

# Gas Production Profiling

**I**ncreased profitability of gas and tougher regulation regarding the production and handling of gas from oil/gas reservoirs has forced producers to take a closer look at their solution gas or gas cap (associated gas) properties. Producers require a better understanding of forecasted

solution gas and gas cap production to allow them to handle future production in a cost effective manner. Engineering analysis methods such as decline analysis were generally used in predicting oil/gas production from solution gas or gas cap (associated gas) reservoirs. However, attempting to understand gas production

profiles assuming a constant gas oil ratio (GOR) or trying to use decline analysis for gas production is sometimes very inadequate. Decline analysis can not take into account all the parameters necessary for an accurate forecast of gas production. These parameters include perforation interval, gas coning, bubble-point pressure, gas-oil contact movement, PVT properties and relative permeability effects. Epic believes that the best way to forecast gas production is through a combination of simple reservoir analysis and reservoir simulation.

What is involved in forecasting solution or associated gas production? As mentioned there are several approaches that one could utilize, including:

- ❶ Oil decline analysis x constant Rs.
- ❷ Oil decline analysis x changing Rs.
- ❸ Total gas decline analysis.
- ❹ Material balance (Tarnier-Tracy).
- ❺ Simulation.

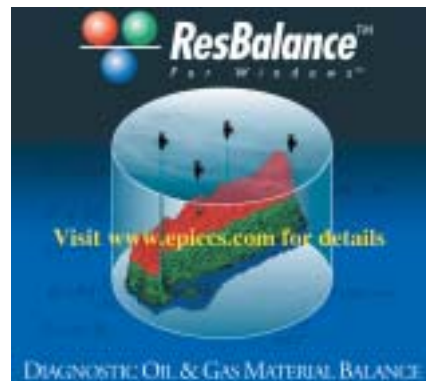
Given the proper conditions (i.e. Strong water drive,  $P_s > P_b$ , well developed oil decline), a decline analysis can be of assistance when predicting oil and gas production. However, there are many instances where it is very difficult to

(Continued on page 2)

## Material Balance – the Fast and Easy Way!!!

**E**pic is pleased and excited to announce the release of ResBalance™, our new oil and gas material balance software package. It was developed in-house for use on client projects. Epic has already completed and verified over 70 ResBalance projects. It is a fast and informative tool that is enjoyable to use. It was designed with the engineer in mind and includes an interactive help and information utility (denoted by ?) that instantly displays information on whatever screen you are viewing. The Results and Diagnostic montage of plots give instant feedback resulting in consistent and confident results. Output includes comparison of calculated versus

actual pressure for testing the validity of the results. Input is easy and includes aquifer functions. Call Epic today at (403) 213-4200 or visit our website at [www.epiccs.com](http://www.epiccs.com) for more details.



# Gas Production Profiling

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determine an appropriate decline from the production data. Often the gas production and GOR history is not linear making prediction difficult. The example below (Figure 1) serves to illustrate the difficulties that can be faced in predicting oil and gas production using decline analysis.



**Figure 1: How would one forecast oil and gas production?**

Possible unreliability of decline analysis is due to the fact that it does not account for all of the factors necessary to make an accurate forecast. There are numerous factors that influence the production of gas from a reservoir, including:

- Pb, Rsi, oil composition, OOIP (fluids)
- Sgc, k, kv/kh, krg/kro/krw (pores)
- Dip? Shales? Fractures? (formation)
- m, We (outside drive mechanisms?)
- Completion interval, lift, (wellbore)
- Well count (be careful)

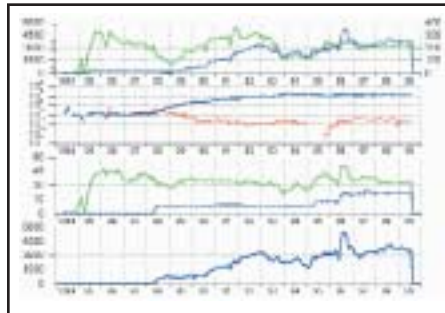
Given the correct circumstances, material balance methods such as Tarner-Tracy can be of value in predicting gas production. Tarner-Tracy is best suited to reservoirs dominated by solution gas drive, no water influx and minimal structural dip.

Reservoir simulation, coupled with reservoir analysis, is the most reliable method for predicting gas production; however it is also more involved than decline analysis or Tracy-Tarner methods.

Simulation is better suited to reservoirs that involve the following:

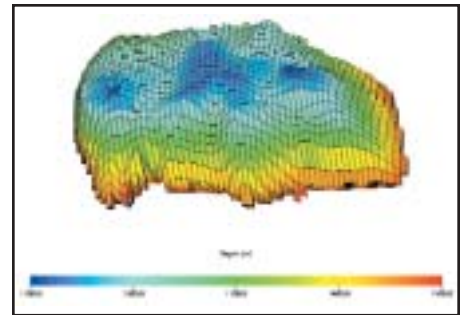
- Gas segregation.
- Gas coning.
- Water Drive.
- Thick reservoirs.
- Tight reservoirs.

A typical simulation study includes preliminary analytical work (Figure 2) to assist in determining the general characteristics and behavior of the reservoir. This work includes analysis of production data (rates and cumulative), water-oil-ratio, gas-oil-ratio, injection and well count.



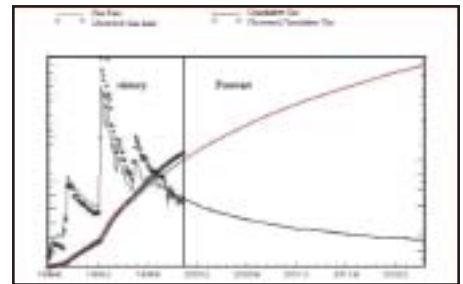
**Figure 2: Composite Plot**

A 3D model (Figure 3) of the reservoir is constructed and history matched to historical production and injection data. Once a satisfactory history match is achieved a forecast of future production



**Figure 3: 3D Model for Simulation**

can be completed (Figure 4). A reliable forecast, be it by decline analysis, material balance (Tarner-Tracy) or reservoir simulation represents valuable and necessary information for the producer. By knowing what to expect the producer can take the necessary steps to handle future gas production and to budget for any future development that may be required. Epic personnel have completed projects throughout western and eastern Canada and around the world. Epic can assist you in your forecasting needs. Visit



**Figure 4: History Match and Forecast**



**Epic Consulting Services Ltd.** is a world class reservoir simulation company, which creates and markets its own reservoir engineering software.

Come join Greg, Sue, and Dennis at the 2002 SPE ATC and Exhibition in San Antonio, TX, Sept 29 - Oct 2. Epic's booth is in **Exhibit Hall B # 210**.

We are excited to introduce **ResBalance**, our new oil and gas material balance package. For those interested in waterflooding, our streamline simulator, **ResAssist+3DSL** has many bells and whistles to show off.

Get the size and performance out of your reserves. For more information, go to [www.epiccs.com](http://www.epiccs.com)

# CO<sub>2</sub> Flooding – It Has Great Potential!

www.epiccs.com for more information.

If conditions are right CO<sub>2</sub> flooding can greatly enhance recovery in your reservoir. Problem is it's difficult to determine if it is worthwhile pursuing CO<sub>2</sub> flooding for your property. Epic is pleased to offer our clients a new service regarding CO<sub>2</sub> flooding. Epic has researched and developed an automated package that can quickly and easily approximate the incremental production related to CO<sub>2</sub> flooding. By inputting specific parameters, including cost estimates for oil and CO<sub>2</sub>, a prediction on the profitability of the flood can be obtained.

The more information that can be included in the calculation, the more

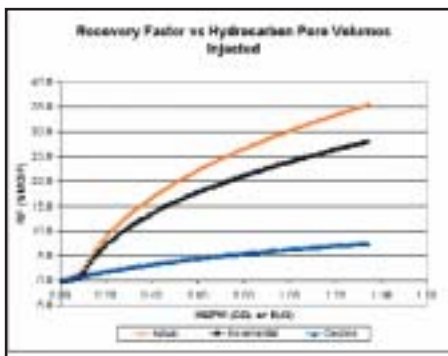


Figure 1: Forecasted Recovery Factor

reliable the estimate for recovery from CO<sub>2</sub> injection. It is difficult to get a reliable estimate of recoveries from CO<sub>2</sub> assuming that the current reservoir pressure and saturations are equivalent to the initial conditions found in the reservoir as some packages out there do. Epic's new program/service takes advantage of the information that is available to describe your reservoir and includes the opportunity to input the following:

- 1 Depth
- 2 API
- 3 Reservoir temperature
- 4 Current pressure

- 5 Remaining oil saturation / current water saturation
- 6 Permeability heterogeneity
- 7 Thickness of pool (horizontal flood, vertical flood)
- 8 Flow geometry
- 9 Viscosity ratio
- 10 Density of CO<sub>2</sub> at reservoir conditions and operating pressures)
- 11 Permeability of formation
- 12 Acceptable payout period
- 13 Slug size
- 14 Waterflood recovery factor
- 15 Cost of NGL recovery
- 16 Cost of recycling solvent
- 17 Number of patterns required for your field.

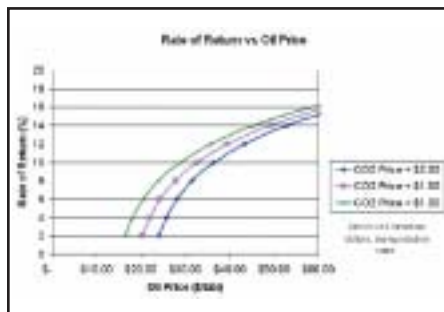


Figure 2: Return versus Oil Price

A projected recovery factor versus hydrocarbon pore volumes injected curve (Figure 1) is calculated based on the above input. The spreadsheet forecasts production and the amount of CO<sub>2</sub> needed for injection through the life of the reservoir.


The economic component of the spreadsheet requires input of economic factors pertaining to setting up a CO<sub>2</sub> flood at your reservoir. These inputs include CO<sub>2</sub> pipeline length, reservoir depth, and the number of

injection wells required. One may also enter an average oil price over the duration of the flood and use it to determine maximum cost for purchase of




- Reservoir Engineering
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- Reservoir Simulation
- Geological Analysis
- Geological Modeling
- Petrophysical Analysis
- Corporate Evaluations
- Regulatory Submissions
- Expert Witness
- Unitization
- Waterflood Optimization
- Reservoir Management
- Horizontal Well Productivity
- Naturally Fractured Reservoirs
- Solution Gas
- Acid Gas
- Coal Bed Methane
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**UNDERSTAND YOUR WATERFLOOD**

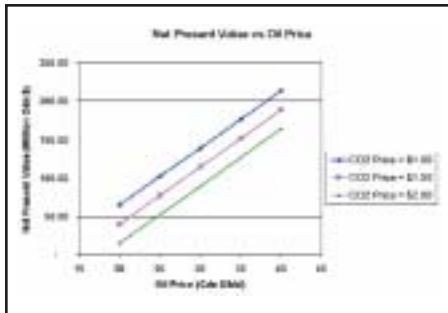
ResAssist™ is an affordable and superior 3D-based streamline simulation package that is ideal for modeling of reservoir engineering scenarios. Includes multi-data import capability and the streamline simulation results can be displayed with the result of a waterflood.



**Visit [www.epiccs.com](http://www.epiccs.com) for details**

**CO<sub>2</sub> Flooding – It Has Great Potential!**

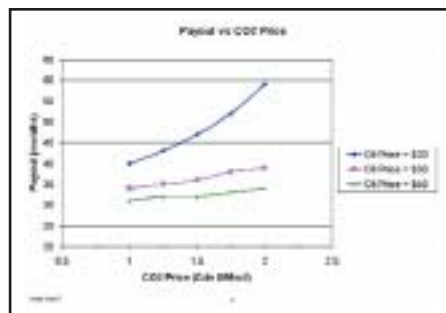
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**Figure 3: Payout versus Co, Price**

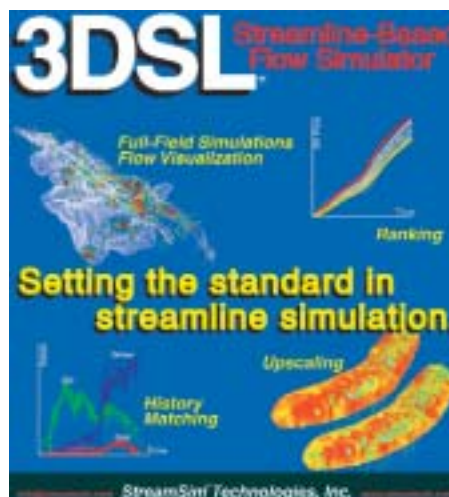
CO<sub>2</sub>. Vice versa one may enter an average CO<sub>2</sub> price to determine what level the price of oil must exceed to meet your desired annual rate of return. Other entries include desired annual rate of return (ROR), incremental operating costs per barrel of oil, and percentage of CO<sub>2</sub> recycled. The spreadsheet will combine this data with the production and injection data calculated in the first part of the analysis and determine economic outcomes for the project, including the net present value of the project, the annual ROR for the specified oil and CO<sub>2</sub> prices, and the payout period. In order to vary any of the parameters simply change the desired input and everything will be recalculated. This makes it simple to run through a variety of scenarios in very little time. This allows one to get a quick and easy overview of the project sensitivity regarding profitability.

Graphs are used to present the data in an effective manner and to show the differences between various combinations of inputs. This allows you to see curves representing the changes different inputs make and therefore the ability to quickly determine economic limits and other variations (Figures 2, 3, 4).



**Figure 4: net Present Value versus Oil Price**

Epic’s CO<sub>2</sub> analysis package is a powerful tool designed to assist you in determining whether a CO<sub>2</sub> flood would be beneficial to your reservoir. It is general in design, so it can handle just about any CO<sub>2</sub> flood situation, yet it is specific enough to cover all major capital costs and expenses. If you are considering a CO<sub>2</sub> flood, this analysis will assist you in making the right decision. Send us an email at [info@epiccs.com](mailto:info@epiccs.com) for more information.



**Fall Newsletter**

Epic wishes to thank the following for their contributions to this newsletter:

- Chris Regier
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- Richard Baker
- Rupam Bora
- Susan Bialowas
- Enrico Delauretis
- Bette Harding

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