An Overview of the Gas Systems Analysis Model (GSAM)

January 12, 2000
Overview of GSAM Development History

- Contract awarded 1992
- Prototype developed in late 1993; required input reservoir data base
- Initial design complete in June 1994
- Environmental module initiated in June 1994
- Data development task initiated in August 1994
- First peer-review meeting in October 1994
- Approved enhancements based on October 1994 review in February 1995
- Utilized for DOE metrics/planning September 1995 - June 1996
- Improvements to models and data implemented October 1996
- Testing, validation, and system enhancements based on first peer review
- Second peer-review meeting in February 1997
- Various system enhancements ongoing
- Applied for various DOE and EPA studies in 1997 and 1998
- Used for 1999 natural gas metrics study
- System applications ongoing (NPC environmental study, DOE federal access study)
GSAM Structure

Inputs

- Resource Module
  - Resource Data
  - User-Specific Technology, Cost, Policy Assumptions
  - Exogenous Macroeconomic, Infrastructure and Industry Characterization

Upstream Model

- Reservoir Performance Module
- E&P Module
- Environmental Module
  - Reservoir Level Analysis
  - Explicit Technology/Costs
  - Uncertainty/Risk Evaluation
  - Site-Specific Environmental Costs/Benefits

Integrating Model

- Serial Simulation Equilibrium
- Maximize Producer/Consumer Surplus
- Inertial, Capital Constraints
- Interfuel Competition
- Seasonal Time Steps

Outputs

- Production Accounting Module
  - Investment, Drilling, Production
  - Supply, Prices
  - Resource Description
  - Technology Use
  - Market Dynamics

Downstream Model

- Demand/Transportation Module
  - Storage Module
  - Regional Sectoral Demand
  - Transport and Storage
  - Endogenous Capacity Additions
GSAM Modules

Resource Module
- Convert raw data to GSAM formats

Reservoir Performance Module
- Assess performance & economics of reservoirs
- Supply curve elements (price & quantity pairs by region, & year)

Exploration and Production Module
- Calculate regional supply based on market factors
- Estimate equilibrium gas prices (by region, season, & year)

Production and Accounting Module
- Compute pro-forma cash flow

Storage Reservoir Performance Module
- Compute costs and deliverabilities for storage reservoirs

Demand and Integrating Modules
- Calculate regional supply/demand prices, quantities, and inter-regional flows
Overview of GSAM Upstream Model

- **Upstream Model includes:**
  - Database of over 17,000 production reservoirs in North America so supply curves can be built from the “bottom up”
  - Database of several hundred storage reservoirs including computation of costs/deliverability for each facility
  - Type curves based on Darcy’s Law for estimating flow
  - Modeling of the exploration and production activities based on economic behavior of each of the reservoir operators given contemporary market prices
  - Full pro-forma cash flow analysis and production values over time
# Reservoir Database Elements in GSAM

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## Development and Performance Data

- Annual Production (Oil, NGL, Gas)
- Cumulative Production (Oil, NGL, Gas)
- Number of Wells
- Ultimate Recovery
- Recovery Efficiency
- Well Spacing
- Producing and Shut In Wells
GSAM’s E&P Decision-Making Process Evaluates Project Opportunities at Each Stage of Development -- From Operator’s Perspective

- **Exploration:**
  - Prospects ranked on full cost, expected value basis
  - Exploration activity constrained by infrastructure
  - Discovery process method used

- **Development:**
  - Evaluated on a sunk exploration cost basis, in context of current markets, reservoir depletion stage, and available technology

- **Production:**
  - Future production based on demonstrated reservoir deliverability, regulatory and market constraints, and future operating costs and conditions
Overview of GSAM Downstream Model

- **Downstream Model includes:**
  - Demand models to account for the residential, commercial, industrial, and electrical power sectors
  - Natural gas demand characterization for four seasons in a year
  - Pipeline network including 44 supply/demand nodes and 79 bi-directional links representing the pipeline system
  - Ability to expand pipeline/storage/peaking supply capacities
  - Integrating linear program to balance supply and demand of gas based on the concept of maximizing consumer surplus + producer surplus for each region, year, and season
  - Computation of equilibrium market prices, quantities, and flows subject to network and other constraints
  - Integrating LP contains over 450,000 variables and over 80,000 constraints
The model has 79 transportation links connecting supply basins and demand regions.

The model internally makes economic decisions to expand pipeline capacity to meet new requirements.

Storage, LNG, propane/air options simultaneously evaluated with pipeline alternatives.
Gas Storage Modeling in GSAM

- Applies upstream model processing to 400 existing and “typical” potential storage reservoirs in each region
- Adds gas injection function
- Selects higher deliverability reservoirs per unit of storage cost
- Storage competes with pipeline capacity
- Provides *characterization of overall demand for seasonal storage services* (3 withdrawal and 1 injection season per year) in North America
Ongoing Tasks

- Update GSAM discovered and undiscovered resource database by utilizing the following
  - 14th Update of Significant Oil and Gas Fields of the United States Database, NRG Associates, August 1999
  - Gas Information System (GASIS) Release 2, June 1999
  - Unconventional Natural Gas Resource and Gas Composition Databases, Gas Research Institute, May 1999
  - Earth Science Associates, USGS - Federal/Private Lands Characterization
  - Digital Data Series, USGS, Release 2, 1996
Ongoing Tasks
(Continued)

- Update other data in GSAM based recent releases
  - Drilling and Completion Data (API’s Joint Association Survey)
  - Operating Cost Data (EIA’s Costs and Indices for Domestic Oil and Gas Field Equipment and Production Operations Study)
  - Regional Drilling Capacity Data (Joint Association Survey)
  - Environmental Cost Data (DOE’s NPC Study)

- Incorporate American Gas Association (AGA) 1999 release of “Underground Storage of Natural Gas in the U.S. and Canada” report in the Storage module of GSAM
Ongoing Tasks (Continued)

- Develop, Test and Calibrate the Industrial Demand Model
- Provide Updated Documentation of User’s Guide for the following Modules of GSAM:
  - Reservoir Performance Module
  - Exploration and Production Module
  - Demand and Integrating Module
  - Production Accounting Module
  - Storage Reservoir Performance Module
Future GSAM Enhancements

Natural Gas Storage/Pipelines
- *High Deliverability Storage*
  - Salt Caverns
  - Other High Deliverability Storage (Refrigerated Mined Caverns, Lined Rock Caverns, Chilled Mined Gas Storage)
- *Improved Storage Reservoir Characterization in GSAM*
- *Storage and Transportation Model*

Natural Gas Supply to Meet Growing Demand
- *Federal Lands*
- *Unconventional Gas (Deep Gas)*
- *Gas Hydrates*
Future GSAM Enhancements (Continued)

- Climate Change Issues
  - *Electrical Power Sector Characterization of Emissions in GSAM*
  - *Industrial Sector Characterization of Emissions in GSAM*

- General GSAM Improvements
  - *Enhance the existing Graphical User Interface of GSAM*
  - *Speeding up the computation of market equilibrium values*
  - *Speeding up the reservoir performance and exploration production modules*
  - *GSAM$^{2000}$ - The Next Generation Model*
Natural Gas Issues Analyzed Using GSAM

- Marginal Gas Well Study (for BLM)
- Exploration and Production Technology Development (for FETC)
- Impact of Canadian Carbon Stabilization Programs on North American Market (for EPA)
- Natural Gas Metrics (for FETC)
- Deepwater Gulf of Mexico Supply Sub-Module Development for NEMS (for EIA)
- Impact of Environmental Regulatory Initiatives (for DOE/HQ)
- Impact of Tax Incentives/Tax Policy (for DOE/HQ)