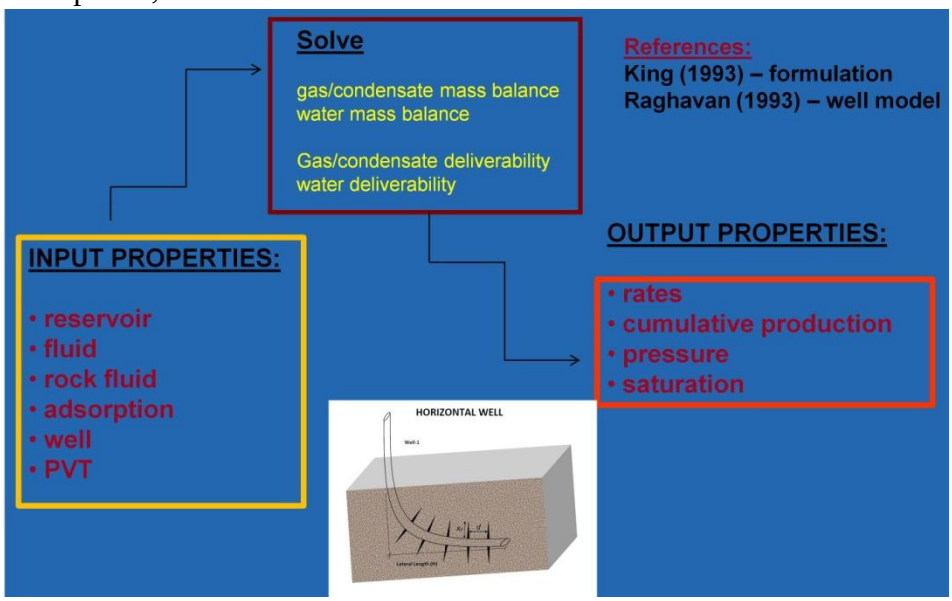
Shale Reservoir Predictive Model (SRPM™) – Software and Application

Background

Immense potential of shale reservoirs (oil, gas and condensate) to supplement domestic energy needs and the recent engineering strides in **multi-staged fractures** in long horizontal well laterals have inevitably increased interest in exploitation of such plays across the country. However, because of the continuous nature of these plays, the production potential can change significantly from one location to the other often within close proximity. For a project to be economically viable, under downward price pressures, large number of wells in multi-well drilling campaigns needs to produce commercial quantities of gas. Not surprisingly, numerous attempts are being made to type-cast mineralogy, organic contents, fracture design and completion optimization in order to reduce exploration and exploitation risks. Many uncertainties still remain, however. The proposed model (**SRPM™**) is developed to **mitigate some of these challenges**. It is simple and easy-to use and unlike grid-based fine-grid models it focuses more on the flow around individual wells while conserving overall mass.

Phone: 469-222-5436 Address: 5000 Quorum Dr. Suite 100, Dallas, TX 75254 Web: www.sitelark.com
Email: dbiswas@sitelark.com

A recent publication on SRPM™[1] compares current status of modeling from fine grid dual-porosity/dual permeability simulations to analytical models for horizontal wells with multiple vertical fractures. The assumptions, formulation and the need for SRPM™ are described as well. The model validation with vertical and horizontal well productions from various shale reservoir plays is presented even for multi-phase flow.



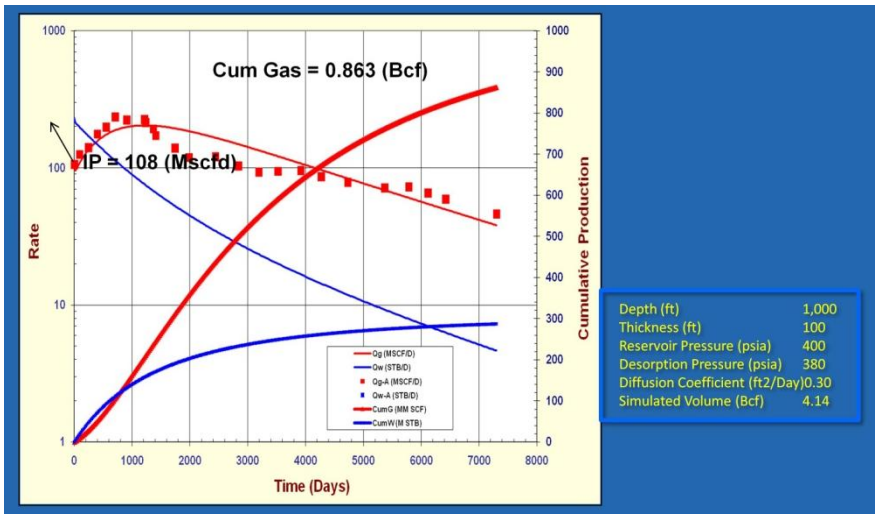
SRPM™ contributes in the following manner:

1. Provides **an alternate framework to history match and forecast** shale reservoir production. This model is better suited for reservoir engineers' routine reserves estimation work because of its quicker turnaround time.
2. Provides a relatively simpler framework to incorporate **specialized asset specific physics and geomechanics**.
3. **Multi-phase flow** feature enables accurate condensate production in plays like Marcellus and Eagle Ford.

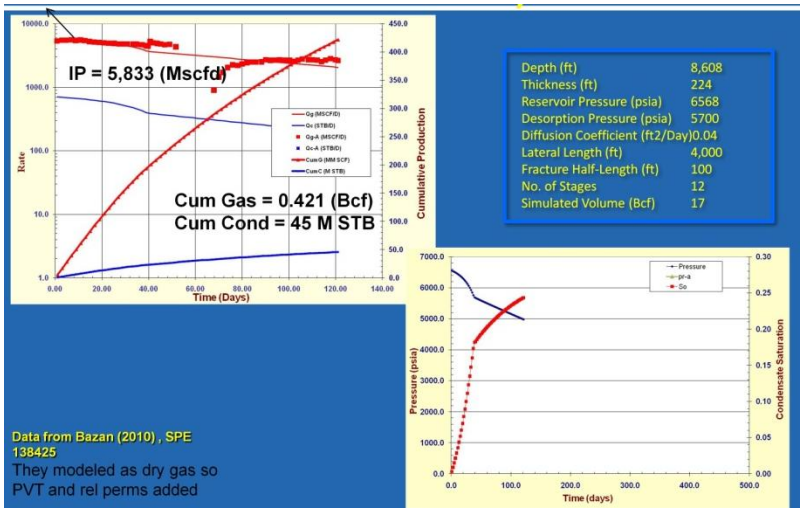
[1] Biswas, D.: "Shale Gas Predictive Model (SGPM) – An Alternate Approach to Predict Shale Gas Production," paper prepared to present at the 2011 SPE Eastern Regional Meeting, Columbus, OH, USA, 17-19 Aug.

Formulation

SRPM™ model formulation inherits conceptual frameworks of solving **material balance and deliverability equations simultaneously** from King *et al.* (1993)[2] and **deliverability of multi-stage fractured horizontal wells** from Raghavan *et al.* (1993)[3]. The feasibility of coupling these two separate concepts is tested first both for vertical and horizontal wells. The originality of the algorithm stems from its extension to capture multi-phase flow (gas-condensate and oil-gas). The **deliverability equations** compute how much a well can produce from a given stimulated rock volume, however the **coupled mass balance equation** constraints the actual production limited by the gas availability.



SRPM™ enables the following:



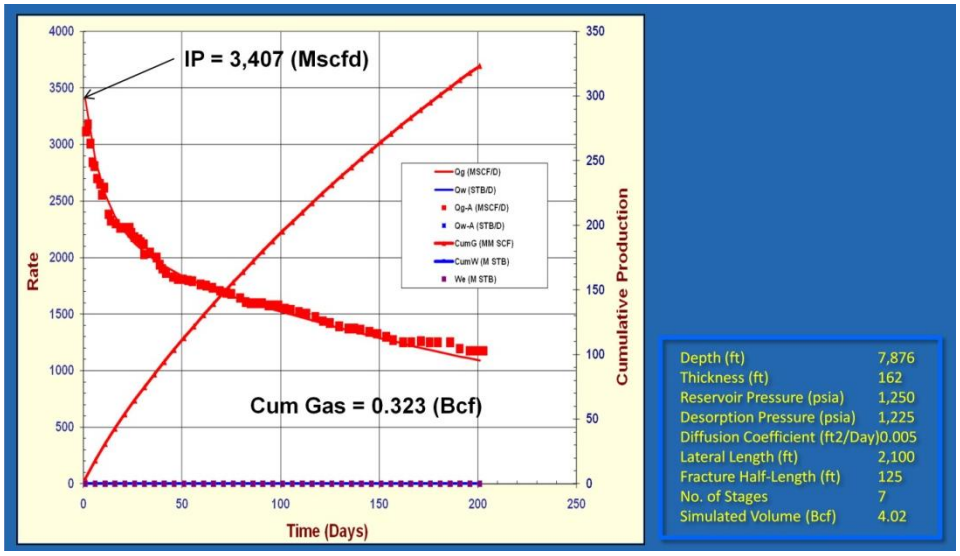
1. Enhance the existing modeling capability by adding concepts of

[2] King, G.E.: "Material Balance Techniques for Coal Seam and Devonian Shale Gas Reservoirs with Limited Water Influx," *SPERE*, Feb 1993.

[3] Raghavan, R. and Joshi, S.D.: "Productivity of Multiple Drainholes or Fractures Horizontal Wells," *SPEFE*, Mar. 1993.

productivity in horizontal wells with multi-stage fractures.

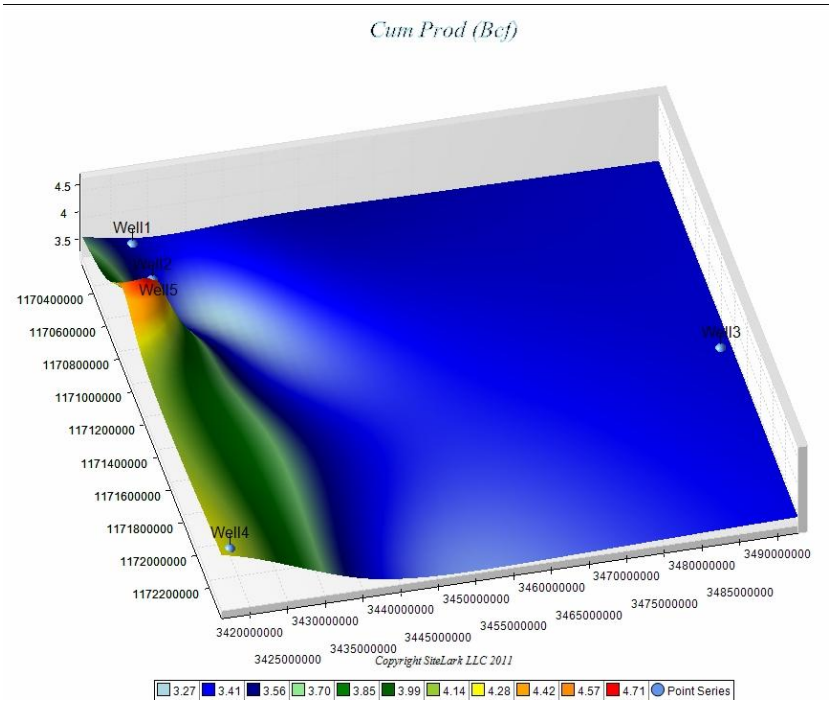
2. Augment and test the developed model against production data from **different unconventional gas plays.**
3. Integrate **visualization mechanism** to examine predictive results, diagnose production results and other intermediate/final computational outputs.
4. Assimilate a **Windows™ Graphics User Interface (GUI)** for the predictive tool to upload input data into the software seamlessly and execute the numerical model systematically.



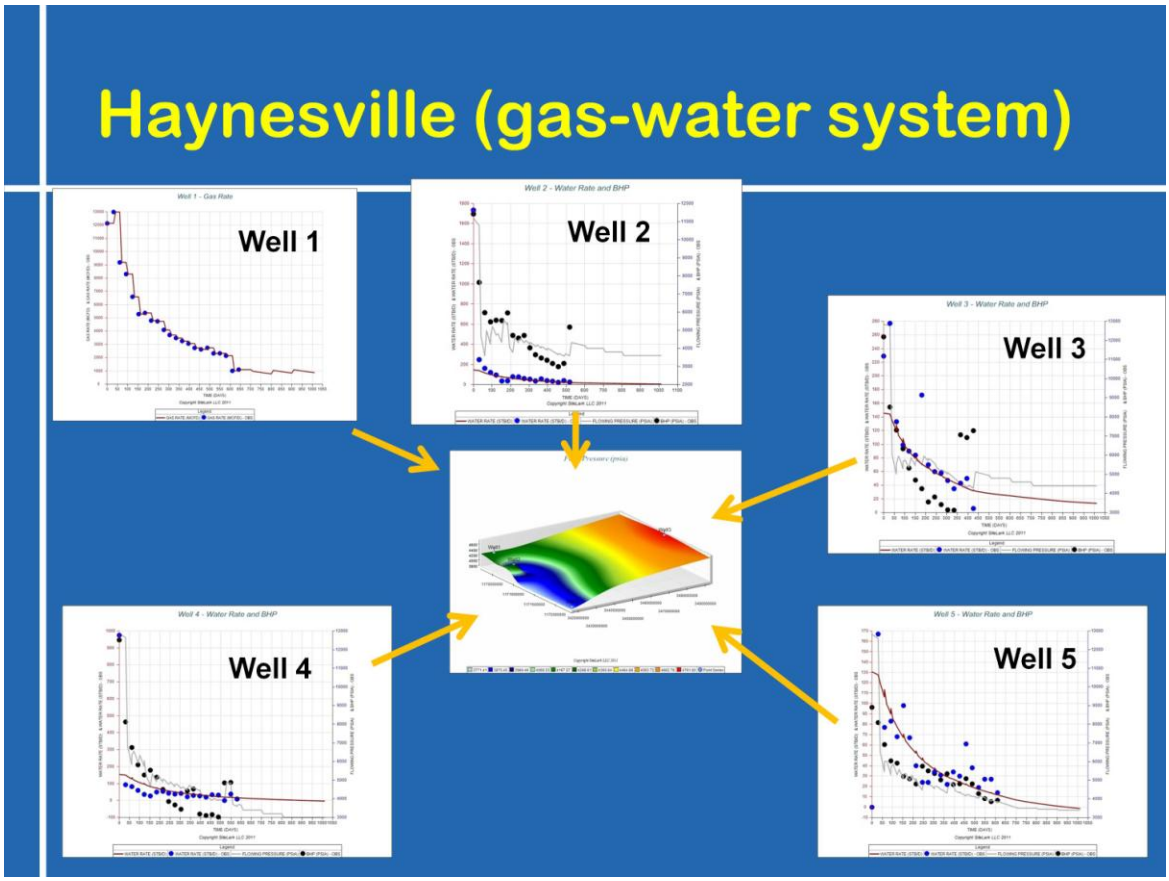
This provides the operators with an alternate way to history match, predict and assess reserves in shale reservoirs and other unconventional resources (e.g. CBM). The algorithm has a much **faster turnaround** time compared to grid-based simulation techniques, on one hand, and **better accuracy** by incorporating more physics compared to simpler analytic techniques, on the other. Furthermore, the user interface eases data input and the plotting routines help to analyze results. The integrated framework enables users to compare and contrast multiple scenarios seamlessly.

Features

1. Applicable in wide range of **unconventional resources** e.g. Shale Oil, Shale Gas, CBM etc.
2. Model both **horizontal and vertical** wells.
3. Model **free and adsorbed gas**.
4. Model **dry gas, gas-water, gas-condensate, and oil-gas** systems.
5. **Pressure dependent** flow and storage properties i.e. geomechanics.
6. Easy **to integrate with in-house software tools** e.g. automatic history matching, fracture mechanics etc.
7. Run in both **history match** (rate constraint) and **forecast** (pressure constraint) modes.
8. Optimize horizontal well length, fracture half length and infer Stimulated Rock Volume (**SRV**).
9. Create and manage **multiple projects** and cases within the same application frame.
10. Simple, user-friendly data creation, execution and **result visualization**.
11. Several sample template data files (for multiple Shale Plays e.g. Eagle Ford, Haynesville, Barnett, Marcellus etc) as starting points for new datafiles.



12. **XY plotting capabilities** to track incremental progress of history match and display multiple variables on multiple axes.
13. **XYZ plots** to visualize spatial relationship to identify sweet spots inside a play e.g. cumulative production, first 90 days cumulative production, first 180 days cumulative production etc.



SPE 148491

Shale Gas Predictive Model (SGPM) – An Alternate Approach to Predict Shale Gas Production

Deepankar Biswas, SPE, SiteLark

This paper was prepared for presentation at the SPE Eastern Regional Meeting held in Columbus, Ohio, USA, 17–19 August 2011.

Abstract

Immense potential of shale gas to supplement domestic energy needs and the recent engineering strides in multi-staged fractures in long horizontal well laterals have inevitably increased interest in exploitation of such plays across the country. However, because of the continuous nature of these plays, the production potential can change significantly from one location to the other often within close proximity. For a project to be economically viable, under downward price pressures, large number of wells in multi-well drilling campaigns needs to produce commercial quantities of gas. Not surprisingly, numerous attempts are being made to type-cast mineralogy, organic contents, fracture design and completion optimization in order to reduce exploration and exploitation risks. Many uncertainties still remain, however. The proposed model (SGPM) is developed to mitigate some of these challenges. It is simple and easy-to use and unlike grid-based fine-grid models it focuses more on the flow around individual wells while conserving overall mass. First, the current status of modeling from fine grid dual-porosity/dual permeability simulations to analytical models for horizontal wells with multiple vertical fractures is explained. The assumptions, formulation and the need for SGPM are described next. The model is validated with vertical and horizontal well productions from various shale gas plays. Results of extensions to the model to account for multi-phase flow are displayed thereafter.

Phone: 469-222-5436 Address: 5000 Quorum Dr. Suite 100, Dallas, TX 75254 Web: www.sitelark.com
Email: dbiswas@sitelark.com

This paper contributes in the following manner:

1. Provides an alternate framework to history match and forecast shale gas production. This model is better suited for reservoir engineers' routine reserves estimation work because of its quicker turnaround time.
2. Provides a relatively simpler framework to incorporate specialized asset specific physics and geomechanics.
3. Multi-phase flow feature enables accurate condensate production in plays like Marcellus and Eagle Ford.

Background

The potential of commercial gas production from shale gas has attracted incredible attention in the recent years. During the last decade of shale gas development, projected recovery of shale gas in-place has increased from about 2% to estimates of about 50% mainly through the development and adaptation of technologies that fits shale gas developments e.g. multi-stage fracturing of horizontal wells, slick-water fluids with minimum viscosity and simultaneous fracturing (King, 2010).