Appendix F

Statistical Considerations

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Sampling Plan

The goal was a sample that would provide estimates of reserves and production of crude oil, natural gas, and lease condensate for the United States. A stratified sample using a single stage and systematic selection with probability proportional to size was designed. The measure of size was the volume of production for crude oil, natural gas, and lease condensate by State by company in 2003. There were two strata: companies selected with certainty and companies selected under the systematic probability proportional to size design.

Operators of crude oil and natural gas wells were selected as the appropriate respondent population because they have access to the most current and detailed information, and therefore, presumably have better reserve estimates than do other possible classes of respondents, such as working interest or royalty owners. EIA conducts extensive frame maintenance activities each year to identify all current operators of crude oil and natural gas wells in the country. While large operators are quite well known, they comprise only a small portion of all operators. The small operators are not well known and are difficult to identify because they go into and out of business, alter their corporate identities, and change addresses frequently.

Sample Design

To meet survey objectives, while minimizing respondent burden, a sampling strategy has been used since 1977. EIA publishes data on reserves and production for crude oil, natural gas, and lease condensate by State for most States, and by subdivision for the States of California, Louisiana, New Mexico, and Texas.The total volume of production varies among the State/subdivisions. To meet the survey objectives while controlling total respondent burden, EIA selected the following target sampling error for the 2003 survey for each product class.

Each operator is asked to report production and reserves for crude oil, natural gas, and lease condensate for each State/subdivision in which he operates. The term State/subdivision refers to an individual subdivision within a State or an individual State that is not subdivided.

EIA selected the following target sampling error for the 2004 survey for each product class.

- 1.0 percent for National estimates and for each of the States having subdivisions: Alaska, California, Louisiana, New Mexico, and Texas.
- 2.5 percent for each State having 1 percent or more of estimated lower 48 States reserves or production in 2003 for any product class.
- 4 percent for each State/subdivision having less than 1 percent of estimated U.S. reserves or production in 2003 (lower 48 States) for all 3 product class.
- 8 percent for States not published separately.

Certainty Stratum

There are three components to the certainty stratum Category I, Category II, and certain Category III Small Operators.

- **Category I** - *Large Operators:* Operators who produced a total of 1.5 million barrels or more of crude, or 15 billion cubic feet or more of natural gas, or both in 2003.
- **Category II** - *Intermediate Operators:* Operators who produced a total of at least 400,000 barrels of crude oil or 2 billion cubic feet of natural gas, or both, but less than Category I operators in 2003, and additionally, all coalbed methane and Federal Offshore operators.
- **Category III** - *Small Operators:* Operators who produced less than the Category II operators in 2003.

Small operators were further subdivided into certainty and noncertainty strata. Small operators who satisfied any of the following criteria based upon their production shown in the operator frame are certainty operators:

- All other operators with production or reserves in a State/subdivision that exceed selected cutoff levels.

Table F1. 2004 EIA–23 Initial Number of Operators in Survey Sample

State and Subdivision	Number of Certainty Operators	Number of Multi–State Operators	Number of Noncertainty Operators	Target Error	
				Oil	Gas
Alabama Onshore	42	1	4	0.040	0.025
Alaska	20	0	0		
Arkansas	67	5	11	0.040	0.025
California - Coastal Region Onshore	18	0	4	0.080	0.080
California - Los Angeles Basin Onshore	13	3	2	0.010	0.010
California - San Joaquin Basin Onshore	41	2	7	0.025	0.040
Colorado	118	3	21	0.025	0.010
Florida - Onshore	5	0	0	0.025	0.025
Illinois	30	6	25	0.040	0.040
Indiana	18	4	19	0.040	0.080
Kansas	184	81	70	0.040	0.080
Kentucky	28	12	14	0.025	0.010
Louisiana-North	115	22	25	0.040	0.040
Louisiana-South Onshore	183	8	21	0.010	0.010
Michigan	36	5	4	0.010	0.010
Mississippi - Onshore	81	4	16	0.040	0.040
Montana	69	1	5	0.040	0.040
Nebraska	25	2	19	0.040	0.040
New Mexico - East	160	1	34	0.040	0.080
New Mexico - West	55	1	3	0.025	0.025
New York	18	9	5	0.025	0.010
North Dakota	65	0	5	0.080	0.040
Ohio	22	23	16	0.040	0.040
Oklahoma	265	26	77	0.040	0.040
Pennsylvania	46	11	11	0.025	0.025
Texas - RRC District 1	137	12	49	0.040	0.040
Texas - RRC District 2 Onshore	186	2	43	0.025	0.025
Texas - RRC District 3 Onshore	269	16	64	0.040	0.025
Texas - RRC District 4 Onshore	198	3	37	0.025	0.025
Texas - RRC District 5	111	2	18	0.040	0.010
Texas - RRC District 6	181	20	47	0.040	0.010
Texas - RRC District 7B	163	35	96	0.025	0.010
Texas - RRC District 7C	167	3	53	0.025	0.025
Texas - RRC District 8	211	7	69	0.040	0.025
Texas - RRC District 8A	191	0	53	0.010	0.010
Texas - RRC District 9	158	23	67	0.010	0.040
Texas - RRC District 10	154	12	30	0.025	0.025
Utah	57	2	3	0.040	0.010
Virginia	17	0	1	0.040	0.025
West Virginia	38	18	14	0.080	0.040
Wyoming	164	2	16	0.040	0.025
Offshore Areas	320	0	0	0.025	0.025
Other States (a)	56	12	0	0.080	0.080
Total	**[b]987**	**399**	**[b]398**	**0.010**	**0.010**

[a]Includes Arizona, Idaho, Iowa, Maryland, Missouri, Nevada, Oregon, South Dakota, Tennessee, and Washington.
[b]Nonduplicative count of operators by States.
Note: Sampling rate was 7 percent except in Alaska, Florida Onshore, Virginia, and Offshore areas where sampling rate was 100 percent.
Source: Energy Information Administration, Office of Oil and Gas.

- The largest operator in each State/subdivision regardless of level of production or reserves.
- Operators with production or reserves of oil or gas for six or more State/subdivisions.

Noncertainty Stratum

Small operators not in the certainty stratum were classified in the noncertainty stratum. They were systematically sampled with probability proportional to size. Only the operators in the following 10 states were included in the noncertainty sample: Illinois, Indiana, Kentucky, Maryland, New York, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. All other States were treated as certainty stratum.

In each State/subdivision the balance between the number of operators and the sample size was determined in an iterative procedure designed to minimize the number of total respondents. The iteration for each State/subdivision began with only the Category I and Category II operators in the certainty stratum. The size of the sample of small operators required to meet the target variance was calculated based on the variance of the volumes of those operators. For a number of State/subdivisions with high correlations between frame values across pairs of consecutive years, an adjusted target variance was calculated, that utilized the information about the correlations. This allowed the selection of a smaller sample that still met the target sampling error criteria. Independent samples of single location operators (operators who, according to the sampling frame, operate in only one State/subdivision) were selected from each State/subdivision using systematic random sampling.

State/subdivision volume estimates are calculated as the sum of the certainty strata and all of the estimates for the sampling strata in that region. The sampling variance of the estimated total is the sum of the sampling variances for the sampling strata. There is no sampling error associated with the certainty stratum. The square root of the sampling variance is the standard error. It can be used to provide confidence intervals for the State/subdivision totals.

For the States in which subdivision volume estimates are published, the State total is the sum of the individual volume estimates for the subdivisions. The U.S. total is the sum of the State estimates. A sampling variance is calculated for each State/subdivision and for the U.S. Total. **Table F1** shows sampling rates.

Total U.S. Reserve Estimates

Conceptually, the estimates of U.S. reserves and production can be thought of as the sum of the estimates for the individual States. Correspondingly, the estimates for the four States for which estimates are published separately by subdivision (California, Louisiana, New Mexico, and Texas) can be thought of as the sum of the estimates by subdivision. The remaining States are not subdivided and may be considered as a single subdivision.

The estimates of year-end proved reserves and annual production for any State/subdivision is the sum of the volumes in the State/subdivision reported by the certainty stratum operators and an estimate of the total volume in the State/subdivision by the noncertainty stratum operators. The total volume of certainty operators in the State/subdivision is simply the sum of individual operator's volumes. The estimated total volume of noncertainty operators in the State/subdivision is the weighted sum of the reports of the noncertainty sample operators.

In many State/subdivisions, the accuracy of the oil and gas estimates was improved by using the probability proportional to size procedure. This procedure took advantage of the correlation between year-to-year production reports. The weights used for estimating the oil production were different from the weights used for estimating the gas production.

The weight used for the estimation is the reciprocal of the probability of selection for the stratum from which the sample operator was selected. In making estimates for a State/ subdivision, separate weights are applied as appropriate for noncertainty operators shown in the frame as having had production in only the State/subdivision, for those shown as having had production in that State/subdivision and up to four other State/ subdivisions, and for operators with no previous record of production in the State/subdivision. National totals were then obtained by summation of the component totals.

Imputation and Estimation for Reserves Data

There were 355 operators sampled proportional to size (Table E1) that responded as Category III noncertainty operators. Only 137 of these, located in 10 states, had their data weighted and used to estimate the production and reserves of the operators that were not

sampled in those states. The remaining 218 noncertainty sampled operators were treated as certainty sampled operators with a weight of 1 and were used in states where the bulk of the operator production data was obtained from auxiliary State data.

The data reported by operator category on Form EIA-23 and data imputed and estimated for report year 2004 are summarized in **Tables F2, F3, F4, and F5**. The reported data in **Table F2** shows that those responding operators accounted for 97.0 percent of the published production for wet natural gas and 95.4 percent of the reserves shown in **Table 9**. Data shown in **Table F3** indicate that those responding operators accounted for 96.9 percent of the nonassociated natural gas production and 95.5 percent of the reserves published in **Table 10**. The reported data shown in **Table F4** indicate that those responding operators accounted for 95.9 percent of published crude oil production and 93.9 percent of the reserves shown in **Table 6**. Additionally, **Table F5** indicates that those responding operators accounted for 97.8 percent of the published production and 96.0 percent of the published proved reserves for lease condensate shown in **Table 15**.

In order to estimate reserve balances for National and State/subdivision levels, a series of imputation and estimation steps at the operator level must be carried out.

- Year-end reserves for operators who provided production data only were imputed on the basis of their production volumes.
- Imputation was also applied to the small and intermediate operators as necessary to provide data on each of the reserve balance categories (i.e., revisions, extensions, or new discoveries).
- Imputation was required for the natural gas data of the small operators to estimate their volumes of associated-dissolved and nonassociated natural gas.
- Adjustments to maintain reserves balance.

Methods used are discussed in the following sections.

Imputation of Year-End Proved Reserves

Category I operators were required to submit year-end estimates of proved reserves. Category II and Category III operators were required to provide year-end estimates of proved reserves only if such estimates existed in their records. Some of these respondents provided estimates for all of their operated properties, others provided estimates for only a portion of their properties, and still others provided no estimates for any of their properties. All respondents did, however, provide annual production data.

A year-end proved reserves estimate was imputed from reported production data in each case where an estimate was not provided by the respondent. A R/P function was derived and used to calculate a reserves-to-production (R/P) ratio, based on operator size and the geographic region where the operator's properties were located. The R/P function has the following functional form for each geographic region:

*Calculated P/[P+R] = Beta * EXP(Alpha * ln (1 + MOS))*

- *Alpha, Beta* = Regional Coefficients (calculated)
- *MOS = Measure of size* for a respondent, which is equal to the barrel oil equivalent volume of a respondent's 2004 production.

Table F6 lists the coefficients used for each region and the number of observations on which it was based. The regional areas used are similar to the National Petroleum Council Regions (**Figure F1**). These regions generally follow the boundaries of geologic provinces wherein the stage of resource development tends to be somewhat similar.

Once the R/P ratio was obtained for an operator, it could be multiplied by the reported or estimated production to give a proved reserves estimate. Operators that had production plus end of year reserves equal to zero were excluded from the respondents selected to calculate the R/P coefficients.

In 2004, rather than rely on a weighted sample, the R/P function was used to estimate the proved reserves of all noncertainty operators in these States: Texas, California, Colorado, Louisiana, Montana, New Mexico, South Dakota, Utah, and Wyoming. These States were chosen for this new procedure because of the many years of historical production and reserves data within EIA and availability of reliable State government and commercial production data for these States. This technique improved the correlation of EIA data with State and commercial production data, and reduced the burden of reporting and analysis on both EIA and the noncertainty operators in these States.

Imputation of Changes to Proved Reserves by Component of Change

Category II and Category III operators that do not keep reserves data were not asked to provide estimates of beginning-of-year reserves or annual changes to

Table F2. Summary of Form EIA-23 Reported, Imputed, and Estimated Natural Gas Data for 2004, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category I	II	Certainty III	Noncertainty III	Auxillary State Data	Total
			Reported			
Number of Operators	171	459	289	336	13,664	14,919
Proved Reserves as of 12/31/03	173,021,831	13,832,380	904,544	1,606	0	187,760,361
(+) Revision Increases	25,344,424	1,379,662	46,603	0	0	26,770,689
(–) Revision Decreases	24,254,297	1,668,617	70,416	0	0	25,993,330
(–) Sales	8,582,347	2,259,065	662,280	0	0	11,503,692
(+) Acquisitions	11,930,606	1,238,458	27,874	13,290	0	13,210,228
(+) Extensions	15,359,064	2,861,495	28,667	0	0	18,249,226
(+) New Field Discoveries	554,690	198,921	388	0	0	753,999
(+) New Reservoirs in Old Fields	818,884	349,950	1,217	0	0	1,170,051
(–) Production With Proved Reserves Reported	16,896,526	1,463,271	45,169	343	0	18,405,309
(–) Production Without Proved Reserves Reported	17,397	456,894	11,680	0	0	485,971
Proved Reserves as of 12/31/04	177,293,000	14,485,809	231,544	14,553	0	192,024,906
			Imputed and Estimated			
Number of Operators	-	-	-	5,751	-	5,751
Proved Reserves as of 12/31/03	-	-	-	-	-	-
(+) Revision Increases	0	0	0	0	1,346,399	1,346,399
(–) Revision Decreases	0	0	0	0	1,297,072	1,297,072
(–) Sales	0	0	0	0	78,056	78,056
(+) Acquisitions	0	0	0	0	350,242	350,242
(+) Extensions	0	0	0	0	819,835	819,835
(+) New Field Discoveries	0	0	0	0	37,444	37,444
(+) New Reservoirs in Old Fields	0	0	0	0	74,259	74,259
(–) Production With Proved Reserves Reported	0	0	0	0	63,314	63,314
(–) Production Without Proved Reserves Reported	3,820	153,710	109,288	266,818	527,016	1,060,652
Proved Reserves as of 12/31/04	22,758	1,296,243	731,272	2,050,273	5,069,781	9,170,327
			Total			
Number of Operators	171	459	289	6,087	13,664	20,670
Proved Reserves as of 12/31/03	173,021,831	13,832,380	904,544	1,606	0	187,760,361
(+) Revision Increases	25,344,424	1,379,662	46,603	0	1,346,399	28,117,088
(–) Revision Decreases	24,254,297	1,668,617	70,416	0	1,297,072	27,290,402
(–) Sales	8,582,347	2,259,065	662,280	0	78,056	11,581,748
(+) Acquisitions	11,930,606	1,238,458	27,874	13,290	350,242	13,560,470
(+) Extensions	15,359,064	2,861,495	28,667	0	819,835	19,069,061
(+) New Field Discoveries	554,690	198,921	388	0	37,444	791,443
(+) New Reservoirs in Old Fields	818,884	349,950	1,217	0	74,259	1,244,310
(–) Production With Proved Reserves Reported	16,896,526	1,463,271	45,169	343	63,314	18,468,623
(–) Production Without Proved Reserves Reported	21,217	610,604	120,968	266,818	527,016	1,546,623
Proved Reserves as of 12/31/04	177,315,758	15,782,052	962,816	2,064,826	5,069,781	201,195,233
			Summary			
Total Number of Operators	**171**	**459**	**289**	**6,087**	**13,664**	**20,670**
Percent of Total	**0.8%**	**2.2%**	**1.4%**	**29.4%**	**66.1%**	**100.0%**
Total Production in 2004	**16,917,743**	**2,073,875**	**166,137**	**267,161**	**590,330**	**20,015,246**
Percent of Total	**84.5%**	**10.4%**	**0.8%**	**1.3%**	**2.9%**	**100.0%**
Total Proved Reserves 12/31/04	**177,315,758**	**15,782,052**	**962,816**	**2,064,826**	**5,069,781**	**201,195,233**
Percent of Total	**88.1%**	**7.8%**	**0.5%**	**1.0%**	**2.5%**	**100.0%**

[a]There were 355 noncertainty responses, 137 were used with their sample weights and 218 were treated as Certainty III operators.
– = Not applicable.
Notes: Table 9 totals include imputed and estimated wet natural gas proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.
Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004.

Table F3. Summary of Form EIA-23 Reported, Imputed, and Estimated Nonassociated Natural Gas Data for 2004, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category I	II	Certainty III	Noncertainty III	Auxillary State Data	Total
Reported						
Number of Operators	171	459	289	336	13,664	14,919
Proved Reserves as of 12/31/03	147,537,859	12,388,805	821,519	636	0	160,748,819
(+) Revision Increases	21,771,601	1,187,590	45,071	0	0	23,004,262
(–) Revision Decreases	21,559,084	1,480,544	51,726	0	0	23,091,354
(–) Sales	7,756,635	2,116,675	626,074	0	0	10,499,384
(+) Acquisitions	11,147,233	1,064,400	26,671	433	0	12,238,737
(+) Extensions	14,613,036	2,766,447	26,099	0	0	17,405,582
(+) New Field Discoveries	528,835	191,991	388	0	0	721,214
(+) New Reservoirs in Old Fields	729,776	343,373	1,217	0	0	1,074,366
(–) Production With Proved Reserves Reported	14,577,571	1,297,837	41,935	194	0	15,917,537
(–) Production Without Proved Reserves Reported	14,364	410,336	9,243	0	0	433,943
Proved Reserves as of 12/31/04	152,435,411	13,062,395	201,345	875	0	165,700,026
Imputed and Estimated						
Number of Operators	-	-	-	5,751	-	5,751
Proved Reserves as of 12/31/03	-	-	-	-	-	-
(+) Revision Increases	0	0	0	0	1,104,909	1,104,909
(–) Revision Decreases	0	0	0	0	1,029,717	1,029,717
(–) Sales	0	0	0	0	78,004	78,004
(+) Acquisitions	0	0	0	0	332,755	332,755
(+) Extensions	0	0	0	0	759,114	759,114
(+) New Field Discoveries	0	0	0	0	36,069	36,069
(+) New Reservoirs in Old Fields	0	0	0	0	72,857	72,857
(–) Production With Proved Reserves Reported	0	0	0	0	56,034	56,034
(–) Production Without Proved Reserves Reported	3,521	139,524	96,008	239,053	389,251	867,357
Proved Reserves as of 12/31/04	21,034	1,169,058	652,333	1,842,425	4,165,195	7,850,045
Total						
Number of Operators	171	459	289	6,087	13,664	20,670
Proved Reserves as of 12/31/03	147,537,859	12,388,805	821,519	636	0	160,748,819
(+) Revision Increases	21,771,601	1,187,590	45,071	0	1,104,909	24,109,171
(–) Revision Decreases	21,559,084	1,480,544	51,726	0	1,029,717	24,121,071
(–) Sales	7,756,635	2,116,675	626,074	0	78,004	10,577,388
(+) Acquisitions	11,147,233	1,064,400	26,671	433	332,755	12,571,492
(+) Extensions	14,613,036	2,766,447	26,099	0	759,114	18,164,696
(+) New Field Discoveries	528,835	191,991	388	0	36,069	757,283
(+) New Reservoirs in Old Fields	729,776	343,373	1,217	0	72,857	1,147,223
(–) Production With Proved Reserves Reported	14,577,571	1,297,837	41,935	194	56,034	15,973,571
(–) Production Without Proved Reserves Reported	17,885	549,860	105,251	239,053	389,251	1,301,300
Proved Reserves as of 12/31/04	152,456,445	14,231,453	853,678	1,843,300	4,165,195	173,550,071
Summary						
Total Number of Operators	**171**	**459**	**289**	**6,087**	**13,664**	**20,670**
Percent of Total	**0.8%**	**2.2%**	**1.4%**	**29.4%**	**66.1%**	**100.0%**
Total Production in 2004	**14,595,456**	**1,847,697**	**147,186**	**239,247**	**445,285**	**17,274,871**
Percent of Total	**84.5%**	**10.7%**	**0.9%**	**1.4%**	**2.6%**	**100.0%**
Total Proved Reserves 12/31/04	**152,456,445**	**14,231,453**	**853,678**	**1,843,300**	**4,165,195**	**173,550,071**
Percent of Total	**87.8%**	**8.2%**	**0.5%**	**1.1%**	**2.4%**	**100.0%**

[a]There were 355 noncertainty responses, 137 were used with their sample weights and 218 were treated as Certainty III operators.
– = Not applicable.
Notes: Table 10 totals include imputed and estimated nonassociated wet natural gas proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.
Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004.

Table F4. Summary of Form EIA-23 Reported, Imputed, and Estimated Crude Oil Data for 2004,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category I	II	Certainty III	Noncertainty III	Auxillary State Data	Total
			Reported			
Number of Operators	171	459	289	336	13,664	14,919
Proved Reserves as of 12/31/03	19,530,949	1,005,518	35,508	1,581	0	20,573,556
(+) Revision Increases	1,668,535	116,677	2,060	0	0	1,787,272
(–) Revision Decreases	1,304,833	100,662	3,861	0	0	1,409,356
(–) Sales	804,315	110,375	20,564	0	0	935,254
(+) Acquisitions	790,706	129,255	378	13,384	0	933,723
(+) Extensions	519,783	58,072	1,131	0	0	578,986
(+) New Field Discoveries	28,926	4,398	26	0	0	33,350
(+) New Reservoirs in Old Fields	125,721	6,051	0	0	0	131,772
(–) Production With Proved Reserves Reported	1,527,996	88,359	2,110	310	0	1,618,775
(–) Production Without Proved Reserves Reported	29	15,179	777	0	0	15,985
Proved Reserves as of 12/31/04	19,026,541	1,021,392	12,569	14,655	0	20,075,157
			Imputed and Estimated			
Number of Operators	-	-	-	5,751	-	5,751
Proved Reserves as of 12/31/03	-	-	-	-	-	-
(+) Revision Increases	0	0	0	0	152,390	152,390
(–) Revision Decreases	0	0	0	0	112,689	112,689
(–) Sales	0	0	0	0	637	637
(+) Acquisitions	0	0	0	0	25,314	25,314
(+) Extensions	0	0	0	0	40,793	40,793
(+) New Field Discoveries	0	0	0	0	1,759	1,759
(+) New Reservoirs in Old Fields	0	0	0	0	1,278	1,278
(–) Production With Proved Reserves Reported	0	0	0	0	13,575	13,575
(–) Production Without Proved Reserves Reported	42	17,329	12,877	30,248	110,460	170,956
Proved Reserves as of 12/31/04	270	143,700	109,695	253,665	786,111	1,293,441
			Total			
Number of Operators	171	459	289	6,087	13,664	20,670
Proved Reserves as of 12/31/03	19,530,949	1,005,518	35,508	1,581	0	20,573,556
(+) Revision Increases	1,668,535	116,677	2,060	0	152,390	1,939,662
(–) Revision Decreases	1,304,833	100,662	3,861	0	112,689	1,522,045
(–) Sales	804,315	110,375	20,564	0	637	935,891
(+) Acquisitions	790,706	129,255	378	13,384	25,314	959,037
(+) Extensions	519,783	58,072	1,131	0	40,793	619,779
(+) New Field Discoveries	28,926	4,398	26	0	1,759	35,109
(+) New Reservoirs in Old Fields	125,721	6,051	0	0	1,278	133,050
(–) Production With Proved Reserves Reported	1,527,996	88,359	2,110	310	13,575	1,632,350
(–) Production Without Proved Reserves Reported	71	32,508	13,654	30,248	110,460	186,941
Proved Reserves as of 12/31/04	19,026,811	1,165,092	122,264	268,320	786,111	21,368,598
			Summary			
Total Number of Operators	**171**	**459**	**289**	**6,087**	**13,664**	**20,670**
Percent of Total	**0.8%**	**2.2%**	**1.4%**	**29.4%**	**66.1%**	**100.0%**
Total Production in 2004	**1,528,067**	**120,867**	**15,764**	**30,558**	**124,035**	**1,819,291**
Percent of Total	**84.0%**	**6.6%**	**0.9%**	**1.7%**	**6.8%**	**100.0%**
Total Proved Reserves 12/31/04	**19,026,811**	**1,165,092**	**122,264**	**268,320**	**786,111**	**21,368,598**
Percent of Total	**89.0%**	**5.5%**	**0.6%**	**1.3%**	**3.7%**	**100.0%**

[a]There were 355 noncertainty responses, 137 were used with their sample weights and 218 were treated as Certainty III operators.
– = Not applicable.
Notes: Table 6 totals include imputed and estimated crude oil proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.
Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004.

Table F5. Summary of Form EIA-23 Reported, Imputed, and Estimated Lease Condensate Data for 2004,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category I	II	Certainty III	Noncertainty III	Auxillary State Data	Total
Reported						
Number of Operators	171	459	289	336	13,664	14,919
Proved Reserves as of 12/31/03	1,055,487	103,119	8,882	0	0	1,167,488
(+) Revision Increases	284,962	26,153	1,482	0	0	312,597
(–) Revision Decreases	263,941	21,945	369	0	0	286,255
(–) Sales	80,417	11,048	4,457	0	0	95,922
(+) Acquisitions	79,008	23,877	1,096	0	0	103,981
(+) Extensions	90,912	18,984	147	0	0	110,043
(+) New Field Discoveries	3,072	905	0	0	0	3,977
(+) New Reservoirs in Old Fields	15,530	9,363	7	0	0	24,900
(–) Production With Proved Reserves Reported	152,210	16,106	668	0	0	168,984
(–) Production Without Proved Reserves Reported	158	3,918	75	0	0	4,151
Proved Reserves as of 12/31/04	1,032,347	133,347	6,120	0	0	1,171,814
Imputed and Estimated						
Number of Operators	-	-	-	5,751	-	5,751
Proved Reserves as of 12/31/03	-	-	-	-	-	-
(+) Revision Increases	0	0	0	0	12,355	12,355
(–) Revision Decreases	0	0	0	0	16,147	16,147
(–) Sales	0	0	0	0	435	435
(+) Acquisitions	0	0	0	0	7,435	7,435
(+) Extensions	0	0	0	0	5,479	5,479
(+) New Field Discoveries	0	0	0	0	354	354
(+) New Reservoirs in Old Fields	0	0	0	0	1,521	1,521
(–) Production With Proved Reserves Reported	0	0	0	0	257	257
(–) Production Without Proved Reserves Reported	108	566	861	1,535	4,426	7,496
Proved Reserves as of 12/31/04	711	2,179	3,392	6,282	35,185	47,749
Total						
Number of Operators	171	459	289	6,087	13,664	20,670
Proved Reserves as of 12/31/03	1,055,487	103,119	8,882	0	0	1,167,488
(+) Revision Increases	284,962	26,153	1,482	0	12,355	324,952
(–) Revision Decreases	263,941	21,945	369	0	16,147	302,402
(–) Sales	80,417	11,048	4,457	0	435	96,357
(+) Acquisitions	79,008	23,877	1,096	0	7,435	111,416
(+) Extensions	90,912	18,984	147	0	5,479	115,522
(+) New Field Discoveries	3,072	905	0	0	354	4,331
(+) New Reservoirs in Old Fields	15,530	9,363	7	0	1,521	26,421
(–) Production With Proved Reserves Reported	152,210	16,106	668	0	257	169,241
(–) Production Without Proved Reserves Reported	266	4,484	936	1,535	4,426	11,647
Proved Reserves as of 12/31/04	1,033,058	135,526	9,512	6,282	35,185	1,219,563
Summary						
Total Number of Operators	**171**	**459**	**289**	**6,087**	**13,664**	**20,670**
Percent of Total	**0.8%**	**2.2%**	**1.4%**	**29.4%**	**66.1%**	**100.0%**
Total Production in 2004	**152,476**	**20,590**	**1,604**	**1,535**	**4,683**	**180,888**
Percent of Total	**84.3%**	**11.4%**	**0.9%**	**0.8%**	**2.6%**	**100.0%**
Total Proved Reserves 12/31/04	**1,033,058**	**135,526**	**9,512**	**6,282**	**35,185**	**1,219,563**
Percent of Total	**84.7%**	**11.1%**	**0.8%**	**0.5%**	**2.9%**	**100.0%**

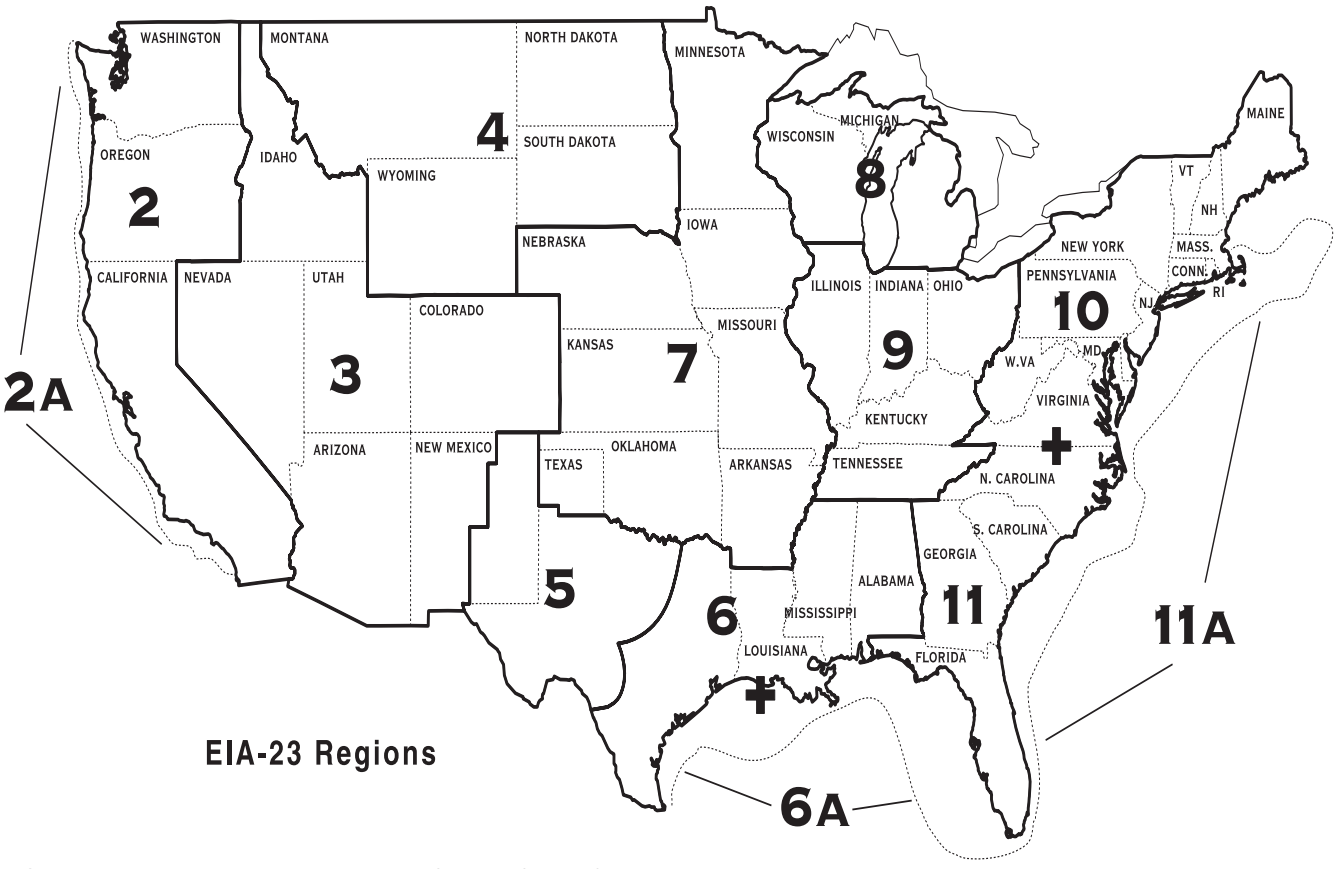
[a]There were 355 noncertainty responses, 137 were used with their sample weights and 218 were treated as Certainty III operators.
– = Not applicable.
Notes: Table 15 totals include imputed and estimated lease condensate proved reserves rounded at the State/subdivision level. Field level data are reported volumes and may not balance due to submission of incomplete reserve component records.
Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004.

Table F6. Statistical Parameters of Reserves Estimation Equation by Region for 2004

Region Number	Region	Number of Nonzero R/P Pairs			Equation Coefficients					
					Oil		Gas		LC	
		Oil	Gas	LC	Alpha	Beta	Alpha	Beta	Alpha	Beta
1	Alaska	8	8	0	-0.1320	0.3987	-0.1295	0.4172	0.0000	0.0000
2	Pacific Coast States	42	56	5	-0.1320	0.3027	-0.1295	0.3526	-0.1166	0.7765
2A	Federal Offshore Pacific	4	6	0	-0.1320	0.5436	-0.1295	0.4245	0.0000	0.0000
3	Western Rocky Mountains	74	130	52	-0.1320	0.2551	-0.1295	0.2928	-0.1166	0.1836
4	Northern Rocky Mountains	163	169	49	-0.1320	0.2583	-0.1295	0.2827	-0.1166	0.2280
5	West Texas and East New Mexico	491	498	167	-0.1320	0.2764	-0.1295	0.3614	-0.1166	0.5075
6	Western Gulf Basin	511	849	577	-0.1320	0.3503	-0.1295	0.4163	-0.1166	0.4956
6A	Gulf of Mexico	75	140	115	-0.1320	0.4990	-0.1295	0.7261	-0.1166	0.7270
7	Mid-Continent	274	367	147	-0.1320	0.2639	-0.1295	0.3172	-0.1166	0.2826
8 + 9	Michigan Basin and Eastern Interior	68	59	16	-0.1320	0.2239	-0.1295	0.1888	-0.1166	0.2684
10 + 11	Appalachians	24	66	9	-0.1320	0.2519	-0.1295	0.1673	-0.1166	0.2526
	United States	1,734	2,348	1,137	-0.1320	0.3627	-0.1295	0.3818	-0.1166	0.4676

Source: Based on data filed on Form EIA-23,"Annual Survey of Domestic Oil and Gas Reserves, 2004".

Figure F1. Form EIA-23 Regional Boundaries



Source: Energy Information Administration, Office of Oil and Gas.

proved reserves by component of change, i.e., revisions, extensions, and discoveries. When they did not provide estimates, these volumes were estimated by either:

- applying an algebraic allocation scheme which preserved the relative relationships between these items within each State/subdivision, as reported by Category I and Category II operators, or
- applying a modified version of the R/P function to each separate component of change, calculated with its own set of geographically dependent coefficients. This method was used in all four states where the R/P Function was applied to calculate end of year reserves.

Both methods preserved an exact annual reserves balance of the following form:

Published Proved Reserves at End of Previous Report Year
+ Adjustments
+ Revision Increases
– Revision Decreases
– Sales
+ Acquisitions
+ Extensions
+ New Field Discoveries
+ New Reservoir Discoveries in Old Fields
– Report Year Production
= Published Proved Reserves at End of Report Year

The algebraic allocation method used for all but nine states in the 2004 survey worked as follows: A ratio was calculated as the sum of the annual production and year-end proved reserves of those respondents who did not provide the reserves balance components, divided by the sum of year-end proved reserves and annual production of those respondents of similar size who did provide these quantities. This ratio was then multiplied by each of the reserves balance components reported by Category I and some Category II operators, to obtain imputed volumes for the reserves balances of the other Category II operators and certainty and noncertainty operators. These were then added to the State/subdivision totals.

Imputation of Natural Gas Volumes

Small operators in the certainty and noncertainty strata were not asked to segregate their natural gas volumes by type of natural gas, i.e., nonassociated natural gas (NA) and associated-dissolved natural gas (AD). The total estimated year-end proved reserves of natural gas and the total annual production of natural gas reported by, or imputed to, operators in the State/subdivision certainty and noncertainty strata were, therefore, subdivided into the NA and AD categories, by State/subdivision, in the same proportion as was reported by large and intermediate operators in the same area.

Adjustments

The instructions for Schedule A of Form EIA-23 specify that, when reporting reserves balance data, the following arithmetic equation must hold:

Proved Reserves at End of Previous Year
+ Revision Increases
– Revision Decreases
– Sales
+ Acquisitions
+ Extensions
+ New Field Discoveries
+ New Reservoir Discoveries in Old Fields
– Report Year Production
= Proved Reserves at End of Report Year

Any remaining difference in the State/subdivision annual reserves balance between the published previous year-end proved reserves and current year-end proved reserves not accounted for by the imputed reserves changes was included in the adjustments for the area. One of the primary reasons that adjustments are necessary is the instability of the noncertainty operators sampled each year. There is no guarantee that in the smaller producing States/subdivision the same number of small operators will be selected each year, or that the operators selected will be of comparable sizes when paired with operators selected in a prior year. Thus, some instability of this stratum from year to year is unavoidable, resulting in minor adjustments.

Some of the adjustments are, however, more substantial, and could be required for any one or more of the following reasons:

- The frame coverage may or may not have improved between survey years, such that more or fewer certainty operators were included in 2004 than in 2003.
- One or more operators may have reported data incorrectly on Schedule A in 2004 or 2003, but not both, and the error was not detected by edit processing.

- Operation of properties was transferred during 2004 from operators not in the frame or noncertainty operators not selected for the sample to certainty operators or noncertainty operators selected for the sample.
- Respondent changed classification of natural gas from NA to AD or vice versa.
- The trend in reserve changes imputed for the small operators, which was based on the trend reported by the large operators, did not reflect the actual trend for the small operators.
- noncertainty operators, who have grown substantially in size since they were added to the frame, occasionally cause a larger standard error than expected.
- The noncertainty sample for either year in a state may have been an unusual one.

The causes of adjustments are known for some but not all areas. The only problems whose effects cannot be expected to balance over a period of several years are those associated with an inadequate frame or those associated with any actual trend in reserves changes for small operators not being the same as those for large operators. EIA continues to attempt to improve sources of operator data to resolve problems in frame completeness.

Sampling Reliability of the Estimates

The sample of noncertainty operators selected is only one of the large number of possible samples that could have been selected and each would have resulted in different estimates. The standard error or sampling error of the estimates provides a measure of this variability. When probability sampling methods are used, as in the EIA-23 survey, the sampling error of estimates can also be estimated from the survey data.

The estimated sampling error can be used to compute a confidence interval around the survey estimate, with a prescribed degree of confidence that the interval covers the value that would have been obtained if all operators in the frame had been surveyed. If the estimated volume is denoted by $\hat{V}_s$ and its sampling error by S.E. (- $\hat{V}_s$), the confidence interval can be expressed as:

$$\hat{V}_s \pm k\,S.E.(\hat{V}_s)$$

where k is a multiple selected to provide the desired level of confidence. For this survey, k was taken equal to 2. Then there is approximately 95 percent confidence that the interval:

$$\hat{V}_s \pm 2S.E.(\hat{V}_s)$$

includes the universe value, for both the estimates of reserves and production volumes. Correspondingly, for approximately 95 percent of the estimates in this report, the difference between the published estimate and the value that would be found from a complete survey of all operators is expected to be less than twice the sampling error of the estimate. **Tables F7 and F8** provide estimates for 2S.E. ($\hat{V}_s$) by product. These estimates are directly applicable for constructing approximate 95 percent confidence intervals. For example, the 95 percent confidence interval for dry natural gas proved reserves is 192,513 ±392 billion cubic feet. The sampling error of $\hat{V}_s$ is equal to the sampling error of the noncertainty estimate $\hat{V}_{sr}$, because the certainty total is not subject to sampling error. The estimated sampling error of a noncertainty estimate is the square root of its estimated sampling variance.

Sources of Errors

The EIA maintains an evaluation program to assess the accuracy and quality of proved reserve estimates gathered on Form EIA-23. Field teams consisting of petroleum engineers from EIA's Reserves and Production Division conduct technical reviews of reserve estimates and independently estimate the proved reserves of a selected sample of operator properties. The results of these reviews are used to evaluate the accuracy of reported reserve estimates. Operators are apprized of the team's findings to assist them in completing future filings. The magnitude of errors due to differences between reserve volumes submitted by operators on the Form EIA-23 and those estimated by EIA petroleum engineers on their field trips were generally within accepted professional engineering standards. Several sources of possible error, apart from sampling error, are associated with the Form EIA-23 survey:

- Operator nonresponse
- Respondent estimation errors
- Reporting errors and data processing errors
- Inadequate frame coverage
- Errors associated with statistical estimates.

Imputation for Operator Nonresponse

The nonresponse rate for certainty operators for the 2004 survey was 3.0 percent and for the noncertainty

operators 5.4 percent. An imputation was made for the production and reserves for the 47 nonresponding operators.

Respondent Estimation Errors

The principal data elements of the Form EIA-23 survey consist of respondent estimates of proved reserves of crude oil, natural gas, and lease condensate. Unavoidably, the respondents are bound to make some estimation errors, i.e., until a particular reservoir has been fully produced to its economic limit and abandoned, its reserves are not subject to direct measurement but must be inferred from limited, imperfect, or indirect evidence. A more complete discussion of the several techniques of estimating proved reserves, and the many problems inherent in the task, appears in Appendix G.

Reporting and Data Processing Errors

Reporting errors on the part of respondents are of definite concern in a survey of the magnitude and complexity of the Form EIA-23 program. Several steps were taken by EIA to minimize and detect such problems. The survey instrument itself was carefully developed, and included a detailed set of instructions for filing data, subject to a common set of definitions similar to those already used by the industry. Editing software is continually developed to detect different kinds of probable reporting errors and flag them for resolution by analysts, either through confirmation of the data by the respondent or through submission of amendments to the filed data. Data processing errors, consisting primarily of random keypunch errors, are detected by the same software.

Frame Coverage Errors

Of all the sources of controllable error connected with the Form EIA-23 survey, errors in the operator frame were expected to be the most important. If the frame does not list all operators in a given State, the sample selected from the frame for the State will not represent the entire operator population, a condition called under coverage. Under coverage is a problem with certain States, but it does not appear to be a problem with respect to the National proved reserve estimates for either crude oil or natural gas. While it is relatively straightforward to use existing sources to identify large operators and find addresses for them, such is not the case for small operators. A frame such as that used in the 2004 survey is particularly likely to be deficient in States where a large portion of total reserves and production is accounted for by small operators. EIA is continuing to work to remedy the under coverage problem in those States where it occurred.

Imputation Errors

Some error, generally expected to be small, is an inevitable result of the various estimations outlined. These imputation errors have not yet been completely addressed by EIA and it is possible that estimation methods may be altered in future surveys. Nationally, 6.0 percent of the crude oil proved reserve estimates, 3.9 percent of the wet natural gas proved reserve estimates, and 3.9 percent of the lease condensate proved reserve estimates resulted from the imputation and estimation of reserves for those certainty and noncertainty operators who did not provide estimates for all of their properties, in combination with the expansion of the sample of noncertainty operators to the full population. Errors for the latter were quantitatively calculated, as discussed in the previous section. Standard errors, for the former, would tend to cancel each other from operator to operator, and are, therefore, expected to be negligible, especially at the National level of aggregation. In States where a large share of total reserves is accounted for by Category III and smaller Category II operators, the errors are expected to be somewhat larger than in States where a large share of total reserves is accounted for by Category I and larger Category II operators.

Calculation of Reserves of Natural Gas Liquids and Dry Natural Gas

Natural Gas Liquids Reserve Balance

The published reserves, production, and reserves change statistics for crude oil, lease condensate, and natural gas, wet after lease separation, were derived from the data reported on Form EIA-23 and the application of the imputation methods discussed previously. The information collected on Form EIA-64A was then utilized in converting the estimates of the wet natural gas reserves into two components: plant liquids reserve data and dry natural gas reserve data. The total natural gas liquids reserve estimates presented in **Table 14** were computed as the sum of plant liquids estimates (**Table 15**) and lease condensate (**Table 16**) estimates.

Table F7. Factors for Confidence Intervals (2S.E.) for Crude Oil Proved Reserves and Production, 2004
(Million Barrels of 42 U.S. Gallons)

State and Subdivision	2004 Reserves	2004 Production	State and Subdivision	2004 Reserves	2004 Production
United States	26	3	Montana[b]	0	0
Alabama[b]	0	0	Nebraska	0	0
Alaska[a]	0	0	New Mexico[b]	0	0
Arkansas[b]	0	0	North Dakota[b]	0	0
California[b]	0	0	Ohio	8	1
Colorado[b]	0	0	Oklahoma[b]	0	0
Florida[a]	0	0	Pennsylvania	0	1
Illinois	9	1	Texas[b]	0	0
Indiana	2	0	Utah[b]	0	0
Kansas[b]	0	0	Virginia[a]	0	0
Kentucky	11	0	West Virginia	1	0
Louisiana[b]	0	0	Wyoming[b]	0	0
Michigan[b]	0	0	Federal Offshore[a]	0	0
Mississippi[b]	0	0	Miscellaneous[c]	0	0

[a]Sampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.
[b]Sampling was not used. Estimates for each operator were made using an imputation function.
[c]Includes Arizona, Missouri, Nevada, New York, South Dakota, Tennessee, and Virginia.
Notes: Confidence intervals are associated with Table 6 reserves and production data.
Factors for confidence intervals for each State and the United States are independently estimated and do not add.
Source: Factor estimates based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004.

Table F8. Factors for Confidence Intervals (2S.E.) for Natural Gas Proved Reserves and Production, Wet After Lease Separation, 2004 (Billion Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

State and Subdivision	2004 Reserves	2004 Production	State and Subdivision	2004 Reserves	2004 Production
United States	392	36	New Mexico[b]	0	0
Alabama[b]	0	0	New York	82	7
Alaska[a]	0	0	North Dakota[b]	0	0
Arkansas[b]	0	0	Ohio	136	14
California[b]	0	0	Oklahoma[b]	0	0
Colorado[b]	0	0	Pennsylvania	309	27
Florida[a]	0	0	Texas[b]	0	0
Kansas[b]	0	0	Utah[b]	0	0
Kentucky	30	3	Virginia[a]	0	0
Louisiana[b]	0	0	West Virginia	37	3
Michigan[b]	0	0	Wyoming[b]	0	0
Mississippi[b]	0	0	Federal Offshore[a c]	0	0
Montana[b]	0	0	Miscellaneous[d]	7	1

[a]Sampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.
[b]Sampling was not used. Estimates for each operator were made using an imputation function.
[c]Includes Federal offshore Alabama.
[d]Includes Arizona, Illinois, Indiana, Maryland, Missouri, Nebraska, Nevada, Oregon, South Dakota, and Tennessee.
Notes: Confidence intervals are associated with Table 8 reserves and production data.
Factors for confidence intervals for each State and the United States are independently estimated and do not add.
Source: Factor estimates based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2004

To generate estimates for each element in the reserves balance for plant liquids in a given producing area, the first step was to group all natural gas processing plants that reported this area as an area-of-origin on their Form EIA-64A, and then sum the liquids production attributed to this area over all respondents. Next, the ratio of the liquids production to the total wet natural gas production for the area was determined. This ratio represented the percentage of the wet natural gas that was recovered as natural gas liquids. Finally, it was assumed that this ratio was applicable to the reserves and each component of reserve changes (except adjustments), as well as production. Therefore, each element in the wet natural gas reserves balance was multiplied by this recovery factor to yield the corresponding estimate for plant liquids. Adjustments of natural gas liquids were set equal to the difference between the end of previous year reserve estimates, based upon the current report year Form EIA-23 and Form EIA-64A surveys, and the end of current year reserve estimates published in the preceding year's annual reserves report.

Natural Gas Reserve Balance

This procedure involved downward adjustments of the natural gas data, wet after lease separation, in estimating the volumes of natural gas on a fully dry basis. These reductions were based on estimates of the gaseous equivalents of the liquids removed (in the case of production), or expected to be removed (in the case of reserves), from the natural gas stream at natural gas processing plants. Form EIA-64A collected the volumetric reduction, or shrinkage, of the input natural gas stream that resulted from the removal of the NGL at each natural gas processing plant.

The shrinkage volume was then allocated to the plant's reported area or areas of origin. Because shrinkage is, by definition, roughly in proportion to the NGL recovered, i.e. the NGL produced, the allocation was in proportion to the reported NGL volumes for each area of origin. However, these derived shrinkage volumes were rejected if the ratio between the shrinkage and the NGL production (gas equivalents ratio) fell outside certain limits of physical accuracy. The ratio was expected to range between 1.558 MMCF per thousand barrels (where NGL consists primarily of ethane) and 0.940 MMCF per thousand barrels (where NGL consists primarily of natural gasolines). When the computed gas equivalents ratio fell outside these limits, an imputed ratio was utilized to estimate the plant's natural gas shrinkage allocation to each reported area of origin.

This imputed ratio was that calculated for the aggregate of all other plants reporting production and shrinkage, and having a gas equivalent ratio within the aforesaid limits, from the area in question. The imputed area ratio was applied only if there were at least five plants to base its computation on. If there were less than five plants, the imputed ratio was calculated based on all plants in the survey whose individual gas equivalents ratio was within the acceptable limits. Less than one percent of the liquids production was associated with shrinkage volumes imputed in this manner. Based on the 2004 Form EIA-64A survey, the national weighted average gas equivalents ratio was computed to be 1,401 cubic feet of natural gas shrinkage per barrel of NGL recovered. The total shrinkage volume (reported plus imputed) for all plants reporting a given area of origin was then subtracted from the estimated value of natural gas production, wet after lease separation, yielding dry natural gas production for the area. The amount of the reduction in the wet natural gas production was then expressed as a percentage of the wet natural gas production. Dry natural gas reserves and reserve changes were determined by reducing the wet natural gas reserves and reserve changes by the same percentage reduction factor.

A further refinement of the estimation process was used to generate an estimate of the natural gas liquids reserves in those States with coalbed methane fields. The States where this procedure was applied were Alabama, Colorado, Kansas, New Mexico, Oklahoma, Pennsylvania, Utah, Virginia, West Virginia, and Wyoming. The first step in the process was to identify all Form EIA-23 reported coalbed methane fields. Coalbed methane fields contain no extractable natural gas liquids. Therefore, when the normal shrinkage procedure was applied to the wet gas volume reserve components, the estimate of State coalbed methane volumes were excluded and were not reduced for liquid extraction. Following the computation for shrinkage, each coalbed field gas volume reserve components was added back to each of the dry gas volume reserve components in a State. The effect of this is that the large increases in reserves in some States from coalbed methane fields did not cause corresponding increases in the State natural gas liquids proved reserves.