

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 2005. 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 2004 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 2006 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 2005 for any product class.
- 4 percent for each State/subdivision having less than 1 percent of estimated U.S. reserves or production in 2005 (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 2005.
- **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 2005, and additionally, all coalbed methane and Federal Offshore operators.
- **Category III - Small Operators:** Operators who produced less than the Category II operators in 2005.

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.
- 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.

Table F1. 2006 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	5	0.040	0.025
Alaska	7	0	0		
Arkansas	64	10	9	0.040	0.025
California - Coastal Region Onshore	14	1	1	0.080	0.080
California - Los Angeles Basin Onshore	13	2	2	0.010	0.010
California - San Joaquin Basin Onshore	42	4	4	0.025	0.040
Colorado	121	2	18	0.025	0.010
Florida	4	0	0	0.025	0.025
Illinois	28	45	34	0.040	0.040
Indiana	23	7	33	0.040	0.080
Kansas	165	53	52	0.040	0.080
Kentucky	32	23	18	0.025	0.010
Louisiana-North	124	19	22	0.040	0.040
Louisiana-South Onshore	182	9	25	0.010	0.010
Michigan	33	6	3	0.010	0.010
Mississippi - Onshore	79	2	11	0.040	0.040
Montana	67	1	4	0.040	0.040
Nebraska	24	1	11	0.040	0.040
New Mexico - East	157	0	27	0.040	0.080
New Mexico - West	47	3	1	0.025	0.025
New York	15	2	7	0.025	0.010
North Dakota	65	0	6	0.080	0.040
Ohio	25	33	14	0.040	0.040
Oklahoma	268	131	79	0.040	0.040
Pennsylvania	46	18	12	0.025	0.025
Texas - RRC District 1	142	30	39	0.040	0.040
Texas - RRC District 2 Onshore	188	2	37	0.025	0.025
Texas - RRC District 3 Onshore	276	25	61	0.040	0.025
Texas - RRC District 4 Onshore	212	13	34	0.025	0.025
Texas - RRC District 5	107	3	20	0.040	0.010
Texas - RRC District 6	178	7	40	0.040	0.010
Texas - RRC District 7B	169	38	98	0.025	0.010
Texas - RRC District 7C	159	1	55	0.025	0.025
Texas - RRC District 8	189	1	46	0.040	0.025
Texas - RRC District 8A	174	9	54	0.010	0.010
Texas - RRC District 9	164	44	83	0.010	0.040
Texas - RRC District 10	141	15	31	0.025	0.025
Utah	56	3	2	0.040	0.010
Virginia	22	0	0	0.040	0.025
West Virginia	38	25	10	0.080	0.040
Wyoming	151	0	10	0.040	0.025
Offshore Areas	322	0	0	0.025	0.025
Other States ^a	46	3	3	0.080	0.080
Total	b1022	592	b383	0.010	0.010

^aIncludes Arizona, Idaho, Iowa, Maryland, Missouri, Nevada, Oregon, South Dakota, Tennessee, and Washington.

^bNonduplicative count of operators by States.

Note: Sampling rate was 10 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.

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 453 operators sampled proportional to size (Table E2) that responded as Category III noncertainty operators. Only 194 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 259 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 (Table F2-F5).

The data reported by operator category on Form EIA-23 and data imputed and estimated for report year 2006 are summarized in **Tables F2, F3, F4, and F5**. The reported data in **Table F2** shows that those responding operators accounted for 90.4 percent of the published production for wet natural gas and 94.5 percent of the

reserves shown in **Table 9**. Data shown in **Table F3** indicate that those responding operators accounted for 90.4 percent of the nonassociated natural gas production and 94.3 percent of the reserves published in **Table 10**. The reported data shown in **Table F4** indicate that those responding operators accounted for 88.1 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 91.8 percent of the published production and 94.5 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:

$$\text{Calculated } P/[P+R] = \text{Beta} * \text{EXP}(\text{Alpha} * \ln(1 + \text{MOS}))$$

- *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 2005 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 2005, 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 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.

Table F2. Summary of Form EIA-23 Reported, Imputed, and Estimated Natural Gas Data for 2006, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	168	427	224	420	9,485	10,724
Proved Reserves as of 12/31/05	168,423,878	33,397,261	71,754	0	0	201,892,893
(+) Revision Increases	17,306,398	3,274,953	4,124	0	0	20,585,475
(-) Revision Decreases	17,759,712	4,661,005	32,328	0	0	22,453,045
(-) Sales	20,900,422	3,012,204	45	0	0	23,912,671
(+) Acquisitions	22,445,453	4,625,322	0	0	0	27,070,775
(+) Extensions	15,437,038	5,671,753	876	0	0	21,109,667
(+) New Field Discoveries	216,759	169,793	500	0	0	387,052
(+) New Reservoirs in Old Fields	753,295	373,524	45	0	0	1,126,864
(-) Production With						
Proved Reserves Reported	14,416,133	3,059,545	11,996	0	0	17,487,674
(-) Production Without						
Proved Reserves Reported	7,162	16,018	0	0	0	23,180
Proved Reserves as of 12/31/06	171,509,399	36,823,576	64,038	0	0	208,397,013
Imputed and Estimated						
Number of Operators	-	-	-	3,096	-	3,096
Proved Reserves as of 12/31/05	-	-	-	-	-	-
(+) Revision Increases	0	0	0	1,627,948	1	1,627,949
(-) Revision Decreases	0	0	0	126,374	10	126,384
(-) Sales	0	0	0	151,668	0	151,668
(+) Acquisitions	0	0	0	274	53	327
(+) Extensions	0	0	0	4,616	373	4,989
(+) New Field Discoveries	0	0	0	617,444	0	617,444
(+) New Reservoirs in Old Fields	0	0	0	11,116	7	11,123
(-) Production With						
Proved Reserves Reported	0	0	0	20,108	17	20,125
(-) Production Without						
Proved Reserves Reported	15,013	32,045	298,476	345,534	1,152,454	1,843,522
Proved Reserves as of 12/31/06	151,038	380,871	2,542,797	3,074,706	5,868,964	12,018,376
Total						
Number of Operators	168	427	224	3,516	9,485	13,820
Proved Reserves as of 12/31/05	168,423,878	33,397,261	71,754	0	0	203,520,841
(+) Revision Increases	17,306,398	3,274,953	4,124	1,627,948	1	22,213,424
(-) Revision Decreases	17,759,712	4,661,005	32,328	126,374	10	22,579,429
(-) Sales	20,900,422	3,012,204	45	151,668	0	24,064,339
(+) Acquisitions	22,445,453	4,625,322	0	274	53	27,071,102
(+) Extensions	15,437,038	5,671,753	876	4,616	373	21,114,656
(+) New Field Discoveries	216,759	169,793	500	617,444	0	1,004,496
(+) New Reservoirs in Old Fields	753,295	373,524	45	11,116	7	1,137,987
(-) Production With						
Proved Reserves Reported	14,416,133	3,059,545	11,996	20,108	17	17,507,799
(-) Production Without						
Proved Reserves Reported	22,175	48,063	298,476	345,534	1,152,454	1,866,702
Proved Reserves as of 12/31/06	171,660,437	37,204,447	2,606,835	3,074,706	5,868,964	220,415,389
Summary						
Total Number of Operators	168	427	224	3,516	9,485	13,820
Percent of Total	1.2%	3.1%	1.6%	25.4%	68.6%	100.0%
Total Production in 2006	14,438,308	3,107,608	310,472	365,642	1,152,471	19,374,501
Percent of Total	74.5%	16.0%	1.6%	1.9%	5.9%	100.0%
Total Proved Reserves 12/31/06	171,660,437	37,204,447	2,606,835	3,074,706	5,868,964	220,415,389
Percent of Total	77.9%	16.9%	1.2%	1.4%	2.7%	100.0%

^aThere were 453 noncertainty responses, 194 were used with their sample weights and 259 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," 2006.

Table F3. Summary of Form EIA-23 Reported, Imputed, and Estimated Nonassociated Natural Gas Data for 2006, Wet after Lease Separation (Million Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxiliary State Data	
Reported						
Number of Operators	168	427	224	420	9,485	10,724
Proved Reserves as of 12/31/05	143,717,198	31,216,588	58,006	0	0	174,991,792
(+) Revision Increases	12,441,499	2,935,760	2,497	0	0	15,379,756
(-) Revision Decreases	15,358,820	4,418,535	26,425	0	0	19,803,780
(-) Sales	19,466,118	2,719,100	45	0	0	22,185,263
(+) Acquisitions	20,659,612	4,447,704	0	0	0	25,107,316
(+) Extensions	14,858,938	5,497,594	876	0	0	20,357,408
(+) New Field Discoveries	182,556	165,085	0	0	0	347,641
(+) New Reservoirs in Old Fields	715,711	349,685	0	0	0	1,065,396
(-) Production With						
Proved Reserves Reported	12,557,479	2,858,572	10,440	0	0	15,426,491
(-) Production Without						
Proved Reserves Reported	6,747	17,023	0	0	0	23,770
Proved Reserves as of 12/31/06	145,195,200	34,657,843	53,505	0	0	179,906,548
Imputed and Estimated						
Number of Operators	-	-	-	3,096	-	3,096
Proved Reserves as of 12/31/05	-	-	-	-	-	-
(+) Revision Increases	0	0	0	1,587,065	1	1,587,066
(-) Revision Decreases	0	0	0	110,025	11	110,036
(-) Sales	0	0	0	147,410	0	147,410
(+) Acquisitions	0	0	0	274	53	327
(+) Extensions	0	0	0	4,616	360	4,976
(+) New Field Discoveries	0	0	0	610,908	0	610,908
(+) New Reservoirs in Old Fields	0	0	0	11,116	6	11,122
(-) Production With						
Proved Reserves Reported	0	0	0	20,108	17	20,125
(-) Production Without						
Proved Reserves Reported	13,938	30,073	288,687	332,698	956,918	1,622,314
Proved Reserves as of 12/31/06	141,076	361,290	2,450,640	2,953,006	4,964,260	10,870,272
Total						
Number of Operators	168	427	224	3,516	9,485	13,820
Proved Reserves as of 12/31/05	143,717,198	31,216,588	58,006	0	0	176,578,857
(+) Revision Increases	12,441,499	2,935,760	2,497	1,587,065	1	16,966,822
(-) Revision Decreases	15,358,820	4,418,535	26,425	110,025	11	19,913,816
(-) Sales	19,466,118	2,719,100	45	147,410	0	22,332,673
(+) Acquisitions	20,659,612	4,447,704	0	274	53	25,107,643
(+) Extensions	14,858,938	5,497,594	876	4,616	360	20,362,384
(+) New Field Discoveries	182,556	165,085	0	610,908	0	958,549
(+) New Reservoirs in Old Fields	715,711	349,685	0	11,116	6	1,076,518
(-) Production With						
Proved Reserves Reported	12,557,479	2,858,572	10,440	20,108	17	15,446,616
(-) Production Without						
Proved Reserves Reported	20,685	47,096	288,687	332,698	956,918	1,646,084
Proved Reserves as of 12/31/06	145,336,276	35,019,133	2,504,145	2,953,006	4,964,260	190,776,820
Summary						
Total Number of Operators	168	427	224	3,516	9,485	13,820
Percent of Total	1.2%	3.1%	1.6%	25.4%	68.6%	100.0%
Total Production in 2006	12,578,164	2,905,668	299,127	352,806	956,935	17,092,700
Percent of Total	73.6%	17.0%	1.8%	2.1%	5.6%	100.0%
Total Proved Reserves 12/31/06	145,336,276	35,019,133	2,504,145	2,953,006	4,964,260	190,776,820
Percent of Total	76.2%	18.4%	1.3%	1.5%	2.6%	100.0%

^aThere were 453 noncertainty responses, 194 were used with their sample weights and 259 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," 2006.

Table F4. Summary of Form EIA-23 Reported, Imputed, and Estimated Crude Oil Data for 2006,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	168	427	224	420	9,485	10,724
Proved Reserves as of 12/31/05	18,910,624	1,497,104	14,348	0	0	20,422,076
(+) Revision Increases	1,128,749	354,685	763	0	0	1,484,197
(-) Revision Decreases	1,363,587	140,374	3,200	0	0	1,507,161
(-) Sales	817,259	166,859	0	0	0	984,118
(+) Acquisitions	957,488	217,684	48	0	0	1,175,220
(+) Extensions	420,329	62,395	146	0	0	482,870
(+) New Field Discoveries	22,780	4,892	901	0	0	28,573
(+) New Reservoirs in Old Fields	25,315	14,750	17	0	0	40,082
(-) Production With						
Proved Reserves Reported	1,316,485	136,772	2,354	0	0	1,455,611
(-) Production Without						
Proved Reserves Reported	0	609	0	0	0	609
Proved Reserves as of 12/31/06	17,968,311	1,707,959	14,762	0	0	19,691,032
Imputed and Estimated						
Number of Operators	-	-	-	3,096	-	3,096
Proved Reserves as of 12/31/05	-	-	-	-	-	-
(+) Revision Increases	0	0	0	20,747	5	20,752
(-) Revision Decreases	0	0	0	1,483	56	1,539
(-) Sales	0	0	0	2,858	0	2,858
(+) Acquisitions	0	0	0	0	32	32
(+) Extensions	0	0	0	0	20,084	20,084
(+) New Field Discoveries	0	0	0	528	4	532
(+) New Reservoirs in Old Fields	0	0	0	0	2,456	2,456
(-) Production With						
Proved Reserves Reported	0	0	0	0	19,787	19,787
(-) Production Without						
Proved Reserves Reported	1,398	6,311	12,331	20,040	137,036	177,116
Proved Reserves as of 12/31/06	23,611	66,330	123,372	213,313	857,835	1,284,461
Total						
Number of Operators	168	427	224	3,516	9,485	13,820
Proved Reserves as of 12/31/05	18,910,624	1,497,104	14,348	0	0	20,442,823
(+) Revision Increases	1,128,749	354,685	763	20,747	5	1,504,949
(-) Revision Decreases	1,363,587	140,374	3,200	1,483	56	1,508,700
(-) Sales	817,259	166,859	0	2,858	0	986,976
(+) Acquisitions	957,488	217,684	48	0	32	1,175,252
(+) Extensions	420,329	62,395	146	0	20,084	502,954
(+) New Field Discoveries	22,780	4,892	901	528	4	29,105
(+) New Reservoirs in Old Fields	25,315	14,750	17	0	2,456	42,538
(-) Production With						
Proved Reserves Reported	1,316,485	136,772	2,354	0	19,787	1,475,398
(-) Production Without						
Proved Reserves Reported	1,398	6,920	12,331	20,040	137,036	177,725
Proved Reserves as of 12/31/06	17,991,922	1,774,289	138,134	213,313	857,835	20,975,493
Summary						
Total Number of Operators	168	427	224	3,516	9,485	13,820
Percent of Total	1.2%	3.1%	1.6%	25.4%	68.6%	100.0%
Total Production in 2006	1,317,883	143,692	14,685	20,040	156,823	1,653,123
Percent of Total	79.7%	8.7%	0.9%	1.2%	9.5%	100.0%
Total Proved Reserves 12/31/06	17,991,922	1,774,289	138,134	213,313	857,835	20,975,493
Percent of Total	85.8%	8.5%	0.7%	1.0%	4.1%	100.0%

^aThere were 453 noncertainty responses, 194 were used with their sample weights and 259 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," 2006.

Table F5. Summary of Form EIA-23 Reported, Imputed, and Estimated Lease Condensate Data for 2006,
(Thousand Barrels of 42 U.S. Gallons)

Level of Reporting	Operator Category					Total
	I	II	Certainty III	Noncertainty III	Auxillary State Data	
Reported						
Number of Operators	168	427	224	420	9,485	10,724
Proved Reserves as of 12/31/05	965,527	231,313	193	0	0	1,197,033
(+) Revision Increases	183,570	63,391	47	0	0	247,008
(-) Revision Decreases	149,518	55,065	31	0	0	204,614
(-) Sales	152,665	17,784	0	0	0	170,449
(+) Acquisitions	132,420	33,364	0	0	0	165,784
(+) Extensions	128,187	43,584	0	0	0	171,771
(+) New Field Discoveries	3,496	3,815	0	0	0	7,311
(+) New Reservoirs in Old Fields	10,875	8,570	0	0	0	19,445
(-) Production With						
Proved Reserves Reported	134,695	31,231	88	0	0	166,014
(-) Production Without						
Proved Reserves Reported	30	673	0	0	0	703
Proved Reserves as of 12/31/06	987,311	280,052	190	0	0	1,267,553
Imputed and Estimated						
Number of Operators	-	-	-	3,096	-	3,096
Proved Reserves as of 12/31/05	-	-	-	-	-	-
(+) Revision Increases	0	0	0	16,382	1	16,383
(-) Revision Decreases	0	0	0	2,740	5	2,745
(-) Sales	0	0	0	3,102	0	3,102
(+) Acquisitions	0	0	0	3	13	16
(+) Extensions	0	0	0	0	10,753	10,753
(+) New Field Discoveries	0	0	0	2,075	0	2,075
(+) New Reservoirs in Old Fields	0	0	0	145	7	152
(-) Production With						
Proved Reserves Reported	0	0	0	275	10	285
(-) Production Without						
Proved Reserves Reported	68	156	2,537	2,761	9,566	15,088
Proved Reserves as of 12/31/06	652	898	17,237	18,787	33,564	71,138
Total						
Number of Operators	168	427	224	3,516	9,485	13,820
Proved Reserves as of 12/31/05	965,527	231,313	193	0	0	1,213,415
(+) Revision Increases	183,570	63,391	47	16,382	1	263,391
(-) Revision Decreases	149,518	55,065	31	2,740	5	207,359
(-) Sales	152,665	17,784	0	3,102	0	173,551
(+) Acquisitions	132,420	33,364	0	3	13	165,800
(+) Extensions	128,187	43,584	0	0	10,753	182,524
(+) New Field Discoveries	3,496	3,815	0	2,075	0	9,386
(+) New Reservoirs in Old Fields	10,875	8,570	0	145	7	19,597
(-) Production With						
Proved Reserves Reported	134,695	31,231	88	275	10	166,299
(-) Production Without						
Proved Reserves Reported	98	829	2,537	2,761	9,566	15,791
Proved Reserves as of 12/31/06	987,963	280,950	17,427	18,787	33,564	1,338,691
Summary						
Total Number of Operators	168	427	224	3,516	9,485	13,820
Percent of Total	1.2%	3.1%	1.6%	25.4%	68.6%	100.0%
Total Production in 2006	134,793	32,060	2,625	3,036	9,576	182,090
Percent of Total	74.0%	17.6%	1.4%	1.7%	5.3%	100.0%
Total Proved Reserves 12/31/06	987,963	280,950	17,427	18,787	33,564	1,338,691
Percent of Total	73.8%	21.0%	1.3%	1.4%	2.5%	100.0%

^aThere were 453 noncertainty responses, 194 were used with their sample weights and 259 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.

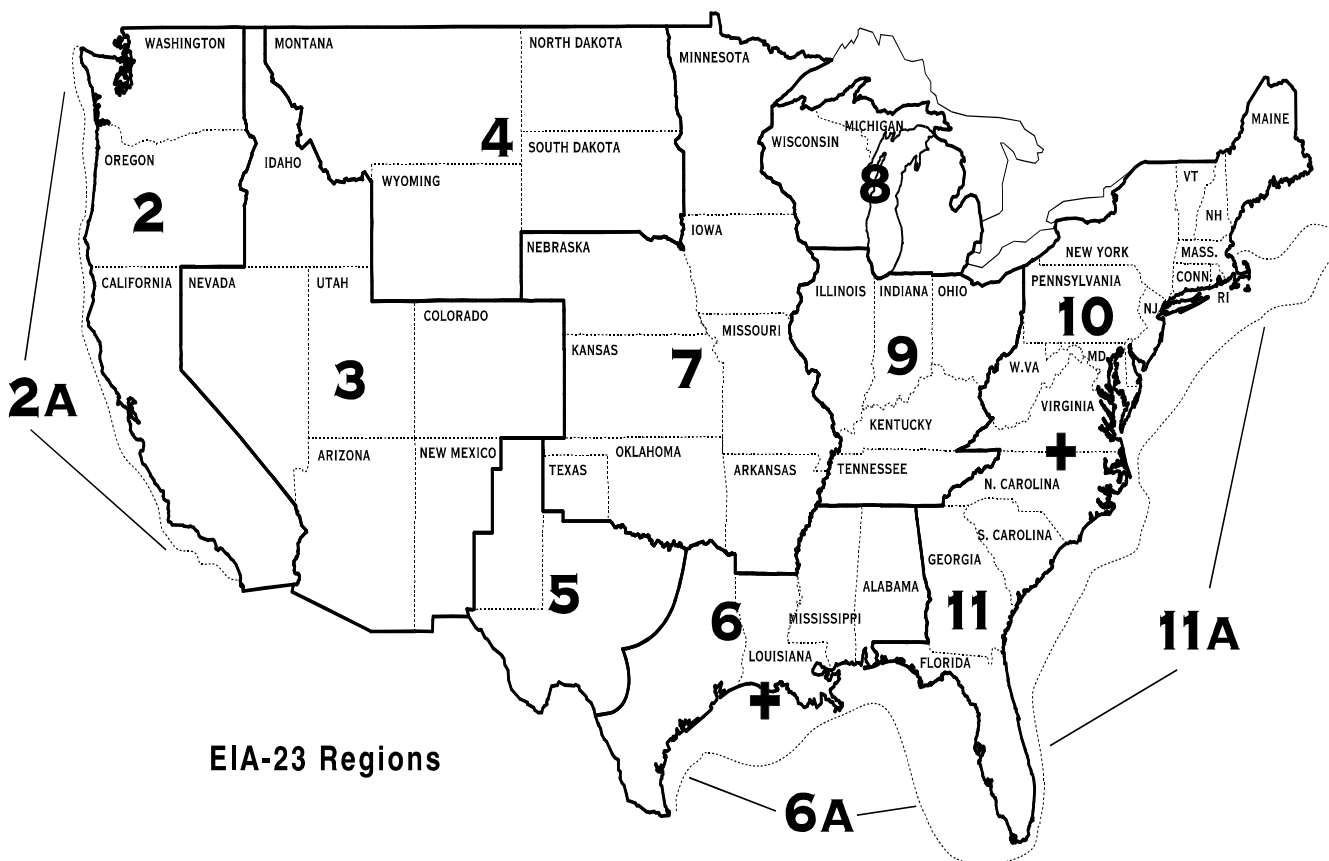
Source: Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves," 2006.

Table F6. Statistical Parameters of Reserves Estimation Equation by Region for 2006

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	6	10	-	-0.1373	0.3427	-0.1486	0.2435	0.0000	0.0000
2	Pacific Coast States	46	57	7	-0.1373	0.2897	-0.1486	0.4199	-0.1224	0.1432
2A	Federal Offshore Pacific	7	7	-	-0.1373	0.2451	-0.1486	0.2284	0.0000	0.0000
3	Western Rocky Mountains	78	136	62	-0.1373	0.2014	-0.1486	0.3279	-0.1224	0.3288
4	Northern Rocky Mountains	163	170	52	-0.1373	0.2619	-0.1486	0.3508	-0.1224	0.2658
5	West Texas and East New Mexico	484	482	171	-0.1373	0.2612	-0.1486	0.3643	-0.1224	0.4047
6	Western Gulf Basin.	508	839	561	-0.1373	0.3344	-0.1486	0.4438	-0.1224	0.4958
6A	Gulf of Mexico	73	130	101	-0.1373	0.4985	-0.1486	0.8075	-0.1224	0.7175
7	Mid-Continent	293	378	141	-0.1373	0.2783	-0.1486	0.3686	-0.1224	0.2943
8 + 9	Michigan Basin and Eastern Interior	78	64	16	-0.1373	0.2028	-0.1486	0.1849	-0.1224	0.4602
10 + 11	Appalachians	26	80	13	-0.1373	0.1988	-0.1486	0.1785	-0.1224	0.2935
	United States	1,762	2,353	1,124	-0.1373	0.3292	-0.1486	0.3940	-0.1224	0.4567

Source: Based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves, 2006".

Figure F1. Form EIA-23 Regional Boundaries



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

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

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

The algebraic allocation method used for all but six states in the 2006 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:

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 2006 than in 2005.
- One or more operators may have reported data incorrectly on Schedule A in 2006 or 2005, but not both, and the error was not detected by edit processing.
- Operation of properties was transferred during 2006 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 V_s and its sampling error by $S.E.(V_s)$, the confidence interval can be expressed as:

$$V_s \pm k S.E.(V_s)$$

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:

$$V_s \pm 2 S.E.(V_s)$$

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 $2S.E.(V_s)$ 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 $211,085 \pm 59$ billion cubic feet. The sampling error of V_s is equal to the sampling error of the noncertainty estimate 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 2006 survey was 4.2 percent and for the noncertainty operators 7.3 percent. An imputation was made for the production and reserves for the 33 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 2006 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, 6.1 percent of the crude oil proved reserve estimates, 5.5 percent of the wet natural gas proved reserve estimates, and 5.5 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.

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

Table F7. Factors for Confidence Intervals (2S.E.) for Crude Oil Proved Reserves and Production, 2006
(Million Barrels of 42 U.S. Gallons)

State and Subdivision	2006 Reserves	2006 Production	State and Subdivision	2006 Reserves	2006 Production
United States	5	1	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 ^b	0	0
Colorado ^b	0	0	Oklahoma ^b	0	0
Florida ^a	0	0	Pennsylvania	0	0
Illinois	0	0	Texas ^b	0	0
Indiana	0	0	Utah ^b	0	0
Kansas ^b	0	0	Virginia ^a	0	0
Kentucky	0	0	West Virginia	0	0
Louisiana ^b	0	0	Wyoming ^b	0	0
Michigan ^b	0	0	Federal Offshore ^a	0	0
Mississippi ^b	0	0	Miscellaneous ^c	2	0

^aSampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.

^bSampling was not used. Estimates for each operator were made using an imputation function.

^cIncludes Arizona, Missouri, Nevada, 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," 2006.

Table F8. Factors for Confidence Intervals (2S.E.) for Natural Gas Proved Reserves and Production, Wet After Lease Separation, 2006 (Billion Cubic Feet at 14.73 psia and 60 Degrees Fahrenheit)

State and Subdivision	2006 Reserves	2006 Production	State and Subdivision	2006 Reserves	2006 Production
United States	59	5	New Mexico ^b	0	0
Alabama ^b	0	0	New York ^b	0	0
Alaska ^a	0	0	North Dakota ^b	0	0
Arkansas ^b	0	0	Ohio ^b	0	0
California ^b	0	0	Oklahoma ^b	0	0
Colorado ^b	0	0	Pennsylvania	7	1
Florida ^a	0	0	Texas ^b	0	0
Kansas ^b	0	0	Utah ^b	0	0
Kentucky	0	0	Virginia ^a	0	0
Louisiana ^b	0	0	West Virginia	10	1
Michigan ^b	0	0	Wyoming ^b	0	0
Mississippi ^b	0	0	Federal Offshore ^{a c}	0	0
Montana ^b	0	0	Miscellaneous ^d	4	0

^aSampling rate was 100 percent in Alaska, Florida Onshore, Virginia, and Offshore areas.

^bSampling was not used. Estimates for each operator were made using an imputation function.

^cIncludes Federal offshore Alabama.

^dIncludes 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," 2006

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 2006 Form

EIA-64A survey, the national weighted average gas equivalents ratio was computed to be 1,421 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.