STANDARDIZED ORDER AND CALCULATION METHOD TO RECONCILE RESERVES

Are the results good enough to use in strategic decisions?

Are the results repeatable?

Are they worth the effort?

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SPEE Annual Meeting
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Reconciliations:

The Benchmark of Corporate Performance

Purpose

Categorizes the impact of:

- Adjustments to predictions
- Deviations of Actual versus Predicted
- Variations of possible outcomes from price, op cost & reservoir predictions

Reconciliations:

The Benchmark of Corporate Performance

Process

Time consuming, vague, and predominantly manual

Results

Inconsistent and difficult to reproduce

- Reconciliations are used to provide:
  - Disclosures to regulatory agencies
  - Corporate Dashboards
  - Tool for lending institutions
- Track migration of reserves from Possible, to Probable, to Proved
- Track replenishment of a company's resources
- Can measure **Reserves** or **Value**

What Is Disclosed?

REQUIRED DISCLOSURES TO REGULATORY AGENCIES

Type of Company	SEC	EIA-23	CSA	CPR
U.S. Publicly Traded	●			
U.S. Operators		●		
All Canadian			●	
Traded on London Stock Exchange				●

● required

BASIS

	SEC	EIA-23	CSA	Corp.	Lenders
Reserves					
Net Volume	●		○	●	●
Company Interest Volume			●		
Gross (8/8ths) Volume		●		○	
Value					
Non-Discounted Cash Flow			○	●	●
PV10 (SMOG)			○	○	○

● required, ○ optional

PRODUCT DISCLOSURES

Product Type	SEC	EIA-23	CSA	Corp.	Lenders
Crude Oil	●*	●		●	●
Light Oil[1] / Med. Oil[2]			●		
Synthetics			●		
Heavy Oil[34]			●		
Bitumen[5]			●		
Natural Gas	●*			●	●
Associated[6]		●	●		
Non-Associated[7]		●	●		
Solution[8]		●	●		
Liquids		●	●	○	○
CBM			●	○	○
Hydrates			●	○	

● required, ○ optional
* SEC crude oil and natural gas reported in BOE

CONSTANT VS. FORECAST ECONOMIC SCENARIOS

	SEC	EIA-23	CSA	Corp.	Lenders
Constant	●	●	○	●	●
Forecast			●	○	○

● required, ○ optional

RESERVE CLASSIFICATIONS REQUIRED

Reserve Class/Category	SEC	EIA-23	CSA	Corp.	Lenders
Proved	●	●	●	●	●
Developed Producing	●		●	●	○
Developed Non-Producing			●		
Undeveloped			●		
Probable			●	●	○
Undeveloped			●		
Proved plus Probable			●	●	○
Possible			○	○	
Contingent Resources[9]				○	
Marginal				○	
Sub-Marginal				○	
Prospective Resources				○	

● required, ○ optional

TYPES OF CHANGE FACTORS REQUIRED

Change Factor	SEC	EIA-23	CSA	Corp.	Lenders
Acquisitions	●	●	●	●	●
Dispositions	●	●	●	●	●
Production	●	●	●	●	●
Economic Factors	○		○	●	●
Price			○	●	●
Op Costs			○	●	○
Fixed				○	
Variable				○	
Royalty			○	○	○
Prod Tax			○	○	○
Development Costs			○	●	●
Abandon & Reclaim Costs			○	●	
Federal Tax			○	●	●
Technical Revisions	●	●	●	●	●
Adds	●				●
Exploration Discovery		●	●	●	○
Extensions		●	●	●	○
Improved Recovery			●	●	○
Infill Drilling			●	●	○
New Res Old Fields		●		●	○
Accretion			○	○	○
Errors in Interest				●	●
Transfers	●		●	●	●

● required, ○ optional

How Are the Calculations Done?

1. Starting Balance
   (From last year's reserve report)
2. Known Quantities
3. Changes due to Economic Factors
4. Quantify Technical Revisions
5. Push Remaining to Technical Revisions
6. Final Balance
   (From current year's reserve report)

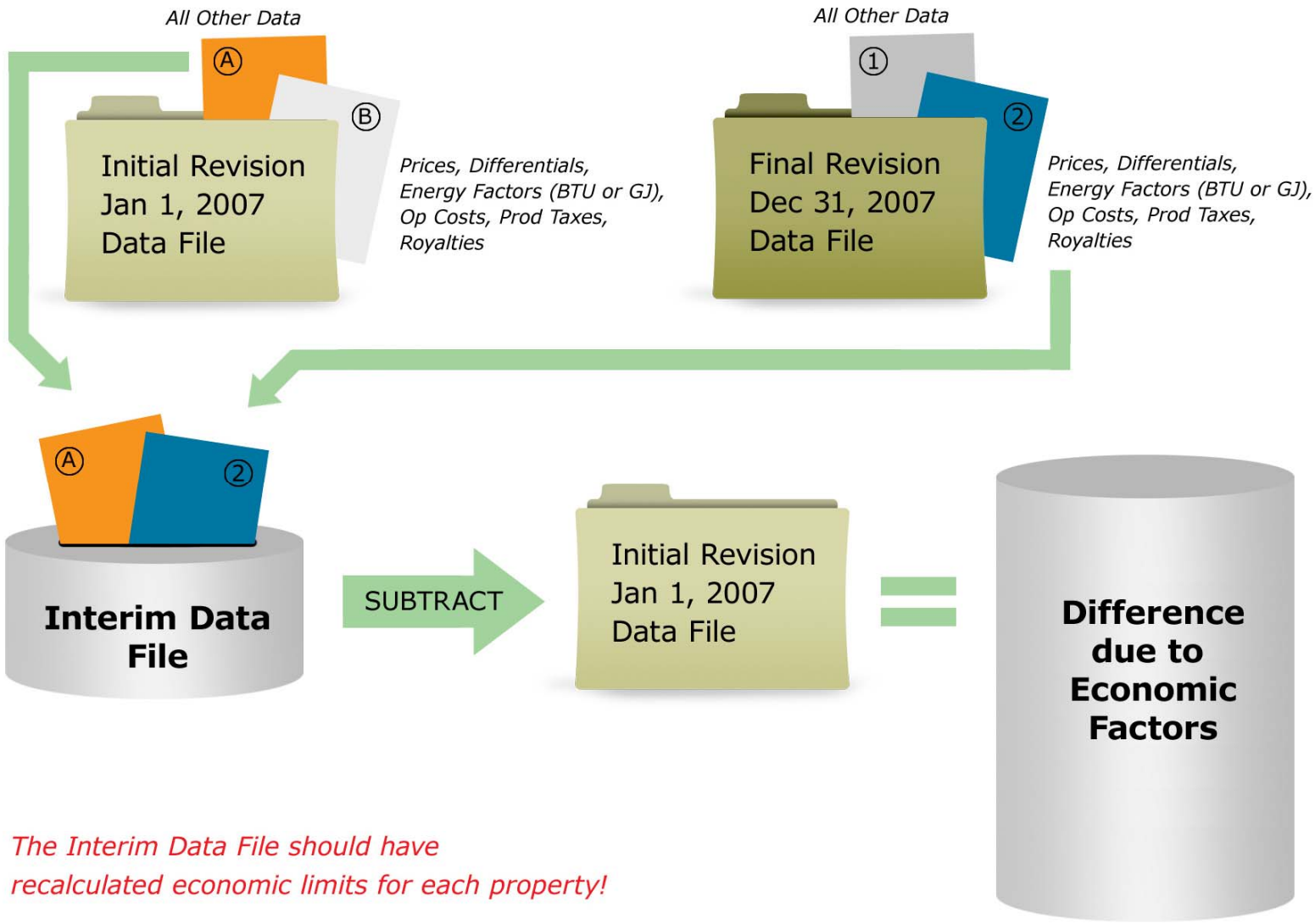
Per COGEH Volume II Section 7

Known Change Quantities

- Production
- Acquisitions
- Dispositions
- Adds (Improved Recovery, Exploration, Infill, Extensions, Discoveries)
- Transfers
- Capital

  (For Value Reconciliations)

Changes Due to Economic Factors



The Interim Data File should have recalculated economic limits for each property!

- Technical Revisions: Summation of forecast changes which are associated with a change in reservoir performance.
- Unclear as to method
  - Sum of individual volume changes
  - Run a sensitivity similar to Economic Factors
- Final Step
  - Push remaining or leftover balance to Technical Revisions

What Are the Obstacles?

Time and Resources

- Case Study Partner (4500 properties in TX, CA, WY)
  - Total time was approx. four man-weeks
    - NI 51 101 Requirements
    - Corporate Dashboard Indicators
    - SEC Requirements

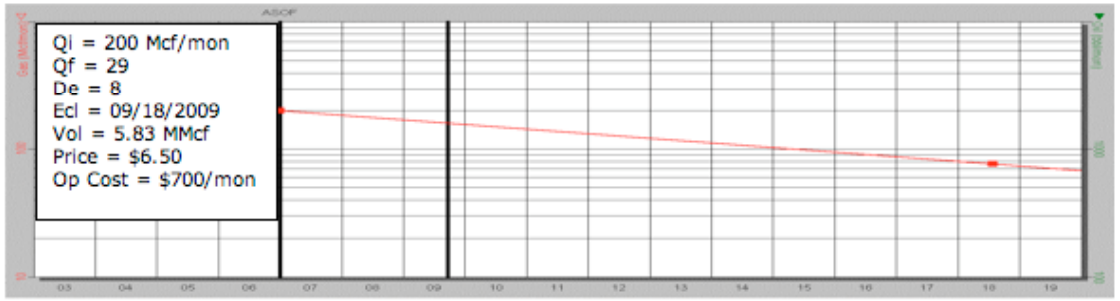
Lack of a Standard

- Results are difficult to reproduce because industry accepted methods vary too much.

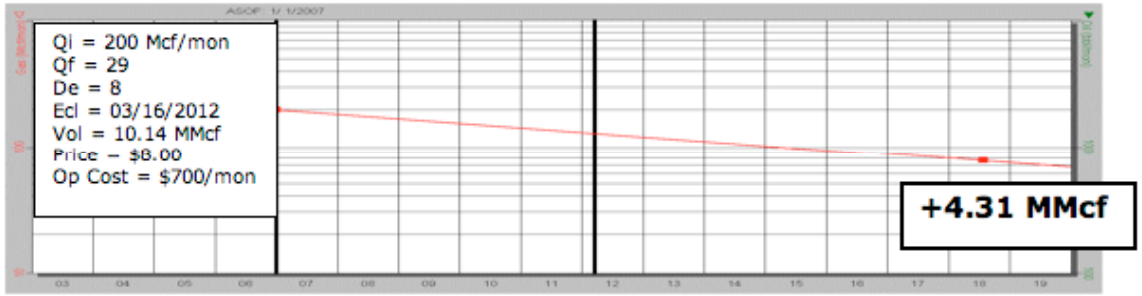
Example Method 1: Incremental Change Accounting

Capture the impact of the change to total reserves as it occurs; making the Economic Change first.

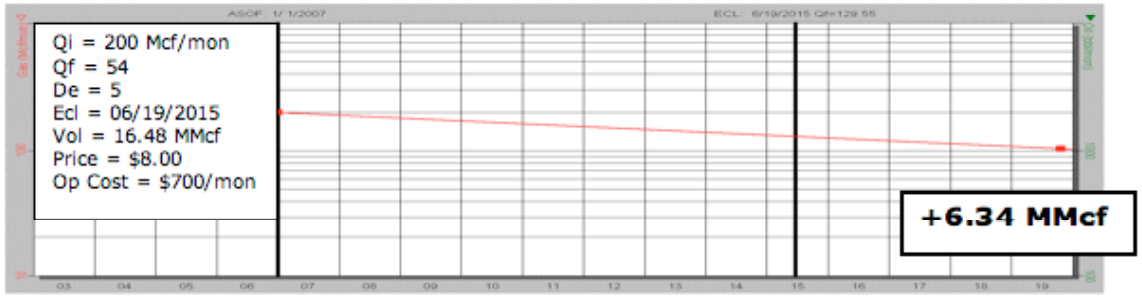
Original Revision



Change made to Economic Factor (Price)



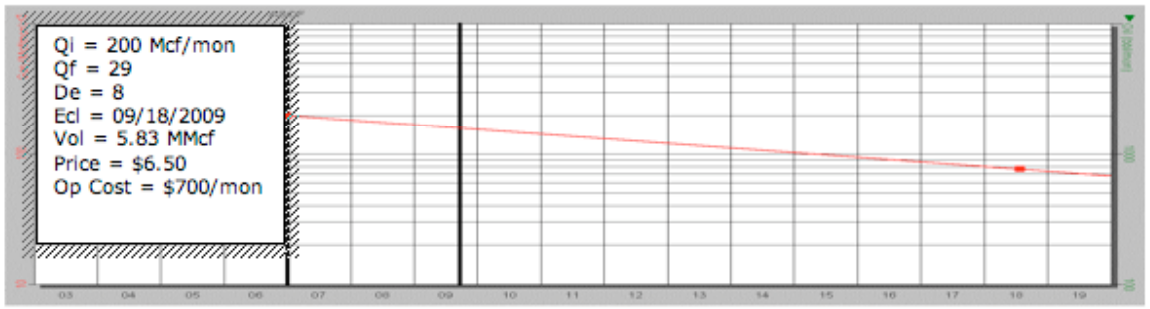
Change made to Technical Revision (Decline Rate)



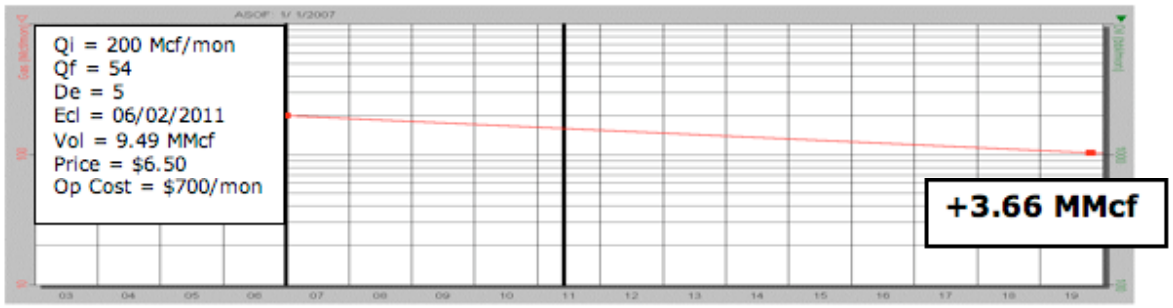
Economic Factor plus Technical Revision = Total Change +10.65 MMcf

Example 1 (continued): Now, make the same exact change but reverse the order so that the Technical Revision is changed first.

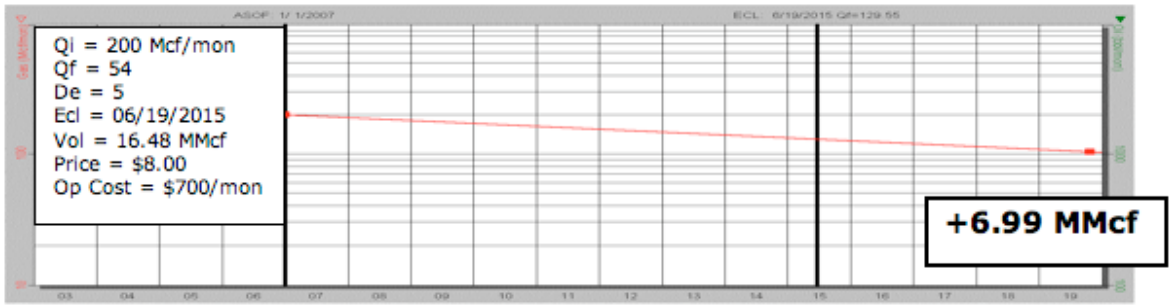
Original Revision



Change made to Technical Revision (Decline Rate)



Change made to Economic Factor (Price)



Economic Factor plus Technical Revision = Total Change +10.65 MMcf

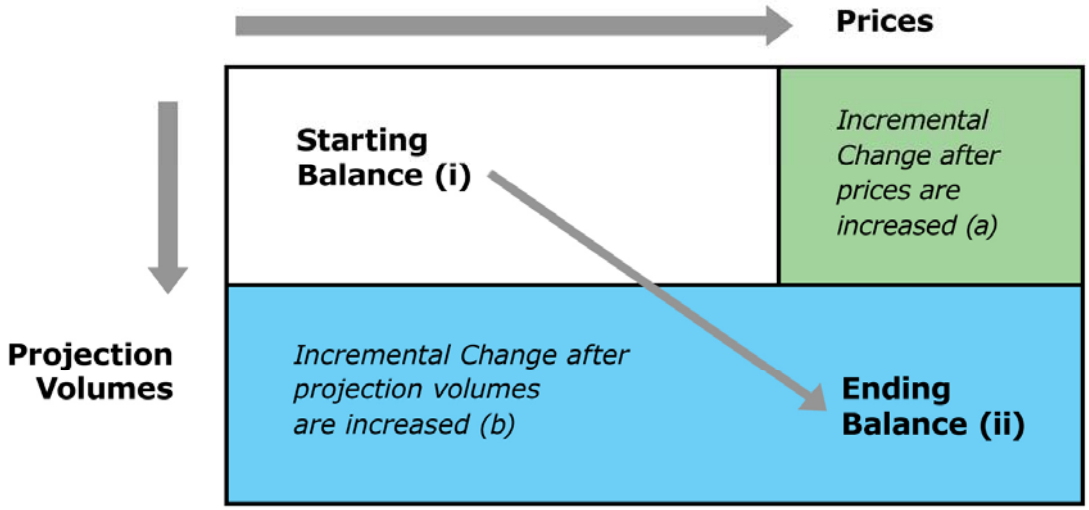
Compare the Results

BIAS RESULTING FROM CALCULATION ORDER

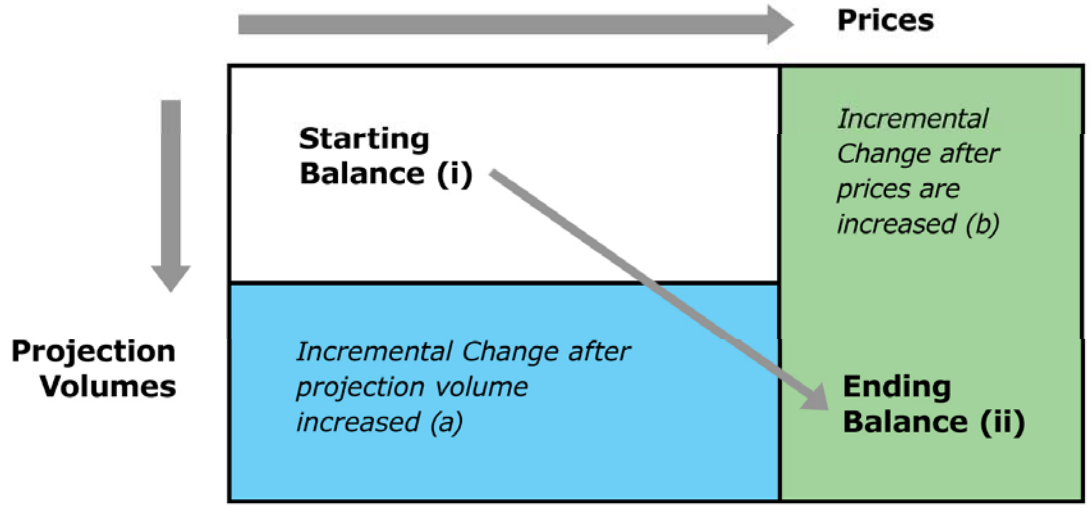
	Economic Change First	Projection Change First
Beginning Balance	5.83 MMcf	5.83 MMcf
Economic Factors	**40%**	**66%**
Technical Revisions	**60%**	**34%**
Ending Balance	16.48 MMcf	16.48 MMcf

What Causes the Bias?

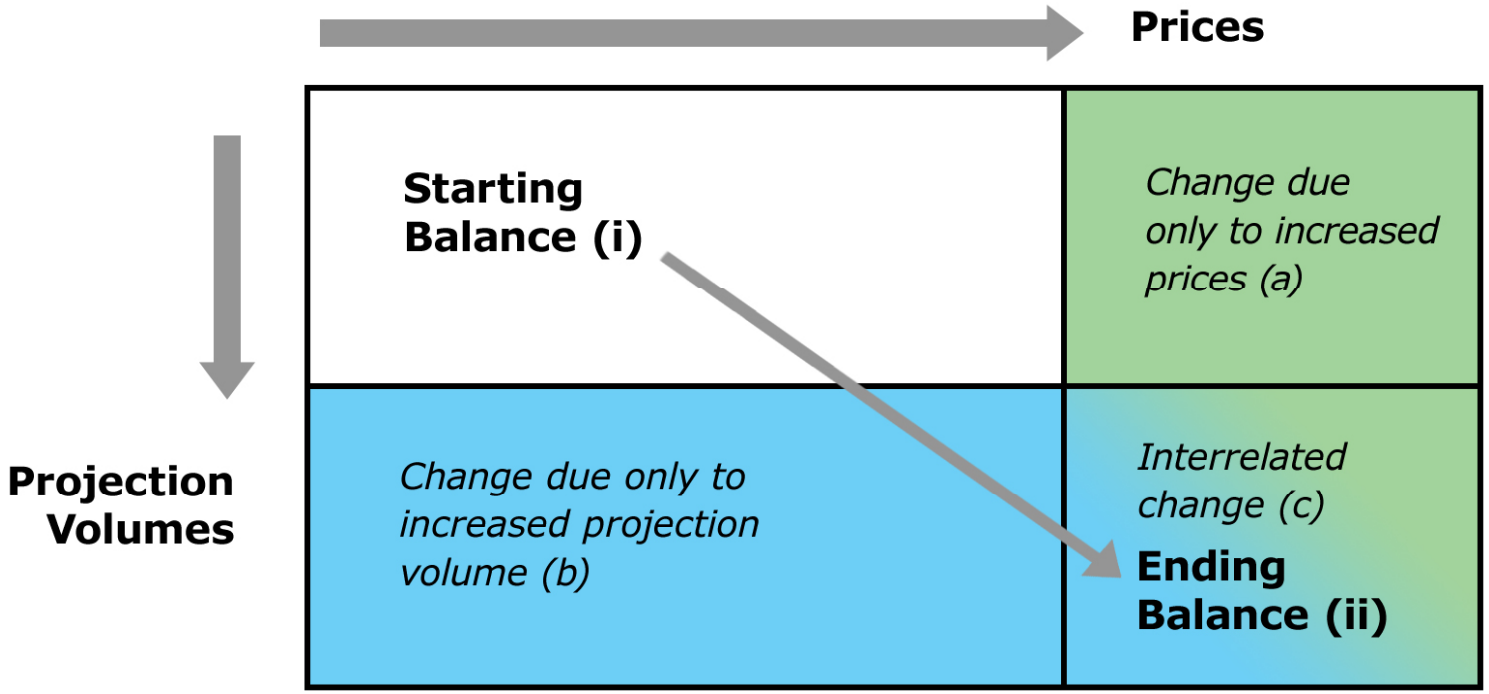
ECONOMICS CHANGED FIRST



TECHNICAL REVISION CHANGED FIRST



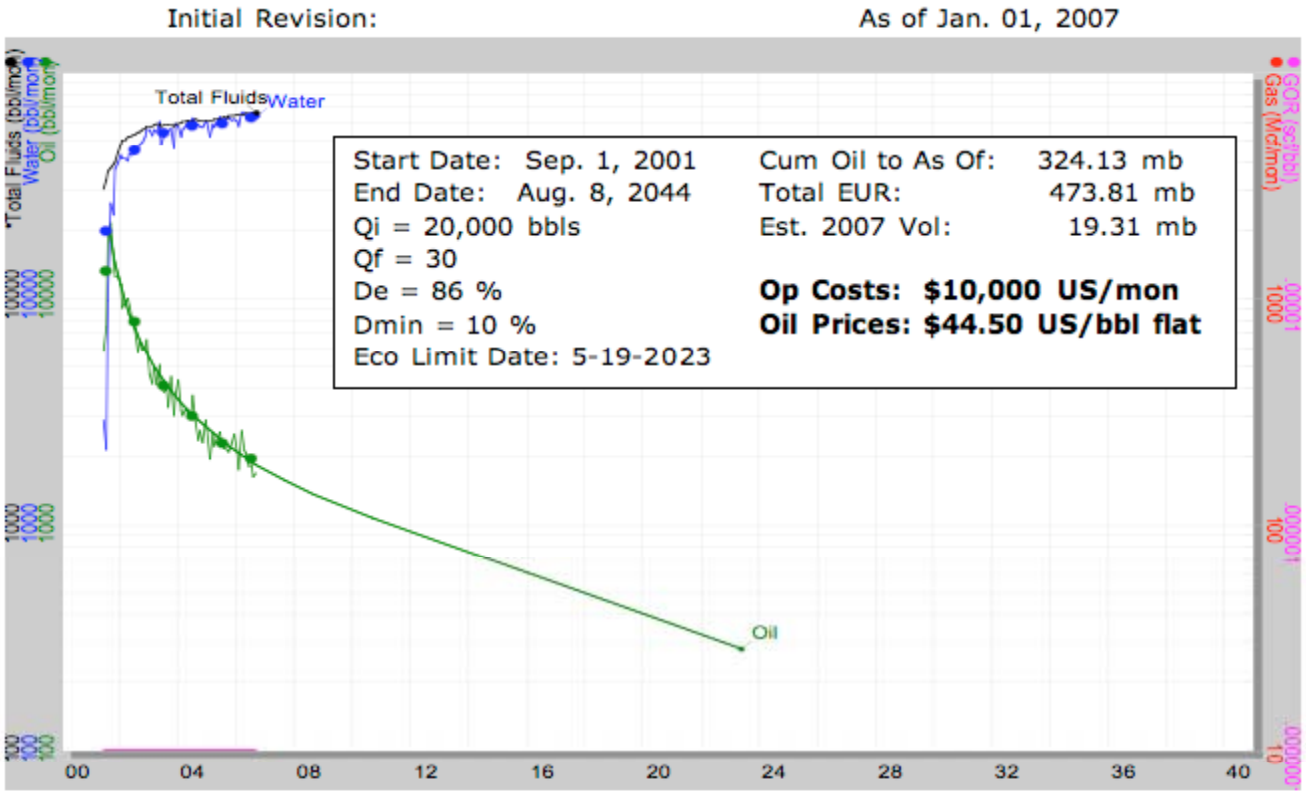
Method 2: Isolation Sensitivities Can Eliminate the Calculation Order Bias



Isolation Sensitivities ignore the effect of Interrelated Changes.

Example Method 2: Isolation Sensitivities

EXAMPLE OF PHANTOM TECHNICAL REVISION: INITIAL REVISION



Example 2 (continued): Change **only** op costs and prices to arrive at a final revision.

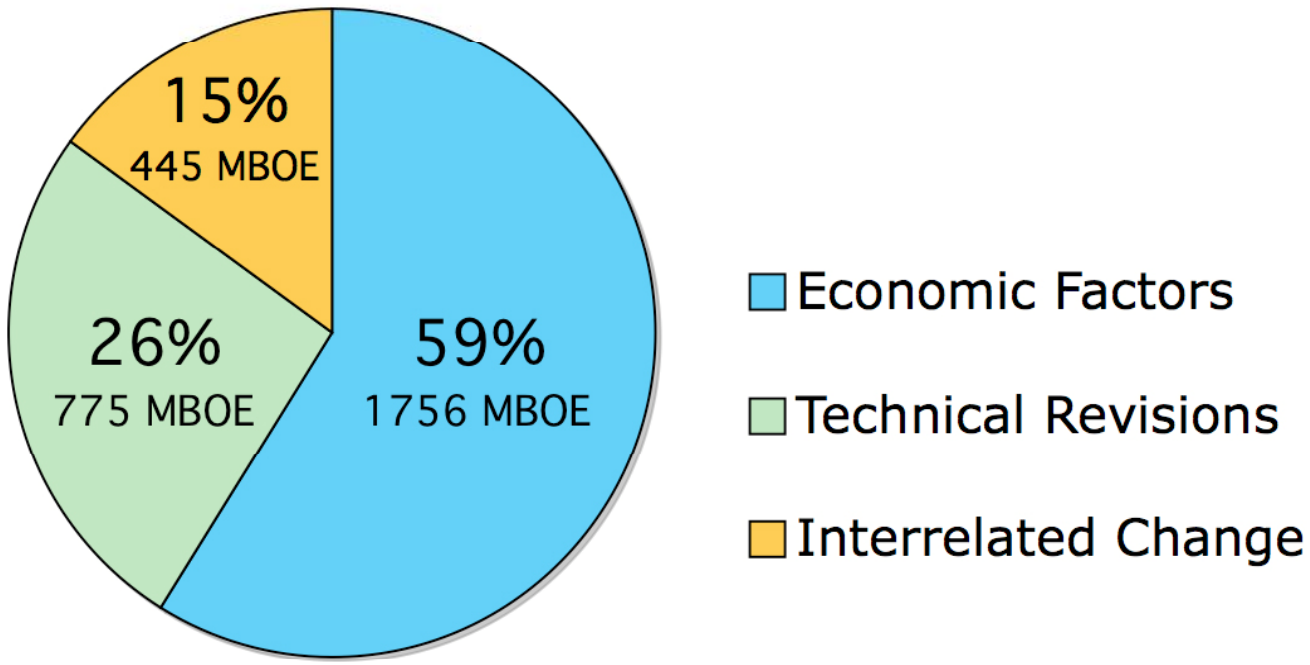
EXAMPLE OF PHANTOM TECHNICAL REVISION-FINAL REVISION

Example 2 (continued): Change categories broken out using Isolation Sensitivities

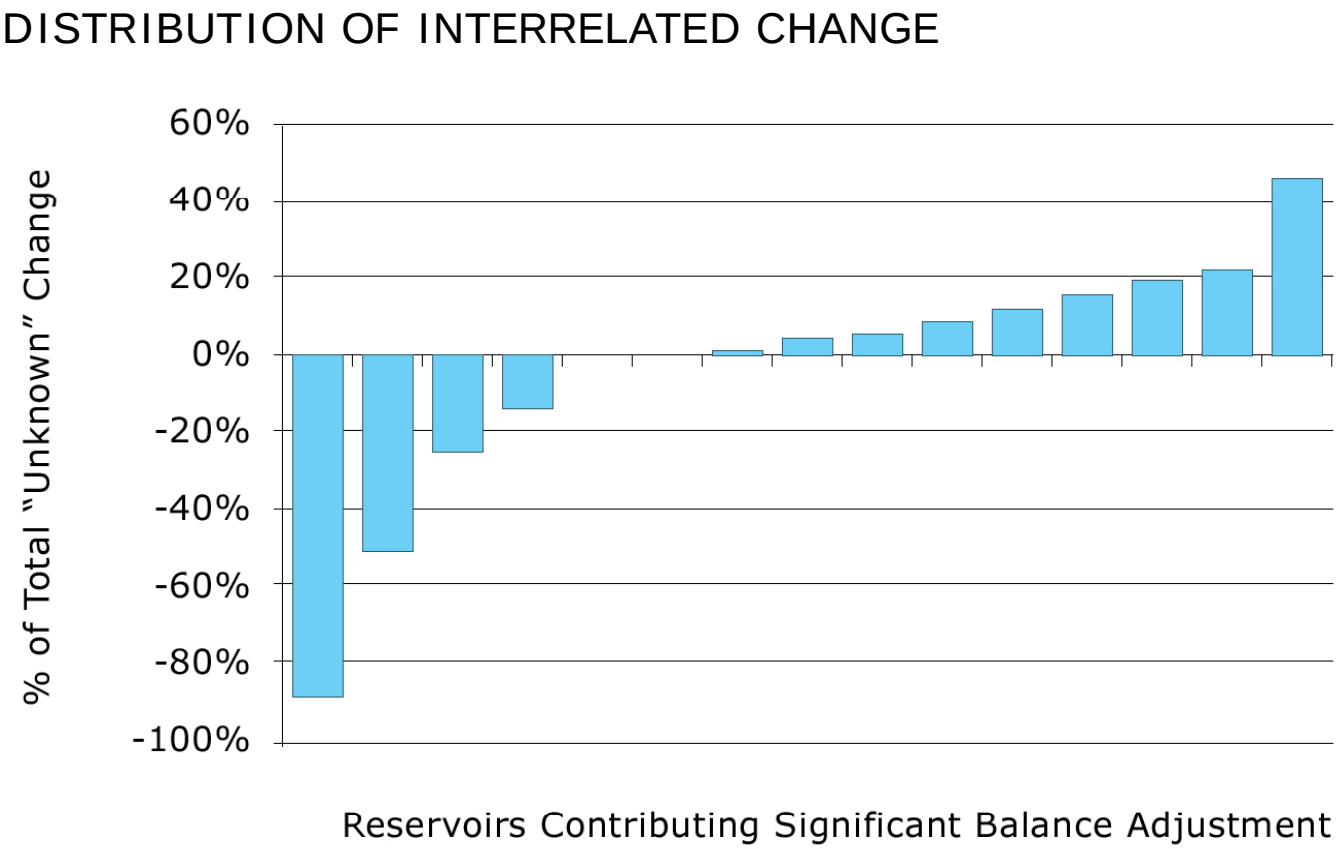
Category	NetBOE (Mbbl)	NetBOE (%)
START BALANCE 1/01/2007	37.420	719.978
UNASSIGNED	2.080	94.0 %
Acquisition	0.000	0.000
Disposition	0.000	0.000
Production	-4.827	-219.0%
Price	0.441	20.0%
Fixed Op Costs	4.515	204.0%
Variable Op Costs	0.000	0.000
Royalty	0.000	0.000
Production Tax	0.000	0.000
Development Cost	0.000	0.000
Abandon & Reclaim Costs	0.000	0.000
Federal Tax	0.000	0.000
Technical Revision	0.000	0.000
Exploration Discovery	0.000	0.000
Extensions	0.000	0.000
Improved Recovery	0.000	0.000
Infill Drilling	0.000	0.000
New Reservoirs in Old Fields	0.000	0.000
Accretion	0.000	0.000
Errors in Interest	0.000	0.000
Transfers	0.000	0.000
TOTAL DIFFERENCE	**2.209**	**100.0 %**

Amount of Total Change Due to Interrelated Factors

AVERAGE IMPACT OF INTERRELATED CHANGE: CASE STUDY



Interrelated Change: Case Study



Standard Deviation 32%

Data Organization

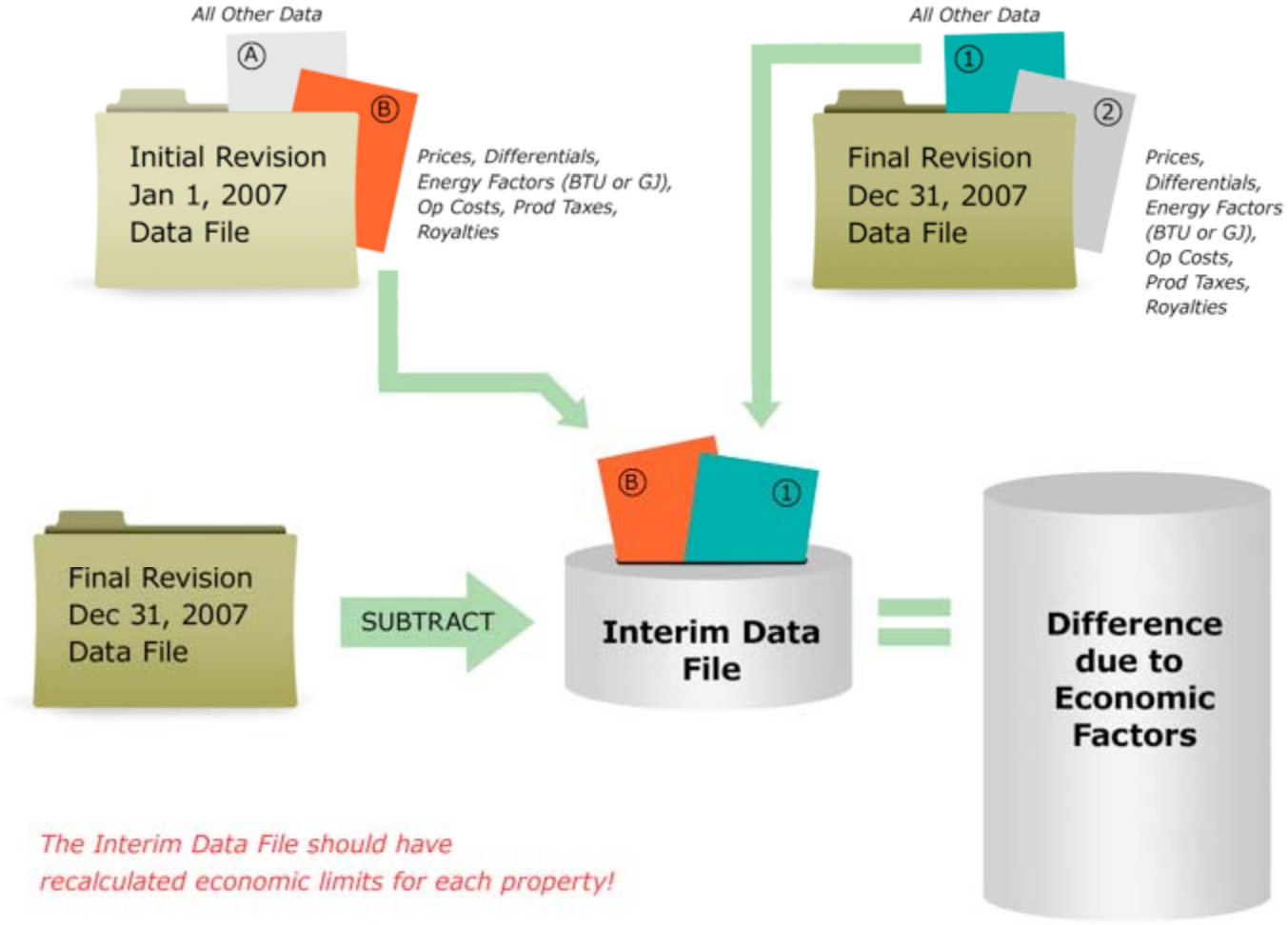
Has historical data been maintained in the evaluation file?

Prices
Projections
Op Costs
Ownership

- Making sure individual property economic limits were re-calculated properly within sensitivities;
- Making sure that Group Facility Economic Limits were re-calculated properly;
- Ensuring that any parameters using automatic date triggers tied to the as of date did not change when changing as of dates;
- Managing the price models effectively so they could be substituted;
- Identifying acquisition, disposition, and add cases;
- Searching individual properties for major contributors to mistakes.

Substitution Polarity can make up for a lack of data organization.

REVERSE POLARITY ISOLATION SENSITIVITY FLOWCHART



What Would Improve the Process?

Automation

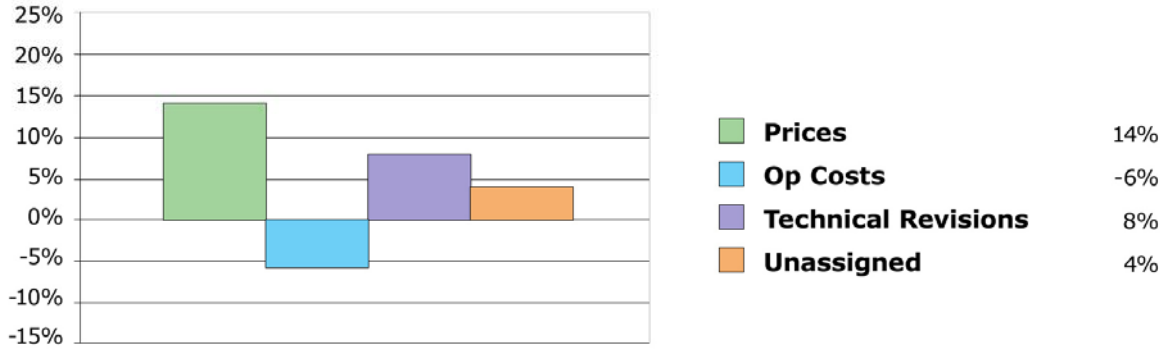
- Reproducibility & Speed
  - Case study was four man weeks versus five hours

Standardization

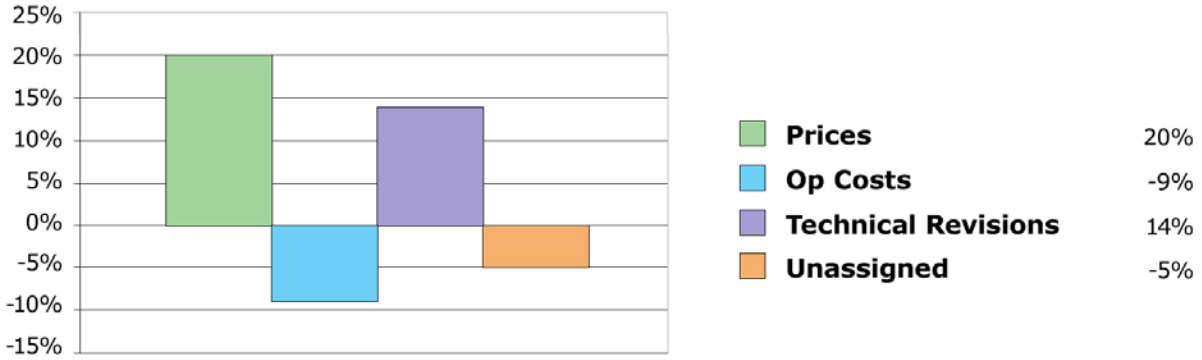
- Consistent Results
  - Need a way to distribute Interrelated Change

Isolation Sensitivities Require a Weighting Method to Distribute the Interrelated Change

NORMAL POLARITY ISOLATION SENSITIVITY RESULTS BEFORE WEIGHTING



REVERSE POLARITY ISOLATION SENSITIVITY RESULTS BEFORE WEIGHTING



POLARITY EFFECT ON WEIGHTED ISOLATION SENSITIVITIES

Distribution of Unassigned % Occurs	Prices	Op Costs	Technical Revisions
Normal Polarity	17.5%	-7.5%	10.0%
Reverse Polarity	16.0%	-7.2%	11.2%

List of Isolation Sensitivities

- Production
- Technical Revisions
- Prices
- Fixed Op Costs
- Variable Op Costs
- Production Taxes & Royalties
- Ownership
- Investment Capital
- Abandonment
- Accretion

CONCLUSION

Accepted industry methods need to do a better job in separating Technical Revisions from Economic Factors.

Repeatable results are very difficult because there is no standard method of performing the calculations.

It is possible to automate the reconciliation process, reducing manpower requirements on the order of 20 to 1.

Distribution of Interrelated Change

POLARITY EFFECT ON WEIGHTED ISOLATION SENSITIVITIES

Distribution of Unassigned % Occurs	Prices	Op Costs	Technical Revisions
Normal Polarity	17.5%	-7.5%	10.0%
Reverse Polarity	16.0%	-7.2%	11.2%

Normal Polarity:

Unassigned = 4%, Prices = 14%, Op Costs = -6%, Technical Revisions = 8%
Total Change = Prices + Op Costs + Tech Rev + Unassigned = 20%
Sum of all runs = Prices + Op Costs + Tech Rev = 16%
Prices = (14%/ 16%) x 20% = 17.5%
Op Costs = (-6%/ 16%) x 20% = -7.5%
Tech Rev = (8%/ 16%) x 20% = 10%

Reverse Polarity:

Unassigned = -5%, Prices = 20%, Op Costs = -9%, Technical Revisions = 14%
Total Change = Prices + Op Costs + Tech Rev + Unassigned = 20%
Sum of all runs = Prices + Op Costs + Tech Rev = 25%
Prices = (20%/ 25%) x 20% = 16.0%
Op Costs = (-9%/ 25%) x 20% = -7.2%
Tech Rev = (14%/ 25%) x 20% = 11.2%

STANDARDIZED ORDER AND CALCULATION METHOD TO RECONCILE RESERVES

Gary J. Gonzenbach

SPEE Annual Meeting, June 7-10, 2008

ABSTRACT

Reserve and value reconciliations are a drain on time and resources for oil and gas companies every year, yet reconciliations provide very useful benchmark information on a company's performance, as well as the required disclosures to various regulatory agencies. However, are the results good enough to rely on for important decision making? Are the results repeatable? Are they worth the effort?

The lack of a truly defined standard for reserve reconciliations makes these questions pertinent. A standardized approach would lead to consistency in the values reported, thus providing a more useful measure of performance. A standardized approach to reconciliations opens the door for automation, which would greatly reduce the time and manpower needed for this task.

Conventional methods were compared and examined. A case study was then performed on a set of properties using conventional "best effort" methods in parallel to an automated procedure with a defined set of rules. The differences in calculations were explored and explained and the overall results were compared, both in time requirements and results.

The results suggest that a standard, automated method can work and can reduce time requirements on the order of 20 to 1. Further, the results and an examination of methods suggest that technical reserves are often overstated in comparison with economic factors easily by as much as twice their relative importance or more.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FIGURES

TABLES

INTRODUCTION

Today's oil companies around the world produce reconciliations on various disclosures such as proved reserves, probable reserves, future net reserves, standardized measure of discounted future net reserves, and many kinds of sensitivities as a means to measuring a company's performance over time. The reconciliation process consists of attributing the relative importance of change that has impacted reserves or value to different categories like technical revisions, improved recovery, purchase and sales, economic parameters, and many others. Currently, this is a very time consuming and predominantly manual process that lacks consistent standardization of methods. Even under very clear circumstances, the process is highly difficult because of the sheer number of calculations and the data organization required to track it all.

The Canadian Oil and Gas Evaluation Handbook (COGEH) contains the most comprehensive published outline to date of a recommended methodology on reconciliations in support of Canadian National Instrument NI 51-101. However, the December 2007 decision to drop economic related factors and value based reconciliations as required disclosures, somewhat mirroring SEC requirements, is evidence of the difficulty companies have had in producing those results and the lack of confidence in what the numbers mean.

There are some inherent problems in the currently accepted methods that introduce a significant bias in results. This bias could be eliminated with the adoption of some standard procedures applied with the proper calculation methods. Expansion of the COGEH reconciliation outline to include concise detail on calculations and terminology could provide a blueprint that oil companies *internationally* could look to as a standard for reconciliation.

Standardization on reconciliation methods would be a great first step in streamlining the process and making the disclosures a true measure of change for both internal and external use by companies. Standardization on the terminology employed would help eliminate confusion in planning and describing the process. With enough commonality of method and procedures, automation becomes possible, and the process becomes a much faster and more meaningful measure of performance for the industry.

WHAT IS A RECONCILIATION AND WHAT IS IT USED FOR?

Strictly speaking, a reconciliation is a detailed balance report that is intended to categorize and account for the different types of changes that occurred in an oil and gas reserve property evaluation. Reconciliation reports begin with a starting balance on a given basis, which could be a volume measurement such as Net BOE reserves, or the basis could be a value such as future non-discounted net cash flow. Changes due to factors that affect the starting balance are listed and an attempt is made to attribute the proper amount of impact that each factor had on the final outcome in terms of reserves or value.

Annual reconciliations are used to disclose an oil company's performance to shareholders and other interested parties. Regulatory agencies require annual reserve and value reconciliations. Reconciliations are used extensively within oil companies as a dashboard for monitoring their own performance. They provide indications as to whether a company's acquisition and drilling programs are adequately replacing sales production, how well a company anticipated sales price and costs, how realistic probable and possible reserves estimates were by tracking their migration into proved, and many other useful indications of company performance.

A single reconciliation report can be performed using property reserve and value evaluations from any two points in time. The most typical would be a year-end reserve report reconciled against last year's reserve forecast, providing indications of how well the company performed over the course of the year. Quarterly reconciliations are done by many companies to prevent unwanted surprises at year's end. Reconciliations also provide excellent sensitivity analysis on possible future outcomes, such as the impact that a 10% variance in price over the next year might have on a company's reserves.

WHAT IS DISCLOSED?

There is tremendous variation in the values required for reconciliation disclosures to agencies such as the Securities and Exchange Commission (SEC), Canadian Securities Administration (CSA), London Stock Exchange (LSE), to internal corporate management, as well as to various lending institutions. Currently, determining what is disclosed in a reconciliation depends on whom the reconciliation is prepared for.

AGENCIES

All publicly traded companies in the United States are required to disclose annual reserve reconciliations as part of their reporting to the SEC. Reports for the SEC are mandated under Regulation S-X (Energy Policy and Conservation Act of 1975) and by EIA-23. For companies reporting to the CSA, National Instrument 51-101 (NI 51-101) dictates the required annual disclosures and COGEH suggests guidelines on how to fulfill those requirements.

Companies seeking an initial offering on the AIM Market of the London Stock Exchange are required to file a Competent Person's Report (CPR). CPRs differ from SEC and CSA disclosures in that they contain a reconciliation against a range of possible future changes, as opposed to a reconciliation of actual changes that occurred over the last year. The exact requirements of CPRs can vary and are specified by the company's "Nominated Advisor," though the concept of attempting to quantify the impact of change is the same.

Corporate and lending institutions have no set list of requirements but generally request to see all available data. Based on what organization or institution is going to receive the disclosure, a company can zero in on the basis, products, scope of reserves and economic scenarios that will come into play when making calculations.

The requirements for corporate and lending institution needs in this section are based on commonly observed practices and may be imprecise. Each company's internal corporate management and bank has their own style and methodology requirements for keeping track of important benchmarks.

TABLE 1. REQUIRED DISCLOSURES TO REGULATORY AGENCIES

Type of Company	SEC	EIA-23	CSA	CPR
U.S. Publicly Traded	●			
U.S. Operators		●		
All Canadian			●	
Traded on London Stock Exchange				●

● required

BASIS

The basis of measurement varies depending on who a report will be compiled for. Companies need to be prepared to measure changing factors in terms of Table 2.

TABLE 2. BASIS

	SEC	EIA-23	CSA	Corp.	Lenders
Reserves					
Net Volume	●		○	●	●
Company Interest Volume			●		
Gross (8/8ths) Volume		●		○	
Value					
Non-Discounted Cash Flow			○	●	●
PV10 (SMOG)			○	○	○

● required, ○ optional

PRODUCTS

The way products are measured also varies depending upon whom the disclosure is made to. Some reporting requirements dictate that simply indicating the amounts of oil and gas is insufficient and demand the products categorized and separated according to viscosity. “Natural gas” may be reported as-is or may be divided into categories such as “associated” or “hydrates” depending upon its gaseous state in the reservoir or production method.

Companies should be prepared to disclose reconciliations on a variety of products as shown in Table 3.

TABLE 3. PRODUCT DISCLOSURES

Product Type	SEC	EIA-23	CSA	Corp.	Lenders
Crude Oil	● *	●		●	●
Light Oil[1] / Med. Oil[2]			●		
Synthetics			●		
Heavy Oil[3][4]			●		
Bitumen[5]			●		
Natural Gas	● *			●	●
Associated[6]		●	●		
Non-Associated[7]		●	●		
Solution[8]		●	●		
Liquids		●	●	○	○
CBM			●	○	○
Hydrates			●	○	

● required, ○ optional
* SEC crude oil and natural gas reported in BOE

ECONOMIC SCENARIOS

Another variable to consider when creating a reconciliation report is the manner in which prices and recurring expenses are forecasted. Constant economic scenarios are constructed using the price of the last day of the last reporting period (usually last day of the previous financial year) and holding them flat throughout the reserve life. Forecast economic scenarios refer to a reasonable outlook of future prices. Both constant and forecast scenarios honor those prices that are under contract obligations.

TABLE 4. CONSTANT VS. FORECAST ECONOMIC SCENARIOS

	SEC	EIA-23	CSA	Corp.	Lenders
Constant	●	●	○	●	●
Forecast			●	○	○

● required, ○ optional

[1] > 31.1 Degrees API (COGEH Vol. 1)
[2] >22.3 Degrees API (COGEH Vol. 1)
[3] >10.0 Degrees API (COGEH Vol. 1)
[4] < = 10.0 Degrees API (COGEH Vol. 1)
[5] Extra Heavy oil that cannot be produced without lowering its native viscosity (NI 51-101)
[6] Gas cap gas overlying crude oil in a reservoir (NI 51-101)
[7] Natural gas in a reservoir where there is no crude oil (NI 51-101)
[8] Gas that is dissolved in crude oil as reservoir conditions (NI 51-101)

SCOPE OF RESERVES

The reserve classifications considered will also vary. Some agencies only desire reports on proved reserves, while others want to track reserves as they move from one class and/or category to another. See Table 5 for guidelines.

TABLE 5. RESERVE CLASSIFICATIONS REQUIRED

Reserve Class/Category	SEC	EIA-23	CSA	Corp.	Lenders
Proved	●	●	●	●	●
Developed Producing	●		●	●	○
Developed Non-Producing			●		
Undeveloped			●		
Probable			●	●	○
Undeveloped			●		
Proved plus Probable			●	●	○
Possible			○	○	
Contingent Resources[9]				○	
Marginal				○	
Sub-Marginal				○	
Prospective Resources				○	

● required, ○ optional

CHANGE FACTORS

After identifying the needs of the various agencies, management or lending institutions, and then determining the basis, products, scope of reserves and economic scenarios, a company can finally begin to capture their change factors. As with the other elements of the disclosure, the types of change factors required will vary.

[9] Quantities of petroleum that are estimated to be potentially recoverable but not considered to be commercially viable (COGEH Vol. 2 Appendix).

TABLE 6. TYPES OF CHANGE FACTORS REQUIRED

Change Factor	SEC	EIA-23	CSA	Corp.	Lenders
Acquisitions	●	●	●	●	●
Dispositions	●	●	●	●	●
Production	●	●	●	●	●
Economic Factors	○		○	●	●
Price			○	●	●
Op Costs			○	●	○
Fixed				○	
Variable				○	
Royalty			○	○	○
Prod Tax			○	○	○
Development Costs			○	●	●
Abandon & Reclaim Costs			○	●	
Federal Tax			○	●	●
Technical Revisions	●	●	●	●	●
Adds	●				●
Exploration Discovery		●	●	●	○
Extensions		●	●	●	○
Improved Recovery			●	●	○
Infill Drilling			●	●	○
New Res Old Fields		●		●	○
Accretion			○	○	○
Errors in Interest				●	●
Transfers	●		●	●	●

● required, ○ optional

HOW ARE THE CALCULATIONS DONE?

Section 7.0 of COGEH gives an intuitive outline on some accepted methods for performing calculations used in reserve reconciliations. COGEH suggests methods that can be used to determine the values attributed to change for various categories. Many companies in the United States will use these as guidelines but not necessarily as hard and fast rules on how the calculations are performed.

According to a very broad interpretation of COGEH, the evaluator begins with a starting balance of a given basis (such as Net BOE reserves) at a specified revision date, working towards a final balance at the end of the revision period.

(1) **Starting Balance** – The starting balance for reserves or value is determined by the last year's evaluation report.
(2) **Known Quantities** – The starting balance should be adjusted positively or negatively to reflect those changes which are considered to be "known quantities."
(3) **Change due to Economic Factors** – Create a sensitivity run at the end of the evaluation period to determine those changes due to economic factors and adjust the balance positively or negatively to include those.
(4) **Quantify Technical Revisions** – Identify positive or negative revisions to previously assigned reserves and adjust the current reserve balance.
(5) **Push Remaining to Technical Revisions** – The remaining difference between the cumulative balance up to this point and the final balance at the end of the evaluation period is considered to be part of technical revisions and further added into that category.
(6) **Final Balance** – Arrive at the final balance which should match the current year's corporate final evaluation on reserves or value.

COGEH recommends constructing the reconciliation on a property-by-property basis, then summarizing to the desired report level. In practice, many companies run reconciliations on an aggregate level, such as a field or reservoir, in order to reduce the amount of data manipulation necessary. There is no mandate on the order in which these calculations must be made other than the final step of adjusting technical revisions to account for the leftover balance.

KNOWN CHANGE QUANTITIES

The known change quantities of a reconciliation should be:

- Production
- Acquisitions
- Dispositions
- Adds (Improved Recovery, Exploration, Infill, Extensions, Discoveries)
- Transfers
- Capital

There is not a great amount of direction on the mechanics of calculating and reporting these values. To a large degree, these known quantity values simply come from a company's accounting department.

PRODUCTION VALUES

The change due to production should match accounting records for sales volumes (allowing for shrinking and processing). A company will disclose acquisition or disposition volumes when a transaction is made, so those volumes will be on record as well.

ACQUISITION OR DISPOSITION TRANSACTIONS

For acquisition or disposition transactions, adjustments need to be made for production occurring after the start of the reconciliation period but before the effective date of the transaction. This can get complicated when the situation is a purchase or sale of additional interest in a previously owned property. In that situation, the property would potentially have changes due to acquisition of the additional interest, plus production, economic factors, and even technical revisions from the previously owned interest portion. Acquisition of properties not previously owned would only have a balance change categorized only under acquisitions.

Production volumes should be calculated from the reserves evaluation to use as a comparison against accounting records. COGEH, much less other documents or entities, does not go into detail on how to accomplish this. The only effective way would be to create two sensitivity runs: one on production that compares cumulative volumes at the beginning and

ending evaluation dates, and one on the change in ownership of existing properties. Sensitivities become more necessary in those situations in which the total actual production for the evaluation period is not yet available and the estimated forecast production is needed to fill in the gap through the end of the year.

ADDS

Adds consist of reserve volumes gained from improved recovery, exploration discovery wells, infill drilling, extension wells, and new reservoir discoveries in old fields. As with volume added with acquisitions, these quantities should be known or at least estimated to some degree of certainty before they are booked or drilled.

TRANSFERS

Reserve classification changes from probable to proved are categorized as proved additions (transfers) in the year in which they are re-classified.

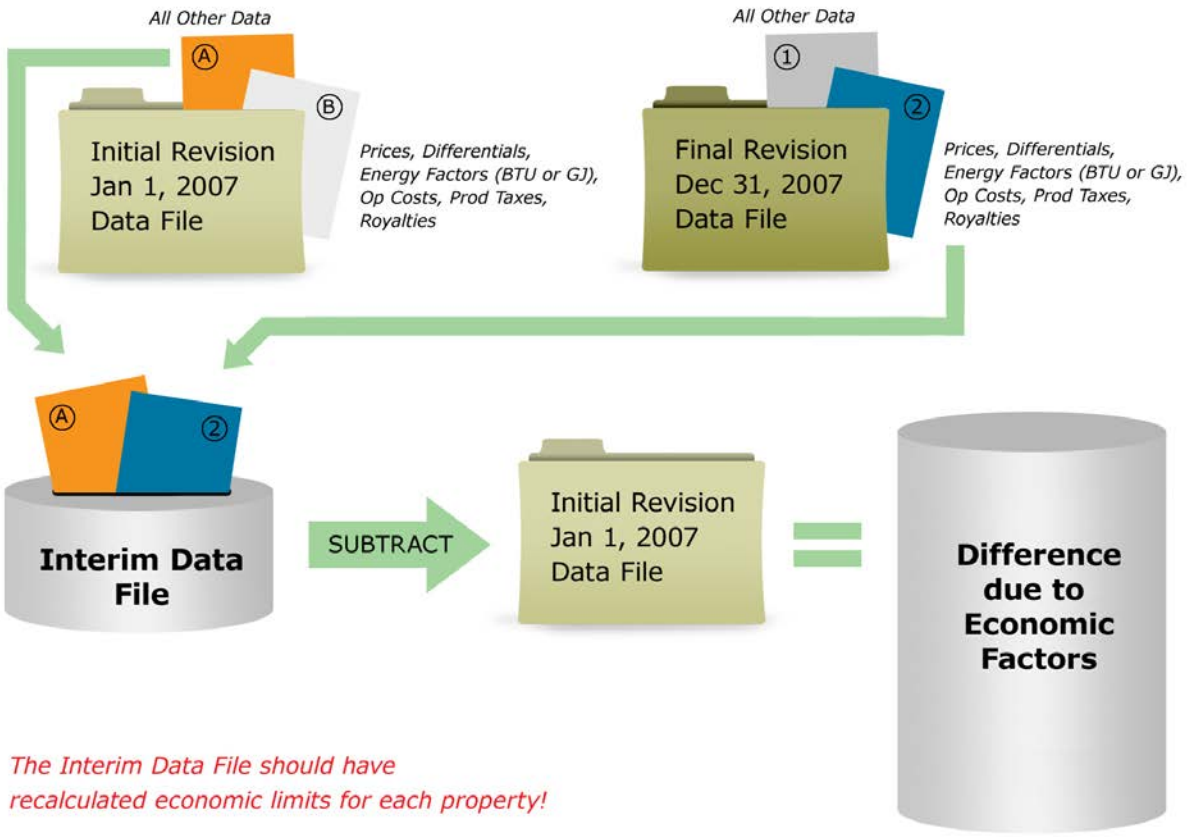
CAPITAL

Certain categories of capital such as development costs are captured if performing value reconciliations.

CHANGES DUE TO ECONOMIC FACTORS

After the starting balance is adjusted for the known change quantities, the change due to economic factors is addressed by running a sensitivity where only economic factors would be taken from the final revision, but run at the initial revision as of date. All other factors would be identical to the initial run. A subtraction of the initial evaluation from the new economic factors would, in theory, yield the changes due only to economics. Note that subtracting the initial revision file from the interim file associates a positive reserve change with an increase of prices from January 1 to December 31.

FIGURE 1. FLOWCHART FOR ISOLATION SENSITIVITY ON ECONOMIC FACTORS



What parameters belong with the economic factors? In practice, many companies would group sales prices, reference prices, differentials, energy factors, fixed operating costs, variable operating costs, production taxes, and royalties within the economic factor umbrella. Note, however, that COGEH Volume II, Section 7 states that op costs are part of technical revisions.

TECHNICAL REVISIONS

Technical revisions are a summation of revised reserve forecast changes. Positive technical revisions are associated with better than expected reservoir performance and negative technical revisions are associated with worse than expected reservoir performance. Neither COGEH nor SEC guidelines explain exactly how to calculate technical revisions, thus the methods that companies use varies. In COGEH, it is unclear as to whether the intention is to anchor the economic limit date or recalculate economic limits when changing parameters.

One popular method involves incrementally recording the actual volume change each time an edit is made to the projections. Another method would be a sensitivity run after all changes have been made, similar in concept to the economic sensitivity suggested by COGEH and outlined above. Technical revisions should include changes in volume projection forecasts, yields, shrinkages, and possibly operating costs.

PUSH REMAINING BALANCES TO TECHNICAL REVISIONS

After the reserve balance at the beginning of the evaluation period has been adjusted for changes that occurred in known quantities, economic factors, and reserve forecasts (technical revisions), there will invariably be a leftover amount of change that has not been accounted for. COGEH suggests that the evaluator attempt to quantify the most material changes possible. They should then group the remaining change balance as part of technical revisions so that the sum of the adjustments made to individual change categories matches the total adjustment required to reach the final reserve balance at the end of the evaluation period. In practice, companies refer to this as a “push to technical revisions”.

WHAT ARE THE OBSTACLES?

The two biggest obstacles facing a company's reconciliation efforts are a lack of time and standardization.

The data management and calculations necessary to produce a consistent reconciliation policy are virtually impossible. Companies take advantage in the lack of definition to short-cut procedures so that the evaluations are feasible from a man-power point of view. Engineering technicians usually handle the rigorous data manipulation of recalculating economic limits and honoring group economics manually. It's a very time consuming operation.

Section 7 of COGEH Volume 2, provides the most comprehensive outline on the procedures for performing reserve and value reconciliations. However, the calculations themselves are not specified in sufficient detail to avoid significant variances. Companies can and do incorporate very different calculation strategies on change categories as a matter of convenience for handling the data, producing erratic results. The most widely accepted methods also introduce a bias in the reported significance of the categories because they do not address the *inter-relational effect* of multiple changes very well. Further, the tendency is to adjust the technical revisions category so that it makes up for a surplus or deficit in accounting for the total change. Thus, one can easily overstate the relative importance of technical revisions to the total project and fool oneself into thinking that one has reported to a higher degree of accuracy than the methods truly allow.

LACK OF STANDARDIZATION LEADS TO ERRATIC RESULTS

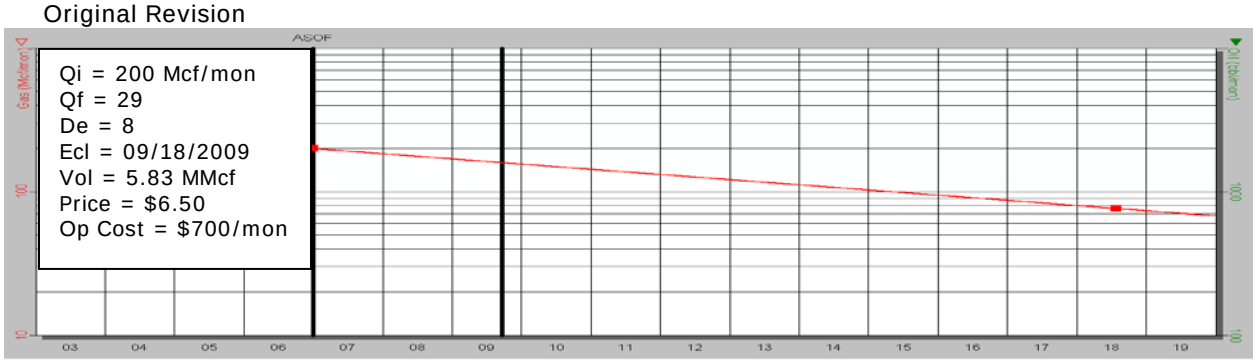
Consider two widely used strategies on performing reconciliations which calculate change values at very different points in the process. Incremental change accounting captures incrementally changed data *as it occurs* during the course of an evaluation. The other strategy is based on an isolation sensitivity, which is a contrived, back-end economics run designed to separate the differences resulting from independent change categories. The isolation sensitivities are performed *after* all changes have been made in the course of an evaluation period.

INCREMENTAL CHANGE ACCOUNTING IS ORDER BIASED

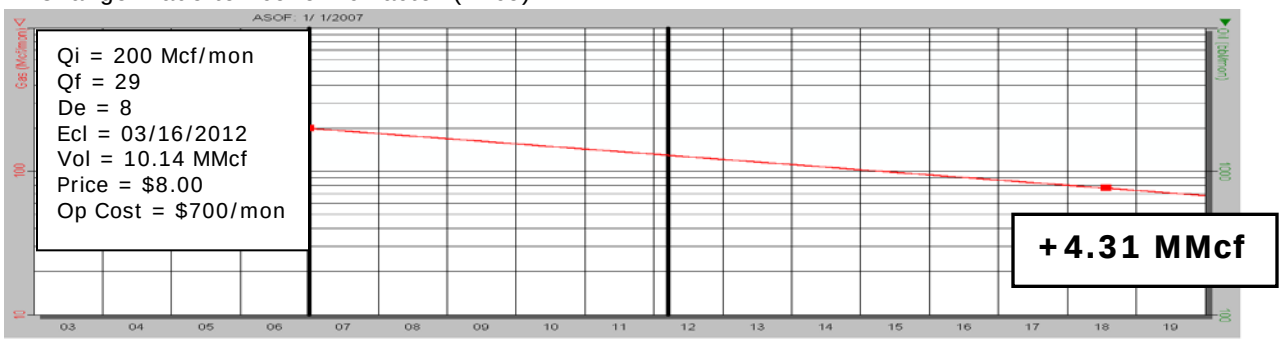
One of the easiest methods for calculating value or reserves changes attributable to a specific category is to capture the change value at the time a change is made. For example, an automated system can log a projection change in real time as the engineer makes it and record the resulting difference to reserve volumes and value. Incremental changes in prices, projections, or anything else can be captured, categorized, and continuously logged throughout an evaluation period. Change value data captured in this manner can then be aggregated and will sum exactly to the total amount of change that occurred during that period. This provides a false sense of security because all the components of change always add up to the total. However, the amount attributed to specific change categories is extremely biased to the order in which the change or calculation was made. Consider Figure 2 as an example.

FIGURE 2. INCREMENTAL CHANGE ACCOUNTING: ECONOMIC FACTOR CHANGED PRIOR TO TECHNICAL REVISION

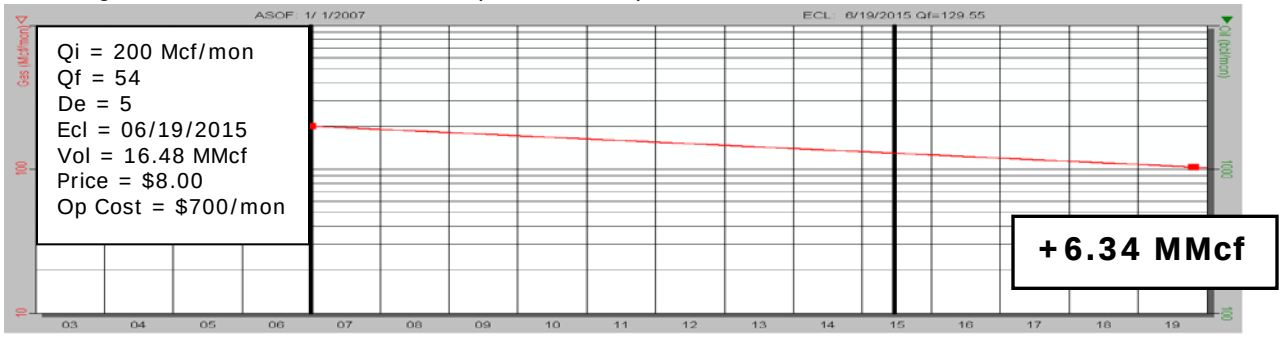
Original Revision



Change made to Economic Factor (Price)



Change made to Technical Revision (Decline Rate)



Economic Factor plus Technical Revision = Total Change +10.65 MMcf

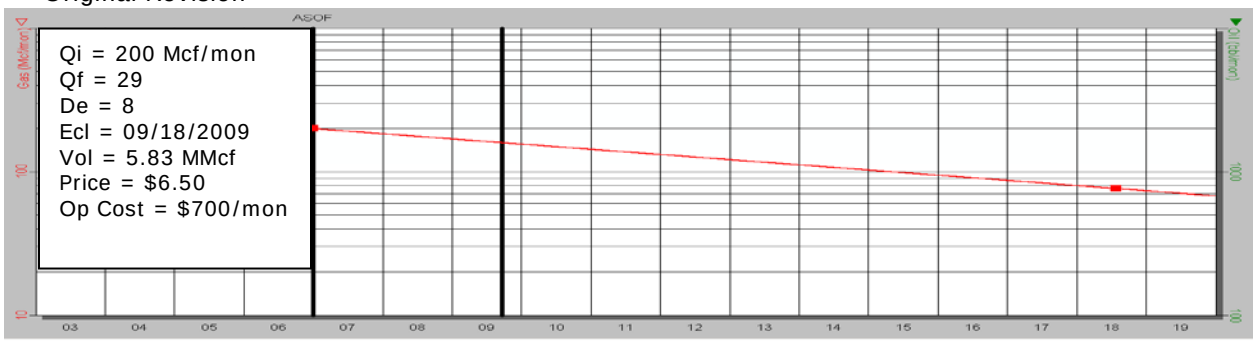
Figure 2 shows an example in which the values credited to changes are recorded as the edits are made. Two revisions were made over the course of this evaluation, one for price and one for the major phase projection. The incremental change attributed to price occurred first and was logged as a negative 3.43 MMcf reserve change due to economic factors. The price change was then followed by a change in the projection that resulted in an additional negative reserve

adjustment of 11.44 cf, which was attributed to technical revision. Therefore, if one were to examine the reconciliation report on this case, one would assume that a technical revision (projection change) was the primary reason for the drop in reserves.

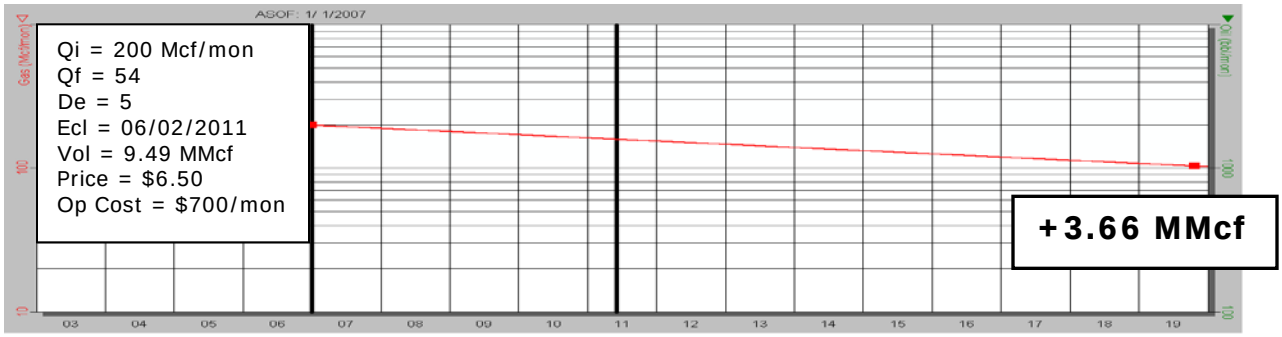
Figure 3 displays an example of an evaluation with the same changes as before, except this time the engineer made his or her change to the projection before making the change for price.

FIGURE 3. INCREMENTAL CHANGE ACCOUNTING: TECHNICAL REVISION CHANGED PRIOR TO ECONOMIC FACTOR

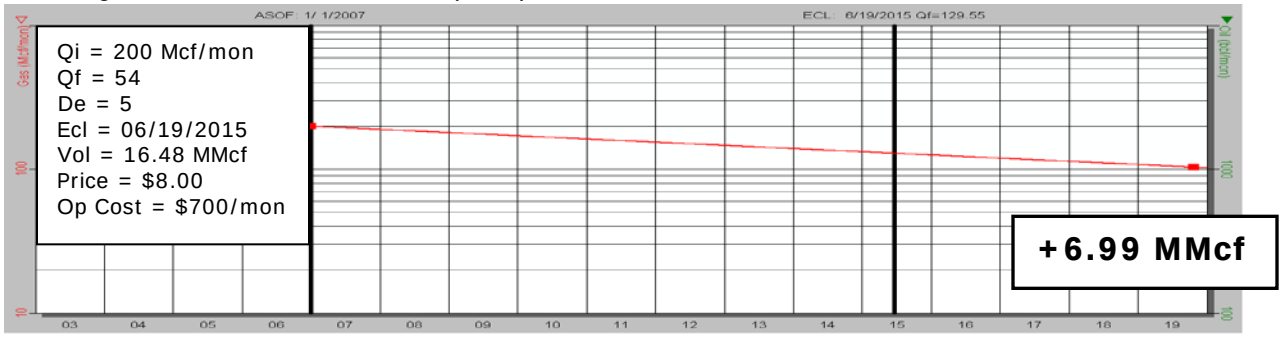
Original Revision



Change made to Technical Revision (Decline Rate)



Change made to Economic Factor (Price)



Economic Factor plus Technical Revision = Total Change +10.65 MMcf

The total reserve change for the evaluation period is identical in Figure 3 compared to Figure 2. However, the reason attributed to the change in reserves reported to shareholders is very different. Note in Table 7 below that, by changing the order in which the edits were made and recorded, we have completely changed the emphasis as to the primary reason for the drop in reserves from technical revisions to economic factors.

TABLE 7. BIAS RESULTING FROM CALCULATION ORDER

	Economic Change First	**Projection Change First**
Beginning Balance	5.83 MMcf	5.83 MMcf
Economic Factors	**40%**	**66%**
Technical Revisions	**60%**	**34%**
Ending Balance	16.48 MMcf	16.48 MMcf

Consider another very common situation in which a company may need to separate the changes due to prices away from the changes due to op costs. Both are under the major heading of economic changes, but it can become necessary to separate them for value reconciliations or for internal management needs. The same thing happens here as did in the example of prices and projections. Incremental change can be measured for a price change followed by an op cost change to reach the total amount of change made during the evaluation. The emphasis would most likely appear to be on the op costs (assuming both changes were significant to the reserves). If the order was reversed to calculate op cost changes first, however, followed by price changes, the results would be reversed, therefore changing the emphasis of what is reported to stockholders or management.

It should be noted that this method of calculating the amount credited to specific change categories can be used somewhat effectively if the order of edits is controlled for this ultimate purpose. For example – a company would be able to get a consistent set of reconciliation values if they followed a policy of always ordering technical revisions first, followed by all price changes, followed by all op cost changes, and so on. The difficulty would be in managing last minute changes for projects that did not follow the pre-conceived order.

Examine the following set of theoretical figures which illustrate the effect of two parameter changes on a reserve reconciliation. Real evaluations are so complex due to the numerous variables, limiting the scope to two variables (as in Figure 4) makes it easier to see what is going on. The upper left hand corner of the figure represents the evaluation in its initial

revision state. The lower right-hand corner represents the final revision of that evaluation. The amount of price change increase from left to right, and the amount of projection change increases from top to bottom.

FIGURE 4. AREA REPRESENTATION OF CHANGE CONTRIBUTION–INCREMENTAL I

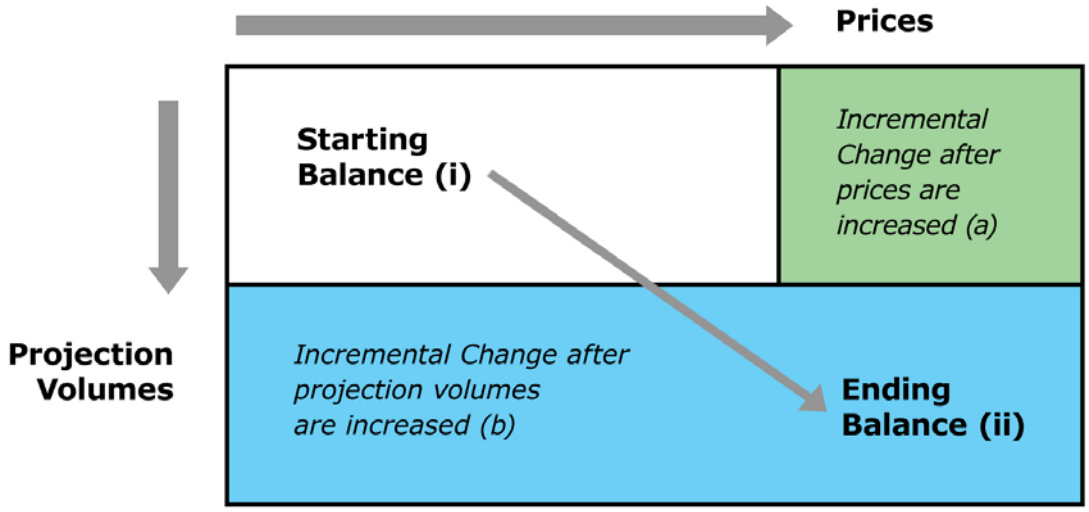
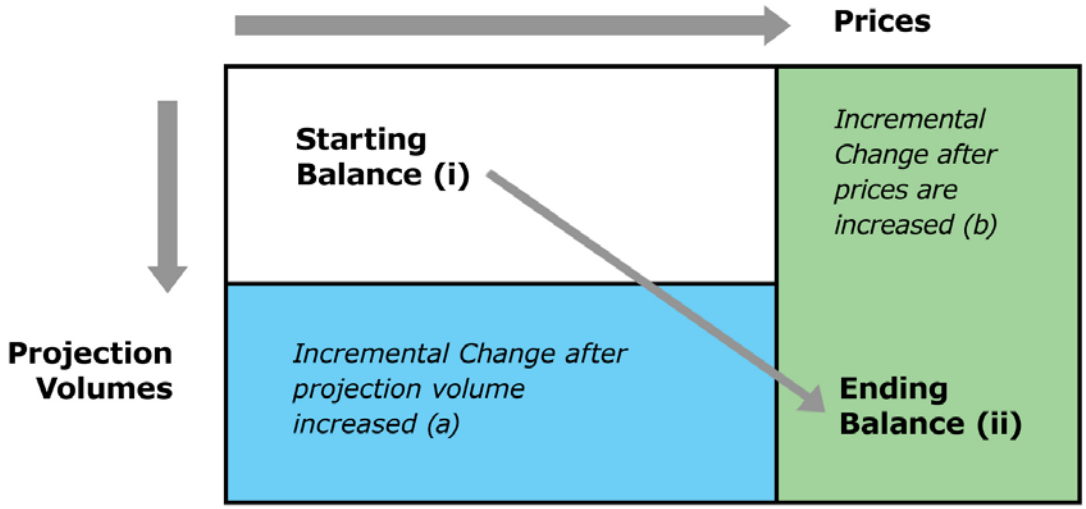


Figure 4 represents the way that incremental change accounting would calculate a price change followed by a projection change. The starting balance (i) increases as the price changes, resulting in a theoretical area which is equal to the new balance of (i) + (a). That change is followed by the increase in projection, or technical revision, which is represented by theoretical area (b), reaching the ending balance (ii).

Note the relative area of the change for price as compared to the area for the change due to projection volume.

FIGURE 5. AREA REPRESENTATION OF CHANGE CONTRIBUTION–INCREMENTAL II



Now, if turned around, as shown in Figure 5, so that the projection change is made first (a), followed by the price change as shown by area (b), it is clear that the impact of each change category on the whole of the project has drastically changed, just as was shown in the example in the previous section.

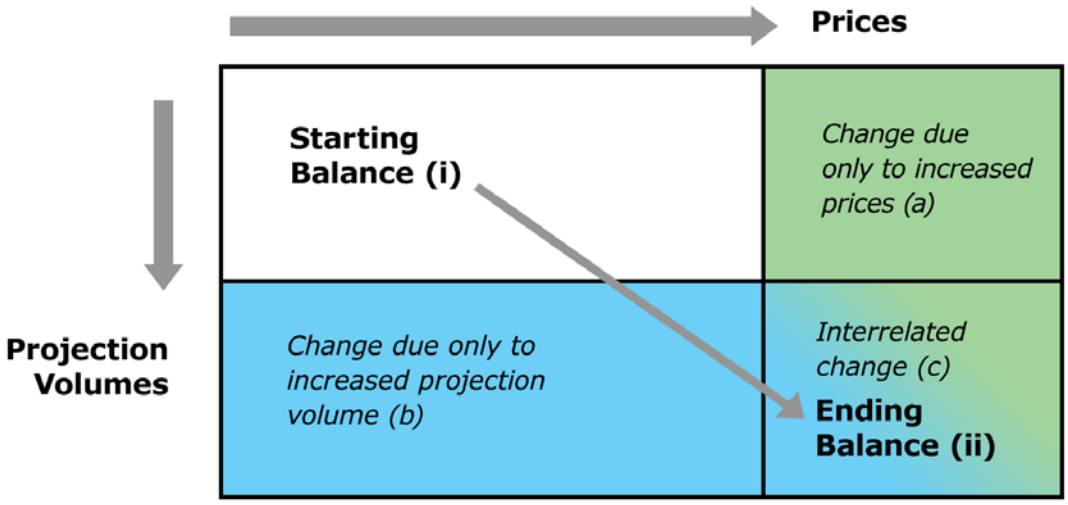
Overall, capturing incremental changes at the time of the edit is not a particularly accurate and consistent method of quantifying value or reserves attributed to specific change categories because the emphasis is biased towards the last calculation made, regardless of the specific parameters. The bias resulting from the order of incremental change accounting calculations occurs when ever more than one factor changes in an evaluation. Unless all changes are performed at the same time within each given category, incremental change accounting can not effectively separate factors into distinct categories.

ISOLATION SENSITIVITIES CAN CAUSE PHANTOM TECHNICAL REVISIONS

To avoid order bias, the categorization calculations should be performed after all changes have been made in an evaluation, mathematically isolating each change category independently, down to the lowest level that is intended to be reported.

Figure 6 constructs another area representation chart as those above. This time, the calculation of change factors is represented in a way that completely isolates them from one another. This type of theoretical diagram illustrates how an isolation sensitivity would determine reconciliation values. These sensitivities are a great way to separate the factors into their independently acting change categories, but they completely ignore the contribution of interacting factors. Thus, the sum of a series on isolation sensitivities will not equal the total evaluation change balance.

FIGURE 6. AREA REPRESENTATION OF CHANGE CONTRIBUTIONS–ISOLATION SENSITIVITIES



Square (a) represents the original revision with only a price change. Square (b) represents the original revisions with only a projection change. The multi-colored square in the lower right hand quadrant represents the amount of change resulting from price changes upon projection changes.

The final revision is the sum of the initial revision + (a) + (b) + (c). It should be further stated that the amount of interrelated change is really a function of the magnitude of the contributing factors to each other. Stated differently, if two factors have relatively the same true impact on reserves or value, then the amount of interrelated change is maximized.

Figures 7 and 8 are actual accounts of a situation in which an isolation sensitivity, combined with the industry accepted method of “push to technical,” created technical revisions that were never made.

Consider a scenario in which, during the course of an evaluation period, only op costs and oil prices have changed, nothing else. In this case, incremental changes will not be measured as they occur. The amount of change for the two parameters will be calculated using isolation sensitivities at the end of the evaluation period in the manner suggested by COGEH. Suppose further, that the projection of estimated production for the year was correct and the actual production volumes tracked perfectly with the estimate. There were no changes to future volume projections. In theory then, technical revisions should be zero.

FIGURE 7. EXAMPLE OF PHANTOM TECHNICAL REVISION–INITIAL REVISION

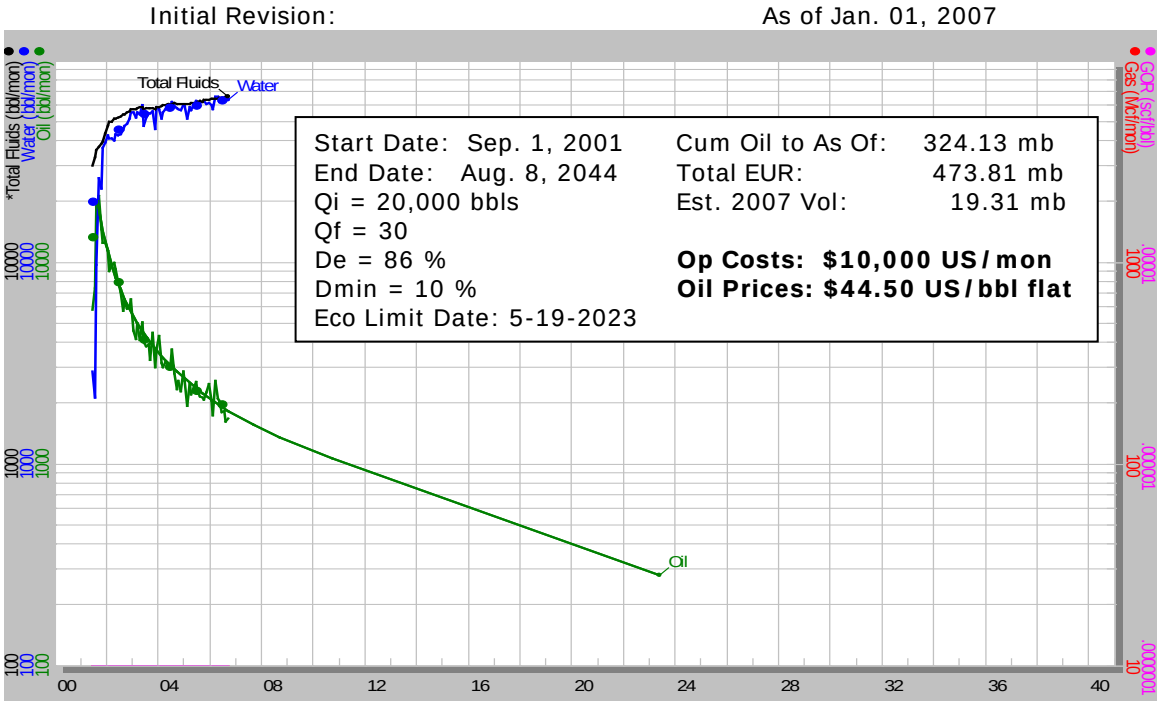
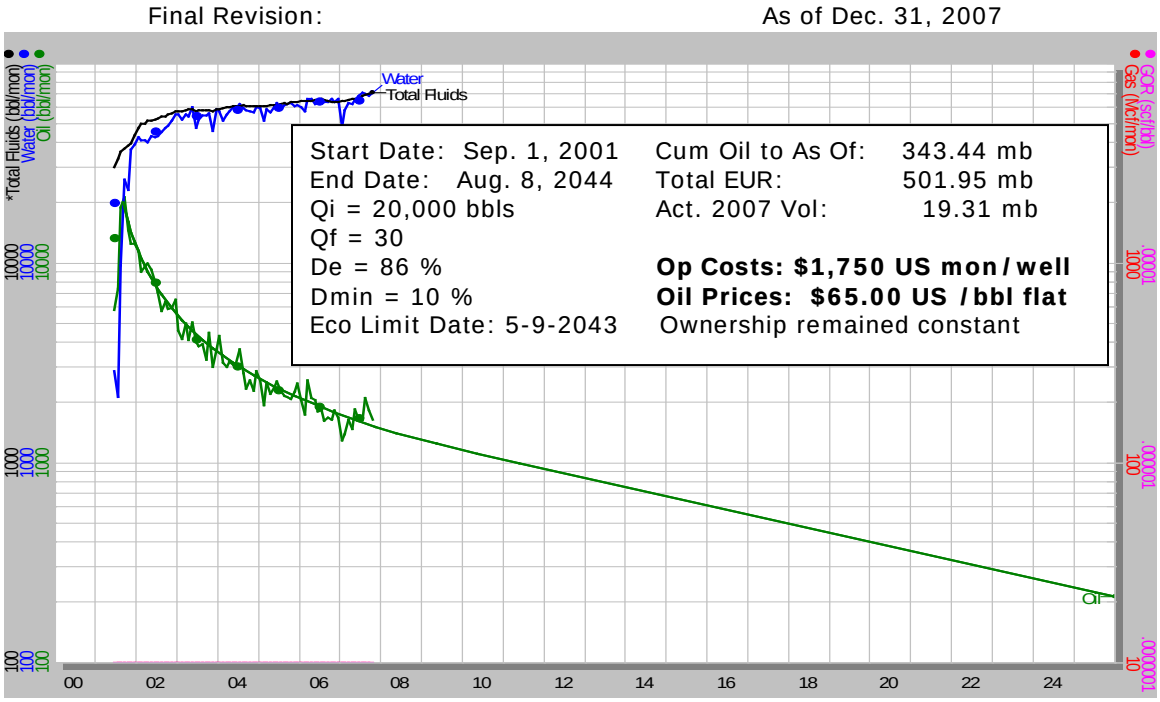


FIGURE 8. EXAMPLE OF PHANTOM TECHNICAL REVISION–FINAL REVISION



A reserve reconciliation analysis of the examples in Figures 7 and 8 results in a total balance of change of 2.209 Net BOEs. There were no acquisitions, dispositions, or any changes to ownership, so the only known value is production. Following the guidelines in COGEH, the next step was to run an isolation sensitivity on economic factors. This was most easily accomplished with two separate sensitivity runs – one for prices and one for op costs. The resulting balance change from each isolation sensitivity was recorded in Table 8 below as shown.

TABLE 8. RESULTS OF ISOLATION SENSITIVITY BALANCES FROM FIGURES 7 & 8

Category	NetBOE (Mbbl)	NetBOE (%)
START BALANCE 1/01/2007	37.420	719.978
UNASSIGNED	2.080	94.0 %
Acquisition	0.000	0.000
Disposition	0.000	0.000
Production	-4.827	-219.0%
Price	0.441	20.0%
Fixed Op Costs	4.515	204.0%
Variable Op Costs	0.000	0.000
Royalty	0.000	0.000
Production Tax	0.000	0.000
Development Cost	0.000	0.000
Abandon & Reclaim Costs	0.000	0.000
Federal Tax	0.000	0.000
Technical Revision	0.000	0.000
Exploration Discovery	0.000	0.000
Extensions	0.000	0.000
Improved Recovery	0.000	0.000
Infill Drilling	0.000	0.000
New Reservoirs in Old Fields	0.000	0.000
Accretion	0.000	0.000
Errors in Interest	0.000	0.000
Transfers	0.000	0.000
TOTAL DIFFERENCE	**2.209**	**100.0 %**

By running isolation sensitivities at the end of the evaluation, the results are not biased by the order in which the calculations were performed. However, the interrelated change has not been accounted for. In focusing on the results for the Net BOE changes, it can be inferred that volumes dropped as predicted for production. The lowering of op costs and increase in prices led to a gain back of almost all of the produced reserves because the economic life of the case changed. The problem becomes apparent when one realizes that the total change was 2.209 m BOEs and the recorded changes do not add up to that amount. In fact, note that there are 2.080 m BOEs leftover that are currently listed as “unassigned” – almost as much as the total change for the evaluation period.

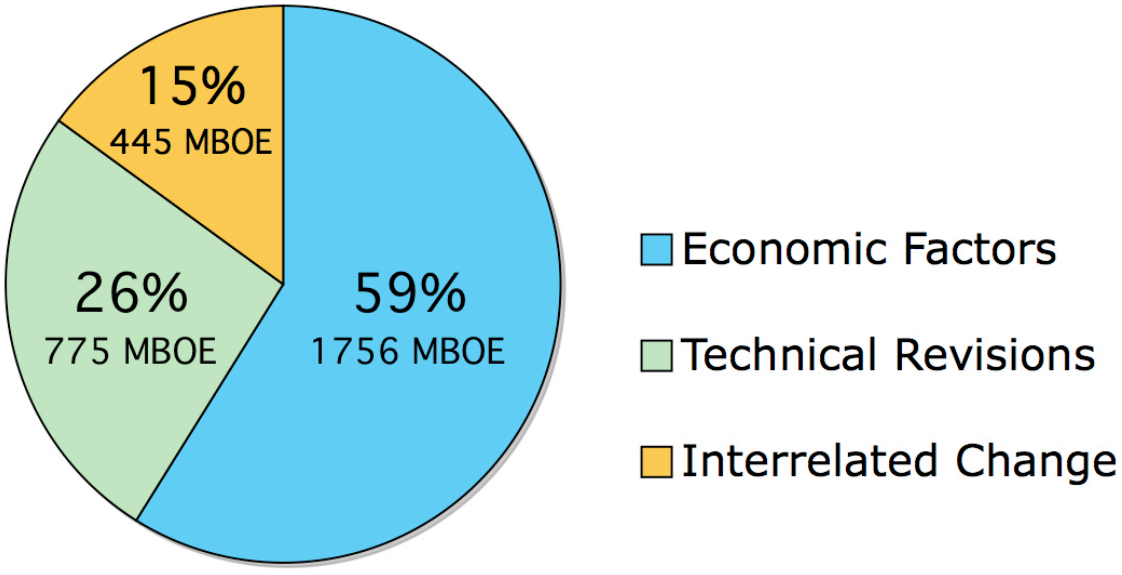
Industry accepted practice would dictate taking any unaccounted-for balances (indicated as “unassigned” in Table 8) and “push to technical revisions.” Thus, in this case, technical revisions numbers will end up almost equal to the total change, even though there were zero projection changes. Currently, companies rely on the evaluators to override situations like this where it is known that there were no projection changes. But where should they put the

unassigned amount? When multiple properties are aggregated together for reporting purposes, such phantom technical revisions can be easily overlooked.

AMOUNT OF TOTAL CHANGE DUE TO INTERRELATED FACTORS

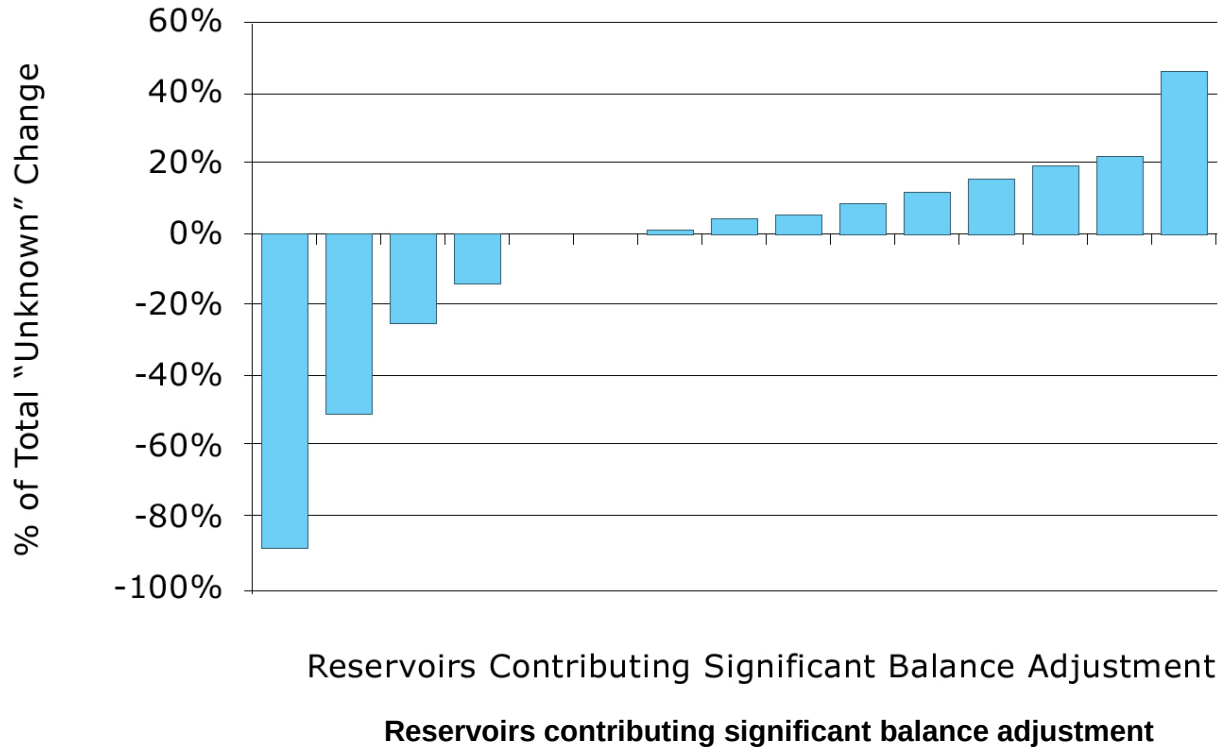
The amount of change due to interrelated factors is data dependent and can easily vary from zero to almost anything. Results of a series of isolation sensitivities on a reconciliation project of approximately 4500 properties indicate that the total average amount of interrelated change on this set of properties was 15 percent. Following normal procedures, all of the "known" values for acquisitions, adds, dispositions, production, and transfers were pulled out of a reconciliation evaluation. This left a total remaining balance for technical revisions and economic factors of 2976 NET MBOEs (which was about 10 percent of the initial revision total reserves). Isolation sensitivities were then run on technical revisions and economic factors, resulting in the following pie chart in Figure 9.

FIGURE 9. AVERAGE IMPACT OF INTERRELATED CHANGE-CASE STUDY



Prior working knowledge of this database anticipated that the majority of these cases came from mature properties where technical revisions were relatively slight with respect to dramatic changes in oil prices.

FIGURE 10. DISTRIBUTION OF INTERRELATED CHANGE



Reservoirs contributing significant balance adjustment

To determine the amount of "scatter" in the case study, the properties were aggregated to the reservoir level and the percentage of the interrelated change for each reservoir was plotted as a function of the difference of the balance. The standard deviation was 32 percent.

DATA ORGANIZATION DIFFICULTY

By anyone's standards, a year-end reconciliation report is a time-consuming and data-intensive operation. There are a tremendous number of parameters that must be run through rigorous sensitivities. These parameters may or may not be easily reproduced and available for substitution in these runs.

Some companies maintain historical prices, op costs, sales volumes, and back-projections within their evaluation files. If this is the case, it is not hard to substitute new

scenarios into older databases (with previous as of dates) and run the sensitivities. If these historical parameters have not been maintained, they have to be inserted into the file, probably by merging pieces of various models from different databases. At times, however, the temptation to get creative or manipulate numbers to produce the necessary runs may be strong.

Currently, engineering technicians work on handling data substitutions for sensitivities or aggregating incremental changes up to report level. If a company has performed reconciliations on individual properties, then it is fairly easy to sort and filter to find obvious mistakes and make corrections. If the entire reconciliation has been done on an aggregate basis, the process of finding or correcting mistakes becomes almost impossible. The 4500 property case study observed for this paper for this paper utilized approximately four man-weeks of time to satisfy the requirements for their internal management benchmarks as well as SEC and NI 51-101 filing requirements.

Technicians encountered problems such as:

- Making sure individual property economic limits were re-calculated properly within sensitivities;
- Making sure that group facility economic limits were re-calculated properly;
- Ensuring that any parameters using automatic date triggers tied to the as of date did not change when changing as of dates;
- Managing the price models effectively so they could be substituted;
- Identifying acquisition, disposition, and add cases;
- Searching individual properties for major contributors to mistakes.

WHAT WOULD IMPROVE IT?

AUTOMATION FOR REPRODUCIBILITY AND SPEED

This paper's case study company used a conventional method that consisted of running various reports and hand substitution of parameters into evaluation files, substituting them from each other, and recording results. Production, acquisition, and adds values were pulled from accounting records. Prices and op costs were determined by isolation sensitivities, and the remainder was assumed to be technical revisions. The process took approximately four man-weeks of resources, capturing nine different change records. In parallel, the process was run in an automated fashion on the same evaluation files, capturing fourteen change categories in approximately five hours.

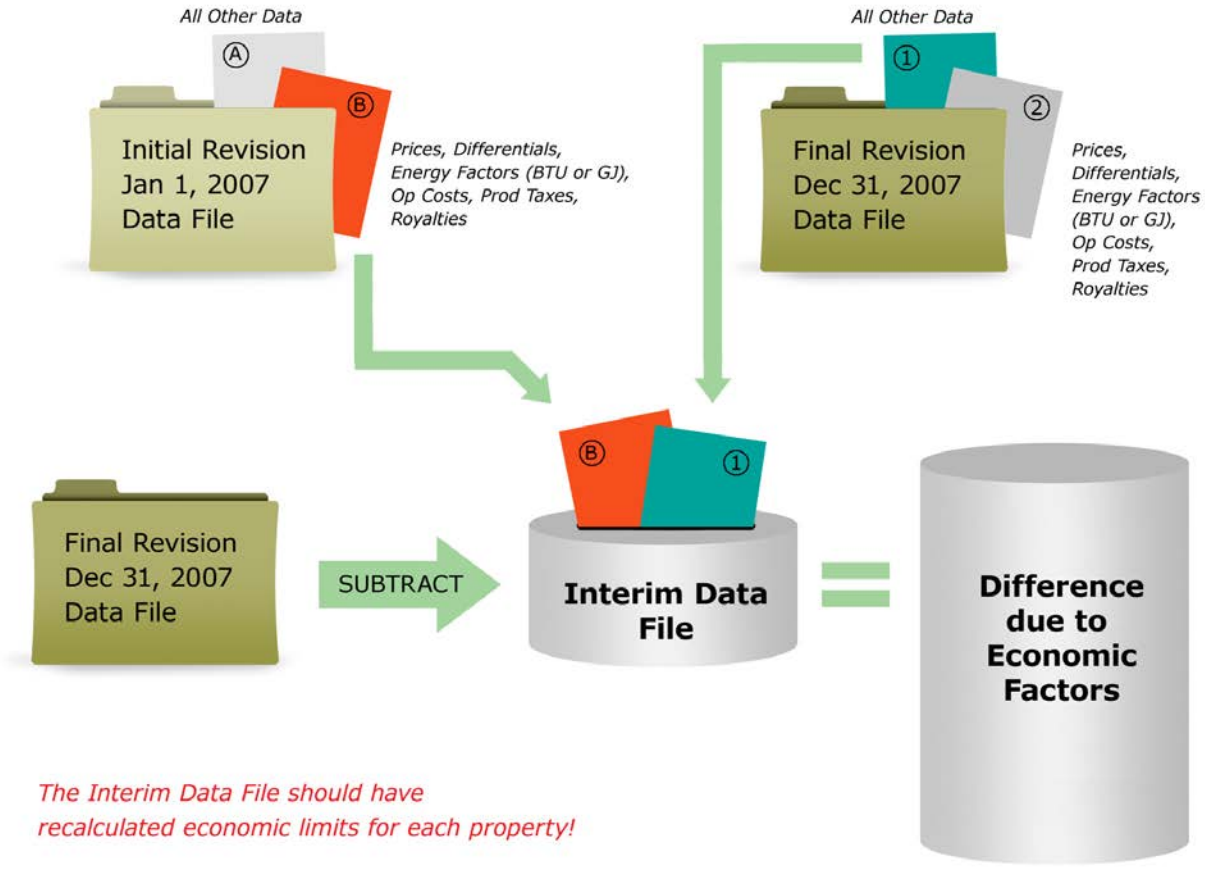
A review process of the methods proved to be extremely challenging. The conventional method was reported down to a field level (as opposed to an individual property level), which was insufficient detail for resolving discrepancies. In the end, reconstructing the numbers at a lower level with the conventional method and then aggregating them to a field level proved too time consuming and the attempt was aborted. Overall, the reported technical revisions from the case study using conventional methods for proved reserves was 996 Net MBOE compared to 447 Net MBOE for the automated procedure. This difference was approximately 2 percent of the total reserves at the initial revision of the evaluation, or about 25 percent of the total reserve change not due to knowns (acquisitions, dispositions, adds, transfers, production).

REVERSE POLARITY CAN EASE DATA MANAGEMENT

Isolation sensitivities provide the most consistent method for calculating the values because they are order independent. Further, they can be run so as to minimize the amount of data preparation required to perform a reconciliation. Suppose a company had not maintained the previous year's pricing forecasts in their evaluation file. It is possible to reverse the order of the parameter substitution in the isolation sensitivity and run it as of the final revision date. For lack of a better term this is called "reverse polarity," referring to the direction of parameter substitution. For proper sign convention, the interim data file is subtracted from the final revision

file and therefore an increase in prices from January 1 to December 31 yields a positive change in reserves.

FIGURE 11. FLOWCHART FOR A REVERSE POLARITY ISOLATION SENSITIVITY



Theoretically, a reverse polarity sensitivity is as good as a normal polarity run. The idea in both cases is to mathematically isolate the change due to a single parameter. The danger is that companies may reverse the direction of parameter substitution (old parameters into the newer databases) for data convenience only in order to calculate *some* of the categories. They may even fall back to incremental change accounting for others. Either way, they end up with a mixture of methods.

Mixing isolation sensitivities with different polarities is expedient in terms of getting the year-end report out, but one calculation strategy includes interrelated factors and the other does not. Parameter substitution in two different directions measures an isolated initial change, versus an isolated final change. The interrelated change component gets in the way because in one direction the calculations already include change due to other factors (because it utilizes the

final revision), and in the alternate method, there are no changes due to other factors (using the initial revision). It is not mathematically sound to combine the two in the same evaluation.

STANDARDIZATION OF CALCULATION METHODS

So far, this paper has noted that incremental change accounting introduces a significant bias towards the last calculation made and that isolation sensitivities do not sum to the total change. Also, data organization makes the overall process extremely time-consuming. What is needed is a consistent set of procedures that are mathematically sound and easy to reproduce. Currently, there is too much latitude in how calculations are performed. Calculation methods should be disclosed with the numbers and should utilize consistent methods each time a reconciliation is performed within a given company.

Reconciliation processes need to be improved through consistency of calculations and concise detail on what is being asked for. COGEH (or a document like it) needs more definition and it needs to be adopted as the widespread standard for creating reconciliation disclosures internationally. The primary goal of a reserve or value reconciliation disclosure is to provide a meaningful measure of change. Currently, variances in calculation methods, and even in terminology, offer too much latitude to accomplish this effectively.

STANDARD METHOD FOR DISTRIBUTION OF INTERRELATED CHANGE

The core concept that requires agreement is the method of calculating the change factors. Hopefully, the illustrations in this presentation have proved that using incremental change accounting introduces a large bias in the results unless great care is taken in the ordering of the calculations because the interrelated change cannot be separated easily. Isolation sensitivities should be the preferred method because they are order independent, so long as the "polarity," or direction of parameter substitution, is consistent.

Isolation sensitivities, however, leave a remaining balance due to the interrelated change from multiple factors, which, for now, industry practice tends to place in the "unassigned" category and then push to technical revisions. This leads to overstatement of the technical revisions. Therefore, the missing step is to distribute this "unassigned" amount by means of a consistent distribution method back to its contributing components. If a distribution

method for the interrelated change could be defined so that different organizations could agree and reproduce it, a workable and consistent method for standardization on reconciliation evaluations could go into use.

CAN A WEIGHTING METHOD FOR DISTRIBUTION BE CONSTRUCTED THAT WORKS?

It seems logical to assume that a direct reapportionment of the amount of change of a single factor, relative to the total amount of change, would be an effective method to distribute the interrelated change amount to the contributing factors.

Using either substitution polarity convention, the values could be weighted by distributing the total change amount based on the relative weight of the individual change category to the sum of all the changes as follows.

$$\text{Weighted Price Change} = \frac{\text{Price Run}}{\text{Sum of All Runs}} \times \text{Total Change}$$

After a considerable amount of empirical testing, this assumption seems to prove true in some situations, namely when the distribution is performed on data sets that have been run with reverse polarity isolation sensitivities. It needs to be further stated that determining what is the "right" answer is almost impossible. It is far easier to determine what method yields results that do not appear to be wrong over a large range of test data. The following set of examples illustrates the hypothesis of a procedure that appears to give reasonable results most of the time.

EXAMPLE OF DIRECT REAPPORTIONMENT DISTRIBUTION OF INTERRELATED CHANGE

Figure 12 and 13 and Table 9 present a situation where there has been an overall 20 percent change in reserves during an evaluation period. Upward price movement and positive technical revisions increased reserves while increasing op costs decreased the reserves. The example was run once in normal polarity (substituting new parameters in the original database) and once in reverse polarity (substituting old parameters into the newer database) so that the results could be compared. As should be expected, each change factor calculated a different amount of change under the different polarity situations before the direct apportionment weighting was applied. What is important to know is whether the two methods would yield the same overall values after weighting.

FIGURE 12. NORMAL POLARITY ISOLATION SENSITIVITY RESULTS BEFORE WEIGHTING

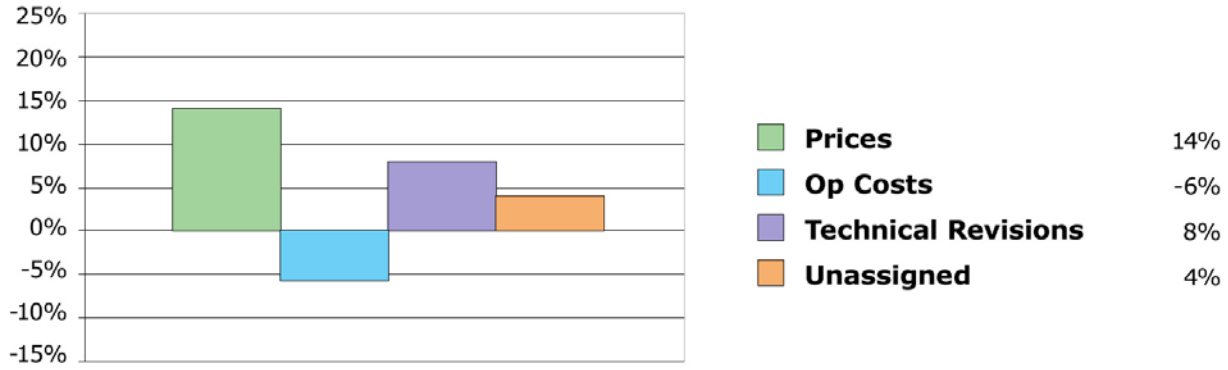


FIGURE 13. REVERSE POLARITY ISOLATION SENSITIVITY RESULTS BEFORE WEIGHTING

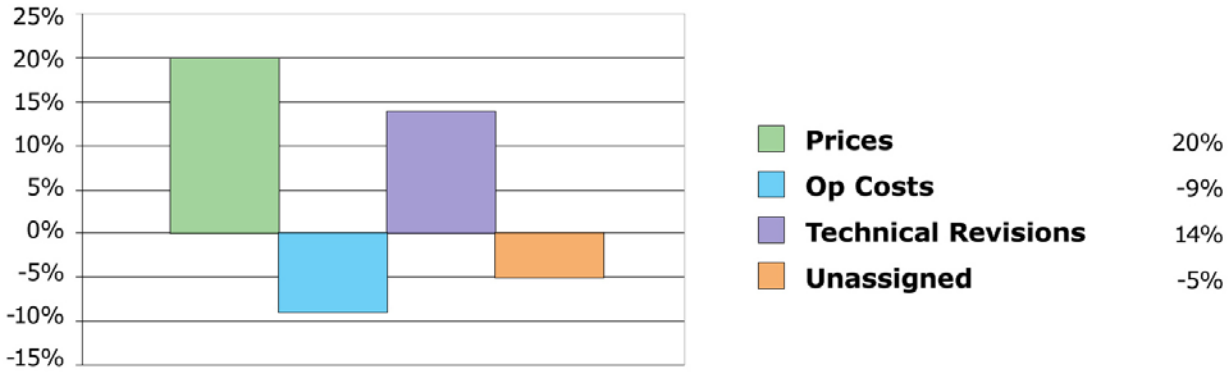


TABLE 9. POLARITY EFFECT ON WEIGHTED ISOLATION SENSITIVITIES

Distribution of Unassigned % Occurs	Prices	Op Costs	Technical Revisions
Normal Polarity	17.5%	-7.5%	10.0%
Reverse Polarity	16.0%	-7.2%	11.2%

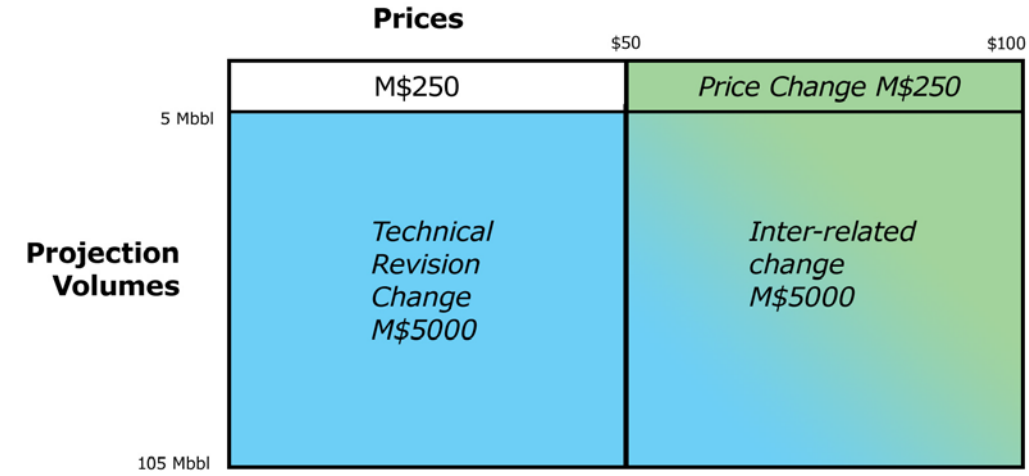
Normal Polarity:
Unassigned = 4%, Prices = 14%, Op Costs = -6%, Technical Revisions = 8%
Total Change = Prices + Op Costs + Tech Rev + Unassigned = 20%
Sum of all runs = Prices + Op Costs + Tech Rev = 16%
Prices = (14%/ 16%) x 20% = 17.5%
Op Costs = (-6%/ 16%) x 20% = -7.5%
Tech Rev = (8%/ 16%) x 20% = 10%
Reverse Polarity:
Unassigned = -5%, Prices = 20%, Op Costs = -9%, Technical Revisions = 14%
Total Change = Prices + Op Costs + Tech Rev + Unassigned = 20%
Sum of all runs = Prices + Op Costs + Tech Rev = 25%
Prices = (20%/ 25%) x 20% = 16.0%
Op Costs = (-9%/ 25%) x 20% = -7.2%
Tech Rev = (14%/ 25%) x 20% = 11.2%

In this example, the different calculations mirrored each other with a reasonable degree of accuracy.

FURTHER TESTING: AN EXAMPLE OF A DIRECT REAPPORTIONMENT METHOD OF DISTRIBUTION OF A VERY LARGE INTERRELATED CHANGE

What if the above example is re-worked with change values of a larger scale? In this case, a dollar amount of change is used to test the theory under a more extreme situation. For situations where the interrelated changes are very large, the differences in polarity become more noticeable. In this example, price doubles and projected volumes increase twenty-fold.

FIGURE 14. EXAMPLE OF LARGE INTERRELATED CHANGE ON WEIGHTING



Normal Polarity:
Unassigned = 5000, Prices = 250, Technical Revisions = 5000
Total Change = Prices + Tech Rev + Unassigned = 10250
Sum of all runs = Prices + Tech Rev = 5250
Prices = (250/ 5250) x 10250 = 488.1 = 4.76% of the total change
Tech Rev = (5000/ 5250) x 10250 = 9761.9 = 95.24% of the total change
Reverse Polarity:
Unassigned = -5000, Prices = 5250, Technical Revisions = 10000
Total Change = Prices + Tech Rev + Unassigned = 10250
Sum of all runs = Prices + Tech Rev = 15250
Prices = (5250/ 15250) x 10250 = 3528.7 = 34.4% of the total change
Tech Rev = (10000/ 15250) x 10250 = 6721.3 = 65.6% of the total change

TABLE 10. POLARITY EFFECT ON LARGE INTERRELATED CHANGES

Distribution of Unassigned %	Prices	Technical Revisions
Normal Polarity	4.76%	95.24%
Reverse Polarity	34.4%	65.6%

In normal polarity, almost all of the total change is distributed to technical revisions, but in reverse polarity, the price change gets more than a third of the total change. Intuitively, it is unlikely that a 100 percent change in price will yield less than a 5 percent change in total value. If a change affected the total difference by such a small percentage, then removing that change entirely would not affect the total by much. However, if the price change is removed entirely (by having constant price of $50 in both revisions), the total change is just M$5000. That is less than 50 percent of what it would have been with the price change.

It is theorized that, in normal polarity, the unassigned amount contains the total interrelated changes. In reverse polarity, each sensitivity contains the portion of the interrelated

changes to which they contribute and the unassigned amount is a negative summation of these interrelated changes. As further illustration, in normal polarity, the un-weighted change due to price was 14 percent, while in reverse polarity the amount resulting from the sensitivity for this was 20 percent. Remember, the reverse polarity calculations begin with a revision that has all of the changes made to the evaluation and one by one substitutes them with the original values. From the point of view of the equation itself, the resulting values start to diverge when the denominator (sum of the sensitivity runs) is large relative to the numerator (individual sensitivity).

Therefore, reverse polarity deals with pulling individual parameters out of a "finished" run, while a "normal polarity" run deals with making a single change to an "incomplete" evaluation. Each component of the reverse polarity situation has been affected by the sum of all the changes, while the normal polarity run can only include it in the total. Attempting to create a weighting factor from a normal polarity run breaks down when the interrelated change is large relative to the individual changes.

HOW MANY ISOLATION SENSITIVITIES ARE NECESSARY AND WHAT PARAMETERS CHANGE?

Some critical factors need to be considered before a weighted distribution of interrelated change becomes possible. These factors include:

- Accounting for all change categories. When the weighting occurs, each category must be allowed to receive its fair share of the interrelated change.
- Examination of data and choice of polarity. Consistency is important.
- Running sensitivities on all properties individually and aggregate to report level.

Isolation sensitivities should be run on all interrelated factors, regardless of what ultimately has to be reported. A workable weighting distribution cannot be constructed on a partial set of values. Known quantities should be determined and recorded first, separate from those factors that contribute to the interrelated change. Sometimes these values could be taken straight from a company's accounting or geology department. Known quantities, by definition, should be excluded from any weighted distribution of the unassigned amount that occurs after the sensitivities are run.

Isolation sensitivities can and should be run on the values considered to be known quantities during the evaluation period. These sensitivities are different from the remaining components in that they are somewhat hard-coded, and value from the unassigned amount should not contribute to them.

LIST OF ISOLATION SENSITIVITIES ON KNOWN QUANTITIES

PRODUCTION

Even if there is a known amount provided by an accounting department, it is recommended that a production sensitivity be run for comparison purposes. It should always be calculated using the final revision database and rolling the as of date back to the initial revision, substituting in prices, differentials, energy factors, escalations, op costs, production taxes, royalties, ownership and capital from the initial revision, then terminating the run at the final revision date. The final revision database is used to prevent any corrections that might have been made to cumulative volumes over the course of the year from skewing the results. Further, if using an automated program to perform the rollback, ensure that parameters using automatic dates such as recompletions, auto start projections, capital, economic life, tax abatements, and ownership reversions are not allowed to shift. There is no secondary file to subtract against. Change attributed to production should not be weighted.

ACQUISITIONS AND DISPOSITIONS

Any newly acquired properties or sale of existing properties need to be identified and the production occurring for those properties (from the date of the acquisition to the final revision date) should be classified as acquisitions or dispositions. Properties identified as new acquisitions or dispositions will not have any technical revisions or any other change category that is not equal to zero. Acquisition and disposition cases should not receive any weighted value or reserves from the unassigned category.

ADDS

Properties identified as adds should only have a non-zero change value in the adds category.

LIST OF ISOLATION SENSITIVITIES ON UNKNOWN QUANTITIES

TECHNICAL REVISIONS

Technical revisions should be the result of two things – the change in forecasted projections for the reserves and the difference between the actual volume and the projected volume during that period where they overlap. Technical revisions can be determined with a forecast change run (substituting forecast projection segments and shrinkages), and a projected production run. The projected production run is simply the initial revision file run only for the duration of the reconcile period from which the actual production from above is subtracted. This result is then added to the results from the forecast change run to get the total technical revision. Development capital associated with the timing of projection segments should be allowed to shift to stay in sync with the changes in projections for value reconciliations.

PRICES

This sensitivity is made by substituting, prices, escalations, and energy factors.

FIXED OP COSTS

This sensitivity is made by substituting fixed expense and expense escalations.

VARIABLE OP COSTS

This sensitivity is made by substituting volume related expenses and their associated escalations.

PRODUCTION TAXES AND ROYALTIES

This sensitivity is made by substituting tax and changes to royalty rates, plus any adjustments or deferments of royalty.

ACCRETION

Take an initial revision and change the as of date to that of the final revision (or vice-versa) and subtract it from the initial revision.

INVESTMENT CAPITAL

This sensitivity is made by substituting capital and its associated escalations.

OWNERSHIP

This sensitivity is made by substituting the ownership decks of the two revisions. Any ownership reversions that are keyed to the as of dates of their prospective revisions must be locked down so that their absolute dates cannot shift. These changes are captured as interest acquisition or disposition to existing properties. Cases that show up in this category should be inspected to determine whether they truly are changes in interest or if the case should be placed in an "errors in interest" category that as been corrected.

ABANDONMENT

This sensitivity is made by substituting abandonment capital and its associated escalation or inflation. The timing of the abandonment should continue to be linked to the correct end of projected production and thus may shift.

CONCLUSIONS

The theories illustrated in this paper represent a large amount of work in terms if research, working with individual companies as an observer, and programs that were used to empirically test them. They are presented as a possible scenario of methods that could be used to standardize reconciliations. Some of the major points arrived at during the course of this work are as follows:

- The current industry method of performing reconciliations uses various combinations of incremental change accounting, isolation sensitivities, and "pushing" the leftovers to technical revisions. This causes technical revisions to be overstated by as much as twice their relative importance when compared to economic factors.
- Current industry methods allow enough latitude to drastically change the results in ways that are not obvious.
- Incremental change accounting is not an effective way of performing reconciliation evaluations because it is order biased.
- Interrelated change results from multiple factors changing simultaneously, thus producing a total change amount that is greater than the sum of individual changes.
- Isolation sensitivities ignore a large portion of the total change caused by the inter-relation of multiple factors.
- Isolation sensitivities can be made to work if they employ a consistent polarity of substitution and a method of dealing with the interrelated change.
- Direct reapportionment of interrelated change can be used to distribute this amount if it is combined with reverse polarity sensitivities.
- Reverse polarity isolation sensitivities do not require a rigorous archive of monthly historical data to be maintained in the evaluation files and can be used to ease data management.
- All areas of change need to be accounted for. Partial calculations skew the numbers.
- If the reconciliation process can be standardized, it can be automated and thus speeded up by as much as 20 to 1. Manual and semi-manual reconciliation efforts are becoming too time-consuming to be practical.

From a review of a reconciliation process, it is obvious that the industry is still learning how best to accomplish it. Various case studies show that many companies struggle with this

process every year. The data organization aspect of such a process is huge. The time spent juggling numbers is mind boggling. How do you know what the right answer really is? Most companies hope that new reports track somewhat with the previous year's numbers. The main question becomes, what good is a performance measure that doesn't really have a standard to measure against?

If companies are very, very, good at being internally consistent, there is still nothing that equalizes the unit of measurement between different companies. Mergers and acquisitions ensure that there is a good chance that the exact same properties will be reconciled in a substantially different manner every time they change owners.

By understanding the effects of different types of calculations, the first benefit we can get is a commonality of terminology. Are op costs called "economic factors," or "technical revisions?" Should changes be measured using sensitivities or incrementally recording them? Are parameters substituted in the same direction every time? Are the same variables included when we reconcile prices?

Through understanding the impact of different types of calculations, it becomes easier to recognize the magnitude of difference for our answers. If companies "push" to technical revisions, versus a "push" to economic factors, they should understand that the rules and the answers have changed dramatically. Hopefully, the second benefit is the knowledge of whether we have provided a meaningful disclosure of change.

From the combination of terminology and an understanding of calculations, one should be able to put together a comprehensive standard that companies can look to each year, opening the door for automation of reconciliation.

It is the manual data management and guess work that takes the vast majority of time and money for this process, but in reality, sensitivities can be run in a matter of hours. Automation would vastly improve consistency, provide a true measure of change, and drastically reduce the time and resources to complete calculations.

APPENDIX - DEFINITIONS OF TERMS

Basis – The basis is the unit of measurement of change in a reconciliation process. Some examples of Basis would be Net Reserves, Gross Reserves, and Net Cash Flow.

Data Polarity – Data polarity is the direction of data substitution of parameters used in Isolation Sensitivity runs.

Incremental Change Accounting – This is a method of compiling the change due to factors as they occur. It is a difference of the resulting balance each time a change is made. It is later summed by category to give the total change occurring over a reconciliation period.

Interrelated Change – Interrelated Change is the effect that multiple changes have in combination with each other. The best explanation comes from the fact that the sum of the individual changes do not add up to the total change because of the incurred additional change resulting from their interaction.

Isolation Sensitivities – A method of determining the impact of specific change to an evaluation by substituting a single parameter into a known database, creating an economic output, and then subtracting the one output result from the other

Normal Polarity – When running Isolation Sensitivities, Normal Polarity is the term for taking the Initial Revision evaluation and substituting into it a single parameter taken from the Final Revision evaluation. Normal Polarity sensitivities would be run at the Initial Revision as of date.

Reverse Polarity – When running Isolation Sensitivities, Reverse Polarity is the term for taking the Final Revision evaluation and substituting into it a single parameter taken from the Initial Revision evaluation. Reverse Polarity sensitivities would be run at the Final Revision as of date.

Weighting Methods – Formulas used to divide up the Interrelated Change resulting from Isolation Sensitivities and proportion this change back to the individual change categories that it belongs to.