

# **Lower-48 Oil and Gas Resource Characterization With the GASIS Database**

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## **Introduction**

The goal of the U.S. Department of Energy's GASIS (Gas Information System) project is to develop the first national public domain electronic database of reservoir property and ultimate recovery data for Lower-48 oil and gas reservoirs. GASIS is scheduled for publication on CD-ROM in 1997 and 1998. The final CD will include 19,000 to 20,000 oil and gas reservoir records with approximately 180 data elements per record. Included reservoirs will be those either meeting minimum cumulative gas production levels (5 or 10 Bcf through 1996) or those included in the GRI/DOE Gas Atlas projects.

GASIS can be viewed as the national extension of the Gas Research Institute/ Department of Energy Gas Atlas project, which has produced six regional atlases and their corresponding reservoir property databases. Gas Atlas projects have included Texas, the Mid-Continent, the Central and Eastern Gulf Coast, the Rockies, the Appalachian Region, and the Gulf of Mexico. GASIS will combine selected Gas Atlas information (including the geological play classification) with information from Dwight's Energydata and other sources to produce a database with powerful capabilities in exploration, development, planning, economic analysis, and market assessment.

## **Objectives**

As shown in Figure 1, the objectives of the GASIS project are as follows:

- Develop the first national-scale public domain oil and gas reservoir and fluid property and gas recovery database

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- Compile the reservoir data needed by DOE for supply technology assessment, resource characterization, and modeling
- Improve the quality and coverage of Lower-48 reservoir property and production data
- Identify and incorporate reservoir data sources not previously available
- Establish a framework for future natural gas resource characterization

## **Approach**

The GASIS reservoir database combines Gas Atlas data, data from Dwight's reservoir and completion level databases, new data from GASIS reservoir studies, electronic GRI data, and new processed and statistical data. Information from multiple sources is used to both expand the scope of information in the database, and to improve the quality and reliability of the data. Where multiple sources of data exist for a single data type, the best source is used. In addition, data "source codes" provide information about data origin and quality. Automated quality control procedures are applied to the database to ensure consistency and to identify questionable data.

A multi-year reservoir study/database development project involving approximately 1,000 reservoirs is designed to improve the quality and coverage of Lower-48 reservoir property and production data and provide the first true "reservoir definition" for many fields in the Mid-Continent and elsewhere. Each reservoir study involves analysis of a sufficient number of wells to determine representative values of key properties such as porosity, net pay, and gas saturation. Documentation of a geological type well and type log provides information about the producing interval and its log characteristics.

Information from multiple sources is processed and combined with uniform formats and definitions. The entire database is assembled on CD-ROM for personal computer applications with a Windows query and retrieval interface.

## **Project Description**

### **Scope of GASIS**

Figure 2 lists the major aspects of GASIS development: database design (content and structure), evaluation of data sources for each type of data, reservoir database development, Source Directory development, reservoir studies/data collection, and software design and development.

The primary component of GASIS is the Reservoir Data System, which will consist of approximately 19,000 to 20,000 reservoir records containing reservoir and fluid properties, play classification, and production and ultimate recovery data. Each record will contain approximately 180 data fields. The other component of GASIS is the Source Directory, documenting over 250 oil and gas supply-related databases and information centers.

The Reservoir Data System will include all of the Lower-48 areas included in the GRI/DOE regional Gas Atlas projects (Figure 3). Included reservoirs will be those either meeting minimum cumulative gas production levels (5 or 10 Bcf through 1996) or those included in the Gas Atlas project. (In the Appalachian and Gulf of Mexico atlas databases, production criteria were not used for reservoir selection).

### **Reservoir Data System**

Figure 4 shows the types of data included in the Reservoir Data System. Included are field and reservoir identification, location, producing status, play classification, reservoir and fluid properties, geologic information, summary production data, and estimated remaining gas reserves and ultimate recovery. Also included are calculated reservoir area and average gas well spacing, completion level ultimate recovery data, a geological type well (reservoir studies), gas composition, and typical drilling and completion practices. Major sources of information for GASIS are shown in Figure 5.

### **Source Directory**

The GASIS Source Directory documents major public domain and commercial databases that contain geological, engineering, production, well completion, and related data of interest to industry. The Source Directory also describes industry information centers, sample repositories, and technology transfer centers. The database can be queried by data type, geographic area, or developer.

### **Reservoir Studies**

A major component of the GASIS project is a four year reservoir study effort designed to improve the quality and coverage of reservoir level data in major gas producing basins. This research includes log correlation, assignment of gas completions to reservoirs (reservoir “definition”), and determination of representative reservoir properties including porosity, pay thickness, gas saturation, and reservoir pressure (Figure 6). A type well is selected and documented for each study. The type well has what is considered a typical reservoir interval.

To the extent possible, the reservoir study effort is designed to obtain information on all major gas producing regions of the Lower-48. Basins studied through 1996 include the Anadarko, Arkoma, Mid-Gulf Coast, Arkla, East Texas, Green River, Piceance, Uinta, Western Overthrust, Denver, and Wind River Basins. Approximately 850 reservoir studies have been completed through January, 1997 and 200 studies are planned for 1997, primarily in the Powder River, San Juan, and Permian Basins (Figure 7). Within each studied basin, an effort is made to obtain representative information for all major gas plays.

The reservoir study effort in the Mid-Continent produced the first accurate reservoir database for the region. Prior to GASIS, Mid-Continent database records often did not represent true reservoirs but producing “intervals” that contained multiple reservoirs. The reservoir property and production data for those records was not reliable. In addition, a large number of pre-GASIS reservoir records had incorrect formation nomenclature and age data that were not consistent with regional stratigraphy. This was corrected in developing the GASIS database.

## **Software**

The GASIS project includes development of Windows-based (FoxPro) software for data retrieval and manipulation. For the Reservoir Data System, the software allows query and retrieval, screen display, report generation, and exporting of data in standard formats. The software also allows query and retrieval of Source Directory information.

## **Project Schedule**

Figure 8 is a summary of the current GASIS schedule. The project was initiated in May 1993 and was originally scheduled for completion in 1996 with production data and other calculated data through December 1994. The contract was later extended to 1998 in order to compile all of the Gas Atlas data (including the Appalachian and Gulf of Mexico data) and additional information needed to meet DOE’s requirements for modeling and forecasting. The 1998 GASIS database will include production and processed information through 1996.

## **Results**

During 1996 and the first quarter of 1997, the following projects were completed in preparation for the initial release of GASIS:

### **Database Development**

- Incorporation of reservoir study information  
All reservoir study data collected through the Fall of 1996 were incorporated into the current database. Subsequent information will be included in the next release of GASIS.
- Identification of tight reservoirs  
The GRI tight gas database was used to identify the specific GASIS reservoirs that are classified as “tight” by the Federal Energy Regulatory Commission.
- Assignment of gas composition data  
GRI gas composition data were merged with GASIS to develop gas composition data elements.

- Conversion of Gas Atlas data elements to GASIS formats  
Gas Atlas information such as lithology, trap, and drive type were converted to GASIS conventions.
- Initial processing and incorporation of Appalachian Atlas data  
The Appalachian atlas database was obtained and evaluated in the last quarter of 1996. Most of the GASIS data elements were processed and converted to GASIS formats.
- Identification of cycled/injected gas reservoirs
- Assignment of USGS field size classes from Dwight's TOTL database.
- Calculation of gas reserves and ultimate recoveries  
Reservoir level reserves and ultimate recoveries were assigned in all areas covered by Dwight's databases (non-Appalachian areas). Reserves were estimated at the gas completion level and summed to the reservoir level.
- Calculation of ultimate recovery per completion statistics  
Completion level ultimate recovery estimates were used to generate values of mean, median, minimum, and maximum recovery per gas completion.
- Determination of typical (median) recovery well  
Completion level ultimate recovery estimates were used to select and document a typical gas recovery well for gas reservoirs.
- Calculation of gas productive area and average spacing  
In areas where well location is reported by section-township-range, the gas productive and total productive area of GASIS reservoirs was determined.
- Development of record and data element source codes  
Major data sources are tracked in GASIS. Sources include GASIS reservoir studies, Dwights databases, and the Gas Atlases.

The initial release of GASIS (Release 1) contains 9,014 reservoir records with 179 data elements. This database contains all Gas Atlas regions except the Gulf of Mexico, which was not available in time to be processed for this release. The GASIS database currently includes cumulative production and calculated data elements through December 1994. Reservoir selection was based upon cumulative gas production of 10 Bcf (or 5 Bcf in the Rockies). Figure 9 shows that the final GASIS database, which will include selected Gulf of Mexico data, is expected to contain approximately 19,000 to 20,000 reservoirs. (The final reservoir count for the offshore atlas was not available at the time of this writing and may differ from what is shown).

## **Reservoir Studies**

Since the inception of the GASIS reservoir study effort in 1994, approximately 850 reservoir studies have been completed, and an additional 200 studies are planned for 1997. Reservoir studies and data collection have been carried out in the following basins:

### Mid-Continent

- Anadarko Basin
- Arkoma Basin

### Central and Eastern Gulf Coast

- East Texas
- Arkla
- Mid-Gulf Coast
- Warrior

### Rockies

- Green River Basin
- Piceance Basin
- Uinta Basin
- Western Overthrust Belt
- Denver Basin
- Wind River Basin
- Powder River Basin

Work in the Mid-Continent, East Texas, and Central and Eastern Gulf Coast was completed during 1994 and 1995, while most of the effort in 1996 involved the Rocky Mountain basins.

A significant portion of the reservoir study effort, especially in the Rockies, has been directed toward analysis of low permeability plays and reservoirs. Approximately 150 tight gas reservoir studies (GRI tight gas database identification) have been completed. (Currently, about 550 out of 9,000 GASIS reservoirs are flagged as “tight”). Major tight formations studied include the Cotton Valley, Travis Peak, Cleveland, Mesaverde, Frontier, Dakota, and Niobrara.

## Supplemental Data

### USGS Play Classification

As part of their 1995 assessment of undiscovered oil and gas resources of the United States, the assessment group of the U.S. Geological Survey defined several hundred Lower-48 oil and gas exploratory plays. The assessment was performed and the results published at the individual play level. For established (productive) plays, the USGS identifies which fields represent each play. However, this information is not published, with the exception that play descriptions often mention several of the major fields in the play. While the USGS has stated that they do not intend to publish the play assignments because of issues related to a commercial database, there is agreement that the public domain play descriptions and play boundary information on the assessment CD can be used to develop a “GASIS equivalent” USGS play code.

When added to GASIS, this information will allow analysts to develop a linkage between discovered and undiscovered oil and gas resources within each play. In addition, it would provide another play classification system to complement the Gas Atlas plays.

During 1996, the play descriptions for each established conventional USGS play were evaluated. Formation and geologic age data from the play descriptions were extracted. This information was then compared to the producing formation in GASIS. This established a “stratigraphic” linkage between GASIS and the USGS plays. Some of the USGS plays are not defined on the basis of a specific formation or stratigraphic interval, but by geographic area (i.e., structural plays encompassing the entire section). For these plays, a separate approach must be taken to assign the play codes.

### Play Level Depositional System Classification

A depositional system (depositional environment) classification allows reservoirs with similar geology to be grouped and evaluated. Major clastic depositional systems include fluvial, eolian, deltaic, barrier/strandplain, shelf, and basin systems. The GASIS database includes *reservoir level* classifications that were developed for the Rocky Mountain and Appalachian region gas atlases. Reservoir level depositional system classifications were not developed as a part of the other atlas projects (Texas, Mid-Continent, and Gulf Coast). With the exception of the DOE TORIS oil database, which has a small “overlap” with GASIS, there is no other source of reservoir level depositional system classifications.

Many of the Gas Atlas plays in Texas and elsewhere are defined on the basis of formation and depositional system (i.e., Frio Barrier-Strandplain). Where this is the case, it is possible to develop a *play level* depositional system classification, and to assign a code to all reservoirs within the play. During 1996, all of the plays in the three atlas regions without classifications were evaluated and preliminary play level assignments were made.

Development of a reservoir level depositional classification for all onshore GASIS reservoirs would provide a powerful tool for exploration and development and for supply R&D. This may be a project that the USGS or state geological surveys would be interested in pursuing.

## **GASIS Software**

Release 1 of GASIS contains Windows (Microsoft FoxPro) software for manipulation of the reservoir database and Source Directory. The software contains query and retrieval, display, report, data export, and “help” functions. On the basic query screen, queries by state, basin, or field name are assisted by scrolling selection lists. A detailed query screen allows record selection on the basis of any data field (such as depth, cumulative production, or geological age). Data can be displayed in either a single record format or “browse” mode with one row for each record. Data can be exported in standard formats for manipulation with other software packages.

## **Applications**

A wide range of applications for GASIS are anticipated. Based upon interviews with potential GASIS users in 1993 and 1994, GASIS database applications will include the following:

- Identification of high potential plays, formations, and areas
- E&P decisionmaking
- Evaluation of industry activity
- Input data for supply modeling and forecasting
- Prioritization of gas supply research (DOE, GRI, private sector)
- Play level discovery history and trends
- Identification of play and reservoir analogues for E&P decision making
- Reservoir and recovery characteristics for economic analysis
- Market assessments for new upstream technologies

GASIS will be used both as a stand-alone database and as a supplemental source of data for company databases. Larger oil and gas firms will use GASIS as a stand-alone database for planning work and regional analysis, and as a source of new data. Smaller E&P companies will use GASIS for play analysis and decisionmaking. Service companies will use the database to evaluate the potential market for upstream technologies and processes.

The Department of Energy and other organizations conducting oil and gas supply-related research will use GASIS to plan and evaluate the potential impact of research activities. DOE plans to use GASIS both as a stand-alone database for program analysis and as a source of data for existing and future gas supply forecasting models.



Other GASIS user groups include gas marketing firms, gas pipeline companies, local distribution companies, engineering and geological consultants, financial institutions, and state and federal agencies.

## **Future Activities**

### **Schedule**

Major anticipated activities for 1997 and 1998 are summarized in Figure 11. Database development and reservoir studies will continue throughout 1997. The current reservoir study effort will be completed in the fourth quarter of 1997. During the first half of 1998, all of the required processing will be completed, leading to the final release of GASIS.

### **Database Development**

Database development activities in 1997 and 1998 will include final processing of the Appalachian database and full processing of the Gulf of Mexico database, processing of the new releases of Dwight's reservoir and completion datasets with production through 1996, updating of the GASIS database through 1996, incorporation of reservoir study data, and additional quality control work.

### **Reservoir Studies**

Additional reservoir studies are planned for the Powder River, San Juan, and Permian Basins, as well as some additional work in the Texas Panhandle portion of the Anadarko Basin.

### **Supplemental Data**

Plans for supplemental data include completion of the USGS play assignment work and completion of the play level depositional system assignments.

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EEA also would like to recognize the contribution of our primary GASIS subcontractor, Dwight's Energydata. The field and reservoir database group in Oklahoma City, under the direction of Mrs. Jerlene Bright and Mr. Paul Smith, has completed reservoir studies and database development activities in the Mid-Continent, Gulf Coast, and Rocky Mountain regions.

The original period of performance for GASIS was 1993 through mid-1996. The current contract extends into 1998.

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## GASIS Project Objectives

- Develop first public domain national oil and gas database.
- Compile data required by DOE for technology assessment and modeling.
- Improve the quality and coverage of U.S. reservoir property and production data.
- Identify/incorporate data not previously available.
- Establish framework for future reservoir characterization.

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## Aspects Of GASIS Development

- Database Design
- Data Sources
- Database Development
- Source Directory Development
- Reservoir Studies
- Software

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## GRI/DOE Regional Gas Atlas Projects

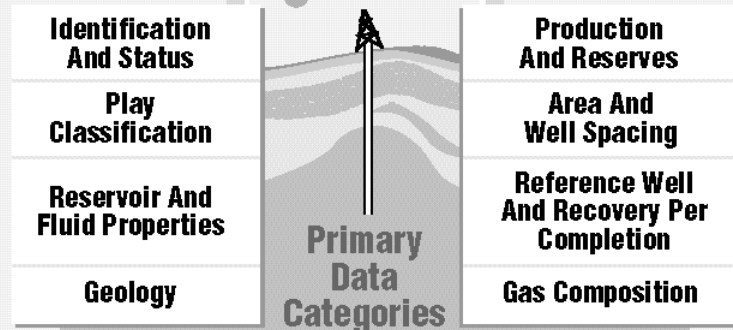
### Status

Published  
Texas  
Rockies  
Gulf Coast  
Mid-Continent  
1997  
Appalachian  
Gulf Of Mexico



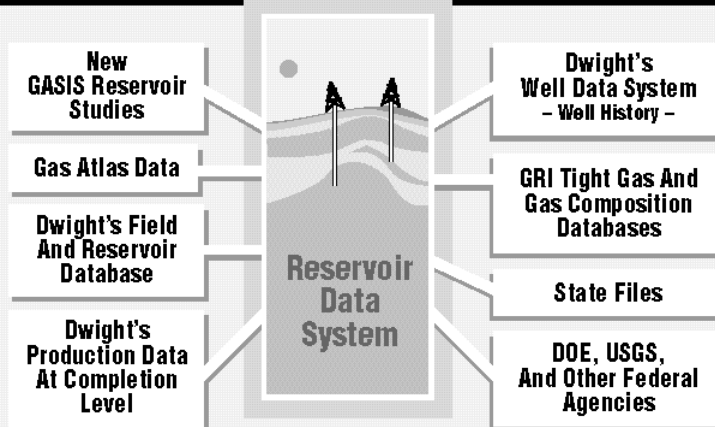
3

## Reservoir Data System



4

## Data Sources For Reservoir Data System



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## Scope Of GASIS Reservoir Studies

### Reservoir Definition

- Log Correlation
- Assignment Of Reservoir Names To Gas Completions
- Correct Cumulative And Annual Production

### Geology

- Regional Stratigraphy
- Nomenclature
- Play Assignment (where needed)
- Lithology, Age, Trap, Drive
- Heterogeneity Level

### Type Well

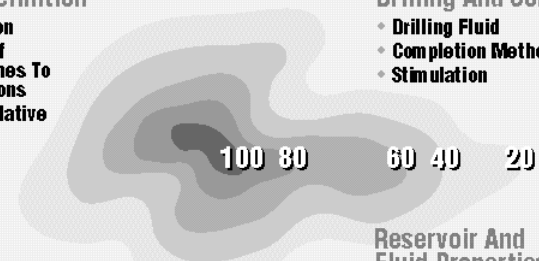
- Well Identification And Location
- Type Log

### Drilling And Completion

- Drilling Fluid
- Completion Method
- Stimulation

### Reservoir And Fluid Properties

- Net Pay
- Porosity And Permeability
- Saturations
- Fluid Properties
- Temperature And Pressure



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## GASIS Reservoir Studies By Basin

Through January 1997

### Mid-Continent

Anadarko ..... 228  
Arkoma ..... 22

### Texas & East Gulf Coast

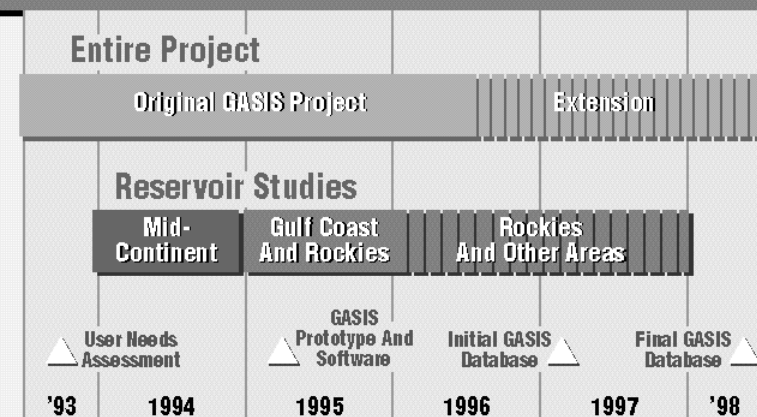
East Texas..... 100  
Arkla .....39  
Mid-Gulf Coast ....63  
Warrior ..... 34

### Rockies

Green River..... 77  
Piceance..... 41  
Denver ..... 100  
Wind River..... 54  
Other ..... 87  
Total ..... 845

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## GASIS Project Schedule



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## Atlas vs. GASIS Reservoir Counts

Area	Gas Atlas	Final GASIS – Approximate –
<b>Texas</b>	<b>1,828</b>	<b>3,265</b>
<b>Mid-Continent</b>	<b>530</b>	<b>806</b>
<b>Cent. &amp; E. Gulf Coast</b>	<b>1,349</b>	<b>1,382</b>
<b>Rockies</b>	<b>861</b>	<b>906</b>
<b>Appalachia</b>	<b>5,156</b>	<b>2,655 *</b>
<b>Gulf Of Mexico</b>	<b>10,370</b>	<b>10,370</b>
<b>Total</b>		<b>19,384</b>

\* Modified version of Appalachian atlas data will be used for GASIS.

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## Summary

*First...*

- ... National public domain reservoir database
- ... Major national reservoir study effort
- ... Electronic type well/type log database
- ... National tight gas & gas composition data
- ... Gas completion recovery database/statistics
- ... Database with accurate gas productive area and spacing
- ... Assignment of 1995 USGS play codes

*GASIS...*

... A major information source for improved understanding of U.S. gas resources

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## 1997-98 Projects

### *Reservoir Studies*

- Powder River, San Juan, Permian Basins

### *Gas Atlas Data*

- Finalize Appalachian database
- Gulf of Mexico data

### *GASIS Development*

- Update with 1996 data
- Type well logs
- USGS plays
- Current reservoir pressure

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