OCS Report
MMS 2001-088

Economic Analysis for the OCS 5-Year Program 2002-2007: Theory and Methodology

U.S. Department of the Interior
Minerals Management Service
Environmental Division

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1. Introduction

The purpose of this paper is to document the theoretical background and methodology of the economic analysis performed for the *Proposed Outer Continental Shelf Oil and Gas Leasing Program 2002 to 2007* (5-Year Program). The economic analysis, which the Minerals Management Service (MMS) prepares, provides the Secretary of the Interior (the Secretary) with a logically consistent analytical basis for determining the timing and location of lease sales and deciding among an array of leasing alternatives. It is important at the outset to make clear that the results of the economic analysis are simply one criterion among many for choosing among the alternatives. Other valid criteria could lead the Secretary to choose an alternative other than the one that would be chosen solely on the basis of the economic analysis.

The United States and many other modern societies traditionally use cost-benefit analysis (CBA) as the technical basis for public decisionmaking. The courts have found the results of CBA to be appropriate grounds for the Secretary's decision about Outer Continental Shelf (OCS) leasing. Thus, the development of estimates using this approach and the Secretary's consideration of those estimates is consistent with a legally sanctioned foundation for decisions concerning OCS leasing.

The theory and practice of CBA has sanctioned a specific measure for determining the desirability of a public action. This measure is the present value of the future stream of net social benefits (gross benefits minus gross costs) from the investment or policy. In this case, the net benefits under consideration are those that would accrue to society from the OCS natural gas and oil leasing included in the 5-Year Program.

The MMS divides the U.S. OCS into 26 "planning areas." In the Draft Proposed Program, MMS ranks the planning areas based on total available resources and the methodology developed in this paper. This ranking, along with other leasing considerations, narrows the locations for leasing within planning areas into "program areas." Program areas are portions of one or more planning areas being considered for leasing in a 5-Year Program. The MMS ranks the program areas in the Proposed Program using the methodology described in this paper. Once again, the ranking is based on estimates of the total resources available, but only those resources in the program areas. The results of the ranking are used as the rationale for determining the location and timing of a discrete number of specific lease sale alternatives called "program alternatives."

The MMS then calculates and compares the net benefits attributable to each program area for each program alternative. Because society receives benefits from past leasing and the resultant production of OCS oil and gas, only the net benefits from additional leasing (or none at all) are considered. This process is called "valuation of program alternatives."

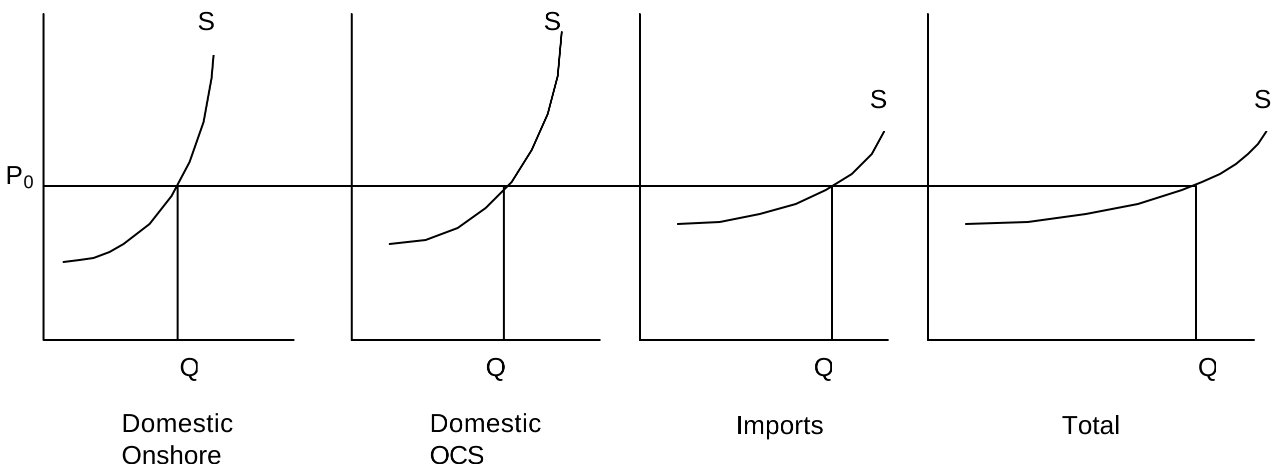
The methodology developed in this paper builds on the work of Boskin et al (1985), Boskin and Robinson (1987), and Rosenthal et al (1988), all of whom estimated the value of total OCS oil and gas resources. This paper also builds on previous "5-Year Programs," especially *Proposed Final Outer Continental Shelf Oil and Gas Leasing Program 1997 to 2002*.

2. Theoretical Development

The CBA focuses on the microeconomic (market specific) benefits and costs associated with investments or policies. Complete consideration of microeconomic measures must encompass both supply and demand sides. For ease of exposition, the following discussion of these components only refers to oil; however, development of a model to estimate benefits from natural gas production would be virtually indistinguishable from that for oil.

Three sources supply the U.S. oil market: (1) domestic onshore production, (2) domestic OCS production, and (3) imports. Figure 1 shows these components summed horizontally to form the total U.S. market supply of oil. Figure 1 and all other figures and analysis in this paper assume that the international oil market acts like a locally competitive system in dealing with the relatively small shifts in international demand being analyzed here. More specifically, the paper assumes that supply curves for oil are locally continuous and upward sloping.

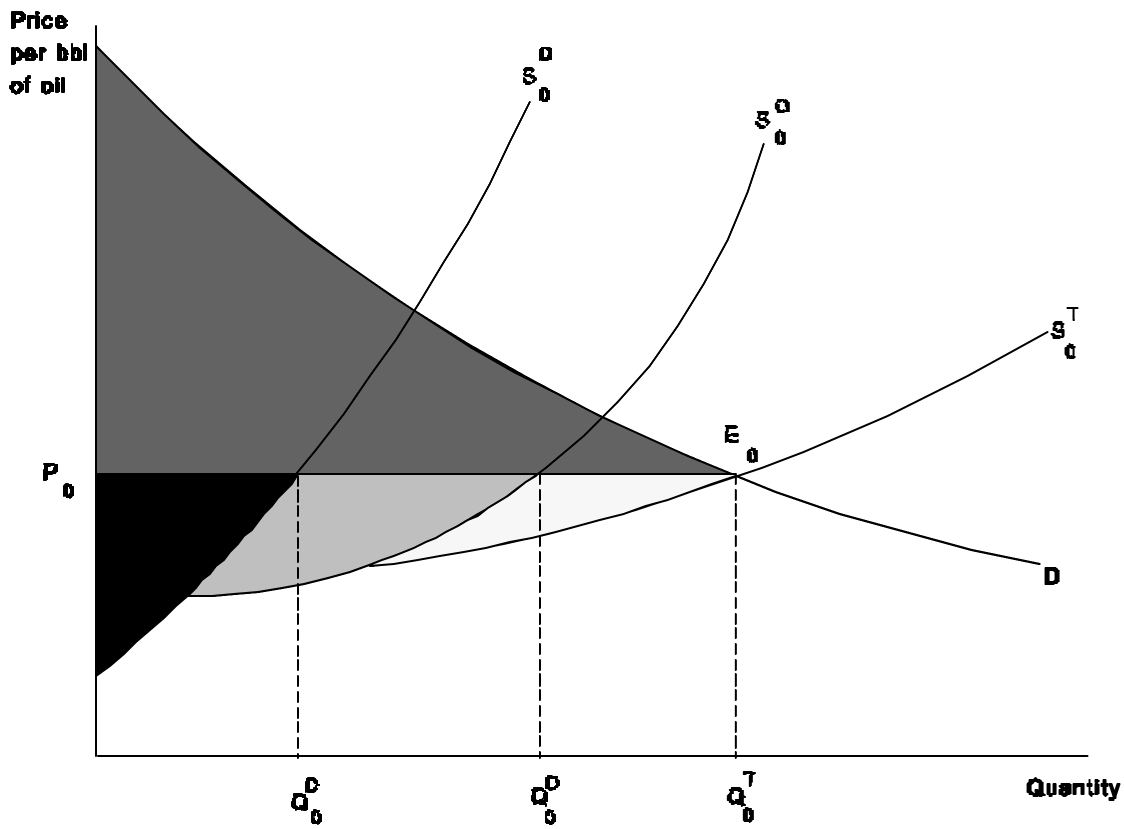
Figure 1. Components of the U.S. Oil Supply



P_0 = the price of crude oil in the initial period
S = the sectoral supply curve for oil
Q = the market clearing quantity of oil at P_0

Figure 2 provides a more detailed view of the three combined components forming a stepped envelope of supply. When U.S. demand intersects the total U.S. supply curve at E_0, domestic onshore provides *0* to Q_0^D of production, domestic OCS provides Q_0^D to Q_0^O of production, and imports provide Q_0^O to Q_0^T; however, these quantities are not drawn to an empirical scale.

Figure 2. Combined Supply Curve for U.S. Oil



E_0 = the equilibrium in the initial period
P_0 = the market clearing price in the initial period
S_0^D = the supply curve for domestic onshore crude oil
S_0^O = the supply curve for domestic OCS crude oil
S_0^T = the supply curve for imported crude oil
Q_0^D = the market clearing quantity of domestic onshore crude oil
Q_0^O = the total market clearing quantity of domestic onshore and OCS crude oil
Q_0^T = the total market clearing quantity of crude oil
The wallpapered area = the consumer surplus
The black area = the economic rent from domestic onshore oil production
The vertically striped area = the economic rent from OCS production
The stippled area = the economic rent from imports

The initial total benefits consist of the economic rent (producer surplus) plus the consumer surplus. Economic rent is the difference between the total revenue collected by producers and their total costs of production including normal returns to labor, money, capital goods, management expertise, and other factors of production. This surplus revenue adds to the income of producers and their investors. Consumer surplus is the difference between the maximum that consumers would be willing to pay for all units up to the market clearing quantity of the good and what they actually had to pay at the market clearing price. Thus, consumers benefit by this amount compared to what they might be forced to pay in a noncompetitive economy. In figure 2, the wallpapered area above the initial price line (P_0) represents consumer surplus. The three shaded areas below P_0 represent economic rent.

Comparing the market without the OCS to the market with the OCS can help identify the benefits from domestic OCS oil production. Figure 3 illustrates the case where there is no oil production from the OCS. Compared to figure 2, the total supply curve shifts leftward by the amount of the lost OCS production and the new equilibrium occurs at E_1. Without OCS production, domestic society experiences a reduction in economic rent represented by the shaded area. This reduction is, of course, a measure of the benefit of continued OCS production.

The MMS calculates a gross economic rent estimate for both oil and gas equivalent to the shaded area in figure 3 using:

$$NEV_i = \sum_{t=1}^{n} \left[\frac{(AG_{it} \bullet PG_t) + (AO_{it} \bullet PO_t) - C_{it}}{(1+r)^t} \right] \tag{1}$$

where:

NEV_i = the estimated net present value of gross economic rent in the ith program area. MMS calls this "net economic value," thus NEV.

AG_{it} = the anticipated production of natural gas from program area i in year t

PG_t = the natural gas price expected in year t

AO_{it} = the anticipated production of oil from program area i in year t

Po_t = the oil price expected in year t

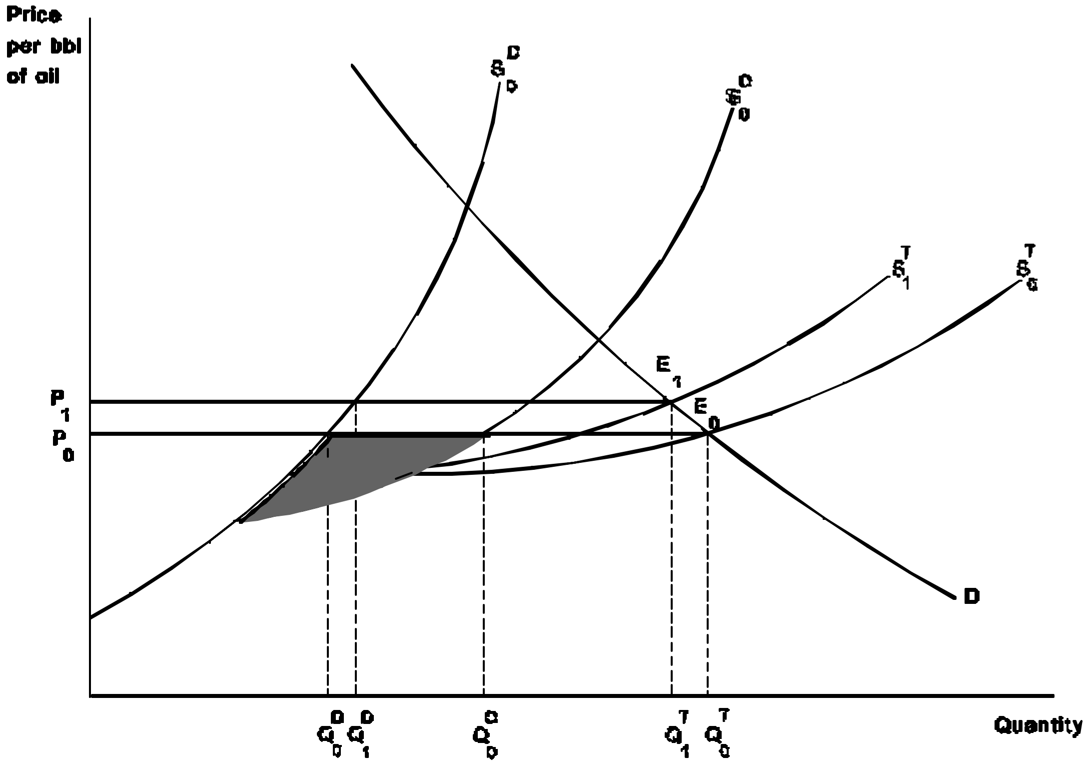
C_{it} = a vector of exploration, development, and operating costs, except transfers to the government

r = a social discount rate

n = years of production associated with the leasing schedule

The NEV defined this way represents the economic rent that would be realized according to a scenario of drilling and production deemed likely by the MMS. Other measures of expected economic rent can be defined that account more fully for the uncertainty of future prices, costs, and other factors, and how the pace and magnitude of drilling and production might optimally respond to the potential future levels of these variables. Typically, these other measures, which reflect operator flexibility to modify

Figure 3. Without OCS Production: Effects on Economic Rent



E_1 = the new equilibrium without OCS production
S_1^T = the total supply curve for crude oil without OCS production
P_1 = the new price without OCS production
Q_1^D = the market clearing quantity of domestic onshore crude oil without OCS production
Q_1^T = the total market clearing quantity of crude oil without OCS production
The wall papered area = the reduction in total economic rent without OCS production = the economic rent benefit from OCS production

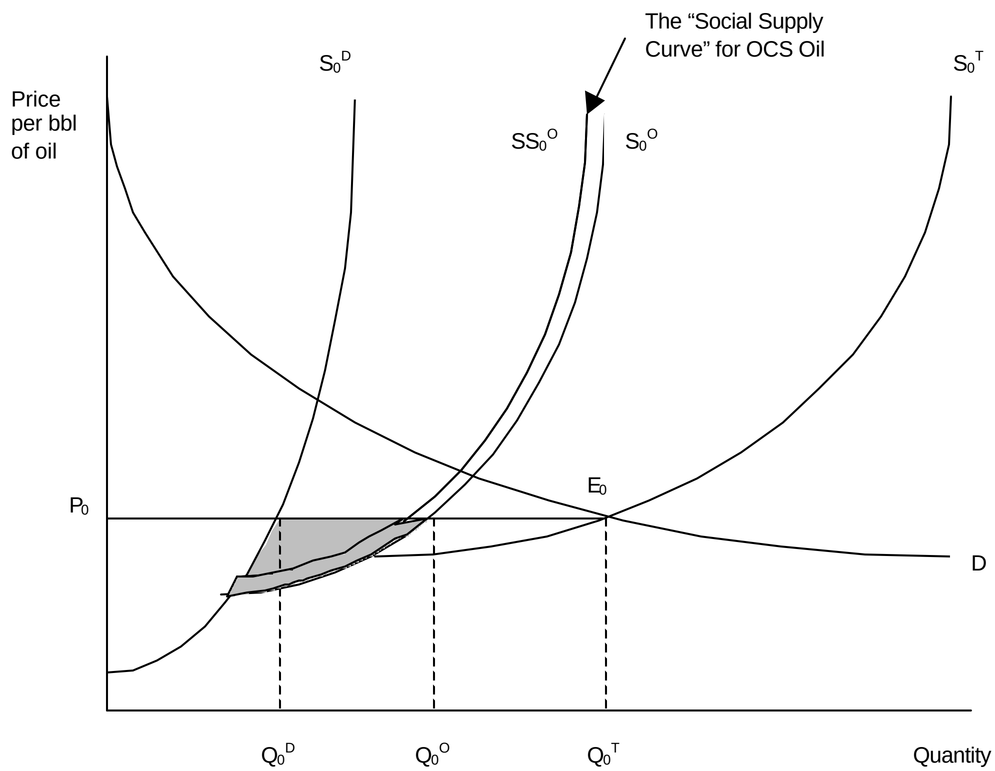
plans and activities in the face of new information, provide a higher estimate of economic value than does the traditional NEV approach.

Production of OCS oil imposes external environmental costs on society. These costs take the form of air pollution, risk of oil spills, pressure on overtaxed local services during development, and a range of similar impacts. Regulations have internalized many of these costs onto production firms' balance sheets; however, some persist. In figure 4, the externalities that have not been internalized are represented by an upward shift (not to scale) in the "social supply curve" of OCS oil which includes the full cost to society of producing OCS oil.

The perceived risk from environmental costs influences the political process to limit the availability of some offshore lands for oil and gas production. Nevertheless, the OCS production process is so structured that the external environmental costs associated with this process that actually occur have no measurable influence on production. Given this relationship, environmental costs reduce society's rent from OCS production as shown by the horizontally shaded area in figure 4. This leaves the net OCS economic rent represented by the vertically shaded area.

Of course, domestic onshore and imported oil also impose external costs. Indeed, a general equilibrium analysis that included all externalities associated with all substitutes and complements could lead to a somewhat different result than this paper. However, the result would probably not be significantly different than the result here.

Figure 4. Environmental Costs from OCS Production



The horizontally striped area = the environmental costs of OCS production
The vertically striped area = the net OCS economic rent

The environmental costs in program area i, E_i, equal

$$E_i = \sum_{k=1}^{s} \sum_{t=1}^{n} \left[\frac{E_{ikt}}{(1+r)^t} \right] \tag{2}$$

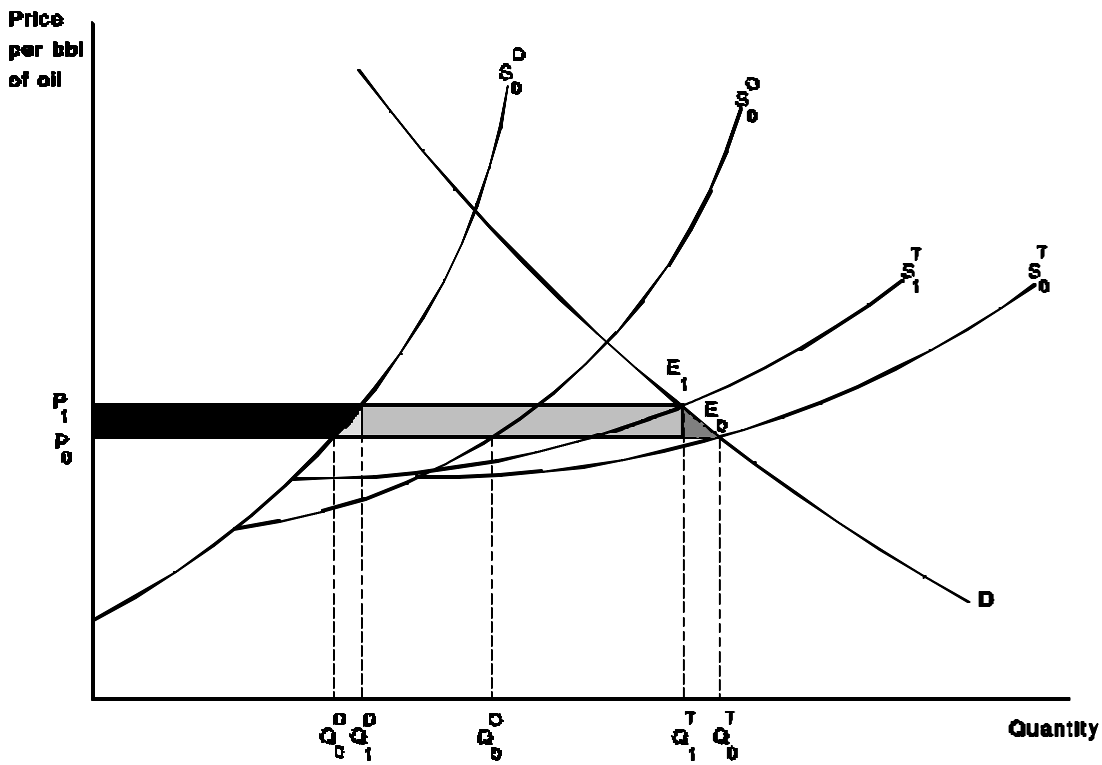
where E_{ikt} = the cost to society of the kth environmental externality occurring in program area i in year t.

The MMS calls the net economic rent from OCS production "net social value." This is a misnomer because it does not include consumer surplus benefits. Nevertheless, net economic rent from program area i (NSV_i) is

$$NSV_I = NEV_I - E_I \qquad (3)$$

In addition to net economic rent, OCS oil also contributes to society's consumer surplus. In figure 5 (which is similar to figure 3), without OCS oil production, consumer surplus declines as shown by the shaded areas bounded by P_1, E_1, E_0, and P_0. This occurs because when the upward sloping supply curve shifts to the left, it intersects the demand curve at a new, higher price (P_1). The higher price reduces consumer surplus.

Figure 5. Without OCS Production: Effects on Consumer Surplus



The black shaded area = the transfer from consumers to domestic onshore producers
The stippled triangle = the additional cost of domestic onshore production
The vertically shaded area = the economic rent transferred to foreign producers of imported oil
The horizontally shaded area = the additional cost of increased foreign production
The crosshatched triangle = the net global loss of consumer surplus

However, that portion of diminished consumer surplus shaded in black in figure 5 is not lost to the U.S. economy. It is a transfer from consumers to domestic onshore producers who add it to their economic rent.

Thus, the net consumer surplus loss to the U.S. economy equals the area shaded in stippling, vertical lines, horizontal lines, and crosshatching. The stippled triangle represents the additional cost to producers of increased domestic onshore production. The vertically shaded area represents the economic rent transferred to foreign producers of imported oil. The horizontally shaded area represents the additional cost of increased foreign production. The crosshatched triangle designates the net global loss of consumer surplus.

Assuming a constant elasticity demand function of the form

$$Q_i^D = aP^h \qquad (4)$$

where a is a constant and $\boldsymbol{h}$ is the elasticity of demand and constant elasticity of supply function of the form

$$Q_i^S = bP^x \qquad (5)$$

where b is a constant and î is the elasticity of supply for domestic onshore oil, the U.S. consumer surplus loss from not producing on the OCS (*L*) can be expressed as

$$L_i = \int_{P_0}^{P_1} (aP^h - bP^x)dP \qquad (6)$$

where the first term inside the parentheses represents the total lost consumer surplus (the shaded areas in figure V) and the second term represents the economic rent transferred to onshore oil producers (the black area). Solving equation 6 yields

$$L_i = \frac{a}{\boldsymbol{h}+1}(P_1^{h+1} - P_0^{h+1})\frac{b}{\boldsymbol{x}+1}(P_1^{x+1} - P_0^{x+1}) \qquad (7)$$

which is the formula for calculating consumer surplus benefits.

As explained earlier, losses in the “without OCS case” represent the benefits of OCS production. Thus, the net benefits from OCS resources in program area i (T_i) equal the net economic rent plus the consumer surplus. Or,

$$T_i = NSV_i + L_i \qquad (8)$$

3. Assumptions and Input Data

Considerable uncertainty surrounds future production from the OCS and resulting impacts on the economy. A broad range of future conditions can result from a lease sale schedule. To be useful an analysis must be both specific and realistic, which is difficult in the face of uncertainty. Price expectations play an especially important role in estimating the value of program alternatives. For instance, industry will be much more likely to develop hydrocarbon resources in frontier areas if industry expects future oil and natural gas prices to remain high. In response to this price uncertainty, the MMS has chosen to identify a pair of likely scenarios of the future. One is a low-to-moderate price scenario that is high enough to result in sufficient offshore activity to be useful for analysis. The second scenario is a plausible high-price situation for which the U.S. Department of the Interior must be prepared.

Scenarios must also be consistent. The MMS ensures consistency by using identical input assumptions in calculating each component of the economic analysis. The analysis in the environmental impact statement (EIS) that accompanies the program decision document also uses the same set of assumptions as the program alternative valuation. Five subsets make up the full assumption set for the economic analysis. For the Proposed Program ranking, the assumption set is:

- oil and natural gas prices
- the discount rate
- total economically recoverable resources
- exploration and development scenarios
- production profiles

For the valuation of program alternatives and EIS analysis, anticipated production is substituted for total economically recoverable resources.

3.1. Oil and Natural Gas Prices

As explained above, the economic analysis for the 5-Year Program includes two price assumptions, a low-to-moderate and a high-price scenario. The low to moderate oil price is $18 per barrel (bbl). This price conforms to actual worldwide oil price levels following the Persian Gulf War. The price of West Texas Intermediate crude oil averaged about $17.25 per bbl in 1994, while the refiner acquisition cost of imported crude averaged $15.51. The high-oil price ($30 per bbl) is consistent with supply and demand conditions at the present time in 2001.

For both scenarios the MMS set the natural gas wellhead price at 66 percent of the oil price on a British thermal unit-equivalent basis. The low to moderate natural gas wellhead price is $2.11 per mcf. The high price is $3.52 per mcf. In both cases, inflation-adjusted, or "real" prices are assumed to remain constant throughout the productive life of all leases resulting from the new 5-year program.

3.2. Discount Rate

Based on a review of the literature, familiarity with returns to the industry, and the rate used in other economic analyses, the MMS chose a discount rate of 7 percent for the 2002-2007 program analysis.

3.3. Total Economically Recoverable Resources

Resource estimates from the 2000 National Assessment form the basis for the MMS's evaluation of program areas. The National Assessment projects the undiscovered, conventionally and economically recoverable oil and natural gas resources located outside of known oil and gas fields on the U.S. OCS. The assessment considers recent geophysical, geological, technological, and economic information and uses a play analysis approach to resource appraisal called the Geologic Resource Assessment Program (GRASP).

Results from GRASP provide the basic geologic inputs into a second model – the Probabilistic Resource Estimates Offshore (PRESTO) model. The costs of exploration, development, and transportation, as well as tariffs based upon logical scenarios are estimated for each area where activities, costs, or other circumstances warrant. Estimates for economically recoverable resources are then derived for a specific price.

The current estimates of undiscovered economically recoverable OCS oil and natural gas resources were developed using the following criteria:

- flat prices
- 12-percent after tax rate-of-return
- 12.5 percent or 16.7 percent royalty rate
- 35 percent tax rate
- 3 percent inflation rate
- cost of exploration, development, transportation, and tariffs with their associated development scheduling scenarios for each OCS region and portions of regions when conditions warrant
- natural gas prices related to oil prices at 66 percent of the oil-energy equivalent

Table 1 shows the total unleased economically recoverable resources in the program areas for the 2002-2007 5-Year Program.

3.4. Anticipated Production

As mentioned above, the MMS constructs a series of alternative schedules for OCS lease sales in the 5-Year Program called the program alternatives. These are logical groupings of many individual options considered by the Department of the Interior decisionmakers and ultimately, the Secretary, prior to making a decision on the final OCS lease sale schedule. The following alternatives are being considered for the 5-Year Program 2002-2007:

Table 1. Total Unleased Economically Recoverable Resources–July 2002

Program Area	Oil (BBO)*	Gas (Tcf)*
Western Gulf of Mexico	2.83 4.55	16.17 23.65
Central Gulf of Mexico	4.16 7.14	21.19 31.95
Eastern Gulf of Mexico	0.12 0.29	0.50 1.16
Beaufort Sea	1.68 2.87	Uneconomic
Chukchi Sea	0.96 6.06	Uneconomic
Cook Inlet	0.42 0.50	0.56 0.86
Hope Basin	0.02 0.04	0.58 1.43
Norton Basin	0.02 0.03	1.04 1.59

*Low range estimates ($18 per bbl and $2.11 per Mcf) are shown first, with high range estimates ($30 per bbl and $3.52 per Mcf) underneath. Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (Tcf).

Alternative 1–The Program Proposal

- Western Gulf of Mexico—annual sales
- Central Gulf of Mexico—annual sales
- Eastern Gulf of Mexico—sales in 2003 and 2005
- Beaufort Sea—sales in 2003, 2005, and 2007
- Chukchi Sea and Hope Basin—sales in 2004 and 2007
- Cook Inlet—sales in 2004 and 2006
- Norton Basin—sale in 2003

Alternative 2–Slow the Pace of Leasing

- Western Gulf of Mexico—annual sales
- Central Gulf of Mexico—annual sales
- Eastern Gulf of Mexico—sale in 2003
- Beaufort Sea—sale in 2003, and perhaps 2007
- Chukchi Sea and Hope Basin—sale in 2007
- Cook Inlet—sale in 2004
- Norton Basin—sale in 2003

Alternative 3–Exclude Some Planning Areas

- Western Gulf of Mexico—annual sales
- Central Gulf of Mexico—annual sales
- Beaufort Sea—sales in 2003, 2005, and 2007
- Chukchi Sea—sales in 2004 and 2007
- Cook Inlet—sales in 2004 and 2006

Alternative 4–Accelerated Leasing

- Western Gulf of Mexico—annual sales
- Central Gulf of Mexico—annual sales
- Eastern Gulf of Mexico—sales in 2003, 2005, and 2007
- Beaufort Sea—annual sales
- Chukchi Sea and Hope Basin—sales in 2004 and 2007
- Cook Inlet—sales in 2004 and 2006
- Norton Basin—sale in 2006

Alternative 5–No Action

The valuation of program alternatives is based on anticipated production, which is the estimated quantity of oil and natural gas that will be produced as a result of the lease sales included in any of the program alternatives if production occurs.

The MMS uses the following information to develop estimates of anticipated production:

- data derived from the MMS (2001) and other resource assessment procedures
- models that estimate the number of blocks expected to be leased
- past statistics and analytical reasoning regarding the number of leased blocks that will be drilled
- estimates of the number of drilled blocks that will yield discoveries
- the proportion of expected discoveries large enough to be commercially viable

Experienced personnel in the MMS regional offices take all this information into account in formulating subjective estimates of production anticipated from each of the specific program options in each of the program areas if production occurs. Estimates of anticipated production for the proposed program are shown in table 2.

3.5. Exploration and Development Scenarios

Associated with various levels of production are activities and facilities related to exploring for and developing oil and gas resources. The list of these activities and facilities is called an exploration and development (e&d) scenario. It is these activities and facilities that produce oil and gas, cost money, and cause environmental and social impacts. Table 3 shows the e&d scenario for the low to moderate and high cases

Table 2. Anticipated Production for the Proposed Action

Program Area	Oil (BBO)*	Gas (Tcf)*
Western Gulf of Mexico	0.68 1.31	4.05 7.20
Central Gulf of Mexico	1.38 3.27	7.95 16.50
Eastern Gulf of Mexico	0.10 0.17	0.41 0.68
Beaufort Sea	1.02 1.71	Uneconomic
Chukchi Sea	0.96 2.42	Uneconomic
Cook Inlet	0.28 0.34	0.38 0.58
Hope Basin	0.01 0.02	0.29 0.71
Norton Basin	0.01 0.01	0.26 0.40

*Low to moderate scenario estimates ($18 per bbl and $2.11 per Mcf) are shown first, with high scenario estimates ($30 per bbl and $3.52 per Mcf) underneath. Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (Tcf).

Table 3. Exploration and Development Scenario for the Proposed Program

Variables	Gulf of Mexico			Alaska			
	Western	Central	Eastern	Beaufort Sea	Chukchi/ Hope	Cook Inlet	Norton Basin
No. of sales	5	5	2	3	2	2	1
Anticipated Production-oil (BBO)	0.68 – 1.31	1.38 – 3.27	0.10 – 0.17	1.02 – 1.71	0.97 – 2.44	0.28 – 0.34	0.01
Anticipated Production-gas (Tcf)	4.05 – 7.20	7.95 – 16.50	0.41 – 0.68	None	0.29 – 0.71	0.38 – 0.58	0.26 – 0.40
Years of activity	40	40	40	30	35	35	20
No. of platforms	50 - 75	130 – 240	2 - 3	6 - 12	4 - 10	2 – 6	1
No. of exploration & delineation wells	185 - 575	555 – 1,235	17 - 26	18 - 30	12 - 34	8 – 18	3 – 5
No. of development & production wells	490 - 825	890 – 2,400	30 - 52	190 - 325	114 - 338	84 – 108	7 – 10
Pipeline miles	500 – 1,500	800 – 2,400	200 - 350	185 - 280	480 - 690	115 – 200	25 – 55
No. of landfalls	0 - 5	0 – 5	1 - 2	2	2	2 – 4	1
No. of shore bases	0 - 3	0 – 1	0	0	2	0	1

Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (TCF).

attributable to each program area included in the program proposal (Alternative 1). Table 4 shows the e&d scenarios attributable to program areas where they change in Alternatives 2 and 4.

Table 4. Exploration and Development Scenario for Alternatives 2 and 4

Variables	Alternative 2				Alternative 4	
	Eastern Gulf of Mexico	Beaufort Sea	Chukchi/ Hope	Cook Inlet	Eastern Gulf of Mexico	Beaufort Sea
No. of sales	1	1 or 2	1	1	3	5
Anticipated Production-oil (BBO)	0.07 – 0.09	0.68 – 1.14	0.97 – 1.22	0.14 – 0.17	0.12 – 0.26	1.70 – 2.85
Anticipated Production-gas (Tcf)	0.27 – 0.34	None	0.15 – 0.36	0.19 – 0.29	0.50 – 1.02	None
Years of activity	40	25	30	30	45	35
No. of platforms	1 – 2	4 – 8	3 – 5	1 – 3	3 – 5	10 – 20
No. of exploration & delineation wells	11 – 13	12 – 20	9 – 17	4 – 9	21 – 39	30 – 50
No. of development & production wells	19 – 27	130 – 220	110 – 169	42 – 54	38 – 78	320 – 545
Pipeline miles	150 – 200	185 – 320	450 – 560	100 – 150	250 – 400	215 – 310
No. of landfalls	1	2	2	1 – 2	1 – 3	2 – 3
No. of shore bases	0	0	2	0	0	0

Oil estimates are expressed in billions of barrels (BBO); natural gas estimates are expressed in trillions of cubic feet (TCF).

3.6. Production Profiles

Production profiles (also called production schedules) show the distribution of anticipated production by year over the life of program related activity in each program area. The production profiles are not shown because they are lengthy and of limited interest.

4. Models and Results

The total net benefits from OCS production include net economic rent and consumer surplus for both oil and natural gas. Section 2 of this paper refers primarily to benefits from oil. This simplifies the discussion since similar analysis applies to natural gas. Empirically, however, differences arise between the two resources. The differences are identified below.

4.1. Net Economic Rent

Following equation 3, net economic rent consists of the gross economic rent minus the environmental and social costs associated with production. Graphically, the vertically shaded area in figure 4 represents net OCS economic rent.

4.1.1. Net Economic Value

Net economic value (NEV) is the difference between the discounted gross market value of total resources or anticipated production and the discounted real cost of exploring, developing, producing, and transporting the product to market (except for transfers to the Government). The U.S. Government (the lessor) collects a portion of the NEV as transfer payments in the form of cash bonuses, rentals, royalties, and taxes. The lessees (private firms) retain the remainder of the NEV as economic profits.

The NEV's of the program areas and program alternatives are calculated using a discounted cash-flow model called NEV. The NEV calculates the gross value of anticipated production in a program area based on expected oil and gas prices. The gross value of the production is then discounted so that values can be expressed in terms of a 2002 program starting date. Likewise, the costs of exploration, development, production, and transportation (excluding transfer payments) are calculated and discounted back to 2002. The discounted costs are then subtracted from the discounted gross production value. This difference represents the NEV, as of 2002, for the program areas and program alternatives.

Table 5 includes NEV's for program areas in the proposed action and Alternatives 2, 3, and 4 (for those program areas where the NEV's are different than the proposed action). Table 6 includes the sums of the NEV's for each of the program alternatives.

4.1.2. Environmental and Social Costs

The net economic value assessment considers the private costs, except for transfer payments to the Government, incurred by the firms that discover and develop OCS oil and natural gas resources. In addition, society incurs environmental and social costs from the activities and facilities associated with OCS oil and natural gas production. These costs take a variety of forms and the MMS has organized the environmental and social costs associated with OCS activities into the following nine categories:

- Beach Recreation
- Recreational Fishing
- Ecological
- Commercial Fisheries
- Subsistence
- Air Quality
- Public Service
- Property Values
- Water Quality

The general public views oil spills as the most serious risk posed by the OCS program. The environmental effects of oil spills and the costs associated with those effects vary widely depending on variables such as the amount and type of oil spilled, the location of the spill, whether the spill hits shore, the sensitivity of the ecosystem affected, weather, season, etc.

Fortunately, the environmental and social costs associated with several oil spills have been relatively well documented so there is a reasonable basis for oil-spill cost modeling in the literature. Nevertheless, modeling efforts are usually limited to assessing the effects of an "average" event like an oil spill. In the case of the analysis performed for this report, the estimates are for the aggregate costs of all the spills that the model suggests would most likely result from anticipated production. This approach cannot and does not try to measure the effects of any individual spill, nor does it take into account the unlikely event of a catastrophic spill of unprecedented proportions.

If OCS oil and, to a lessor extent, natural gas are not produced, imports of foreign oil will increase substantially. Most of this oil would be imported by tanker, entailing risks of oil spills and environmental costs. Subtracting the environmental costs associated with these increased imports from the environmental costs associated with OCS production leaves an estimate of the net environmental and social costs associated with OCS activities. To ensure consistency, the MMS employs the MarketSim2000 model to estimate imports that would substitute for OCS production. MarketSim2000 also estimates consumer surplus benefits and provides energy substitution estimates for the no action alternative in the EIS and the energy alternatives evaluation.

For the 2002-2007 5-Year Program, the MMS has adopted the Offshore Environmental Cost Model (OECM) for estimating environmental and social costs associated with OCS activities. The OECM, which was completed in 2001, is designed to model the impact of typical activities associated with OCS production and typical oil spills occurring on the OCS. This model is not designed to represent impacts from catastrophic events or impacts on unique resources such as endangered species. The reader is referred to the EIS accompanying the decision document for assessment of catastrophic effects and impacts on unique resources. Decisionmakers are cautioned that the environmental and social costs included in this analysis are not necessarily all the costs that might be associated with the proposed action and other options, although the MMS attempted to assess accurately costs that could reasonably be expected.

The OECM is a nine-sector spreadsheet model. The nine sectors are the same as those listed above as the categories of environmental and social costs. The model uses economic inputs, anticipated production, and e&d scenarios as the basis for its calculations.

Both the gross environmental and social costs and the costs of replacement imports have been allocated to the program areas on the basis of production. The rationale for this decision is twofold. First, all benefits are allocated to the program areas where the production occurs; therefore, it would be inconsistent to do otherwise for costs. Second, and more importantly, if benefits and costs are not allocated to the area of production, it would be nearly impossible to maintain the cause-and-effect link between a decision to lease in a specific program area and the costs and benefits likely to result from that decision.

Table 5 includes net environmental and social costs for program areas in the proposed action and Alternatives 2, 3, and 4. Table 6 includes the sums of the net environmental and social costs for each of the program alternatives.

The OECM uses habitat equivalency analysis to overcome the problem of passive enjoyment value. Passive enjoyment value, also called passive use or non-use, is the benefit people derive from (1) knowing a natural resource continues to exist in a specific condition, (2) retaining the option to use that resource in the future, and (3) being able to pass the resource to future generations (which may be a subset of (2)). Passive enjoyment value represents an important component of the value of natural resources; however, it is very difficult and extremely expensive to measure accurately. Some economists question whether it can ever be measured accurately. Exacerbating the difficulty and expense of estimating passive enjoyment is the complication imposed on measurement by the vast extent of territory, many program areas, and great diversity of natural resources covered by this program. Habitat equivalency analysis avoids the passive enjoyment problem by estimating the cost of providing additional habitat equivalent to that lost from an environmental event such as an oil spill.

4.2. Consumer Surplus

The MMS calculates consumer surplus benefits associated with anticipated production using the MarketSim2000 model. To maintain consistency, this same model with the same assumptions is used for other portions of the 5-Year Program analysis. MarketSim2000 includes submodels for oil and natural gas.

4.2.1. Consumer Surplus – Oil

Consumer surplus attributable to OCS production is represented graphically by the areas shaded in stippling, vertically, horizontally, and crosshatching in figure 5. The equation that forms the basis for the oil submodel in the market simulation model includes a shift in oil price analogous to the price change in figure 5. Oil prices are set on a world market. Simulating a shift in world oil market equilibrium entails a simultaneous model with multiple sectors of demand and supply. However, obtaining information from many different sources compounds the data compatibility problem in an effort such as this one. Thus, this paper limits input data to five sources. Among these are the anticipated production estimates, e&d scenarios, and production profiles developed and modified by the MMS. Another source is data found in the U.S. Department of Energy, Energy Information Administration *Annual Energy Outlook 2000* (DOE (1999)). The final source is a set of demand and supply elasticity estimates developed by Foster Associates (Foster (2000)).

The DOE (1999) reports international oil production for five groups of countries and oil consumption for seven groups. The five groups on the production side were combined to form three: United States, OPEC, and Rest of World. The U.S. estimate was divided into OCS and onshore domestic to make a total of four production sectors. The consumption estimates were combined to form United States, Other OECD, OPEC, and Rest of World. Thus, the model contains four production and four consumption sectors for which Foster (2000) provides elasticity estimates. Retaining the constant elasticity functional form for the demand and supply sectors, the world oil market is represented by the following simultaneous system:

$$
\begin{aligned}
Q^{OCSS} &= b^{OCSS} P_0^{x^{OCSS}} \\
Q^{ODOMS} &= b^{ODOMS} P_0^{x^{ODOMS}} \\
Q^{OPECS} &= b^{OPECS} P_0^{x^{OPECS}} \\
Q^{ROWS} &= b^{ROWS} P_0^{x^{ROWS}} \\
Q^{USD} &= a^{USD} P_0^{h^{USD}} \\
Q^{OECDD} &= a^{OECDD} P_0^{h^{OECDD}} \\
Q^{OPECD} &= a^{OPECD} P_0^{h^{OPECD}} \\
Q^{ROWD} &= a^{ROWD} P_0^{h^{ROWD}} \\
Q^{OCSS} + Q^{ODOMS} + Q^{OPECS} + Q^{ROWS} &= Q^{USD} + Q^{OECDD} + Q^{OPECD} + Q^{ROWD}
\end{aligned}
\qquad (9)
$$

where the first four equations are the sectoral supply equations, the second four are the sectoral demand equations, and the last is the world oil market equilibrium equation.

The first step in calculating consumer surplus is to solve for the sectoral constants (a^s and b^s) in each of the demand and supply equations. Input to these equations consists of oil price, production quantity, and consumption quantity projections in 5-year intervals from the DOE (1999), plus the elasticity estimates from Foster (2000).

The model then introduces the sectoral constants back into the equation system, sets Q^{OCSS} to zero, and solves the system. The products of the solution are a new price without OCS production (P_1) and a new set of sectoral quantity estimates. The model next calculates consumer surplus using equation 7 where the *a* and the η are from the *USD* equation and the *b* and the ξ are from the *ODOMS* equation. It performs this sequence of actions for each year in the analysis period. The yearly estimates are allocated to program areas on the basis of the anticipated production in each program area in that year. Finally, the model takes the net present value of each vector of consumer surplus estimates allocated to each program area.

4.2.2. Consumer Surplus – Natural Gas

The natural gas submodel uses the same sources of input data as the oil submodel. However, unlike oil, imports constitute a relatively small fraction of U.S. natural gas consumption. As a result, the natural gas submodel includes only three production sectors (OCS, onshore domestic, and imports) and only a single domestic consumption sector. A second difference with oil is that the wellhead price of gas drives production while the delivered price drives consumption and the trends in these two prices may diverge. Therefore, the U.S. natural gas market can be represented by system 10

$$
\begin{aligned}
Q^{OCSS} &= b^{OCSS} P_{W0}^{x^{OCSS}} \\
Q^{ODOMS} &= b^{ODOMS} P_{W0}^{x^{ODOMS}} \\
Q^{IMPRTS} &= b^{IMPRTS} P_{W0}^{x^{IMPRTS}} \\
Q^{USD} &= a^{USD} P_{D0}^{h^{USD}} \\
Q^{OCSS} + Q^{ODOMS} + Q^{IMPRTS} &= Q^{USD} \\
P_{D0} &= P_{W0} + l
\end{aligned}
\qquad (10)
$$

where the first three equations are the sectoral supply equations, the fourth is the U.S. demand equation, the fifth is the market equilibrium equation, and the last is the price reconciliation equation in which ë equals the difference between wellhead and delivered natural gas prices.

The natural gas submodel follows the same steps as the oil submodel. The market simulation model adds the totals from oil and natural gas submodels to get total consumer surplus benefits by program area which are included in table 5. Table 6 includes the total consumer surplus benefits for each of the program alternatives.

5. Valuation of Program Alternatives

The ultimate purpose of the economic analysis for the new 5-Year Program is to help the Secretary select the best schedule of proposed sales. Those program areas with positive net benefits are appropriate for inclusion in the leasing program from an economic point of view. It should be remembered that decisionmakers can and should bring to their decisions other valid points of view besides economics. In other words, positive net benefits ought not to be the sole criterion for selecting any particular option or for including or excluding a program area from the leasing schedule.

Table 5 shows the estimates of net benefits for program areas in the proposed action and Alternatives 2, 3, and 4, as well as the totals for each of the categories of benefits and costs that went into calculating the net benefits. Only those program areas in Alternatives 2, 3, and 4 that are different from the proposed action are shown. Although the Hope Basin and Norton Basin Planning Areas had positive anticipated production, they are “uneconomic” in table 5. This is because anticipated production is based on factors that would hold if production occurs. The NEV estimates are based on economic factors that suggest whether or not any production will actually occur.

Table 6 shows the estimates of total net benefits for each of the program alternatives as well as the totals for each of the categories of benefits and costs that went into calculating the net benefits. Because each of the categories of benefits for each alternative is calculated in comparison to the No Action Alternative (Alternative 5), the No Action Alternative has no benefits or costs listed in the benefit categories. While Alternative 5 does have positive net benefits in the environmental and social costs category, these benefits are not shown because they have been included as costs under the other alternatives.

Table 5. Program Area Net Benefits *

Program Areas	Net Economic Value	Environmental Costs	Net Social Value	Consumer Surplus Benefits	Net Benefits
Alternative 1					
Western Gulf of Mexico	$1,967 $11,410	($65) ($108)	$1,902 $11,302	$701 $1,302	$2,603 $12,604
Central Gulf of Mexico	$3,445 $25,100	($112) ($219)	$3,333 $24,881	$1,403 $3,140	$4,736 $28,021
Eastern Gulf of Mexico	$10 $929	($2) ($3)	$8 $926	$89 $150	$97 $1,076
Beaufort Sea	$170 $4,328	($36) ($69)	$134 $4,259	$801 $1,342	$935 $5,601
Chukchi Sea	$257 $5,350	($24) ($63)	$233 $5,287	$635 $1,599	$868 $6,886
Cook Inlet	$267 $1,015	($10) ($14)	$259 $1,001	$218 $274	$477 $1,275
Hope Basin	** **	** **	** **	** **	** **
Norton Basin	** **	** **	** **	** **	** **
Alternative 2					
Eastern Gulf of Mexico	$7 $255	($1) ($2)	$6 $253	$58 $75	$64 $328
Beaufort Sea	$15 $2,571	($27) ($46)	($12) $2,525	$631 $1,057	$619 $3,582
Chukchi Sea	$257 $1,292	($28) ($40)	$229 $1,252	$754 $950	$983 $2,202
Cook Inlet	$110 $471	($6) ($8)	$104 $463	$129 $163	$233 $626
Hope Basin	** **	** **	** **	** **	** **
Alternative 4					
Eastern Gulf of Mexico	$22 $1,114	($2) ($5)	$20 $1,109	$110 $225	$130 $1,334
Beaufort Sea	$676 $6,833	($52) ($88)	$624 $6,745	$1,124 $1,883	$1,748 $8,628

*All figures in the table are in millions of 2002 dollars. Low scenario estimates are shown first, with high scenario estimates underneath.

**Net economic value is considered negligible. Assuming no exploration or other activity, environmental costs would not be incurred, and there would be no net social value or consumer surplus benefits.

Table 6. Valuation (Net Benefits) of Program Alternatives *

Program Areas	Net Economic Value	Environmental Costs	Net Social Value	Consumer Surplus Benefits	Net Benefits
Alternative 1 (Proposed Action)	$6,118 $48,132	($249) ($476)	$5,869 $47,656	$3,847 $7,807	$9,716 $55,463
Alternative 2 (Slow the Pace of Leasing)	$5,801 $41,099	($239) ($423)	$5,562 $40,676	$3,677 $6,689	$9,239 $47,365
Alternative 3 (Exclude Some Planning Areas)	$6,108 $47,203	($247) ($473)	$5,861 $46,730	$3,759 $7,659	$9,620 $54,389
Alternative 4 (Accelerated Leasing)	$6,636 $50,822	($328) ($497)	$6,308 $50,325	$4,191 $8,423	$10,499 $58,748

*All figures in the table are in millions of 2002 dollars. Low scenario estimates are shown first, with high scenario estimates underneath.

References

Boskin, Michael J., and Marc S. Robinson (1987). "The Value of Mineral Rights, Correction and Update." *American Economic Review* 77(5): 1073-4.

Boskin, Michael J., Marc S. Robinson, Terrance O'Reilly, and Praveen Kumar (1985). "New Estimates of the Value of Federal Mineral Rights and Land." *American Economic Review* 75(5): 923-36.

Foster, William G. (2000). *Petroleum Supply and Demand Elasticity Estimates*. Presented to the U.S. Department of the Interior, Minerals Management Service in partial fulfillment of Contract No. 1435-01-99-CT-30996.

Plater, J. R. and William W. Wade (2001). *Forecasting Environmental and Social Externalities Associated with OCS Oil and Gas Development: The Offshore Environmental Cost Model, Volume 1: Model Methodology, Documentation, and Sample Output*. MMS OCS Study 2001-017. U.S. Department of the Interior, Minerals Management Service, 76 pp.

Roach, Brian, William W. Wade, and J. R. Plater (2001). *Forecasting Environmental and Social Externalities Associated with OCS Oil and Gas Development: The Offshore Environmental Cost Model, Volume 2: Determinants of Environmental and Social Costs*. MMS OCS Study 2001-018. U.S. Department of the Interior, Minerals Management Service, 254 pp.

Rosenthal, Donald H., Marshall B. Rose, and Lawrence J. Slaski (1988). "Economic Value of the Oil and Gas Resources on the Outer Continental Shelf." *Marine Resource Economics* 5(2): 171-89.

U.S. Department of Energy, Energy Information Administration (1999). *Annual Energy Outlook 2000.* DOE/EIA-0383-2000.

U.S. Department of the Interior, Minerals Management Service (1996). Proposed Outer Continental Shelf Oil & Gas Leasing Program 1997 to 2002, Decision Document.

U.S. Department of the Interior, Minerals Management Service (2001). Outer Continental Shelf Petroleum Assessment 2000.

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.