

Estimated Ultimate Recovery (EUR) Study of 7,300 Marcellus Shale Wells in Pennsylvania. February 2021 Update

Gary S. Swindell, P.E., Consulting Petroleum Engineer, Dallas, Texas

<http://garyswindell.com>

Copyright 2021, Gary S. Swindell.

Summary

This study summarizes the results of an updated and expanded evaluation of the estimated ultimate recovery (EUR) for all horizontal Marcellus Shale completions from 2008 through 2018 in Pennsylvania. Individual well rate vs. time plots using publically available production data through September 2020 were used to forecast the EUR of 7,336 wells. Not included were the 516 wells with first production in 2019 and 392 wells with first production in 2020 (through September) as the decline behavior is not believed to be sufficiently established for reliable projections. The primary study objective was to determine the distribution and trends in EUR.

A considerable number of wells are exhibiting a change in the nature of the decline, generally about 2,500 MCF per day and about 3 years into the production. This may represent a different flow regime in the reservoir than that present in the early months of production.

For 7,336 horizontal wells first produced in 2008-2018 with enough history to forecast a decline profile, the estimated ultimate recovery across the whole state averages 7.7 billion cubic feet equivalent (Bcfe) per well with a median of 6.5 Bcfe. Note that the distribution covers all the wells during a 10 year period – there are further changes over time. The results vary considerably by region – in six counties in the Northeast part of Pennsylvania, the average is 8.6 Bcfe per well and in Wyoming County the mean EUR is 13 Bcfe. In that Northeast region there are a number of wells exceeding 20 Bcfe EUR.

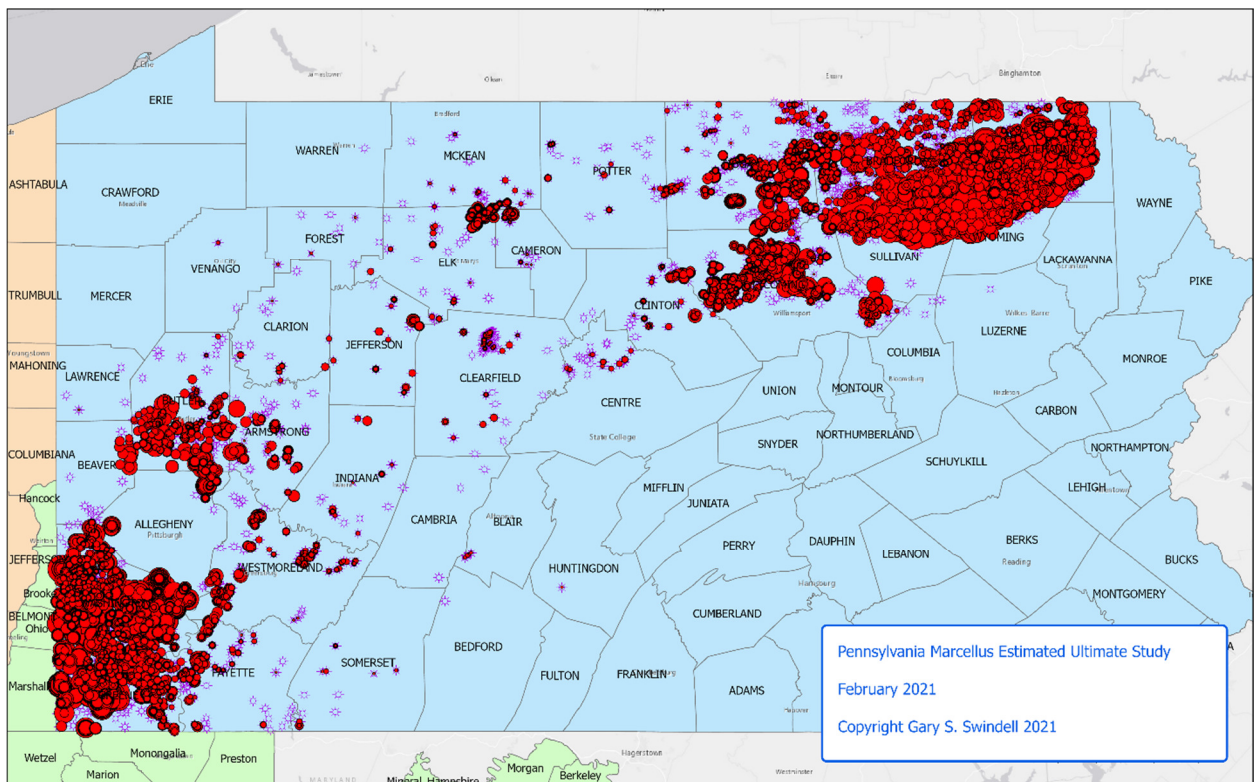
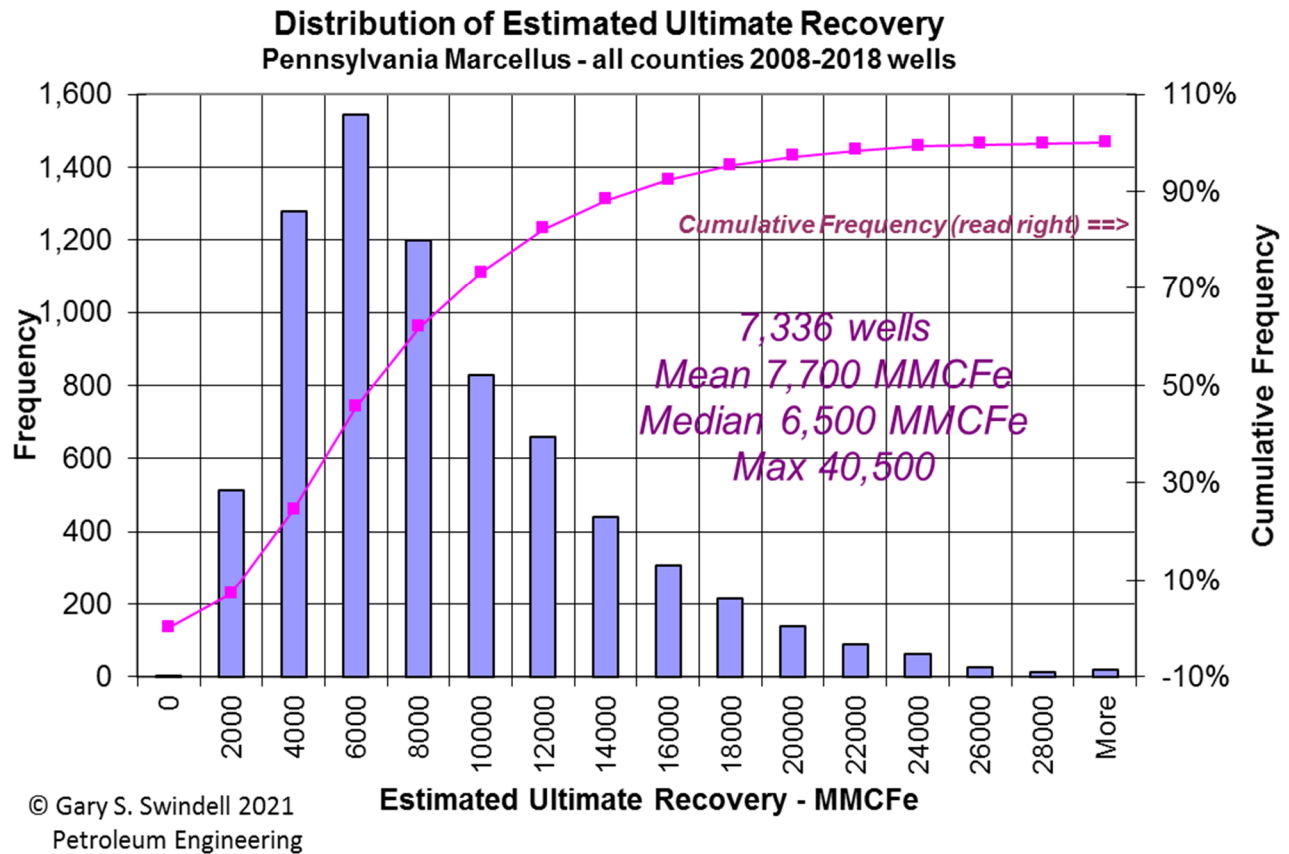
Lease liquids (oil and condensate) were converted to an equivalent gas volume using a *price ratio* of 20 thousand cubic feet (Mcf) per barrel). Much of the reported lease liquids production is from wells in Washington and a few other southwestern counties, however only Range Resources and a few other operators are reporting those liquids. The economic limit was estimated assuming final operating costs of \$3,000/month per well, \$2.50/MCF and 20% royalty burdens.

The data shows that apparent operational changes across the area, probably due to compression and added take-away capacity along with higher hyperbolic behavior in the rate vs. time plots, have improved EUR estimates by about 6% for those wells which were included in the 2018 study.

It should be noted that the estimates are done under the Proved Developed Producing reserve classification and by deterministic methods (rate vs. time). While deterministic estimates may have broadly inferred confidence levels, they do not have the defined confidence levels of Probabilistic estimating methods, which for PDP is a 90% confidence that the reserves are *less than* the amounts stated. Furthermore, operational improvements such as well recompletions, re-fracs and additional compression cannot usually be considered in a Proved Producing reserve classification, with the result that the Proved reserves tend to grow over time as other reserve classes are moved into the Proved category.

A regional breakdown, dividing the state into six areas, Northeast, Northwest, West Central, Mountain, Green-Fayette, and Washington, was made to analyze well performance in a more local way. **Fig. 3** in the appendix shows the location of many of the wells in the study and the regional divisions.

Charts and tables in the following pages summarize the results.



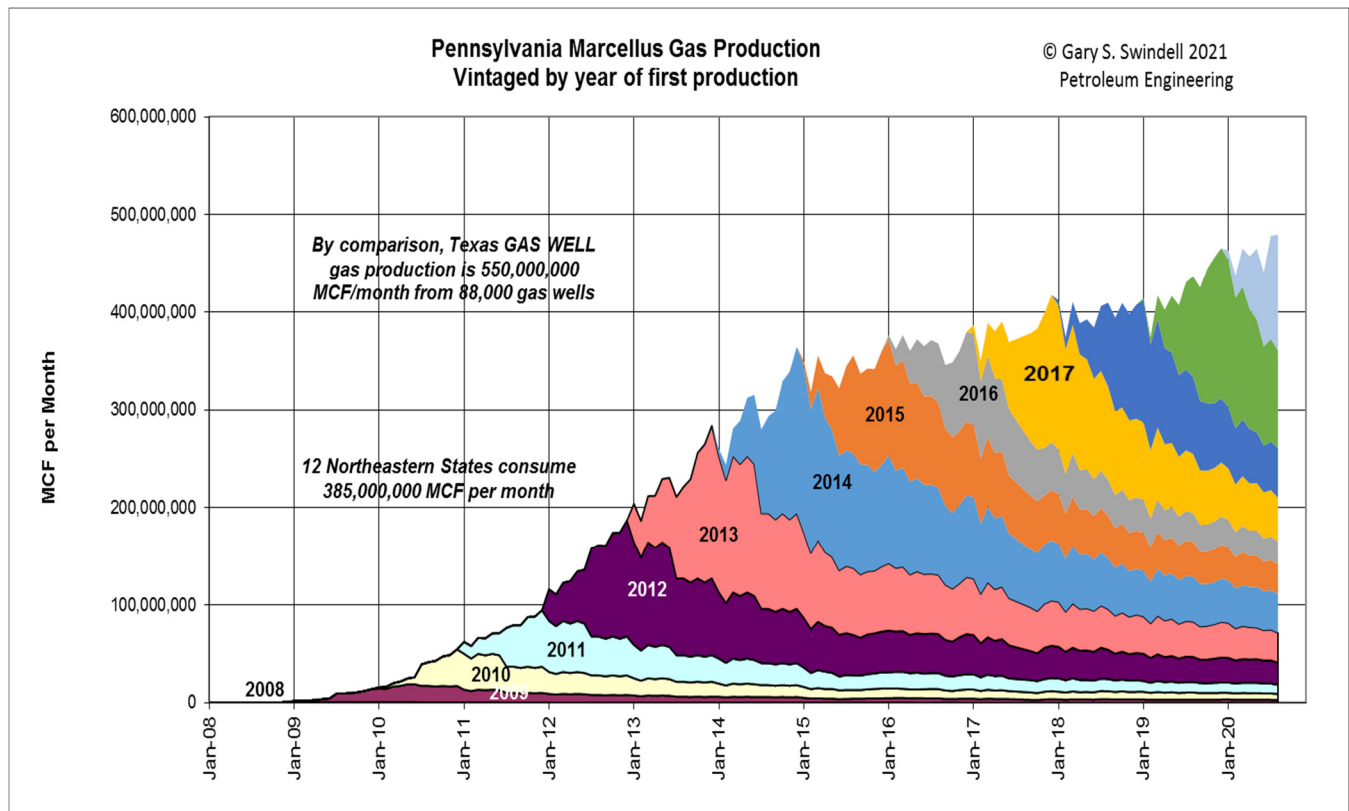


Fig. 1 – Total Pennsylvania Marcellus gas production – vintaged by year.

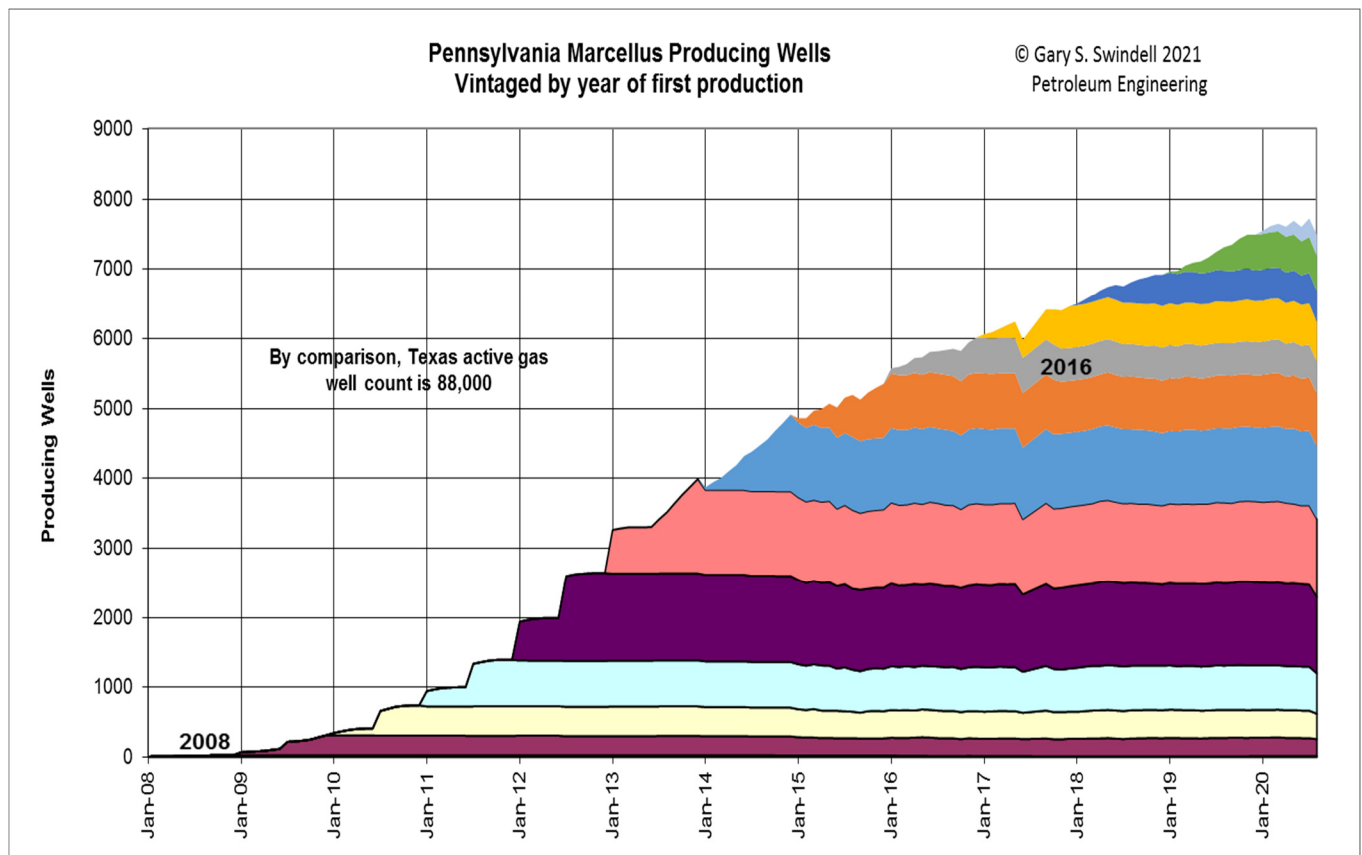


Fig 2. Pennsylvania Marcellus Horizontal Well Count.

Summary of Projected EUR by County

Number of Study wells	County	Average EUR - BCFe per Well	County Well Density - Acres per well	Avg Gas Cumulative Prod ~9/2020 - MCF
87	ALLEGHENY	7.86	5,476	4,554,094
83	ARMSTRONG	5.55	5,133	2,935,275
15	BEAVER	7.93	18,965	2,702,864
6	BLAIR	1.48		917,341
955	BRADFORD	8.77	778	5,436,855
314	BUTLER	5.67	1,621	2,641,738
51	CAMERON	3.58	5,014	1,666,644
13	CENTRE	2.69	54,881	1,667,487
13	CLARION	2.98	29,913	1,510,432
74	CLEARFIELD	2.17	9,977	1,500,033
54	CLINTON	3.73	10,590	2,393,081
102	ELK	5.30	5,227	2,343,606
172	FAYETTE	4.61	2,972	2,614,163
4	FOREST	0.80		590,110
809	GREENE	8.43	457	4,781,269
1	HUNTINGDON	0.74		545,084
21	INDIANA	3.30	25,452	2,162,495
32	JEFFERSON	4.05	13,102	2,117,092
7	LAWRENCE	3.45	33,189	1,957,226
752	LYCOMING	6.31	1,059	4,106,811
87	MC KEAN	3.93	7,248	1,815,737
1	MERCER	1.65		1,020,220
30	POTTER	3.02	23,089	1,831,628
16	SOMERSET	2.51	43,276	1,563,581
109	SULLIVAN	11.80	2,655	6,459,416
1171	SUSQUEHANNA	10.58	455	6,792,564
603	TIOGA	5.06	1,207	3,050,710
1	VENANGO	1.58		859,074
1343	WASHINGTON	7.76	411	3,905,114
189	WESTMORELAND	4.51	3,511	2,917,367
221	WYOMING	13.00	1,173	8,338,320

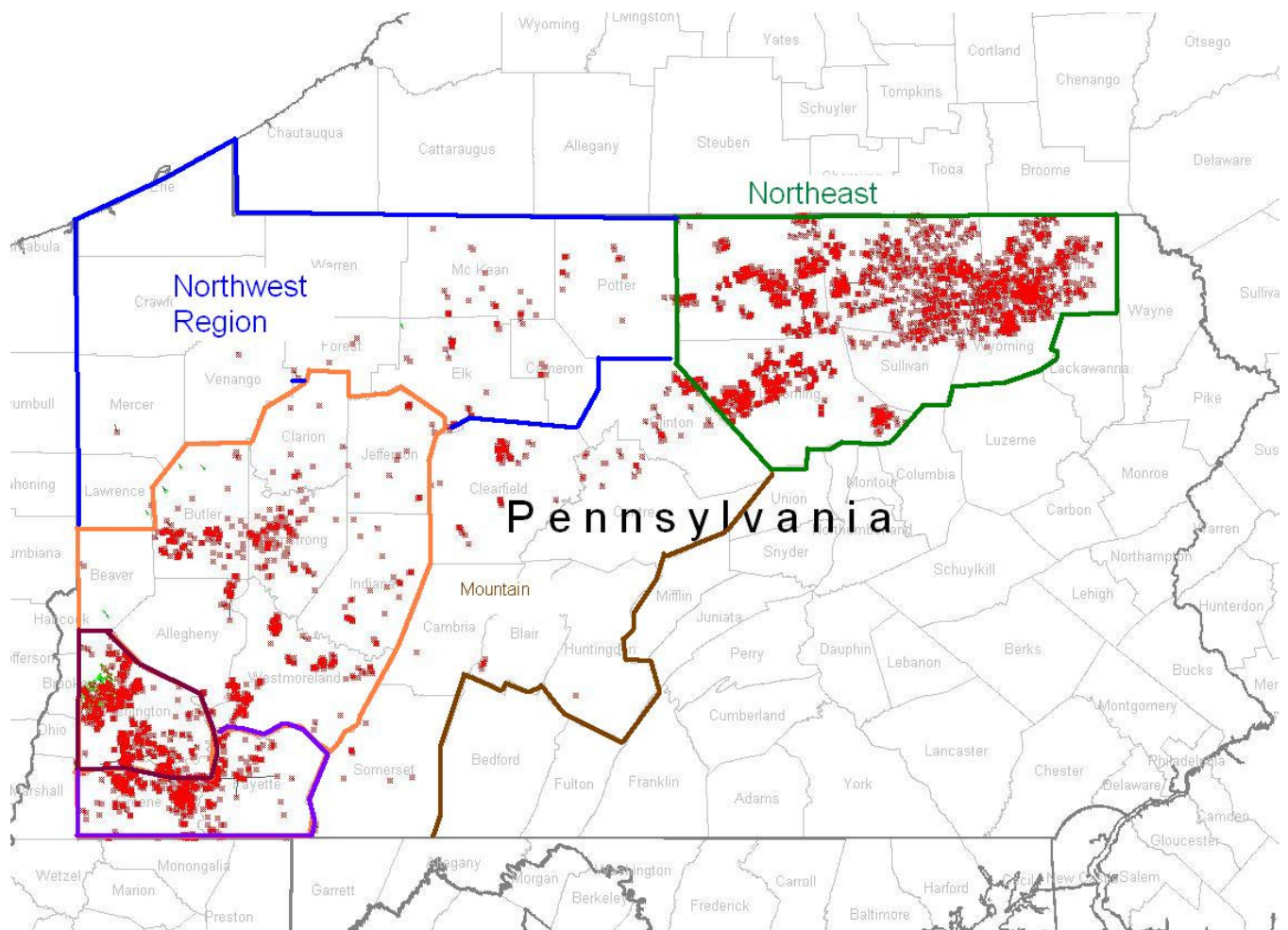
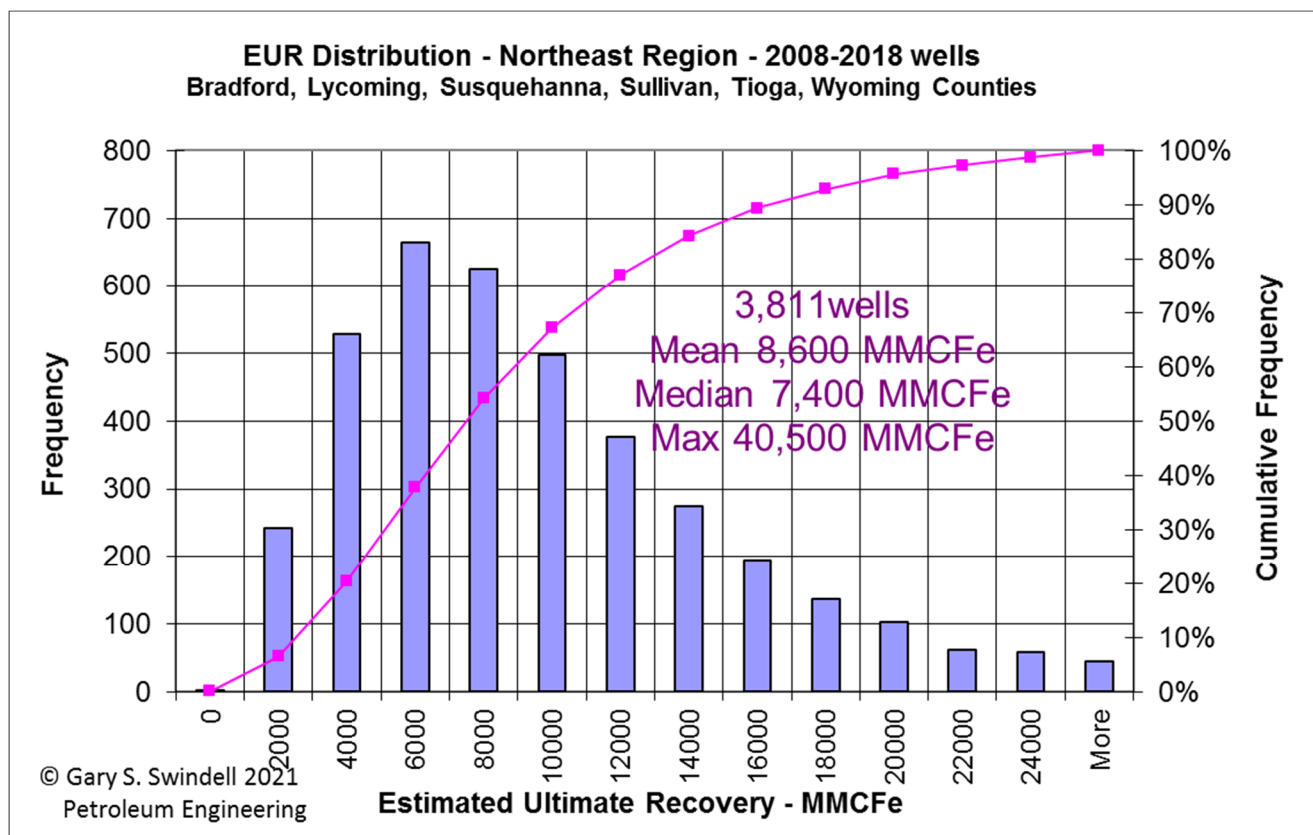
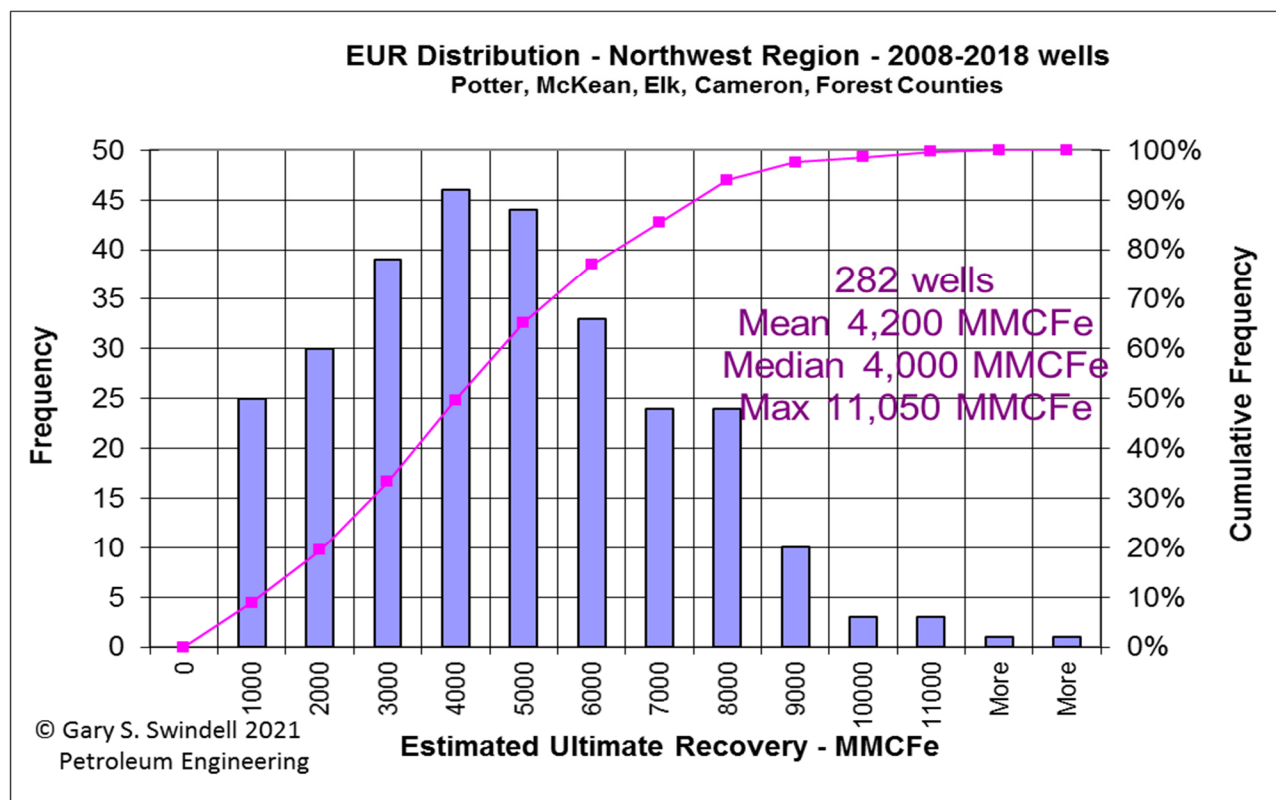
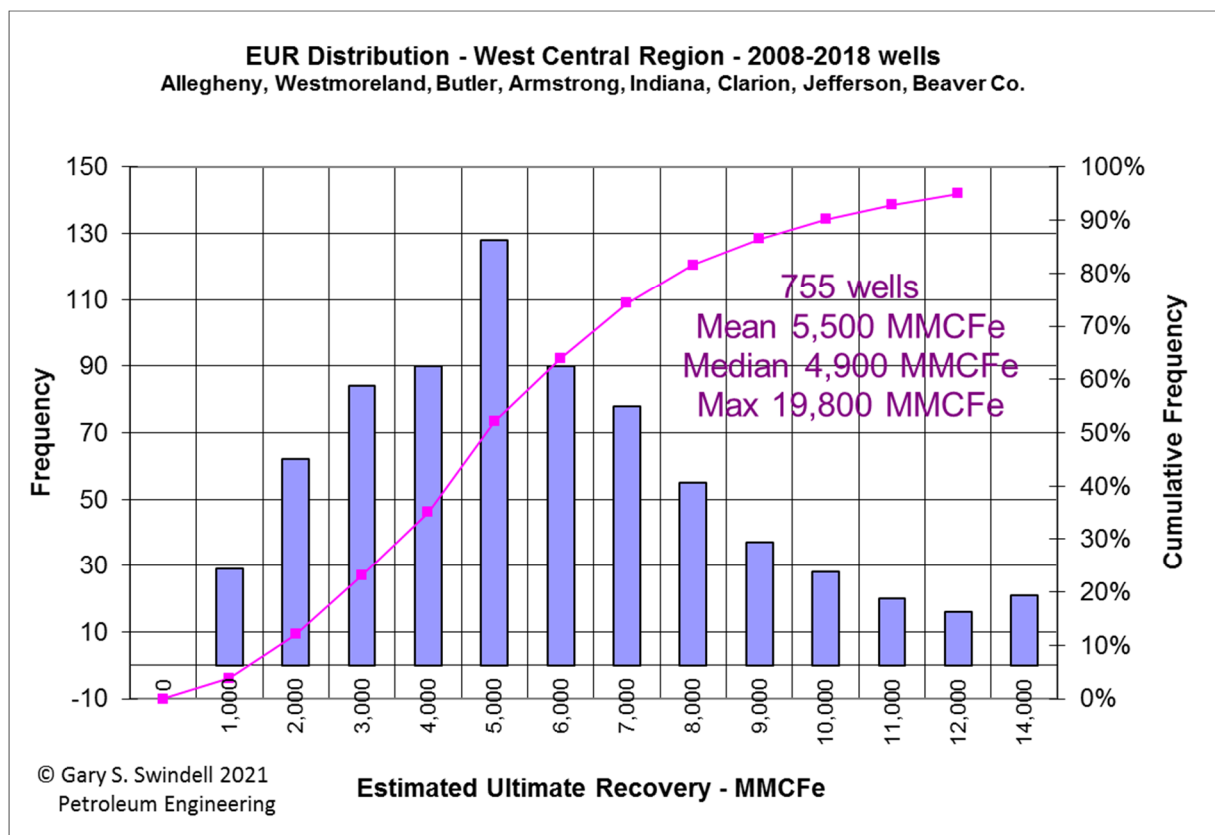
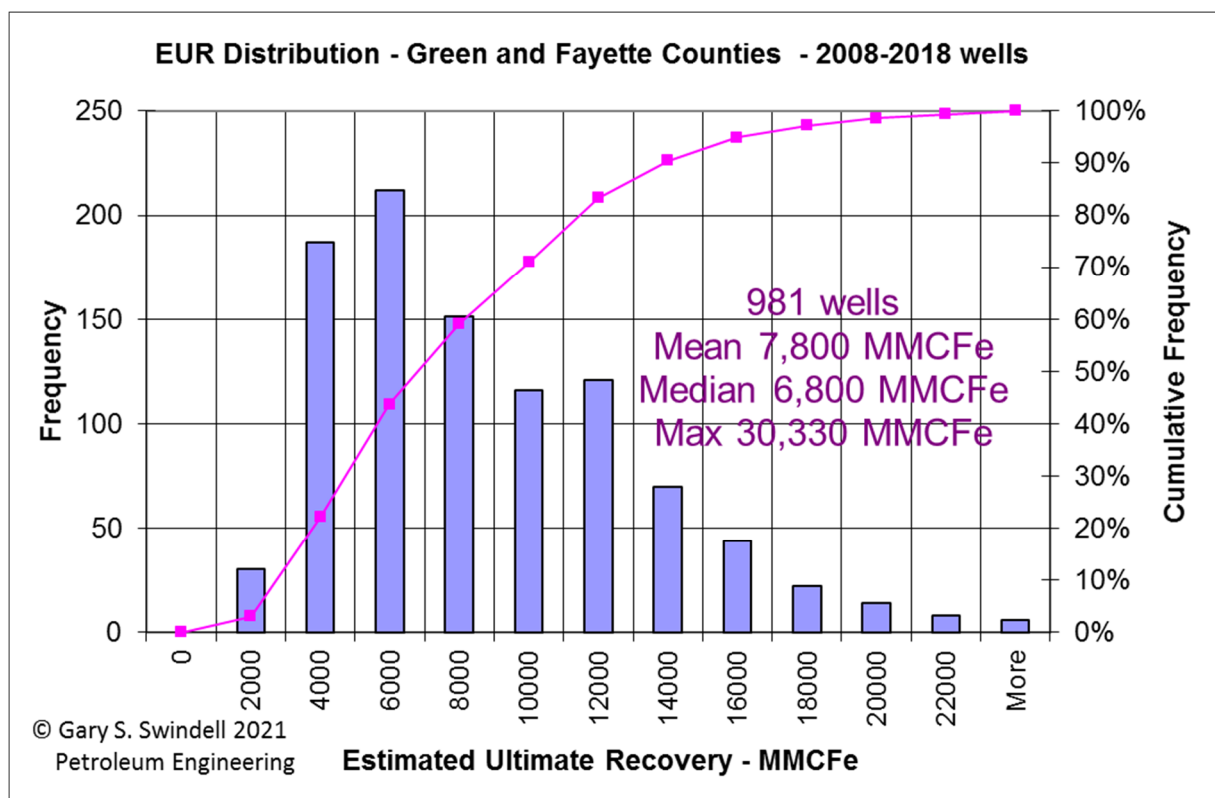
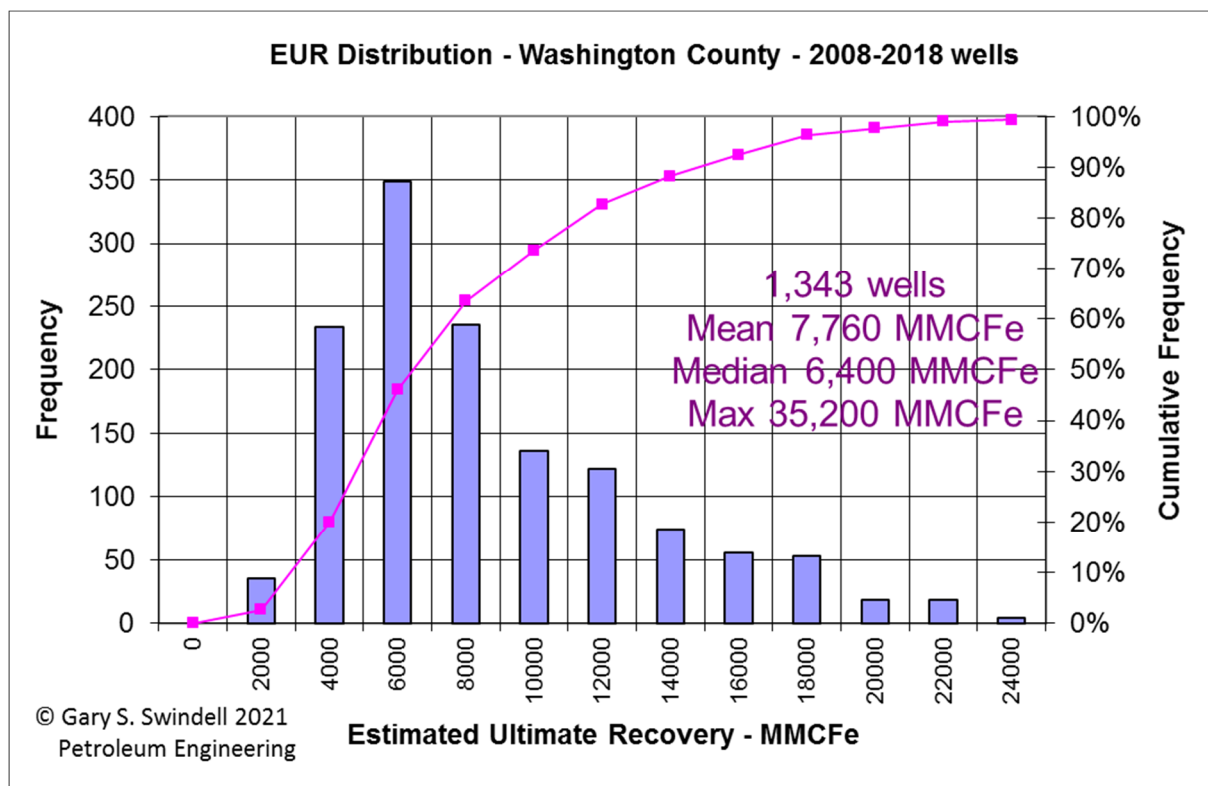


Fig. 3 – Some of the wells and the regions of the study.

NORTHEAST REGION – Bradford, Lycoming, Sullivan, Susquehanna, Tioga, Wyoming counties

NORTHWEST REGION – Cameron, Elk, Forest, McKean and Potter counties


WEST CENTRAL REGION – Allegheny, Armstrong, Beaver, Butler, Clarion, Indiana, Jefferson, Westmoreland**GREEN-FAYETTE REGION – Greene and Fayette counties**

WASHINGTON COUNTY**MOUNTAIN REGION – Blair, Centre, Clearfield, Clinton, Somerset counties**