GAS MONETISATION SOLUTIONS

Gas Global Flare Reduction programme

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Barriers that impede Associated Gas monetisation include:

- Distance to market
- Lack of local infrastructure
- Small gas deposits
- Price distortion due to local fuel subsidies
- Absence of stable long-term low-cost feed gas supply
- Availability of capital

Associated Gas monetisation traditionally viewed as requiring economies of scale to meet economic hurdles, and hence also requiring significant investment in gas gathering facilities and central gas plant.

Drawback of central gas plants is focus on gas export to the international market (e.g. via LNG) with minimal local benefits or employment spin-offs.

Challenge is to develop new skid-mounted re-deployable monetisation technologies, for small-scale opportunities, that can be deployed close to the actual gas source in a phased manner.
MONETISATION OPTIONS AND DECISION DRIVERS

- Associated Gas reinjection
- Gas to Power
- Gas to Chemicals (Methanol, DME)
- Liquefied Natural Gas (LNG)
- Compressed Natural Gas (CNG)
- Pipeline
- Gas to Liquids (GTL)

Drivers:
- Carbon and energy efficiency
- Community interdependency
- Transportation to market
- Associated Gas production profile
- Gas composition sensitivity to contaminants
- Revenue/product uplift
- Capital and operating costs
- Operational safety
- Carbon tax?
- Community interdependency

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**GAS REINJECTION**

- Reinjection is the base case for any Associated Gas development in the absence of a clear alternative evacuation opportunity
- Typically applied for enhanced oil recovery or for disposal of highly contaminated gas
- Reinjection can be into existing oil reservoir, an undeveloped gas reservoir or a water filled trap
- Reservoir engineering considerations can be the main concept driver and need to be well matured. They may also be a showstopper
- Other considerations include compressor sparing philosophy and matching of compressor duties over full field life

**Associated Gas Reinjection Projects**

**Shell Pearls Project 70 km offshore Kazakhstan**
- Oil project where reinjection was selected as the least uneconomical Associated Gas development option
- Reinjection involves separation of gas from oil, dehydration and compression to 250 bar
- Gas then reinjected into either oil or gas cap reservoir of nearby Khazar field

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**Gas reinjection against key decision drivers**

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PIPELINE EVACUATION

- Pipelines, in combination with compression if required, are the simplest method for evacuating Associated Gas to market
- Ultimate destination is domestic gas grid or power plant. Piped gas could also feed LNG or GTL plant with resultant price upside
- Land ownership/access rights can be a significant non-technical risk
- Other considerations include single or multiphase pipelines, hydrate management strategy and materials of construction

Pipeline evacuation of Associated Gas

Nigeria LNG is an example of a large scale gas monetisation project supplied, in part, by an Associated Gas gathering scheme

650 MW Afam Power Plant: supplied by a combination of associated and non-associated gas from the 240 MMscf/d Okoloma gas plant

Pipeline option against key decision drivers

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COMPRESSED NATURAL GAS (CNG)

- CNG involves compressing natural gas up to 250 bar to reduce the volume before transportation to market by trucks, trains or specialised ships.
- Level of gas processing required is quite low—gas must be sufficiently dew-pointed to avoid liquid dropout during compression.
- CNG is stored in a cascade of cylinders referred to as a Gas Transport Module for transportation.
- CNG is also used as fuel for the transportation market widely in Pakistan, Iran, Brazil, India and Argentina.
- Road safety issues with CNG transportation.

Arrow Energy, Australia
CNG selected to monetise ramp-up coal seam gas from Arrow Energy’s Bowen Basin in Australia.
Pilot well gas will be compressed and trucked to a central facility.

Green Fuels, Nigeria
Green Fuels purchases pipeline gas from Shell Nigeria Gas, compresses it to CNG and sells to industrial consumers within a 150 km radius at $14/MMBTU.

CNG against key decision drivers

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LIQUEFIED NATURAL GAS (LNG)

- Micro LNG (up to 0.05 mtpa) and Mini LNG (0.1 to 0.5 mtpa) are suitable options for monetisation of associated gas
- Shell, together with Kryopak, has developed a proprietary Moveable Modular Liquefaction System (MMLS) targeting Mini LNG applications
- Micro and Mini LNG utilise nitrogen or Single Mixed Refrigerant refrigeration technologies
- LNG can serve as replacement for diesel or LPG in power stations or as transportation fuel in dedicated LNG-fuelled vehicles
- Road safety issues with LNG product evacuation to market

Application of Micro LNG within Shell

Cuervo I Micro LNG facility in New Mexico, United States

Involves extended well test on the Tucumcari basin gas play which required gas utilisation scheme to proceed

Facilities owned and operated by third party (in this case Prometheus), who also take responsibility for onward transportation and marketing of the LNG produced

LNG against key decision drivers

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Cuervo I facility, New Mexico, U.S.
Small-scale GTL plants are not currently field proven technologies in the industry

The target product for small-scale GTL is synthetic crude which can be spiked into the main crude stream

Application window for small-scale GTL is relatively limited and currently primarily driven by regulatory compliance

Most likely area for first commercial small-scale GTL plant is the pre-salt area of Brazil due to unique combination of drivers such as economically and operationally challenging for pipeline evacuation and gas reinjection

Small-scale GTL Deployment
CompactGTL commissioned a GTL demonstration plant in 2011 in Brazil in support of Petrobras’ pre-salt reserves portfolio development.

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Gas to Wire involves using stranded natural gas to generate electricity for own use or sale to local grid system.

Gas pre-treatment is minimal but should be examined considering both gas quality and flexibility of gas turbine or engine.

For extended well testing, power generation equipment can often be rented or leased.

Scope for local stakeholder engagement and capacity building, with significant Sustainable Development/Social Performance spin-off benefits (e.g. Bonny Utility Company in Nigeria).

**Gas to Wire Applications**

- **650 MW Afam Power plant.** Partially supplied by associated gas from the 240 MMSCFD Okoloma gas plant. Afam was developed as a Kyoto Protocol Clean Development Mechanism (CDM) project.

- **Sevan, a Norwegian FPSO company, has teamed up with Siemens to offer an offshore floating power concept.**

  It will generate and transmit hundreds of MW of power over distances of up to 70-100 km.

**Gas to Wire against key decision drivers**

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## Qualitative Ranking

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