FINAL REPORT

ECONOMIC ANALYSIS FOR A NATIONAL ULTRA-DEEPWATER AND UNCONVENTIONAL OIL AND GAS SUPPLY RESEARCH FUND

Eugene M. Kim and Scott W. Tinker

SUBMITTED TO GTI

BUREAU OF
ECONOMIC GEOLOGY
Scott W. Tinker, Director
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EXECUTIVE SUMMARY

This study provides an analysis of future incremental Federal lands and U.S. oil and gas production, and its associated economical benefits, that could be achieved through the establishment of a supply research fund. The supply research fund is based on H.R. 6, Subtitle E—Fossil Energy, Part 1, Sec. 21501(b) and Part 3—Ultra-deepwater and Unconventional Natural Gas and Other Petroleum Resources, submitted to the 108th U.S. Congress. The legislation provides for the establishment of a supply research fund from a percentage of the amount of royalties, rents, and bonuses derived from Federal onshore and offshore oil and gas leases issued under the Outer Continental Shelf Lands Act and the Mineral Leasing Act for each of fiscal years 2003 through 2010. This report is an update to a previous report, *Benefit/cost analysis of GRI's gas supply research initiative* (Kim and others, 2000), which contains an analysis of the benefits and costs of a gas supply research fund.

The value of technology developed and advanced through the supply research fund was examined in terms of resulting incremental production. Incremental production was expected to be greatest among complex and new resource areas such as the deepwater offshore and unconventionals. Federal lands incremental oil and gas production forecast by technological advancements achieved by the supply research fund during the period from 2003 through 2025 was calculated as 4,202 million bbl and 28.79 Tcf, respectively. The resulting incremental production and royalty revenue was $204,233 million and $28,749 million, respectively.

Incremental production response for the technologically dependent resources is great, and the resources do, in fact, increase quickly because they are currently not exploited or the production levels are limited by current technology. Creation of a robust research, development, demonstration, and commercialization program for oil and gas such as the supply research fund outlined in this study would allow for accelerated work on many promising technologies and make it possible to address multiple challenges to incremental production of deepwater and unconventional oil and gas resources. The results of this new supply research fund, according to our analysis of past research and development (R&D) and the resulting supply response, will be quick and dramatic increases in Federal lands and U.S. oil and gas production.

INTRODUCTION

This study provides an analysis of future incremental Federal lands and U.S. oil and gas production, and its associated economic benefits, possible through the establishment of a supply research fund. It provides an update to a previous report, *Benefit/cost analysis of GRI's gas supply research initiative* (Kim and others, 2000), that contains analysis of the benefits and costs of a gas supply research fund. The previous report analyzes past gas projection trends on Federal lands and describes not only the impact of technological advancements on those trends, but also the impact of GRI (Gas Research Institute, the predecessor of GTI)-funded technology research on historical gas production. It forecasts the economic value of continued GRI research on future production and revenue streams. In the report, annual gas production from Federal lands was forecast to increase from 7.3 to 10.2 Tcf by 2015. Increased production, however, depended on continued development and application of technology. By 2015, the value of technology in terms of incremental gas production on Federal lands was estimated to be 45 Tcf from deepwater/subsalt and unconventional resources alone. This technology-dependent production represented a potential incremental royalty revenue of more than $22 billion. Past GRI programs were estimated to account for approximately 15 percent of total gas R&D in the United States; for unconventional natural gas resources, GRI's contribution has been even greater. By 2015, continued technological R&D by GRI was expected to deliver more than 10 Tcf in incremental production to the total U.S. gas supply. On Federal lands, GRI's impact was estimated to achieve an incremental production of more than 6.7 Tcf. These scenarios assumed a fully funded GRI program throughout this period. A benefit/cost (B/C) analysis of a proposed GRI gas technological research program, funded by a 10-percent annual nomination of royalty revenue from Federal Outer Continental Shelf (OCS) natural gas production, showed positive economics. Using a base-price case of $3/Mcf, escalating it 1 percent annually, and a discount rate of 10 percent, this program was projected to produce an internal rate of return (IRR) of 101 percent, with a net present value (NPV) of $5 billion. This amount was based on projected incremental gas production and royalty revenue on Federal lands alone. In the context of the broader impact of GRI technological R&D on total U.S. gas production, and using the same project economics, the program was projected to produce IRR of 143 percent, with an NPV of $8 billion.

The supply research fund analyzed in this study originates from H.R. 6, Subtitle E — Fossil Energy, Part 1, Sec. 21501(b) and Part 3—Ultra-deepwater and Unconventional Natural Gas and Other Petroleum Resources, submitted to the 108th U.S. Congress. In summary, the legislation provides for the establishment of the Ultra-Deepwater and Unconventional Natural Gas and Other Petroleum Research Fund (hereafter referred to as the supply research fund) from a percentage of the amount of royalties, rents, and bonuses derived from Federal onshore and offshore oil and gas leases issued under the Outer Continental Shelf Lands Act and the Mineral Leasing Act for each of fiscal years 2003 through 2010. The study focuses on analysis of

(1) Compilation and management of production and economic data.

(2) Records of historical Federal lands and U.S. oil and gas production.

(3) Forecasts of oil and gas production and royalty revenue from Federal lands and the United States.

(4) The potential impact of technology targeted at increasing oil and gas production and royalty payments from Federal lands and the United States.

(5) Economic effects of incremental oil and gas production attained through establishment of the supply research fund.

FEDERAL LANDS OIL AND GAS RESOURCES, PRODUCTION, AND ASSOCIATED MINERAL REVENUES

Federal lands are divided into Federal offshore, Federal onshore, and American Indian. American Indian lands are administered by the Bureau of Land Management (BLM), whereas the Federal offshore and onshore are administered by the Minerals Management Service (MMS). The total onshore component of the Federal lands comprises approximately 29 percent of total land area of the United States (BLM, 1996). Geographic distribution of the onshore component of Federal lands is very uneven. States having a large percentage of Federal lands include Nevada, Alaska, Utah, Idaho, Oregon, Wyoming, California, and Arizona. The Federal offshore comprises four OCS provinces managed by MMS: Alaska, Atlantic, Pacific, and Gulf of Mexico (GOM).

For Federal lands oil and gas resources evaluated as of 2001, the Energy Information Administration (EIA) compiled latest estimates generated from the U.S. Geological Survey (USGS), the National Petroleum Council (NPC), and the MMS (table 1). As seen in figures 1 through 4, unconventional and offshore resource components compose a large majority of both oil and gas resources on Federal lands. Most undiscovered conventional resources on Federal lands are in northern Alaska, the Powder River Basin of Montana and Wyoming, and the Wyoming Thrust Belt. Continuous-type gas accumulations (those pervasive throughout a large area that is not significantly affected by hydrodynamic influences and for which the standard methodology for assessment of sizes and numbers of discrete accumulations is not appropriate) on Federal lands, largely in southeast Wyoming, as well as coalbed methane, largely in the Uinta-Piceance Basin of Utah and Colorado and the San Juan Basin of New Mexico, account for a large proportion of undiscovered unconventional gas resources.

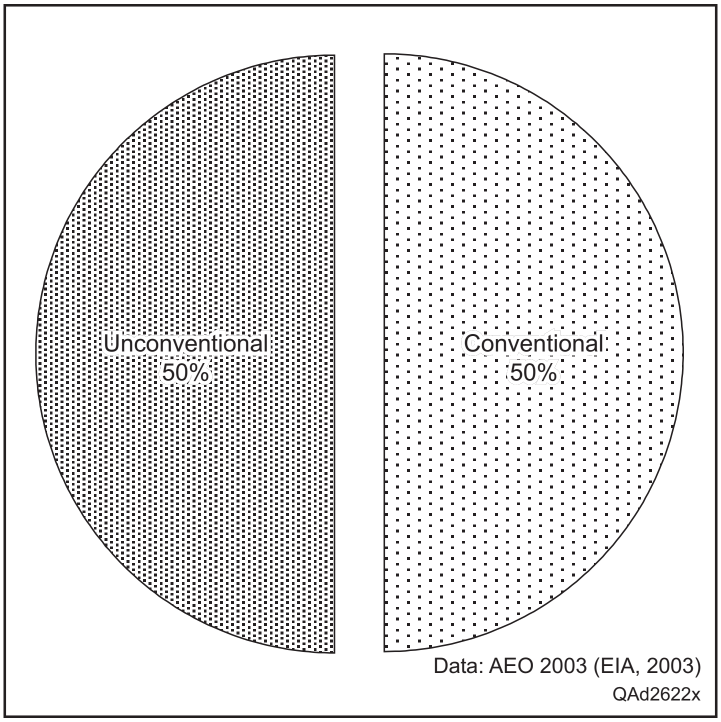

Figure 1. Conventional vs. unconventional technically recoverable oil resources on Federal Lands.

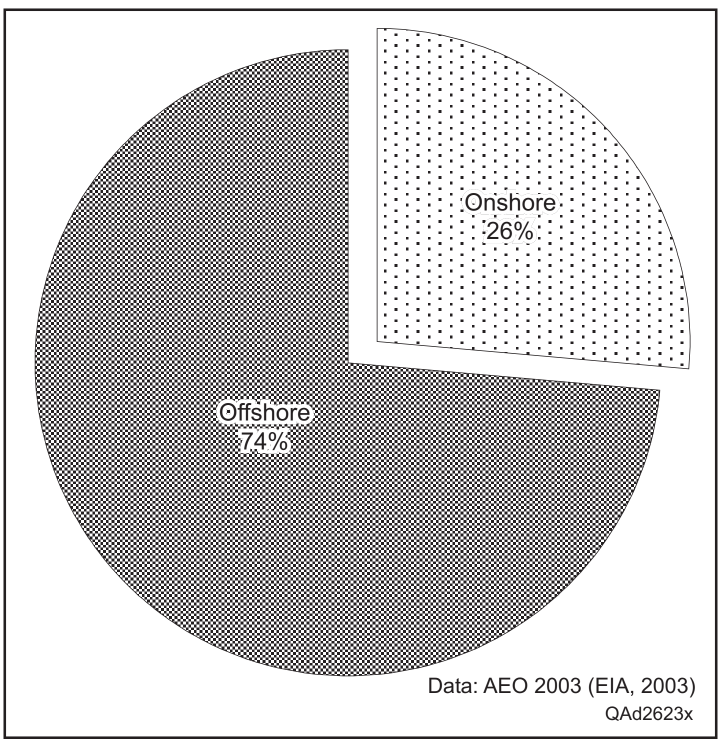

Figure 2. Onshore vs. offshore technically recoverable oil resources on Federal Lands.

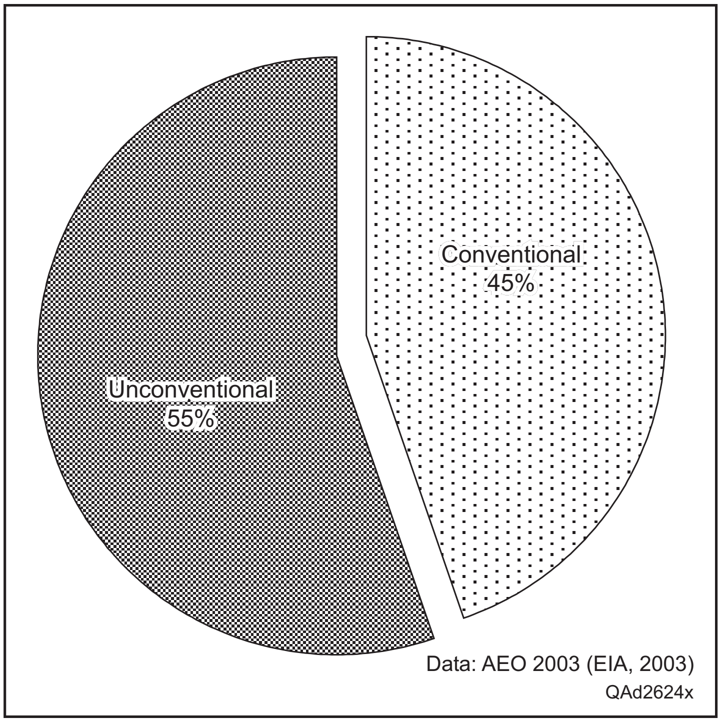

Figure 3. Conventional vs. unconventional technically recoverable gas resources on Federal Lands.

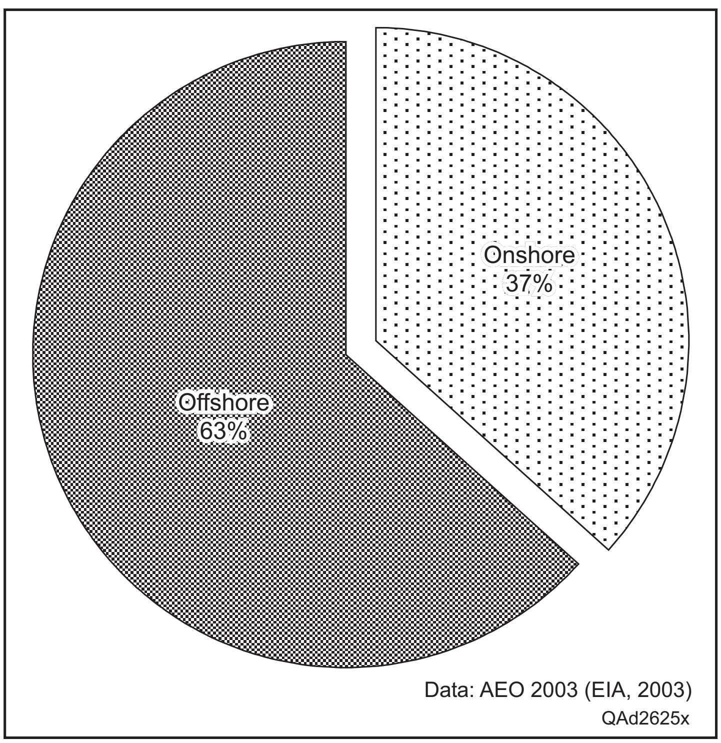

Figure 4. Onshore vs. offshore technically recoverable gas resources on Federal Lands.

Table 1. Technically recoverable oil and gas resources on Federal Lands.

	Oil (Bbbl)	Gas (Tcf)
Undiscovered Conventional Offshore	75.0	362.2
Undiscovered Conventional Onshore	9.3	57.9
Discovered Conventional Offshore	7.7	68.0
Discovered Conventional Onshore	19.3	118.7
Undiscovered Unconventional Offshore	82.2	430.2
Undiscovered Unconventional Onshore	30.4	319.8
Total	223.9	1356.8

Data: AEO 2003 (EIA, 2003)
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The Federal offshore comprises the bulk of current Federal lands oil and gas production (figs. 5 and 6). Although a large resource base exists in the Alaska OCS, economically recoverable resources are minor because of transportation and access problems. Most Federal OCS production and remaining reserves are from the GOM OCS.

Significant mineral revenues are derived from Federal lands. In 2000, more than $7 billion was collected as Federal lands mineral revenues (table 2). Components of mineral revenues include royalties, rents, bonuses, and other revenue (fig. 7). Historically and in the present, oil and gas royalties make up most of the mineral revenues from Federal lands (table 3). Although rents and bonuses are a significant component of mineral revenues on Federal lands, they are not divided according to whether they are derived from oil, gas, coal, or other royalty lands. Assuming that the royalty collected from each component of royalty lands is representative of the rents and bonuses collected, oil and gas rents and bonuses have been calculated. However, when compared historically in terms of oil and gas royalties, no discernible trend can be established. For example, in 1992, oil and gas rents and bonuses were calculated to compose 8 percent of oil and gas royalties, whereas in 1998 the amount surged to 51 percent,

Figure 5. Historical Federal Lands oil production.

Table 2. Federal Lands 2000 mineral revenues.

	Offshore	Onshore	American Indian	Total
Coal Royalties		$329,566,786	$58,383,154	$387,949,940
Gas Royalties	$2,451,875,964	$703,994,981	$124,684,429	$3,280,555,374
Oil Royalties	$1,642,700,114	$263,851,425	$57,888,348	$1,964,439,887
Other Royalties	$141,221,225	$107,954,462	$14,688,708	$263,864,395
Rents	$207,828,582	$44,504,085	$726,339	$253,059,006
Bonuses	$441,798,474	$134,376,053		$576,174,527
Other Revenue	$324,238,283	$60,999,723	$12,481,681	$397,719,687
Total	$5,209,662,642	$1,645,247,515	$268,852,659	$7,123,762,816

Data: Mineral Revenues 2000 (MMS, 2001)
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Figure 6. Historical Federal Lands gas production.

and in 2000 it dropped back down to 15 percent. Oil and gas royalty rates for Federal lands have remained relatively constant, and their averages are shown in table 4. In terms of resource area, the Federal offshore comprises 79 percent of the total oil and gas royalty revenue (fig. 8).

Three significant recent developments in terms of Federal lands mineral revenues are the OCS Deep Water Royalty Relief Act of 1995, the proposed new incentive for deep shelf gas, and royalty-in-kind programs. Under amendments to the OCS Act, the OCS Deep Water Royalty Relief Act of 1995 provides royalty relief for new production of as much as 17.5 million barrels of oil equivalent (boe) in water depths of 200 to 400 meters, 52.5 million boe in 400 to

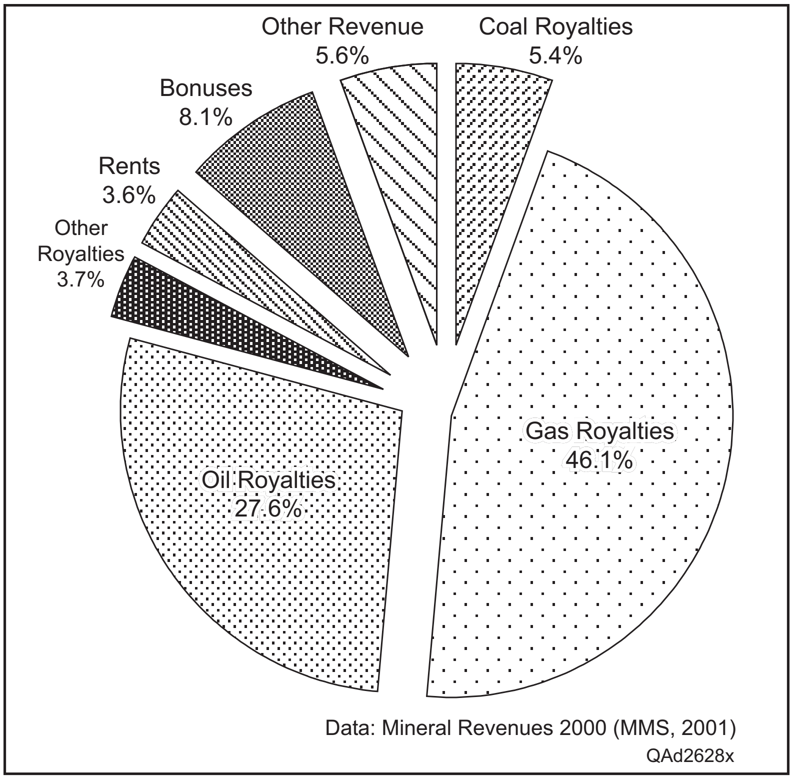

Figure 7. Components of 2000 mineral revenue from Federal Lands.

Table 3. Historical Federal Lands mineral revenues.

Year	Coal Royalties	Gas Royalties	Oil Royalties	Other Royalties	Rents	Bonuses	Other Revenue	Total	% of Total for Oil and Gas Royalties	Calculated Oil and Gas Rents & Bonuses	Oil and Gas Rents & Bonuses as % of Oil and Gas Royalties
1992	325,462,818	1,612,052,771	1,294,794,084	166,703,578	96,837,548	142,970,711	50,501,169	3,689,322,679	86%	225,786,488	8%
1993	328,991,951	1,999,819,793	1,148,553,538	164,112,874	74,751,577	203,573,631	152,517,006	4,072,320,370	86%	268,202,845	9%
1994	360,175,024	1,934,866,134	1,014,553,730	146,494,922	72,924,538	428,821,887	264,521,209	4,222,357,444	85%	491,055,536	17%
1995	369,295,252	1,462,764,791	1,176,250,348	174,753,380	121,668,163	501,035,526	23,905,151	3,829,672,611	83%	601,908,191	23%
1996	364,948,773	2,223,895,262	1,499,523,768	180,370,999	197,135,800	965,734,373	62,376,077	5,493,985,052	87%	1,137,686,611	31%
1997	352,178,744	2,657,964,734	1,605,762,863	203,276,680	266,017,564	1,496,659,928	139,926,121	6,721,786,634	88%	1,732,016,507	41%
1998	345,734,171	2,290,930,934	1,072,675,622	148,923,817	298,645,651	1,454,514,764	-3,040,955	5,608,384,004	87%	1,714,871,839	51%
1999	372,392,664	2,183,314,452	1,094,333,400	154,021,752	248,995,621	439,316,723	67,817,605	4,560,192,217	86%	653,855,788	20%
2000	387,949,940	3,280,556,607	1,964,438,654	263,864,395	253,059,006	576,174,527	397,719,687	7,123,762,816	89%	801,261,206	15%
Average	*356,347,704*	*2,182,907,275*	*1,318,987,334*	*178,058,044*	*181,115,052*	*689,866,897*	*128,471,452*	*5,035,753,759*	*86%*	*847,405,001*	*24%*

Data: Mineral Revenues 2000 (MMS, 2001)

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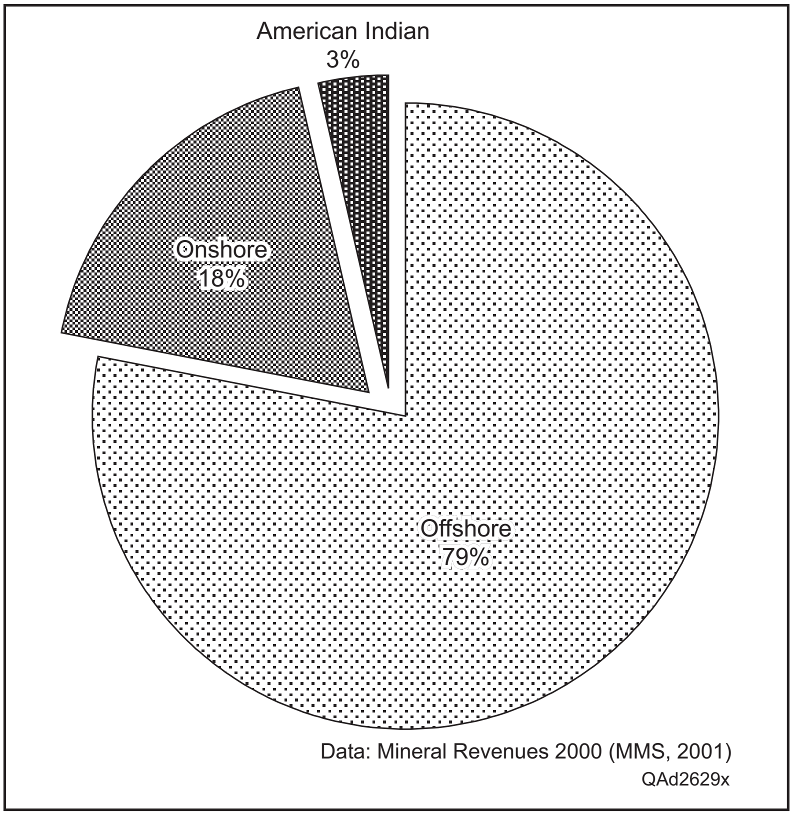

Figure 8. Federal Lands 2000 oil and gas royalty revenues.

Table 4. Federal Lands royalty rates.

	Oil			Gas		
Average Royalty Rates:	Offshore	Offshore	Amercan Indian	Offshore	Offshore	Amercan Indian
3-year Average	14.22%	9.69%	16.58%	15.60%	11.60%	14.52%
5-year Average	14.51%	9.86%	16.57%	15.70%	11.56%	14.38%
10-year Average	14.80%	10.77%	16.43%	15.88%	11.69%	14.14%
Historical Average	16.78%	12.35%	13.78%	15.84%	12.22%	13.65%

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800 meters of water, and 87.5 million boe in water depths greater than 800 meters to promote deepwater drilling and production. Royalty relief is provided in any year during which the arithmetic average of the closing prices on the New York Mercantile Exchange for light sweet crude oil and gas is less than $28 per barrel and $3.50 per MM btu, respectively.

With gas prices climbing sharply and gas production in the GOM shelf declining, MMS announced on March 26, 2003, proposed new incentives to increase deep shelf gas production. Under the proposal, the MMS would provide royalty suspension incentives when companies take the risk of exploring and developing deep shelf gas. A royalty suspension is offered on the first 15 Bcf of gas produced from a well drilled and completed from 15,000 feet to less than 18,000 feet below sea level or on the first 25 Bcf of gas from a well drilled and completed 18,000 feet or deeper below sea level. Moreover, as many as two royalty suspension supplements of 5 Bcf each, applied to future production of oil or gas from any drilling depth on that lease, are allowed for an unsuccessful well drilled to a target reservoir 18,000 feet or deeper below sea level.

Historically, most of the royalties collected by MMS have been in the form of royalty in value (RIV). A feasibility study conducted by MMS in 1997 documents that taking royalty in kind (RIK) and marketing the minerals through competitive sales or other means could be revenue neutral or positive. On the basis of the early successes of RIK pilot projects, MMS has decided to proceed with RIK starting in December 2003, after a 3-year evolvement process under its *Road Map to the Future* (MMS, 2001a). Currently, MMS receives 160,000 bbl/day of oil and 400 MMcf/day of gas in RIK (Oil & Gas Journal Online, 2003).

FORECAST OF U.S. AND FEDERAL LANDS OIL AND GAS PRODUCTION

U.S. oil and gas production has been forecast by a variety of organizations. The EIA's Annual Energy Outlook (AEO) 2003 was used in this study to forecast Federal lands future production, royalty revenues, and the effects of technology on maintaining and increasing current production levels since it was determined to be the most current, widely utilized, and extensive forecast available. The reference oil and gas production case of AEO 2003 was utilized to forecast Federal land oil and gas production. Components of the U.S. oil production forecast are shown in figure 9. A steady decline for lower 48 onshore oil production, increased lower 48 offshore oil production to 2007, and an increase in Alaskan oil production from 2010 is

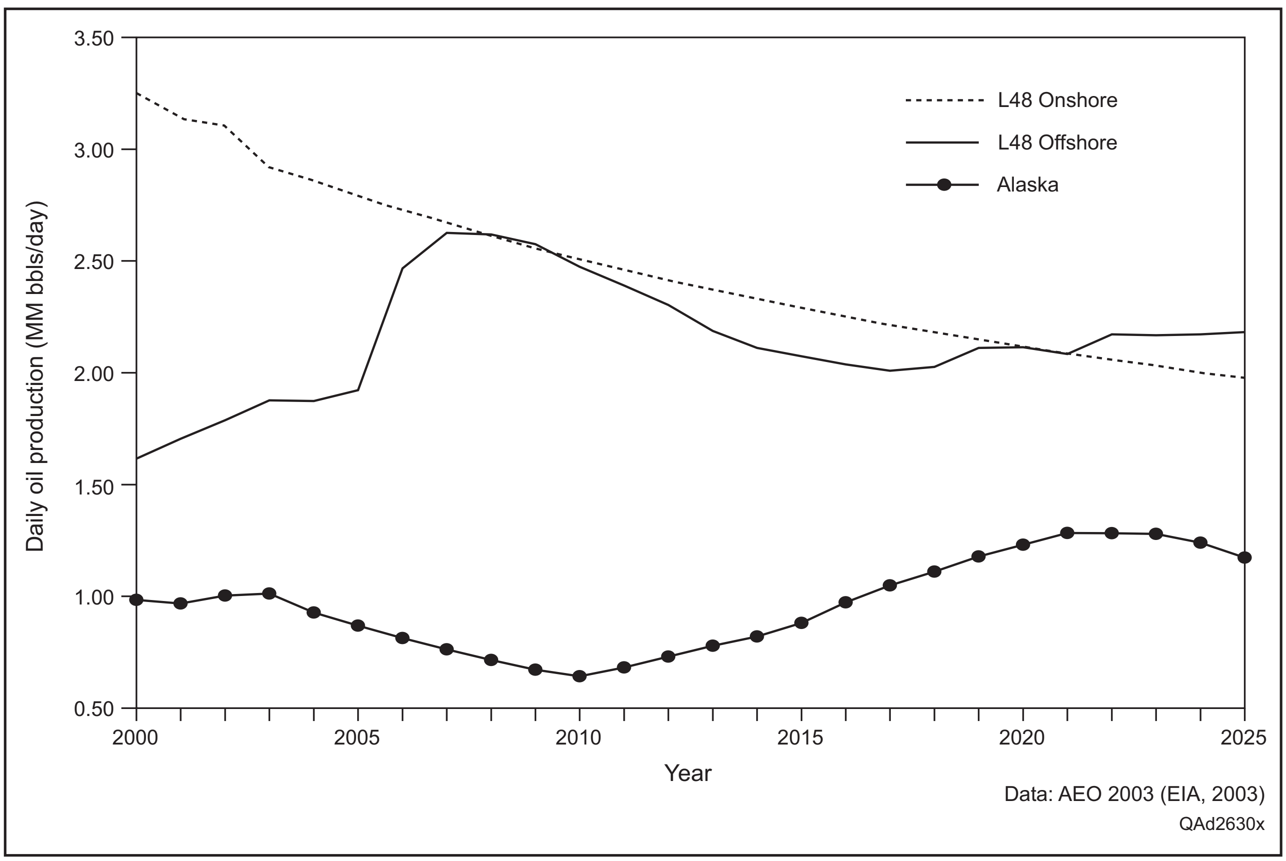

Figure 9. Components of U.S. oil production forecast.

forecast. Total U.S. oil production and average wellhead price forecasts assumed by AEO 2003 are given in figure 10. Oil production declines to 2005, increases thereafter until 2007 as the deepwater GOM OCS production increases, and declines significantly until 2015 as Alaskan production increases. Relatively modest oil prices are forecast with the 2025 average wellhead price forecast at slightly higher than $26/bbl. Components of the U.S. gas production forecast are shown in figure 11. Lower 48 onshore conventional gas production increases slightly; lower 48 onshore unconventional gas production significantly increases; lower 48 offshore production remains relatively stable; and an increase in Alaskan gas production from 2020 is forecast as transportation issues are forecast to be resolved. Total U.S. gas production and

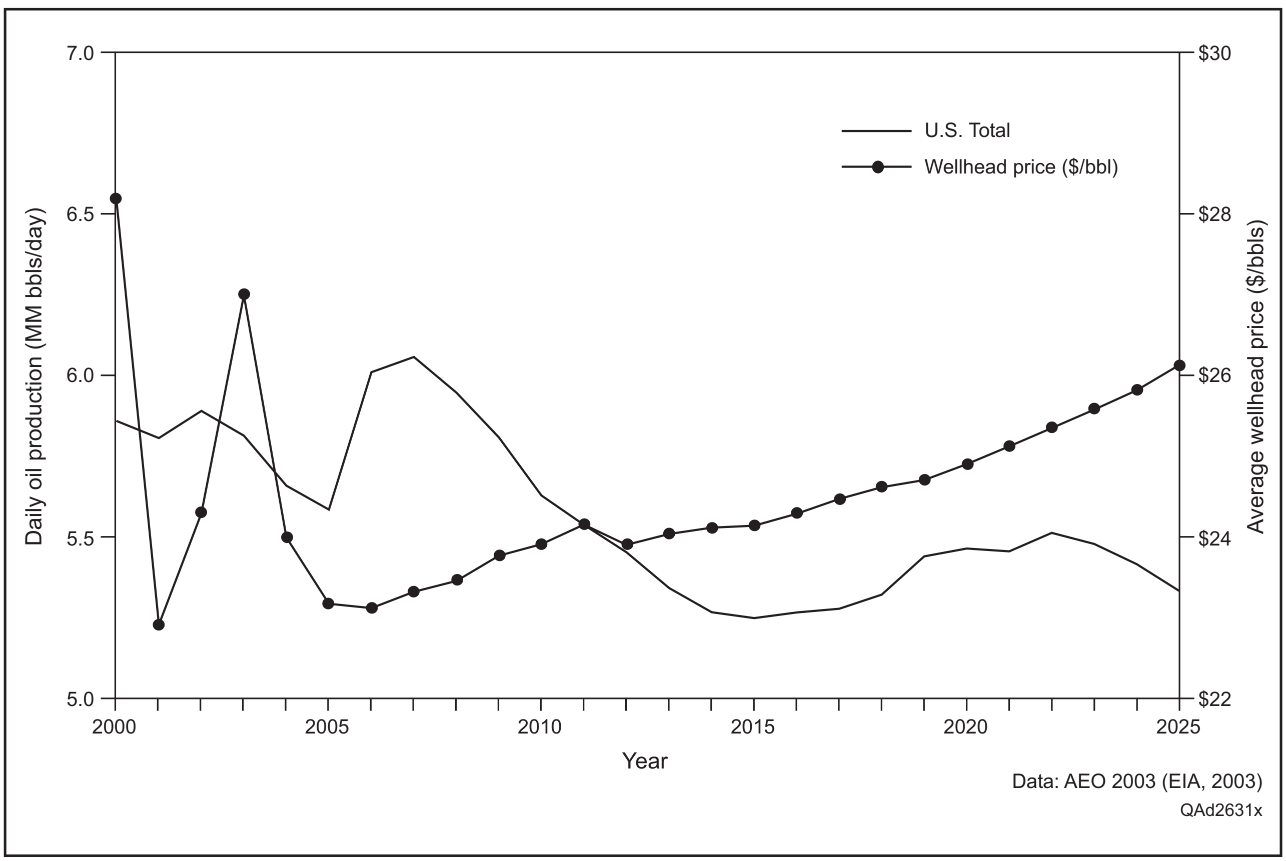

Figure 10. U.S. oil production vs. price forecast.

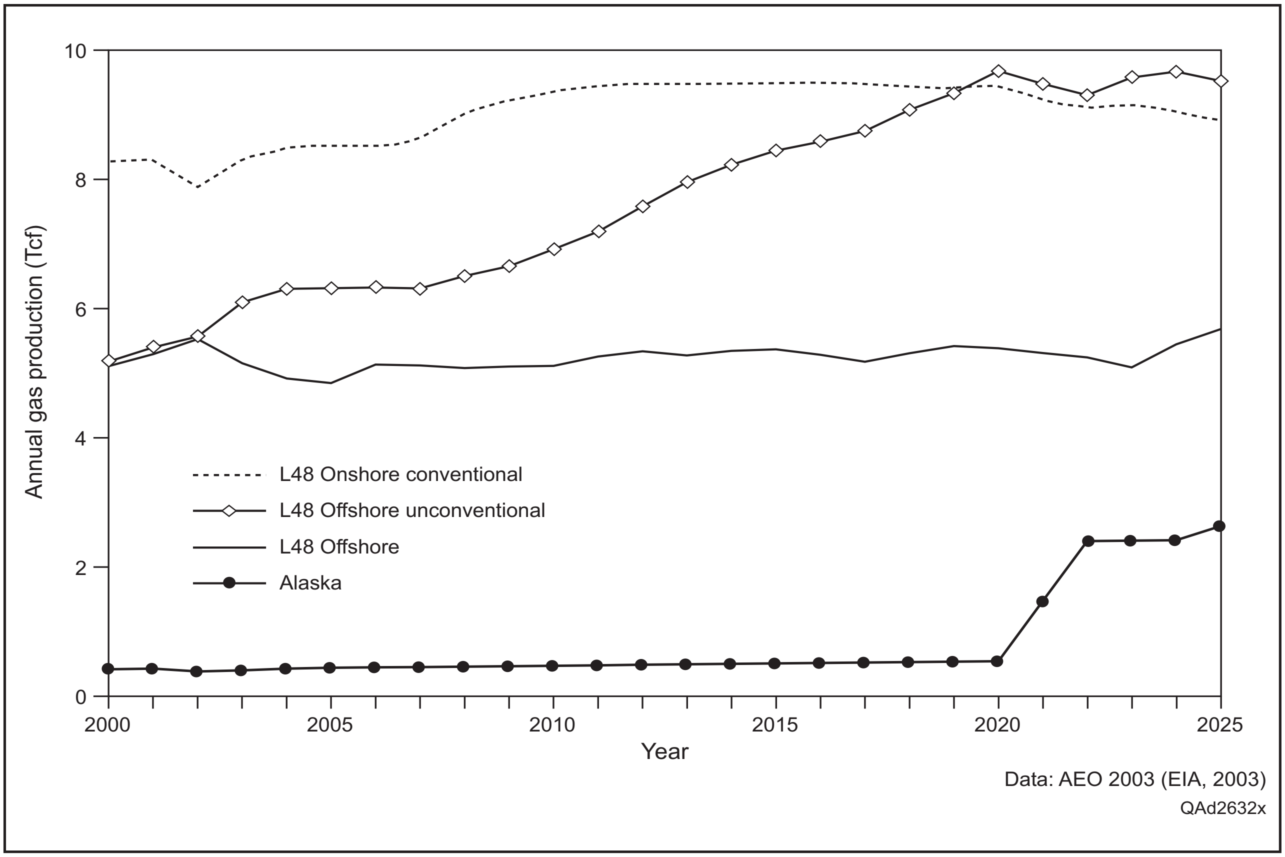

Figure 11. Components of U.S. gas production forecast.

average wellhead price forecasts assumed by AEO 2003 are given in figure 12. A steady increase in gas production and average wellhead prices are forecast.

For the Federal offshore, onshore, and American Indian lands, it is assumed that oil and gas production will mirror U.S. production trends forecast in AEO 2003. The annual percentage increases/decreases for U.S. oil and gas production onshore and offshore are assumed to hold true also for oil and gas production on Federal lands. This assumption was used by MMS to calculate future Federal lands oil and gas production and projections of Federal onshore revenues (MMS, 2000). The annual percentage increases/decreases forecast by AEO 2003 for the onshore

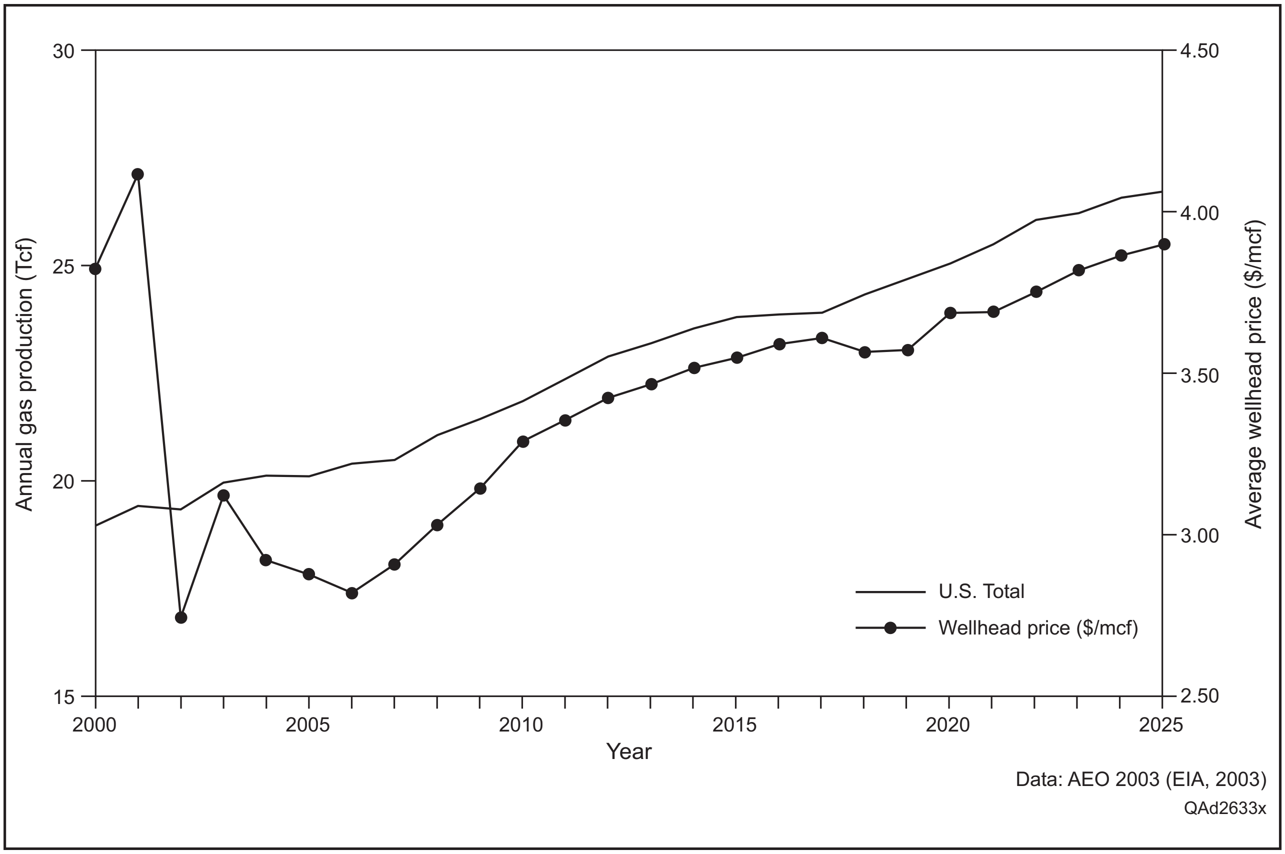

Figure 12. U.S. gas production vs. price forecast.

component of U.S. lower 48 oil and gas production can be applied to historical Federal onshore and American Indian lands oil and gas production to obtain a future production forecast. Likewise, the U.S. lower 48 oil and gas offshore component's percentage increase/decrease of future natural gas production can be applied to historical Federal offshore oil and gas production. For each year, the percentage increase/decrease is multiplied by the current year's production to forecast the following year's production. Combining these results, U.S. Federal lands future oil and gas production forecasts can be derived as in figures 13 and 14.

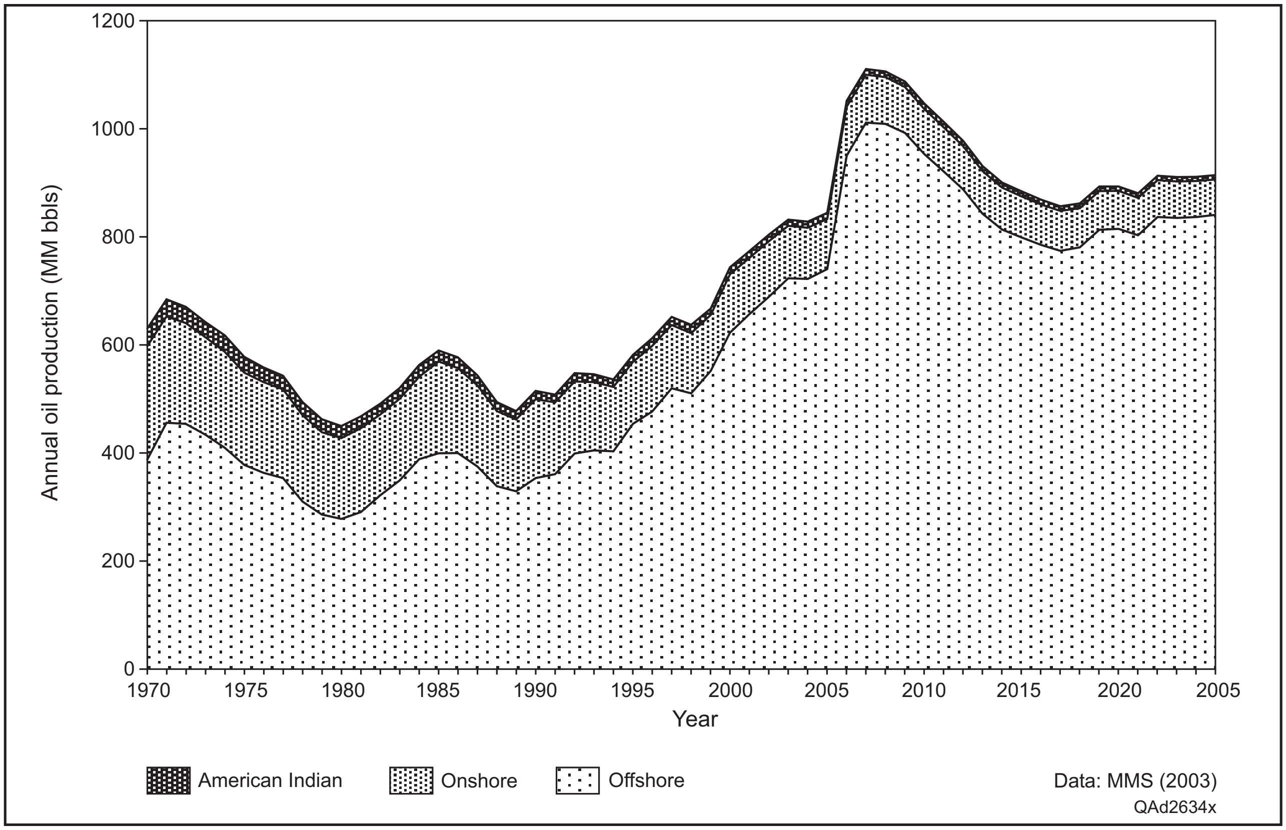

Figure 13. Federal Lands oil production forecast.

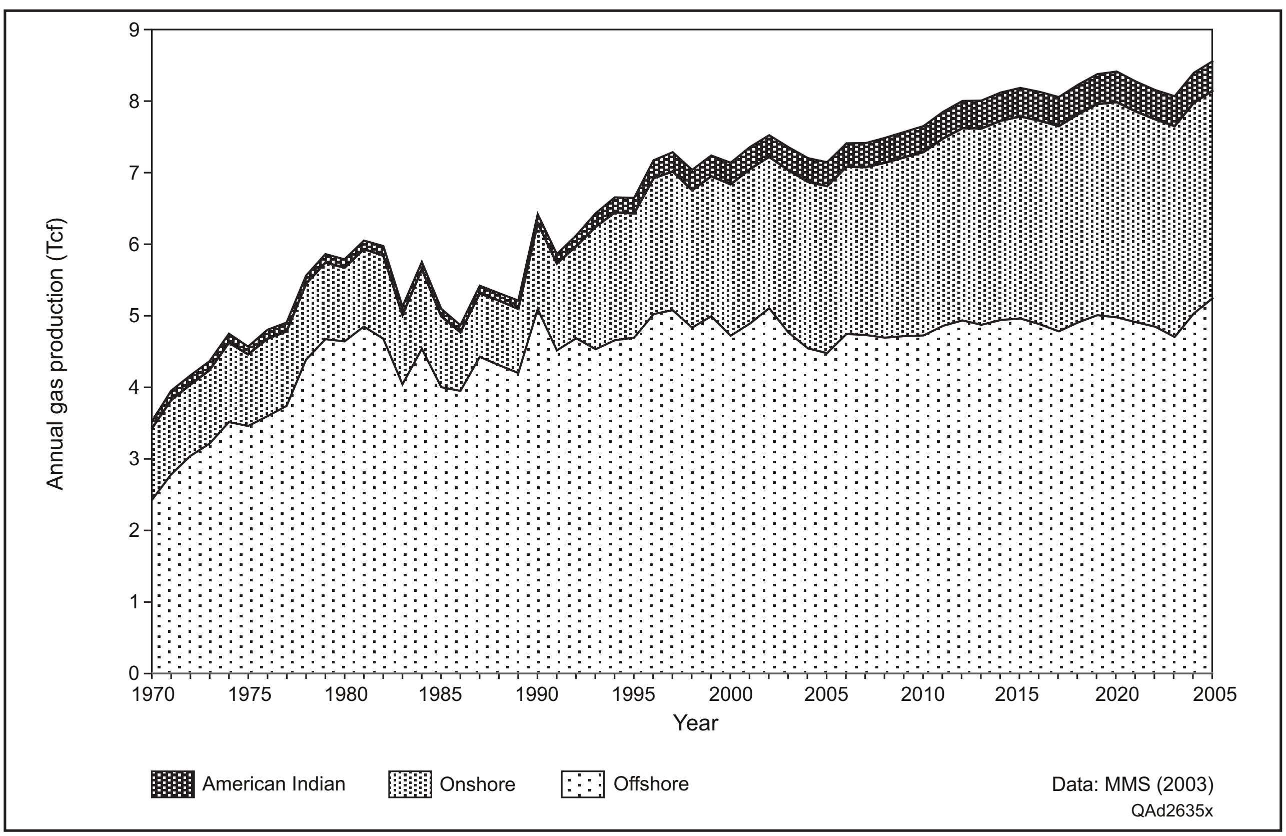

Figure 14. Federal Lands gas production forecast.

FORECAST OF ROYALTY REVENUE FROM OIL AND GAS PRODUCTION ON FEDERAL LANDS

Future royalty revenues from oil and gas production on Federal lands can be calculated by multiplying annual production, price, and royalty rates. Annual oil and gas production forecasts for the Federal offshore, onshore, and American Indian lands were discussed in the previous section. Royalty rates are estimated through data provided by MMS (table 4). Annual average oil and gas royalty rates for the Federal offshore, onshore, and American Indian lands were calculated by dividing the royalty revenue by the sales value. A 3-year average royalty rate from 1998, 1999, and 2000 was utilized as the royalty rate for the projection period because it was assumed to be the most recent level of royalty rates and no programs or actions that should materially change this figure could be foreseen. Oil and gas prices of the reference case in AEO 2003 were used, along with high- and low-price scenarios (tables 5 and 6). Oil and gas prices are extremely difficult to forecast, and the AEO reference prices are relatively conservative. However, it should be noted that the AEO 2003 reference price case for gas seems relatively lower than other forecasts, and even the high-price scenario would be lower than the current consensus views of gas prices especially for the near and short term.

On the basis of the above assumptions, a reference case Federal lands oil and gas royalty revenue forecast was made (figs. 15 and 16). It can be seen that most of the royalty revenues, especially for oil, are forecast from the Federal offshore. To more finely disaggregate the Federal offshore, historical Federal GOM OCS oil and gas production values (figs. 17 and 18) were utilized to extrapolate future production by water depths of less than 200 meters, 200 to 400 meters, 401 to 800 meters, and greater than 800 meters. Additionally, for the gas production and royalty revenue forecast, Federal onshore and American Indian onshore totals

Table 5. Oil-price scenarios.

Year	Reference Price ($/bbl)	Low Price (-25%) ($/bbl)	High Price (+25%) ($/bbl)
2001	$22.91	$17.18	$28.63
2002	$24.29	$18.21	$30.36
2003	$26.99	$20.24	$33.74
2004	$23.99	$17.99	$29.98
2005	$23.17	$17.37	$28.96
2006	$23.11	$17.33	$28.89
2007	$23.31	$17.48	$29.14
2008	$23.45	$17.59	$29.31
2009	$23.76	$17.82	$29.70
2010	$23.90	$17.93	$29.88
2011	$24.15	$18.11	$30.18
2012	$23.89	$17.92	$29.87
2013	$24.03	$18.02	$30.04
2014	$24.11	$18.08	$30.13
2015	$24.13	$18.10	$30.17
2016	$24.28	$18.21	$30.35
2017	$24.46	$18.35	$30.58
2018	$24.61	$18.46	$30.76
2019	$24.70	$18.52	$30.87
2020	$24.89	$18.67	$31.12
2025	$25.12	$18.84	$31.40
2022	$25.34	$19.01	$31.68
2023	$25.57	$19.18	$31.97
2024	$25.81	$19.36	$32.26
2025	$26.12	$19.59	$32.65
Average:	$24.40	$18.30	$30.50

Data: Reference price from AEO 2003 (EIA, 2003)
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in terms of conventional versus unconventional gas were disaggregated through the use of the U.S. production divisions made in AEO 2003.

Table 6. Gas-price scenarios.

Year	Reference price ($/Mcf)	Low Price (-25%) ($/Mcf)	High Price (+25%) ($/Mcf)
2001	$4.12	$3.09	$5.15
2002	$2.75	$2.06	$3.43
2003	$3.13	$2.34	$3.91
2004	$2.92	$2.19	$3.66
2005	$2.88	$2.16	$3.60
2006	$2.82	$2.12	$3.53
2007	$2.91	$2.18	$3.64
2008	$3.03	$2.28	$3.79
2009	$3.15	$2.36	$3.93
2010	$3.29	$2.47	$4.12
2011	$3.36	$2.52	$4.20
2012	$3.43	$2.57	$4.28
2013	$3.47	$2.60	$4.34
2014	$3.52	$2.64	$4.40
2015	$3.55	$2.66	$4.44
2016	$3.59	$2.70	$4.49
2017	$3.61	$2.71	$4.52
2018	$3.57	$2.68	$4.46
2019	$3.58	$2.68	$4.47
2020	$3.69	$2.77	$4.61
2025	$3.69	$2.77	$4.62
2022	$3.75	$2.82	$4.69
2023	$3.82	$2.87	$4.78
2024	$3.87	$2.90	$4.84
2025	$3.90	$2.93	$4.88
Average:	$3.42	$2.56	$4.27

Data: Reference price from AEO 2003 (EIA, 2003)
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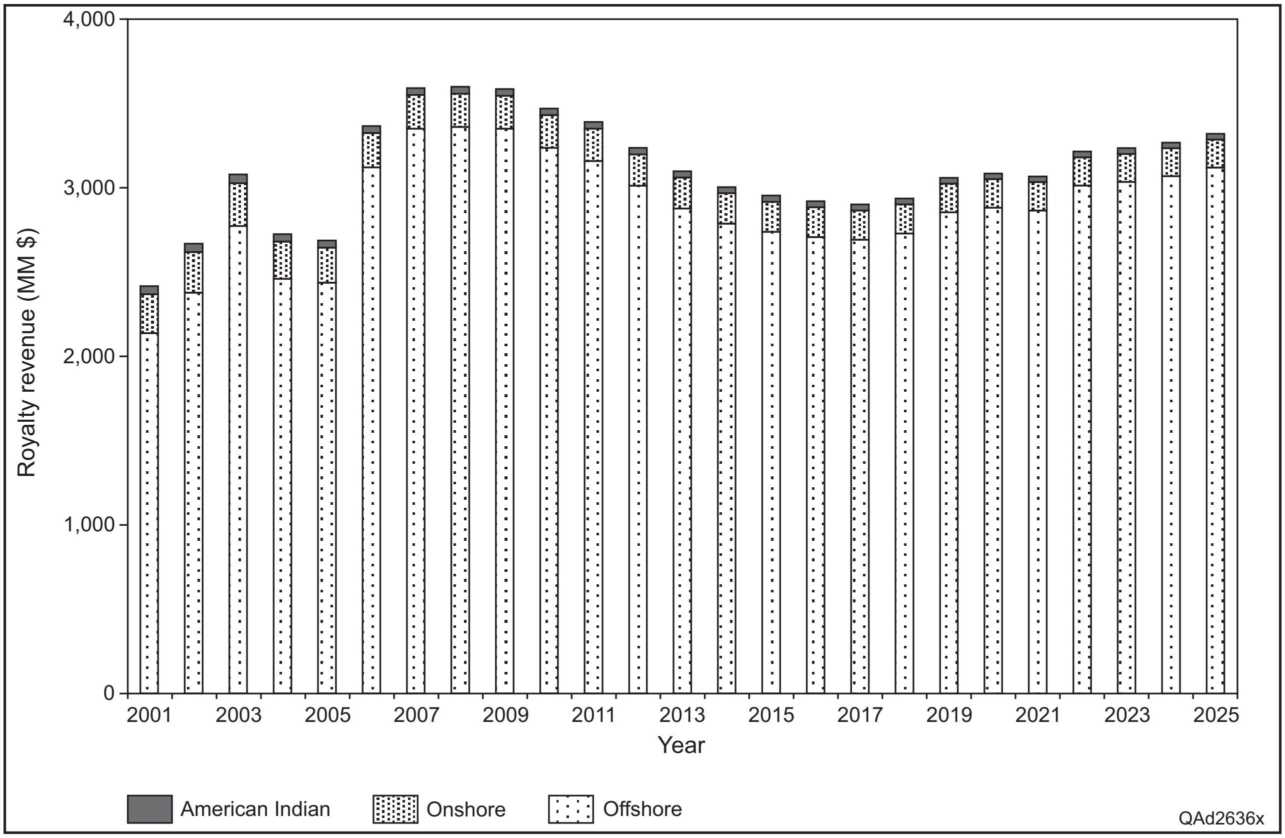

Figure 15. Reference Federal Lands oil royalty revenue forecast.

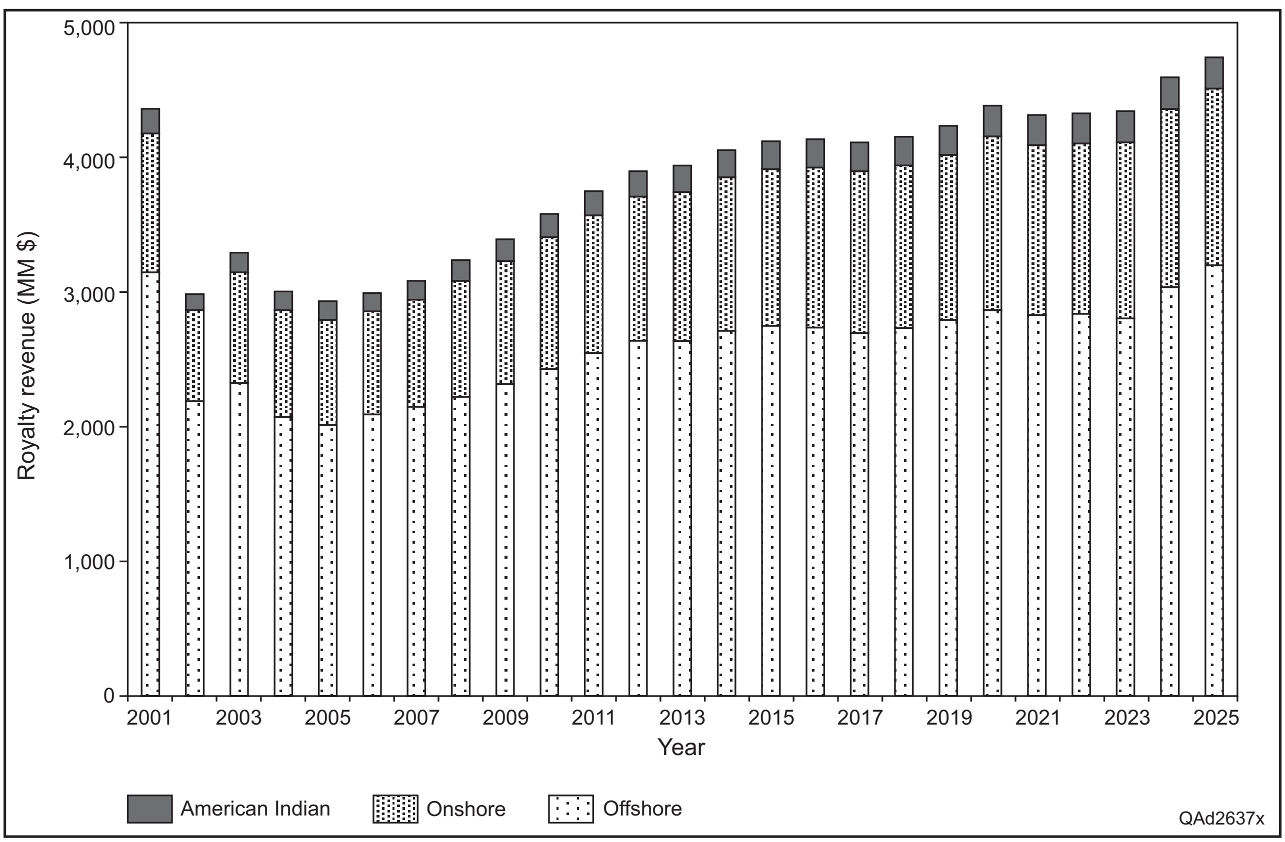

Figure 16. Reference Federal Lands gas royalty revenue forecast.

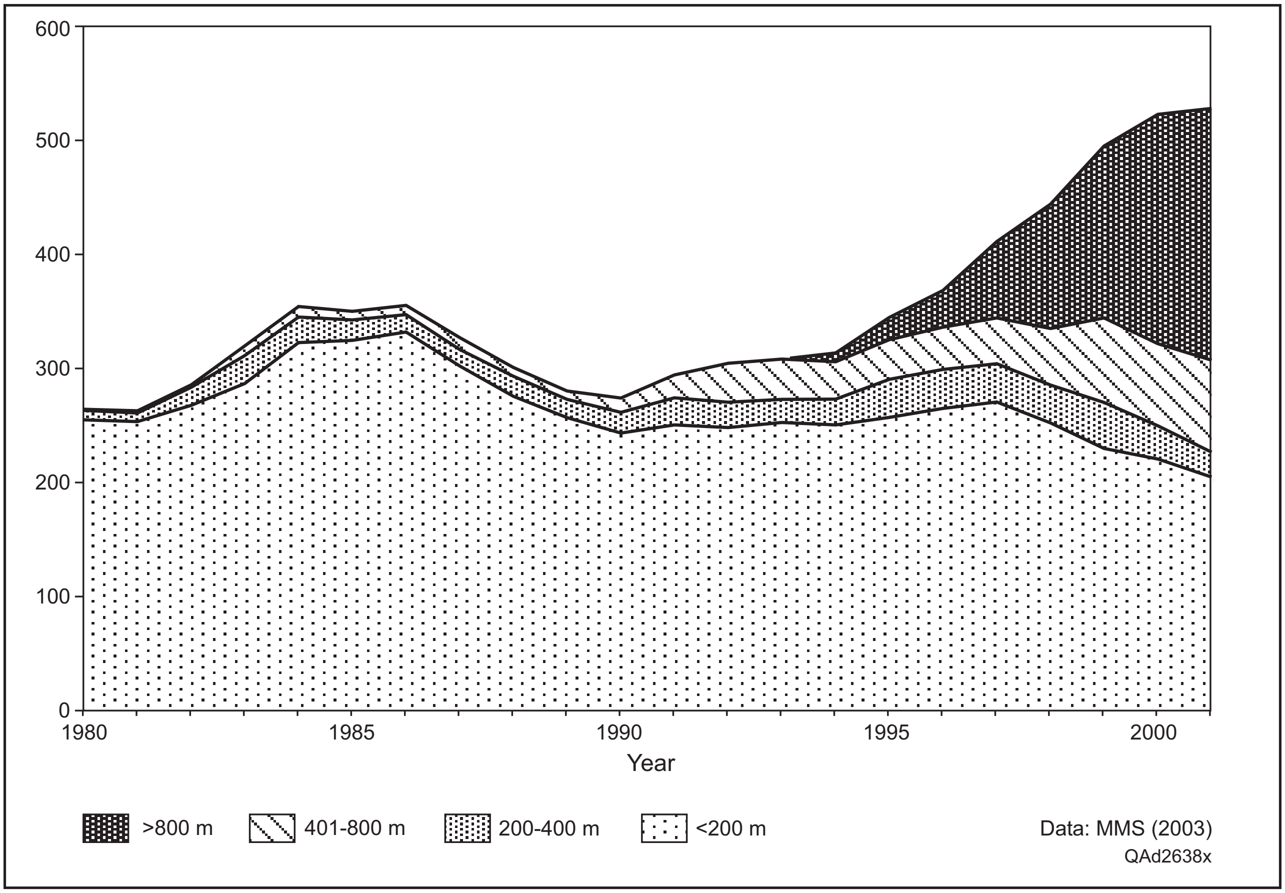

Figure 17. Historical Federal GOM OCS oil production by water depths.

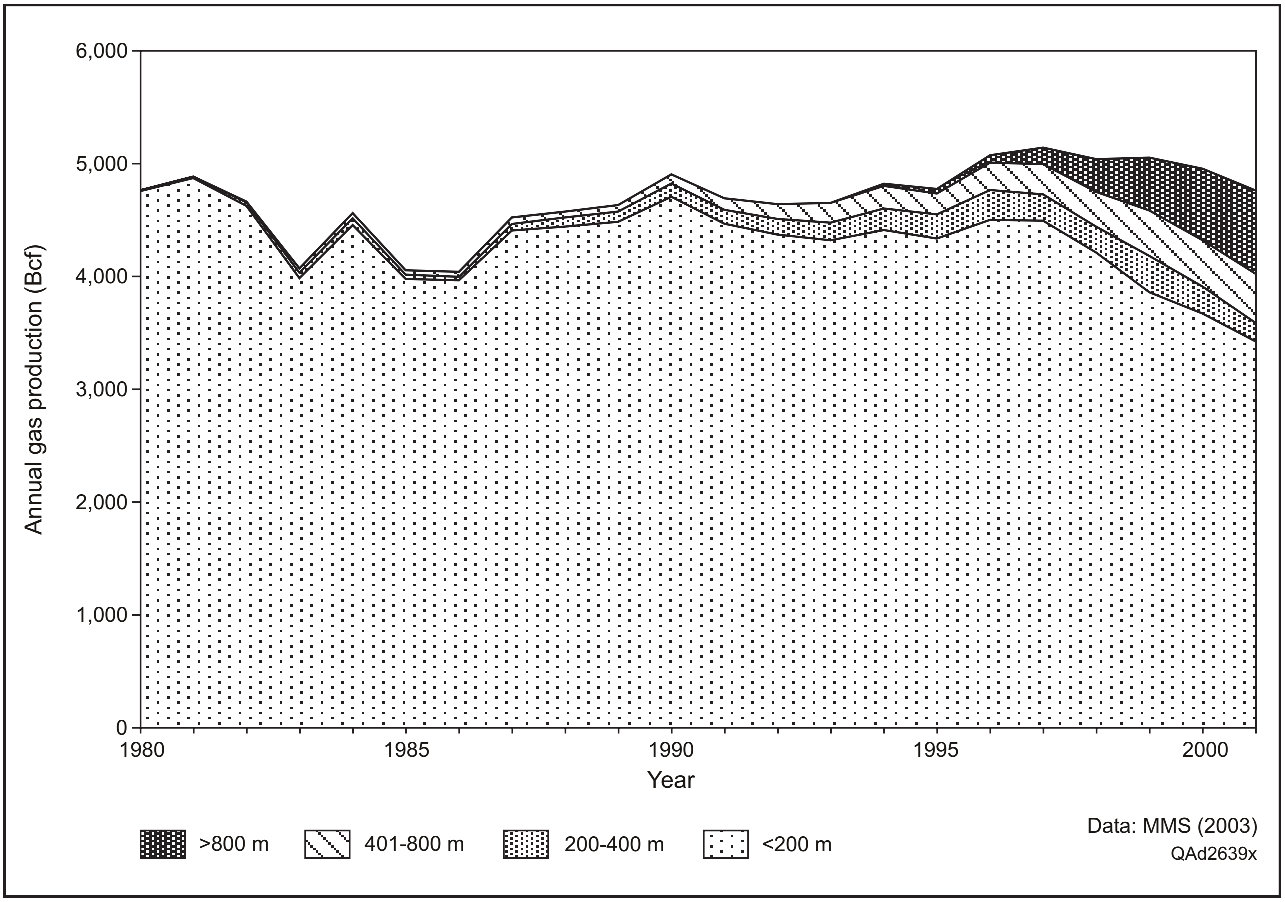

Figure 18. Historical Federal GOM OCS gas production by water depths.

ENHANCING THE VALUE OF FEDERAL OIL AND GAS RESOURCES: THE ROLE OF TECHNOLOGY IN INCREASING PRODUCTION AND SUPPLY

In a time of tightening supplies of oil and gas, it is critical that models for projecting future domestic oil and gas resources assess the supply impacts of technology advancements. Such modeling and analysis will both inform policymakers about the efficacy of public investment in supply technologies and inform the government about the value of technology for maximizing its resources on Federal lands.

The U.S. Government, through the EIA, produces annual projections of oil and gas resource supply growth, using rapid, slow, and reference case technology assumptions. Although the EIA projections provide valuable data for policymakers and the marketplace, more dynamic analysis is required to assess the impacts of specific supply research programs, such as the one found in H.R. 6. This supply research fund would establish a significant, multiyear R&D program to develop U.S. oil and gas resources that are currently uneconomic to produce but have the greatest potential for significant future growth, the offshore ultra-deepwater and unconventional onshore oil and gas resources.

This section begins with a brief overview of how models have accounted for and valued the impacts of new technology on the availability and production of oil and gas supplies. It then examines the data on how major investments in new oil and gas technology over the past two decades have led to significant growth in gas resources and production. The data show that new technologies are adopted and used at a rapid rate to develop previously inaccessible or uneconomic new oil and gas fields and extract additional oil and gas from fields that were previously thought to be exhausted.

The section concludes with a discussion of a dynamic model that the University of Texas' Bureau of Economic Geology (BEG) has developed and employed to more accurately forecast the incremental oil and gas production that will result over time from the supply research fund that would be established by H.R. 6. The model is focused on offshore ultra-deepwater and unconventional onshore resources, and it provides the basis for an analysis of the impacts of such a program on production on Federal lands and on royalties associated with that production.

Statistically Based Resource Assessments

Statistically based resource assessments, mainly through the highly publicized works of M. King Hubbert (1962, 1967, 1974), viewed U.S. oil and gas as a rapidly depleting resource and provided the basis for the warning call in the1980's that U.S. oil and gas supplies would be exhausted by the end of the century. Hubbert's analyses, in their failure to account for the impacts of technology advancements on increases in the resource base, actually underscore the substantial value of technology to oil and gas supply.

When based on extrapolation of historic data alone, as was done in Hubbert's analyses, U.S. oil and gas resources were considered to be rapidly depleting. Hubbert's analyses, however, were hindered by the critical and inaccurate assumption that the oil and gas resource base was limited by known technologies; they did not assume technology advances.

Indeed, Hubbert's analyses of resource depletion, depicted in a bell-shaped life cycle curve, would have been essentially correct if oil and gas production growth from offshore deepwater and unconventional resources (two provinces for which advanced technologies were critical to development) were omitted. The actual picture of oil and gas production looks quite different, however, because technological advancements have resulted in significant resource production in areas that were considered physically or economically unreachable at the time of Hubbert's analyses.

The National Petroleum Council on the Need for Technology Investment

Offshore deepwater and unconventional resources are forecast to provide the bulk of future production growth and are crucial to meeting the forecasted growth in gas demand of 54 percent by 2025. The National Petroleum Council's (NPC) gas supply study of 1999 concluded that "Technology improvements are particularly important given the difficult conditions accompanying new resources." The NPC study identified the following examples of technological advances that have enabled substantial additional oil and gas production:

- Three-dimensional (3-D) seismic imaging techniques now allow geologists to image underground rock formations in graphic detail and to reduce drilling risk by more accurately predicting locations for oil and gas accumulations.

- Improved drilling techniques enable producers to drill targets and reach otherwise difficult formations more accurately through the use of directional/horizontal drilling and offshore deepwater production systems.

- Advancements in stimulation, fracturing, and completion techniques have resulted in tremendous production increases in unconventional gas resources such as tight gas, coalbed methane, and gas shales. Deepwater production technologies now enable producers to access oil and gas in excess of 1,500 feet of water depth.

Looking forward, the NPC study also concluded that "deeper wells, deeper water and unconventional sources will be the key to future supply." According to the NPC, developing these two components of future U.S. oil and gas supply will be extremely dependent on technological advancements, which play a major role in the increase of oil and gas supply by

(1) improving efficiency of drilling, equipment, operating, and other costs;

(2) increasing recovery factors of discovered oil and gas in place;

(3) improving success rates by reducing the number of dry holes; and

(4) revealing new areas and types of resources for exploitation through innovative geologic and engineering concepts.

Further, the NPC concluded that the pace of technology development will be critical to the availability of gas supplies at affordable costs. The NPC study noted that "investment in research and development is needed to maintain the pace of advancements in technology." Also, the NPC study indicated that meeting gas demand by 2015 will require "driving research and technology at a rapid rate."

Advances in technology do not happen in a vacuum. The U.S. Department of Energy has produced the *Offshore Technology Roadmap for the Ultra-deepwater Gulf of Mexico* (DOE, 2000), which lays out a path for future technology development in the ultra-deepwater environment. During the producer workshops for this road-mapping effort, consensus views were that a $2 billion Government effort over 5 years would be necessary for a significant step change to be demonstrated. Moreover, the path for future technology research and development for unconventional onshore development was detailed in the *Unconventional Onshore Technology*

Roadmap (New Mexico Institute of Mining and Technology & GTI, 2002). If the investment is made to implement these roadmaps, new technologies that could have a significant impact on future U.S. oil and gas production include improved seismic techniques; deep wireline measurements; integrated well planning; improved drilling systems; improved stimulation techniques; advances in deepwater drilling technology; and formulation of new geologic frontiers.

The Impacts of Technology on Production: Historical Experience

Forecasts that demonstrate production increases in offshore deepwater and unconventional resources assume continued deployment and advances in technology. Conversely, forecasts that do not assume additional technology development and deployment demonstrate flat or declining production levels.

The EIA's AEO 2003 oil and gas supply projection provides forecasts assuming both a "rapid" and "slow" technology improvement. The rapid technology case assumes some technology improvement and shows modest production increases. The slow technology case, however, forecasts a decline in production over time. The delta between EIA's rapid and slow technology case forecasts for all gas production in the United States is 12 percent; for unconventional onshore gas production there is a supply delta of 21 percent between rapid and slow technology cases.

However, even the rapid technology case forecast assumes only modest technology improvements when compared with the programs of technology R&D laid out in the ultra-deepwater and unconventional onshore roadmaps. The EIA's AEO 2003 forecast is not predicated on the institutionalization of a focused, well-funded R&D program. As we will discuss, the

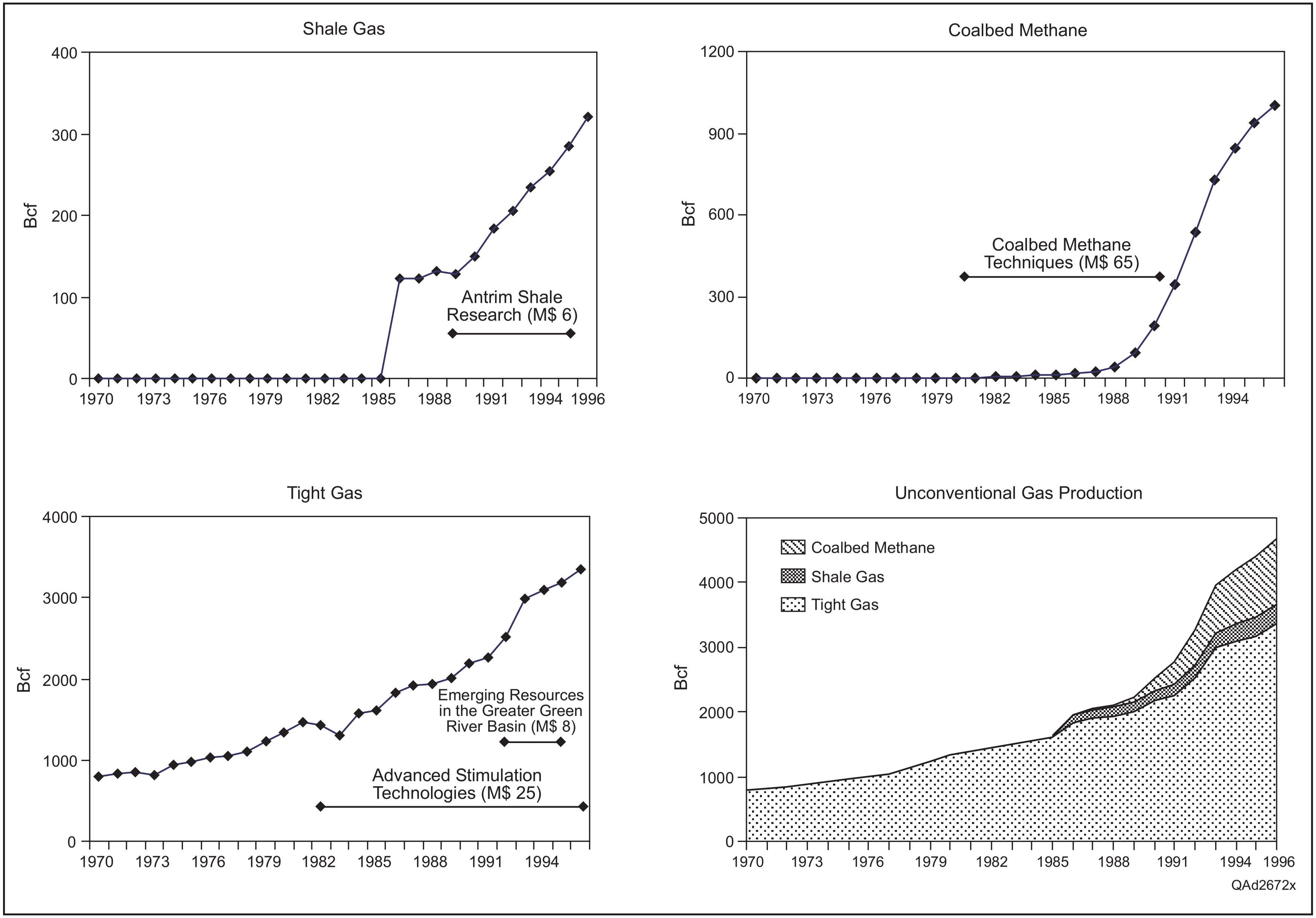

Figure 19. GRI/GTI's major historical programs and unconventional gas production.

BEG's analysis of the GRI/GTI technology program for the development of unconventional gas resources, a set of sustained and focused collaborative R&D efforts, yielded dramatically greater gas production than the EIA rapid technology case (fig.19). GTI is a natural gas research organization formed by the merger of two corporations: the Gas Research Institute (GRI) and the Institute for Gas Technology. The development of unconventional gas supplies represents a major GRI (and now GTI) research thrust.

Many unconventional gas resources were uneconomic prior to GRI/GTI's technology research, development, and deployment programs. GRI/GTI's coalbed methane program is especially noteworthy for transforming coalbed methane from a nuisance or hazard of coal production into a natural gas resource that now constitutes more than 1.5 Tcf of annual U.S. gas production. More than 11 Tcf of coalbed methane had been produced in the United States through 1999.

A more detailed profile of the GRI/GTI coalbed methane R&D program reveals the following: the program cost about $140 million over 10 years; production began to increase shortly after the start of the program; and annual production of coalbed methane continues to increase and currently supplies around 7 percent of U.S. domestic annual gas production. Coalbed methane research programs now exist in at least 13 countries worldwide.

The measurable impacts of technology on gas supply are also demonstrated in GRI/GTI's research on gas shales. Modern gas shale production was initially spurred by the Section 29 nonconventional fuels production tax credit, but that tax credit expired in 1992, and operators have continued to expand gas shale programs. Today, more than 28,000 gas shale wells produce nearly 380 Bcf of gas annually from 5 basins: Appalachian, Michigan, Illinois, Ft. Worth, and

San Juan. In 1998, fractured shale gas reservoirs supplied 1.6 percent, or 0.3 Tcf, of total U.S. gas production and contained 2.3 percent, or 3.9 Tcf, of total U.S. gas reserves.

Antrim shale in the Michigan Basin was the first to maximize the use of technology. In 1989, the year GRI/GTI's antrim shale research program was launched, production was around 130 Bcf per year. Steady incremental production growth occurred each subsequent year, and antrim shale production levels represented a 150-percent incremental production growth, or 321 Bcf, in 1996. GRI/GTI's advanced stimulation techniques catalyzed this production. GRI/GTI's supply programs in advanced stimulation techniques and emerging resources in the Greater Green River Basin have also contributed to the substantial growth in tight gas production.

The utilization of GRI/GTI's technology on gas supply is specifically demonstrated in its research on Barnett shales. The Barnett was first drilled in 1981. Gas was found, but it was not economic to produce. In 1985, gas production from Barnett shales was less than 1 Bcf of gas annually from 25 wells. By 1995, 19.2 Bcf of gas was being produced annually from 306 wells. During the past 5 years alone, production has more than doubled to 40.6 Bcf from more than 500 wells (Shirley, 2001, 2002).

The value of technology advances on gas supply can be measured in terms of incremental production—the difference between current forecasts and forecasts that estimate the impact of new technology on production levels. Incremental production increases are frequently the result of the deployment and advancement of new technologies. Incremental production is expected to be greatest in complex and new resource areas such as the deepwater offshore and unconventionals. Incremental production can be calculated for each component of unconventional natural gas resources for which there was a GRI/GTI R&D program by measuring the growth from the production levels prior to program implementation.

Development and deployment of advanced technologies will provide access to new resources, as well as enhance production in more mature regions. Although technology is important in the production of conventional and shallow offshore resources, its role in these regions is relatively small compared with its tremendous impact on increasing production from offshore deepwater and unconventional resources. Nevertheless, technologies developed for the offshore deepwater and unconventional resources will trickle down to assist in the more efficient development and production of conventional and shallow offshore oil and gas resources as well.

Production responses due to technology generally occur very quickly, especially in more geologically and technically complex resource areas. For example, production responses occur almost immediately after a new hydraulic fracturing technology is applied to tight gas reservoirs or expandable tubing technology is used to drill in the ultra-deepwater. Today's new oil and gas production technologies will not necessarily have long lead times to develop. New technologies will mainly arise from advancements in different industries applied with new ideas—for example, high-intensity design; cycle-time reduction; and nanotechnology. However, the new technologies and processes are typically expensive to develop, and initial deployment and/or implementation can involve economic risk that producers deem too great to undertake on their own.

Moreover, the positive impacts of new R&D or incentive programs can be demonstrated relatively quickly even prior to deployment. Typically, when a new research or incentive program is announced, industry will book reserves that were previously deemed uneconomic; the simple announcement of a program focused on changing the economics of production of a certain type or in specific regions is often sufficient for the industry to book reserves.

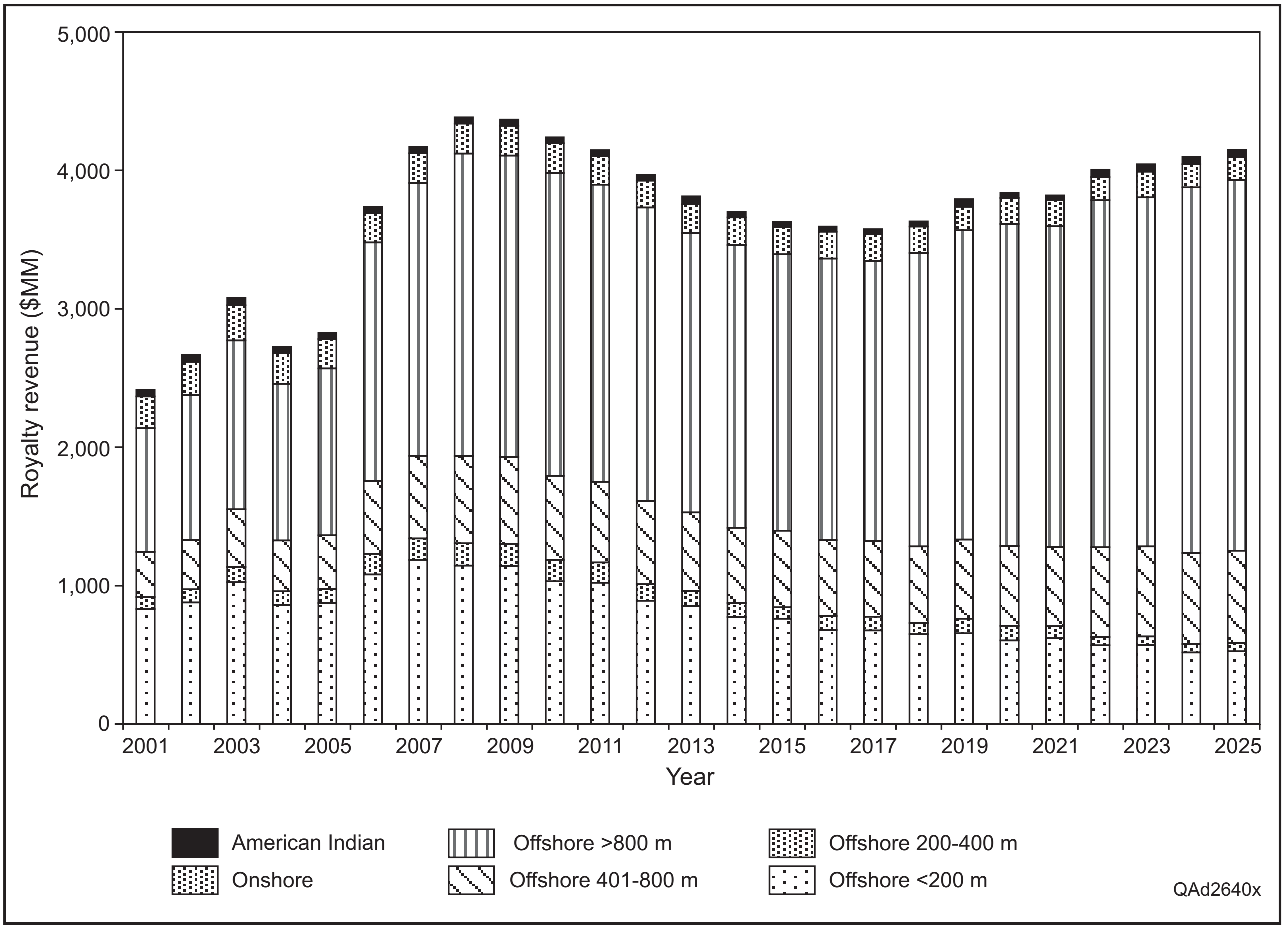

Figure 20. Royalty revenue from technology advancement oil production on Federal Lands.

Modeling the Value of Technology for the Supply Research Fund

The BEG has developed a model for the dynamic analysis of the value of technology to incremental oil and gas production over time. The BEG has employed this model to assess the economics of a supply research fund based on the supply R&D program included in H.R. 6, Subtitle E—Fossil Energy, Part 1, Sec. 21501(b) and Part 3—*The Ultra-deepwater and Unconventional Natural Gas and Other Petroleum Resources Supply Research and Development Program*.

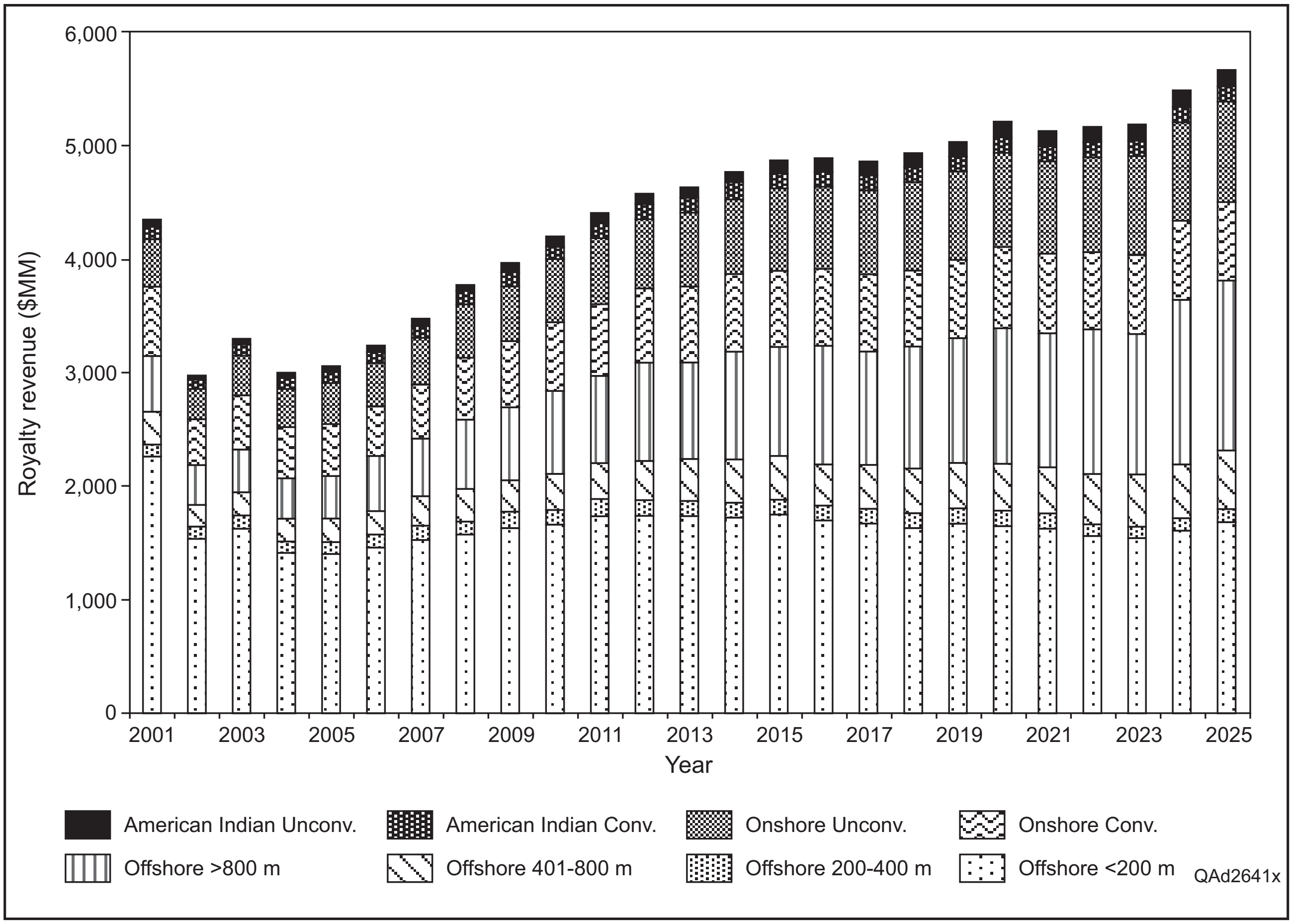

Figure 21. Royalty revenue from technology advancement gas production on Federal Lands.

Specific features of the legislation relevant to the BEG analysis are

- o A focused, large-scale R&D program, funded from a percentage of Federal offshore and onshore oil and gas royalties;
- o An R&D program focused on two specific regions or types of resource: ultra-deepwater offshore and unconventional onshore for both oil and gas;
- o A program sunset 9 years after the enactment date of the legislation.

Two key data sets were also employed in the BEG model: (1) the most current national production and price forecast used in EIA's AEO 2003 and (2) annual Federal lands oil and gas

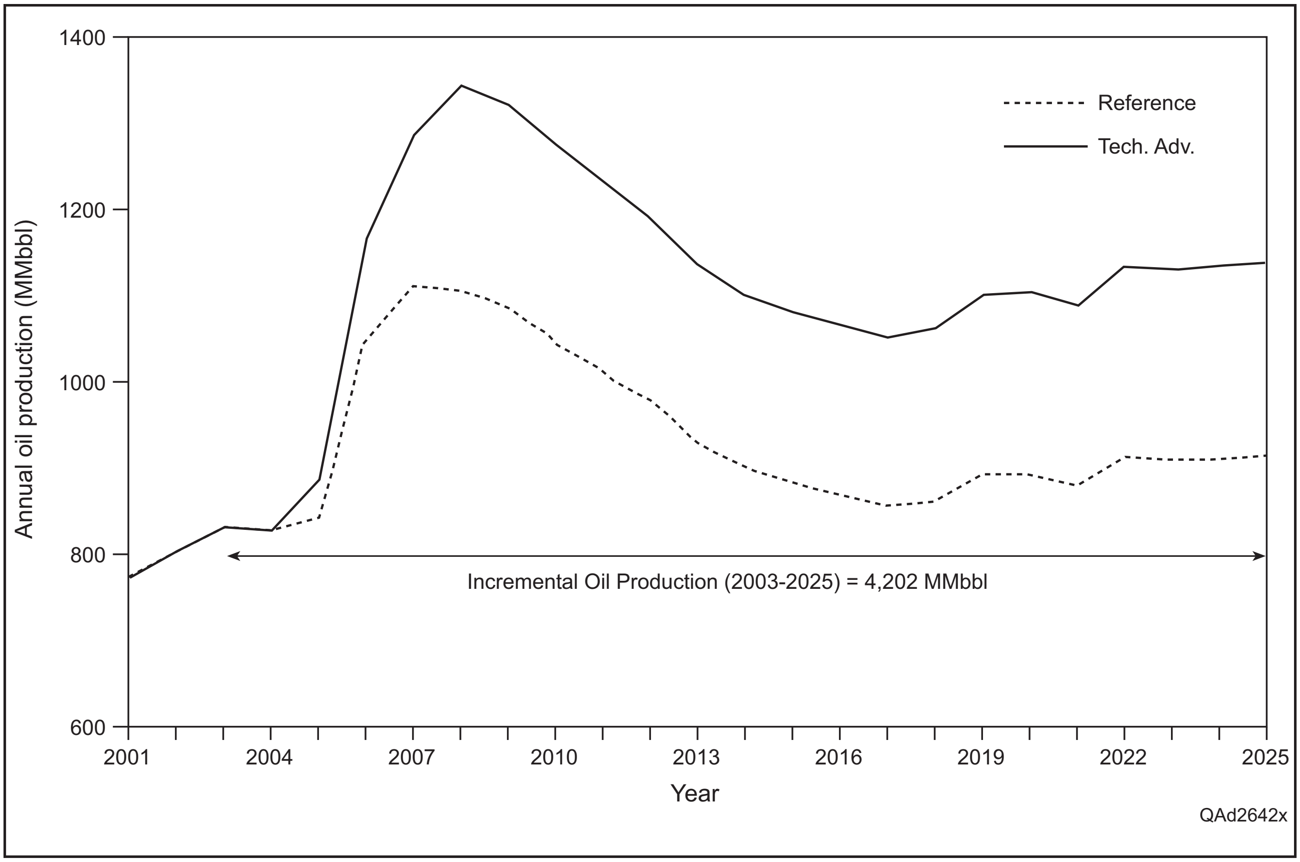

Figure 22. Federal Lands oil production forecast by technology advancements.

production data from the MMS. The MMS data are further broken down into production from Federal Offshore, Onshore, and American Indian lands.

The BEG analysis

- Divides the Federal Offshore into water depth intervals of <200 m, 200–400 m, 401–800 m, and >800 m as maintained by MMS;
- Divides the Federal Onshore and American Indian into conventional and unconventional production utilizing the national production divisions as specified in EIA's AEO 2003;
- Expresses the effect of technology as a percentage incremental increase over the production forecast;

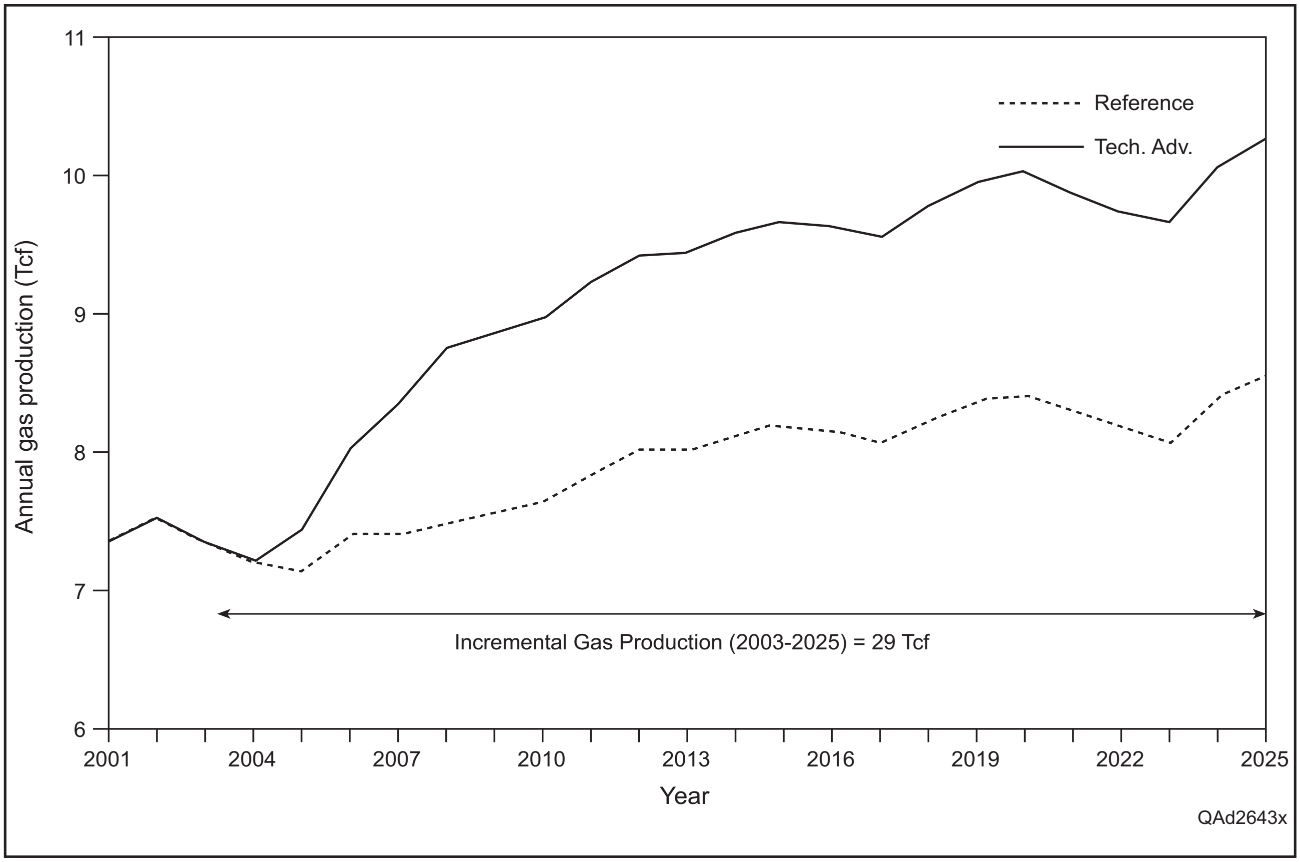

Figure 23. Federal Lands gas production forecast by technology advancements.

- o Calculates Federal royalties by multiplying the current 3-year average royalty rate specific to the Federal Offshore, Onshore, and American Indian lands by the production forecast. This calculation was performed in two ways: (1) as a reference case where the supply research fund was absent (fig. 20) and (2) as a technological advancement case where the supply research fund was present (fig. 21). The difference between the two cases was viewed as the benefits of the supply research fund (figs. 22 through 25).

The BEG model assumes the following:

- o Oil and gas production on Federal lands will grow at the same rate as production nationwide;

Table 7. Federal Lands economic analysis of the supply research fund.

Year	Federal Lands incremental production (MMbbl, Tcf)		Federal Lands incremental production revenue ($MM)			Federal Lands incremental royalty revenue ($MM)		
	Oil	Gas	Oil	Gas	Total	Oil	Gas	Total
2001	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-
2003	0	0.00	$0	$0	$0	$0	$0	$0
2004	0	0.00	$0	$0	$0	$0	$0	$0
2005	43	0.30	$997	$854	$1,851	$139	$120	$260
2006	115	0.62	$2,649	$1,760	$4,408	$372	$249	$621
2007	176	0.93	$4,108	$2,714	$6,822	$577	$384	$961
2008	238	1.27	$5,585	$3,865	$9,450	$785	$546	$1,332
2009	234	1.29	$5,566	$4,057	$9,623	$783	$573	$1,356
2010	229	1.33	$5,474	$4,367	$9,841	$770	$616	$1,386
2011	221	1.36	$5,346	$4,584	$9,930	$752	$647	$1,399
2012	217	1.42	$5,196	$4,870	$10,067	$731	$687	$1,418
2013	207	1.43	$4,970	$4,963	$9,933	$699	$699	$1,397
2014	203	1.48	$4,895	$5,196	$10,091	$688	$732	$1,420
2015	199	1.49	$4,812	$5,298	$10,111	$676	$746	$1,422
2016	199	1.50	$4,834	$5,408	$10,242	$680	$761	$1,440
2017	196	1.49	$4,803	$5,395	$10,198	$675	$757	$1,432
2018	201	1.55	$4,943	$5,540	$10,483	$695	$779	$1,474
2019	209	1.58	$5,158	$5,663	$10,821	$726	$796	$1,522
2020	212	1.62	$5,285	$5,969	$11,254	$744	$838	$1,582
2021	209	1.59	$5,254	$5,873	$11,128	$740	$825	$1,565
2022	221	1.59	$5,611	$5,965	$11,576	$790	$840	$1,630
2023	221	1.58	$5,648	$6,026	$11,675	$796	$845	$1,641
2024	225	1.66	$5,795	$6,432	$12,227	$817	$907	$1,724
2025	225	1.69	$5,890	$6,614	$12,504	$830	$936	$1,766
Total (2003-2025)	4,202	28.79	$102,819	$101,414	$204,233	$14,465	$14,284	$28,749

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Table 8. U.S. economic analysis of the supply research fund.

Year	U.S. incremental production (MMbbl, Tcf)		U.S. incremental production revenue ($MM)		
	Oil	Gas	Oil	Gas	Total
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	0	0.00	$0	$0	$0
2004	0	0.00	$0	$0	$0
2005	72	0.89	$1,662	$2,551	$4,213
2006	165	1.80	$3,809	$5,097	$8,906
2007	254	2.71	$5,917	$7,889	$13,806
2008	338	3.73	$7,924	$11,307	$19,231
2009	331	3.80	$7,862	$11,946	$19,808
2010	323	3.91	$7,726	$12,879	$20,605
2011	316	4.03	$7,628	$13,526	$21,153
2012	312	4.19	$7,466	$14,346	$21,812
2013	303	4.29	$7,274	$14,872	$22,146
2014	299	4.40	$7,215	$15,493	$22,708
2015	297	4.47	$7,160	$15,887	$23,047
2016	298	4.52	$7,247	$16,248	$23,496
2017	297	4.55	$7,277	$16,427	$23,704
2018	303	4.69	$7,453	$16,733	$24,186
2019	312	4.78	$7,700	$17,104	$24,804
2020	316	4.91	$7,864	$18,109	$25,973
2021	314	4.91	$7,884	$18,116	$26,000
2022	324	4.95	$8,222	$18,569	$26,790
2023	323	5.00	$8,258	$19,113	$27,370
2024	324	5.11	$8,363	$19,762	$28,126
2025	322	5.12	$8,401	$19,975	$28,376
Total (2003-2025)	6,143	86.73	$150,310	$305,949	$456,259

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Table 9. Federal Lands economic analysis of the supply research fund (high-price scenario).

Year	Federal Lands incremental production (MMbbl, Tcf)		Federal Lands incremental production revenue ($MM)			Federal Lands incremental royalty revenue ($MM)		
	Oil	Gas	Oil	Gas	Total	Oil	Gas	Total
2001	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-
2003	0	0.00	$0	$0	$0	$0	$0	$0
2004	0	0.00	$0	$0	$0	$0	$0	$0
2005	43	0.30	$1,246	$1,067	$2,314	$174	$150	$325
2006	115	0.62	$3,311	$2,200	$5,511	$465	$311	$777
2007	176	0.93	$5,134	$3,393	$8,527	$722	$480	$1,202
2008	238	1.27	$6,981	$4,831	$11,813	$982	$683	$1,665
2009	234	1.29	$6,957	$5,071	$12,028	$978	$716	$1,694
2010	229	1.33	$6,843	$5,459	$12,301	$962	$770	$1,733
2011	221	1.36	$6,682	$5,730	$12,412	$940	$809	$1,748
2012	217	1.42	$6,495	$6,088	$12,583	$913	$859	$1,773
2013	207	1.43	$6,213	$6,203	$12,417	$873	$873	$1,746
2014	203	1.48	$6,119	$6,494	$12,614	$860	$915	$1,775
2015	199	1.49	$6,016	$6,623	$12,639	$846	$932	$1,778
2016	199	1.50	$6,043	$6,760	$12,803	$849	$951	$1,801
2017	196	1.49	$6,004	$6,743	$12,747	$844	$947	$1,791
2018	201	1.55	$6,179	$6,925	$13,104	$869	$973	$1,842
2019	209	1.58	$6,447	$7,079	$13,526	$907	$995	$1,902
2020	212	1.62	$6,606	$7,461	$14,067	$930	$1,048	$1,978
2021	209	1.59	$6,568	$7,341	$13,909	$925	$1,032	$1,956
2022	221	1.59	$7,013	$7,457	$14,470	$988	$1,050	$2,038
2023	221	1.58	$7,061	$7,533	$14,593	$995	$1,057	$2,052
2024	225	1.66	$7,244	$8,040	$15,283	$1,021	$1,134	$2,155
2025	225	1.69	$7,362	$8,268	$15,630	$1,038	$1,170	$2,208
Total (2003-2025)	4,202	28.79	$128,524	$126,768	$255,292	$18,081	$17,855	$35,936

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Table 10. U.S. economic analysis of the supply research fund (high-price scenario).

Year	U.S. incremental production (MMbbl, Tcf)		U.S. incremental production revenue ($MM)		
	Oil	Gas	Oil	Gas	Total
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	0	0.00	$0	$0	$0
2004	0	0.00	$0	$0	$0
2005	72	0.89	$2,077	$3,189	$5,266
2006	165	1.80	$4,761	$6,371	$11,133
2007	254	2.71	$7,396	$9,862	$17,258
2008	338	3.73	$9,905	$14,134	$24,039
2009	331	3.80	$9,827	$14,933	$24,760
2010	323	3.91	$9,657	$16,099	$25,756
2011	316	4.03	$9,535	$16,907	$26,441
2012	312	4.19	$9,332	$17,933	$27,265
2013	303	4.29	$9,092	$18,590	$27,682
2014	299	4.40	$9,019	$19,366	$28,385
2015	297	4.47	$8,950	$19,858	$28,809
2016	298	4.52	$9,059	$20,310	$29,370
2017	297	4.55	$9,096	$20,534	$29,630
2018	303	4.69	$9,316	$20,917	$30,232
2019	312	4.78	$9,624	$21,380	$31,005
2020	316	4.91	$9,830	$22,636	$32,466
2021	314	4.91	$9,855	$22,645	$32,500
2022	324	4.95	$10,277	$23,211	$33,488
2023	323	5.00	$10,322	$23,891	$34,213
2024	324	5.11	$10,454	$24,703	$35,157
2025	322	5.12	$10,501	$24,968	$35,470
Total (2003-2025)	6,143	86.73	$187,887	$382,437	$570,324

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Table 11. Federal Lands economic analysis of the supply research fund (low-price scenario).

Year	Federal Lands incremental production (MMbbl, Tcf)		Federal Lands incremental production revenue ($MM)			Federal Lands incremental royalty revenue ($MM)		
	Oil	Gas	Oil	Gas	Total	Oil	Gas	Total
2001	-	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-	-
2003	0	0.00	$0	$0	$0	$0	$0	$0
2004	0	0.00	$0	$0	$0	$0	$0	$0
2005	43	0.30	$748	$640	$1,388	$105	$90	$195
2006	115	0.62	$1,987	$1,320	$3,306	$279	$187	$466
2007	176	0.93	$3,081	$2,036	$5,116	$433	$288	$721
2008	238	1.27	$4,189	$2,899	$7,088	$589	$410	$999
2009	234	1.29	$4,174	$3,043	$7,217	$587	$430	$1,017
2010	229	1.33	$4,106	$3,275	$7,381	$577	$462	$1,040
2011	221	1.36	$4,009	$3,438	$7,447	$564	$485	$1,049
2012	217	1.42	$3,897	$3,653	$7,550	$548	$516	$1,064
2013	207	1.43	$3,728	$3,722	$7,450	$524	$524	$1,048
2014	203	1.48	$3,672	$3,897	$7,568	$516	$549	$1,065
2015	199	1.49	$3,609	$3,974	$7,583	$507	$559	$1,067
2016	199	1.50	$3,626	$4,056	$7,682	$510	$571	$1,080
2017	196	1.49	$3,602	$4,046	$7,648	$506	$568	$1,074
2018	201	1.55	$3,707	$4,155	$7,862	$521	$584	$1,105
2019	209	1.58	$3,868	$4,248	$8,116	$544	$597	$1,141
2020	212	1.62	$3,964	$4,477	$8,440	$558	$629	$1,187
2021	209	1.59	$3,941	$4,405	$8,346	$555	$619	$1,174
2022	221	1.59	$4,208	$4,474	$8,682	$593	$630	$1,223
2023	221	1.58	$4,236	$4,520	$8,756	$597	$634	$1,231
2024	225	1.66	$4,346	$4,824	$9,170	$612	$680	$1,293
2025	225	1.69	$4,417	$4,961	$9,378	$623	$702	$1,325
Total (2003-2025)	4,202	28.79	$77,114	$76,061	$153,175	$10,849	$10,713	$21,562

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Table 12. U.S. economic analysis of the supply research fund (low-price scenario).

Year	U.S. incremental production (MMbbl, Tcf)		U.S. incremental production revenue ($MM)		
	Oil	Gas	Oil	Gas	Total
2001	-	-	-	-	-
2002	-	-	-	-	-
2003	0	0.00	$0	$0	$0
2004	0	0.00	$0	$0	$0
2005	72	0.89	$1,246	$1,913	$3,160
2006	165	1.80	$2,857	$3,823	$6,680
2007	254	2.71	$4,438	$5,917	$10,355
2008	338	3.73	$5,943	$8,480	$14,423
2009	331	3.80	$5,896	$8,960	$14,856
2010	323	3.91	$5,794	$9,659	$15,454
2011	316	4.03	$5,721	$10,144	$15,865
2012	312	4.19	$5,599	$10,760	$16,359
2013	303	4.29	$5,455	$11,154	$16,609
2014	299	4.40	$5,411	$11,620	$17,031
2015	297	4.47	$5,370	$11,915	$17,285
2016	298	4.52	$5,436	$12,186	$17,622
2017	297	4.55	$5,458	$12,320	$17,778
2018	303	4.69	$5,589	$12,550	$18,139
2019	312	4.78	$5,775	$12,828	$18,603
2020	316	4.91	$5,898	$13,582	$19,480
2021	314	4.91	$5,913	$13,587	$19,500
2022	324	4.95	$6,166	$13,926	$20,093
2023	323	5.00	$6,193	$14,334	$20,528
2024	324	5.11	$6,272	$14,822	$21,094
2025	322	5.12	$6,301	$14,981	$21,282
Total (2003-2025)	6,143	86.73	$112,732	$229,462	$342,195

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Table 13. Additional economic impact of the supply research fund from Federal Lands incremental production.

	Oil	Gas	Total
Incremental production, Tcf and MMbbl	4,202	29	
Incremental production revenue ($MM)	**$102,819**	**$101,414**	**$204,233**
Incremental royalty revenue ($MM)	**$14,465**	**$14,284**	**$28,749**
Severance tax rate from wellhead value	0.075	0.046	
Severance taxes ($MM)	**$7,711**	**$4,665**	**$12,376**
Ad valorem tax rate from wellhead value	0.0395	0.0395	
Ad valorem taxes ($MM)	**$4,061**	**$4,006**	**$8,067**
Franchise tax rate from economic value	0.0018	0.0018	
Franchise taxes ($MM)	**$539**	**$531**	**$1,070**
Sales tax rate from economic value	0.02	0.02	
Sales taxes ($MM)	**$5,984**	**$5,902**	**$11,886**
Economic value (2.91 × production revenue)	**$299,203**	**$295,115**	**$594,318**
Jobs created (19.1 per $MM wellhead value)	**1,963,843**	**1,937,007**	**3,900,850**

Based on the Texas Railroad Commission's "General Model of Oil and Gas Impact on the Texas Economy" derived from the Texas Comptroller's Input/Output model of the Texas economy.

QAd2652x

- Modest percentage incremental production increases from technology advancements will generally track historical and current trends as outlined in the previous section. More specifically, the model assumes
  - a 10-percent production increase for *conventional* gas onshore and for offshore water depths <200 m;
  - a 20-percent production increase for offshore water depths of 200–400 m;
  - a 25-percent production increase for offshore water depths 400–800 m;
  - and a 30-percent production increase for offshore water depths >800 m, as well as for unconventional onshore production;
- Zero incremental production growth due to technologies developed through the research supply fund in years one and two of the program (2003 & 2004) due to lag time required to develop and apply technologies;

Table 14. Additional economic impact of the supply research fund from U.S. incremental production.

	Oil	Gas	Total
Incremental production, Tcf and MMbbl	6,143	87	
Incremental production revenue ($MM)	**$150,310**	**$305,949**	**$456,259**
Severance tax rate from wellhead value	0.075	0.046	
Severance taxes ($MM)	**$11,273**	**$14,074**	**$25,347**
Ad valorem tax rate from wellhead value	0.0395	0.0395	
Ad valorem taxes ($MM)	**$5,937**	**$12,085**	**$18,022**
Franchise tax rate from economic value	0.0018	0.0018	
Franchise taxes ($MM)	**$787**	**$1,603**	**$2,390**
Sales tax rate from economic value	0.02	0.02	
Sales taxes ($MM)	**$8,748**	**$17,806**	**$26,554**
Economic value (2.91 × production revenue)	**$437,402**	**$890,312**	**$1,327,714**
Jobs created (19.1 per $MM wellhead value)	**2,870,921**	**5,843,626**	**8,714,547**

Based on the Texas Railroad Commission's "General Model of Oil and Gas Impact on the Texas Economy" derived from the Texas Comptroller's Input/Output model of the Texas economy.

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- More technologically dependent resources (deepwater offshore and unconventional) will show greater *incremental* production increases than less technologically dependent resources (shallow offshore and conventional);

- A "scaled-up" effect of technology for the early years of the program: 25 percent impact in 2005, 50 percent impact in 2006, 75 percent impact in 2007 are assumed as technology is first deployed in the early years;

- A 100-percent impact of technology in years 2008–2025 as technology is deployed and fully applied and primary production response is achieved.

The BEG analysis determined that incremental production responses for technologically dependent resources are significant and increase quickly. As demonstrated by a review of the impacts of technology on development of unconventional gas resources, key technology developments greatly increased the portion of the resource base that could be economically and technlog-ically exploited. As illustrated in figure 19, production from these resource areas most commonly

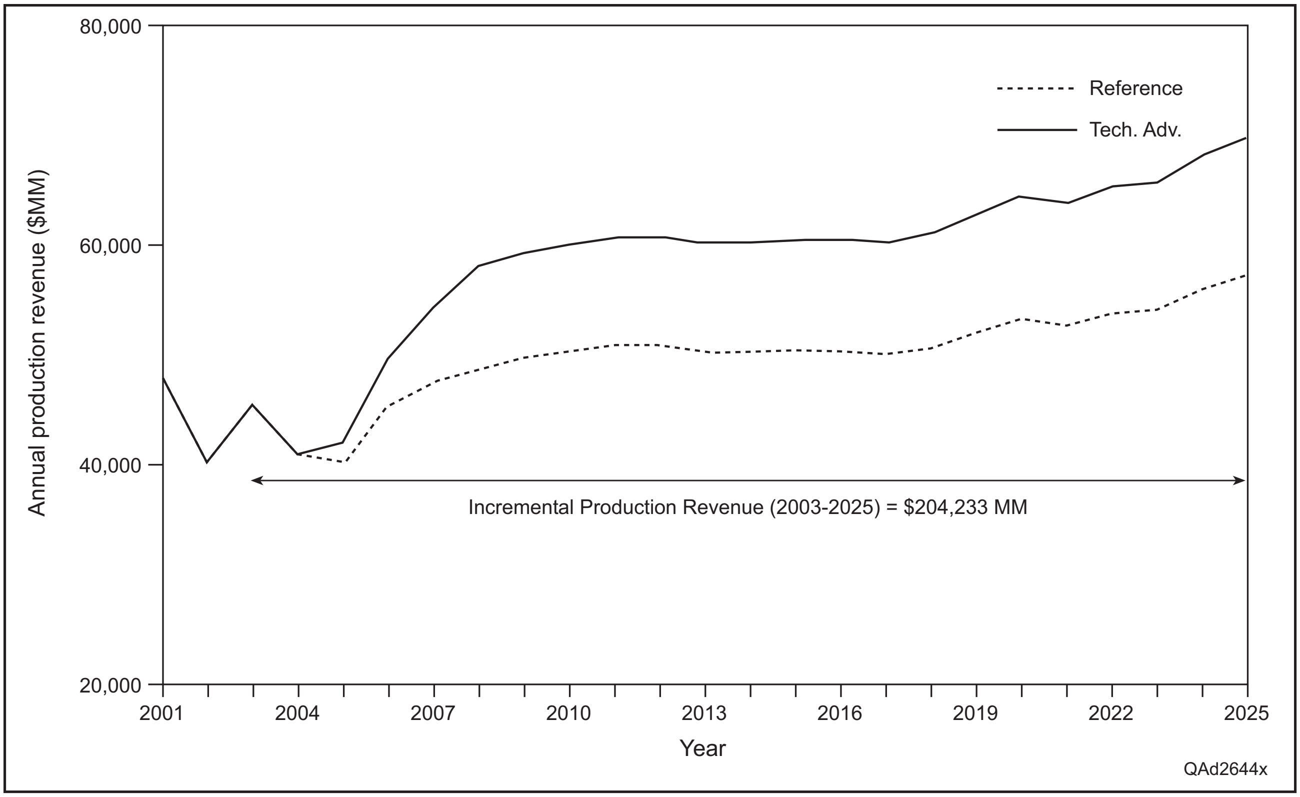

Figure 24. Federal Lands production revenue forecast by technology advancements.

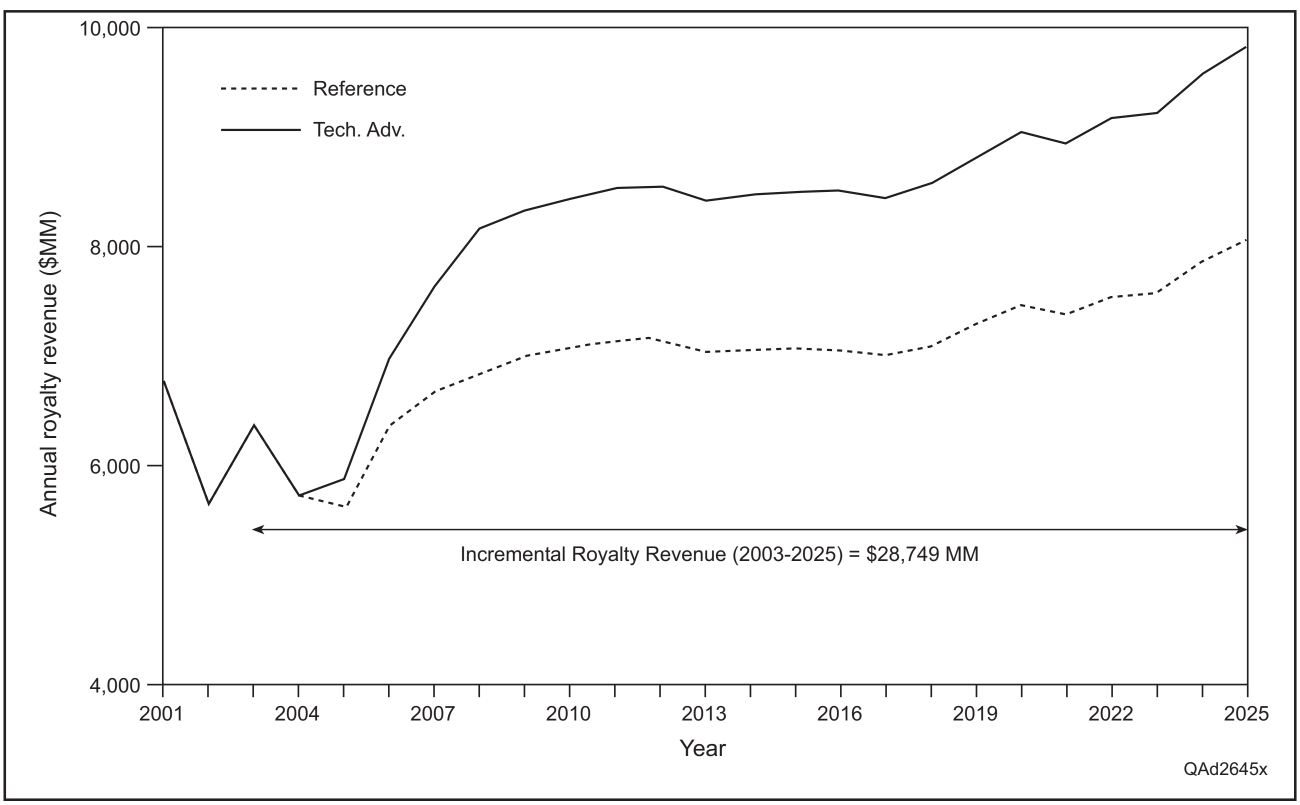

Figure 25. Federal Lands royalty revenue forecast by technology advancements.

starts at zero or is very minimal. When technologies are applied, production increases rapidly.

Economic analysis of the supply research fund in terms of Federal lands incremental production revenue under the reference price case revealed positive economics (table 7). Moreover, when the entire U.S. incremental production revenue was taken into consideration, economic benefits were greatly increased (table 8). The economic analysis results of the high and low price scenarios are given in tables 9 through 12. Furthermore, the Texas Railroad Commission's *"General Model of Oil and Gas Impact on the Texas Economy"* derived from the Texas Comptroller's input-output model of the Texas economy was utilized to examine additional economic impacts of the supply research fund. Such additional economic impact from taxes, economic value, and jobs created was examined in the case of both Federal lands and U.S. incremental production resulting from the supply research fund (tables 13 and 14). Although this model was developed on the state level for use in Texas, it reveals some important potential additional economic impacts of the supply research fund.

The methodology of calculating the value of technology in terms of incremental production has been frequently utilized in projects conducted at the BEG, such as the State of Texas Advanced Oil and Gas Resource Recovery and the University Lands Advanced Recovery Initiative. The fundamental basis of how technology application leads to incremental production is also given in several articles as those by Hickman (1995) and Sneider and Sneider (1998). It should be noted that additional Federal mineral revenues from bonuses and rents were not assessed, and the impact of current and proposed tax-related legislation such as the deepwater royalty relief act, deep-shelf gas tax incentives, and RIK programs was not analyzed in this report.

CONCLUSIONS

The U.S. oil and gas resource base is vast and will contribute significantly to rising oil and gas demand with continued technological advancements. Major increases in oil and gas supply are attributable to successes in the technologically difficult and complex offshore deepwater and unconventional resource areas. These oil and gas resource areas are very dependent on continued technological advancements for their incremental production growth and economic recovery.

In the past, GRI/GTI's multiyear, high-risk, high-cost gas supply research programs such as coalbed methane, advanced stimulation technologies, Antrim shales, and emerging resources in the Greater Green River Basin resulted in significant economic increases in gas production. Incremental gas production achieved through these gas supply research programs has contributed greatly to increased Federal royalty revenue and, in fact, has provided an excellent rate of return on the Federal investment.

On the basis of current legislation the previous study, *Benefit/cost analysis GRI's gas supply research initiative* (Kim and others, 2000), has been updated. Through compilation and management of production and economic data an analysis of historical U.S. and Federal lands oil and gas production was undertaken. On the basis of this analysis forecasts of oil and gas production and royalty revenue from Federal lands were made. The potential impact of technology targeted at increasing oil and gas production on Federal lands as well as in the U.S. was determined through various parameters such as incremental production, production revenue, and royalty revenue. Additional economic impacts such as taxes, economic value, and jobs created further revealed the benefits of the proposed supply research fund.

A supply research trust fund is a critically important and economically viable R&D investment. It establishes a balanced approach for responsibly developing the nation's oil and gas resource base by driving research and technology development at a rapid rate necessary to meet the nation's increasing future oil and gas demands. The consequences of decreasing investment in technological developments would severely limit potential incremental production and Federal mineral revenues from difficult and complex resource areas such as the offshore deepwater and unconventionals.

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