May 29, 2008

Impact Assessment of Consumer Emission Allowance Costs under the Lieberman/Warner *Climate Security Act of 2007* on US Natural Gas Production

Summary

If consumer emission allowance costs under the Lieberman/Warner *Climate Security Act of 2007*, and pending substitute legislation, are born by US natural gas producers, US natural gas production will be reduced.

Introduction

The American Exploration and Production Council (AXPC), has requested that Wood Mackenzie provide an independent and objective estimate of the potential risks to the economic development of US natural gas production, from 2012 – 2017, resulting from added costs associated with the Lieberman/Warner Climate Security Act of 2007 ("Lieberman/Warner"), as well as pending substitute legislation. These costs result from the requirement under Lieberman/Warner that natural gas processors and/or producers purchase allowances for consumer emissions. Wood Mackenzie has been asked to provide estimates of potential US natural gas production changes associated with the upstream sector's absorbing 100% and 50% of the allowance cost of consumer emissions that might result from this legislation.

Wood Mackenzie is an international energy research and consulting firm, based in Edinburgh, Scotland, providing commercial analysis and strategic advice to the world's leading energy companies. Wood Mackenzie has developed a unique formulation of knowledge, experience and understanding of a broad range of markets and companies. More than 80 companies from all sectors of the energy business subscribe to Wood Mackenzie's North American Gas Insight service. As such, Wood Mackenzie's views, including any US natural gas production changes that might result from cost and/or policy shifts, are independent of any single sector of the energy business.

Estimates of total annual allowance costs of consumer emissions resulting from Lieberman/Warner are based on those contained on page ES20 of the ICF International report submitted to the American Petroleum Institute, dated April of 2008, titled "Addendum to Impact Assessment of Mandatory GHG Control Legislation on the Refining and Upstream Segments of the U.S. Petroleum Industry, Lieberman/Warner Climate Security Act of 2007, S. 2191." As such, these cost estimates were not developed by Wood Mackenzie, and Wood Mackenzie makes no representation regarding the validity of these estimates. These estimated costs from the ICF report range from $39.620 billion in 2012, to $59.891 billion in 2020.

Summary of Findings

Costs of this magnitude, if born by US natural gas producers, would place a substantial portion of US production at risk.

- If 100% of the consumer emission costs are born by producers, approximately 32% to 46% of expected US production during the years 2012 – 2017 becomes uneconomic to develop, and many higher-cost prospects would not be drilled. These percentages correspond to

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approximately 18.1 to 25.9 billions of cubic feet per day (Bcfd), out of a US natural gas production base expected to range from 56.0 to 56.7 Bcfd during that period.

- If half of the consumer emission costs are born by producers, approximately 5 – 14% of US production becomes uneconomic to develop, corresponding to approximately 3.1 to 7.6 Bcfd of production placed at risk for lack of development.
- The costs addressed in this study are in addition to the direct emission allowance costs associated with exploration and production activity and processing facilities, as addressed in the ICF study for the API. According to ICF, those costs range from $6.8 billion in 2012 to $9.1 billion in 2020. If producers were to bear all of these costs in total, production at risk would be greater than found in this report.

In Wood Mackenzie's view, increased reliance upon natural gas for power generation in the US will drive sharply higher prices in response to any threat to US natural gas supplies. These higher prices would allow an adequate return once again for the development of at least a part of this production placed at risk. However, the speed of this market response, and the amount of production lost as a result, is uncertain. This uncertainty alone is likely to affect for a time producer capital budgets, and the supply of a fuel on which the US will increasingly rely.

Methodology

Wood Mackenzie utilizes the GPCM model as the engine for analyzing the effects of shifts in supply and demand in North America on prices, pipeline flows and basis. GPCM is a linear-programming model that reconciles supply, demand, price and flows throughout the North American gas marketplace and infrastructure set. Wood Mackenzie has invested 3+ years in enhancing the accuracy and detail within this model for various pipeline systems and storage facilities. In addition, WM uses its own analysis to populate the supply and demand data within this model, as well as the supply and demand elasticity assumptions. As such, supply curves are contained within Wood Mackenzie's version of the GPCM model, and are consistent with Wood Mackenzie's own upstream analytic teams' views of costs of production in given producing areas within the US.

In this assignment Wood Mackenzie has:

1) Reduced prices at supply nodes in the GPCM model by the per MMBtu costs consistent with the ICF/API report, by amounts representing 100% and 50% of consumer emission allowance cost absorption by producers. The original prices at each supply node are as contained in Wood Mackenzie's most recent available Base Case GPCM model run. As such, no effect on consumer prices, or demand response, is considered in this production change estimate.

2) Calculated the reduction in economic production volumes at each major supply basin resulting from each price reduction. These individual supply reductions are according to the development cost supply curves currently contained in Wood Mackenzie's GPCM model, as consistent with Wood Mackenzie's upstream teams' analysis of development costs for natural gas reserves in various producing basins the US.

3) Aggregated all estimated supply reductions for each basin into a US total.

Each of these steps is described in more detail in the remainder of this report.

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Step 1A: Development of the Consumer Emission Allowance Costs per Mcf

To develop an estimate of consumer emission allowance costs per thousand cubic feet (Mcf) of production, Wood Mackenzie divided the total annual cost figure from the ICF/API report by the expected US annual production volume in Wood Mackenzie's Base Case. These results are illustrated in Table 1 below:

Table 1: Production Outlook by Basin, and Consumer Emission Allowance Costs per Mcf

Production (MMCFD)	2012	2013	2014	2015	2016	2017	
Eastern US	2,900	2,989	3,074	3,159	3,263	3,349	
Gulf Coast	14,437	14,189	14,020	13,861	13,995	14,001	
Gulf of Mexico	3,367	3,199	3,049	2,912	2,831	2,753	
Deepwater	3,480	3,379	3,454	3,722	3,734	3,617	
Barnett Shale	4,357	4,333	4,236	4,157	4,106	3,948	
Mid-Continent	8,101	8,188	8,269	8,386	8,512	8,476	
Permian Basin	3,585	3,547	3,492	3,425	3,421	3,413	
Rocky Mountains	12,107	12,218	12,314	12,445	12,587	12,694	
San Juan Basin	3,508	3,374	3,275	3,153	3,061	2,964	
West Coast	651	632	614	595	584	572	
Total	56,722	56,275	56,018	56,034	56,311	55,994	
Annual Prod. (TCF)	20.70	20.54	20.45	20.45	20.55	20.44	
ICF Cost	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2020**
Carbon Price	41.21	42.94	44.67	46.40	48.58	50.76	57.31
Consumer Allowances	39,620						59,891
Spread	39,620	41,669	43,749	45,860	48,565	51,319	59,891
Allowance Cost per MCF							
2006$	1.91	2.03	2.14	2.24	2.36	2.51	
2008$	2.01	2.13	2.25	2.36	2.48	2.64	

The ICF/API report provided an estimate of annual costs for the years 2012 and 2020. Wood Mackenzie interpolated between the two years, and divided the costs, in billions of dollars ($2006) by the total US production volume. For example, for 2012, $39.62 billion was divided by 20.70 trillions of cubic feet (Tcf) to obtain a cost figure of $1.91 per thousand cubic feet (Mcf). This was escalated forward by 2 years at 2.5% annually to obtain the $2008 cost figure of $2.01 per Mcf. Wood Mackenzie's estimates of development costs by production area within each major basin are in 2008 dollars. An assumption implicit within this estimate is that consumer emission allowance costs are applied uniformly to all natural gas. Depending upon how the legislation may be interpreted, differing impurities contents and efficiencies of transporting and using natural gas could result in differing charges; however, such differences are difficult to quantify and should not vary significantly from a broader US average.

More importantly, Wood Mackenzie's supply outlook is relatively stable over the 2012 – 2017 time period, as US production plateaus. Growth in production from and increasing reliance upon more expensive, unconventional resource plays no longer offsets declines in existing production over this

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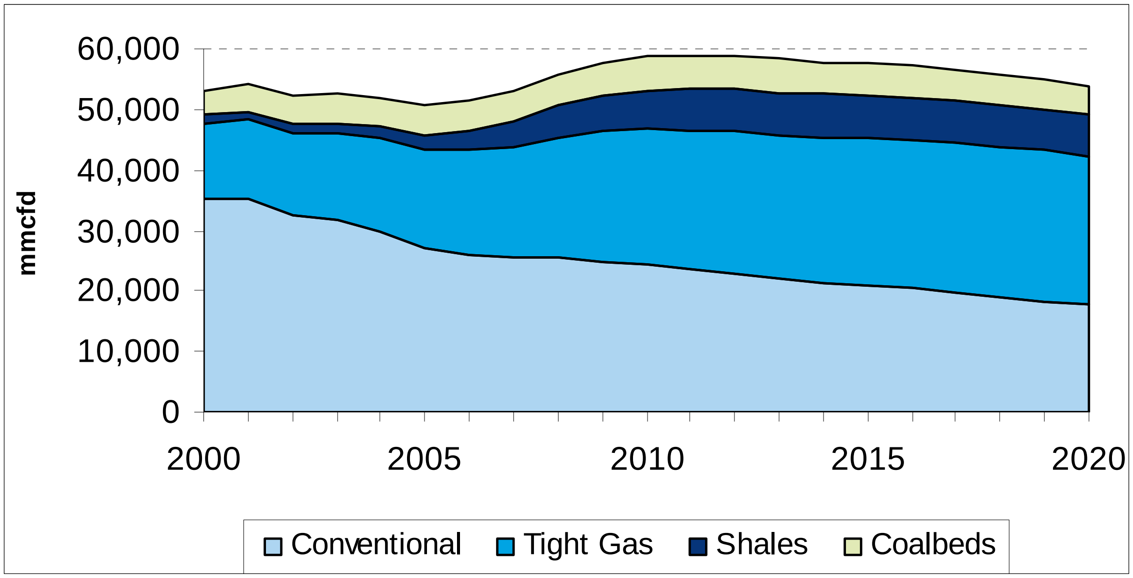
time period. The increased reliance upon unconventional production, from formations such as tight gas reservoirs, shales, and coal beds is illustrated in Figure 1 below:

Figure 1: US Natural Gas Production: Growing Reliance upon Unconventional Resource Plays



In Figure 1 above, the percentage of total US production represented by on average higher cost, unconventional resource plays grows from nearly 55% today (2008), to 61% in 2012, and to 65% by 2017. Although greater experience with unconventional production techniques can slow the increase in development costs associated with these types of plays, Wood Mackenzie's development cost outlook is stable or slightly rising over this period due to greater reliance upon historically unconventional production resources.

Step 1B: Natural Gas Prices Available to Producers

Wood Mackenzie's price outlook at the Henry Hub and the average price available to producers within each basin at the model supply nodes, analogous to the wellhead, are listed in Table 2 below.

Table 2: The Price Outlook Assumption - $2008 per Mcf

Price ($/MCF)	2012	2013	2014	2015	2016	2017
Henry Hub	6.94	6.99	7.04	7.07	7.39	7.72
Avg. Producer						
Eastern US	6.99	7.02	7.20	7.27	7.50	7.68
Gulf Coast	6.28	6.23	6.32	6.37	6.73	6.98
Gulf of Mexico	6.62	6.55	6.60	6.62	7.01	7.25
Fort Worth	6.00	5.99	6.00	6.00	5.98	6.00
Mid-Continent	6.26	6.24	6.31	6.32	6.66	6.89
Permian Basin	6.00	6.17	6.26	6.30	6.60	6.88
Rocky Mountains	6.07	5.77	5.97	5.95	6.22	6.33
San Juan Basin	6.18	6.11	6.20	6.23	6.66	6.84
West Coast	6.37	6.29	6.34	6.34	6.74	6.94

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These prices are consistent with Wood Mackenzie's analysis of supply/demand fundamentals for natural gas in the US, world oil prices, and import/export balances. Oil prices within this period are expected to fall within an approximate $70 - $75 price range per barrel for West Texas Intermediate (WTI) crude oil. Natural gas prices rise over this time frame as US production plateaus (see Table 1 above), demand pressure continues to build especially in power generation markets, and the US requires increasing volumes of natural gas imports from other world markets, which themselves often price with tighter links between natural gas and oil prices.

Again, these prices are not assumed in this analysis to change as the result of any emissions allowance costs imposed on US natural gas producers.

Step 2: Development Cost Curves – The Cost of Developing Natural Gas Production in US Producing Basins

Wood Mackenzie's research and consulting practice includes teams of upstream analysts which provide independent production outlooks for major producing basins while maintaining constant contact with US producers. These teams focus on providing analytic products covering the US Gulf of Mexico, the Mid-Continent, the Gulf Coast, Permian, San Juan and the Rockies producing areas. Direct coverage of the eastern US is also under development. Because this analytic coverage includes the Arkoma Basin, the Rockies, and the Fort Worth Basin, Wood Mackenzie's direct coverage includes between 90% and 95% of all US production expected during the 2012 – 2017 time period.

Development costs, those costs required to initiate an economic production stream at an attractive rate of return, once reserves are found, include such costs as drilling costs, service costs, labor, and materials, as well as equity return. These are analyzed directly by these teams within Wood Mackenzie for a variety of individual production "plays" within each larger basin area. Analytic detail varies, from development costs of proven, probable, and yet-to-find resources by field in the Deep Water Gulf of Mexico, to individual estimates of 93 separate plays in the Gulf Coast region. A high-cost stack of production economic at each dollar increment from $7 - $12 is also provided for each basin.

The development cost curves provided in the graphics below are, in Wood Mackenzie's view, on balance conservative (lower than many producers would face in reality), in that they include no aspect of finding costs, which producers might expect even in some established plays. Such finding costs include acquisition of seismic data that may exist, and land and acreage mineral rights. In addition, the development costs included are computed allowing only a 10% rate of return, lower than many producers' hurdle rates (often 15% or more) for investing in new projects. Partly offsetting this conservatism, development costs for certain production plays are developed at the processing plant or major marketing hub, whereas the pricing within the model provided in part 1B above is at the wellhead. However, on balance cost conservatism likely is greater than any mismatch in location between the pricing data and development costs provided. As such, these curves are likely lower, and the effect on production somewhat more limited, in the results provided below than they otherwise might be.

Development costs in individual areas are highly proprietary to Wood Mackenzie's clients. However, Wood Mackenzie is pleased to provide the curves below for the most significant production areas for six separate regions for the years 2012 and 2017 (twelve separate graphics).

Each of the curves below illustrates the original modeled basin price and production volume (in *red*), as well as the shift in price and economic volume associated with imposing 50% of the allowance costs of consumer emissions (in *blue*), and the further shift in price available to producers and economic volume associated with producers' bearing 100% of the allowance costs of consumer emissions, as developed in the ICF/API report (in *purple*).

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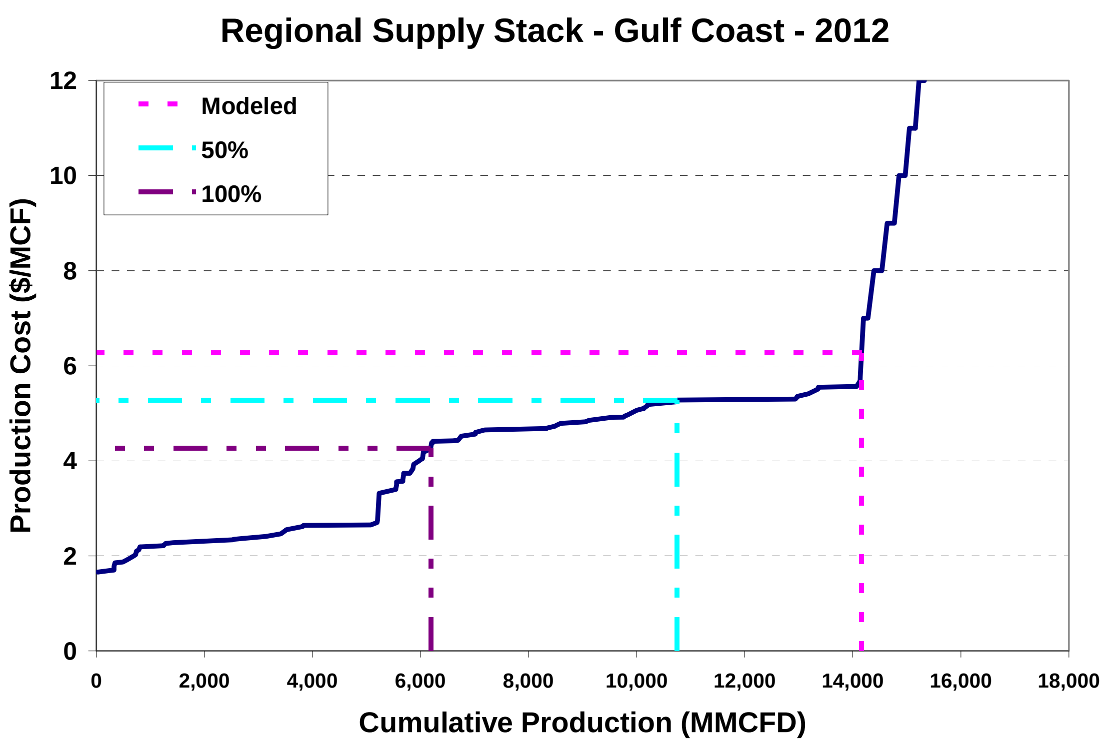
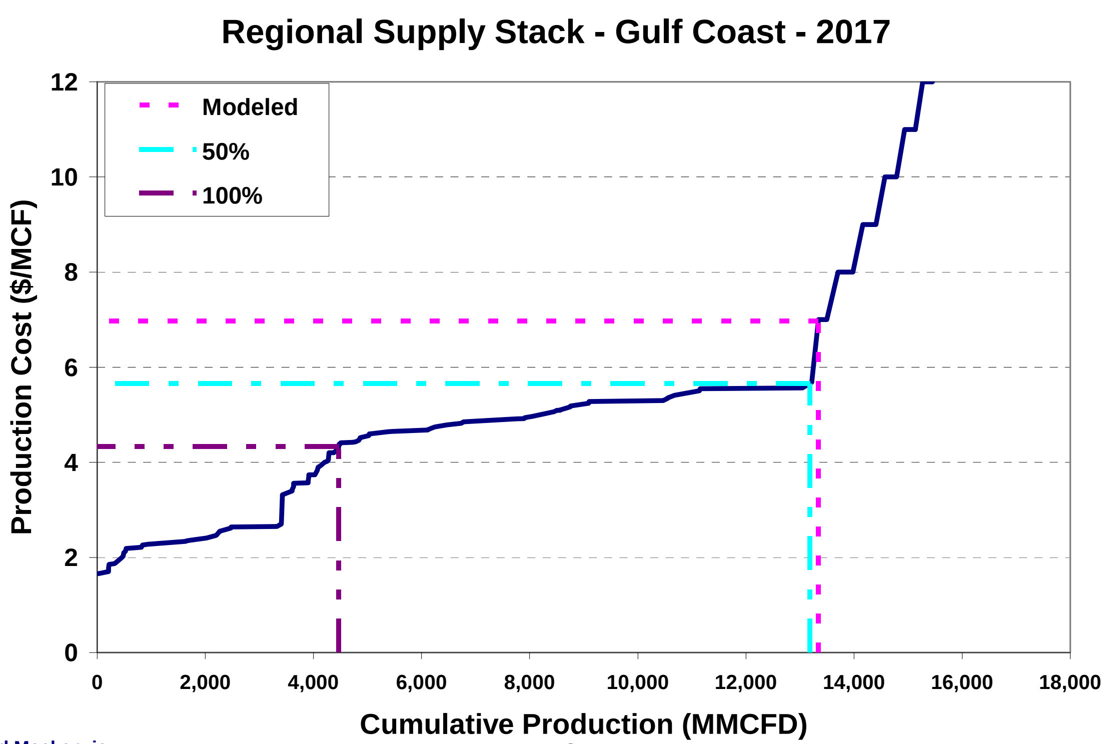
Figures 2-13: Development Cost Curves in Six Separate Regions, 2012 and 2017

Figures 2 and 3: The Gulf Coast Region





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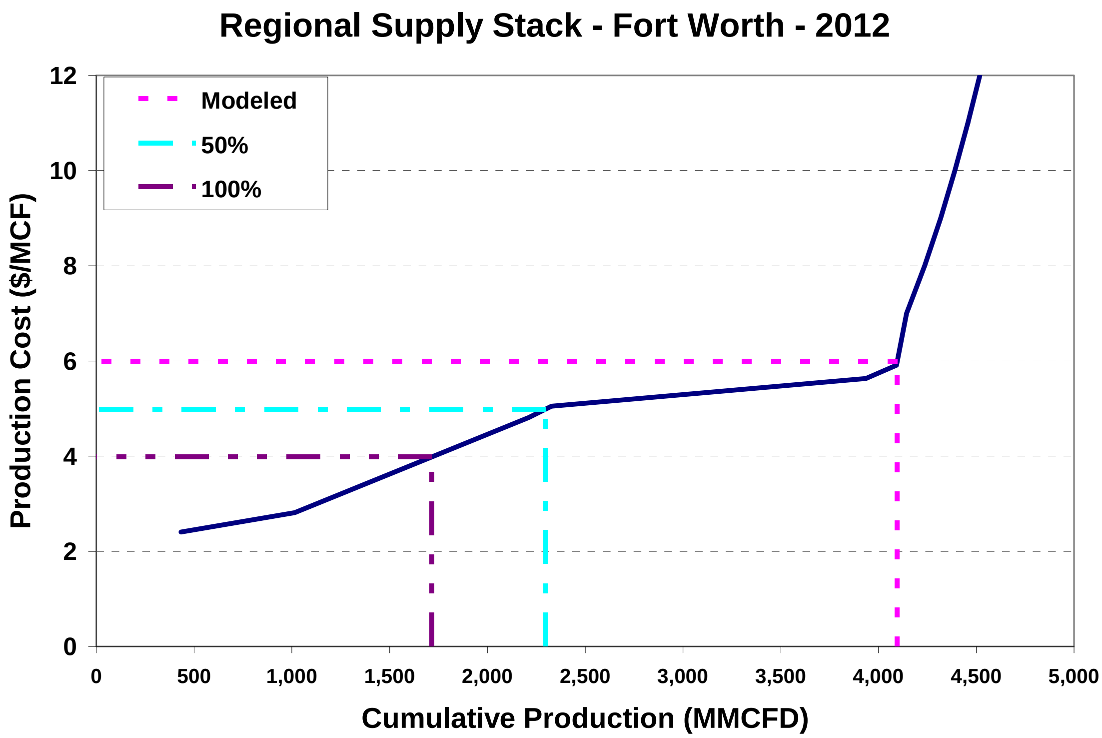
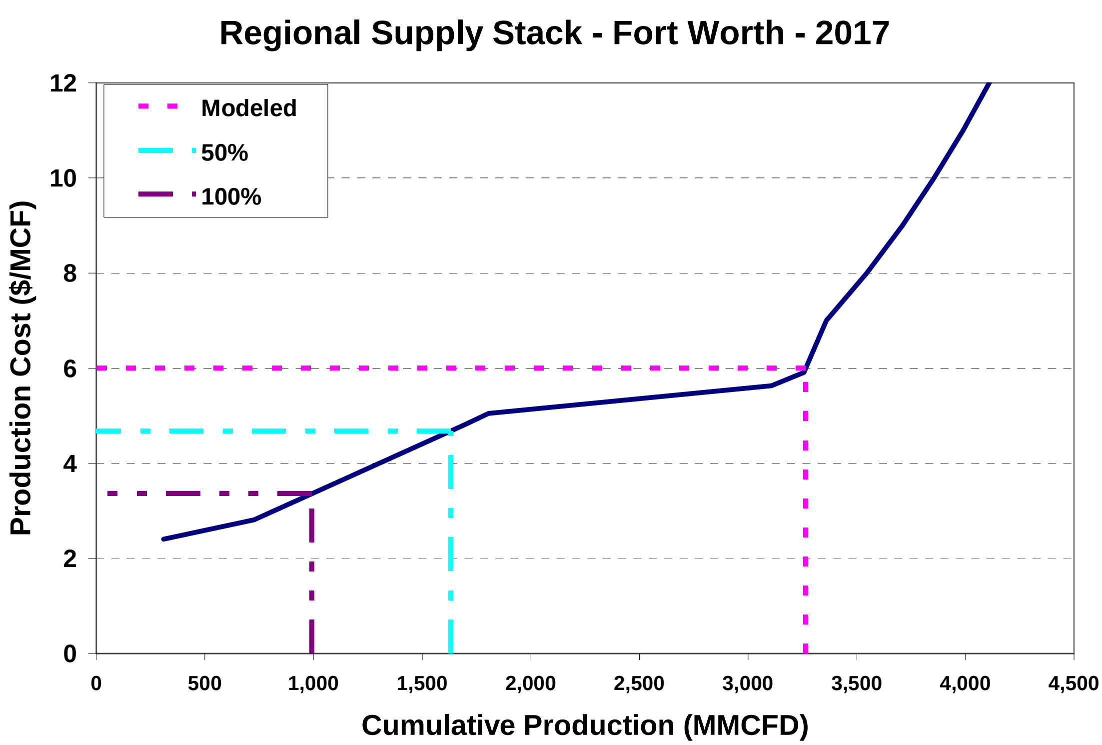
Figures 4 and 5: The Fort Worth Basin





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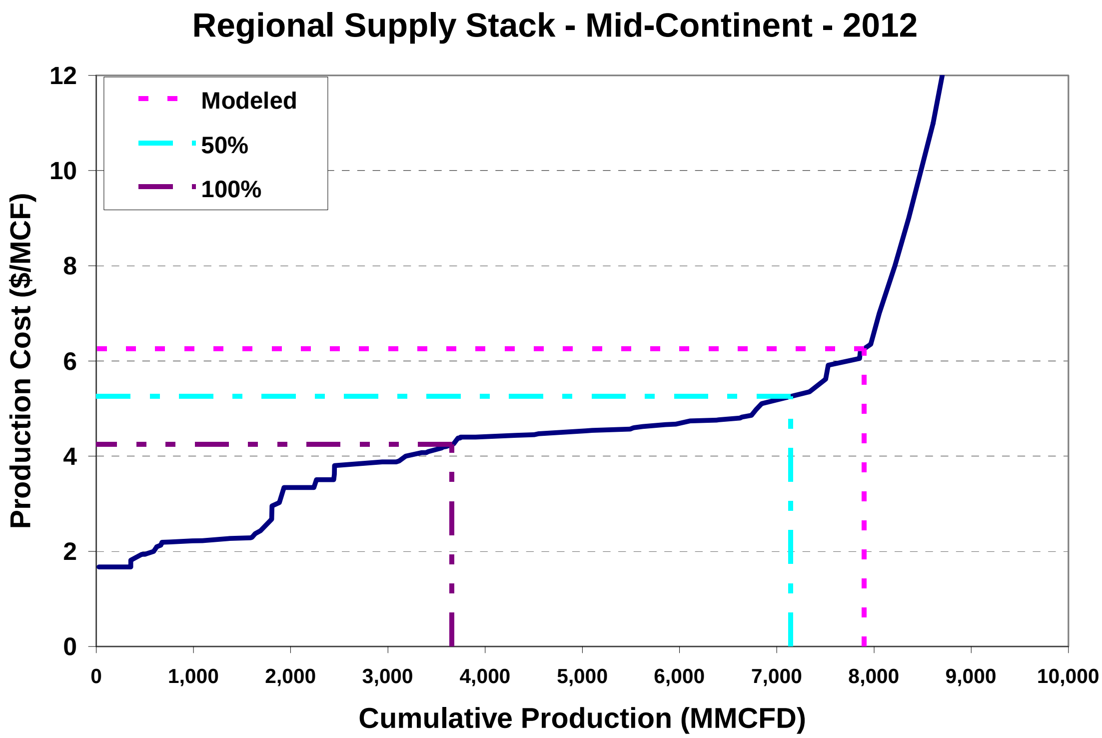
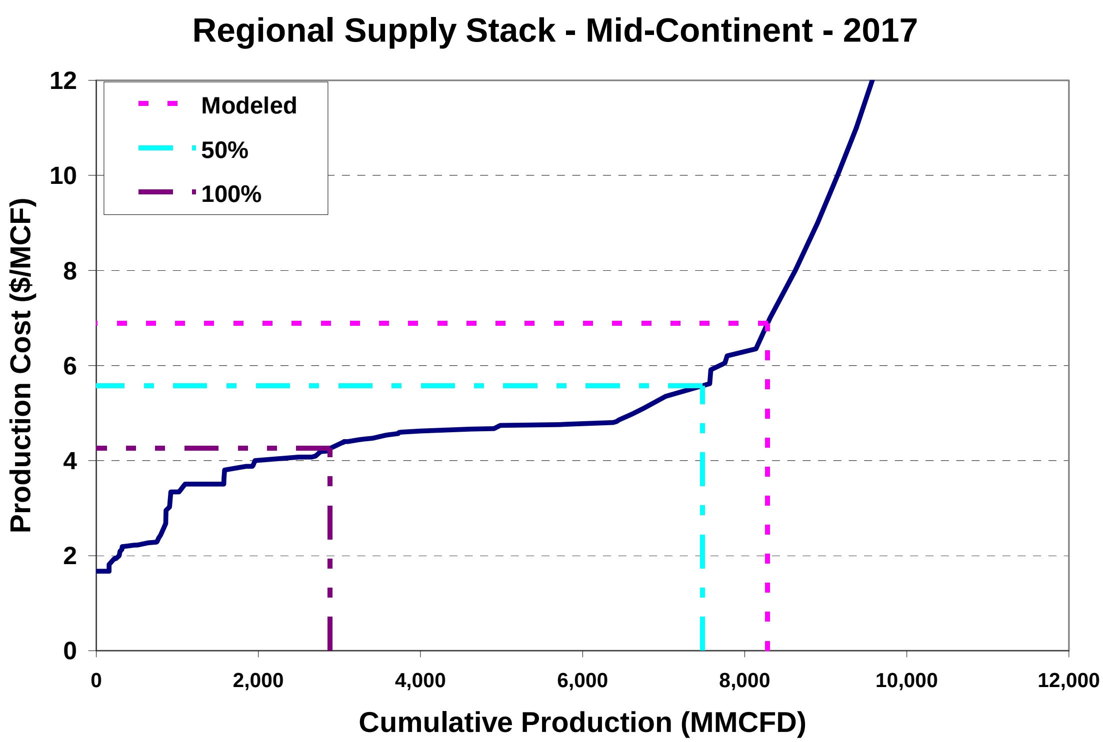
Figures 6 and 7: The Mid-Continent





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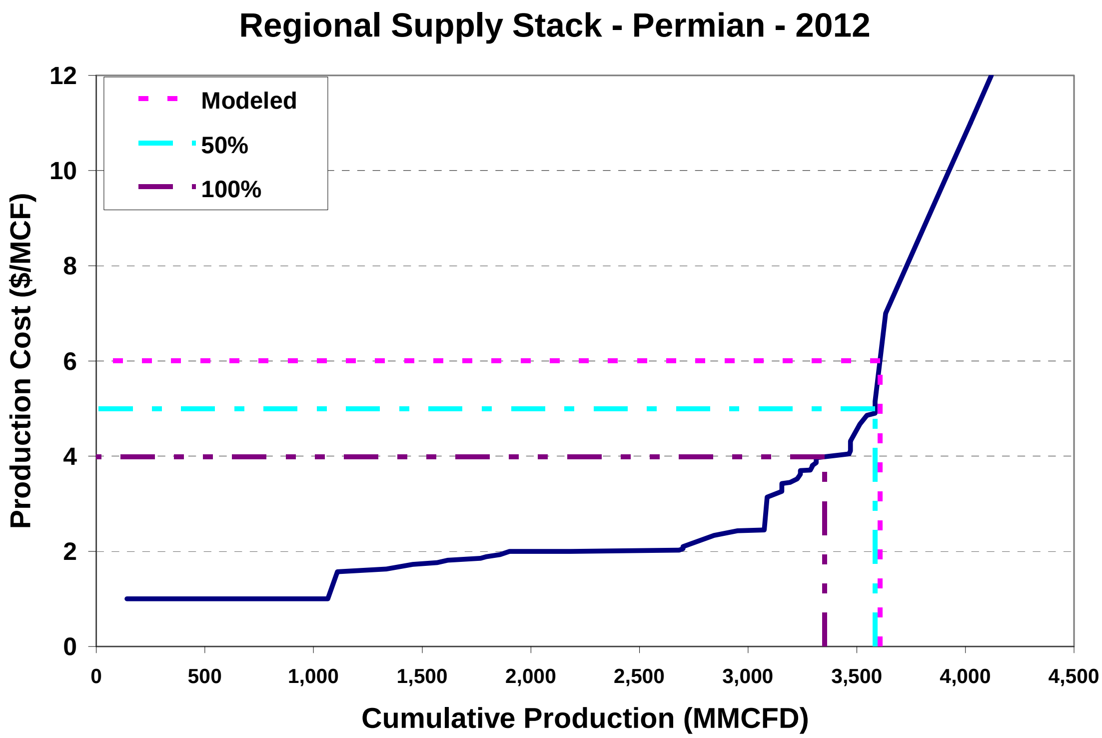
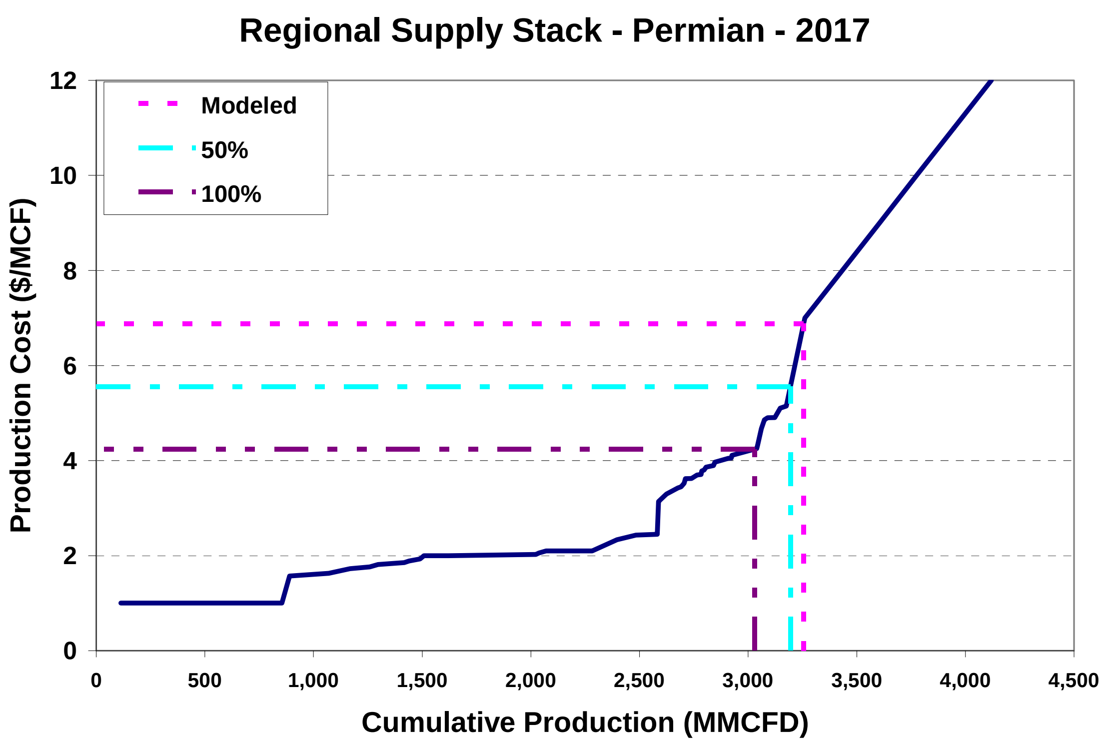
Figures 8 and 9: The Permian Basin





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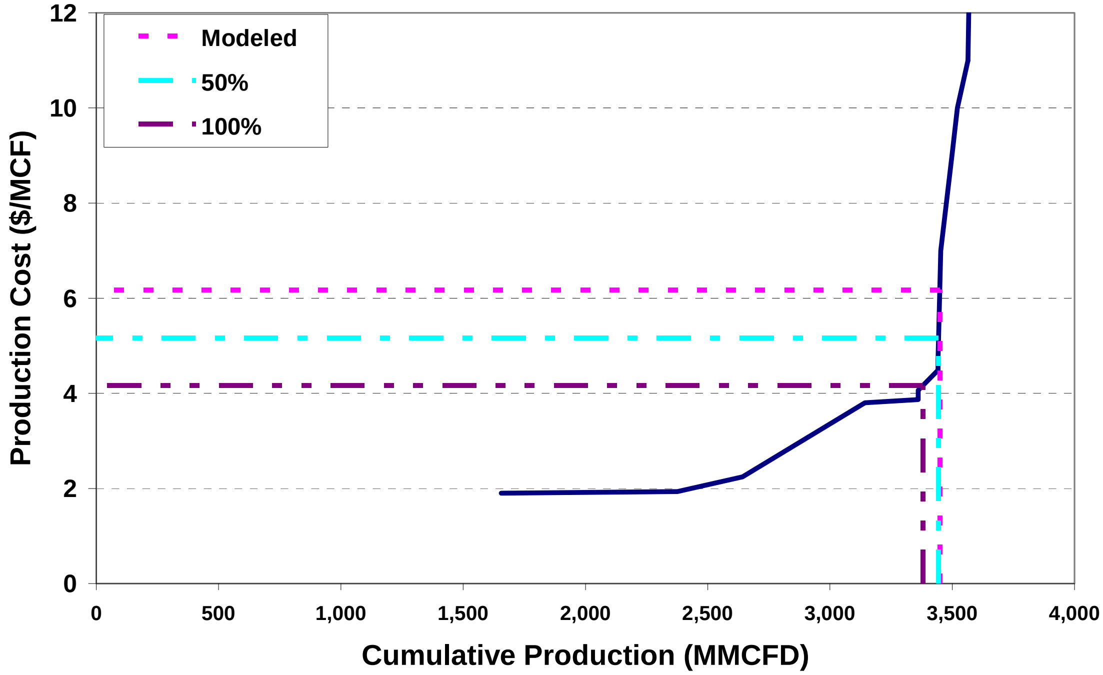
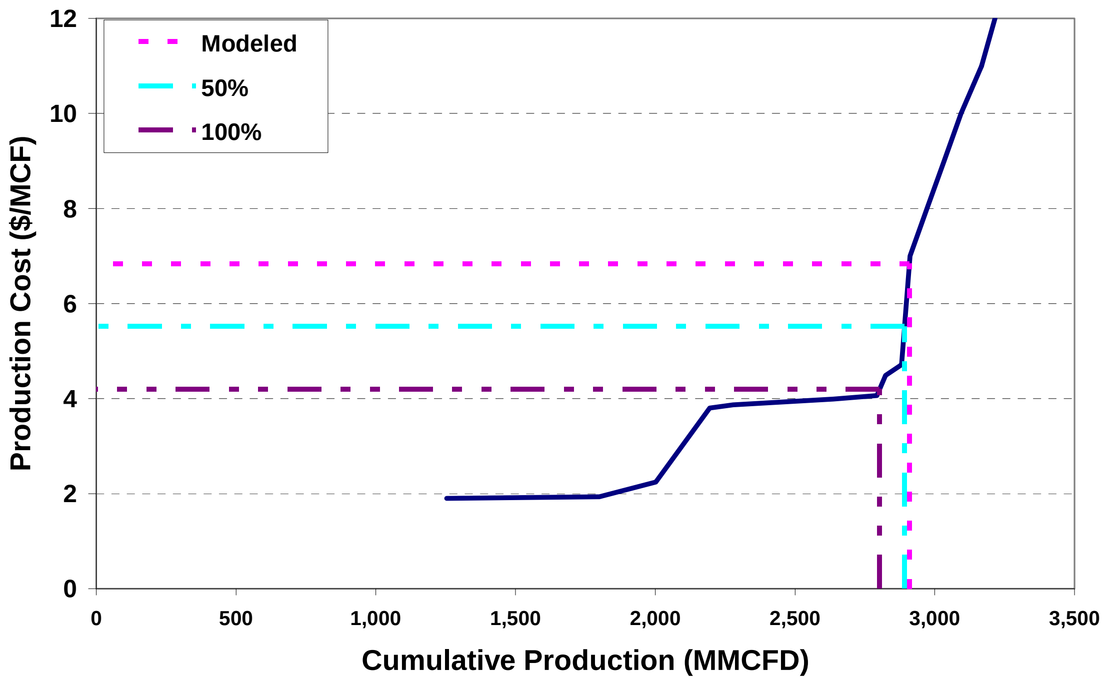
Figures 10 and 11: The San Juan

Regional Supply Stack - San Juan - 2012



Regional Supply Stack - San Juan - 2017



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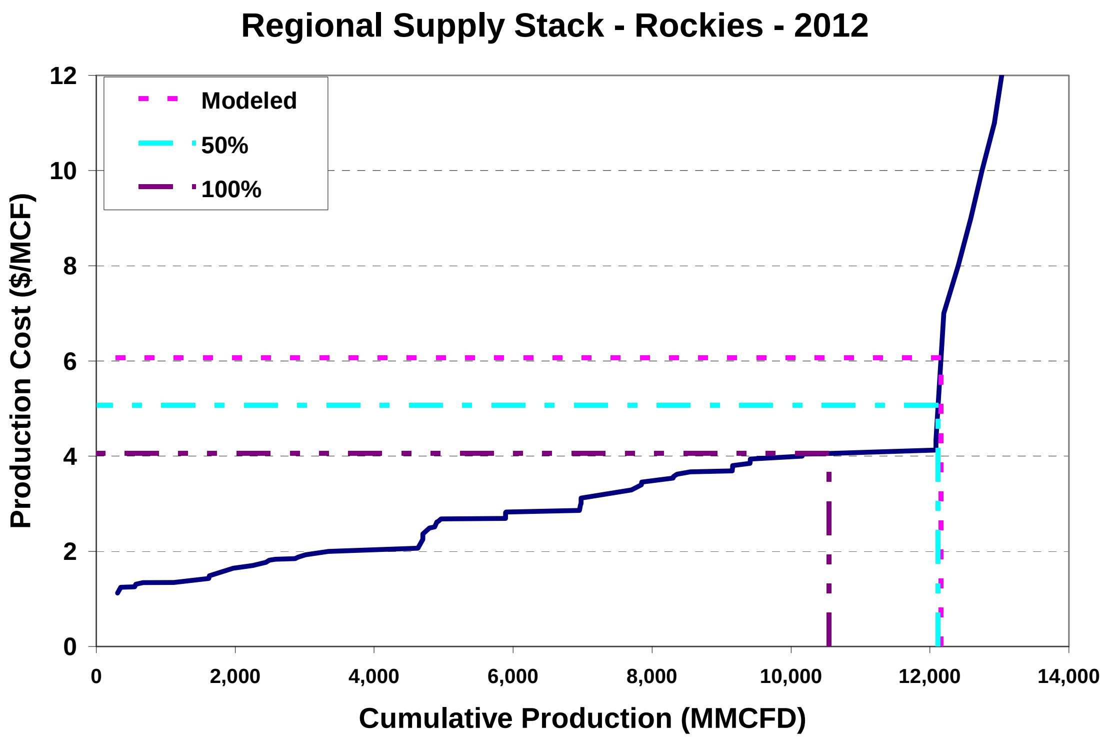
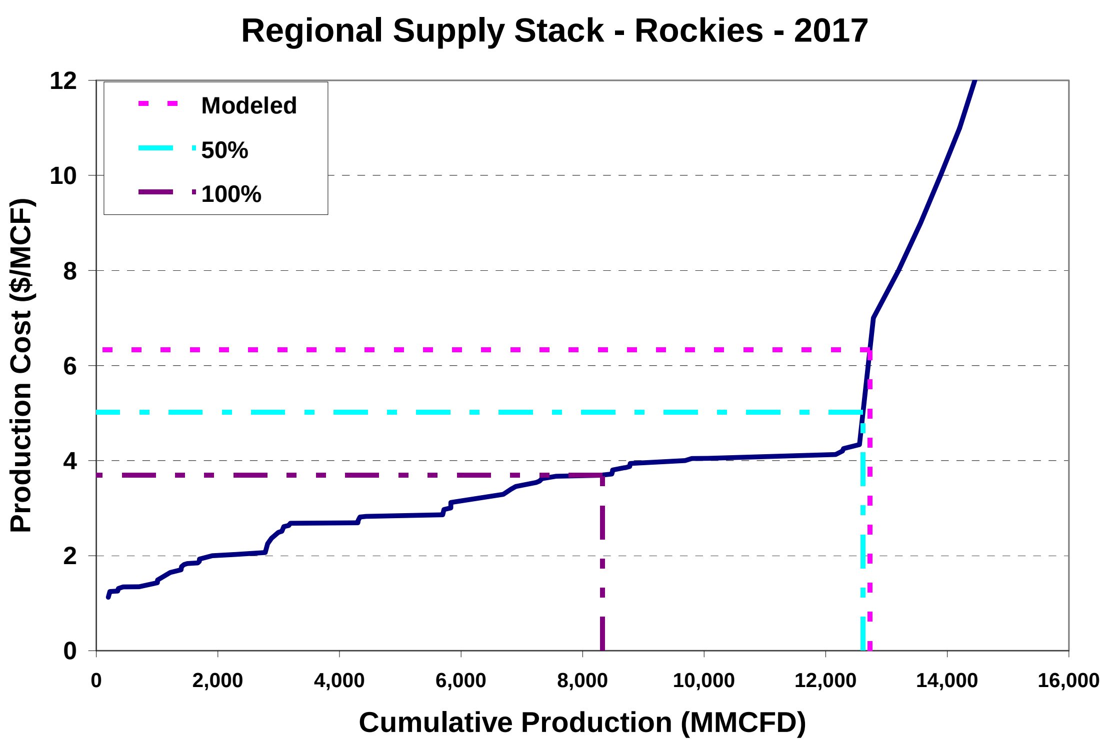
Figures 12 and 13: The Rockies





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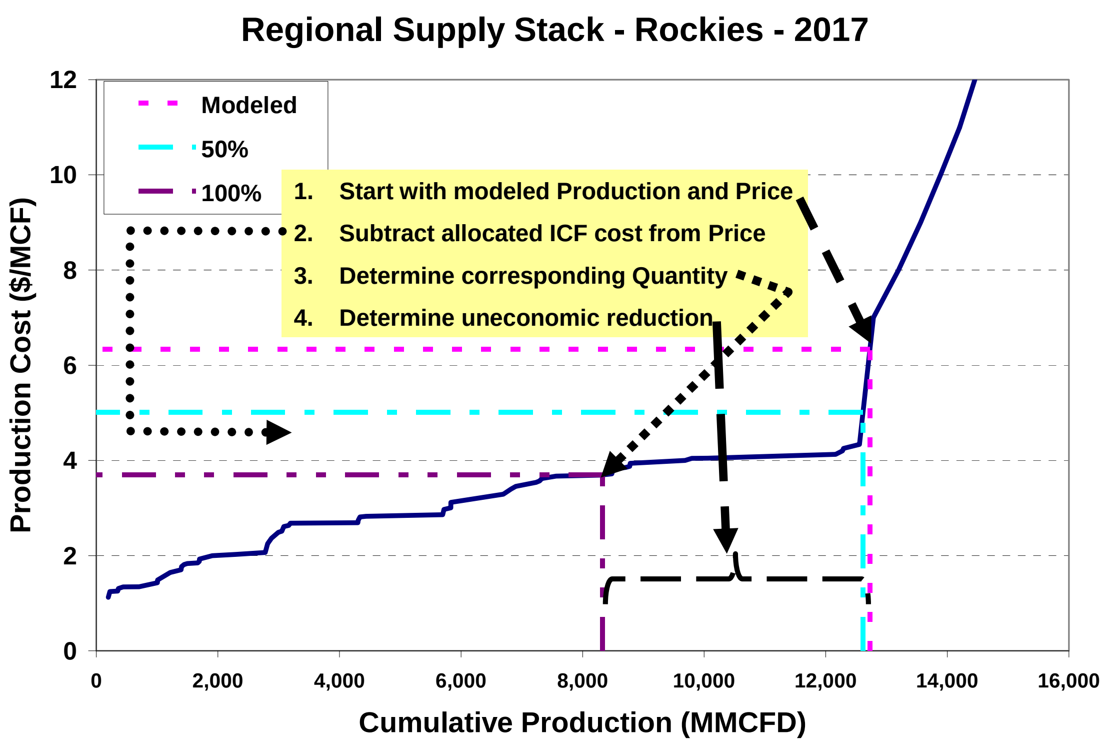
In general, the supply curves move up over time; however, the expected price does as well. Especially important to note is that in some regions, including the Rockies above, prices are above costs in most producing areas, so that even after allocating 50% of the allowance costs of consumer emissions to producers, economic production volumes do not decline proportionately to a 100% allocation. Costs in individual plays do not necessarily increase in a linear manner. In addition, the pattern of sharp increase in costs at high production levels was developed based on historic experience with supply responses to extreme prices, within each region.

Major potential producing areas in the Gulf Coast, Mid-Continent, and Fort Worth basins become uneconomic to develop as costs are imposed upon producers. Production in the Rockies would also be hit, whereas production in some of the older producing areas, including the Permian and San Juan basins, is, in relative terms, less affected.

A simplified illustration of the use of these curves to determine the change in economic producing volumes is provided for the Rockies in the year 2017 in Figure 14 below.

Figure 14: Determining a Reduction in Economic Production Volumes as Prices Available to Producers are Reduced



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Step 3: Aggregation of All Reductions in Economic Production Volumes

Adding the volumes that become uneconomic to produce as 50% and 100% of the allowance costs of consumer emissions are born by producers results in the reductions shown in Table 3 below.

Table 3: Absolute and Percent Production Volumes which become Uneconomic to Develop as 50% and 100% of the Allowance Costs of Consumer Emissions are Born by US Natural Gas Producers

	2012	2013	2014	2015	2016	2017
Modeled Production (MMCFD)	56,722	56,275	56,018	56,034	56,311	55,994
Expected Uneconomic Volume (MMCFD)						
50% Case	6,100	7,094	7,224	7,637	5,220	3,054
100% Case	18,130	21,910	22,691	25,930	24,802	25,303
Expected Uneconomic Volume (%)						
50% Case	10.8%	12.6%	12.9%	13.6%	9.3%	5.5%
100% Case	32.0%	38.9%	40.5%	46.3%	44.0%	45.2%

Tables 4 and 5 below provide numeric results for each major producing area, for the 50% and the 100% cases respectively. .

Table 4: Basin Results – 50% of Costs Born by Producers – Avg MMcfd

	2012			2017		
	Modeled Production	Remaining Economic Production	Uneconomic Volume	Modeled Production	Remaining Economic Production	Uneconomic Volume
Eastern US	2,900	2,898	(2)	3,349	3,239	(110)
Gulf Coast	14,437	11,025	(3,413)	14,001	13,844	(157)
Gulf of Mexico	6,847	6,786	(61)	6,370	6,216	(154)
Fort Worth	4,357	2,559	(1,797)	3,948	2,315	(1,633)
Mid-Continent	8,101	7,346	(755)	8,476	7,672	(804)
Permian	3,585	3,563	(22)	3,413	3,352	(61)
Rockies	12,107	12,064	(43)	12,694	12,580	(114)
San Juan	3,508	3,503	(5)	2,964	2,947	(18)
West Coast	651	649	(2)	572	567	(4)
Total	56,493	50,393	(6,100)	55,786	52,732	(3,054)

Table 5: Basin Results – 100% of Costs Born by Producers – Avg MMcfd

	2012			2017		
	Modeled Production	Remaining Economic Production	Uneconomic Volume	Modeled Production	Remaining Economic Production	Uneconomic Volume
Eastern US	2,900	2,896	(4)	3,349	3,234	(115)
Gulf Coast	14,437	6,463	(7,975)	14,001	5,128	(8,873)
Gulf of Mexico	6,847	5,252	(1,594)	6,370	2,466	(3,904)
Fort Worth	4,357	1,978	(2,379)	3,948	1,674	(2,273)
Mid-Continent	8,101	3,863	(4,238)	8,476	3,078	(5,398)
Permian	3,585	3,331	(254)	3,413	3,188	(226)
Rockies	12,107	10,493	(1,613)	12,694	8,295	(4,399)
San Juan	3,508	3,439	(69)	2,964	2,857	(107)
West Coast	651	647	(4)	572	563	(9)
Total	56,493	38,363	(18,130)	55,786	30,483	(25,303)

The supply elasticity is highest at these expected price levels in the Gulf Coast, with its multiple unconventional plays; the Mid-Continent; the Fort Worth; and the Rockies basins.

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