INEOS Shale
John Hunter CEng MIMMM
Wells Team Leader, INEOS Shale

The Mining Institute of Scotland
Safeguarding Scotland’s Energy Resources

11th January 2017
Keeping the lights on
Keeping the heating on
Gridwatch - 6th January 2017 @ 09:15hrs

G.B. National Grid Status

Data courtesy of Elexon portal and Sheffield University

- UK Demand (GW)
  - Demand 45.66GW

- UK GRID Frequency (Hz)
  - Frequency 49.986Hz

- Coal (GW)
  - Coal 7.20GW (15.77%)

- Nuclear (GW)
  - Nuclear 7.39GW (16.19%)

- CCGT (GW)
  - CCGT 23.00GW (50.38%)

- Wind (GW)
  - Wind 3.78GW (8.28%)

Demand: This is the total demand of the entire country (plus or minus exports) less any unmetered generating sources like wind but including an estimate for solar.

The amber warning represents the demand level that cannot be reliably met by wind or fossil burning and nuclear generation, but must be augmented by imports, or unreliable intermittent 'renewable' energy.
Agenda

- Who are INEOS
- What are our plans
- How are we safely going to extract the gas
INEOS – Who Are We?

- A leading global chemical company
- Sales $40bn
- 17,000+ employees*
- 65 manufacturing sites in 16 countries
- 6 manufacturing sites in the UK
- Produce gas from the North Sea to serve 1 in 10 homes
- Grangemouth contributes around 3.7% of Scotland’s GDP

*excl. joint ventures

Our name isn’t on the product label but we make the vital chemicals that go into the manufacture of everyday items
To make our products and power our sites we need:

- **Gas (methane) = Power generation**
- INEOS uses 2% of the UK’s gas supply
- **Feedstocks (ethane) = Plastics**
- We make raw materials and chemicals that go on to make items we all use in our everyday lives
“Virtual pipeline” bringing US Shale Gas to the UK

- Methane – the energy source for our chemical plants
- Ethane - the raw material (fuel) to make our chemical products
- We make raw materials and chemicals that go on to make items we all use in our everyday lives
- North Sea gas supplies reducing
- Invested $2bn in bringing shale gas to Europe
- Boosts UK manufacturing
Investing in the Future

- First shipment of Ethane arrived September 2016
- Secures 10,000 direct and indirect jobs at Grangemouth

Grangemouth Ethane Tank under construction – 2015

Dragon ships to carry ethane from the US to Grangemouth
We Keep People...

Healthy

Mobile

Housed

Clothed

And...in Touch
Our Plans...

Shale Gas in Scotland
Resource in a Licence

Petroleum Exploration and Development Licences can include the following resources:

- Coal Bed Methane
- Shale Gas
- Shale Oil
- Conventional Oil & Gas

We are obligated by Government to explore for these
INEOS Licences In Scotland

- PEDL 133
- PEDL 162
Shale Gas

Area considered prospective for gas-mature Carboniferous shale (in red, holes within the extent are dashed), Midland Valley of Scotland in relation to the urban areas of central Scotland. Contains Ordnance Survey data ©Crown copyright 2014.
Cross Section – North / South
Cross Section – East / West

WEST

CAMSIE HILLS
KINCARDINE BASIN
ROSYTH BASIN
BURNTISLAND ARCH
FIFE BASIN
CARNOCK FAULT

EAST

DURIE FAULT
LATHONES FAULT

HIGHLY EXAGGERATED
HORIZONTAL SCALE 1:250,000
VERTICAL SCALE 10X HORIZONTAL

CARBONIFEROUS
P
PERMIAN
d³
BARRIEN COAL MEASURES
d²
PRODUCTIVE COAL MEASURES
d¹
PASSENGER GROUP
d⁰
UPPER LIMESTONE GROUP
d⁻¹
LIMESTONE COAL GROUP
d⁻²
LOWER LIMESTONE GROUP

UPPER OIL SHALES
d⁻³
LOWER OIL SHALES

d⁻⁴
CEMENTSTONE GROUP

d⁻⁵
DEVONIAN

d⁻⁶
SILURIAN

B
CARBONIFEROUS VOLCANICS
(Only main build-ups shown)

INEOS
THE WORD FOR CHEMICALS
www.ineosupstream.com
SURFACE ASSESSMENT

• PEDL 133 & 162
• 40-45% Urbanisation
• Further Reductions
  • Designations
  • Subsurface Resource
  • Complex Geology
  • Planning Constraints
• All this reduces site & well numbers
Reserves In Scotland

- The British Geological Survey (BGS) & Department of Energy and Climate Change (DECC) has completed an estimate for the amount of shale gas and oil in the Midland Valley of Scotland.

- The estimate is in the form of a range to reflect geological uncertainty.

- The range of shale gas in place is estimated to be between 49.4 and 134.6 trillion cubic feet (tcf), with the central estimate being 80.3 tcf.

- The range of shale oil in place is estimated to be between 3.2 and 11.2 billion barrels (bbl), with the central estimate being 6.0 bbl.
How are we safely going to extract the gas
The INEOS approach

- UK Shale gas is a national asset and an opportunity
  - Manufacturing Industry
  - The Treasury
  - Communities
  - Security of supply
  - Protect existing jobs
  - Create new jobs and exportable skills

- Our approach is to demonstrate
  - Technical rigour
  - Transparent and open communications
INEOS’ UK Shale Experience

• History of engineering excellence in the Chemical and Refining industry

• Handling chemicals and gas safely on a daily basis

• In-house onshore and offshore experts
  • Acquired a material UK offshore gas business in 2015
  • Assembled a team of UK onshore experts (drilling and UK geology)
  • Brought in top expertise from US on shale gas geology, drilling and fracking
UK Shale Regime & Regulations

- DECC (Department for Business, Energy & Industrial Strategy)
- Environmental Regulations
  - Environment Agency (England, Wales & N. Ireland)
  - SEPA (Scotland)
- The Health and Safety Executive
- Local Planning Approval
- Scottish Government Planning Approval
- Independent Well Verification
Independent Assessments

- Trusted and independent bodies have studied the evidence and concluded that Shale Gas development is safe provided it is subject to best practice and robust regulation

- These include;
  - The Royal Society
  - The Royal Academy of Engineers
  - The Health and Safety Executive
  - The Environment Agency
  - Public Health England

- Independent environmental campaigners also support Shale Gas development as a part of a balanced and transitional energy mix
Scottish Government (Sept 2013):

- Independent Expert Scientific Panel – Report on Unconventional Oil & Gas
  - A number of technical challenges… none of these are insurmountable
  - The technology exists to allow the safe extraction of such reserves
  - Subject to robust regulations being in place
  - Careful planning…
  - Early consultation with communities is vital…
  - Public engagement is necessary…

- Why is there still a moratorium??
Royal Society Report:  *Shale gas extraction in the UK: a review of hydraulic fracturing*

“The health, safety and environmental risks associated with hydraulic fracturing (often termed ‘fracking’) as a means to extract shale gas can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation.”
Public Health England: Review of the potential public health impacts of exposures to chemical and radioactive pollutants as a result of shale gas extraction

“The currently available evidence indicates that the potential risks to public health from exposure to emissions associated with the shale gas extraction process are low if operations are properly run and regulated.”
A fractious debate but a clear outcome

- **ASA & Friends Of The Earth (5th January 2017)**
  - Guy Parker, Chief Executive ASA

So let me be clear. We told Friends of the Earth that based on the evidence we’d seen, claims it made in its anti-fracking leaflet or claims with the same meaning cannot be repeated, and asked for an assurance that they wouldn’t be. Friends of the Earth gave us an assurance to that effect. Unless the evidence changes, that means it mustn’t repeat in ads claims about the effects of fracking on the health of local populations, drinking water or property prices.

- Friends of the Earth has said we “dropped the case”. That’s not an accurate reflection of what’s happened. We thoroughly investigated the complaints we received and closed the case on receipt of the above assurance.

- Because of that, we decided against publishing a formal ruling, but plainly that’s not the same thing as “dropping the case”. Crucially, the claims under the microscope mustn’t reappear in ads, unless the evidence changes. Dropped cases don’t have that outcome.
Geological Review & Surface Management

2 Years

- Desktop Geology & Environmental Study
- 2D & 3D Seismic
- Identification of Surface Drill Sites
- Land Negotiations & Agreement
- Planning Application
- Drill
- Hydraulic Fracture

www.ineosupstream.com
Reference Material

In planning a well we will refer to:

- Offshore Installation and Wells (Design & Construction etc) Regulations 1996
- Borehole Safety & Operations Regulations 1995
- UKOOG shale gas guidelines
- UKOOG Oil and Gas Guidelines
- HSE
- Well Examiner
- External Websites - AER Website
Learnings

- **Cuadrilla Preese Hall-1 Well**
  - April / May 2011 a number of earthquakes (largest 2.3ML) recorded near Blackpool
  - A series of studies were commissioned by Cuadrilla Resources Ltd to examine the possible relationship between hydraulic fracture operations at the Preese Hall well
  - The reports from these studies conclude that the earthquake activity was caused by direct fluid injection into an adjacent fault zone during the treatments, but that the probability of further earthquake activity is low

- **Learning**
  - Traffic Light system
  - Need 3D Seismic before fracking
  - Need for a robust pumping and flow back schedule
Vertical drilled well uses multiple casing layers to ensure aquifer protection.

First string to below aquifer level using only water as the drilling fluid.

Casing is cemented back to surface creating a further barrier.

Second casing string to 75-100m below aquifer, and cemented to surface.

Subsequent casing strings all cemented to surface.
Drilling rigs
Proposed drilling equipment and well trajectories

- Exploration Phase
- Initial Program is Vertical Core Wells
- Appraisal Phase
- Horizontals
- Full Field Development
- Multi Well Pads
- Wont be able to model the frac design till we know and understand the reservoir.
- Premium Casing through reservoir
- 5 ½” or 4 ½” Casing through reservoir
- Run the Completion
Comparisons with offshore operations

What’s the same:
- The hazards – losses, kicks, stuck pipe
- Need good planning
- Logistics – WOW v Protestors
- DP, casing, BHA’s, muds…..

What’s different:
- Logistics – robust journey management plan
  - Travelling through villages / schools / holidays
- Protestors
- Noise monitoring
- Light monitoring
- Hours of working on rig up
Casing - Welded

- Project ongoing with UK Steel, UKOOG & IMechE
- Steel Casing Project Expert Committee
- In my wells I have run a mix of ERW and seamless casing.
- Seamless became a marketing strategy by mills like TENARIS when fracking became the norm.
- However most companies are going back to ERW because:
  - It is cheaper to produce
  - More mills
  - Greater controls on thickness
  - More uniform pipe body and if compliant with ISO 10400 testing and their QC can achieve greater yields for burst and collapse.
Drilling and production challenges

- Politics
- Protestors
- Safety
- Well Integrity Key at all times
- Aquifers
- Mine Workings
  - Type of mining (Room & Pillar / Long Wall)
  - Road ways from mines
  - Abandoned equipment - steel
- Loss zones
- Faults
- Differential sticking
- Kicks
- Matching the frac design to the rock
  - Will know this when we have the cores
- Construction of the well site is done over a 3-4 week period
- Drilling a horizontal well will take 60 days
- 24hr operations
- UK shale on average 3,000m deep
- Horizontal section extends up to 2,000m
- The rigs are truck mounted and specially modified to work onshore close to communities
Shale Well Spacing

Surface footprint

Sub-surface footprint
Hydraulic Fracturing

- Frack fluid consists of water (98%), sand (1.5%) and chemical additives (0.5%)
- Well is hydraulically fractured in stages taking 1 hour for each stage
- Sand carried in the fluid props open the fissures created during the fracturing process
Hydraulic Fracture Fluid

- 0.5% of the frack fluid consists of chemical additives
- The number of additives used will depend on the specific characteristics of the rock for each well site. Very low concentrations are used
- The additives in frack fluid are classified by the Environment Agency as non-hazardous in the proportions proposed
<table>
<thead>
<tr>
<th>Additives</th>
<th>Uses in Everyday Life</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GUAR GUM</strong></td>
<td>Thickens water and found in cooking sauces, toothpaste and ice cream</td>
</tr>
<tr>
<td><strong>CROSSLINKERS</strong></td>
<td>Used in soap and cosmetics</td>
</tr>
<tr>
<td><strong>BRINE</strong></td>
<td>Typically produced with potassium chloride, a low sodium table salt substitute</td>
</tr>
<tr>
<td><strong>SCALE INHIBITORS</strong></td>
<td>Used in antifreeze</td>
</tr>
<tr>
<td><strong>FRICTION REDUCERS</strong></td>
<td>Used in water treatment and face creams</td>
</tr>
<tr>
<td><strong>HYDROCHLORIC ACID</strong></td>
<td>Used in food production, cleaning swimming pools and created naturally in the stomach</td>
</tr>
<tr>
<td><strong>BREAKERS</strong></td>
<td>Used in detergent and hair cosmetics</td>
</tr>
<tr>
<td><strong>CORROSION INHIBITORS</strong></td>
<td>Prevents corrosion of pipes. Used in pharmaceuticals, food flavouring, cosmetics and beverage production</td>
</tr>
<tr>
<td><strong>ADJUSTING AGENTS</strong></td>
<td>Used in soap, water softener, glass and ceramics</td>
</tr>
</tbody>
</table>
### Concerns raised & how industry addresses them

<table>
<thead>
<tr>
<th>CONCERN</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquakes</td>
<td>Traffic light seismic monitoring system</td>
</tr>
<tr>
<td>Chemicals in fracking</td>
<td>Fully disclosed and must be harmless in concentrations used</td>
</tr>
<tr>
<td>Aquifer protection</td>
<td>Multiple layers of steel and cement to provide well integrity</td>
</tr>
<tr>
<td>Industrialisation of the countryside</td>
<td>Very small footprint after drilling and fracking operation</td>
</tr>
<tr>
<td>Truck movements</td>
<td>Established road network combined with traffic management plan</td>
</tr>
<tr>
<td>Fugitive emissions</td>
<td>Closed loop systems and ongoing monitoring</td>
</tr>
<tr>
<td>Baseline monitoring</td>
<td>Will be undertaken ahead of operations</td>
</tr>
<tr>
<td>On-going monitoring</td>
<td>Wells, equipment and surrounding area to be monitored</td>
</tr>
<tr>
<td>Responsibility for damage</td>
<td>If we cause damage it is our responsibility to pay</td>
</tr>
<tr>
<td>Public health</td>
<td>Public health bodies satisfied no issue</td>
</tr>
<tr>
<td>Waste water disposal</td>
<td>Captured, treated and disposed of safely &amp; under licence</td>
</tr>
<tr>
<td>NORM’s and other containments</td>
<td>Captured, treated and disposed of safely &amp; under licence</td>
</tr>
<tr>
<td>Fracking under property</td>
<td>Possible but in a hole 15-23cm wide at more than 2.4km below ground</td>
</tr>
</tbody>
</table>
Stages of Site Development

Drilling Rig

Hydraulic Fracture Spread

Production Site
Community Benefits

• INEOS is committed to sharing the benefits of shale gas development with landowners and the community

• 6% of shale gas revenues will be distributed to homeowners, landowners & communities close to well sites

• It is estimated that we will give away over £2.5bn from our new shale gas business
Next steps and views on role for the MIS

- IOM³ – Institute of Materials, Minerals & Mining

- Oil & Gas Division

- The Institute has as members a very wide range of minerals professionals – we should tap into that knowledge

- Encourage Best Practice

- Educating within the Industry and the public

- Continue to influence key opinion formers in government, industry, academia, the public and professions.
I’ve hopefully told you:

- Who we are
- What our plans are
- How we will safely extract the gas
Thank you

www.ineosupstream.com
@INEOS_UPSTREAM
shale.information@ineos.com