

Appendix C

Year-by-Year Results

Unconventional Gas Production and Production Shares

The projected unconventional gas share of total gas production and the projected quantity of unconventional gas production change significantly between cases (Tables C1 and C2). The projected unconventional gas share of total production is more than 10 percent smaller (as compared with the reference case with all technological advances included) in the later years for two out of three cases where there is a partial removal of the effect of technological advances. In the case where all the effects of technological advances are removed, the projected unconventional gas share of total production is more than 15 percent lower in the last 12 years and 28 percent lower by the end of the forecast period. The relative differences are greater with respect to projected production levels. By 2020, unconventional gas production in the case with no advances in unconventional gas technology is projected to be 35 percent lower than production in the reference case.

Table C1. Unconventional Gas Share of Total Gas Production

Year	Reference	No Exploration Technological Advances		No Drilling and Completion Technological Advances		No Production Technological Advances		No Technological Advances	
	UG Production Share	UG Production Share	% Change from Reference	UG Production Share	% Change from Reference	UG Production Share	% Change from Reference	UG Production Share	% Change from Reference
1998.	0.24	0.24	0.00%	0.24	0.00%	0.24	0.00%	0.24	0.00%
1999.	0.24	0.24	0.00%	0.24	0.00%	0.24	0.00%	0.24	0.00%
2000.	0.25	0.25	-0.09%	0.25	-0.19%	0.25	-0.83%	0.25	-1.11%
2001.	0.26	0.26	0.22%	0.25	-0.67%	0.25	-1.84%	0.25	-2.59%
2002.	0.26	0.26	0.19%	0.26	-1.10%	0.25	-3.20%	0.25	-4.65%
2003.	0.26	0.26	-0.07%	0.26	-1.54%	0.25	-4.36%	0.24	-7.02%
2004.	0.26	0.26	-0.52%	0.25	-2.10%	0.24	-5.28%	0.24	-8.89%
2005.	0.26	0.25	-0.98%	0.25	-3.07%	0.24	-6.08%	0.23	-11.37%
2006.	0.25	0.25	-1.20%	0.24	-4.82%	0.23	-7.02%	0.22	-13.32%
2007.	0.25	0.24	-1.23%	0.23	-5.65%	0.23	-6.67%	0.21	-14.11%
2008.	0.24	0.24	-0.91%	0.23	-6.13%	0.23	-5.99%	0.20	-14.63%
2009.	0.24	0.23	-0.51%	0.22	-6.82%	0.22	-5.48%	0.20	-15.14%
2010.	0.24	0.24	-0.23%	0.22	-7.32%	0.22	-5.12%	0.20	-15.58%
2011.	0.24	0.24	-0.84%	0.22	-7.90%	0.23	-5.13%	0.20	-15.93%
2012.	0.25	0.24	-1.80%	0.23	-8.34%	0.23	-5.04%	0.21	-16.85%
2013.	0.25	0.24	-3.22%	0.23	-8.97%	0.24	-5.43%	0.21	-17.94%
2014.	0.26	0.25	-4.42%	0.23	-9.61%	0.24	-6.41%	0.21	-19.00%
2015.	0.26	0.25	-5.75%	0.24	-10.52%	0.24	-7.49%	0.21	-21.02%
2016.	0.27	0.25	-8.33%	0.24	-11.79%	0.25	-8.34%	0.21	-23.34%
2017.	0.28	0.25	-10.24%	0.24	-13.04%	0.25	-8.51%	0.21	-25.73%
2018.	0.28	0.25	-11.82%	0.24	-13.66%	0.26	-8.13%	0.20	-27.18%
2019.	0.28	0.25	-11.88%	0.24	-13.42%	0.26	-7.72%	0.20	-27.68%
2020.	0.28	0.25	-12.17%	0.25	-12.66%	0.26	-8.02%	0.20	-28.21%

Table C2. Unconventional Gas Production
(Trillion Cubic Feet)

Year	Reference	No Exploration Technological Advances		No Drilling and Completion Technological Advances		No Production Technological Advances		No Technological Advances	
	Production	Production	% Change from Reference	Production	% Change from Reference	Production	% Change from Reference	Production	% Change from Reference
1997.	4.51	4.51	0.00%	4.51	0.00%	4.51	0.00%	4.51	0.00%
1998.	4.51	4.51	0.00%	4.51	0.00%	4.51	0.00%	4.51	0.00%
1999.	4.45	4.45	0.00%	4.45	0.00%	4.45	0.00%	4.45	0.00%
2000.	4.74	4.73	-0.08%	4.73	-0.21%	4.70	-0.88%	4.68	-1.19%
2001.	4.71	4.72	0.19%	4.67	-0.76%	4.61	-2.01%	4.58	-2.82%
2002.	4.80	4.81	0.22%	4.74	-1.18%	4.63	-3.54%	4.55	-5.07%
2003.	4.90	4.90	-0.09%	4.82	-1.74%	4.66	-4.89%	4.52	-7.85%
2004.	4.94	4.92	-0.50%	4.83	-2.34%	4.64	-6.09%	4.44	-10.12%
2005.	5.03	4.97	-1.03%	4.85	-3.51%	4.67	-7.16%	4.37	-13.02%
2006.	5.12	5.05	-1.29%	4.86	-5.15%	4.70	-8.21%	4.35	-15.10%
2007.	5.15	5.07	-1.40%	4.82	-6.25%	4.74	-7.98%	4.31	-16.16%
2008.	5.14	5.09	-0.97%	4.79	-6.84%	4.78	-7.18%	4.28	-16.75%
2009.	5.16	5.14	-0.36%	4.77	-7.62%	4.82	-6.50%	4.26	-17.49%
2010.	5.33	5.29	-0.75%	4.86	-8.81%	4.97	-6.83%	4.35	-18.32%
2011.	5.55	5.49	-0.97%	5.03	-9.34%	5.17	-6.75%	4.49	-19.15%
2012.	5.79	5.67	-2.04%	5.21	-10.00%	5.40	-6.66%	4.61	-20.39%
2013.	6.04	5.82	-3.55%	5.38	-10.88%	5.61	-7.01%	4.72	-21.87%
2014.	6.31	6.00	-4.90%	5.58	-11.68%	5.79	-8.30%	4.84	-23.28%
2015.	6.59	6.18	-6.21%	5.74	-12.91%	5.97	-9.45%	4.90	-25.68%
2016.	6.84	6.23	-8.90%	5.85	-14.42%	6.13	-10.33%	4.90	-28.30%
2017.	7.11	6.33	-10.95%	5.99	-15.79%	6.36	-10.60%	4.92	-30.83%
2018.	7.29	6.37	-12.67%	6.08	-16.62%	6.54	-10.30%	4.90	-32.80%
2019.	7.35	6.39	-12.97%	6.12	-16.76%	6.59	-10.26%	4.86	-33.86%
2020.	7.43	6.42	-13.53%	6.20	-16.48%	6.62	-10.94%	4.82	-35.17%

Unconventional Gas Revenue

Firms involved primarily in unconventional gas activities would generally be increasing their revenues by engaging in R&D. The total revenue for producers of unconventional gas is projected to be lower throughout the forecast in two of the three cases in which the effect of technological advances is partially removed (Table C3). Total revenue is projected to be slightly higher (less than 1 percent) in the early years of the forecast with the removal of technological advances in exploration technology. In this instance, wellhead prices in two regions are expected to be driven up by decreased production in the other regions. In these two regions, the Midcontinent and the Southwest, the negative effects on production from the absence of exploratory technological advances are quite small in the early years. Accordingly, production is higher there in response to higher prices, despite the lack of advances in exploration technology. The revenues for these two regions are also projected to be higher than in the reference case in those years, high enough to offset lower revenues in other regions. In the later years, when the absence of the benefits of advances in exploration technologies is felt the most, total revenue is lower than in the reference case. Lower projected revenues in several regions, particularly the Rocky Mountain, offset any higher projected revenues elsewhere. In the case where all the effects of technological advances on unconventional gas recovery are removed, total revenue from unconventional gas is lower throughout and by more than 10 percent in the last 4 years of the projection period.

Table C3. Unconventional Gas Revenue
(Billion 1998 Dollars)

Year	Reference	No Exploration Technological Advances		No Drilling and Completion Technological Advances		No Production Technological Advances		No Technological Advances	
	Revenue	Revenue	% Change from Reference	Revenue	% Change from Reference	Revenue	% Change from Reference	Revenue	% Change from Reference
1998.	8.27	8.27	0.00%	8.27	0.00%	8.27	0.00%	8.27	0.00%
1999.	8.83	8.83	0.00%	8.83	0.00%	8.83	0.00%	8.83	0.00%
2000.	9.76	9.76	0.03%	9.74	-0.14%	9.71	-0.45%	9.69	-0.67%
2001.	9.79	9.83	0.43%	9.74	-0.55%	9.71	-0.88%	9.65	-1.47%
2002.	10.10	10.17	0.64%	10.02	-0.81%	9.97	-1.30%	9.90	-2.05%
2003.	10.61	10.68	0.61%	10.50	-1.05%	10.46	-1.39%	10.29	-3.02%
2004.	11.08	11.14	0.52%	10.95	-1.17%	10.91	-1.60%	10.68	-3.65%
2005.	11.74	11.75	0.10%	11.54	-1.72%	11.48	-2.24%	11.11	-5.38%
2006.	12.45	12.44	-0.06%	12.11	-2.71%	12.01	-3.49%	11.62	-6.66%
2007.	12.99	12.96	-0.21%	12.55	-3.35%	12.50	-3.70%	12.06	-7.14%
2008.	13.29	13.31	0.21%	12.84	-3.39%	12.85	-3.27%	12.36	-6.98%
2009.	13.45	13.56	0.85%	12.95	-3.70%	13.12	-2.40%	12.49	-7.14%
2010.	13.99	14.03	0.27%	13.34	-4.67%	13.60	-2.78%	12.96	-7.39%
2011.	14.63	14.69	0.46%	13.96	-4.57%	14.27	-2.42%	13.58	-7.18%
2012.	15.27	15.32	0.31%	14.59	-4.47%	15.00	-1.79%	14.19	-7.05%
2013.	15.83	15.82	-0.04%	15.13	-4.39%	15.66	-1.04%	14.79	-6.55%
2014.	16.49	16.44	-0.31%	15.82	-4.04%	16.21	-1.67%	15.56	-5.64%
2015.	17.16	17.08	-0.45%	16.42	-4.32%	16.73	-2.49%	16.07	-6.35%
2016.	17.84	17.32	-2.88%	16.81	-5.76%	17.17	-3.75%	16.35	-8.32%
2017.	18.57	17.78	-4.24%	17.35	-6.59%	17.89	-3.68%	16.68	-10.16%
2018.	19.17	18.08	-5.72%	17.86	-6.84%	18.65	-2.71%	16.94	-11.66%
2019.	19.47	18.42	-5.39%	18.14	-6.80%	19.07	-2.03%	17.15	-11.92%
2020.	19.93	18.87	-5.33%	18.68	-6.28%	19.45	-2.44%	17.36	-11.92%

Note: Revenue values were calculated by multiplying regional production projections times regional wellhead price projections.

Wellhead Prices and Price Differentials

For most of the forecast period the sum of the price differentials (from the reference case) for the three cases with partial removal of the effect of technological progress on unconventional gas is projected to be less than the price for the case where all of the effects are removed (Tables C4 and C5). For 15 of 23 years this difference is less than 12 percent. The percentage difference is as high as 28 percent in the middle years, but by the last year of the forecast it is down to 6 percent: 73 cents for the summation versus 78 cents for the price in the case with no advances in any technology. The projected differences are partly due to an overlap in the effect of the technologies represented in the three respective major categories. Once the technologies in one category render a play economic, the technologies in another category that would also have made the play economic just make it more profitable. When this occurs, the effects (increased production and decreased price) of the two different technology options are not strictly additive.

Table C4. Wellhead Price Differentials: Partial No Technological Advances and No Technological Advances
(1998 Dollars per Thousand Cubic Feet)

Year	Reference Wellhead Price	(A) No Exploration Technological Advances vs. Reference	(B) No Drilling and Completion Technological Advances vs. Reference	(C) No Production Technological Advances vs. Reference	(A)+(B)+(C)	(D) No Technological Advances vs. Reference	(A)+(B)+(C) vs. (D)
1998.	1.96	0.00	0.00	0.00	0.00	0.00	0.00%
1999.	2.12	0.00	0.00	0.00	0.00	0.00	0.00%
2000.	2.17	0.00	0.00	0.00	0.01	0.01	5.23%
2001.	2.17	0.00	0.00	0.01	0.02	0.02	-3.56%
2002.	2.18	0.00	0.01	0.03	0.04	0.04	-9.87%
2003.	2.21	0.00	0.01	0.05	0.06	0.07	-10.38%
2004.	2.26	0.01	0.02	0.07	0.10	0.11	-7.57%
2005.	2.34	0.01	0.03	0.09	0.13	0.14	-8.15%
2006.	2.43	0.01	0.04	0.09	0.14	0.16	-10.65%
2007.	2.51	0.01	0.05	0.09	0.15	0.18	-16.21%
2008.	2.56	0.01	0.06	0.09	0.16	0.21	-21.68%
2009.	2.59	0.01	0.08	0.10	0.18	0.23	-20.28%
2010.	2.62	0.00	0.09	0.10	0.18	0.26	-28.62%
2011.	2.65	0.00	0.11	0.10	0.21	0.29	-27.89%
2012.	2.68	0.01	0.13	0.11	0.24	0.32	-25.47%
2013.	2.69	0.02	0.15	0.12	0.30	0.37	-20.57%
2014.	2.70	0.04	0.19	0.14	0.38	0.45	-15.55%
2015.	2.72	0.06	0.23	0.17	0.46	0.52	-11.44%
2016.	2.74	0.08	0.25	0.18	0.51	0.58	-11.20%
2017.	2.75	0.10	0.27	0.19	0.55	0.63	-11.89%
2018.	2.76	0.12	0.29	0.20	0.60	0.68	-10.75%
2019.	2.78	0.14	0.31	0.21	0.67	0.73	-8.85%
2020.	2.81	0.17	0.33	0.23	0.73	0.78	-6.58%

Table C5. U.S. Average Wellhead Natural Gas Price
(1998 Dollars per Thousand Cubic Feet)

Year	Reference	No Exploration Technological Advances		No Drilling and Completion Technological Advances		No Production Technological Advances		No Technological Advances	
	Price	Price	% Change from Reference	Price	% Change from Reference	Price	% Change from Reference	Price	% Change from Reference
1997.	2.39	2.39	0.00%	2.39	0.00%	2.39	0.00%	2.39	0.00%
1998.	1.96	1.96	0.00%	1.96	0.00%	1.96	0.00%	1.96	0.00%
1999.	2.12	2.12	0.00%	2.12	0.00%	2.12	0.00%	2.12	0.00%
2000.	2.17	2.17	-0.04%	2.17	-0.04%	2.18	-0.22%	2.18	-0.28%
2001.	2.17	2.17	0.00%	2.18	-0.16%	2.19	-0.65%	2.19	-0.83%
2002.	2.18	2.18	-0.03%	2.18	-0.31%	2.20	-1.26%	2.22	-1.76%
2003.	2.21	2.21	-0.11%	2.22	-0.56%	2.26	-2.12%	2.28	-3.07%
2004.	2.26	2.27	-0.28%	2.29	-1.00%	2.33	-2.99%	2.37	-4.52%
2005.	2.34	2.35	-0.30%	2.38	-1.38%	2.43	-3.52%	2.48	-5.50%
2006.	2.43	2.44	-0.37%	2.47	-1.71%	2.52	-3.59%	2.59	-6.12%
2007.	2.51	2.52	-0.37%	2.56	-1.98%	2.60	-3.47%	2.69	-6.67%
2008.	2.56	2.57	-0.36%	2.62	-2.37%	2.65	-3.38%	2.77	-7.43%
2009.	2.59	2.60	-0.37%	2.67	-2.91%	2.69	-3.60%	2.82	-8.17%
2010.	2.62	2.62	0.00%	2.71	-3.23%	2.72	-3.53%	2.88	-8.92%
2011.	2.65	2.65	0.00%	2.76	-3.85%	2.75	-3.63%	2.94	-9.72%
2012.	2.68	2.68	-0.21%	2.80	-4.50%	2.78	-3.85%	3.00	-10.69%
2013.	2.69	2.71	-0.75%	2.84	-5.31%	2.81	-4.42%	3.06	-12.16%
2014.	2.70	2.74	-1.46%	2.90	-6.70%	2.85	-5.07%	3.15	-14.22%
2015.	2.72	2.78	-2.25%	2.95	-7.88%	2.89	-5.76%	3.24	-16.08%
2016.	2.74	2.82	-2.83%	2.99	-8.51%	2.91	-6.11%	3.31	-17.41%
2017.	2.75	2.85	-3.46%	3.02	-8.95%	2.93	-6.34%	3.38	-18.64%
2018.	2.76	2.88	-4.02%	3.05	-9.50%	2.96	-6.73%	3.44	-19.71%
2019.	2.78	2.91	-4.70%	3.09	-10.15%	2.99	-7.16%	3.51	-20.81%
2020.	2.81	2.97	-5.56%	3.14	-10.65%	3.04	-7.50%	3.59	-21.71%