US unconventional gas plays: Estimated Ultimate Recovery (EUR)

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Aim: to get a global mean figure for the EUR of a shale oil well, which might be applicable to the UK.

Problems include:

- Sourcing reliable figures
- Matching USGS play definitions to more informal names.

For example, the 'Marcellus' shale gas play in an EIA report of 2011 includes the main Interior Marcellus and the minor Western Margin Marcellus, but not the Fold Belt Marcellus. These are the standard Assessment Unit names used by the USGS; shapefiles are available for plotting their locations. For the purpose of comparison I equated the EIA 'Marcellus' with just the main Interior Marcellus. Omitting the Western Margin play makes little difference to the comparison, as so few wells have been drilled there.

The five main plays analysed – Barnett, Haynesville, Woodford, Fayetteville and Marcellus – conform to the single main assessment unit in each basin.

ATTRIBUTES OF FIVE MAJOR SHALE GAS PLAYS - 2011
Oil & Gas Journal, 3 December 2012

		Notes on Barnett & F'ville	Fayetteville	Haynesville	Marcellus	Woodford	All plays
	Barnett						
Production start-up	1998		2006	2008	2008	2006	
Original gas-in-place, tcf	327		52	717	1500	150	3764
Area, sq miles	6500		9000	9300	94000	3000	
Depth, ft	5000-8000		1000-7000	9600-13500	4000-8500	6000-1000	
Thickness, ft	100-500		20-200	200-300	50-200	120-220	
Well spacing/sq mile	6		8	8	8	4	
Output, bcf/day	5.3		2.45	4.23	1.5	1.1	20
Cumulative production, bcf	10.8		2.2	1.9	1	1.2	24
Estimated recoverable gas, tcf	19	1	5	34	84	10	482
Recovery factor, %	5.8	1	10	4.7	5.6	6.6	13
Estimated production potential, bcf/day	5.5	2	3	10	26	2.7	
Avg. well EUR, bcf/well	1.3		1.1	3	1.2	3	
Avg. Well costs, $ million	3.5		2.8	9.5	6	7	

1. Value was estimated by decline analysis
2. Field values
Note: Estimated recoverable gas = unproved technically recoverable gas.
Recovery factor = recoverable gas / gas-in-place;
estimated production potential is calculated with Equation 2.640 acres = 1 sq mile.
Sources: EIA 2012, USGS 2010, producer estimates, and several other sources cited in references.

Average EUR weighted by estimated recoverable gas **1.73**

This is a table published in the *Oil & Gas Journal* in December 2012 (ref. 1). To calculate a mean EUR for the five plays I weighted each play by the value for estimated recoverable gas (ERG). This gives a mean of **1.73 bcf/well**. But in 2012 the USGS used a probably more sophisticated method to estimate EURs, uniformly applied over 26 assessment units (AU). The paper was not quoted by the *Oil & Gas Journal.*

U.S. Energy Information Administration

INTEK, Inc.

The EIA published a review of shale gas and oil plays in July 2011 (ref. 2). Essentially it is a review for the EIA by INTEK dated December 2010.

I have inserted the ERG figures from the *Oil & Gas Journal* table (previous slide) for comparison (yellow column).

The five main plays with USGS AU number, in order of decreasing play maturity:

Woodford 50580161
Haynesville 50490161
Barnett 50450161
Fayetteville 50620362
Marcellus 50670468

Table 1. INTEK estimates of undeveloped technically recoverable shale gas and shale oil resources remaining in discovered shale plays as of January 1, 2009 — Table i

Submodule	Shale play	Estimated recoverable gas Gas tcf	OGJ 2012 tcf	Oil BBO	EUR bcf/well
Northeast	Marcellus	410	84		1.18
	Antrim	20			0.33
	Devonian Low Thermal	14			0.30
	New Albany	11			0.19
	Greater Siltstone	8			1.10
	Big Sandy	7			0.28
	Cincinnati Arch*	1			0.12
Gulf Coast	Haynesville	75	34		3.57
	Eagle Ford	21		3	5.00
	Floyd-Neal & Conasauga	4			0.90
Mid-Continent	Fayetteville	32	5		2.07
	Woodford	22	10		2.98
	Cana Woodford	6			5.20
Southwest	Barnett	43	19		1.42
	Barnett-Woodford	32			3.07
	Avalon & Bone Springs			2	
Rocky Mountain	Mancos	21			0.18
	Lewis	12			1.30
	Williston-Shallow Niobraran*	7			0.45
	Hilliard-Baxter-Mancos	4			1.00
	Bakken			4	
West Coast	Monterey/Santos			15	
Total		**750**		**24**	

AU number	AU name	Area (source: USGS)	Province	Year assessed	Minimum EUR	Median EUR	Max EUR	Mean EUR	EIA 2011 play area	Notes	ERG from OGJ 2012	ERG (OGJ) x mean EUR	ERG from EIA 2011	ERG (EIA) x mean EUR
50210362	Cane Creek Shale Gas	11266	Paradox Basin	2011	0.02	0.3	5	**0.446**						
50210364	Gothic, Chimney Rock, Hovenweep Shale Gas	25441	Paradox Basin	2011	0.02	0.4	10	**0.672**		Little overlap with Gothic AU of Paradox basin				
50390761	Niobrara Chalk	194410	Denver Basin	2001	0.025	0.2	2	**0.261**		No EIA shale play				
50440161	Delaware/Pecos Basins Woodford Continuous Shale Gas	23893	Permian Basin	2007	0.02	0.6	8	**0.842**	43850	Barnett-Woodford (Delaware) shale play EIA2011				
50440162	Delaware/Pecos Basins Barnett Continuous Shale Gas	33044	Permian Basin	2007	0.02	0.6	8	**0.842**	43850	Barnett-Woodford (Delaware) shale play EIA2011				
50440163	Midland Basin Woodford/Barnett Continuous Gas	7798	Permian Basin	2007	0.02	0.3	5	**0.446**						
50450161	Greater Newark East Frac-Barrier Continuous Barnett	4026	Bend Arch-Fort Worth Basin	2003	0.02	0.7	10	**1.000**	68309	Part of Barnett EIA shale play (2)	19	19	43	43
50450162	Extended Continuous Barnett Shale Gas	12725	Bend Arch-Fort Worth Basin	2003	0.02	0.2	5	**0.334**	68309	Part of Barnett EIA shale play				
50490161	Haynesville Sabine Platform Shale Gas	23379	Gulf Coast Mesozoic	2010	0.02	2	20	**2.617**	29032	Northern part of Haynesville-Bossier play	34	89	75	196
50490163	Mid-Bossier Sabine Platform Shale Gas	5274	Gulf Coast Mesozoic	2010	0.02	1	10	**1.308**	29032	South overlapping part of Haynesville-Bossier play				
50490165	Maverick Basin Pearsall Shale Gas	43466	Gulf Coast Mesozoic	2010	0.02	0.25	5	**0.391**	48687	Eagle Ford shale play				
50490167	Eagle Ford Shale Gas	198487	Gulf Coast Mesozoic	2010	0.02	0.8	10	**1.104**	48687	Eagle Ford shale play				
50580161	Woodford Shale Gas	27099	Anadarko Basin	2010	0.02	0.8	15	**1.233**	8620	Woodford (Anadarko) shale play	10	12	22	27
50580261	Thirteen Finger Limestone-Atoka Shale Gas	21627	Anadarko Basin	2010	0.02	0.5	10	**0.785**	8620	Woodford (Anadarko) shale play				
50620261	Woodford Shale Gas	24428	Arkoma Basin	2010	0.02	0.5	10	**0.785**	7447	Woodford-Caney (Arkoma Basin) play				
50620262	Chattanooga Shale Gas	24195	Arkoma Basin	2010	0.02	0.1	6	**0.223**	15054	Fayetteville (Arkoma Basin) play (3)				
50620362	Fayetteville Shale Gas - High Gamma-Ray Depocenter	10509	Arkoma Basin	2010	0.02	0.8	10	**1.104**	15054	Fayetteville (Arkoma Basin) play (3)	5	6	32	35
50620363	Fayetteville Shale Gas - Western Arkansas Basin Margin	13832	Arkoma Basin	2010	0.02	0.3	6	**0.470**	15054	Fayetteville (Arkoma Basin) play (3)				
50620364	Caney Shale Gas	20029	Arkoma Basin	2010	0.02	0.08	5	**0.179**	7447	Woodford-Caney (Arkoma Basin) play				
50630561	Devonian Antrim Continuous Gas	145651	Michigan Basin	2004	0.02	0.4	4	**0.523**	112837	Antrim (Michigan Basin) play				
50640361	Devonian to Mississippian New Albany Continuous Gas	198962	Illinois Basin	2007	0.01	0.08	1	**0.110**	32200	New Albany shale play				
50670462	Northwestern Ohio Shale	117593	Appalachian Basin	2002	0.01	0.04	0.5	**0.055**		outside main Marcellus play				
50670463	Devonian Siltstone and Shale	58775	Appalachian Basin	2002	0.01	0.03	0.5	**0.044**	199276	Marcellus shale play (1)				
50670467	Foldbelt Marcellus	48847	Appalachian Basin	2011	0.02	0.1	5	**0.208**		outside Marcellus shale play				
50670468	Interior Marcellus	115949	Appalachian Basin	2011	0.02	0.8	12	**1.158**	199276	Marcellus shale play (1)	84	97	410	475
50670469	Western Margin Marcellus	95306	Appalachian Basin	2011	0.02	0.05	5	**0.129**						
										Total ERG (tcf)	152		582	
										Sum of EURs weighted by ERG		223		777
										Weighted mean EUR		**1.5**		**1.3**

Footnotes

1 84tcf ERG from USGS 2011

2 USGS 2003 said 15 + 11 = 26 in the 2 barnett plays

3 EIA 2011 says 27 tcf and 5 tcf for central and western AR areas, resp.

USGS science for a changing world

This is Table 1 from the USGS report of 2012 (ref. 3), with columns added on the right. The essential bits are shown at a bigger scale in the next slide. There are 26 shale gas assessment units (AU). The mean EUR column figures are calculated by fitting a truncated lognormal curve to the EUR range for each AU, the range being expressed by the three figures: minimum, median and maximum.

The five coloured rows correspond to the five main plays shown in slide 3.

AU number	AU name	Mean EUR	EIA 2011 play area	Notes	ERG from OGJ 2012	ERG (OGJ) x mean EUR	ERG from EIA 2011	ERG (EIA) x mean EUR
	Detail from previous table							
50210362	Cane Creek Shale Gas	0.446						
50210364	Gothic, Chimney Rock, Hovenweep Shale Gas	0.672		Little overlap with Gothic AU of Paradox basin				
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50620262	Chattanooga Shale Gas	0.223	15054	Fayetteville (Arkoma Basin) play (3)				
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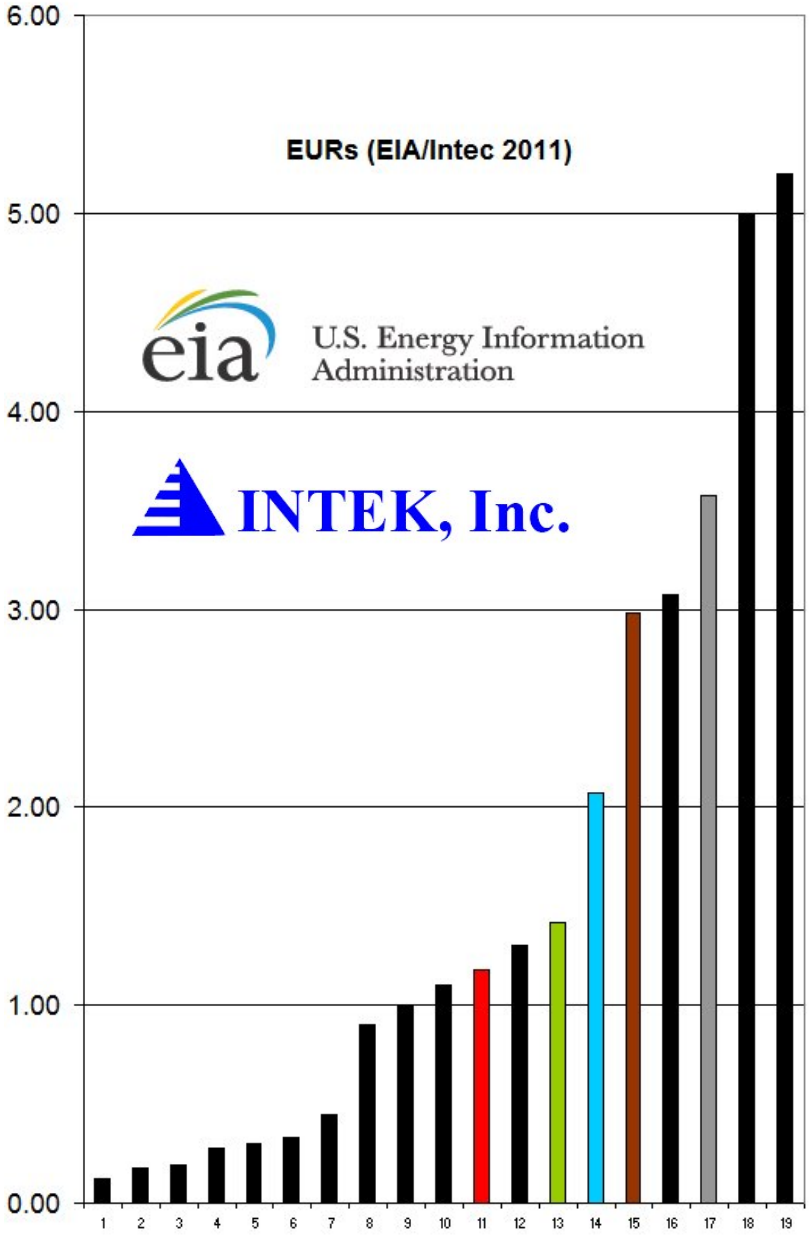
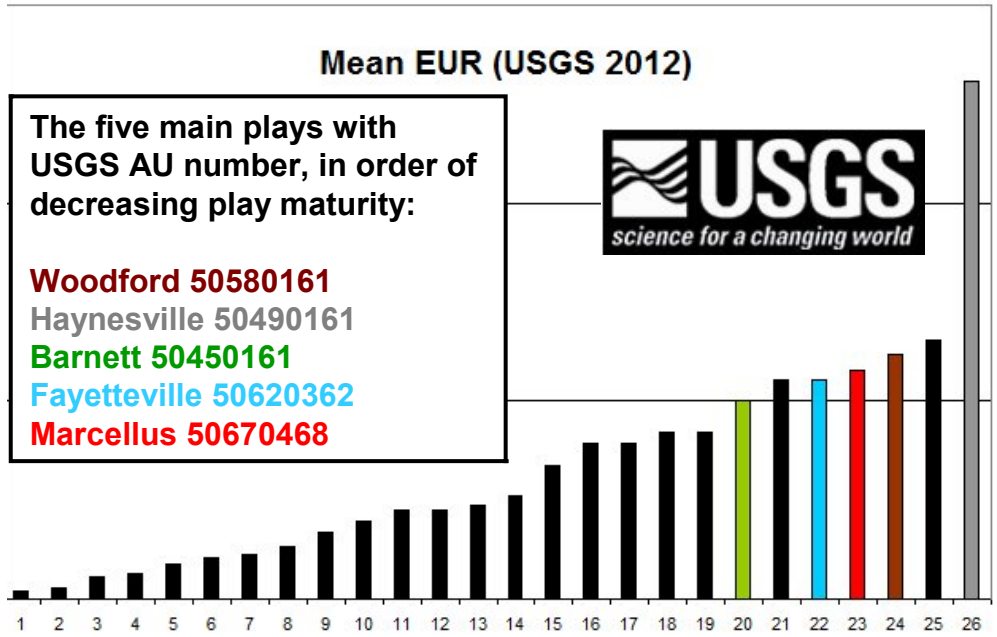
50620363	Fayetteville Shale Gas - Western Arkansas Basin Margin	0.470	15054	Fayetteville (Arkoma Basin) play (3)				
50620364	Caney Shale Gas	0.179	7447	Woodford-Caney (Arkoma Basin) play				
50630561	Devonian Antrim Continuous Gas	0.523	112837	Antrim (Michigan Basin) play				
50640361	Devonian to Mississippian New Albany Continuous Gas	0.110	32200	New Albany shale play				
50670462	Northwestern Ohio Shale	0.055		outside main Marcellus play				
50670463	Devonian Siltstone and Shale	0.044	199276	Marcellus shale play (1)				
50670467	Foldbelt Marcellus	0.208		outside Marcellus shale play				
50670468	Interior Marcellus	**1.158**	199276	Marcellus shale play (1)	84	97	410	475
50670469	Western Margin Marcellus	0.129						
				Total ERG (tcf)	152		582	
				Sum of EURs weighted by ERG		223		777
				Weighted mean EUR		**1.5**		**1.3**

USGS science for a changing world

The yellow pair of columns comprises the estimated recovery of gas from the *Oil & Gas Journal* table, multiplied by the USGS mean EUR. The flesh-coloured columns are the same but use the EIA/Intek ERGs from 2010-2011. The weighted mean EURs are **1.5** and **1.3**, respectively.



The estimated ultimate recoveries (EUR) in tcf for a well in each play are much greater in the EIA dataset (left) than in the USGS dataset (below). The plays have been ordered by ascending EUR. The bars corresponding to the five main plays are coloured.



Discussion and conclusions

The EIA forecasts are more optimistic than those of the USGS, roughly by a factor of two.

Recent papers (ref. 4) by the industry-funded Bureau of Economic Geology of the University of Texas estimate more optimistic lifetime EURs (i.e. past and forecast) for the Barnett and Fayetteville plays. They also predict that the EUR of each will increase in the future, compared with the proven EUR of the past. By coincidence (or does it suggest a flaw in methodology?) both plays are currently at their peak production.

I suggest a 'mean of means' as a guide figure for guesstimating possible UK shale gas production, i.e. from the two figures 1.3 and 1.5 shown in slide 5 we arrive at:

EUR 1.4 bcf/well.

From the range of EURs shown for various US plays, it is possible that this figure could be out by a factor of two in either direction. On the other hand, the relative complexity of UK shale basin geology will tend to lower, rather than increase, this figure.

References

1. Sandrea, R. 2012. Evaluating production potential of mature US oil, gas plays. *Oil & Gas Journal*, 3 December 2012.

2. Energy Information Administration 2012. *Review of emerging resources: U.S. shale gas and shale oil plays.* July 2011.

3. USGS 2012. *Variability of Distributions of Well-Scale Estimated Ultimate Recovery for Continuous (Unconventional) Oil and Gas Resources in the United States*. Open-File Report 2012–1118.

4. Bureau of Economic Geology studies:

Browning, J. et al. 2013a. Barnett shale model – 1. Study develops decline analysis, geologic parameters for reserves, production forecast. *Oil & Gas Journal*, 5 August, 2013, p. 62.

Browning , J. et al. 2013b. Barnett shale model - 2 (Conclusion) Barnett study determines full-field reserves, production forecast. *Oil & Gas Journal*, 2 September, 2013.

Browning , J. et al. 2014. Study develops Fayetteville shale reserves, production forecast. *Oil & Gas Journal*, 6 January 2014.