Unconventional Gas in Europe

Response to DECC Consultation

29th October 2010

centrica energy

This document has been prepared in response to DECC's call for evidence regarding unconventional gas in Europe

Questions in DECC's Call for Evidence

1. **When and how great are unconventional gas resources outside of North America?**
   a) In particular, how do you see the distribution of gas resources within Europe?
2. **What do the economics of developing unconventional gas look like?**
   a) How do the costs compare across unconventional plays or between conventional and unconventional plays?
   b) What are the key drivers of these costs?
   c) What are the main technical and economic challenges to bringing unconventional gas to market?
3. **Where (in which region) and what magnitude are current and planned unconventional gas projects?**
   a) What fraction/magnitude of investments are aimed at developing unconventional gas?
   b) At what stage are these investments (e.g. FID, under construction, development stage)?
   c) What do you think is the likelihood of different plays being delayed or not coming to market at all?
   d) What are your projections for the amount of unconventional gas (in your portfolio) that will be produced in the coming years?
4. **What are the barriers in each region to the further development of unconventional gas?**
   a) Environmental legislation
   b) Land rights
   c) Geology
   d) Technology
   e) The availability of infrastructure

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Unconventional gas covers a range of gas sources, some of which need technological breakthroughs for economic exploitation

	Gas Play	European Context	Considered in this document	Remarks
CONVENTIONAL	Offshore Conventional Gas	Conventional gas production offshore Europe	No	Not unconventional
	Offshore Stranded Gas	Gas stranded due to sub-economical size, geo-political risks etc. Deposits in West of Ireland, Norway	No	Not unconventional
	Onshore	Conventional gas production onshore in Europe	No	Not unconventional
UNCONVENTIONAL	Shale Gas	Production of gas trapped in shale – considerable potential in Europe but very little activity and no production to date	Yes	Discussed in this document
	Coal Bed Methane	Production of methane from coal seams – some commercial production into the grid has begun in 2009	Yes	Discussed in this document
	Renewable Gas	Production of gas from sewage, landfill, manure and other biodegradable waste; small scale projects operational in UK to feed local demand	Yes	Discussed in this document
	Tight Gas	Production of gas from low-permeability reservoirs	Yes	Discussed in this document
	"Off-spec" Gas	Gas with high concentration of Hydrogen Sulphide, carbon dioxide, nitrogen etc. No significant sour gas in Europe; potentially high CO_2 & N_2 off-spec gas in the North Sea	No	Technologically proven, economically not viable
	Others - Hydrates, UCG	UCG (Underground Coal Gasification) – huge deposits in existing coals seams. Hydrates – significant potential in deep water environment in Norway and the North Sea	No	Very early stages of infancy, requires technological breakthrough

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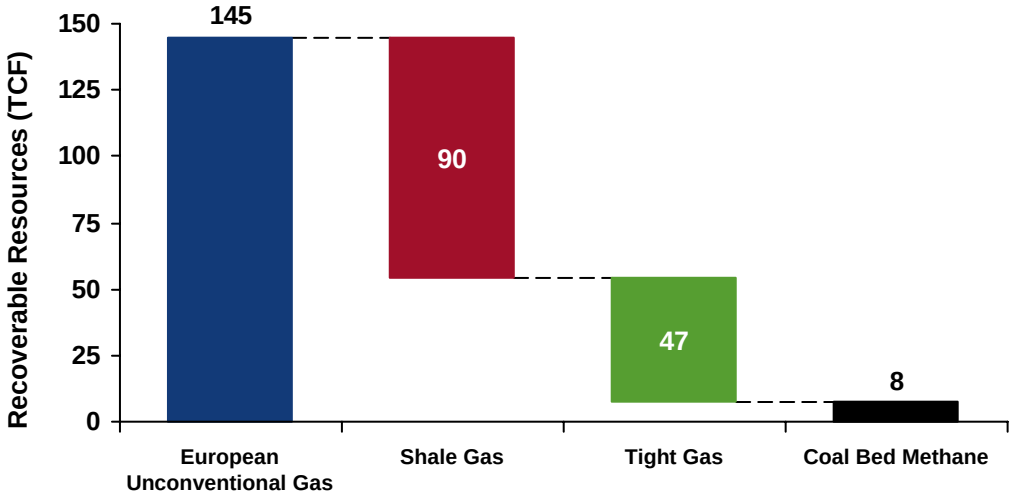
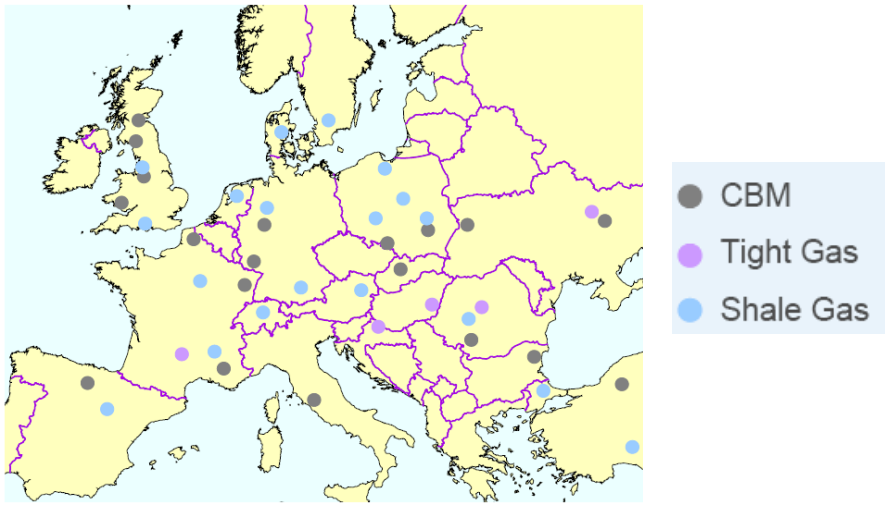
Recoverable unconventional gas resources in Europe are estimated to be 145 TCF

Recoverable Resources by Gas Type[1]





- Gas Initially In Place for Unconventional Gas in Europe is estimated to be 1,780 TCF
- The recoverable resources of 145 TCF represent the low recovery rates (3% to 18%) expected for European Unconventional Gas
- However, it should be noted that as development takes place, the recovery factors can rise significantly
- Hence the recoverable resources could well turn out to be significantly higher than 145 TCF

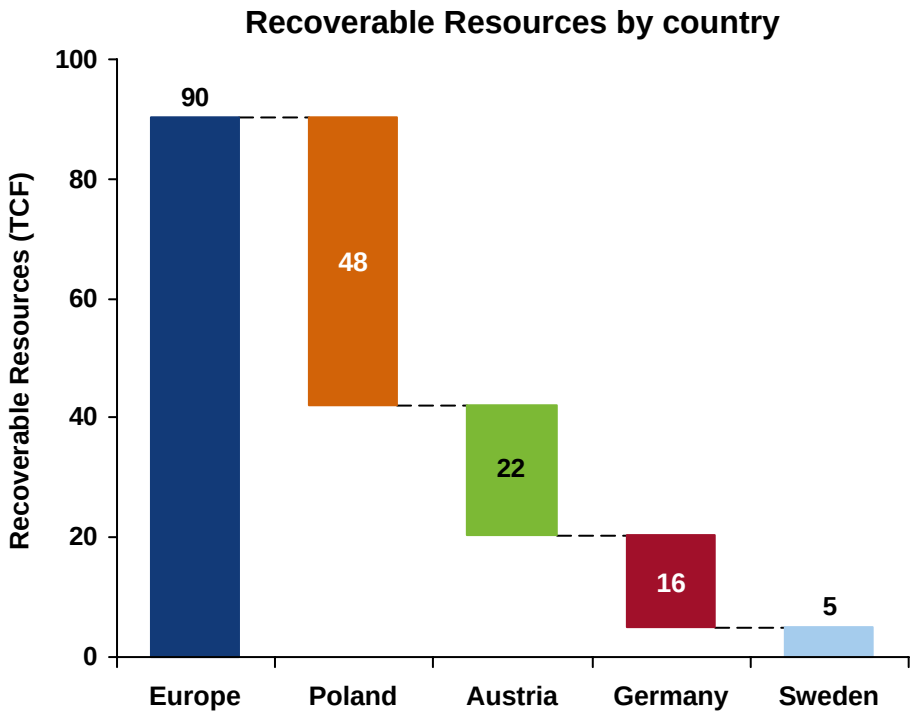
Unconventional Gas in Europe has potential in the long term

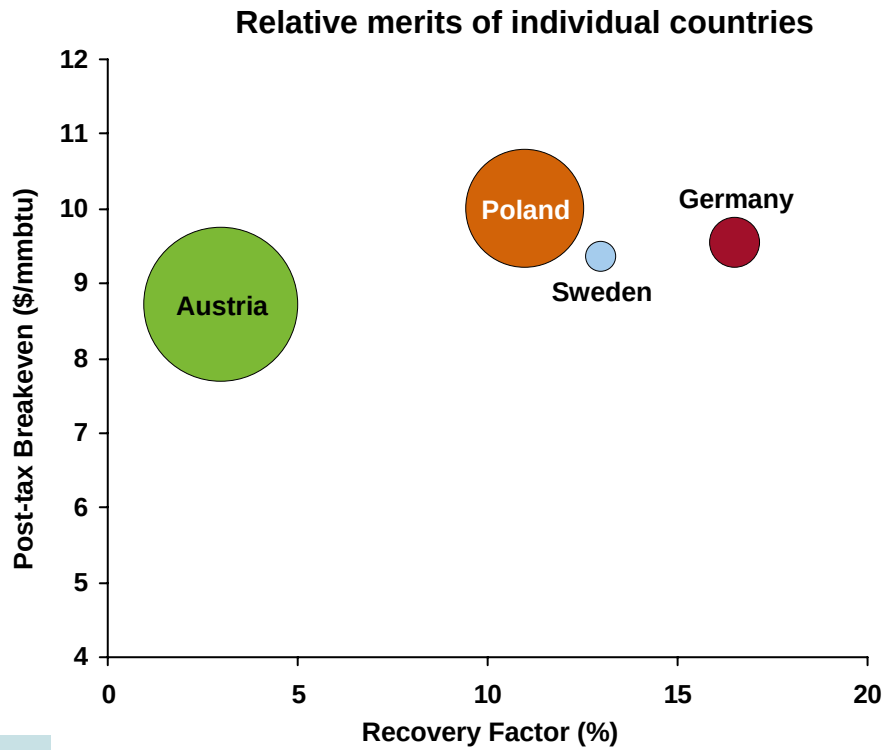
Source: WoodMac and industry press

1) Tight Gas includes onshore resources only and does not include offshore resources

1

European Shale Gas, Potential Size of the Opportunity
GIIP[1] = 1,343 TCF, Recoverable = 90 TCF, RF[2] = 3% - 17%





- Shale depths: 2,200m in Sweden, 3,200m in Poland and 6,250m in Austria
- No wells drilled to date and no production so far

Area of bubble represents GIIP (Gas Initially In Place)

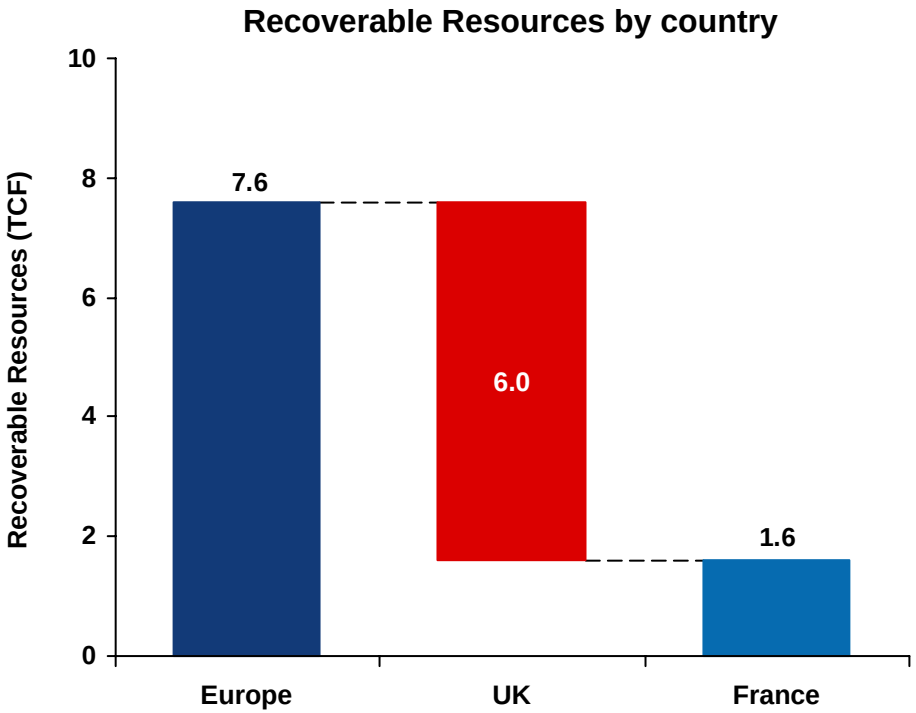
- Austria (Vienna Basin) = 750 TCF
- Poland (Silurian Shale) = 460 TCF
- Germany (Posidonia Shales) = 94 TCF
- Sweden (Alum hale) = 39 TCF

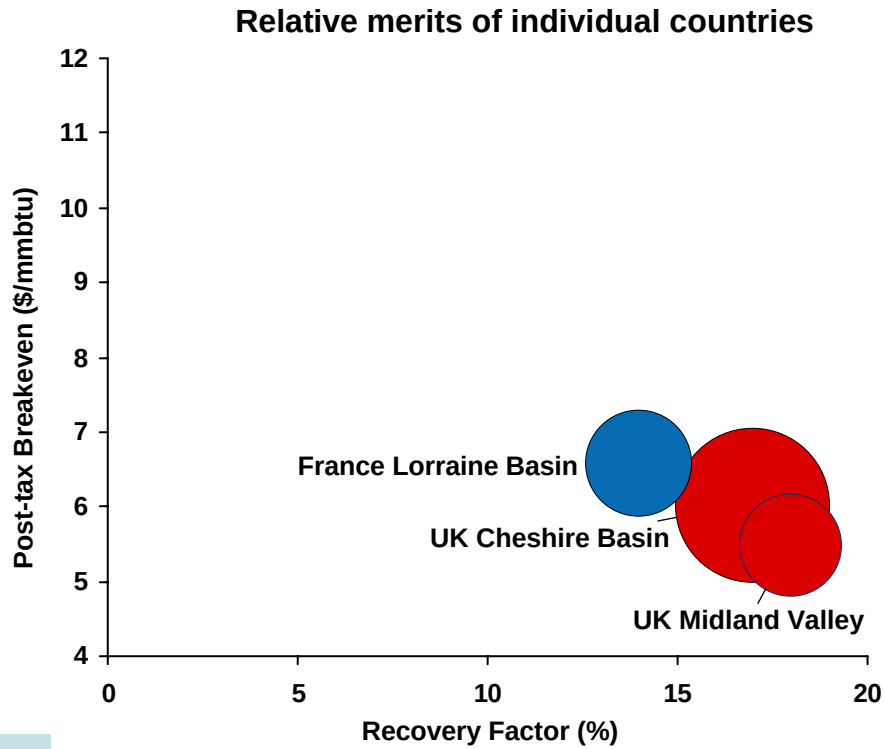
Total Europe = 1,343 TCF

Source: WoodMac
Note: 1 - GIIP = Gas Initially In Place; 2 – RF = Recovery Factor

1

European CBM, Potential Size of the Opportunity
GIIP[1] = 46.5 TCF, Recoverable = 7.6 TCF, RF[2] = 14% - 18%





- Depth of the coal seams ranges from 1,150m in France to 1,600m in the Midlands Valley and 2,750m in the Cheshire Basin, both on the UK
- Commercial production to the grid in UK has begun in 2009 (IGas+Nexen)
- Most of the bigger players entered the market by farming in and providing technical expertise to the original licence holders

Area of bubble represents GIIP (Gas Initially In Place)

- UK Cheshire Basin = 24.0 TCF
- UK Midland Valley = 10.5 TCF
- **UK Total = 34.5 TCF**
- France Lorraine Basin = 12.00

Total Europe = 46.5 TCF

Source: WoodMac
Note: 1 - GIIP = Gas Initially In Place; 2 – RF = Recovery Factor

1

UK Renewable Gas, Potential Size of the Opportunity
Current ~1.4 bcm, with potential for ~5+ bcm by 2020

Potential Renewable Gas Production in the UK

National Grid Paper, Jan 2009	2020 (baseline) million m^3	2020 (stretch) million m^3
Sewage / waste water	270	629
Manure - dairy and cattle	254	507
Agricultural waste	234	967
Food waste	729	1,333
Biodegradable waste	1,042	8,328
Wood waste	1,253	2,697
Miscanthus	1,845	3,971
Total	**5,625**	**18,432**
As % total UK gas demand (~97bcm)	5%	18%
As % residential gas demand (~35bcm)	15%	48%

Baseline Scenario – significant proportion of waste still goes to landfill, is not sorted or is still used for electricity rather than for heat

- **Present Situation**
  - At present ~1.4 bcm of renewable gas are produced in the UK; this could meet ~1% of total UK gas demand
  - All this gas is used to generate electricity (efficiency 30%) due to ROCs
  - If this gas were to be injected in the gas grid, efficiency rates in excess of 90% could be achieved
- **Future Scenarios (National Grid Paper)**
  - Baseline Scenario (more realistic) - Potential to ramp up to ~5 bcm by 2020 i.e. 5% of total UK gas demand, 15% of UK residential demand
  - Stretch Scenario – Not realistic and represents an aspiration rather than reality. Estimated production jumps to ~18 bcm by 2020 i.e. 18% of total UK gas demand, 48% of UK residential demand

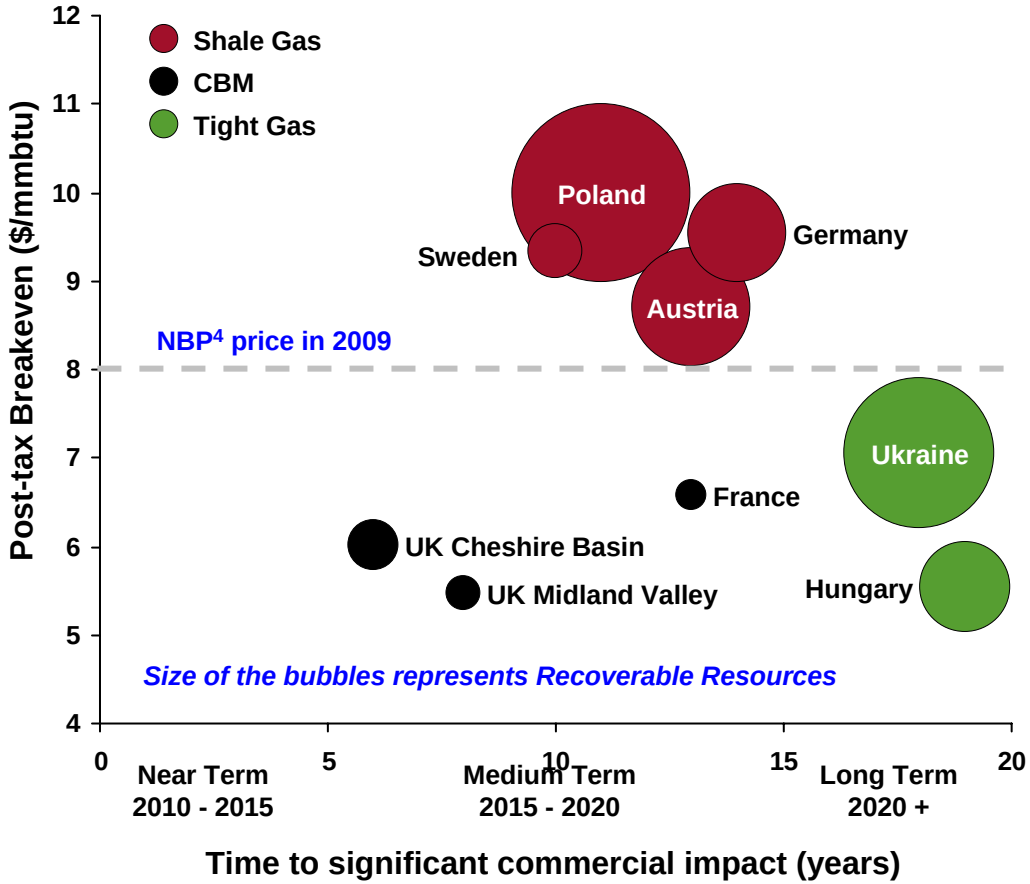
Stretch Scenario – "technical potential" figure, requires every person & business in UK to sort & direct waste appropriately; would be a significant challenge – not realistic

Source: "The potential for Renewable Gas in the UK" – National Grid paper, Jan 2009

1

With the exception of UKCS tight gas, no other unconventional gas play is big enough AND commercially viable NOW, but some could make a big impact in the future

Relative Merits of Individual Unconventional Gas[1] Plays in Europe



Gas Type	Country	GIIP[2] (TCF)	Recoverable Resources (TCF)	RF[3]	Pre-Tax Break-even cost ($/mmbtu)
Shale Gas	Poland	460.00	48.30	11%	9.99
	Austria	750.00	21.60	3%	8.71
	Germany	94.00	15.50	17%	9.54
	Sweden	39.00	4.90	13%	9.34
	Total	**1,343.00**	**90.3**	**7%**	
CBM	UK Cheshire Basin	24.00	4.1	17%	6.01
	UK Midland Valley	11.00	1.9	18%	5.47
	France	12.00	1.6	14%	6.57
	Total	**47.00**	**7.6**	**16%**	
Tight Gas (Onshore only – does NOT include UKCS offshore)	Ukraine	290.00	34.00	12%	7.04
	Hungary	100.00	13.00	13%	5.54
	Total	**390.00**	**47.00**	**12%**	
TOTAL		**1,780.00**	**144.90**	**8%**	

Source: WoodMac and industry press

1) Tight Gas on this slides includes onshore tight gas only and DOES NOT include offshore UKCS tight gas, which is addressed on the next slide
2) GIIP = Gas Initially In Place
3) RF = Recovery Factor
4) NBP = National Balancing Point; a virtual trading location for the sale, purchase and exchange of UK natural gas

1

UKCS[1] Tight Gas, Potential Size of the Opportunity
~4 TCF of recoverable reserves in new developments

UKCS Tight Gas – Opportunity Size and Time to Commercial Production

- **Opportunity Size**
  - Based on initial studies, we estimate ~4 TCF of recoverable gas reserves for the UKCS in new developments
  - Additionally, an even larger amount of undeveloped tight gas is expected from existing fields in the UKCS
  - The consensus seems to be that there is more undeveloped tight gas in existing fields rather than in new discoveries/prospects.
- **Time to Commercial Production**
  - Given that some of the tight gas reserves are part of existing acreages, these are expected to come on stream fairly quickly; typically new developments are expected to come onstream within the next 1-3 years

1) UKCS = UK Continental Shelf, the offshore oil and gas fields around the UK

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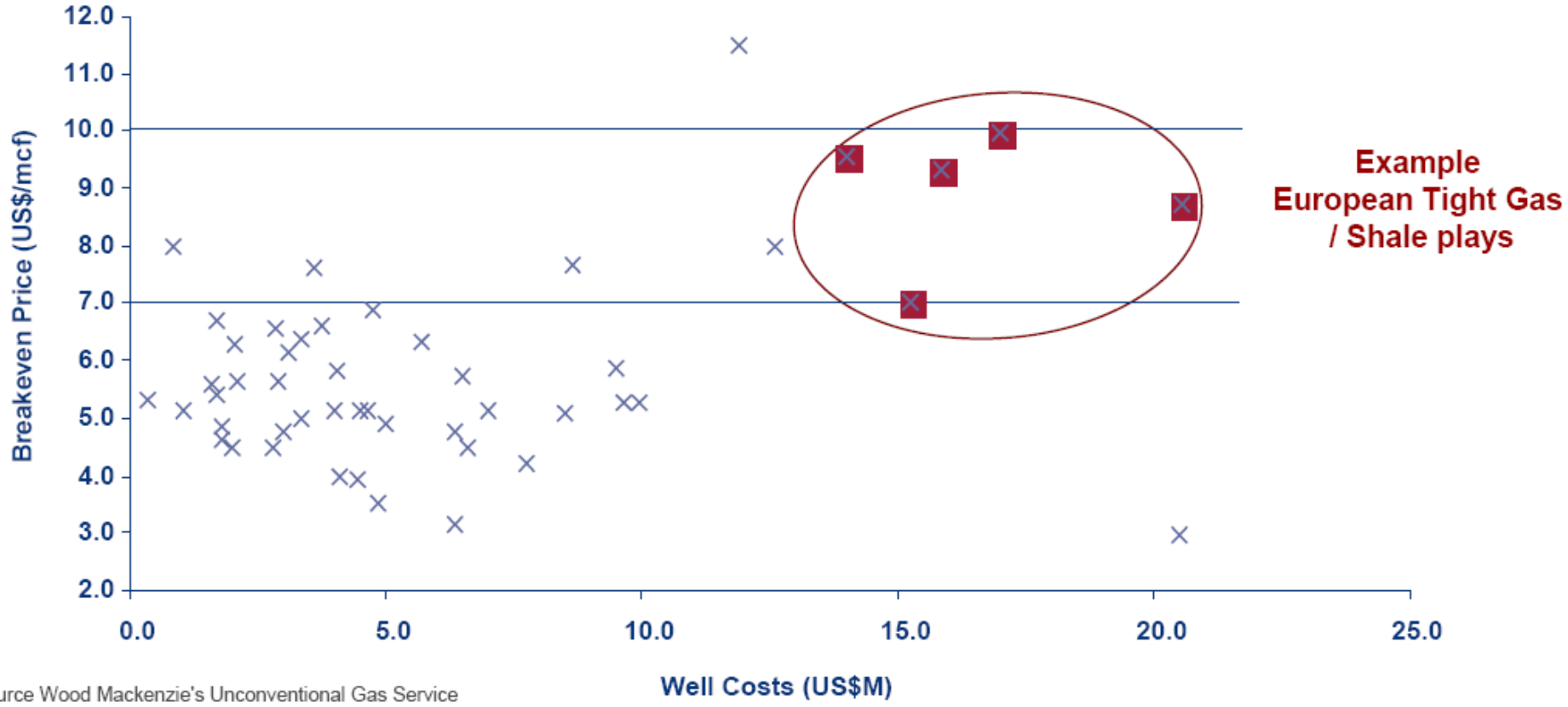
Current forecasts of breakeven costs for European shale gas and tight gas are significantly higher than those for the US and Australia

Well Costs vs. Breakeven Prices for Shale Gas and Tight Gas Plays Around the World

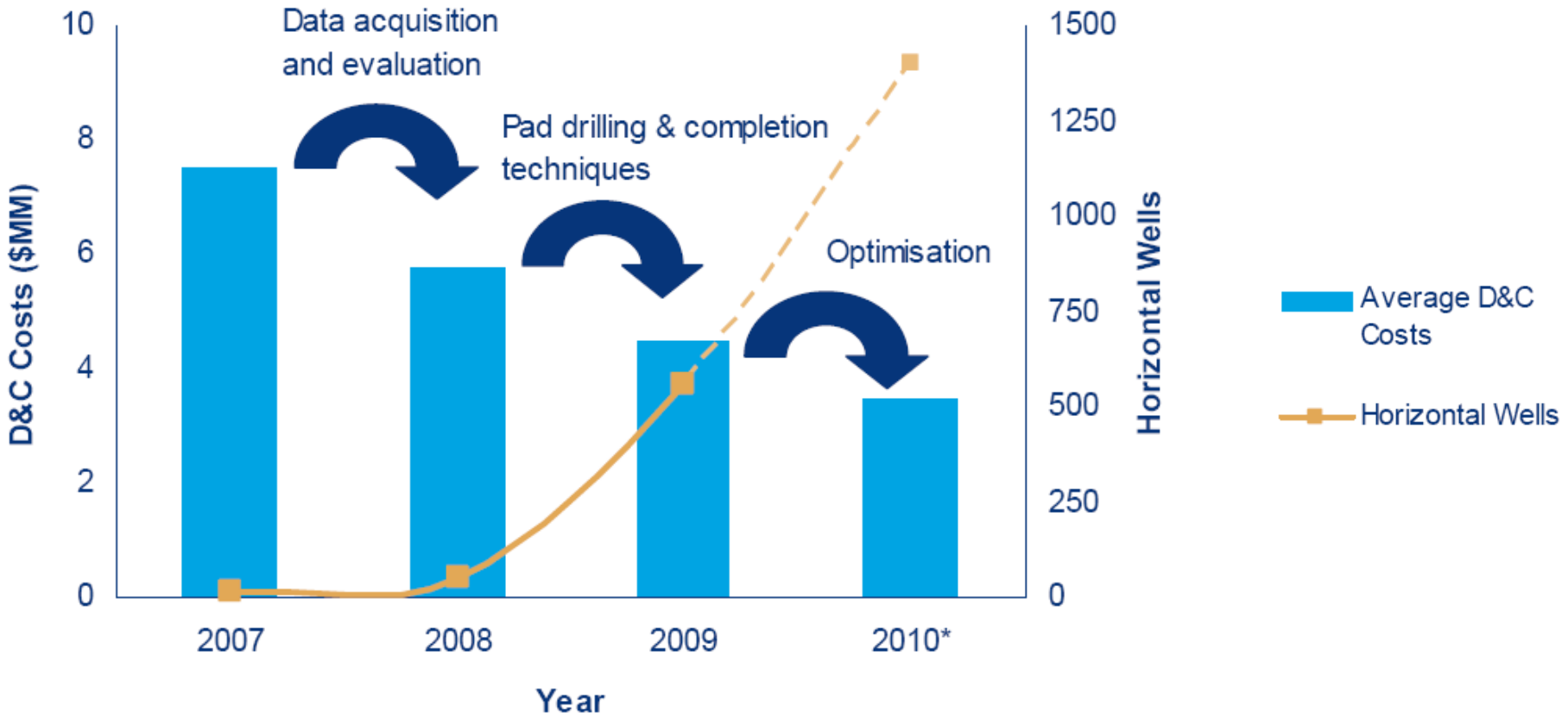


Source Wood Mackenzie's Unconventional Gas Service

2

However, the US experience shows that costs will fall significantly as production increases and the benefits of experience, competition and economies of scale kick in

Cost Efficiencies in the Marcellus Shale in the US over time



Source: WoodMac analysis of data from Pennsylvania DEP, Wright & Co.

2

For UKCS tight gas, the upfront costs in drilling and fracturing the wells is high and may increase further as operators pursue opportunities in tighter reservoirs

UKCS Tight Gas – Indicative Economics

- **Typical Well Costs**
  - £30 m - £40m for an offshore tight gas well vs. £10 m for an offshore conventional well
- **Key Drivers of Cost**
  - Long horizontal well sections and hydraulic fracturing are required to maximise the output from each well. These are the biggest cost drivers for tight gas wells
- **Main Technical & Economic Challenges**
  - Higher risk of unsuccessful wells (in the event of less-than-optimal well fracturing)
  - High costs combined with lower production rates (marginal economics, hence the need for tax incentive
  - Limited access to infrastructure can increase production costs significantly

Source: WoodMac analysis of data from Pennsylvania DEP, Wright & Co.

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European Shale Gas
Centrica – current involvement and future plans

Centrica's Current Involvement

- **Centrica does not own any licences for shale gas at present and no activity has been undertaken yet**
- **Other operators have planned pilots in Poland and Sweden in 2010 and 2011**

European Shale Gas, Time to Significant Impact
Unlikely in this decade; Poland is ahead of the others

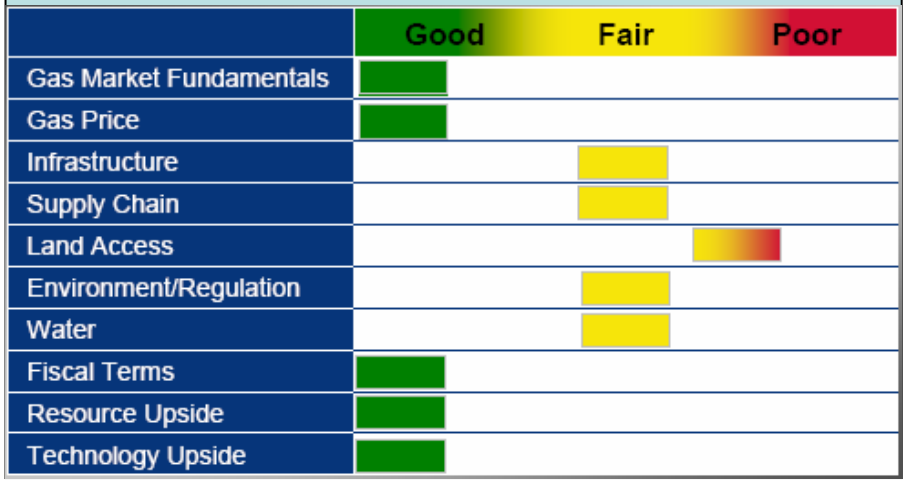
3

European Shale Gas Summary

Description

- The play maturity is early life and there has been no production to date. There is some activity in progress currently.
- Technically feasible; questions around cost, environmental and regulatory issues
- Total reserves (GIIP) of 1,343.1 tcf of which 90.3 tcf are recoverable
- The main countries are Austria, Germany, Poland, Sweden, Romania, UK, Hungary, Ukraine & France

Key Indicators



Key Enablers

- Key Success Factors
  - Government and local population support
- Milestones
  - Successful outcomes of pilot projects and reasonable and repeatable flow rates
  - Development of unconventional supply chain promising reduced costs e.g. fraccing equipment, CBM rigs
  - Sustained interest of larger companies

Pros and Cons

- Policy/Regulatory
  - ⊖ Proximity to populous areas
  - ⊖ Requirement of large quantities of water
  - ⊖ Access to land, pipelines
- Techno-commercial Factors
  - ⊖ Some complications in geology
  - ⊖ Absence of oilfield services supply chain/talent
  - ⊖ Higher cost structure

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European Coal Bed Methane
Centrica – current involvement and future plans

Centrica's Current Involvement

- **Centrica has CBM licences in the South of Wales, both on its own and also through a JV with Coastal Oil and Gas and Eden Energy**
- **Current plans include**
  - Phase 1: Exploration and testing 2010-2013 (Approved)
  - Phase 2: Pilot production from 2012 onwards
  - Phase 3: Full-scale production from 2014/15 onwards
- **In the UK there has been some commercial CBM production into the grid in 2009**

European CBM, Time to Significant Impact
Commercial in the UK but still 5-10 years away from full-scale development

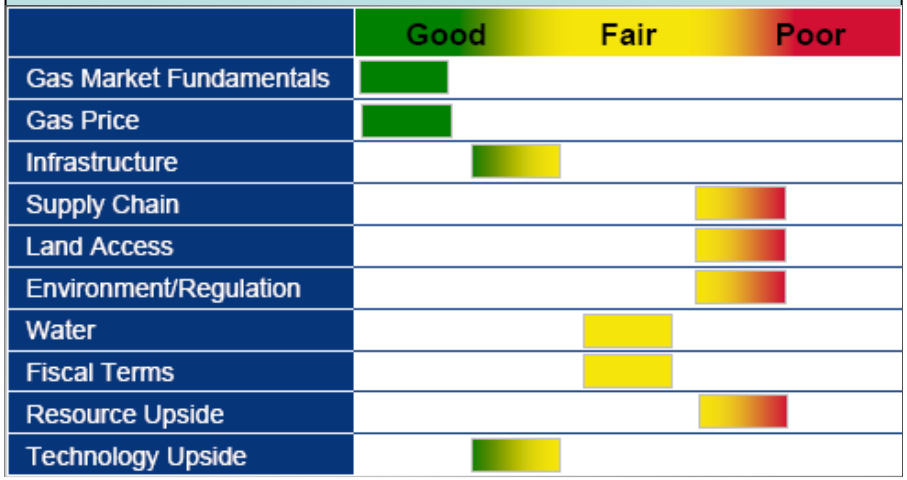
3

European Coal Bed Methane Summary

Description

- The play maturity is early life and there has been a little commercial production in the UK (IGas+Nexen in Apr 2009).
- Technically feasible; questions around cost, environmental and regulatory issues
- Total reserves (GIIP) of 46.5 tcf of which 7.6 tcf are recoverable
- The main countries are UK, France, Germany, & Poland

Key Indicators



Key Enablers

- Key Success Factors
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  - Sustained interest of larger companies

Pros and Cons

- Policy/Regulatory
  - ⊖ Proximity to populous areas
  - ⊖ Requirement of large quantities of water
  - ⊖ Disposal of produced water
  - ⊖ Access to land
- Techno-commercial Factors
  - ⊖ Absence of oilfield services supply chain/talent
  - ⊖ Cost is still an issue

3

Although renewable gas is commercial in Europe, there are a few issues in the UK that need to be resolved

•Key Benefits

- Renewable source of energy
- When used for domestic heating through the national grid, renewable gas can be delivered using existing gas distribution infrastructure
- Improves waste management solutions
- Provides security of supply benefits

Issues

- Renewable gas has a lower calorific value than natural gas; this can be solved by enriching it with propane to improve the calorific value or through billing
- Currently, renewable gas in the UK is commercially viable only with a support mechanism like the RHI
- Economic viability on a large scale needs to be proved due to potential issues with waste sorting and collecting

Developments to Date

- British Gas announced five biomethane demonstration projects in partnership with Thames Water in Feb 2010
- SSE have signalled their intention to develop biogas as part of their citywide environmental project in Glasgow
- E.ON already has a plant for biomethane production in Germany since 2008, generating at a rate of 1,000 cubic metres per hour
- RWE Innology has a biogas plant with a thermal capacity of ~6.5 MW in Saxony-Anhalt since 2009. It has signed letters of intentto build a further 10 plants in Germany by 2012

Scale

- UK plants are of smaller capacities than the German ones
- While scaling up is technically possible, the feasibility of the same in the UK hasn't been proven conclusively yet
- With developments in place, it is expected that ramping up will not be an issue

3

Centrica has announced biomethane demonstration projects, but next steps will depend on the degree of their success

Centrica's Current Involvement

- **5 demonstration projects in partnership with Thames Water have been announced in Feb 2010**
- **Key issues expected to be addressed in these demonstration plants**
- **Potential plans could include**
  - Anaerobic Digestion Plants (900 million therms at the rate of 90 million therms per year over ten years)
    - Up to 2 large projects of 25 million therms each
    - Up to 30 medium-sized projects of 1 million therms each
    - Up to 20 small projects of 0.5 million therms each
  - Gasification Plants (900 million therms)
    - Up to 2 gasification projects of 450 million therms

European CBM, Time to Significant Impact
Commercial in the UK but large scale impact will depend on degree of success of demonstration projects

3

UKCS Tight Gas
Centrica – current involvement and future plans

Centrica's Current Involvement

- **Centrica has plans for development of UKCS tight gas**
- **Current plans include**
  - Ensign First Gas ~2011
  - Ketex First Gas ~2013
  - Arrol First Gas ~2014

UKCS Tight Gas, Time to Significant Impact
Certain projects are commercial (due to advantaged infrastructure access etc.) and are expected to come onstream in 1-3 years

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Although there are no serious technical constraints, significant obstacles prevent early and economic production

	Technical Feasibility	Size of Opportunity	Production Economics	Absence of political or regulatory barriers	Presence of enabling infrastructure	Remarks
Offshore Stranded Gas	◔	◕	◑	●	◔	Depends on development of technologies for FLNG and Offshore GTL
Shale Gas	●	◕	◔	◔	◑	Gas deposits are in/near densely populated areas. Protests in Sweden. Costs are currently very high as the oilfield services supply chain isn't in place yet
CBM (Coal Bed Methane)	●	◔	◕	◑	◑	Gas deposits are in/near populated areas Costs are currently very high as the oilfield services supply chain isn't in place yet
Renewable Gas	●	◑	◑	◔	◔	Govt intervention required to address issues of waste management etc. Gas cleaning up needs to be looked at closely as is the ability to inject renewable gas into the grid
Tight Gas (Onshore Europe)	◑	◑	○	○	◑	Geological issues have forced operators to abandon exploration for now in Hungary Domestically fixed sale price of US$1.50/mcf makes it economically unviable
UKCS Tight Gas (Offshore)	◕	◑	◔	◑	◔	Issues are mostly around cost and in some areas, geology and/or technology
Others– Hydrates, UCG	○	●	○	◔	◔	Very early stages of infancy – technologies yet to be developed and at least for UCG, serious environment concerns exist

○ Most unfavourable ◑ Breakeven ● Most Favourable

4

However, as unconventional gas in Europe is in its infancy, it does not have the advantages of similar plays in the US …

Key Factors Against Unconventional Gas in Europe

- **Challenging economics**
  - Supply chain (drilling rigs, fracc units) is in its infancy and hence lacks the scale as well as the cost advantage of the US. Additionally, rigs capable of drilling horizontally are scarce too
  - Infrastructure to monetise the gas is not always accessible or available
  - Skilled labour is scarce unlike the US
  - In Europe, unconventional gas deposits are deeper than those in the US – leading
- **Regulatory barriers**
  - Considerably higher population density in Europe implies that the close well spacing that is a norm for unconventional gas would result in drilling close to populated areas
  - Land ownership is extremely fragmented with smaller and more numerous farms present in Europe – this makes access to land very difficult
- **Environmental concerns**
  - Rick of contaminating water tables due to intensive use of water for fraccing
  - Disposal of produced water in the case of CBM is an issue in some areas

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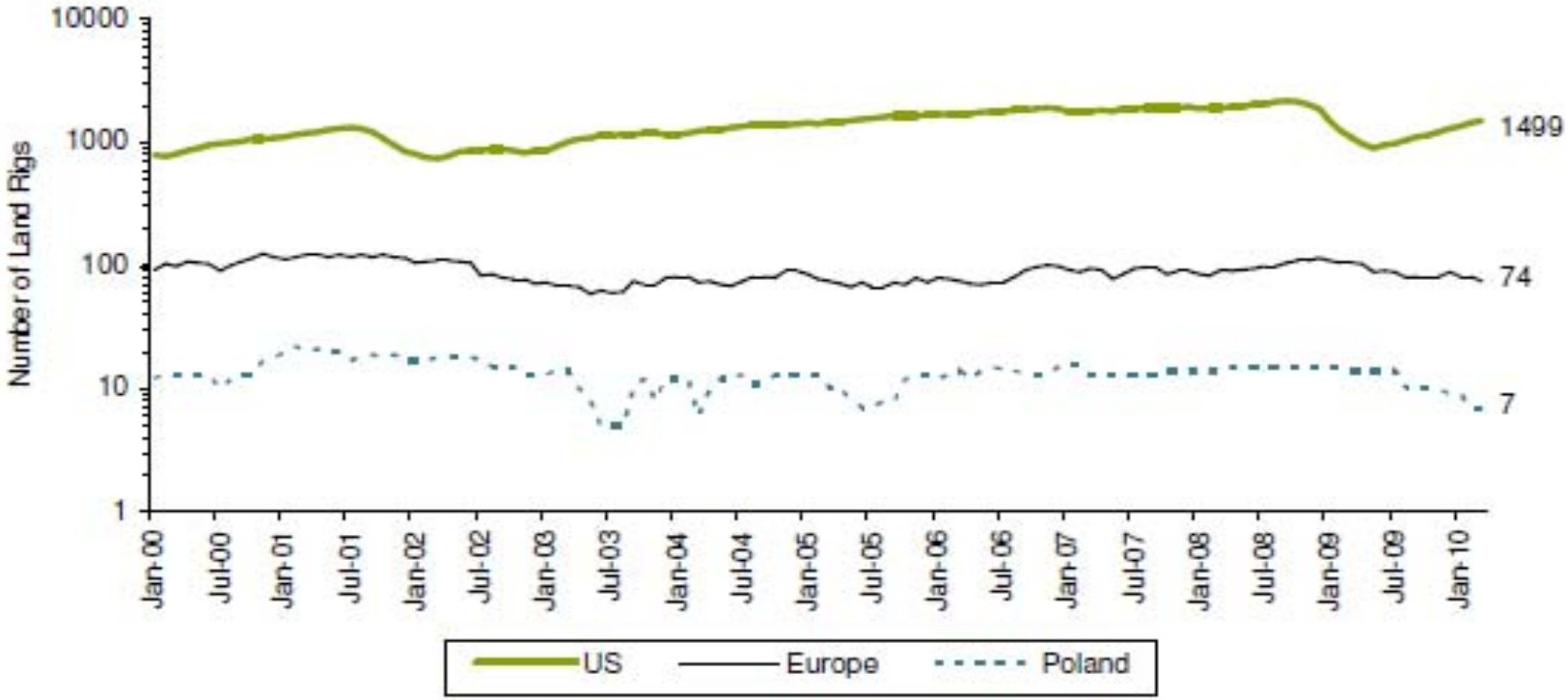
Rig capacity in Europe will need to increase dramatically

Comparison of numbers of land drilling rigs



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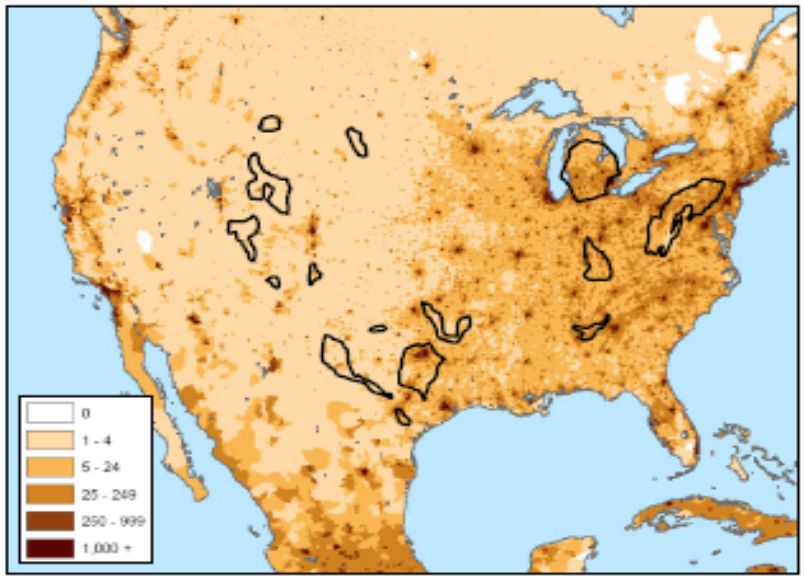
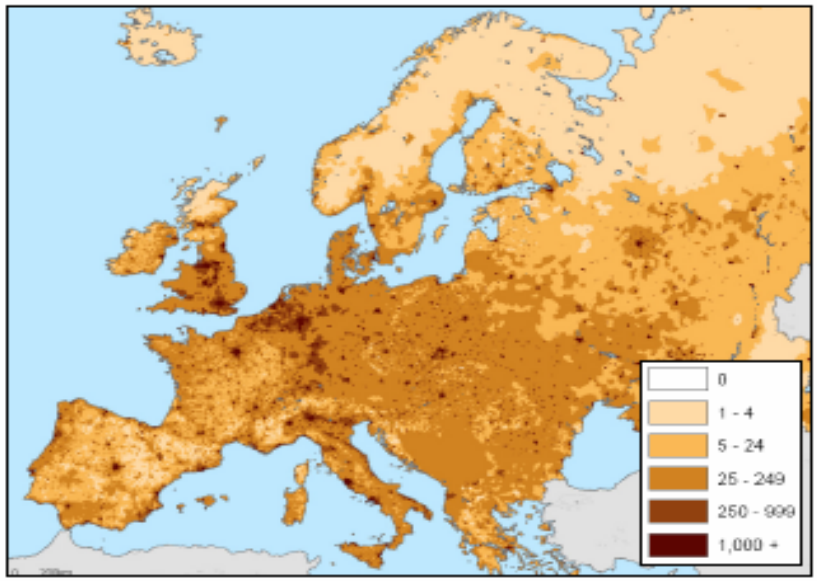
The higher population concentration in Europe as compared to that in the US is a significant obstacle

Comparison of population density US vs. Europe

- Poland and its European cousins are disadvantaged due to higher population densities of 100+ people/km², versus only 32 people/km² on average for the US





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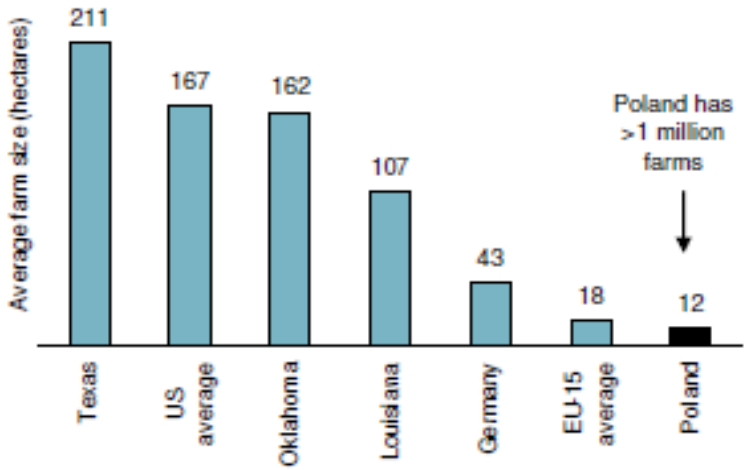
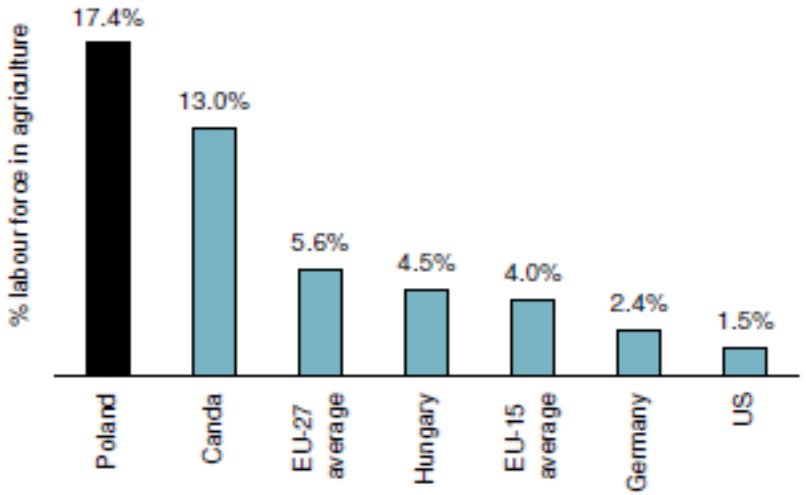
Europe has much smaller farms making land access more challenging that NA or Australia

Comparison of average farm sizes

- The Polish landscape is littered with small farms with an average plot size of just 12 hectares versus 160 hectares in Oklahoma or 210 hectares in Texas. Agriculture remains a core part of the Polish economy with a 17% share compared to just 6% in EU-27 and 1.5% in the US





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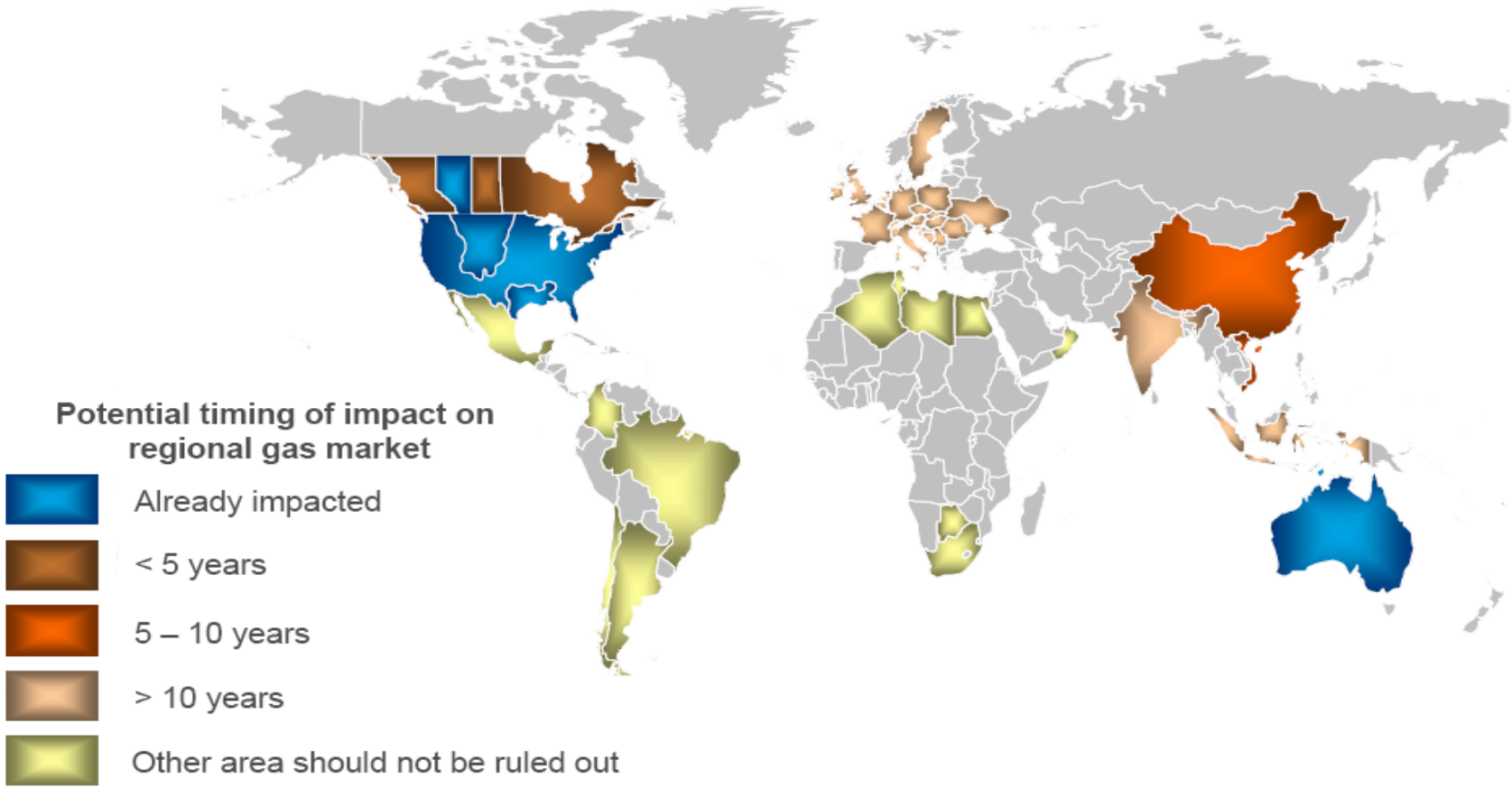
Hence it will be more than 10 years before unconventional gas makes a significant impact in Europe

Potential Timing of Impact of Unconventional Gas on Regional Markets



Summary

- Some unconventional gas plays in Europe are already commercial but are too small to make a significant impact
- For unconventional gas to have a significant impact on European gas markets, various developments (markets, supply chain and regulatory) need to take place
- We do not see as any European unconventional gas as being a game changer for the next 10-15 years
- We do see European unconventional gas as having significant potential, an opportunity that needs to be watched closely and developed within the constraints of technological, economic, financial and regulatory barriers