Sixth Biennial Report to Congress: Estimates of Natural Gas and Oil Reserves, Reserves Growth, and Undiscovered Resources in Federal and State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama

Energy Policy Act of 2005 – Section 965(c)

Prepared by

Bureau of Ocean Energy Management
Office of Strategic Resources

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Preface

This report on estimated oil and gas reserves and resources off the coasts of Texas, Louisiana, Mississippi, and Alabama is required by Section 965(c) of the Energy Policy Act of 2005. Specifically, the Secretary of the Interior has been directed to, in consultation with other appropriate federal agencies, submit to Congress a report on the latest estimates of natural gas and oil reserves, reserves growth, and undiscovered resources in federal and state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama.

The Department of the Interior's (DOI) Bureau of Ocean Energy Management (BOEM) coordinated with appropriate federal agencies in preparing this report. The Department of Energy's Energy Information Administration (EIA) supplied BOEM with the oil and gas reserves estimates and recent production information for fields within the state waters of Texas, Louisiana, Mississippi, and Alabama. The United States Geological Survey (USGS) provided BOEM with estimates of undiscovered conventionally recoverable oil and gas resources for the same areas. Estimates of oil and gas resources within federal waters offshore Texas, Louisiana, Mississippi, and Alabama are based on BOEM's 2016a National Assessment of Undiscovered Technically Recoverable Oil and Gas Resources of the Nation's Outer Continental Shelf.

Based on existing offshore administrative boundaries (see Figure 1), the cumulative production, reserves and contingent resources that exist within the geographic area identified by BOEM as the Western Gulf of Mexico Planning Area (WGOM PA) were allocated to the State of Texas. Cumulative production, reserves and contingent resources that exist on Outer Continental Shelf (OCS) blocks in the Central Gulf of Mexico Planning Area (CGOM PA), were also allocated based on the existing administrative boundaries offshore Louisiana, Mississippi, and Alabama, as appropriate.

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Executive Summary

This report summarizes the results of BOEM's compilation of the technically recoverable resources for state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama, and the adjacent Gulf of Mexico (GOM) OCS. Technically recoverable resources are hydrocarbons potentially amenable to conventional production regardless of the size, accessibility, and economics of the accumulations assessed. The OCS comprises the portion of the submerged seabed whose mineral estate is subject to federal jurisdiction (see Figure 1). No new government-sponsored geological or geophysical data acquisition was undertaken for this inventory.

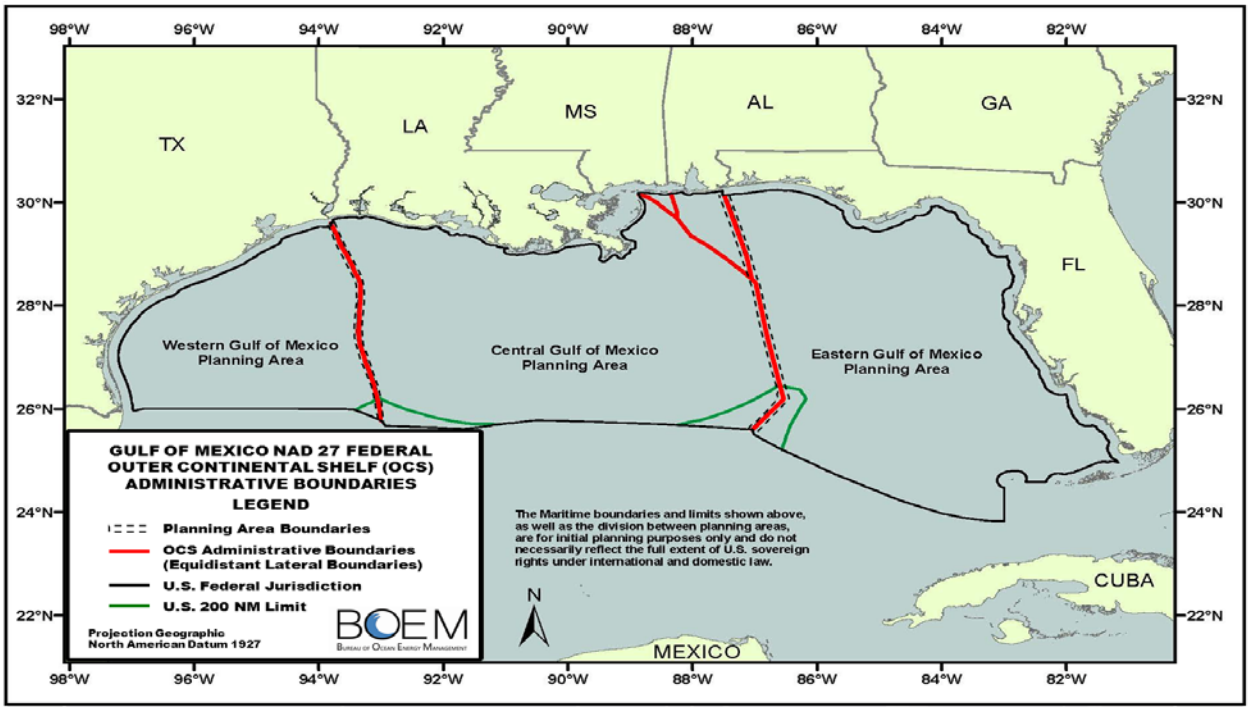

Figure 1: Map Showing the Gulf of Mexico OCS Administrative Boundaries

The petroleum commodities assessed in this report are crude oil, natural gas liquids (condensates), and natural gas that exist in conventional reservoirs producible with typical traditional recovery techniques. The terms "natural gas" and "gas" are used interchangeably in this report. The volumetric estimates of oil resources reported represent combined volumes of crude oil and condensate. In developing these estimates, it was necessary to make fundamental assumptions regarding future application of technology, which introduces additional uncertainty to the resource assessment. Although not considered in this report, the continued expansion of the technological frontiers can reasonably be expected to partially mitigate the impacts of a lower quality remaining resource base (smaller pool sizes, less concentrated accumulations, and more remote locations) and less favorable economic conditions.

It is important to note that resource estimates are just that—*estimates*. All methods of assessing potential quantities of technically recoverable resources are efforts in quantifying a value that will not be reliably known until the resource is nearly depleted. Thus, there is considerable uncertainty intrinsic to any resource estimate. The estimates in this report incorporate uncertainty, but they cannot account for the unforeseen. As such, resource estimates should be used as general indicators and not predictors of absolute volumes.

All resource estimates are subject to continuing revision as undiscovered resources are converted to reserves and reserves to production, and as improvements in data and assessment methods occur. The assessment results do not imply a rate of discovery or a likelihood of discovery and production within a specific time frame. However, uncertainty surrounding the estimates decreases as the asset progresses through this cycle. Resource estimates should be viewed from the perspective of the point in time the assessment was performed—based on the data, information, and methodology available at that time.

Resource estimates are highly dependent on the current knowledge base. In general, risk and uncertainty in estimates of undiscovered oil and natural gas are greatest for frontier areas that have had little or no past exploratory effort. For other areas that have been extensively explored and are in a mature development stage, many of the risks have been reduced or eliminated and the degree of uncertainty in possible outcomes narrowed considerably. As a result, resource potential can be evaluated with much more confidence in non-frontier areas. However, even in some mature producing areas, such as the GOM shelf, considerable uncertainty remains regarding the petroleum potential at greater drilling depths.

Despite this inherent uncertainty, conventional energy resource assessments provide decision-makers with information critical to developing energy policy, given that oil and natural gas resources are major contributors to the world's energy supply. Oil and gas resources produced from state waters and the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama are important to future domestic energy production in the United States. These areas are currently available for leasing in the Department's National OCS Oil and Gas Leasing Program for 2017-2022, and through the leasing programs of the individual states.

The results of this assessment are presented in Tables 1(a) and 1(b), and in section IV of this report. The total endowment of technically recoverable oil and gas in the state waters and on the OCS is comprised of known resources—i.e., cumulative production and estimates of remaining proved reserves, contingent resources and reserves appreciation—plus estimates of Undiscovered Technically Recoverable Resources (UTRR). The estimate of the total hydrocarbon endowment in state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama (Table 1(a)) is 3.53 billion barrels of oil (Bbo) and 61.37 trillion cubic feet of gas (Tcfg), for a total of 14.45 billion barrels of oil equivalent (BBOE)[1], and the total endowment in federal waters offshore of these same states is 80.93 Bbo and 370.89 Tcfg, for a total of 146.92 BBOE (Table 1(b)).

[1] Gas volumes are converted to barrels of oil equivalent using a factor of 5.62 (i.e., 5,620 cubic feet of gas per barrel of oil).

Table 1(a): Total Endowment of Technically Recoverable Oil and Gas Resources in State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama, 2020

State	Resources in Known Fields		Undiscovered Technically Recoverable Resources (mean estimate from 2018)	Total Endowment (mean estimate)
	Cumulative Production (through 2018)	Reserves (2018)		
OIL (Billion Barrels)				
Texas	0.07	0.00	0.43	0.50
Louisiana	1.87	0.05	0.98	2.90
Mississippi	0.00	0.00	0.08	0.08
Alabama	0.00	0.00	0.05	0.05
Total in State Waters off the Coasts of TX, LA, MS, and AL	1.94	0.05	1.53	3.53
NATURAL GAS (Trillion Cubic Feet)				
Texas	4.95	0.01	11.34	16.29
Louisiana	14.58	0.10	22.09	36.77
Mississippi	0.00	0.00	2.90	2.90
Alabama	3.91	0.44	1.06	5.41
Total in State Waters off the Coasts of TX, LA, MS, and AL	23.44	0.54	37.39	61.37
BOE (Billion Barrels)				
Texas	.95	0.00	2.45	3.40
Louisiana	4.47	0.07	4.91	9.45
Mississippi	0.00	0.00	0.59	0.59
Alabama	0.70	0.08	0.24	1.01
Total in State Waters off the Coasts of TX, LA, MS, and AL	6.11	0.15	8.19	14.45

Table 1(b): Total Endowment of Technically Recoverable Oil and Gas Resources in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama, 2020

State	Resources in Known Fields				Undiscovered Technically Recoverable Resources (mean estimate; updated 2016)	Total Endowment (mean estimate)
	Cumulative Production (through end of 2018)	Reserves (end of 2018)	Contingent Resources (end of 2018)	Reserves Appreciation (end of 2018)		
OIL (Billion Barrels)						
Texas	1.15	0.09	0.23	0.56	11.57	13.59
Louisiana	20.11	3.34	3.02	7.27	32.78	66.51
Mississippi	<0.01	<0.01	<0.01	<0.01	0.07	0.07
Alabama	0.17	<0.01	0.02	0.15	0.40	0.75
Total in the OCS off the Coasts of TX, LA, MS, and AL	21.42	3.44	3.27	7.98	44.82	80.93
NATURAL GAS (Trillion Cubic Feet)						
Texas	34.86	0.27	1.34	8.21	38.99	83.68
Louisiana	151.31	5.34	9.02	24.28	85.80	275.74
Mississippi	0.62	0.03	0.07	0.22	1.08	2.02
Alabama	3.06	0.08	0.31	1.60	4.39	9.45
Total in the OCS off the Coasts of TX, LA, MS, and AL	189.85	5.71	10.74	34.32	130.26	370.89
BOE (Billion Barrels)						
Texas	7.35	0.14	0.46	2.02	18.50	28.48
Louisiana	47.03	4.29	4.62	11.59	48.04	115.58
Mississippi	0.11	<0.01	0.01	0.04	0.26	0.43
Alabama	0.71	0.02	0.08	0.44	1.19	2.43
Total in the OCS off the Coasts of TX, LA, MS, and AL	55.21	4.45	5.18	14.09	68.00	146.92

Of the total endowment in state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama, about 1.99 Bbo and 23.98 Tcfg (6.26 total BBOE), approximately 43 percent on a barrel of oil equivalent (BOE) basis, is represented by resources in known fields—the total of cumulative production and remaining reserves.

- Cumulative production in state waters through 2018 was 1.94 Bbo and 23.44 Tcfg (6.11 total BBOE); historical production represents 42 percent of the estimated mean total endowment.
- Estimates of the discovered resources (reserves) remaining to be produced total 0.05 Bbo and 0.54 Tcfg (0.15 total BBOE).
    - The estimated reserves (as of year-end 2018) in fields within state waters are comprised of approximately 64 percent natural gas and 34 percent oil and condensate.
    - The prolific Norphlet deep gas trend discovered in 1979 in state waters of Alabama has been producing for approximately 40 years, while producing fields in state waters of Texas and Louisiana have been producing for more than 50 years. BOEM did not attribute additional growth or appreciation to reserves in known discoveries for state waters.

The mean estimate for UTRR in state waters totals 1.53 Bbo and 37.39 Tcfg (8.19 total BBOE). Of this total BOE estimate, 19 percent is comprised of oil and condensate and 81 percent is natural gas.

In the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama, approximately 54 percent of the total endowment (36.11 Bbo and 240.63 Tcfg, or 78.92 total BBOE) is represented by resources in known fields—the total of cumulative production, remaining proved and contingent resources, and reserves appreciation.

- Cumulative production in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama through 2018 was 21.42 Bbo and 189.85 Tcfg (55.21 total BBOE); historical production represents 38 percent of the estimated mean total endowment.
- Estimates of the discovered resources remaining to be produced (reserves, contingent resources, and reserves appreciation) total 14.69 Bbo and 50.77 Tcfg (23.72 total BBOE). Of this total discovered resource remaining, approximately 62 percent is oil and condensate and 38 percent is natural gas.
    - BOEM estimates that reserves remaining within the over 1300 fields discovered through 2018 total 3.44 Bbo and 5.71 Tcfg (4.45 total BBOE).
    - The estimated contingent resources total 3.27 Bbo and 10.74 Tcgf (5.18 total BBOE).
    - An additional volume of reserves growth or appreciation—the projected increase in current estimates of reserves within existing fields based on historical trends—totaling 7.98 Bbo and 34.32 Tcfg (14.09 total BBOE) is also forecast to be ultimately recoverable from this same set of existing offshore fields. This growth occurs primarily from the in-field discovery of new reservoirs and an increase in the estimate of the recoverable portion of in-place hydrocarbons within known reservoirs, due to future advances in technology, an increased understanding of reservoir performance, and improvements in economics.

The mean estimate for UTRR in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama is 44.82 Bbo and 130.26 Tcfg (68.00 total BBOE). Of this total BOE, approximately 66 percent is oil and condensate and 34 percent is natural gas.

The results of this assessment indicate that the GOM OCS remains a significant potential domestic source of new oil and natural gas resources from fields yet to be discovered.

It is important to note that this assessment reflects a snapshot in time that should not be viewed as either understated or overstated when compared to later assessments, which will reflect changed circumstances and knowledge. The actual volume of oil and natural gas resources that can be recovered from the GOM OCS is never definitively known. As discussed earlier, evolving technological capabilities, coupled with more recent seismic evaluations and exploratory drilling, can lead to higher or lower estimates when the assessments are updated in later years. True knowledge of the actual volume of oil and natural gas resources can only come through the drilling of wells and the production of resources.

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I. Introduction

The OCS and state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama contain significant quantities of oil and natural gas resources, but are subject to a number of technological challenges affecting industry's ability to explore for and develop these resources. These constraints include the need for both improvements in technology to handle high pressures and temperatures found in deep wells greater than 30,000 feet below the surface, and mobile drilling rigs and floating production facilities for exploration and development in water depths greater than 9,500 feet. Industry also needs to comply with legal and regulatory requirements and policies designed to ensure safety, environmental protection, and fair return for use of the OCS. Section 965(c) of the Energy Policy Act of 2005 directed the Secretary of the Interior, in consultation with other appropriate federal agencies, to submit to Congress a report on the latest estimates of natural gas and oil reserves, reserves growth, and undiscovered resources in federal and state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama within two years of the date of enactment of the Act and every two years thereafter; however, a five year gap exists between the fourth and fifth versions of this report. This is the Sixth Biennial Report to Congress.

The following sections of this report provide background information and summarize the status of knowledge concerning the resource potential of the areas identified:

Section II provides background discussion on oil and gas resource assessments, schema, and terminology.

Section III presents the methodology and data sources used to generate estimates of resources.

Section IV discusses results from the resource inventory.

Section V presents conclusions that can be drawn from the results of the resource inventory.

Appendix A presents the glossary that defines relevant terms used in this report.

Appendix B presents a list of relevant abbreviations, acronyms, and symbols used throughout this report.

Appendix C lists the references consulted for this report.

II. Background

Energy is critical to the world's economy. Oil and natural gas resources are major contributors to the world's energy supply, and this reliance on petroleum is likely to continue for decades.

Geologists, statisticians, and economists have been performing resource assessments for decades to provide insights regarding the future of petroleum supply. The demands of and uses for these assessments have led to the evolution of increasingly complex quantitative techniques and

procedures to meet the challenge. Generally, the evolution has been from deterministic to stochastic methods, incorporating uncertainty and risk analyses. Scientific disciplines involved in the assessment process have evolved in parallel with the methodology, from primarily geology in the early assessments to a complex multi-disciplinary array of geology, geophysics, petroleum engineering, economics, and statistics.

1. Purposes of Resource Assessments: Resource assessments are performed by BOEM at various scales and for many purposes. Regional assessments may be prepared simply to develop an inventory of potential oil and natural gas resources as part of an evaluation of future supply options. Alternatively, assessments may be undertaken to analyze the relative merits of oil and gas development proposals and alternatives versus other competing uses. Resource estimates provide critical input to decision makers regarding the virtues of various policy alternatives. Detailed site-specific assessments provide data essential for valuing federal lands prior to leasing or analyzing industry exploration and development proposals.

Large corporations and financial institutions use resource estimates for long-term planning, in their analysis of investment options, and as a guide in analyzing the future health of the oil and gas industry. Exploration companies use resource assessments to design exploration strategies and target expenditures. Increasingly, resource estimates are used by the Federal Government, Congress, and the public to provide objective statements of how much oil and natural gas could be available for future domestic consumption.

This report presents the results of regional, play-based resource assessments of the OCS and state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama. The assessments consist of a thorough investigation of the petroleum geology and an identification of appropriate domestic and international analogs, coupled with a probabilistic methodology to estimate the remaining hydrocarbon potential.

2. Terminology and Classification Schema: A set of precise, universally-accepted definitions regarding resource assessment terminology does not exist, so it is important that the terminology associated with this resource assessment is understood so that the results can be correctly interpreted.

The following are important terms related to this resource assessment. The definitions presented here should be viewed as general explanations, rather than strict technical definitions of the terms.

Resources: Concentrations in the earth's crust of naturally-occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered. Normal use of this term encompasses both discovered and undiscovered resources.

Undiscovered Resources: Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. Also included are resources from undiscovered pools within known fields to the extent that they occur within separate plays.

Undiscovered Technically Recoverable Resources (UTRR): Hydrocarbons that may be produced as a consequence of natural pressure, artificial lift, pressure maintenance (gas or water injection), or other secondary recovery methods, but without any consideration of

economic viability. The UTRR do not include quantities of hydrocarbon resources that could be recovered by enhanced recovery techniques, gas in geopressured brines, natural gas hydrates, or oil and gas that may be present in insufficient quantities or quality (low permeability "tight" reservoirs) to be produced via conventional recovery techniques. Also, the UTRR are primarily located outside of known fields. UTRR estimates are often presented as a range of estimates. For the purposes of this report, only the mean UTRR estimates are reported.

Reserves: The quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

Proved Reserves: The quantities of hydrocarbons estimated, with reasonable certainty, to be commercially recoverable from known accumulations under current economic conditions, operating methods, and government regulations. Current economic conditions include prices and costs prevailing at the time of the estimate. Estimates of proved reserves do not include reserves appreciation.

Contingent Resources: The quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations by application of development projects, but which are not currently considered to be commercially recoverable due to one or more contingencies.

Reserves Appreciation: The observed incremental increase through time in the estimates of reserves (proved and unproved) of an oil and/or natural gas field. It is that part of the known resources over and above proved and unproved reserves that will be added to existing fields through extension, revision, improved recovery, and the addition of new reservoirs. This is commonly referred to as reserves growth or field growth.

Cumulative Production: The sum of all produced volumes of hydrocarbons prior to a specified point in time.

Estimated Ultimate Recovery (EUR): All hydrocarbon resources within known fields that can be profitably produced using current technology under existing economic conditions. The EUR is the sum of cumulative production plus proved reserves plus unproved reserves plus reserves appreciation.

Total Endowment: All technically recoverable hydrocarbon resources of an area. Estimates of total endowment equal UTRR plus EUR.

The BOEM scheme of classifying technically (or conventionally) recoverable hydrocarbons (see Figure 2) is modified from the well-known McKelvey diagram (United States Bureau of Mines and USGS, 1980). The scheme is dynamic, with hydrocarbon resources migrating from one category to another over time. Resource availability is expressed in terms of the degree of certainty about the existence of the resource and the feasibility of its economic recovery. With increasing geologic assurance, hydrocarbon accumulations advance from undiscovered resources to discovered resources to reserves.

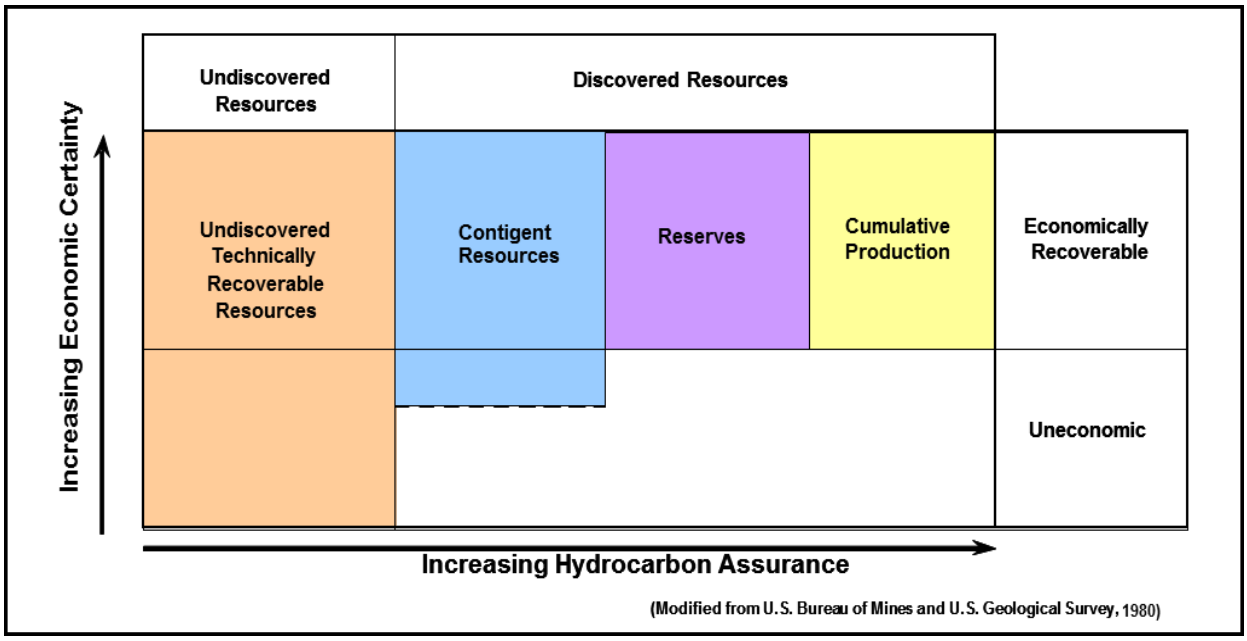


Figure 2: BOEM Resource Classification Schema

The overall movement of petroleum resources within the schema is upward and to the right as development and production ensue. The degree of uncertainty as to the existence of resources decreases to the right in the diagram. The degree of economic viability decreases downward and also implies a decreasing certainty of technologic recoverability.

Reserves can be classified as proved when sufficient economic and geologic knowledge exists to confirm the likely commercial production of a specific volume of hydrocarbons. Proved reserves must, at the time of the estimate, either have facilities that are operational to process and transport those reserves to market, or a commitment or reasonable expectation to install such facilities in the future (Society of Petroleum Engineers and World Petroleum Congress, 1997). The resource classifications used in this report have been modified from the Society of Petroleum Engineers (SPE), World Petroleum Congress (WPC), American Association of Petroleum Geologists (AAPG) and Society of Petroleum Evaluation Engineers (SPEE), 2007, *Petroleum Resource Management System* where necessary to conform to the requirements of BOEM's Reserves Inventory Program.

3. Commodities Assessed: The petroleum commodities assessed in this inventory are crude oil, natural gas liquids (condensate), and natural gas that exist in conventional reservoirs and are producible through conventional recovery techniques. Crude oil exists in a liquid state in the subsurface and at the surface; it may be described on the basis of its American Petroleum Industry (API) gravity as "light" (i.e., approximately 20^{o} to 50^{o} API) or "heavy" (i.e., generally less than 20^{o} API). Condensate is a very high-gravity (i.e., generally greater than 50^{o} API) liquid; it may exist in a dissolved gaseous state in the subsurface but liquefy at the surface. Crude oil with a gravity greater than 10^{o} API and condensate can be removed from the subsurface with conventional extraction techniques and have been assessed for this inventory.

Natural gas is a gaseous hydrocarbon resource, which may consist of associated and/or nonassociated gas; the terms natural gas and gas are used interchangeably in this report. Associated gas exists in spatial contact with crude oil; it may exist in the subsurface as undissolved gas within a gas cap or as gas that is dissolved in crude oil (solution gas). Nonassociated gas exists spatially independent of crude oil. Gas resources that can be removed from the subsurface with conventional extraction techniques have been assessed for this inventory.

Crude oil and condensate are reported jointly as oil; associated and nonassociated gas are reported as gas. Oil volumes are reported as stock tank barrels and gas as standard cubic feet. Oil-equivalent gas is a volume of gas (associated and/or nonassociated) expressed in terms of its energy equivalence to oil (i.e., 5,620 cubic feet of gas per barrel of oil) and is reported in barrels. The combined volume of oil and oil-equivalent gas resources is referred to as BOE and is reported in barrels.

This report encompasses only a portion of all the oil and natural gas resources believed to exist on the GOM continental margin. This assessment does not include potentially large quantities of hydrocarbon resources that could be recovered from known and future accumulations by enhanced recovery techniques, gas in geopressured brines, natural gas hydrates, or oil and natural gas that may be present in insufficient quantities or qualities (low permeability "tight" reservoirs) to be produced by conventional recovery techniques. These unconventional resources are not widely produced from the OCS or state waters, but with improved extraction technologies and different economic conditions, they may become future sources of domestic oil and gas production.

Estimates of the quantities of historical production, reserves, and future reserves appreciation are presented to provide a frame of reference for analyzing the estimates of the UTRR. Furthermore, reserves appreciation and the UTRR comprise the resource base from which the midterm future oil and gas supplies will emerge.

4. Limitations of Resource Assessments: It is important to recognize that estimates of undiscovered oil and natural gas resources are just that—*estimates*. Resource assessments are an attempt to quantify something that cannot be accurately known until the resource has been essentially depleted.

Imperfect knowledge is associated with almost every facet of the assessment process. Dreyfus and Ashby (1989) noted that resource assessments are performed at widely varying levels of detail and precision. At one end of the spectrum lie estimates of proved reserves. These assessments rely primarily upon detailed investigations incorporating relatively abundant subsurface geological and geophysical data, as well as actual reservoir performance information associated with the particular reservoir. At the other end of the spectrum is the appraisal of undiscovered resources that might exist in areas of regional, national, or even global scope. While dealing with the same type of data as reserve estimates, the scope is extended to a generalized inference of the probable quantities of undiscovered hydrocarbon resources that may exist in broad areas.

All resource estimates are subject to continuing revision as undiscovered resources are converted to reserves and reserves to production and as improvements in data and assessment methods occur. Though uncertainty surrounding the estimates decreases as the asset progresses through this cycle,

the assessment results do not imply a rate of discovery or a likelihood of discovery and production within a specific timeframe. In other words, resource assessments cannot be used directly to draw conclusions concerning the rate of conversion of these undiscovered resources to reserves and ultimately production.

The various estimates presented in this report should be considered general indicators and not predictors of the absolute volumes of petroleum potential of the areas. It is also important to realize that the UTRR volumes estimated may not be found or, in fact, produced. It is, however, implied that these resources have some chance of existing, being discovered, and possibly produced. Finally, serendipitous plays, those found as complete surprises, are not considered in this assessment. These unknown plays do not have a geologic model that can be logically assessed at this time. In sum, resource estimates should be viewed from the perspective of the point in time the assessment was performed—based on the data, information, and methodology available at that time.

In spite of the inherent uncertainty and limitations for resource assessments, they are a valuable input to inform the development of energy policy and corporate planning—e.g., for ranking exploration opportunities, as a basis for economic analyses, and assessments of technology and capital needs.

5. Role of Risk and Uncertainty in Resource Assessments: Exploration for hydrocarbons is a high-risk proposition. Risk and uncertainty are integral parts of every resource assessment, with nearly every component of the assessment process incorporating a consideration of risk and uncertainty. The accumulation of petroleum in significant quantities requires the juxtaposition of many complex geologic events: the accumulation of organic matter in a source rock; the maturation of this organic matter into petroleum; the presence of a reservoir rock with sufficient thickness, porosity, and permeability; the migration of the petroleum into a trap with adequate size and seals; and the preservation of the petroleum in the trap. Prior to drilling, the actual existence of these geologic conditions is unknown. Not only must all of these conditions coexist, they must also converge at a particular location, an unlikely event that results in a high probability of failure often described as dry hole or geologic risk. Even if all of these conditions coexist at a particular location, there remains considerable uncertainty regarding the effectiveness of a seal, the size of a trap, the quality and thickness of the reservoir, and the volume and type of hydrocarbons that not only migrated into the trap, but were preserved and still remain to be recovered.

In general, risk and uncertainty in estimates of undiscovered oil and natural gas are greatest for frontier areas that have had little or no past exploratory effort. For areas that have been extensively explored and are in a mature development stage, many of the risks have been reduced or eliminated and the degree of uncertainty in possible outcomes narrowed considerably. As a result, resource potential can be evaluated with much more confidence. However, even in some mature producing areas, such as the GOM shelf, considerable uncertainty remains about the petroleum potential at greater drilling depths. Uncertainty also pervades projections of whether potential reservoirs have been unrecognized or bypassed in past drilling.

Scientists can estimate the quantity of the UTRR based on the present state of geological and engineering knowledge, modified by a consideration of future technological advancement. However, the percentage of that quantity that may actually be discovered and produced is

ultimately an economic question. Uncertainties about future crude oil and natural gas prices and the costs of exploration and development (including the impacts of technology advances on costs) adversely affect all economic resource estimates. In terms of the commercial viability of an accumulation, there is substantial uncertainty concerning total costs and future market prices, resulting in additional economic risk and uncertainty for a project.

Finally, there are no foolproof, completely mechanical methods for estimating potential quantities of undiscovered hydrocarbon resources. Because all methods contain elements of subjective judgment or expert opinion, the risk analysis and degree of uncertainty reflected in an estimate is affected by the knowledge, experience, and assessment expertise of the personnel performing the assessment. This expertise is continually refined as new information tests the validity of previous assumptions.

6. Role of Technology and Economics in Resource Assessment: This inventory assesses only technically recoverable hydrocarbon resources, both discovered and undiscovered. In developing these estimates, it is necessary to make fundamental assumptions regarding future technology and economics.

Scientists can estimate the quantity of technically recoverable resources (both discovered and undiscovered) on the basis of the present state of geologic and engineering knowledge, modified by a subjective consideration of future technologic advancement. However, the quantity of resources that may ever actually be produced is dependent in large part upon economics. Actual cost/price relationships are critical determinants. New capital-intensive exploration and development technologies require higher product prices for implementation. Typically, as these high-cost technologies are more widely employed, costs decrease, resulting in even more widespread use of these techniques. On the other hand, new modest-cost exploitation technologies that increase recoveries or decrease finding, development, or operating costs can markedly increase estimates of technically recoverable resources without requiring an increase in product prices. A decrease in price, as experienced in the late 1980's, can be moderated or offset by the implementation of a technology that reduces unit costs or vice versa. Rogner (1997) concluded that “over the last century technology has probably had a more profound and lasting impact on prices than prices have had on technology.”

Generally, the effects of price and technology can be considered interchangeable within the context of a resource assessment. There is a technologic and economic limit to the amount of in-place oil and natural gas resources that can be physically recovered from a reservoir. Within conventional reservoirs, approximately 30 to 40 percent of the in-place oil and 65 to 80 percent of the in-place natural gas resources are typically recovered through primary and secondary recovery mechanisms. Three principal factors affect the amount of oil or gas that can be recovered from a known reservoir—rock properties, technology, and economics. While industry cannot change the properties of the rock, it can develop new techniques to recover more oil from the rock, thus adding to the resource base. For example, recent technological advances, such as horizontal wells and multi-lateral completions, enable the recovery of a higher percentage of the in-place resources from a field.

Additional technologic and economic constraints are applicable to the circumstances under which exploration and development activities can occur (e.g., ultra-deep water or ultra-deep drilling).

Advanced technology now provides for the exploitation of resources in these operating environments that were not previously economically viable. New technologies also reduce the cost of exploring for and developing resources that are otherwise still technically recoverable, e.g., long-distance subsea tie-backs to host production facilities, extended reach drilling, Single Point Anchor Reservoir (SPAR) platforms, or the introduction of Floating Production Storage and Offloading (FPSO) vessels (for a definition of the terms SPAR and FPSO, see Appendix A). A reduction in exploration or development costs lowers the minimum threshold volume that must be discovered for commercial development, thus increasing the number of opportunities for production. In each of these ways, the introduction of new technologies serves to expand the resource base that is identifiable and "technically or economically recoverable."

Another important aspect of the role of technology in a resource assessment is the opportunity to rethink fundamental approaches to developing exploration play methods through the deployment of new technology. Scientific advances aided by new technologies have affected the ability to identify previously-unknown potential exploration plays. An example of this was the introduction of new seismic data acquisition techniques, which when combined with high end computing technology and new data processing algorithms, resulted in the ability for geoscientists to, for the first time, "see" below massive salt bodies underlying a large portion of the GOM OCS, opening up the "subsalt play."

Understanding the natural evolution in technological progress is critical to fully comprehending resource assessments. It is a reasonable assumption that continued expansion of the technological frontiers can partially mitigate the impacts of a lower quality resource base and less favorable economic conditions. Because they significantly affect the cost/price relationship, many forecasters choose to model the impacts of technological advancements primarily as a reduction in the future cost of finding and producing domestic oil and natural gas resources. BOEM resource assessments capture this effect in the price (cost) supply curves, which present estimates of the volumes of economically recoverable resources at various product prices.

III. Methodology and Data Sources

1. OCS:

A. Data Sources: The OCS component of this assessment required the compilation and analysis of both published information and proprietary geologic, geophysical, and engineering data obtained by industry from operations performed under permits or mineral leases and furnished to BOEM.

B. Reserves and Production: Proved and unproved reserves for the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama are derived from BOEM-internal databases, using a cutoff date of December 31, 2018. A summary of reserves and production data is available in OCS Report BOEM 2020-028 "Estimated Oil and Gas Reserves Gulf of Mexico OCS Region December 31, 2018". Based on existing offshore administrative boundaries (see Figure 1), the cumulative production and proved and unproved reserves that exist within the geographic area identified by BOEM as the Western Gulf of Mexico Planning Area (WGOM PA) were allocated to the state of Texas. Cumulative production, proved reserves and contingent resources that exist on OCS blocks

in the Central Gulf of Mexico Planning Area (CGOM PA), were also allocated based on existing offshore administrative boundaries to Louisiana, Mississippi, and Alabama as appropriate.

C. Reserves Appreciation: As part of the BOEM National Resource Assessment process identified in *Report to Congress: Comprehensive Inventory of U.S. OCS Oil and Natural Gas Resources, February 2006* (Minerals Management Service, 2006), the initial reserves estimate for each active and expired field in the GOM is grown at the geologic play level 50 years from the field's geologic play discovery date using a reserves growth function. This growth function is determined by summing reserve estimates for all fields/plays having the same elapsed time between discovery year and the reserve estimate year and then comparing that sum to the sum of the reserve estimates for those same fields/plays one year later. The estimates of reserves appreciation presented in this report have increased due to recent discoveries of significant deepwater fields in the GOM OCS. The initial reserve estimates associated with these recent discoveries are expected to receive the full complement of nearly 50 years of reserves appreciation resulting in higher grown volumes. Reserves appreciation volumes were allocated to the States of Texas, Louisiana, Mississippi, and Alabama using the methods described above.

D. Assessment of UTRR: Estimates of UTRR reported are based on BOEM's Assessment of Undiscovered Oil and Gas Resources of the Nation's Outer Continental Shelf, 2016a, (BOEM Fact Sheet RED-2017-12). Mean estimates of UTRR were allocated to the States of Texas, Louisiana, Mississippi, and Alabama using the methods described above.

2. State Waters:

A. Data Sources: The data for the state water component of this assessment comes from two sources within the federal government. The USGS provided to BOEM the most recent results of an assessment of the potential volume of undiscovered conventionally recoverable oil and gas resources within state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama. The EIA provided to BOEM estimates of reserves and annual production that is collected from operators of fields located within state waters.

B. Reserves and Production: EIA maintains a historical database of reserve estimates and production data for oil and gas fields located in state waters. This database consists of operator-reported reserves estimates and production submitted on Form EIA-23L. EIA provided BOEM with annual production for natural gas and oil, and reserve estimates for fields located in state waters for the period from 1985-2018. Estimates for the volume of cumulative production prior to 1985 were taken from *Federal Offshore Statistics: 1995* (MMS, 1997). Since the BOEM data for reserves are available only through 2018, the same cutoff date was used for the EIA data.

EIA's survey information is primarily collected under the authority of the Federal Energy Administration Act of 1974 (Pub. L. No. 93-275, 15 U.S.C. 761 et seq.) and/or the DOE Organization Act (Pub. L. No. 95-91, 42 U.S.C. 7101 et seq.). EIA and BOEM developed a data sharing agreement to share information in the possession of the EIA under 15 U.S.C. 771(f) which provides that EIA shall disclose certain data to "other Federal Government departments, agencies, and officials for official use upon request."

C. Reserves Appreciation: The BOEM review of the EIA data indicates that there is a general across-the-board trend of decline in the estimates of ultimately recoverable reserves with no indication of reserve appreciation. This is primarily a result of the maturity of the state water fields and their high level of depletion. Many of the fields in state waters off the coasts of Texas and Louisiana have been producing for more than 50 years and have already appreciated in their estimates of recoverable reserves through extensional and deeper drilling within the fields. Also, some of the significant new deep discoveries are classified as new fields and are offset to the old fields at depth to avoid the problem of drilling through multiple depleted zones within the old fields. Therefore, only minimal, if any, future reserves appreciation is anticipated in the mature fields common throughout state waters.

D. Assessment of UTRR: USGS prepares estimates of undiscovered conventionally recoverable oil and gas resources of the onshore United States and within state waters adjacent to each state. Undiscovered conventionally recoverable resources are equivalent to BOEM's UTRR. The USGS allocated the resource estimates to the individual state waters offshore Texas, Louisiana, Mississippi, and Alabama from the larger resource estimates conducted as part of its Gulf Coast petroleum assessment. The USGS used a variety of data and information to conduct geologically-based assessments of more than 80 assessment units and plays, more than 40 of which extended offshore into state waters. USGS makes available publications detailing and explaining the conventional assessment methodologies (Schmoker and Klett, 2005; Charpentier and Klett, 2005), which have been subjected to rigorous peer reviews by non-federal panels.

IV. Results

The results in this section are summarized by state and aggregated to a total GOM estimate for both state waters (Table 2(a)) and the waters of the OCS (Table 2(b)). Additionally, results are described and shown graphically for both state waters and OCS waters for the categories of cumulative production, reserves, contingent resources, reserves appreciation, and UTRR (Figures 3 – 7). Finally, the total endowment by product type and by state is shown for both state waters and OCS waters (Figure 8).

Table 2(a): Total Endowment of Technically Recoverable Oil and Gas Resources in State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama, 2020

State	Cumulative Production (through 2018)			Reserves			Reserves Appreciation			Undiscovered Technically Recoverable Resources (Mean)			Total Endowment (Mean)		
	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)
Texas	0.07	4.95	0.95	0.00	0.01	0.00	0.00	0.00	0.00	0.43	11.34	2.45	0.50	16.29	3.40
Louisiana	1.87	14.58	4.47	0.05	0.10	0.07	0.00	0.00	0.00	0.98	22.09	4.91	2.90	36.77	9.45
Mississippi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	2.90	0.59	0.08	2.90	0.59
Alabama	0.00	3.91	0.70	0.00	0.44	0.08	0.00	0.00	0.00	0.05	1.06	0.24	0.05	5.41	1.01
Total in State Waters off the Coasts of TX, LA, MS, and AL	**1.94**	**23.44**	**6.11**	**0.05**	**0.54**	**0.15**	**0.00**	**0.00**	**0.00**	**1.53**	**37.39**	**8.19**	**3.53**	**61.37**	**14.45**

Table 2(b): Total Endowment of Technically Recoverable Oil and Gas Resources in the Federal OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama, 2020

State	Cumulative Production (through 2018)			Reserves			Reserves Appreciation			Undiscovered Technically Recoverable Resources (Mean)			Total Endowment (Mean)		
	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)	Oil (Bbbl)	Gas (Tcf)	BOE (Bbbl)
Texas	1.15	34.86	7.35	0.09	0.27	0.14	0.56	8.21	2.02	11.57	38.99	18.50	13.59	83.68	28.48
Louisiana	20.11	151.31	47.03	3.34	5.34	4.29	7.27	24.28	11.59	32.78	85.80	48.04	66.51	275.74	115.58
Mississippi	<.01	0.62	0.11	<.01	0.03	<.01	<.01	0.22	0.04	0.07	1.08	0.26	0.07	2.02	0.43
Alabama	0.17	3.06	0.71	<.01	0.08	0.02	0.15	1.60	0.44	0.40	4.39	1.19	0.75	9.45	2.43
Total in the Federal OCS off the Coasts of TX, LA, MS, and AL	**21.42**	**189.85**	**55.21**	**3.44**	**5.71**	**4.45**	**7.98**	**34.32**	**14.09**	**44.82**	**130.26**	**68.00**	**80.93**	**370.89**	**146.92**

1. ***Cumulative Production***: Cumulative production is a measured quantity that can be accurately determined. The uncertainty associated with these estimates is less than with comparable estimates of volumes of reserves and considerably less than estimates of undiscovered resources.

   Cumulative production through 2018 off the coasts of Texas, Louisiana, Mississippi, and Alabama includes 1.94 Bbo and 23.44 Tcfg (6.11 total BBOE) from state waters (Figure 3(a) and Table 2(a)), and 21.42 Bbo and 189.85 Tcfg (55.21 total BBOE) from the OCS (Figure 3(b) and Table 2(b)).

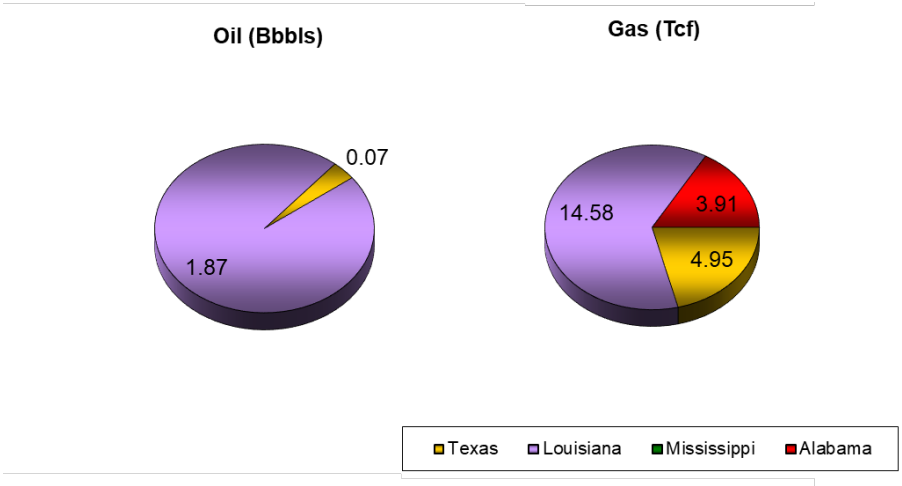


Figure 3(a): Distribution of Cumulative Production in State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

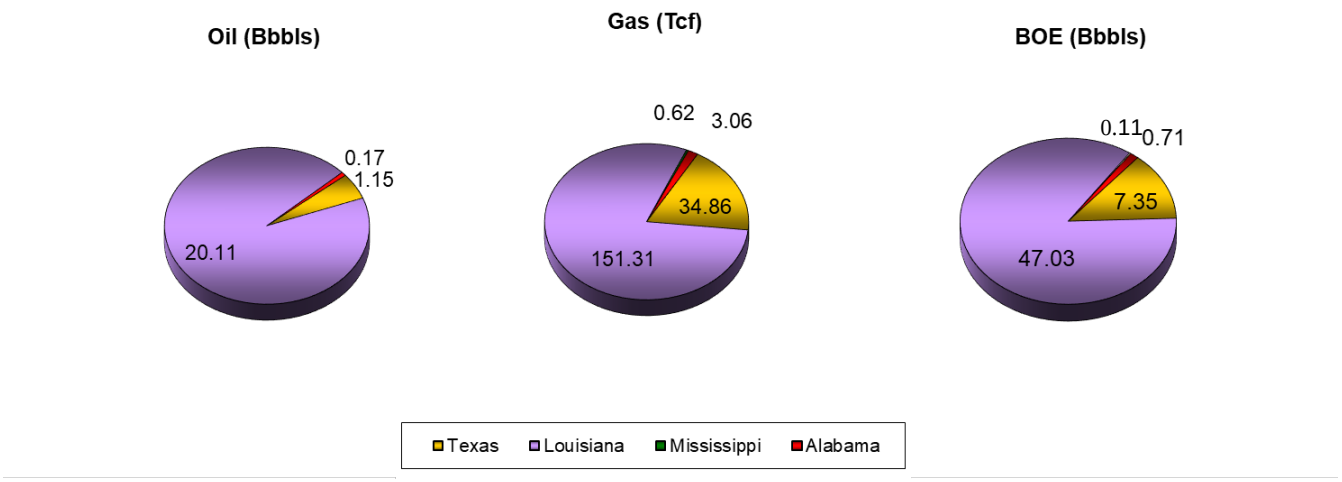


Figure 3(b): Distribution of Cumulative Production in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

2. ***Reserves***: Reserves are frequently estimated at different stages during the exploration and development cycle of a hydrocarbon accumulation, i.e., after exploration and delineation drilling, during development drilling, after some production and, finally, after production has been well-established. Different methods of estimating the volume of reserves are appropriate at each stage. Reserve estimating procedures generally progress from volumetric to performance-based techniques as oil and gas fields mature. The relative uncertainty associated with these estimates decreases as more subsurface information and production history become available. Estimates of reserves are uncertain; however, traditional industry practice has been to calculate reserves through a deterministic process and present the results as single point estimates. Table 2(a) and Figure 4(a) show that the total reserves remaining in state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama are estimated to be 0.05 Bbo and 0.54 Tcfg (0.15 total BBOE). Table 2(b) and Figure 4(b) show that the total reserves remaining in the over 1300 fields in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama are estimated to be 3.44 Bbo and 5.71 Tcfg (4.45 total BBOE).

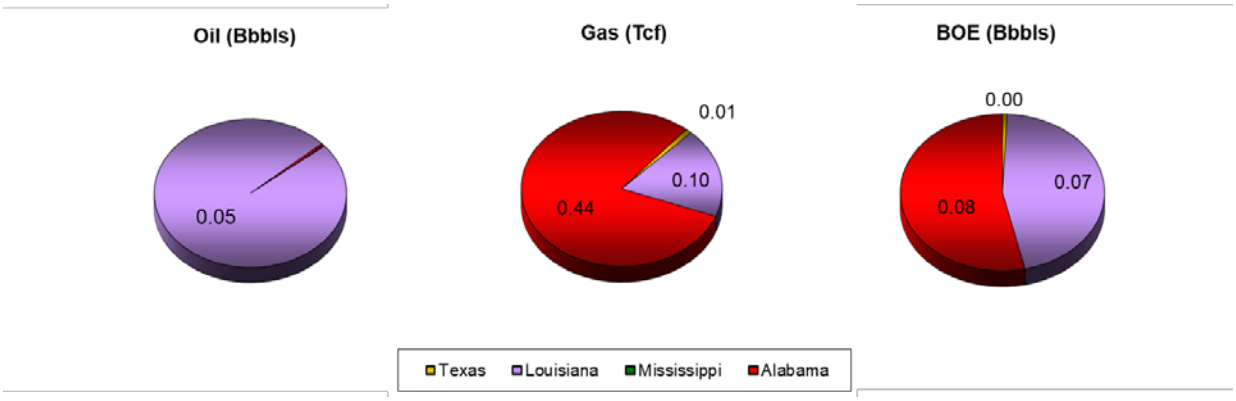


Figure 4(a): Distribution of Reserves in State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

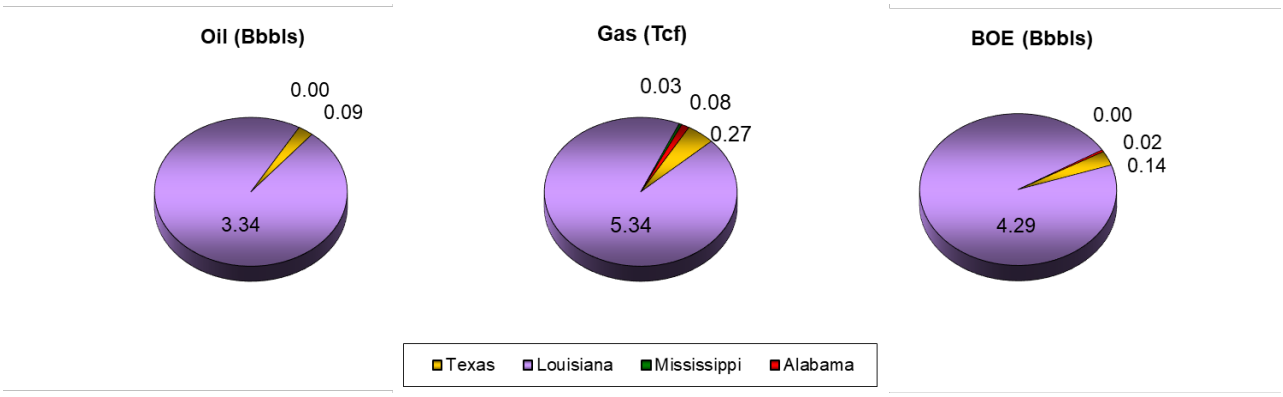


Figure 4(b): Distribution of Reserves in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

3. ***Contingent Resources****:* The contingent resources remaining in the over 1300 fields in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama are estimated to be 3.27 Bbo and 10.74 Tcfg (5.18 total BBOE) (Table 2(b) and Figure 5). Contingent resources were not provided to BOEM for oil and gas fields in state waters.

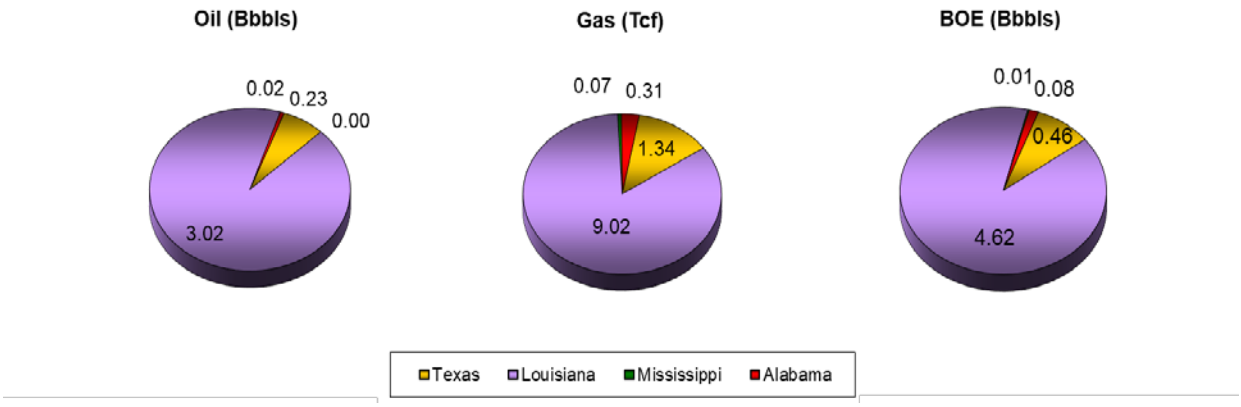


Figure 5: Distribution of Contingent Resources in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

4. ***Reserves Appreciation***: Cumulative production plus total estimated future production (from reserves) equals the estimate of the ultimate recovery (EUR) from a field. Predicting a field's true EUR requires an estimate of its future reserves growth or appreciation. The reserves appreciation phenomenon has been observed in onshore and offshore basins for years. During the initial years after discovery, reserve estimates typically increase rapidly. The rate of growth then tends to level off at a much smaller annual rate of increase. Appreciation is the result of numerous factors which occur as a field is developed and produced, most importantly:
    - consistently conservative standard industry practices for reporting proved reserves;
    - an increased understanding of the petroleum reservoir;
    - physical expansion of the field through the discovery of new reservoirs or the extension of existing reservoirs; and
    - improved recoveries due to experience with actual field performance, the implementation of new technology, and/or changes in the cost-price relationships.

    Growth functions were modeled from empirical historical trends derived from the set of existing OCS fields having proved reserves at the end of 2018, and were used to develop an estimate of an existing field's size at a future date. Growth factors represent the ratio of the size of a field several years after discovery to the initial estimate of its size in the year of discovery. The assumptions central to this analysis are:
    - the amount of growth in any year is proportional to the size of the field;
    - this proportionality varies inversely with the age of the field;
    - the age of the field is a reasonable proxy for the degree to which the factors causing appreciation have occurred; and
    - the factors causing future appreciation will result in patterns and magnitudes of growth similar to those observed in the past.

The appreciation model used in this assessment projects no growth for fields more than 55 years of age, which fits well with the observed data and does not entail extending projections considerably beyond the timeframe of the observations. On balance, however, the model used in this assessment of reserves appreciation is apt to be conservative as the oldest fields are generally the largest and contribute the bulk of the original proved reserves. Although the total volume of hydrocarbons presumed to be available through future reserves growth is substantial, the resources associated with this phenomenon are attainable only in relatively small increments.

Discoveries in the state waters of Alabama have been producing for approximately 30 years, while the fields in the state waters of Texas and Louisiana have been producing for more than 50 years. BOEM did not attribute additional growth and appreciation to reserves in known discoveries in coastal state waters.

Reserves appreciation in the OCS routinely exceeds new field discoveries and contributes the bulk of annual additions to proved reserves; it is an important consideration in any analysis of future oil and natural gas supplies. Future reserves appreciation within the existing active fields in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama is estimated at 7.98 Bbo and 34.32 Tcfg (14.09 total BBOE) (Table 2(b) and Figure 6).

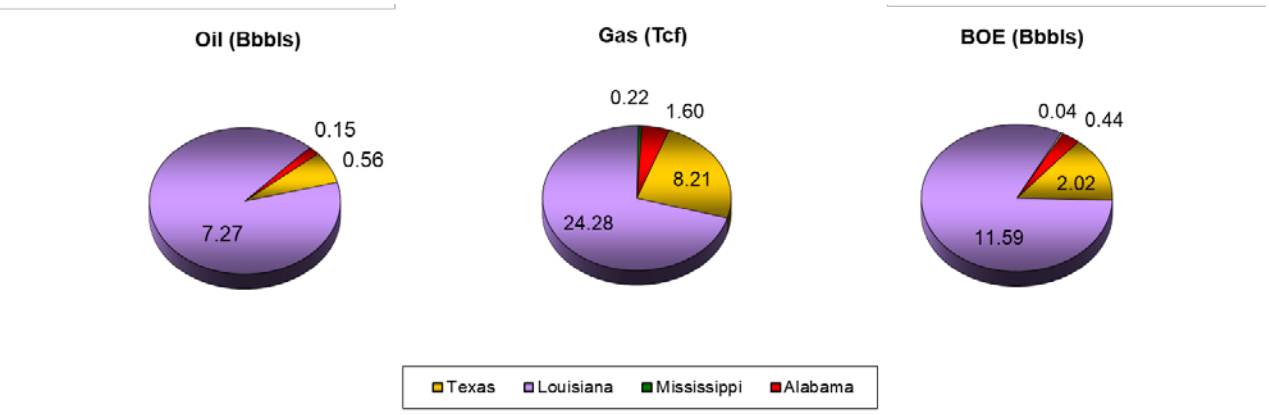


Figure 6: Distribution of Reserves Appreciation in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

5. ***UTRR***: Estimates of the UTRR for state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama have a mean of 1.53 Bbo and 37.39 Tcfg (8.19 total BBOE) (Figure 7(a) and Table 2(a)). Similarly, estimates for the OCS have a mean of 44.82 Bbo and 130.26 Tcfg (68.00 total BBOE) (Figure 7(b) and Table 2(b)).

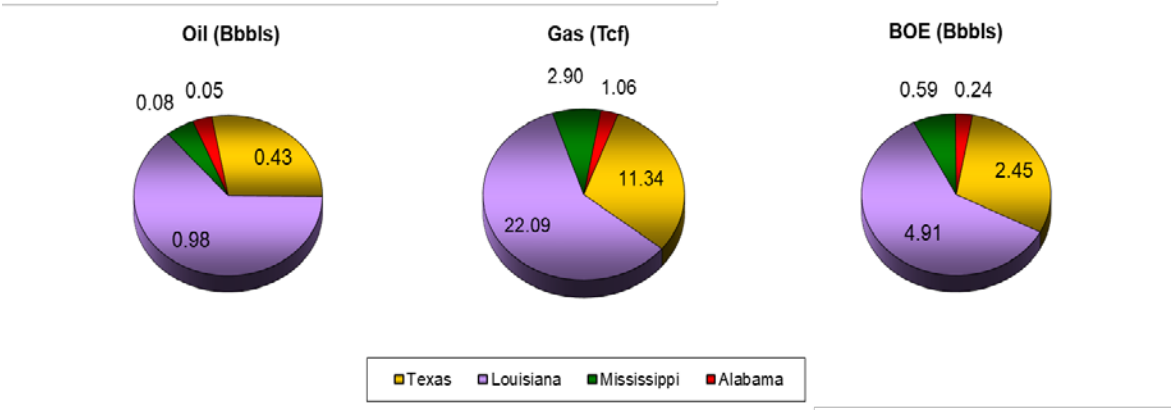


Figure 7(a): Distribution of UTRR in the State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

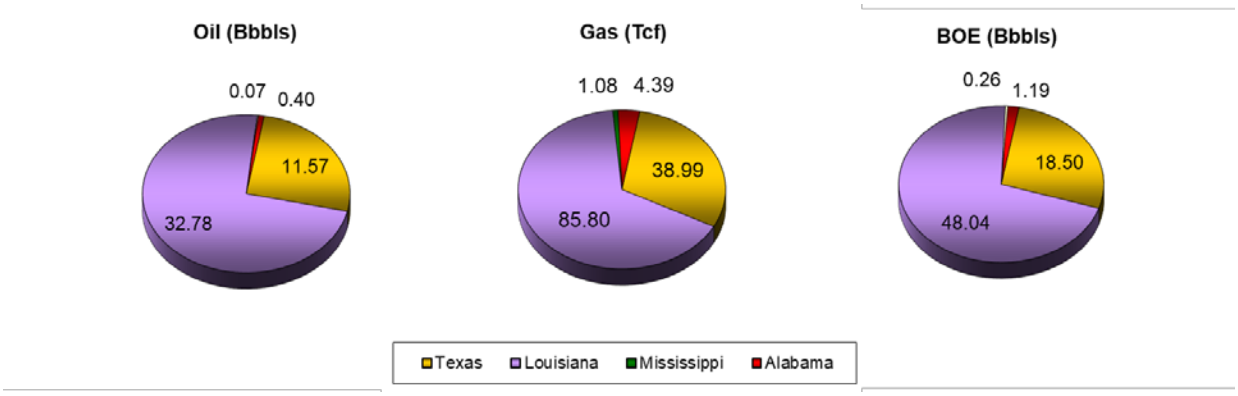
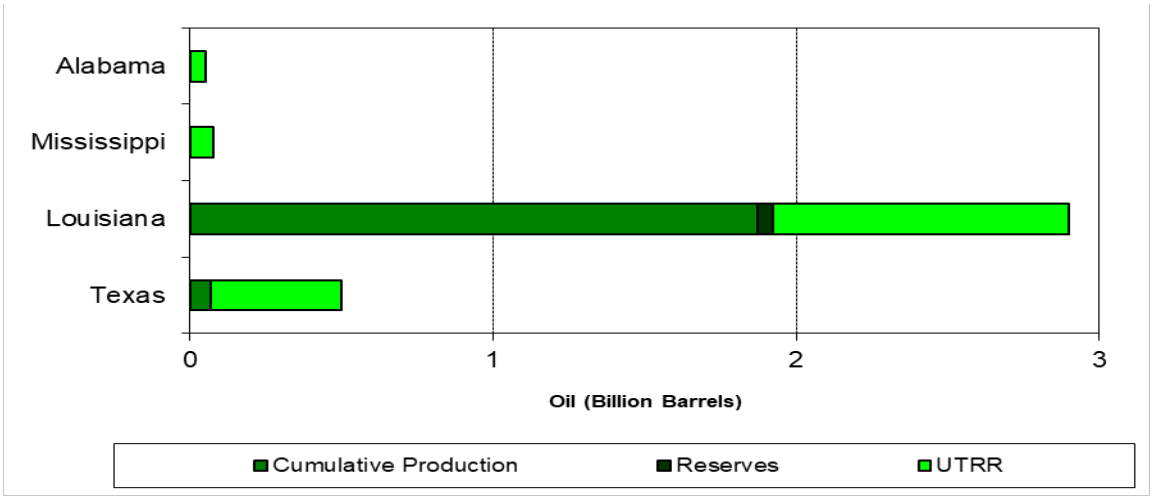
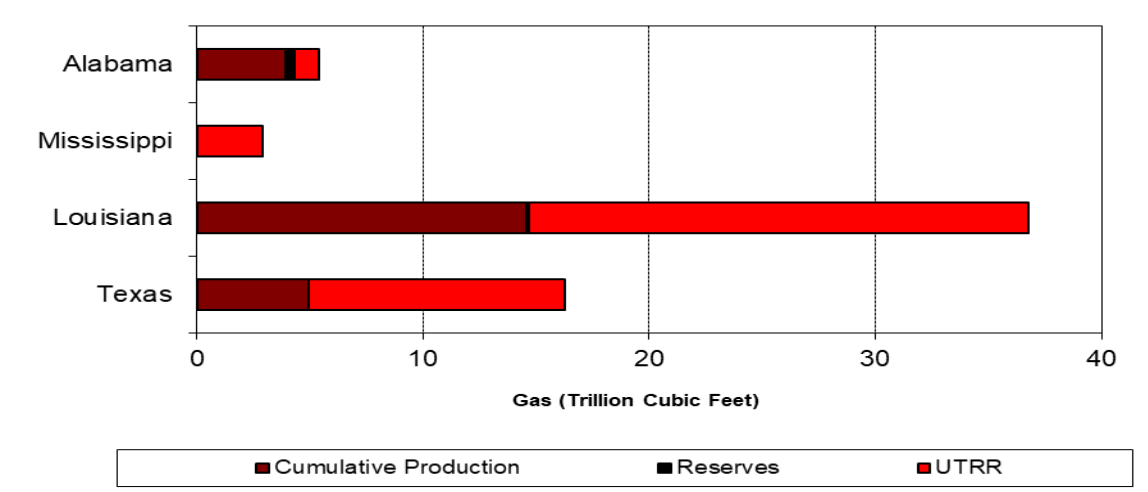


Figure 7(b): Distribution of UTRR in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type and State

6. Total Endowment: Mean estimates of the total hydrocarbon endowment for state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama are 3.53 Bbo and 61.37 Tcfg (14.45 total BBOE) (Figure 8(a) and Table 2(a)). More than 42 percent of the total endowment in terms of the mean estimate of the BOE has already been produced.

Mean estimates of the total hydrocarbon endowment for the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama are 80.93 Bbo and 370.89 Tcfg (146.92 total BBOE) (Figure 8(b) and Table 2(b)). More than 37 percent of the total endowment in terms of the mean estimate of the BOE has already been produced. An additional 16 percent is contained within the various reserves categories, the source of near and midterm production.





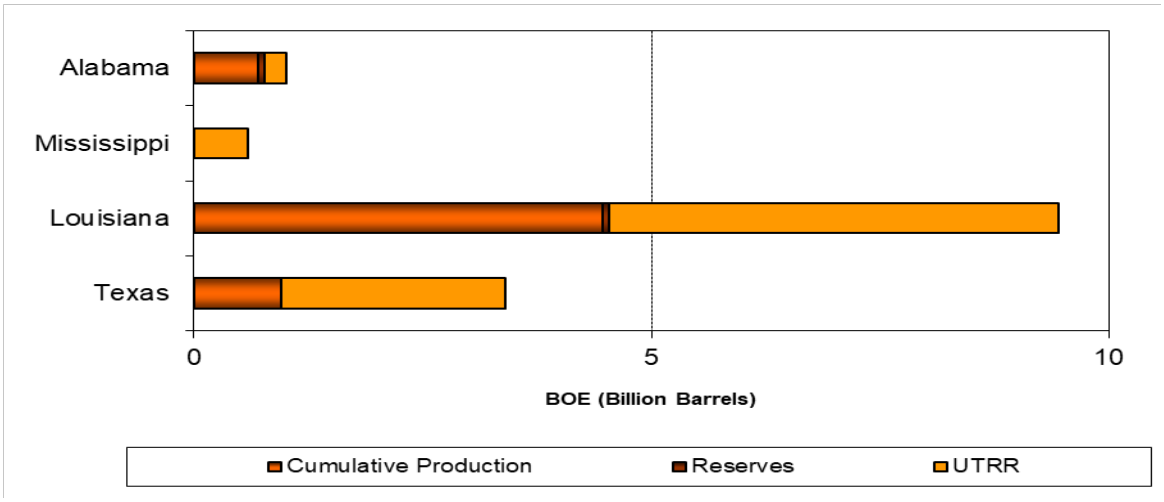
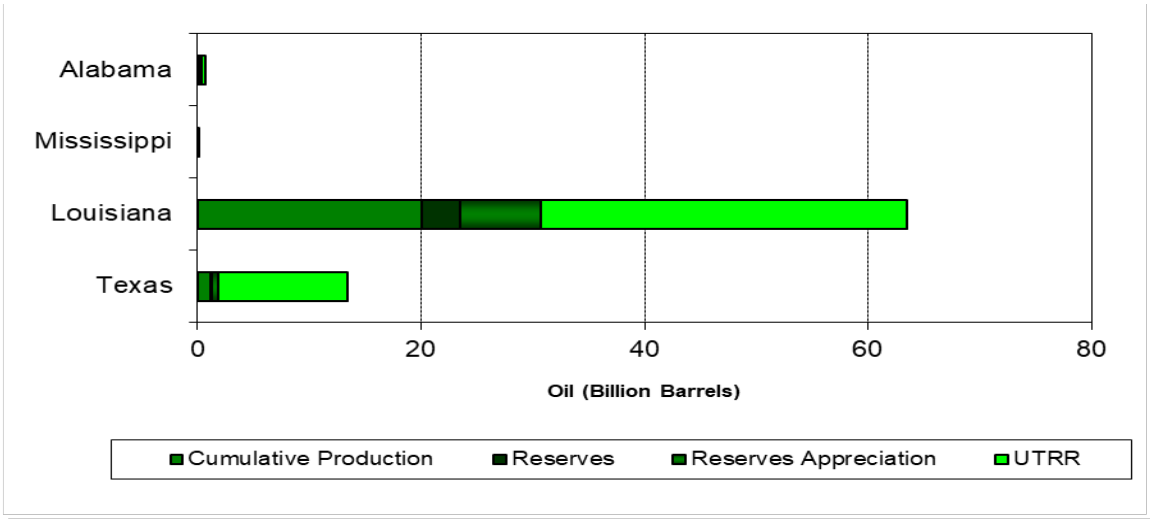
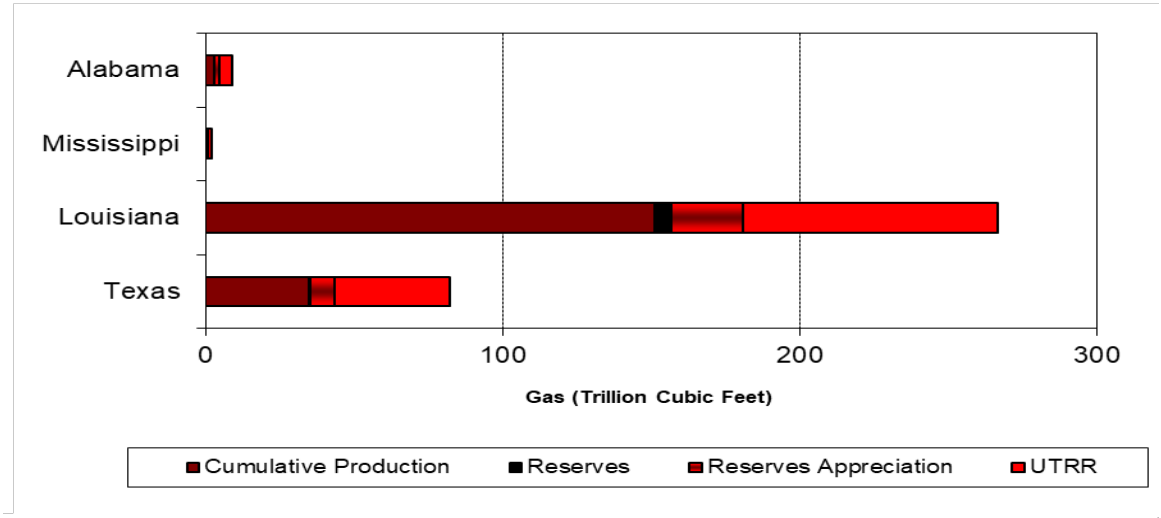


Figure 8(a): Distribution of Total Hydrocarbon Endowment in State Waters off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type, State, and Resource Category





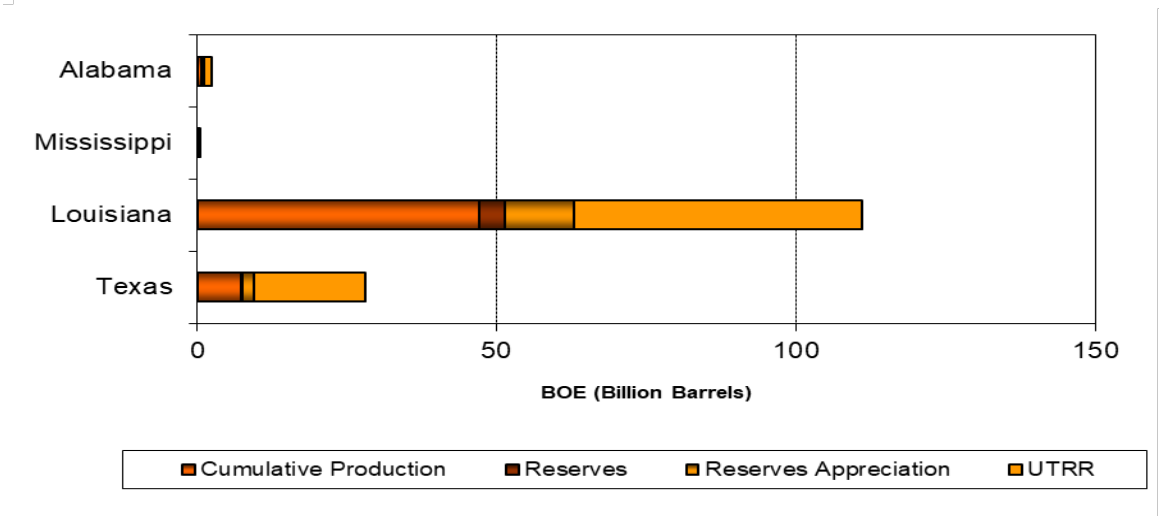


Figure 8(b): Distribution of Total Hydrocarbon Endowment in the OCS off the Coasts of Texas, Louisiana, Mississippi, and Alabama by Type, State, and Resource Category

V. Conclusions

Oil and gas resources located off the coasts of Texas, Louisiana, Mississippi, and Alabama are important to the future domestic energy supply of the United States. These areas are made available for leasing through various state and federal leasing programs.

The estimate of the total hydrocarbon endowment, which includes cumulative production, off the coasts of Texas, Louisiana, Mississippi, and Alabama, is 3.53 Bbo and 61.37 Tcfg (14.45 total BBOE) for state waters and 80.93 Bbo and 370.89 Tcfg (146.92 total BBOE) for the OCS.

Of the total endowment in state waters off the coasts of Texas, Louisiana, Mississippi, and Alabama, about 1.99 Bbo and 23.98 Tcfg (approximately 43 percent on a BOE basis) is represented by resources in known fields—the total of cumulative production and remaining reserves.

Of the total endowment in the OCS off the coasts of Texas, Louisiana, Mississippi, and Alabama, about 36.11 Bbo and 240.63 Tcfg (78.92 BBOE; approximately 54 percent on a BOE basis) is represented by resources in known fields—the total of cumulative production, remaining proved and contingent resources, and reserves appreciation.

Appendices

Appendix A: Glossary
Appendix B: Abbreviations, Acronyms, and Symbols
Appendix C: References

Appendix A: Glossary

The glossary defines relevant terms generally rather than in a strictly technical manner.

American Petroleum Industry (API) gravity: An arbitrary scale expressing the gravity or density of liquid petroleum products. The measuring scale is calibrated in terms of degrees API. The higher the API gravity, the lighter the fluid.

Appreciation: Analogous to reserves appreciation. See "reserves."

Assessment: The estimation of potential amounts of technically recoverable hydrocarbon resources.

Associated Gas: See "gas, natural."

Barrel: A volumetric unit of measure for crude oil equivalent to 42 U.S. gallons.

Barrel of Oil-Equivalent (BOE): The sum of gas resources, expressed in terms of their energy equivalence to oil, plus the oil volume. The conversion factor of 5,620 standard cubic feet of gas equals 1 BOE is based on the average heating values of domestic hydrocarbons.

Chance: See "probability" or "risk."

Condensate: Hydrocarbons associated with saturated gas that are present in the gaseous state at reservoir conditions, but are produced as liquid hydrocarbons at the surface.

Continental Margin: The composite continental rise, continental slope, and continental shelf as a single entity. The term, as used in this report, applies only to the portion of the margin whose mineral estate is under federal jurisdiction; geographically synonymous with Outer Continental Shelf (OCS).

Continental Shelf: The shallow, gradually sloping zone extending from the shoreline to a depth at which there is a marked steep descent to the ocean bottom.

Continental Slope: The portion of the continental margin extending seaward from the continental shelf to the continental rise or ocean floor.

Contingent Resources: See "reserves."

Conventionally Recoverable: Producible by natural pressure, pumping, or secondary recovery methods, such as gas or water injection.

Cumulative Production: The sum of all produced volumes of hydrocarbons prior to a specified point in time.

Deterministic: A process in which future states can be forecast exactly from knowledge of the present state and rules governing the process. It contains no random or uncertain components.

Development: Activities following exploration, including the installation of production facilities and the drilling and completion of wells for production.

Dissolved Gas: See "gas, natural."

Economic Analysis: An assessment performed in order to estimate the portion of the undiscovered conventionally recoverable resources in an area that is expected to be commercially viable in the long term under a specific set of economic conditions.

Economic Risk: See "risk."

Estimated Ultimate Recovery (EUR): See "reserves."

Exploration: The process of searching for minerals prior to development. Exploration activities include geophysical surveys, drilling to locate hydrocarbon reservoirs, and drilling of delineation wells to determine the extent and quality of an existing discovery prior to a development decision.

Floating Production, Storage, and Offloading (FPSO): A Floating Production, Storage and Offloading (FPSO) unit is a floating vessel used by the offshore oil and gas industry for the processing of hydrocarbons and for storage of oil.

Field: A producible accumulation of hydrocarbons consisting of a single pool or multiple pools related to the same geologic structure and/or stratigraphic condition. In general, usage of this term refers to a commercial accumulation.

Gas, Natural: A mixture of gaseous hydrocarbons (typically methane with lesser amounts of ethane, propane, butane, pentane, and possibly some nonhydrocarbon gases).

Associated Gas: Natural gas that occurs in crude oil reservoirs as free gas (gas cap).

Dissolved Gas: Natural gas that occurs as gas in solution within crude oil reservoirs.

Nonassociated Gas: Natural gas that occurs in reservoirs not in contact with significant quantities of crude oil.

Geologic risk: See "risk."

Growth Factor: A function used to calculate an estimate of a field's size at a future date. Growth factors reflect technology, market, and economic conditions existing over the period spanned by the estimates.

Annual Growth Factor: The function representing the ratio of the size of a field of a specific age as estimated in a given year to the size estimated for that same field in a previous year.

Cumulative Growth Factor: The function representing the ratio of the size of a field for a specific number of years after discovery to the initial estimate of its size in the year of discovery.

Hydrocarbon Maturation: The process by which organic material trapped in source rocks is transformed naturally by heat and pressure through time and depth of burial into oil and/or gas.

Hydrocarbons: Any of a large class of organic compounds containing primarily carbon and hydrogen. Hydrocarbons include crude oil and natural gas. As used in this report, the term is synonymous with petroleum.

Mean: A statistical measure of central tendency; the arithmetic average or expected value, calculated by summing all values and dividing by the number of values.

Model: A geologic hypothesis expressed in mathematical form.

Nonassociated Gas: See "gas, natural."

Oil, Crude: A mixture of hydrocarbons that exists naturally in the liquid phase in subsurface reservoirs.

Outer Continental Shelf (OCS): The continental margin, including the shelf, slope, and rise, beyond the line that marks the boundary of state ownership; that part of the seabed under federal jurisdiction.

Petroleum: A collective term for oil, gas, and condensate.

Planning Area: A subdivision of an offshore area used as the initial basis for considering blocks to be offered for lease in the Department of the Interior's OCS oil and gas leasing program.

Play: A group of known and/or postulated pools that share common geologic, geographic, and temporal properties, such as history of hydrocarbon generation, migration, reservoir development, and entrapment.

Probability: A means of expressing an outcome on a numerical scale that ranges from impossibility to absolute certainty; the chance that a specified event will occur.

Proved Reserves: See "reserves."

Recoverable resources: See "resources."

Region: A very large expanse of acreage usually characterized or set apart by some aspect such as a political division or area of similar geography. In this report, the regions are groupings of planning areas.

Reserves: The quantities of hydrocarbon resources anticipated to be recovered from known accumulations from a given date forward. All reserve estimates involve some degree of uncertainty.

Proved Reserves: The quantities of hydrocarbons estimated with reasonable certainty to be commercially recoverable from known accumulations and under current economic conditions, operating methods, and government regulations. Current economic conditions include prices and costs prevailing at the time of the estimate. Estimates of proved reserves do not include reserves appreciation.

Reserves Appreciation: The observed incremental increase through time in the estimates of reserves of an oil and/or gas field. It is that part of the known resources over and above proved and unproved reserves that will be added to existing fields through extension, revision, improved recovery, and the addition of new reservoirs. Also referred to as reserves growth or field growth.

Contingent Resources: The quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations by application of development projects but which are not currently considered to be commercially recoverable due to one or more contingencies.

Estimated Ultimate Recovery (EUR): All hydrocarbon resources within known fields that can be profitably produced using current technology under existing economic conditions. Estimates of ultimate recovery equal the sum of cumulative production, proved reserves, unproved reserves, and reserves appreciation.

Reservoir: A subsurface, porous, permeable rock body in which an isolated accumulation of oil and/or gas is stored.

Resource Assessment: The estimation of potential amounts of recoverable resources. The focus is normally on conventionally or technically recoverable hydrocarbons.

Resources: Concentrations in the earth's crust of naturally occurring liquid or gaseous hydrocarbons that can conceivably be discovered and recovered. Normal use encompasses both discovered and undiscovered resources.

Recoverable Resources: The volume of hydrocarbons that is potentially recoverable, regardless of the size, accessibility, recovery technique, or economics of the postulated accumulations.

Technically Recoverable Resources: The volume of hydrocarbons that may be produced from a wellbore as a consequence of natural pressure, artificial lift, pressure maintenance (gas or water injection), or other secondary recovery methods. They do not include quantities of hydrocarbon resources that could be recovered by enhanced recovery techniques, gas in geopressured brines, natural gas hydrates, or oil and gas that may be present in insufficient quantities or quality (low permeability "tight" reservoirs) to be produced via conventional recovery techniques.

Undiscovered Resources: Resources postulated, on the basis of geologic knowledge and theory, to exist outside of known fields or accumulations. Included also are resources from undiscovered pools within known fields to the extent that they occur within separate plays.

Undiscovered Technically Recoverable Resources (UTRR): Resources in undiscovered accumulations analogous to those in existing fields producible with current recovery technology and efficiency, but without any consideration of economic viability. These accumulations are of sufficient size and quality to be amenable to conventional primary and secondary recovery techniques. Undiscovered conventionally recoverable resources are primarily located outside of known fields.

Risk: The chance or probability that a particular event will not occur.

Economic Risk: The chance that no commercial accumulation of hydrocarbons will exist in the area under consideration (e.g., prospect, play, or area). The chance that an area may not contain hydrocarbons, or the volume present may be noncommercial is incorporated in the economic risk.

Geologic Risk: The chance that technically recoverable volumes of hydrocarbons will not exist in the area under consideration (e.g., prospect, play, basin or area). The commercial viability of an accumulation is not a consideration.

Single Point Anchor Reservoir (SPAR): An offshore facility consisting of a large diameter vertical cylinder supporting a deck. It has a typical fixed platform topside (surface deck with drilling and production equipment), three types of risers (drilling, production, and export), and a hull which is moored using a taut catenary system of 6 to 20 lines anchored into the seafloor. SPAR's are presently used in water depths up to 3,000 feet, although existing technology can extend this to about 10,000 feet.

Subsea System: An offshore facility ranging from single subsea wells producing to a nearby platform, floating production system, or tension leg platform to multiple wells producing

through a manifold and pipeline system to a distant production facility. These systems are now used in water depths up to 7,000 feet, although existing technology can extend this to about 10,000 feet.

Stochastic: A process in which each observation possesses a random variable.

Subjective Judgment: A technique utilized to assign probabilities of occurrence to possible events when all of the possible outcomes of an event are not known and when the frequency of recognized outcomes cannot be estimated with certainty; often referred to as expert opinion.

Total Endowment: All conventionally recoverable hydrocarbon resources of an area. Estimates of total endowment equal the sum of UTRR, cumulative production, proved reserves, unproved reserves, and reserves appreciation.

Uncertainty: Imprecision in estimating the value (or range of values) for a variable.

Undiscovered Resources: See "Recoverable resources."

Undiscovered Technically Recoverable Resources (UTRR): See "Recoverable resources."

Unproved Reserves: See "reserves."

Appendix B: Abbreviations and Acronyms

API	American Petroleum Institute
Bbbl	Billion Barrels
Bbo	Billion Barrels of Oil
BBOE	Billion Barrels of Oil Equivalent
BOE	Barrel of Oil Equivalent
BOEM	Bureau of Ocean Energy Management
CGOM	Central Gulf of Mexico
DOE	Department of Energy
DOI	Department of the Interior
EIA	Energy Information Administration
EUR	Estimated Ultimate Recovery
GOM	Gulf of Mexico
MMS	Minerals Management Service
OCS	Outer Continental Shelf
PA	Planning Area
Tcf	Trillion Cubic Feet
Tcfg	Trillion Cubic Feet of Gas
UTRR	Undiscovered Technically Recoverable Resources
U.S.	United States
USGS	U.S. Geological Survey
WGOM	Western Gulf of Mexico

Appendix C: References

Bureau of Ocean Energy Management, 2016. Assessment of Undiscovered Oil and Gas Resources of the Nation's Outer Continental Shelf, 2016a: BOEM Fact Sheet RED-2017-12, December 2017, 8 p.

Bureau of Ocean Energy Management, 2020. Estimated Oil and Gas Reserves, Gulf of Mexico OCS Region, December 31, 2018. OCS Report BOEM 2020-028, 2-3, 18, 46 p. https://www.boem.gov/sites/default/files/documents/oil-gas-energy/BOEM-2020-028.pdf

Charpentier, R. and T. Klett, 2005. A Monte Carlo Simulation Method for the Assessment of Undiscovered, Conventional Oil and Gas, *in* Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah. U.S. Geological Survey Digital Data Series DDS–69–D.

Dreyfus, D. and A. Ashby, 1989. Global natural gas resources: Energy, v.14, no. 12, p. 734-784.

Minerals Management Service, 1997. Federal Offshore Statistics:1995: MMS OCS Report MMS 97-007, 122 p.

Minerals Management Service, 2006. Report to Congress: Comprehensive inventory of U.S. oil and natural gas resources, Energy Policy Act of 2005 – Section 357, 144 p.

National Research Council, 1991. Undiscovered oil and gas resources: an evaluation of the Department of the Interior's 1989 assessment procedures: National Academy Press, Washington, D.C., 179 p

Rogner, H., 1997. An assessment of world hydrocarbon resources: annual review of energy and the environment, v. 22, p. 217-262.

Schmoker, J. and T. Klett, 2005. U.S. Geological Survey Assessment Concepts for Conventional Petroleum Accumulations, *in* Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah. U.S. Geological Survey Digital Data Series DDS–69–D.

Society of Petroleum Engineers (SPE), American Association of Petroleum Geologists (AAPG), World Petroleum Council (WPC), and Society of Petroleum Evaluation Engineers (SPEE), 2007, *Petroleum Resource Management System*, 49 p.

U.S. Bureau of Mines and U.S. Geological Survey, 1980. Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.