SPE 123987

Gas Storage Facility Design Under Uncertainty

Amin Ettehadtavakkol, SPE, Christopher Jablonowski, SPE, and Larry W. Lake, SPE, The University of Texas at Austin

This paper was prepared for presentation at the 2009 SPE Annual Technical Conference and Exhibition held in New Orleans, Louisiana, USA, 4–7 October 2009.

Abstract

During the screening and concept selection stages of gas storage projects, many estimates are required to value competing projects and development concepts. These estimates are important because they influence which projects are selected and which concept proceeds into detailed engineering. In most cases, there is uncertainty in all of the estimates. As a result, operators are faced with the complex problem of determining the optimal design. A systematic uncertainty analysis can help operators solve this problem and make better decisions. Ideally, the uncertainty analysis is comprehensive and includes all uncertain variables, and simultaneously accounts for reservoir behavior, facility options, and economic objectives. This paper proposes and demonstrates a workflow and integrated optimization model for uncertainty analysis in gas storage. The optimization model is fast-solving and eliminates most constraints on the scope of the uncertainty analysis. Using this or similar workflows and models should facilitate analysis and communication of results within the project team and with other stakeholders.

Introduction

Demand for natural gas is seasonal, and gas storage facilities are used to balance supply and demand. Gas storage facilities are typically located close to demand centers, and most employ depleted oil or gas reservoirs as the storage medium.[1] The reservoirs are often high permeability and lie in intermediate depths (2000-5000 ft) with normal temperature gradients. The reservoirs do not bear mobile aqueous phase or mobile oleic phase (Bennion et al., 2000). A reservoir is good gas storage candidate if it has sufficient permeability to allow production and injection at high rates in peak periods. It should also have sufficient pore volume and structural closure. The major components of a reservoir-based gas storage facility include the reservoir, horizontal and/or vertical wells, gathering lines and associated flow controls, and dehydration and compression equipment. One may also consider the base gas (the quantity of gas intended as permanent inventory) as part of the facility because it requires a significant capital expenditure akin to the surface facilities and wells. More detailed information on the technology, economics, and regulation of the gas storage industry can be found in FERC (2004) and EIA (2004, 2006).

During the screening and concept selection stages of gas storage projects, many estimates are required to value competing projects and development concepts. These estimates determine which projects are selected and which concept proceeds into front end engineering and design. Estimates are required for reservoir properties, well performance, capital costs, operating costs, facility performance, construction schedule, and market demand and price. The importance of these estimates is self-evident, they determine which projects go forward, the configuration and sizing of facilities, project timing, and ultimately, the value derived from the project.

In most cases, there is uncertainty in all of the estimates used in screening and concept selection. As a result, operators are faced with the complex problem of developing a design that is robust to various revelations of the uncertain variables. A systematic uncertainty analysis can help operators solve this problem by describing and quantifying the sensitivity of project value to the design decisions and to the uncertainties. Use of the information from the uncertainty analysis should result in better decisions. Ideally, an uncertainty analysis is comprehensive and includes all uncertain variables, and simultaneously accounts for reservoir and production behavior, facility options, and economic objectives.

Determining the optimal facility design is complicated. McVay and Spivey (2001) provide concise descriptions of several investigations that proposed and demonstrated methods for gas storage facility design optimization. This review includes

[1] Gas is also stored in salt caverns and aquifers. Total storage capacity in the United States is estimated to be 4.2 tcf (Haines, 2009).