Appendix: 2012 Proved Reserves Estimation Methodology

Introduction

The U.S. Energy Information Administration (EIA) report, U.S. Crude Oil and Natural Gas Proved Reserves, 2012, provides reliable estimates of U.S. natural gas, crude oil, and lease condensate proved reserves as of December 31, 2012. The estimates within the report are based on data filed on Form EIA-23, "Annual Survey of Domestic Oil and Gas Reserves". Because the Form EIA-23 is a sample survey, not a census, of operators of U.S. oil and gas fields, EIA performs additional procedures to develop its final estimates from the subtotal of reported data. Descriptions of the sample design and the estimation procedures are given below, along with other statistical considerations.

Sample design

The Form EIA-23 implements an annual cutoff sample survey of operators of crude oil and natural gas wells. The survey provides data that are used to estimate the quantity of proved reserves of crude oil, lease condensate, associated-dissolved natural gas, and nonassociated natural gas on an annual basis by state and subdivision. Estimates of proved reserves are also generated separately for shale natural gas and coalbed natural gas.

Sample universe. The universe of currently active oil and natural gas well operators in the United States contains roughly 13,000 operators. Although the larger well operators are quite well-known to EIA, they comprise only a small portion of all operators. The small well operators are not well-known and are difficult to identify, because they go into and out of business more easily, frequently alter their corporate identities, make relatively large property sales and acquisitions that significantly change their size, and often change addresses. EIA uses commercial vendors of production data, such as Drilling Info (DI), and operator data from state regulatory agencies, to build and maintain the EIA-23 survey frame.

Sampling plan. Beginning with the collection of 2012 data, the EIA changed the sample design from a combined certainty stratum and probability-proportional-to-size (PPS) to a cutoff sample in order to reduce respondent burden and decrease processing costs. As part of using the cutoff sample design, a model-based estimation procedure must be used. The skewness of the proved reserves reported within the regions of interest is sufficiently large to enable a cutoff design that will maintain estimates of similar quality as under the previous sample design.

Sampling is done by region. These regions are defined by EIA based on publication needs and geological characteristics. All operators producing a quantity of gas or liquids above a predefined value in a particular region are included in the sample for that region. When an operator is sampled in one region, their data is collected for all regions. This causes operators producing below the cutoff in certain regions to be included in the sample for that region.

As part of the model-based estimation procedure, relative standard errors (RSE) will be calculated on the estimates of proved reserves. A standard error of an estimate is a statistical measure that indicates how an estimate derived from a sample may vary compared to the result of a complete enumeration. In each region, the cutoff is determined by adding the largest operators in a region to the sample until the expected RSE of the region's estimated reserves falls below 5%. The exception to this rule is if the

operator produces less than 500 barrels of liquids per day and 300 thousand cubic feet (Mcf) per day of natural gas. The last operator sampled determines the regional cutoff.

The former certainty stratum plus PPS design typically yielded a sample of 1,200 respondents, while the new cutoff sample design yields fewer than 800 respondents. The quantity of operators sampled by state is shown in Table 1. This quantity includes operators that were added to the sample because of their production volumes in other states.

Table 1. Quantity of operators sampled by State, 2012

State and Subdivision	Operators Sampled
Alaska South State Offshore	6
Alaska South Onshore	7
Alaska North Slope	6
Alabama	35
Alabama State Offshore	4
Arkansas	42
Arizona	1
California State Offshore	5
California San Joaquin Basin Onshore	25
California Coastal Region Onshore	17
California Los Angeles Basin Onshore	16
Colorado	83
Florida	3
Illinois	18
Indiana	19
Kansas	125
Kentucky	20
Louisiana State Offshore	31
Louisiana South Onshore	125
Louisiana North	84
Maryland	4
Michigan	34
Missouri	1
Mississippi	56
Montana	55
North Dakota	63
Nebraska	17
New Mexico East	93
New Mexico West	20
Nevada	2
New York	22
Ohio	56
Oklahoma	141
Oregon	1
Pennsylvania	55
South Dakota	6
Tennessee	6
Texas State Offshore	15
Texas RRC District 1	106
Texas RRC District 2 Onshore	120
Texas RRC District 3 Onshore	171
Texas RRC District 4 Onshore	114
Texas RRC District 5	80
Texas RRC District 6	118
Texas RRC District 7B	85
Texas RRC District 7C	105
Texas RRC District 8	134
Texas RRC District 8A	100
Texas RRC District 9	83
Texas RRC District 10	75
Utah	42
Virginia	14
West Virginia	38
Wyoming	90
U.S. Total	**712**[a]

[a]Nonduplicative count of operators by States

Estimation procedures

Estimates of proved reserves. The disseminated estimates of U.S. proved reserves and production are the sum of the estimates for the individual states. Correspondingly, the estimates for the states for which estimates are disseminated separately by subdivision (California, Louisiana, New Mexico, and Texas) are the sum of the subdivision estimates. The remaining states are not subdivided and may be considered as a single subdivision. The cut-off sample accounts for roughly 90% of the U.S. proved reserves for both oil and gas, leaving only 10% to be estimated.

Production data from other sources (DI or the state regulatory agencies) are used to estimate proved reserves for the non-surveyed operators. Reserve estimates for the non-surveyed operators are performed at the operator/field level. The estimates are created using weighted least squares to fit an equation relating field production to reserves. Operators are grouped into geological provinces, and the equation is fitted separately for each province.

Estimation groups are developed by geologic provinces to benefit from the inherently higher geologic affinity and more similar stage of resource development that these provinces provide. The boundaries of the geologic provinces used for this purpose are similar to the province and basin boundaries developed by the United States Geological Survey (viewable at http://certmapper.cr.usgs.gov/geoportal/catalog/search/browse/browse.page). A total of 45 geologic provinces are identified, although only about 40 regions are used in practice. Some provinces are combined because they have too few operator/fields for sufficient statistical rigor when analyzed individually.

Use of this estimation procedure reduces reporting and analysis burden by minimizing the number of operators that have to be surveyed. Since the statistical distributions of production and proved reserves are to a significant degree positively skewed, weighted linear regression estimation is used to reduce a propensity for dominance of the provincial fit by the largest operators and largest fields, which can often have higher reserves/production ratios. The weight is defined as the squared inverse of the operator/field's size or annual production.

The following ratio estimation function is used in the provincial estimation models:

Equation 1. Ratio estimation function

$$R_{FP} = \beta * P_{FP}$$

where:

R_{FP} = Operator's Year-End Reserves in Field (F) in Province (P),

P_{FP} = Operator's Annual Production in Field (F) in Province (P), and

β = fit parameter determined by weighted least squares.

For each geologic province, ratio estimation functions were derived for conventional liquids production and conventional gas production, using Equation 1. Three more functions are derived for shale natural gas, coalbed natural gas, and tight oil. Operators that report a reserve-to-production ratio greater than 50 are excluded from the calculation of the province coefficients. (Note that the aforementioned situation is rare—the reported values of this type are typically based on less than a full year's production.)

The ratio function is applied to data for non-sampled operators from DI, or operator/field production data from the states, to estimate the proved reserves of non-surveyed operators in all states except Illinois, Indiana, and Tennessee. Current production information is not available in these three states, so the same estimation procedure described above is not applicable.

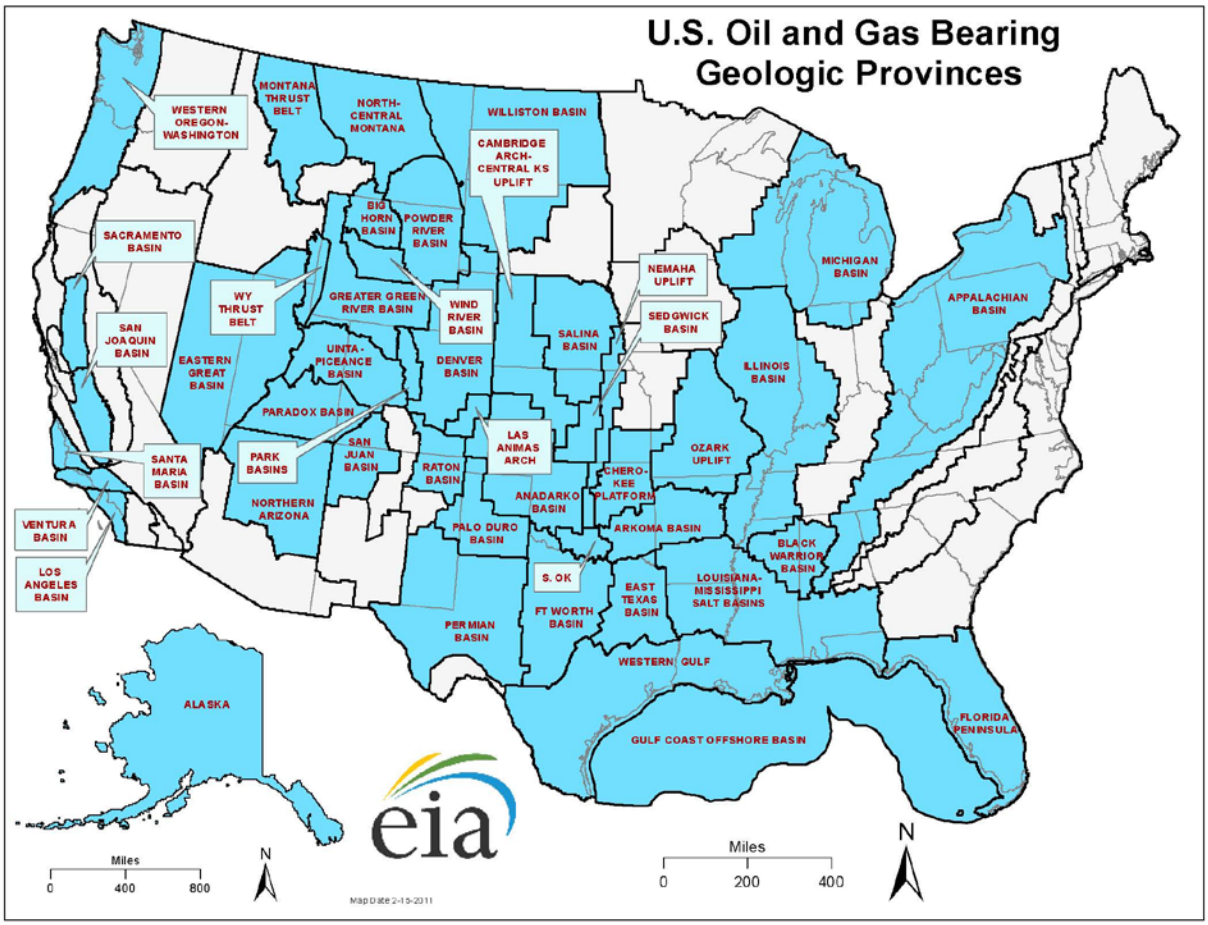
Determining which operators in the data from DI and the states were non-sampled is complicated by differences in reporting between the sources. As a result, EIA looks at each region (state, subdivision, geological province, and reservoir type) separately. If the total surveyed production in that region was greater than or equal to the production reported by the frame data, no estimation is done. If the surveyed production is less than the production reported in the frame data, the ratio function is applied to enough of the smallest operators in the frame to account for the difference.

Obtaining operator production data for the smaller oil and gas producing states of Tennessee, Illinois, and Indiana requires an alternative approach to using DI data, because DI excludes these states or the data are not current. Samples of operators in these states must be built from lists of oil and gas companies licensed to do business in the state, internet searches, and past reports on the Forms EIA-23L and EIA-23S. Because production data are not current or not available, the sampling process described in the previous section cannot be used. Reported reserves for these states are included under "Miscellaneous" as reported without any estimation or imputation.

The largest operators in the states of Illinois, Indiana, and Tennessee are identifiable. However, the frame will be incomplete and may be insufficient to reliably estimate reserves for non-sampled operators. These three states, when combined, are estimated to hold less than 0.5% of U.S. total oil and condensate reserves and less than 1.0% of U.S. total natural gas reserves.

Figure 1 shows the map of geologic provinces used to group the reported data and estimate proved reserves for the non-sampled operators. The reported reserves and the estimated reserves are summed to the field level. The field level reserves are then summed to the state/subdivision level, which is then summed to the U.S. level.

Figure 1. U.S. Oil and gas bearing geologic provinces



Estimating reserves balancing categories. Three of the seven proved reserves balancing categories (new field discoveries, sales of existing fields, acquisitions of existing fields) are disseminated as reported with no estimation. The remaining four reserves balancing categories (revision increases, revision decreases, extensions, and new reservoirs discovered in old fields) have an estimate portion within the disseminated total. Each category is assumed to have the same relationship to estimated year-end reserves as the reported proved reserves balancing categories have to the reported year-end reserves. Ratios for the total reported category in a state are applied to the estimated reserves volumes to calculate the estimated category total. Estimated reserves balancing categories will have the same proportion to estimated year-end reserves as do the reported volumes.

The instructions for Form EIA-23L specify that, when reporting proved reserves balance data, the following arithmetic equation applies:

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
=	**Proved reserves at end of report year**

Any remaining difference in the annual proved reserves balance between the disseminated previous reporting year-end proved reserves and current reporting year-end proved reserves, not accounted for by the estimated proved reserves changes, is included in the adjustments for the area.

Reasons for more substantial adjustments to the annual proved reserves balance may include any combination of the following:

- The frame sample coverage may or may not have improved between survey years, such that more or fewer operators were included in the reporting year than the previous year.
- One or more operators may have reported data incorrectly in one reporting year or the next, but not both, and the error was not detected by data validation/edit rules processing.
- Operation of properties was transferred during the reporting year from operators not in the frame, or operators not selected for the sample, to surveyed operators.
- Operation of properties was transferred during the reporting year to an operator with a different evaluation of the proved reserves associated with the properties than that of the previous year's operator.
- The respondent changed the classification of their natural gas from nonassociated gas to associated-dissolved gas, or vice versa.
- The trend in reserve changes imputed for the non-sampled operators, which was based on the trend reported by the sampled operators, did not reflect the actual trend for the non-sampled operators.

The causes for adjustments are known for some but not all instances of imbalance. The only problems for which the effects cannot be expected to balance over a period of several years are problems associated with an inadequate survey frame or with any actual trend in reserve changes for non-sampled operators not being the same as the reserve changes for sampled operators. EIA continues to attempt to improve sources of operator data to resolve problems in frame completeness.

Tables 2 through 7 show the quantities of reserves and balancing categories estimated and reported.

Table 2. Nonassociated natural gas, reported and imputed, wet after lease separation, 2012

billion cubic feet

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	305,986	34,343	81,869	8,819	5,941	37,023	629	179	22,704	-1,195	269,514
Reported	287,124	32,253	77,327	8,819	5,941	34,746	629	170	20,731	-402	253,584
Estimated	18,862	2,090	4,542	0	0	2,277	0	9	1,973	-793	15,930

Table 3. Associated-dissolved natural gas, reported and imputed, wet after lease separation, 2012

billion cubic feet

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	42,823	8,162	6,250	1,131	2,150	10,030	151	229	3,393	385	53,156
Reported	39,555	7,596	5,713	1,131	2,150	9,223	151	218	2,983	570	49,634
Estimated	3,268	566	537	0	0	807	0	11	410	-185	3,522

Table 4. Crude oil reported and imputed, 2012

million barrels

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	26,544	4,319	3,384	734	1,150	4,462	53	122	2,112	109	30,529
Reported	24,732	4,024	3,174	734	1,150	4,168	53	119	1,885	131	28,587
Estimated	1,812	295	210	0	0	294	0	3	227	-22	1,942

Table 5. Lease condensate reported and imputed, 2012

million barrels

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	2,406	590	613	85	84	729	2	7	274	28	2,874
Reported	2,165	550	567	85	84	692	2	7	246	68	2,673
Imputed	241	40	46	0	0	37	0	0	28	-40	201

Table 6. Shale natural gas reported and imputed, wet after lease separation, 2012

billion cubic feet

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	131,616	17,469	42,706	1,785	1,807	32,359	353	128	10,371	526	129,396
Reported	131,616	16,326	40,731	1,785	1,807	30,290	353	124	9,511	-5,982	122,508
Estimated	0	1,143	1,975	0	0	2,069	0	4	860	6,508	6,888

Table 7. Coalbed natural gas reported and imputed, wet after lease separation, 2012

billion cubic feet

	Proved Reserves as of 12/31/2011	Revision Increases	Revision Decreases	Sales	Acquisitions	Extensions	New Field Discoveries	New Reservoirs in Old Fields	Production	Adjustments	Proved Reserves as of 12/31/2012
Total	16,817	971	3,871	200	36	166	0	0	1,655	1,327	13,591
Reported	15,999	847	3,112	200	36	147	0	0	1,419	-366	11,933
Estimated	818	124	759	0	0	19	0	0	236	1,693	1,658

Imputation for nonresponse

Unit and item nonresponse on the EIA-23 is imputed for using the same ratio function that is applied to unsampled operators. The error in this imputation is included in the estimate of sampling uncertainty given in the following section, although nonresponse bias is not evaluated.

Data reliability

The annual data published in this report are subject to two sources of error—nonsampling error and sampling error. Nonsampling errors occur in the collection and processing of the data. Sampling error may be defined as the difference between the results obtained from a sample and the results that a complete enumeration would provide. The standard error statistic is a measurement of this sampling error.

Standard errors. A standard error of an estimate is a statistical measure that indicates how the estimate from the sample compares to the result from a complete enumeration. When presented as a percentage of the estimated total, it is called the relative standard error (RSE).

The RSEs for estimated proved reserves by state and subdivision are given in Tables 8-10. They are constructed so that over the long run the true value is within two RSEs of its estimate 95% of the time. The relative standard error of an estimate is the square root of the variance of the estimate divided by the estimate. For the Ratio Estimation Function (Equation 1), the formula for calculating the variance of the reserves estimate is:

Equation 1: Variance Calculation

$$Var(R_s) = \sum_{g=1}^{G} \left\{ \frac{\hat{\sigma}_g^2}{n_g} \left(\sum_{i=n_{sg}+1}^{N_{sg}} x_{isg} \right)^2 + \hat{\sigma}_g^2 \left(\sum_{i=n_{sg}+1}^{N_{sg}} x_{isg}^2 \right) \right\}$$

where:

R_s= The total reserves for state 's' of a product (gas, for instance).

$\hat{\sigma}_g^2 = \frac{1}{n_g - 1} \sum_{i=1}^{n_g} \frac{\left(R_{ig} - \hat{\beta}_g x_{ig}\right)^2}{x_{ig}^2}$ is the weighted sum of squared errors in geologic province 'g'.

n_g= The number of sampled operators in geologic province 'g'.

N_{sg}= The number of operators in the frame for state/subdivision 's' and geologic province 'g'.

n_{sg}= The number of sampled operators in state/subdivision 's' and geologic province 'g'.

x_{isg}= The production for operator 'i' in state/subdivision 's' and geologic province 'g'.

G = The number of geologic provinces in state/subdivision 's'.

R_{ig}= The reported reserves of operator 'i' in geologic province 'g'.

$\hat{\beta}_g$= The ratio coefficient for geologic province 'g' estimated by weighted least squares.

x_{ig}^2= The production for operator 'i' in geologic province 'g'.

RSEs on the end of year reserves 12/31/2012 estimates are presented in tables 8, 9, and 10.

Table 8 corresponds to the official report tables 10, 11, and 12.
Table 9 corresponds to the official report tables 6, 7, and 8.
Table 10 corresponds to the official report tables 14 and 16.

Table 8. Natural gas proved reserves RSEs

State/Subdivision	Total Gas RSE	Nonassociated Gas RSE	Associated-dissolved Gas RSE
Alaska	NA	NA	NA
Alabama	2.70%	2.60%	21.80%
Arkansas	0.20%	0.10%	15.00%
California	**1.20%**	**4.20%**	**1.00%**
State Offshore	2.20%	0.00%	2.20%
San Joaquin Basin Onshore	1.30%	4.20%	1.10%
Coastal Region Onshore	1.90%	8.60%	1.90%
Los Angeles Basin Onshore	4.10%	83.70%	4.10%
Colorado	1.10%	1.30%	0.10%
Florida	1.30%	0.00%	50.10%
Federal Offshore	**NA**	**NA**	**NA**
Pacific (California)	NA	NA	NA
Gulf of Mexico (Louisiana)	NA	NA	NA
Gulf of Mexico (Texas)	NA	NA	NA
Kansas	1.10%	1.10%	0.00%
Kentucky	0.00%	0.00%	0.00%
Louisiana	**0.30%**	**0.20%**	**4.10%**
State Offshore	8.80%	9.40%	21.10%
South Onshore	0.80%	0.70%	2.70%
North	0.10%	0.10%	6.00%
Michigan	0.00%	0.00%	0.00%
Mississippi	2.40%	2.20%	8.10%
Montana	1.20%	2.10%	0.90%
North Dakota	0.60%	0.90%	0.60%
Nebraska	0.00%	23.70%	47.40%
New Mexico	**0.30%**	**0.40%**	**0.50%**
East	0.20%	0.30%	0.20%
West	0.50%	0.50%	8.10%
New York	5.30%	5.20%	20.00%
Ohio	1.00%	0.90%	2.10%
Oklahoma	0.30%	0.30%	0.50%

State/Subdivision	Total Gas RSE	Nonassociated Gas RSE	Associated-dissolved Gas RSE
Pennsylvania	0.30%	0.30%	3.00%
Texas	**0.50%**	**0.60%**	**0.30%**
State Offshore	0.00%	0.00%	0.00%
RRC District 1	0.10%	0.20%	0.30%
RRC District 2 Onshore	1.20%	1.20%	2.50%
RRC District 3 Onshore	1.20%	1.30%	1.60%
RRC District 4 Onshore	3.60%	3.70%	17.70%
RRC District 5	0.10%	0.10%	8.40%
RRC District 6	1.50%	1.60%	0.20%
RRC District 7B	4.90%	5.10%	12.70%
RRC District 7C	0.30%	0.50%	0.30%
RRC District 8	0.30%	0.60%	0.30%
RRC District 8A	0.00%	0.10%	0.00%
RRC District 9	0.00%	0.00%	0.00%
RRC District 10	0.30%	0.30%	0.80%
Utah	0.40%	0.40%	0.70%
Virginia	0.90%	0.90%	0.00%
West Virginia	2.10%	2.10%	29.70%
Wyoming	1.00%	0.80%	23.30%
Miscellaneous	1.30%	0.80%	25.40%
U.S. Total	**0.20%**	**0.30%**	**0.40%**

Table 9. Crude oil and lease condensate proved reserves RSEs

State/Subdivision	Crude Oil and Lease Condensate RSE	Lease Condensate RSE	Crude Oil RSE
Alaska	NA	NA	NA
Alabama	2.90%	3.70%	3.40%
Arkansas	4.10%	20.50%	4.20%
California	**0.40%**	**10.10%**	**0.40%**
State Offshore	0.00%	0.00%	0.00%
San Joaquin Basin Onshore	0.50%	23.90%	0.50%
Coastal Region Onshore	0.30%	0.00%	0.30%
Los Angeles Basin Onshore	2.30%	0.00%	2.30%
Colorado	1.00%	1.60%	1.20%
Florida	5.60%	83.80%	5.60%
Federal Offshore	**NA**	**NA**	**NA**
Pacific (California)	NA	NA	NA
Gulf of Mexico (Louisiana)	NA	NA	NA
Gulf of Mexico (Texas)	NA	NA	NA
Illinois	0.00%	0.00%	0.00%
Indiana	0.00%	0.00%	0.00%
Kansas	2.10%	1.30%	2.20%
Kentucky	0.00%	0.00%	0.00%
Louisiana	**1.10%**	**2.20%**	**1.20%**
State Offshore	7.00%	18.70%	7.50%
South Onshore	0.60%	1.30%	0.70%
North	1.20%	1.70%	1.40%
Michigan	2.10%	1.10%	2.60%
Mississippi	3.60%	7.80%	3.70%
Montana	1.00%	2.50%	1.00%
North Dakota	0.40%	0.40%	0.40%
Nebraska	5.30%	9.00%	5.80%
New Mexico	**0.10%**	**0.60%**	**0.10%**
East	0.10%	0.30%	0.10%
West	2.40%	1.90%	5.30%
Ohio	2.70%	0.00%	3.50%
Oklahoma	0.50%	0.40%	0.70%
Pennsylvania	4.70%	0.00%	6.30%
Texas	**0.20%**	**1.10%**	**0.20%**
State Offshore	0.00%	0.00%	0.00%
RRC District 1	0.50%	1.30%	0.50%
RRC District 2 Onshore	0.00%	0.00%	0.10%
RRC District 3 Onshore	1.40%	2.80%	1.60%
RRC District 4 Onshore	8.00%	8.90%	4.40%
RRC District 5	1.90%	6.30%	2.00%
RRC District 6	0.70%	0.80%	0.80%
RRC District 7B	1.90%	3.20%	1.90%
RRC District 7C	1.00%	6.20%	1.00%
RRC District 8	0.20%	0.70%	0.20%
RRC District 8A	0.20%	2.90%	0.20%
RRC District 9	1.90%	1.20%	2.10%
RRC District 10	0.40%	0.60%	0.60%
Utah	0.80%	1.30%	0.90%
West Virginia	2.80%	3.20%	4.90%
Wyoming	0.50%	0.20%	0.70%
Miscellaneous	8.00%	4.10%	8.10%
U.S. Total	**0.10%**	**0.60%**	**0.10%**

Table 10. Unconventional gas proved reserves RSEs

State/Subdivision	Shale natural gas RSE	Coalbed natural gas RSE
Alabama	0.00%	5.60%
Arkansas	0.00%	0.00%
California	**0.10%**	**0.00%**
San Joaquin Basin Onshore	0.10%	0.00%
Colorado	14.40%	3.00%
Kansas	11.00%	14.50%
Kentucky	0.00%	0.00%
Louisiana	**0.00%**	**0.00%**
South Onshore	49.80%	0.00%
North	0.00%	0.00%
Michigan	0.00%	0.00%
Mississippi	15.40%	0.00%
Montana	1.10%	11.90%
North Dakota	0.70%	0.00%
New Mexico	**7.00%**	**1.00%**
East	0.00%	0.00%
West	14.80%	1.20%
Oklahoma	0.60%	11.40%
Pennsylvania	0.40%	23.70%
Texas	**1.00%**	**27.80%**
RRC District 1	0.00%	0.00%
RRC District 2 Onshore	1.50%	57.10%
RRC District 3 Onshore	8.60%	31.40%
RRC District 4 Onshore	11.10%	56.00%
RRC District 5	0.10%	0.00%
RRC District 6	4.20%	0.00%
RRC District 7B	5.60%	0.00%
RRC District 7C	0.00%	0.00%
RRC District 8	0.00%	0.00%
RRC District 8A	77.90%	0.00%
RRC District 9	0.00%	0.00%
RRC District 10	24.30%	29.20%
Utah	0.00%	1.70%
Virginia	2.20%	1.50%
West Virginia	3.40%	0.00%
Wyoming	4.00%	5.20%
Miscellaneous	0.60%	1.30%
U.S. Total	**0.50%**	**1.80%**

Nonsampling errors. Several sources of possible error, apart from sampling error, are associated with the Form EIA-23 survey. These include bias due to nonresponse of operators in the sample, proved reserve estimation errors, and reporting errors on the part of the respondents to the survey. On the part of EIA, possible errors include inadequate frame coverage, and errors associated with statistical estimates. Each of these sources is discussed below. Bias from nonresponse is discussed in the section on imputation for nonresponse.

- *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. Respondents are likely 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.
- *Reporting 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. 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 has been developed to detect different kinds of probable reporting errors and to flag them for resolution by analysts, either through confirmation of the data by the respondent or through submission of amendments to the filed data.
- *Model Misspecification Errors*. The model described by Equation 1 is a simplified theoretical ideal that will never be perfectly mirrored by observation of actual systems. Some degree of error, generally expected to be small, is an inevitable result of the use of any statistical model that is applied to a system it does not perfectly describe. The error introduced by model misspecification has not yet been completely addressed by EIA, and it is possible that estimation methods may be altered in future surveys. In states where a larger percentage of the total reserves were estimated, the error due to model misspecification tends to be larger as well.
- *Frame Coverage Errors*. Of all the sources of controllable error connected with the Form EIA-23, errors in the operator frame are expected to be the most important. If the frame does not list all operators in a given state, the estimate of the unsampled portion of frame will not represent the actual unsampled portion of the population, a condition called under coverage. Under coverage is a problem with certain states, but does not appear to be a problem with respect to the national proved reserves estimates. 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. The frame for the Form EIA-23 is particularly deficient in the states of Illinois, Indiana, Kentucky, and Tennessee.

Comparison with previous methodology

With the adoption of a new sampling and estimation methodology, breaks in series can occur. In certain regions, the new methodology provides higher estimates than the old one. In the interest of making the change transparent, this section presents a comparison of 2011 reserves as disseminated, and the reserves that would have been estimated had the current estimation methodology been used. This

comparison does not necessarily reflect the different sampling methodology. The only difference evaluated here is the use of Equation 1 to impute reserves. This is intended to aid users in evaluating the significance of perceived changes in reserves on a year-to-year basis. Nationally, there is less than a 1% change in liquids and natural gas reserves estimates.

Table 11. Wet gas after lease separation, methodology comparison

billion cubic feet

State and Subdivision	2011 Reserves, 2011 Methodology	2011 Reserves, 2012 Methodology
Alaska	**9,511**	**9,511**
Lower 48 States	**339,298**	**341,783**
Alabama	2,570	2,578
Arkansas	16,374	16,262
California	**3,042**	**3,252**
Coastal Region Onshore	173	189
Los Angeles Basin Onshore	102	108
San Joaquin Basin Onshore	2,685	2,871
State Offshore	82	84
Colorado	26,151	25,843
Florida	6	6
Kansas	3,747	3,988
Kentucky	2,128	2,151
Louisiana	**30,545**	**30,743**
North	27,411	27,505
South Onshore	2,615	2,703
State Offshore	519	535
Michigan	2,549	2,527
Mississippi	868	882
Montana	792	810
New Mexico	**16,138**	**16,241**
East	4,884	4,953
West	11,254	11,288
New York	253	311
North Dakota	2,652	2,662
Ohio	758	1,083
Oklahoma	29,937	30,194
Pennsylvania	26,719	26,886
Texas	**104,454**	**104,943**
RRC District 1	6,127	6,159
RRC District 2 Onshore	3,690	3,714
RRC District 3 Onshore	2,490	2,613
RRC District 4 Onshore	10,054	10,107
RRC District 5	28,187	28,157
RRC District 6	15,995	16,084
RRC District 7B	3,887	3,921
RRC District 7C	5,236	5,324
RRC District 8	8,088	8,107
RRC District 8A	1,289	1,295
RRC District 9	10,920	10,864
RRC District 10	8,373	8,480
State Offshore	118	118
Utah	8,108	8,129
Virginia	2,832	2,841
West Virginia	10,532	10,600
Wyoming	36,930	37,641
Federal Offshore	**10,820**	**10,820**
Pacific (California)	711	711
Gulf of Mexico (Louisiana)	8,555	8,555
Gulf of Mexico (Texas)	1,554	1,554
Miscellaneous	393	390
U.S. Total	**348,809**	**351,294**

Table 12. Crude oil and lease condensate

million barrels

State and Subdivision	2011 Reserves, 2011 Methodology	2011 Reserves, 2012 Methodology
Alaska	**3,852**	**3,852**
Lower 48 States	**25,098**	**25,273**
Alabama	65	68
Arkansas	40	48
California	**3,009**	**3,013**
Coastal Region Onshore	564	565
Los Angeles Basin Onshore	295	293
San Joaquin Basin Onshore	1,950	1,955
State Offshore	200	200
Colorado	555	562
Florida	22	22
Illinois	54	49
Indiana	7	7
Kansas	350	406
Kentucky	22	22
Louisiana	**525**	**548**
North	136	145
South Onshore	328	339
State Offshore	61	64
Michigan	59	64
Mississippi	245	252
Montana	384	381
Nebraska	21	23
New Mexico	**960**	**957**
East	921	918
West	39	39
North Dakota	2,658	2,639
Ohio	55	58
Oklahoma	1,150	1,199
Pennsylvania	44	46
Texas	**8,108**	**8,122**
RRC District 1	893	879
RRC District 2 Onshore	691	626
RRC District 3 Onshore	261	275
RRC District 4 Onshore	222	220
RRC District 5	28	31
RRC District 6	232	240
RRC District 7B	126	139
RRC District 7C	672	681
RRC District 8	2,709	2,719
RRC District 8A	1,800	1,814
RRC District 9	181	202
RRC District 10	290	293
State Offshore	3	3
Utah	582	582
West Virginia	51	53
Wyoming	919	939
Federal Offshore	**5,171**	**5,171**
Pacific (California)	352	352
Gulf of Mexico (Louisiana)	4,567	4,567
Gulf of Mexico (Texas)	252	252
Miscellaneous	42	42
U.S. Total	**28,950**	**29,125**