Abstract

Numerous undeveloped gas discoveries remain undeveloped in the UK Southern North Sea despite their common proximity to production infrastructure. The UK Oil and Gas Authority estimates 3.8 TCF of gas is currently stranded in the basin, mostly in discoveries in low permeability sandstones, each with less than 100 BCF of potential recoverable resource and is implementing a strategy to ‘Maximise Economic Recovery’. However, technical advances in well productivity, combined with the point in the economic cycle are driving development plans. Significant ullage in a nearby late-life pipeline (LAPS) will not be available beyond 2023 without developing additional gas, so time is of the essence. One such development project is outlined in this article which is projected to produce up to 400 BCF in conjunction with 1 GW of wind-hybrid electricity. Production would amount to 2% of the UK’s power needs and 4% of its indigenous gas production by 2022.

In the central part of the Southern Gas Basin in the UK is a major inverted basin where the primary reservoir, the Early Permian Rotliegendes aeolian-dominated sandstone, has been deeply buried and uplifted during the Tertiary inversion of the Sole Pit Basin. This has led to significant burial diagenesis, including illitization that has reduced unstimulated well productivity to sub-economic levels. Recent use of horizontal multi-hydraulically fractured wells in the Clipper South Field has demonstrated the commerciality of developing these tight reservoirs. Horizontal hydraulically fractured wells testing dry gas at over 20 mmscfd compare better than unstimulated wells testing at less than 1 mmscfd. OK Energy has built a portfolio of tight gas assets in neighbouring acreage and is proposing development of a hub and up to four satellites. The development of these reserves depends on several factors all aligning at the same time in order to create a good economic outcome: proven tools to overcome low permeability issues, low cost drilling and other capex, industry synergies, access to under-utilised infrastructure and strengthening gas prices.
Developing Tight Gas in a Mature Basin
UK North Sea

Paul Barrett
OK Energy (North Sea) Limited
UK Southern North Sea
Strategic conventional gas basin

- Produces 20% of the UK’s gas demand
- Enough to keep going for 20 years+
- £3bn of developments planned/investments
- Imports 25% of UK’s gas demand
- 27 licence holders
- 40tcf gas produced to date
Commercial Case for UK Gas

**Government Take and Projected IRR**

- **Angola**: 80%
- **Norway**: 70%
- **Indonesia**: 60%
- **Denmark**: 50%
- **Australia**: 40%
- **Gulf of Mexico**: 30%
- **UK**: 20%

*Source: Wood Mackenzie*

**UK Gas Self-sufficiency**

- **Net Exporter**
- **Net Importer**

No realistic potential for reversing import dependency

**Value drivers**

- Activity alignment based on concept maturity
- Integrated work programmes
- Standardisation and simplification options
- Economies of scale
- Optimised use of infrastructure
- Leverage industry and OGA initiatives

**OGA promote & influence**

- Consider proactive license alignment
- Guide proposed development concepts
- Support infrastructure access
- Support commercial alignment & progress

Creating a future for the Southern North Sea

Government initiatives to Maximise Economic Recovery
SNS is a highly mature basin...
... with relatively limited play types
2TCF undeveloped gas in existing plays

SNS strategic priorities

Significant potential remains

- 3.7 tcf remaining from current assets
- 2.9 tcf from further drilling in current fields
- 2.1 tcf discovered undeveloped new fields

SNS focus

- Promote exploration and appraisal activity
- Deliver major developments and projects
- Protect critical infrastructure
- Support marginal and small pool developments
- Tight gas collaboration across the basin
- SNS Energy Hub: GTW opportunities
- Efficient decommissioning

Creating a future for the Southern North Sea
Vast Majority of Undeveloped Reserves in Permian Rotliegendes Play…

Figure 4: distribution of SNS tight gas opportunities by geology (OGA)
Large number of individual gas discoveries in Permian Rotliegendes Play

Source: OGA
Rotliegendes Reservoir Challenges
Depth Conversion – Structural Discordance

Jurassic Structure

Early Permian Structure
**Rotliegendes Reservoir Challenges**

**Depth Conversion**

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Example: Guinevere Field, 48/17 Kyari and Elders, 2012

Widespread Mesozoic remnant grabens provide significant overburden velocity anisotropy

Rotliegend Target beneath Permian evaps
Rotliegendes Reservoir Challenges

Depth Conversion – Example 1

Resulting mapping shows significant closure only in TWT

Note 50ft of gas in 48/24a-1 but no closure in Depth!

Significant challenge to technical staff of convincing management to drill here

Example: Harvey Structure 48/23, Source: Independent Oil & Gas 2017 CPR

Figure 2-4: ERCE Top Rotliegend TWT and depth structure maps over Harvey
Rotliegendes Reservoir Challenges

Depth Conversion – Example 2

Anisotropy boundaries proved too sharp for PSDM to accurately image. Decision taken to go back to first principles and layer-cake depth convert time data.

Low velocity zone in overburden (blue)

Mesozoic faults want to trend WNW instead of underlying Palaeozoic NW fabric, so results in stepping of grabens

Velocity contrast between graben and unfaulted areas is over 20%

Resulting depth map
Rotliegendes Reservoir Challenges

Pre-inversion diagenesis

Significant pre-inversion burial in the Sole Pit has degraded the initially excellent dune facies sands of the Rotliegendes to c.10% Φ, sub mD K.
The Low Perm Problem

- Tight Rotliegend vertical wells have historically tested at around 3mmscfpd.
- Post-frac 10mmscfpd – sub-economic for sub-50bcf reserve cases.

### EXAMPLE ‘OLD SCHOOL’ WELL ECONOMICS

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<td><strong>Payback</strong></td>
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Solving the Low Perm Problem

Highly successful recent development - Clipper South
Horizontal multi-fracced wells – target 30mmscfpd initial per well
Hi perm streaks 10mD along dune foresets
Fractures generally closed, compartmentalised

Source: Shaoul J et al, 2013, SPE
Solving the Low Perm Problem

Clipper South discovery well tested 3mmscpd post-frac
First unstimulated horizontal well tested at 1.5mmscpfd
Field was given up for dead in 1992
20 years later - First multi frac (8) horizontal well drilled and came on-stream at 43mmscfpd
Current field production 60-80mmscfpd

There is more where that came from – up to 2.1 TCF worth*
With the advances in tight gas, it is rapidly becoming low hanging fruit

* According to the OGA
Building a Critical Mass of Resource

SW EXCALIBUR

LANCELOT AREA PRODUCING FIELDS

E EXCALIBUR

THORESBY

BEDEVERE

ANGLIA REDEVELOPMENT

CLIPPER AREA PRODUCING FIELDS

FIRM OK ENERGY WELL LOCATION 2019

POTENTIAL OK ENERGY WELL LOCATIONS 2019-2021
500bcf within 20km

- Medina Prospect P50 Rec. 100bcf
- SW Excalibur Discovery P50 Rec. 105bcf
- Shiraz Prospect Under Review
- Thoresby Discovery P50 Rec. 103bcf
- E Excalibur Disc. P50 Rec. 64bcf
- E Excalibur Terraces P50 Rec. 52bcf
- Bedevere Core Rec. 90bcf
- NW Anglia Undeveloped Gas P50 Rec. 50bcf
The ‘Use it or Lose it’ Case for Development

Target day rate for modern Jackups Q1 ‘19 North Sea sub $60k/day

Gas export infrastructure ullage increasing

But decommissioning has already started

Spare capacity also increasing in electricity infrastructure

Wind Farms only utilize 40% of power cable capacity

BH Frac Stimulation vessel

Slashing rig time for fraccing

Theddlethorpe Terminal closing in 2018!
First well planned for 2019

**Bedevere Core Area**

2 well development in P50 case
- 2 x 1km horizontals
- Both drilled from close to #4 location
- 2 x 3-4 stage frac completions
- Estd. 30mmscfpd per well initials

**1st Well**
- 48/18a-4 (1984)
  - Vertical well
  - 3mmscfpd pre-frac, 10mmscfpd post frac

**Site Survey Area for Rig and Production Facility**
Summary

- UK Southern North Sea is a mature basin with limited new plays
- ‘Hiding in plain sight’ an estimated 2.1 TCF discovered resource
- Remaining undeveloped primarily because of reservoir quality issues and secondly because of depth conversion complexity
- Advances in multifracced wells transform field economics
- Hub concepts required to take advantage of significant ullage in gas export lines
- Current low drilling cost coupled with strong gas price futures and UK energy security are the key drivers