National Instrument 51-101 (NI 51-101) Reserves Reconciliation—Part 2, A Review of Technical Revisions in Annual Information Form Filings for End 2003

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- Monograph No. 1: Determination of Oil and Gas Reserves, the Petroleum Society;
- Reserves Definitions, the Petroleum Society;
- NI 51-101, Alberta Securities Commission (ASC); and,
- The Canadian Oil and Gas Evaluation Handbook (SPEE).

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Introduction

One of the requirements of National Instrument 51-101, Standards of Disclosure for Oil and Gas Activities, is the submission of Form 51-101F1, Statement of Reserves Data and Other Oil and Gas Information, at a date that coincides with the end of a company's financial year. For the majority of companies, this is December 31. Part 4 of Form 51-101F1 is the requirement for a reconciliation of reserves between reporting periods. This was described and discussed in Part 1 of this paper, in the November 2004 issue of the *JCPT*. One of the most important elements of this reconciliation is the technical revisions. This paper continues the discussion of technical revisions and reports on the analysis of the technical revisions reported in filings at the year-end of 2003.

Technical revisions are changes in reserves for properties contained in the opening balance and which are still owned at the end of the reconciliation period. The revisions occur mainly as the result of poor evaluation practices and of new technical information that was not known at the start of the reconciliation period. 238 companies submitted National Instrument 51-101 F1 Statements with reconciliation tables containing technical revisions for the period December 31, 2002 to December 31, 2003. 216 companies were in the database at the time of the analysis here, although not all companies had reserves for all product groups. This data is available on the SEDAR Web site (www.sedar.com).

Technical revisions are intended to be "pure" revisions to volumes in the opening balance. However, due to a misunderstanding of the requirements in this first year for NI 51-101, some filers included infill drilling and technical revisions for acquisitions made during the year. The data discussed here contains some corrections for these items.

A number of companies have been excluded from the analysis. These were:

- 14 companies that have exemptions that allow them to report using SEC/FASB requirements. The "Changes in the Net

Quantities of an Enterprise's Proved Reserves of Oil and Gas During the Year, Revisions of Previous Estimates," of the SEC/FASB system is not a "pure" technical revision since it contains other factors, such as development drilling and economic factors, and cannot be used for the type of analysis carried out here;

- A small number of companies that had not filed at the time of the analysis or had unresolved questions in their reserves numbers. Their omission has no significant effect on the general results; and,
- 23% of the companies in the analysis had no reserves at December 31, 2002, and hence no technical revisions.

Although the authors are employees of the ASC, the views expressed in this series of articles do not necessarily represent those of the ASC, CSA, SPEE, or the Petroleum Society.

The Analysis of Technical Revisions

The discussion contained in Part 1 of this paper on criteria for technical revisions is continued here. All of the data analyzed is for reported reserves, which must satisfy the following criteria:

1. Reported proved reserves must satisfy the criterion that there is "at least a 90% probability that the actual quantities recovered will equal or exceed the estimated proved reserves."
2. Reported proved + probable reserves must satisfy the criterion that there is "at least a 50% probability that the quantities recovered will equal or exceed the sum of the estimated proved plus probable reserves."
3. Reserves are estimates made using uncertain and limited information. Any estimate, including reserves, is subject to measurement error and may be affected by bias or a trend*.

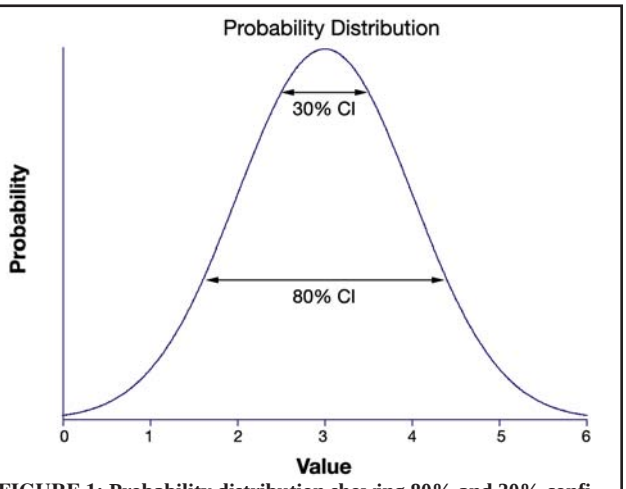

FIGURE 1: Probability distribution showing 80% and 30% confidence intervals.

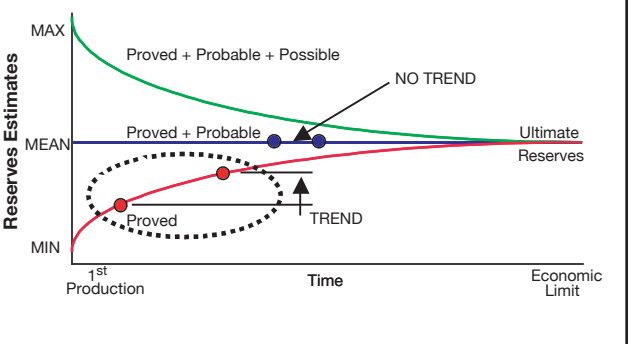

FIGURE 2: Trends in reserves estimates during the lifetime of a field.

Measurement Error

Reserves estimation is a measurement process, and like any measurement is subject to error. Any estimate lies within a range of values, known as the Confidence Interval (CI), with a certain probability (although related, this is not the same as a probability, such as a P_{90}, on a cumulative probability curve used in the reserves definitions). The smaller the CI, the less likely it is that the true value lies within it (see Figure 1). For instance:

- There is an 80% probability that the actual reserves lie within a CI between 1.7 and 4.3 Bcf; and,
- There is a 30% probability that the actual reserves lie in a smaller CI from 2.6 and 3.4 Bcf.

The envelope of all possible CIs for a particular parameter defines a probability distribution for that parameter.

Bias

Any measurement or estimate may be subject to bias, which may be intentional or unintentional. It can be of two forms:

- Displacement Bias occurs when all measurements are too high or too low by the same amount; and,
- Variability Bias occurs when the range of uncertainty is altered, usually underestimated, giving a spurious air of certainty. This can be envisioned by imagining that the central portion of the distribution curve (shown in Figure 1) is squeezed inwards without disturbing the total range.

Simple Trend

In addition to measurement error and bias, because technical revisions are the difference between sequential estimates, they may also exhibit a trend. Figure 2 is the well-known illustration of the change in the range of ultimate recovery as additional information becomes available over time. Successive estimates of proved, and of proved + probable reserves, are denoted by circles on the respective curves. In this figure, it can be seen that there should be:

- No trend in technical revisions to proved + probable reserves;
- A positive trend in technical revisions to proved reserves; and,
- A negative trend in technical revisions to proved + probable + possible reserves.

This is further illustrated for proved reserves in Figure 3, which is an enlargement of the part of Figure 2 that is enclosed in the dotted ellipse. Estimates are made at two times, labelled A and B, as shown by the probability distributions. The figure shows the following:

- A decrease in uncertainty as more information becomes available in the period between times A and B, as shown by the decrease in the width of the distribution between these two times;

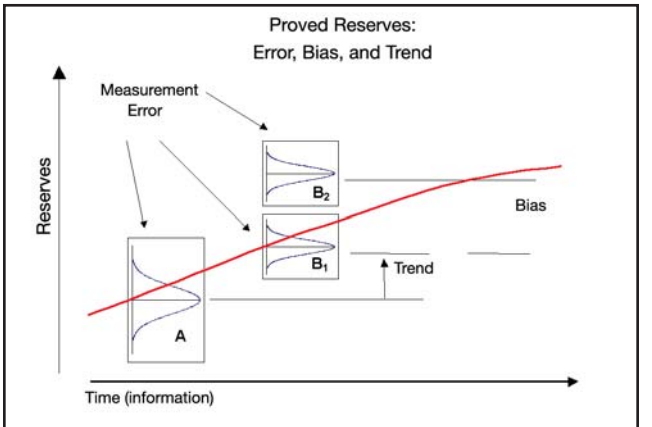

FIGURE 3: Error, bias, and trend in proved reserves estimates.

* See Determination of Oil and Gas Reserves, Petroleum Society Monograph No. 1, Chapter 22, 2nd Edition, 2004, for a more detailed discussion of Measurement Error and Bias.

- A positive trend as proved reserves increase from time A to time B; and,
- A possible bias at time B. B1 shows the unbiased reserves and B2 shows the reserves with a positive displacement bias.

Skewness Trend

The idealized Figure 2 shows a symmetrical distribution of reserves estimates about the proved + probable reserves estimate for which the mean, median, and mode are the same. However, in many cases, the distribution will be asymmetric, and the mean, median, and mode will not coincide. By definition, proved + probable reserves are the median (P_{50}), but the ultimate recovery will be the mean. Over time, therefore, the proved + probable reserves will converge towards the mean, and technical revisions to proved + probable reserves will not be zero. The magnitude and direction of this trend will depend on the skewness of the initial distribution, but the most common case is probably a right-hand skew; that is, the mean (ultimate recovery) will be greater than the median (proved + probable reserves), and there will be an apparent positive trend in technical revisions to proved + probable reserves. The significance of this factor is not known, but it is probably not great in the Western Canadian Sedimentary Basin where few fields are likely to have significantly skewed distributions.

Discussion

For any reserves entity, successive estimates will be affected by all of the factors described above, and, although the end point is fixed (but unknown), are unlikely to change as smoothly as the idealized picture in Figure 2.

The discussion so far is for a single entity. However, the technical revisions that have been reported in the F1 filings are reported reserves; that is, they are the sum of a number, often very many, individual entity estimates. The effects of this summation on the four factors are:

- Measurement Error. It is a fundamental feature of unbiased estimates that, in a summation, measurement errors will tend to cancel out and the proportionate error in the sum will be less than for the individual estimates[**]; that is, although individual entity technical revisions can be up or down, as the number of revisions increase, the ups and downs will tend to compensate for each other, and, provided they are unbiased, the sum of the revisions will decrease rapidly as the number of properties or total volume increases. This is commonly referred to as the portfolio or aggregation effect;
- Bias. In a summation, the bias in the sum will be the sum of the individual entity biases, or the average entity bias times the number of entities. If, for a group of properties, biases are randomly distributed, the effect would be the same as for measurement error, and they would tend to cancel out. However, this is not likely to be the case, since the bias exhibited during an evaluation is much more likely to be consistently in one direction and the bias in the sum will be in the same direction. The sum of biases on a series of estimates made over the lifetime of a single entity or of the sum of multiple entities must be zero, since the end point is fixed. Any bias will, therefore, sooner or later be corrected by a technical revision.
- Simple trend. Since proved + probable reserves exhibits zero simple trend, summation has no effect. For proved reserves, the trend of the sum will be the sum of the individual entity trends; and,
- Skewness trend will affect only the proved + probable reserves, which the trend of the sum to a particular point in time will be the sum of the individual entity technical revisions to that point, arising from a skewness trend, and will ultimately be equal to the difference between the median and the mean.

Table 6 in Part 1 of this paper (Reserves Reconciliation Objectives) describes tests that can be applied to technical revisions and is repeated here as Table 1.

It should be noted that this discussion is concerned with the analysis of technical revisions over a period of one year. The analysis of data from a period of more than one year may be more complex than suggested here.

Data Quality

This analysis uses technical revisions as reported by the filing companies. In the first year of implementation of the new legislation, there were some misunderstandings as to what should be included in a technical revision. These are:

- Including the results of infill drilling as a technical revision instead of as improved recovery. Although a number of corrections were made for this, some of the reported values may still be uncorrected;
- Reporting revisions to reserves acquired during the year as technical revisions, resulting in some cases in technical revisions that were greater than the opening reserves, which for some companies were zero. The appropriate way for the reconciliation is to report the reserves as estimated at the end of the year as an acquisition, and if desired, to report elsewhere

TABLE 1: Reserves reconciliation objectives (reproduced from Table 6 of Part 1 of this paper).

Reserve Classification	Entity Level	Reported Level
1P = PV	Positive reserves revisions should occur in the vast majority of the entities	Only positive reserve revisions should occur at this level unless the reported level is for a small number of entities (less than ten) or for a group of entities dominated by one or two large reserve entities
2P = PV + PB	Positive reserves revisions should equal negative reserves revisions	Only very minor positive or negative revisions should occur at this level
3P = PV + PB + PS	Negative reserves revisions should occur in the vast majority of the entities	Only negative reserves revisions should occur at this level unless the reported level is for a small number of entities (less than ten) or for a group of entities dominated by one or two large reserve entities

[**] This is a consequence of the Law of Large Numbers, which is an aspect of the fundamental Central Limit Theory of Statistics. A detailed discussion is beyond the scope of this paper, but can be found in many statistical texts.

TABLE 2: Summary of technical revisions by product group and reserves class.

	Light & Medium Oil		Heavy Oil		Natural Gas	
	1P MMbbl	2P MMbbl	1P MMbbl	2P MMbbl	1P Bcf	2P Bcf
Number of companies	138	138	44	44	155	155
RESERVES DEC 31, 2002	793.5	969.8	220.8	270.6	6,392.6	7,953.3
Total technical revisions						
Volume	(41.8)	(3.7)	(43.6)	(40.4)	(571.4)	(338.7)
% revision	(5.3)	(0.4)	(19.7)	(14.9)	(8.9)	(4.3)
Average per company	(0.3)	(0.0)	(1.0)	(0.9)	(3.7)	(2.2)
Positive technical revisions						
Volume	14.7	32.7	4.3	9.1	59.4	150.2
Number of positive revisions	55	66	16	17	47	59
Average positive revisions	0.3	0.5	0.3	0.5	1.3	2.5
Negative technical revisions						
Volume	(56.4)	(36.4)	(47.9)	(49.5)	(630.8)	(488.9)
Number of negative revisions	75	67	25	24	103	93
Average negative revisions	(0.8)	(0.5)	(1.9)	(2.1)	(6.1)	(5.3)
Number of zero revisions	8	5	3	3	5	3

(for instance in a footnote) the reported reserves that had been reduced during the year since acquisition. Some corrections were made for this error; and,

- Possibly other unidentified errors could have occurred as a result of unfamiliarity with a new process. For example, reconciliation for gas should be done only on associated and non-associated gas, and should not include solution gas.

Despite these concerns, the general picture presented by the analysis of the reconciliations is considered to be valid. In fact, reconciliation is a useful tool for identifying some errors, which often show as data outliers.

Results of the Analysis of 2003 NI 51-101F1 Technical Revisions

Table 2 summarizes the technical revisions in reserves for light and medium oil, heavy oil, and gas. Bitumen and synthetic oil have not been included because of insufficient data, and natural gas liquids has not been included since it is a by-product of gas production and in any event, is not required for NI 51-101 reporting. None of the companies in the analysis reported coal bed methane reserves.

The total technical revisions, the number of companies, and the average technical revision are shown, and also the total technical revision, as a percentage of the opening reserves at December 31, 2002. The total technical revisions are shown broken up into positive and negative technical revisions. In almost every case, and especially so for gas, the number and magnitude of negative revisions is significantly larger than the positive revisions. A small number of companies reported no technical revisions.

Figures 4 to 6 show histograms of percentage revisions in reserves for different product groups and reserves classes.

A simple histogram provides only a partial picture and greater insight can be attained by recognizing that the data consist of the sum of the technical revisions to reported reserves for a company and should display a portfolio effect. This effect is actually due to the number of entities rather than to the reserves volumes, but it is

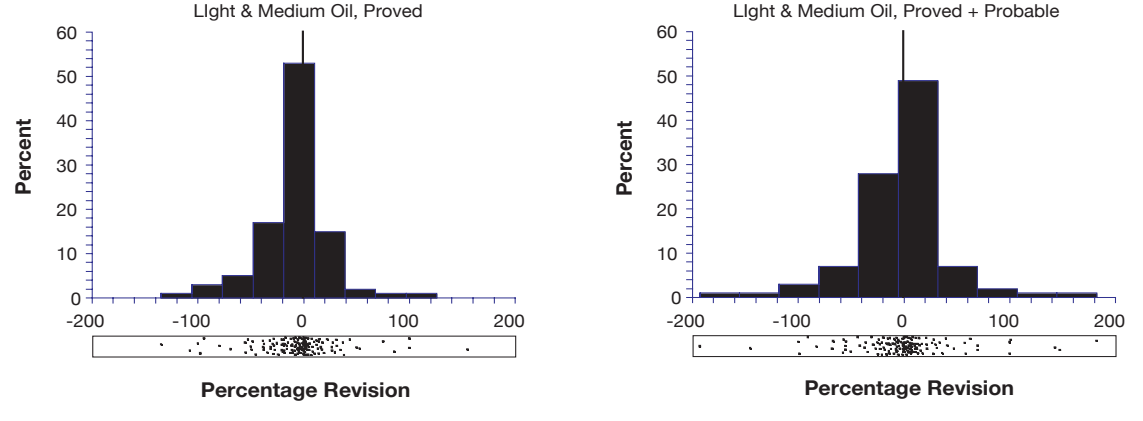

FIGURE 4: Light and medium oil, percent technical revisions in: a) opening proved reserves; and, b) opening proved + probable reserves.

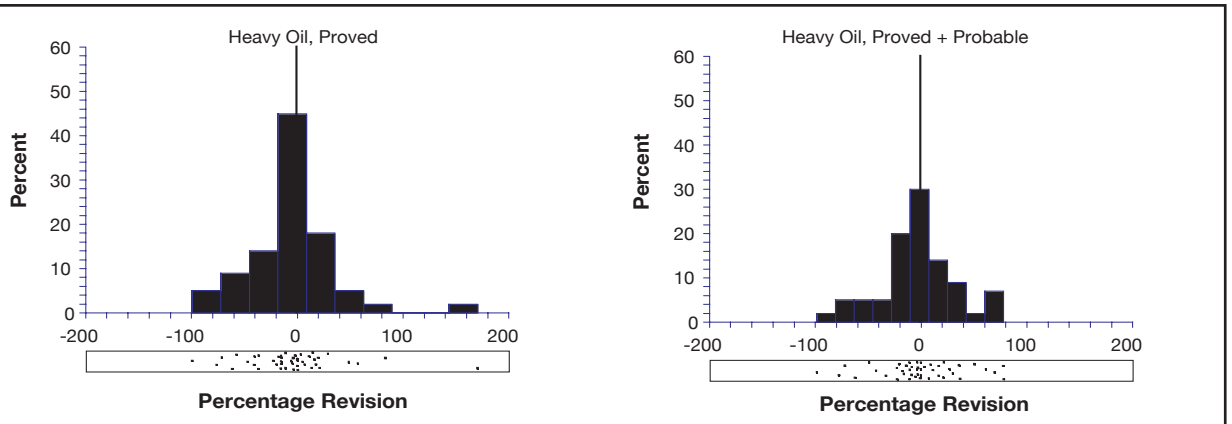

FIGURE 5: Heavy oil, percent technical revisions in: a) opening proved reserves; and, b) opening proved + probable reserves.

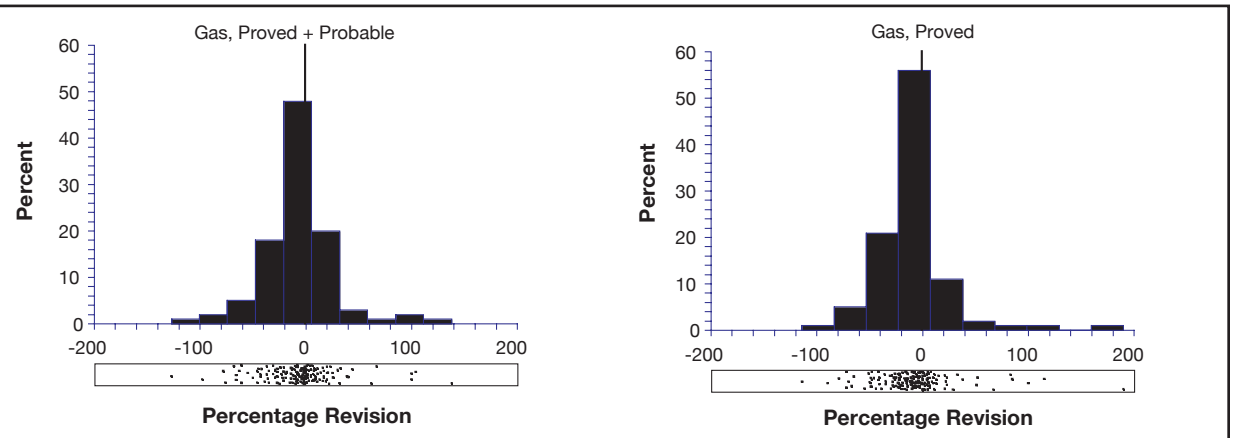

FIGURE 6: Gas, percent technical revisions in: a) opening proved reserves; and, b) opening proved + probable reserves.

probably not unreasonable to assume that there is a general relation between the number of entities in a reported reserve and the total reserves volumes for a company.

Figures 7 to 12 show the technical revisions as a percentage of the opening balance reserves plotted against the opening balance reserves for different reserves classes and product types. All the plots of technical revisions as a percentage of opening reserves vs. opening reserves conform strongly to what would be expected from a portfolio effect since the percentage technical revision decreases rapidly as the volume of reserves increases. Outliers on this type of plot may warrant further review. The anomalous points showing negative technical revisions of greater than 100% are probably the result of erroneously reporting revisions to acquisitions made during the year as technical revisions.

For proved reserves, the proportion of positive revisions is much lower than expected, and the average technical revision should be positive. The magnitude of the average revision for gas seems to be particularly high. If this is due to corrections of previous overestimates in the first year of NI 51-101, next year's figures should be closer to the anticipated numbers.

For proved + probable reserves for light and medium oil, the proportion of positive revisions and the average revision are close to the anticipated values. For heavy oil and associated and non-associated gas, the proportion of positive revisions is low, although the magnitude of the average revision for heavy oil is probably within reasonable limits. The positive average revision for gas appears high, but more data over a number of years is required to establish acceptable criteria.

The magnitude and spread of revisions for those companies with small reserves volumes appears to be high, suggesting that more care is needed in estimating entity level reserves and thus in reported volumes.

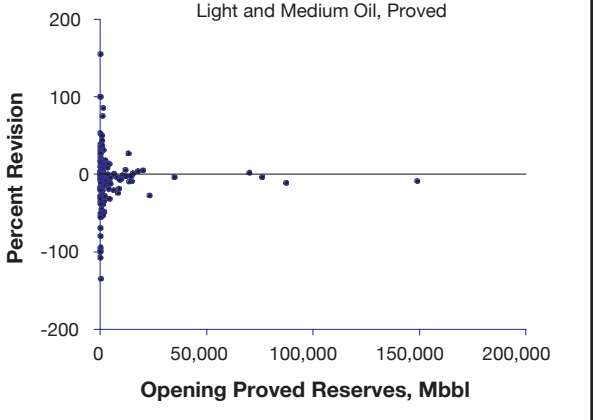

FIGURE 7: Light and medium oil, proved reserves technical revisions vs. reported opening proved reserves.

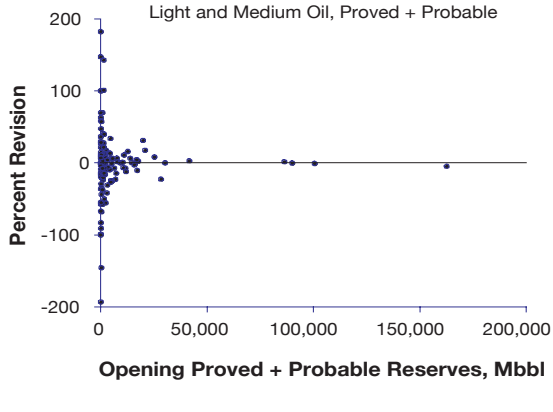

FIGURE 8: Light and medium oil, proved + probable reserves technical revisions vs. reported opening proved + probable reserves.

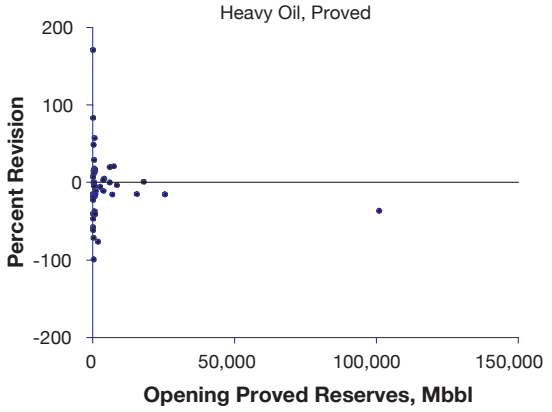

FIGURE 9: Heavy oil, proved reserves technical revisions vs. reported opening proved reserves.

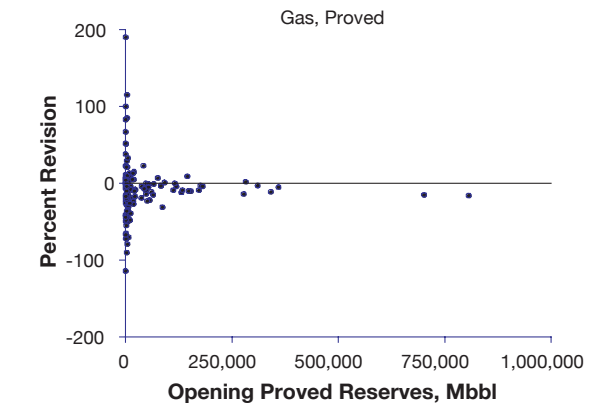

FIGURE 11: Gas, proved reserves technical revisions vs. reported opening proved reserves.

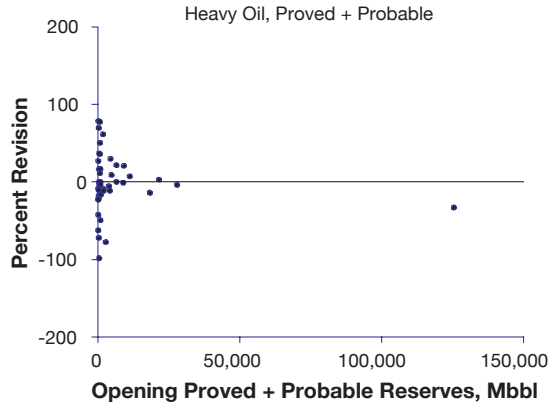

FIGURE 10: Heavy oil, proved + probable reserves technical revisions vs. reported opening proved + probable reserves.

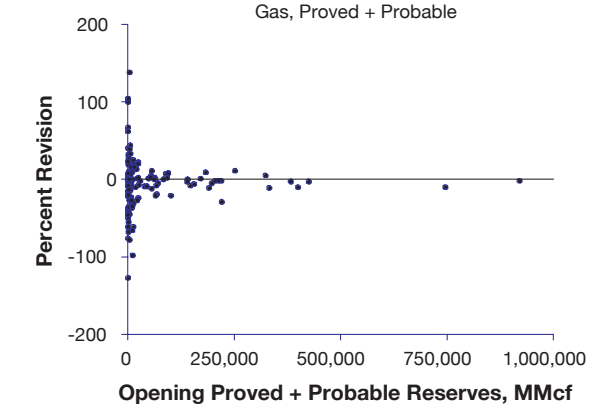

FIGURE 12: Gas, proved + probable reserves technical revisions vs. reported opening proved reserves.

Conclusions

This is the first year of reporting under NI 51-101 and, although the change from the previous National Policy 2B did not introduce any fundamental changes in reserves definitions, a first year is, inevitably, one of adjustment. However, the analysis of this one year of data indicates that National Policy 2B reserves estimates were generally optimistic. Technical revisions will continue to be analyzed in subsequent years.

REFERENCES

1. Information on oil and gas disclosure can be found on the Alberta Securities Commission Web site, www.albertasecurities.com, under the section titled Oil and Gas Disclosure Standards, including:
   - *National Instrument 51-101 Standards of Disclosure for Oil and Gas Activities;*
   - *National Instrument 51-101 Form 51-101F1 Statement on Reserves Data and Other Oil and Gas Information;*
   - *Frequently Asked Questions re NI 51-101 (CSA Notice 51-313); and,*
   - *NI 51-101 and the FAQs.*
2. Canadian Oil and Gas Evaluation Handbook,Volume 1; *Reserves Definitions and Evaluation Procedures, Society of Petroleum Evaluation Engineers, Calgary Chapter.*
3. ROBINSON, J.G. and ELLIOTT, D.C., National Instrument 51-101 (NI 51-101) Reserves Reconciliation—Part 1; *Journal of Canadian Petroleum Technology, Vol. 43, No. 11, pp. 6-12, November 2004.*