

- "Associated" Gas – is gas associated (i.e. produced with) Oil
- Once produced the Associated Gas MUST all be disposed of
- Options for disposal of Associated Gas:
  1. Flaring (i.e. Burning offshore)
     - PROHIBITED BY LAW for significant quantities
  2. **Re-Injection into the Reservoir**
     - **currently the solution for >45 Million m3/day in Brazil** (of Total Brazil production of c. 124 mm m3/d)
     - **Much more Re-Injection planned for new FPSOs to be installed**
  3. **Processing & Transportation to Customers to Burn**
     - Industrial (e.g. Ceramics)
     - Petrochemical
     - Thermo-Electric Power
     - Residential
  4. **Underground Storage for Later Use**
     - Common solution in North America and Europe
     - Currently NO Storage Capacity in Brazil
- If Associated Gas cannot be disposed of, then Oil Production MUST be curtailed

Requirements for Oil Producers to Export Gas

- Fundamental Equation:
  - Associated Gas Production = Total Aggregate Gas Disposal
    - (i.e. Sum of Re-Injection + T&P/Consumption + Storage MUST equal X)
- If Flaring is net Zero, then as Associated Gas Production Grows, then One or More of the other Options Must Grow
- For T&P/Consumption to be an Alternative, then Oil Producer must design FPSO and Wells to allow for Gas Export – AT LEAST 5 Years in Advance
- Oil Producer will only design FSPO and Wells for Gas Export if T&P/Consumption WILL CERTAINLY BE AVAILABLE
- **T&P/Consumption Infrastructure (including Permitting and Contracting) Needs to be Firm c. 4 to 6 years in Advance of any FPSO Sanction**

T&P/Consumption Infrastructure Required

- Offshore Gas Evacuation Pipeline Capacity
  - Currently No Additional Capacity
  - All Pipes Operated by Petrobras – and Petrobras seeking to exit this business
  - No active plans to expand capacity (except for Problematic Rota 3)
- Gas Processing Capacity
  - 100% owned and operated by Petrobras
  - Petrobras seeking to exit this business
- Liquids Offtake Logistics – see next slide
- Onshore Gas Pipeline Transportation Capacity
- Gas Distribution Capacity
- FIRM CUSTOMERS TO CONSUME THE GAS
- **Limitations on ANY ONE of these items create a CAP on volumes**
- **There must be near certainty on availability of ALL these elements before FPSO sanction (i.e. 4 to 6 years in advance)**

The Problem of Natural Gas Liquids

- Typically, Gas will be produced with Natural Gas Liquids – Condensates and LPG
- Santos Basin production often has large volumes of NGLs
- If you produce Gas and do not Re-Inject, then you must deal with the NGLs by:
  - Processing (i.e. separating from Gas and into individual products)
  - Logistics to deliver to Refineries
- Access to Processing & Logistics & Refining currently is 100% Petrobras
- Petrobras does not currently contract for these services - they buy the rich gas
- Santos Basin NGL production is expected to exceed Brazil domestic demand
- Export facilities/Ports/Transportation to Ports is very limited at Present
- **To decide not to Re-Inject, there must also be certainty of adequate Processing and Logistics for Condensate and LPG prior to FPSO sanction**

How the Power Sector Can Help

- **Inclusion of Thermo-Electric Generation in Baseload**
  - Create certainty of Demand and Consumption
- **Allow for Bidding for PPPs with Portfolio Gas Supplies, rather than 20 year firm contract:**
  - Current requirements for 20 year firm contracts can only be met by Petrobras (who will not offer contracts any longer) or LNG suppliers
  - Portfolio approach will allow various domestic gas producers to become suppliers to power sector
- **Create PPA Auction incentives for dispatch by Thermo-electric generators**:
  - Include a premium (or a penalty) for Reliability and Dispatch ability of the plant. Such factor would recognize the back up role of the thermal plants (both combine cycles and open cycles) and their contribution to the Brazilian integrated system reliability.
  - Capture more precisely the transmission costs associated with each plant (as a function of the distance from the load center) and its contribution.
- **Be prepared to spill water from Hydro – to allow for Oil AND Associated Gas production**

How Gas Storage Can Help

- In North America and Europe – underground gas storage is a fundamental part of the gas market infrastructure
- Brazil currently has NO GAS STORAGE in place
- **Brazil has a number of depleted reservoirs which could be developed into gas storage with significant volumes**
  - All of these assets are owned by Petrobras
- **Gas Storage can make a material contribution to BALANCING ASSOCIATED GAS PRODUCTION VERUS DEMAND by:**
  - Taking all surplus Associated Gas and allowing CONSTANT OIL PRODUCTION
  - Storing gas through the multi-year hydrological cycle
  - Storing gas through recessionary demand-reduction periods
  - Dealing with Brazil holiday demand cycles
  - Storing gas as new Power and Industrial Demand Centers are installed
  - Allowing for Swaps of Domestic Gas and also imported LNG
  - Allowing for necessary ratable (steady) supply of gas to LNG Export plants