Oil Production Capacity Expansion Costs For The Persian Gulf

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Preface

Oil Production Capacity Expansion Costs for the Persian Gulf provides estimates of development and operating costs for various size fields in countries surrounding the Persian Gulf. In addition, a forecast of the required reserve development and associated costs to meet the expected demand through the year 2010 is presented. This report takes a different approach than that normally seen in the literature. Results are based on geologic plays and their individual development costs rather than country-level economics. Petroconsultants *Estimator* database and software provided the cost data and field properties on which this analysis is based.

Organizations requesting specific information on the cost to develop Persian Gulf oil supplies include: the International Energy Agency, the U.S. Geological Survey, and the Department of Energy's Policy Office. Other customers include Congress, Federal and State agencies, industry analysts, financial institutions, the oil and gas industry, and

the general public. Publication of this report is in keeping with responsibilities given the Energy Information Administration (EIA) in Public Law 95-91/Section 205(a) and Section 657(2)(a) for gathering and disseminating foreign energy supply information.

General information about this publication may be obtained from Diane Lique, (202)586-6401, Director of the Office of Oil and Gas, or John Wood, (214)767-2200, Director of the Dallas Field Office.

This analysis is also available on a computer disk. The disk contains a Microsoft *Excel 5.0* workbook that allows a user to enter other data for each play and immediately see the results in summary tables and graphs for any other desired conditions. Specific information regarding the content or preparation of this publication may be obtained from the author, Gary Long, (214)767-0882, fax (214)767-2204 or glong@eia.doe.gov.

Oil Production Capacity Expansion Costs For The Persian Gulf

Summary

Countries surrounding the Persian Gulf supply 27 percent of world oil demand and 22 percent of U.S. imports. The Energy Information Administration's *International Energy Outlook* projects that, by the year 2010, these countries will be asked to supply 39 percent of the world's thirst for oil. U.S. imports are expected to grow 48 percent over the same time period. Persian Gulf oil supplies will increase in importance to both the global and U.S. oil markets. Persian Gulf countries will need to invest large sums to increase production capacity to meet the demand.

Persian Gulf oil development, production, and operating costs have received the attention of industry analysts in recent years[1,2]. Concerns range from the revenue available for the local economy, to the investment necessary to meet the expected growth in oil demand. The total cost of the projected capacity expansion is a relatively small percentage of the gross revenue. However, oil export revenues provide the vast majority of government income in the Persian Gulf countries. Typically, national oil companies have to compete with defense spending, social programs, and other government services for investment funds from their governments. Other options are for the government/company to borrow the investment funds or allow foreign companies to acquire equity positions. The advantages and disadvantages of these funding options vary among the Persian Gulf countries. Before the year 2010, the Persian Gulf countries will have to develop between 38 and 251 billion barrels of oil at a cost of 31 to 371 billion dollars to meet the expected demand for Persian Gulf oil.

This report attempts to quantify the cost of expanding oil production capacity using individual geologic plays in the countries surrounding the Persian Gulf through the year 2010. The countries included in this report are Iran, Iraq, Kuwait, Qatar, Saudi Arabia, Abu Dhabi, and Dubai.

Petroconsultants' *Estimator*[3] database and software were used to define eight geologic plays in formations of Mesozoic and Tertiary ages, both onshore and offshore. (Data for Saudi Arabia and Kuwait are not available in this database, but the surrounding plays are assumed to be representative for these countries.) Development and operating cost scenarios based on the three field sizes provided by *Estimator* for each play were defined yielding low-, mid-, and high-case values. Because this analysis is focused on oil, all gas production is assumed to be flared so that all costs are for oil production only. (In practice, the flaring of gas has been curtailed and normally is done only at remote locations.) All costs are in constant 1994 dollars (no inflation or discounting was used).

Costs for the eight plays and three field sizes were calculated and averaged for each of the three cases (low, mid, and high field sizes) to yield low-, mid-, and high-case cost estimates for the Persian Gulf area. The following summary table defines the investment cost in two ways: 1) the cost of increasing production capacity, 2) the cost of developing reserves. Also shown are the production operating expense and a peak daily production yield per developed reserves.

Field Size Case	Capital Invest/ Increased Capacity $/bbl/d	Capital Invest/ Developed Reserves $/bbl	Producing Operating Expense $/bbl	Daily Prod Yield per Reserves bopd/MMbbl
Low	4,866	1.70	1.49	322
Mid	2,784	0.66	0.99	227
High	2,515	0.57	1.03	218

The currently reported remaining oil reserves for the Persian Gulf countries of Iran, Iraq, Kuwait, Qatar, Saudi Arabia, Abu Dhabi, and Dubai are about 585 billion barrels (*World Oil*, August 1994). Current production is about 19 million barrels per day (assuming Iraqi production at pre-embargo rates). This yields an annual reserves-to-production (R/P) ratio of about 83. A country may more prudently develop its oil reserves at an R/P ratio near 20. Developing reserves that will not be produced for many years is economically unwise. Applying an annual R/P ratio of 20 to the current production rate yields an estimate of developed reserves of about 140 billion barrels. This leaves about 445 billion barrels of

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[1]"Yamani Predicts World Crude Price Likely to Falter Again in 1995," *Oil & Gas Journal* (April 17, 1995), pp. 26.

[2]Stauffer, Thomas R., "Trends in Oil Production Costs in the Middle East, Elsewhere," *Oil & Gas Journal (March 21, 1994), pp. 105-107.*

[3]Available from Petroconsultants, Inc. International Energy Services, Houston, Texas, ph. 713-995-1764. Petroconsultants collects, compiles, and analyzes information for the international oil exploration and production industry.

remaining undeveloped (or non-producing) oil reserves for the Persian Gulf area. (In addition, the U.S. Geological Survey estimates undiscovered resources of about 112 billion barrels for these same countries.)

The Energy Information Administration (EIA) forecasts oil production capacity from Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates to grow to from about 20 million barrels per day currently to 30.0 to 36.6 million barrels per day in the year 2010 (*International Energy Outlook 1995*). Applying the mid-case values from the summary table above to the projected production capacity requires additional developed reserves of 54 to 83 billion barrels at a cost of 34 to 53 billion dollars by the year 2010. This assumes current capacity can be maintained without replacing produced reserves from an equal quantity of undeveloped reserves. The undeveloped reserves determined above (445 billion barrels) are more than adequate to support the projected demand. This scenario does not include the replacement of produced reserves by the development of undeveloped reserves. Currently, the replacement of produced reserves is minor, but will grow to significant levels in the future (exact timing is unknown). (Appendix A contains tables and graphs that address the replacement of produced reserves using the same costs as used for adding capacity. If the replacement of production is included, the comparable volume of undeveloped reserves to be developed is 194 to 248 billion barrels at a cost of 127 to 161 billion dollars through 2010 (mid-case). The actual costs will likely be somewhere between those associated with no replacement of produced reserves and those associated with total replacement of produced reserves.)

This analysis is available on a computer disk from EIA's Dallas Field Office, telephone 214/767-2200 or 214/767-2204 fax. The disk contains a Microsoft *Excel 5.0* workbook that allows a user to enter other data for each play and immediately see the results in summary tables and graphs for any other desired conditions.

Geologic Plays

Selected Persian Gulf geologic plays were used for this analysis. A play is defined as a group of discovered and/or undiscovered fields with similar geologic, geographic, and temporal characteristics. For example, the Mesozoic Era of the Zagros fold-belt in Iran is one of the plays considered in this analysis. The particular parameters for each of the eight plays used here were determined using Petroconsultants' *Estimator* database and software.

The *Estimator* database contains field and production characteristics for each play. Three field sizes (ultimate recovery) provided by *Estimator* for each play are the basis for the low-, mid-, and high-cases. For example, in the database, the Zagros Mesozoic play in Iran contains 30, 200, and 1,000 million barrels for the three field sizes (Appendix B). The respective reservoir depths are 2,500, 6,000, and 12,500 feet. Well productivity is defined by 830, 1,520, and 2,790 barrels per day for this same play. Peak field production is determined as a percentage of the field size for the three cases. Appendix B contains the details for the eight plays used in this study. No data on geologic plays are available for Saudi Arabia and Kuwait. Information from the eight plays used is assumed to be representative of the countries addressed here.

Estimating Development Costs

Development costs include wells, production facilities, pipelines, construction, and management costs. Exploration costs are not included in this analysis since only partial development of the very large reserve base in the region is necessary to achieve the projected increase in production capacity. Development of discovered non-producing reserves will be more than adequate for the time period considered here (through 2010).

After selecting the field and production characteristics for a low-, mid-, and high-case in each play, *Estimator* determines the development costs. Peak field production, as a percentage of the field size, yields annual and daily peak field production. Peak field production determines the size and cost of the field's production facilities. Well productivity determines the number of wells and reservoir depth determines the cost of the wells. Other parameters, such as, the gas-oil ratio, terrain, remoteness, and a development well success ratio, are also included in the development cost estimate.

Estimating Operating Expenses

Operating expenses are based partially on the development cost and partially on the production rate. Five percent of the estimated development cost is used as an annual fixed operating expense. A variable operating expense of $0.25 to $1.00 per barrel of production is also included in the operating cost estimate. Well workovers were scheduled at a rate of one every other year per well and are included in the estimated operating expense as well. All operating expenses are for the peak production year.

Country and Play	Field Size MMbbl	Peak Field Prod bopd	Est Dev Cost MM$	Capital Invest per bbl of Annual Prod Cap $/bbl	Capital Invest per bbl of Daily Prod Cap $/bbl	Capital Invest per bbl of Reserves $/bbl	Peak Prod Year Oper Expense per Well $/month	Peak Prod Year Oper Expense per bbl of Prod $/bbl	Peak Daily Prod per Developed Reserves bopd/MMbbl
				Low Case Field Sizes					
Iran Zagros Tertiary	30	8,100	24.943	8.55	3,079	0.83	26,113	1.07	270
Iran Zagros Mesozoic	30	7,470	24.464	9.10	3,275	0.82	27,706	1.11	249
Iraq Zagros Tertiary	5	960	9.444	27.29	9,838	1.89	34,924	2.42	192
Iraq Zagros Mesozoic	5	960	9.444	27.29	9,838	1.89	34,924	2.42	192
Iraq Arabian Mesozoic	20	4,650	19.011	11.36	4,088	0.95	35,980	1.29	233
Abu Dhabi Arabian Mesozoic	10	4,000	15.411	10.70	3,853	1.54	39,623	1.32	400
Abu Dhabi Arabian Mesozoic Offshore	10	5,700	61.720	30.08	10,828	6.17	56,509	2.64	570
Offshore	25	11,680	65.103	15.48	5,574	2.60	81,494	1.86	467
Weighted Average (by Field Size)	**17**	**7,101**	**32.265**	**13.51**	**4,866**	**1.70**	**42,089**	**1.49**	**322**
				Mid Case Field Sizes					
Iran Zagros Tertiary	200	38,750	88.591	6.35	2,286	0.44	39,074	0.84	194
Iran Zagros Mesozoic	200	39,520	95.862	6.74	2,426	0.48	39,127	0.86	198
Iraq Zagros Tertiary	50	9,020	31.986	9.85	3,546	0.64	28,151	1.14	180
Iraq Zagros Mesozoic	50	9,020	31.986	9.85	3,546	0.64	28,151	1.14	180
Iraq Arabian Mesozoic	150	29,580	83.027	7.80	2,807	0.55	48,814	0.94	197
Abu Dhabi Arabian Mesozoic	200	49,830	110.571	6.16	2,219	0.55	36,351	0.80	249
Abu Dhabi Arabian Mesozoic Offshore	50	18,960	93.631	13.72	4,938	1.87	83,911	1.77	379
Offshore	75	26,510	108.115	11.33	4,078	1.44	116,622	1.61	353
Weighted Average (by Field Size)	**122**	**34,764**	**89.690**	**7.73**	**2,784**	**0.66**	**47,169**	**0.99**	**227**
				High Case Field Sizes					
Iran Zagros Tertiary	1,500	290,080	651.181	6.24	2,245	0.43	63,494	0.82	193
Iran Zagros Mesozoic	1,000	192,510	551.002	7.95	2,862	0.55	73,799	0.88	193
Iraq Zagros Tertiary	300	50,540	124.105	6.82	2,456	0.41	37,329	0.94	168
Iraq Zagros Mesozoic	300	50,540	124.105	6.82	2,456	0.41	37,329	0.94	168
Iraq Arabian Mesozoic	1,000	193,380	394.771	5.67	2,041	0.39	93,626	1.07	193
Abu Dhabi Arabian Mesozoic	1,000	248,640	508.546	5.68	2,045	0.51	63,791	0.95	249
Abu Dhabi Arabian Mesozoic Offshore	200	72,540	259.567	9.94	3,578	1.30	122,634	1.75	363
Offshore	500	166,760	694.332	11.57	4,164	1.39	211,970	1.86	334
Weighted Average (by Field Size)	**725**	**206,528**	**500.799**	**6.99**	**2,515**	**0.57**	**82,649**	**1.03**	**218**

Source: Petroconsultants *Estimator*.

Considering all fields in all plays, the lowest of the field production rates was given a $1.00 per barrel cost and the highest of the field production rates was given a $0.25 per barrel cost (variable operating expense portion). All other field production rates between the lowest and the highest were determined from a straight line connecting these two extremes on a log-log plot. The following equation defines this straight line.

$$Vari\ Oper\ Cost = 0.7714 * Field\ Rate^{-0.2423}$$

The variable operating cost for all low-case fields ranged from $0.54 to $1.00, all mid-case fields from $0.38 to $0.58, and all high-case fields from $0.25 to $0.38 per barrel of oil production.

Cost Ratios

After *Estimator* was used to determine the field and production characteristics, development costs, and operating expenses, several cost ratios were calculated. The development cost can be shown as: capital investment per barrel of annual production capacity, capital investment per barrel of daily production capacity, and capital investment per barrel of reserves or field size. Peak operating expenses can be shown as the peak operating expense per well or per barrel of peak year production (Table 1).

One additional item was calculated. The peak daily production per developed reserves or field size shows the daily production potential for each million barrels of newly developed reserves. The use of this number is explained later in the section *Projected Development and Costs*.

Persian Gulf Average Costs

Field sizes were used to determine weighted averages for the columns in Table 1. The low-case field sizes of the eight plays were weight-averaged to yield a low-case for the Persian Gulf. Weighted averages were also determined for the mid-case and high-case field sizes.

A typical field-size distribution for any given area would show many more small fields than large fields. The weighted averages as used here do not account for the number of fields of any particular size. Weighting the costs by total volume would be more accurate (field sizes x number of fields). However, neither the number of fields nor the field-size distribution is known so this is not possible.

Projected Development and Costs

EIA projects production capacity for the Persian Gulf countries of Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates (*International Energy Outlook 1995*). Production capacity for these countries is expected to be between 30.0 and 36.6 million barrels per day in the year 2010. The low-, mid-, and high-case development costs from Table 1 can be applied to the annual increase in the projected production capacity to yield a cumulative development cost in the year 2010 (Tables 2 and 3). Similarly, the peak daily production per developed reserves is inversely applied to the annual increase in production capacity to yield cumulative reserves developed by 2010.

For example, applying the mid-case weighted average costs to the production projections yields cumulative costs between 34 and 53 billion dollars to develop between 54 and 83 billion barrels of oil reserves. Low- and high-case weighted averages are applied in the same manner. As little as 31 billion dollars could be spent to develop 56 billion barrels of oil (high-case) or as much as 92 billion dollars to develop 59 billion barrels (low-case) (Figures 1 and 2).

Tables A1 and A2 show the same analysis but include the replacement of produced reserves by the development of undeveloped reserves. (Replacing produced reserves will maintain current oil production capacity.) If production replacement is included at the same cost as increasing capacity, then the mid-case would yield cumulative costs between 127 and 161 billion dollars to develop between 194 and 248 billion barrels of oil reserves. Looking at the low- and high-cases, as little as 111 billion dollars could be spent to develop 197 billion barrels of oil (high-case) or as much as 371 billion dollars to develop 223 billion barrels of oil (low-case) (Figures A1 and A2).

Figure 1 shows the three weighted average cumulative development costs applied to the low and high projected production capacity (same data as in Table 3). The result is a range of development costs for each of the low-, mid-, and high-case averages for the Persian Gulf. These ranges are depicted by pairs of lines with the same style (dotted, solid, and dashed). The cumulative reserves development is depicted similarly in Figure 2. The same application is used in Figures A1 and A2 for including the replacement of production.

Undeveloped Reserves Available

The reported remaining reserves for the Persian Gulf countries are about 585 billion barrels of oil (Table 4). Current production is estimated to be a little more than 19

Table 2. Persian Gulf Oil Production Capacity and Development Cost Forecast (without additional development to replace production)

| | IEO/95 Production Capacity Projections | | | | Based on *Low-Case* Weighted Average Development Costs | | | | Based on *Mid-Case* Weighted Average Development Costs | | | | Based on *High-Case* Weighted Average Development Costs | | | |
| | | | | | Low Capacity | | High Capacity | | Low Capacity | | High Capacity | | Low Capacity | | High Capacity | |
Year	Low Capacity MMbbl/d	High Capacity MMbbl/d	Low Capacity Change MMbbl/d	High Capacity Change MMbbl/d	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$
1990	18.6	18.6														
1991	16.2	16.2	-2.4	-2.4												
1992	17.7	17.7	1.5	1.5												
1993	18.6	19.2	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1994	19.6	20.7	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1995	20.5	22.1	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1996	21.5	23.6	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1997	22.4	25.1	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1998	23.3	26.6	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1999	24.3	28.0	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
2000	25.2	29.5	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
2001	25.6	30.2	0.4	0.7	1,241	1,946	2,295	3,601	1,763	1,114	3,262	2,060	1,834	1,006	3,393	1,861
2002	26.0	31.0	0.4	0.7	1,241	1,946	2,295	3,601	1,763	1,114	3,262	2,060	1,834	1,006	3,393	1,861
2003	26.4	31.7	0.4	0.7	1,241	1,946	2,295	3,601	1,763	1,114	3,262	2,060	1,834	1,006	3,393	1,861
2004	26.8	32.5	0.4	0.7	1,241	1,946	2,295	3,601	1,763	1,114	3,262	2,060	1,834	1,006	3,393	1,861
2005	27.2	33.2	0.4	0.7	1,241	1,946	2,295	3,601	1,763	1,114	3,262	2,060	1,834	1,006	3,393	1,861
2006	27.8	33.9	0.6	0.7	1,737	2,725	2,109	3,309	2,468	1,559	2,997	1,893	2,568	1,408	3,118	1,710
2007	28.3	34.6	0.6	0.7	1,737	2,725	2,109	3,309	2,468	1,559	2,997	1,893	2,568	1,408	3,118	1,710
2008	28.9	35.2	0.6	0.7	1,737	2,725	2,109	3,309	2,468	1,559	2,997	1,893	2,568	1,408	3,118	1,710
2009	29.4	35.9	0.6	0.7	1,737	2,725	2,109	3,309	2,468	1,559	2,997	1,893	2,568	1,408	3,118	1,710
2010	30.0	36.6	0.6	0.7	1,737	2,725	2,109	3,309	2,468	1,559	2,997	1,893	2,568	1,408	3,118	1,710
Totals			12.3	18.9	38,155	59,853	58,628	91,970	54,218	34,246	83,311	52,621	56,396	30,935	86,657	47,534
Averages			0.7	1.1	2,120	3,325	3,257	5,109	3,012	1,903	4,628	2,923	3,133	1,719	4,814	2,641

Sources: Production Capacity Projections from EIA *International Energy Outlook, 1995* (IEO/95), Reserves and Costs from Petroconsultants *Estimator*.

Table 3. Cumulative Persian Gulf Oil Production Capacity and Development Cost Forecast (without additional development to replace production)

Year	IEO/95 Production Capacity Projections				Based on *Low-Case* Weighted Average Development Costs				Based on *Mid-Case* Weighted Average Development Costs				Based on *High-Case* Weighted Average Development Costs			
			Low Capacity	High Capacity	Low Capacity		High Capacity		Low Capacity		High Capacity		Low Capacity		High Capacity	
	Low Capacity	High Capacity	Capacity Change	Capacity Change	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost
Year	MMbbl/d	MMbbl/d	MMbbl/d	MMbbl/d	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$
1990	18.6	18.6														
1991	16.2	16.2	-2.4	-2.4												
1992	17.7	17.7	1.5	1.5												
1993	18.6	19.2	0.9	1.5	2,908	4,562	4,575	7,178	4,132	2,610	6,502	4,107	4,298	2,358	6,763	3,710
1994	19.6	20.7	0.9	1.5	5,816	9,124	9,151	14,355	8,265	5,220	13,004	8,213	8,597	4,716	13,526	7,419
1995	20.5	22.1	0.9	1.5	8,724	13,686	13,726	21,533	12,397	7,831	19,505	12,320	12,895	7,073	20,289	11,129
1996	21.5	23.6	0.9	1.5	11,633	18,248	18,302	28,710	16,530	10,441	26,007	16,427	17,194	9,431	27,052	14,839
1997	22.4	25.1	0.9	1.5	14,541	22,810	22,877	35,888	20,662	13,051	32,509	20,533	21,492	11,789	33,814	18,548
1998	23.3	26.6	0.9	1.5	17,449	27,372	27,453	43,065	24,795	15,661	39,011	24,640	25,791	14,147	40,577	22,258
1999	24.3	28.0	0.9	1.5	20,357	31,934	32,028	50,243	28,927	18,271	45,512	28,747	30,089	16,505	47,340	25,967
2000	25.2	29.5	0.9	1.5	23,265	36,496	36,604	57,420	33,060	20,882	52,014	32,854	34,388	18,863	54,103	29,677
2001	25.6	30.2	0.4	0.7	24,506	38,442	38,899	61,021	34,823	21,995	55,276	34,914	36,222	19,869	57,496	31,538
2002	26.0	31.0	0.4	0.7	25,747	40,389	41,195	64,622	36,586	23,109	58,538	36,974	38,056	20,875	60,889	33,399
2003	26.4	31.7	0.4	0.7	26,988	42,335	43,490	68,223	38,349	24,223	61,800	39,035	39,890	21,881	64,282	35,260
2004	26.8	32.5	0.4	0.7	28,228	44,282	45,786	71,824	40,113	25,336	65,062	41,095	41,724	22,887	67,675	37,121
2005	27.2	33.2	0.4	0.7	29,469	46,228	48,081	75,425	41,876	26,450	68,324	43,155	43,558	23,893	71,068	38,983
2006	27.8	33.9	0.6	0.7	31,206	48,953	50,191	78,734	44,344	28,009	71,321	45,048	46,125	25,301	74,186	40,693
2007	28.3	34.6	0.6	0.7	32,943	51,678	52,300	82,043	46,813	29,568	74,318	46,942	48,693	26,709	77,303	42,403
2008	28.9	35.2	0.6	0.7	34,681	54,403	54,409	85,352	49,281	31,127	77,316	48,835	51,260	28,118	80,421	44,113
2009	29.4	35.9	0.6	0.7	36,418	57,128	56,519	88,661	51,750	32,687	80,313	50,728	53,828	29,526	83,539	45,823
2010	30.0	36.6	0.6	0.7	38,155	59,853	58,628	91,970	54,218	34,246	83,311	52,621	56,396	30,935	86,657	47,534

Sources: Production Capacity Projections from EIA *International Energy Outlook, 1995* (IEO/95), Reserves and Costs from Petroconsultants *Estimator, and Table 2.*

million barrels per day (assuming Iraqi production at pre-embargo levels). This gives an annual reserves-to-production ratio (R/P) of about 83. Not all of the 585 billion barrels of remaining reserves are developed and ready for production. Developing reserves that may not be produced for 80 years is economically unwise. Assuming a more prudent R/P ratio of 20 and working backwards gives an indication of the reserves currently developed for production. An R/P ratio of 20 indicates developed reserves of 140 billion barrels leaving about 445 billion barrels undeveloped. The following table shows developed and undeveloped reserves for annual R/P ratios from 10 to 30. The U.S. Geological Survey has estimated another 112 billion barrels yet to be discovered for the Persian Gulf countries (*World Petroleum Assessment and Analysis*, World Petroleum Congress, May 1994, modal values).

R/P Ratio	Developed Reserves Billion barrels	Undeveloped Reserves Billion barrels
10	70	514
15	105	479
20	140	445
25	174	410
30	208	376

From 1994 through 2010, cumulative production will be between 134 and 158 billion barrels of oil (assuming production at 85 percent of projected capacity) (Tables 5 and 7, Figure 3). In the year 2010, remaining reserves will be between 426 and 450 billion barrels (assuming no discoveries). The annual R/P ratio in 2010 will be between 37 and 48, about half the current R/P ratio. Undeveloped reserves in the year 2010 will be between 199 and 264 billion barrels using an R/P ratio of 20 to determine the developed reserves. This compares to the current undeveloped reserves of 445 billion barrels. The developed producing reserves currently at about 140 billion barrels will increase to between 186 and 227 billion barrels. These changes reflect the transfer of undeveloped to developed

reserves and the reduction of total reserves due to production.

Conclusions

Table 6 shows a summary comparison of the two mid-case development possibilities (with and without reserves replacement). Currently, complete replacement of produced reserves is not necessary to maintain current capacity, but it will be necessary in the future. Likewise, some of the reserves development in an existing field will not cost as much as the reserves development for new fields because of the existing equipment and infrastructure. Actual costs probably lie somewhere between these two scenarios. Through 2010, oil reserves that would be developed are between 54 and 248 billion barrels (mid-case). The cost to develop these reserves is between 34 and 161 billion dollars. Total development costs plus operating expenses will consume 7 to 12 percent of gross revenues assuming a $17/bbl oil price. Similarly, total development costs plus incremental operating costs will consume 11 to 26 percent of the incremental gross revenue. Potentially, by the year 2010, hundreds of billions of dollars will have been spent to develop hundreds of billion barrels of oil. Production capacity will have increased by 53 to 77 percent, remaining reserves will be 23 to 27 percent less, developed reserves will have increased 33 to 62 percent, while undeveloped reserves dropped by 41 to 55 percent.

Other Possible Scenarios

All of the data and calculations for this analysis are contained in an *Excel 5.0* workbook. A computer disk containing these spreadsheets is available from the Dallas Field Office of EIA (214)767-2200, (214)767-2204 fax. The spreadsheets are linked in a way that allows the user to easily enter different costs, production capacity forecasts, and reserve data to test other scenarios.

**Figure 1. Persian Gulf Projected Cumulative Development Costs Using
High and Low Production Capacity Projections**
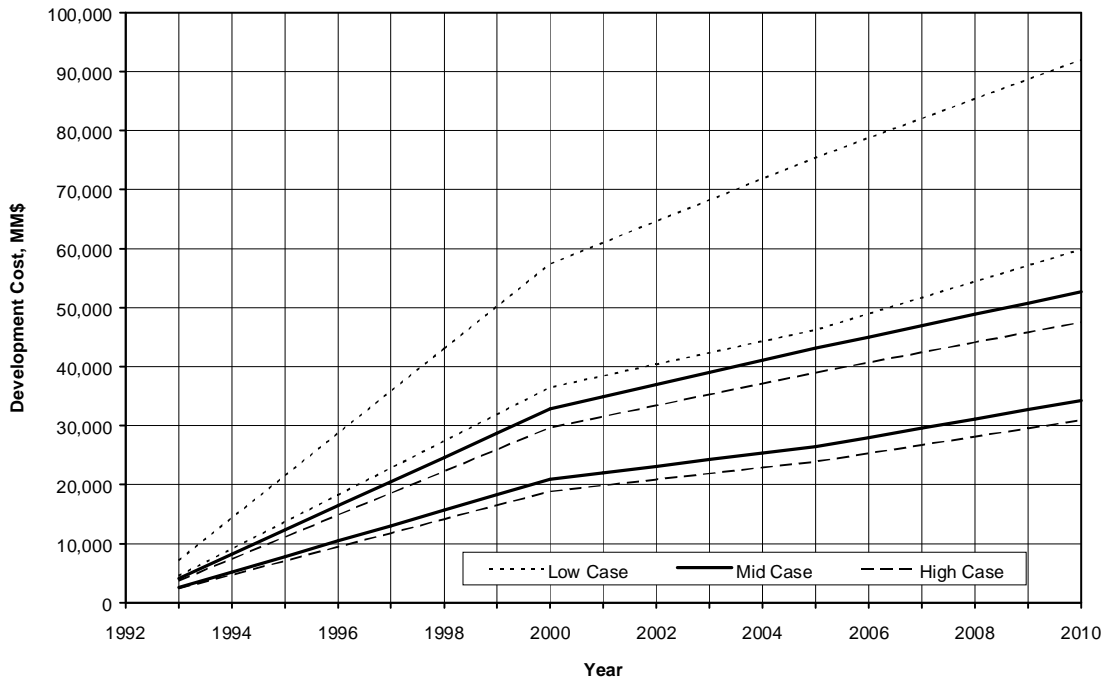
Note: Each case is bracketed by a pair of lines.
Source: Table 3.

**Figure 2. Persian Gulf Projected Cumulative Reserves Development Using
High and Low Production Capacity Projections**

Note: Each case is bracketed by a pair of lines.
Source: Table 3.

**Energy Information Administration
Oil Production Capacity Expansion Costs for the Persian Gulf**
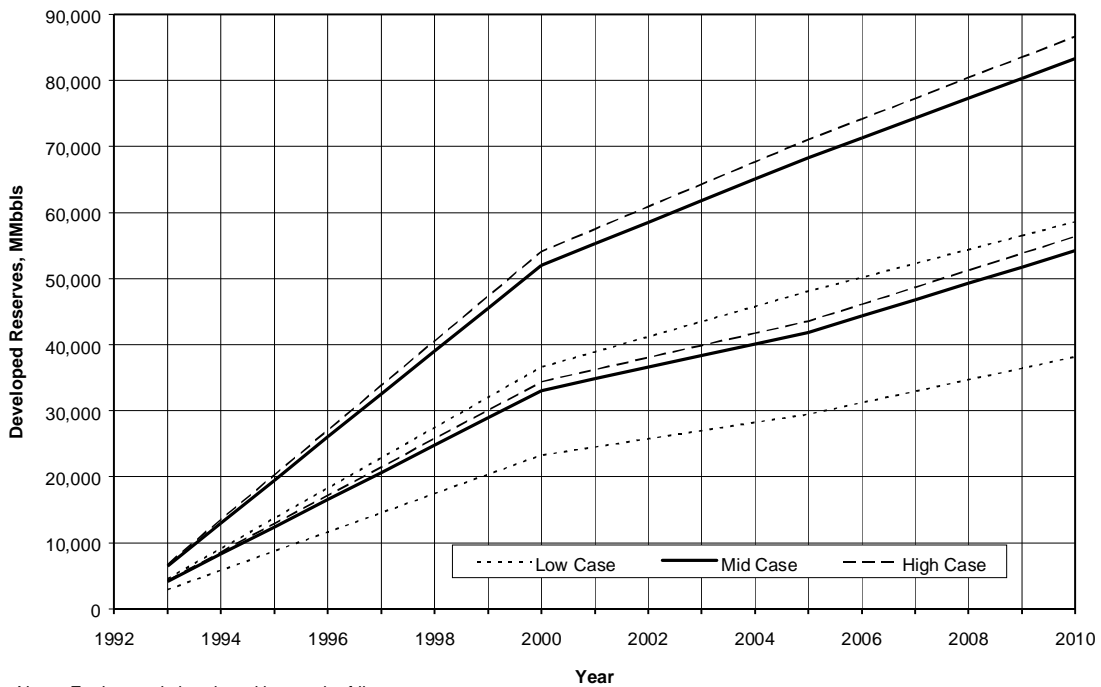
<u>**Table 4. Persian Gulf Oil Reserves, Oil Production, and Undiscovered Oil Resources, 1993**</u>

	Remaining Reserves MMbbls	Daily Prod bopd	Current R/P	Undeveloped Reserves for R/P= 20 MMbbls	Producing Reserves MMbbls	Undiscovered Resources MMbbls
Iran	59,964	3,600,000	45.6	33,684	26,280	19,000
Iraq	99,628	2,897,000	94.2	78,480	21,148	35,000
Kuwait	94,241	2,033,000	127.0	79,400	14,841	3,000
Qatar	4,192	448,000	25.6	922	3,270	0
Saudi Arabia	262,430	8,133,000	88.4	203,059	59,371	51,000
Abu Dhabi	62,975	1,887,000	91.4	49,200	13,775	4,200
Dubai	1,083	350,000	8.5	0	1,083	- -
Totals	**584,513**	**19,348,000**	**82.8**	**444,744**	**139,769**	**112,200**

Note: Saudi Arabia and Kuwait each include half of the Neutral Zone. Abu Dhabi Undiscovered Resources include Dubai. Iraqi production rate prior to Gulf War. R/P indicates annual Reserves-to-Production Ratio.

Source: Reserves are from *World Oil,* August 1994. Daily Production is from *World Oil* and *EIA's International Petroleum Statistics Report* (DOE/EIA-0520(95/01)). Undiscovered Resources are modal values from *World Petroleum Assessment and Analysis*, U.S. Geological Survey, 14th World Petroleum Congress, May 1994.

Figure 3. Persian Gulf Historical Oil Production and High-Low Production Capacity Projections

Source: Table 7.

Energy Information Administration
Oil Production Capacity Expansion Costs for the Persian Gulf

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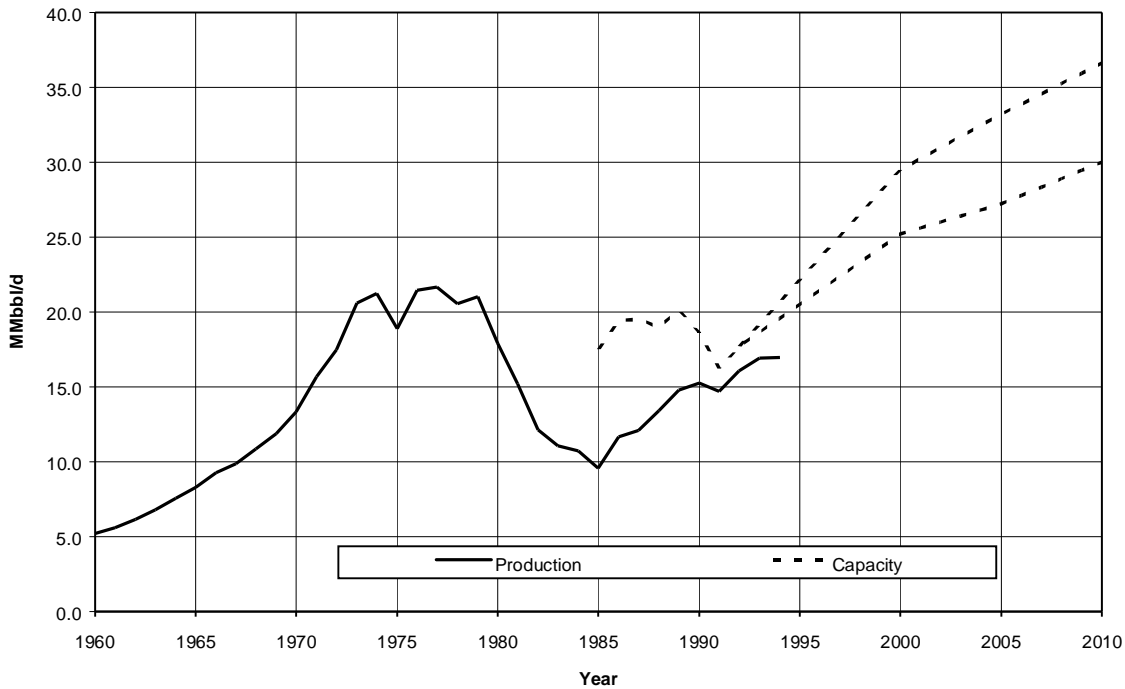
Table 5. Persian Gulf Situation in 1994 and 2010 in Relation to High-Low Production Capacity Projections

	1994		2010		Change		Percent Change	
	Low	High	Low	High	Low	High	Low	High
Oil Production Capacity, MMbbl/d	19.6	20.7	30.0	36.6	**10.4**	**16.0**	**53**	**77**
Daily Oil Production, MMbbl/d	19.3	19.3	25.5	31.1	**6.2**	**11.8**	**32**	**61**
Cumulative Oil Production, Bbbls	0	0	134	158	**134**	**158**	**na**	**na**
Remaining Reserves, Bbbls	585	585	426	450	**-158**	**-134**	**-27**	**-23**
R/P Ratio	82.8	82.8	37.5	48.4	**-45.2**	**-34.4**	**-55**	**-42**
Developed Reserves, Bbbls	140	140	186	227	**46**	**87**	**33**	**62**
Undeveloped Reserves, Bbbls	445	445	199	264	**-246**	**-181**	**-55**	**-41**

Note: Assumes an R/P ratio for developed reserves of 20 with no new discoveries. Cumulative production is from 1994-2010.
Daily Oil Production assumes pre-embargo Iraqi production.
Source: Energy Information Administration, Office of Oil and Gas.

Table 6. Summary Results with and without Repalcement of Produced Reserves (Mid-Case Only, 1994-2010)

	Without Replacement Of Produced Reserves		With Replacement Of Produced Reserves	
	Low Capacity	High Capacity	Low Capacity	High Capacity
Average Annual Developed Reserves, MMbbl	3,012	4,628	10,803	13,761
Total Developed Reserves, MMbbl	54,218	83,311	194,461	247,691
Average Annual Development Cost, MM$	1,903	2,923	7,047	8,953
Total Development Cost, MM$	34,246	52,621	126,844	161,158
Total Gross Revenue at $17/bbl, MM$	2,285,822	2,693,327	2,285,822	2,693,327
Total Development + Total Operating Expense, MM$	167,237	209,322	259,836	317,858
Total Development + Total Operating Expense as a Percentage of Gross Revenue	7.32%	7.77%	11.37%	11.80%
Total Incremental Gross Revenue at $17/bbl, MM$	614,742	974,054	614,742	974,054
Total Development + Total Incremental Oper Expense, MM$	70,012	109,293	162,611	217,829
Total Development + Total Incremental Oper Expense as a Percentage of Incremental Gross Revenue	11.39%	11.22%	26.45%	22.36%

Note: All costs and revenues are in nominal dollars.
Sources: Petroconsultants *Estimator*, and Energy Information Administration, Office of Oil and Gas.

Table 7. Annual Historical Production and Production Capacity Projections of the Persian Gulf, MMbbl/d

	Iran	Iraq	Kuwait	Qatar	Saudi Arabia	U.A.E.	Production Total	Low IEO Capacity Projection	High IEO Capacity Projection
1960	1.07	0.97	1.69	0.17	1.31		5.2		
1961	1.20	1.01	1.73	0.18	1.48		5.6		
1962	1.34	1.01	1.96	0.19	1.64	0.02	6.1		
1963	1.49	1.16	2.09	0.19	1.79	0.05	6.8		
1964	1.71	1.26	2.30	0.21	1.90	0.18	7.6		
1965	1.91	1.31	2.35	0.23	2.21	0.28	8.3		
1966	2.13	1.39	2.49	0.29	2.60	0.36	9.3		
1967	2.60	1.23	2.50	0.32	2.81	0.38	9.8		
1968	2.84	1.50	2.64	0.34	3.04	0.50	10.9		
1969	3.38	1.52	2.80	0.36	3.22	0.61	11.9		
1970	3.83	1.55	2.99	0.36	3.80	0.78	13.3		
1971	4.54	1.69	3.20	0.43	4.77	1.06	15.7		
1972	5.02	1.47	3.28	0.48	6.02	1.20	17.5		
1973	5.86	2.02	3.02	0.57	7.60	1.53	20.6		
1974	6.02	1.97	2.55	0.52	8.48	1.68	21.2		
1975	5.35	2.26	2.08	0.44	7.08	1.66	18.9		
1976	5.88	2.42	2.15	0.50	8.58	1.94	21.5		
1977	5.66	2.35	1.97	0.45	9.25	2.00	21.7		
1978	5.24	2.56	2.13	0.49	8.30	1.83	20.6		
1979	3.17	3.48	2.50	0.51	9.53	1.83	21.0		
1980	1.66	2.51	1.66	0.47	9.90	1.71	17.9		
1981	1.38	1.00	1.13	0.41	9.82	1.47	15.2		
1982	2.21	1.01	0.82	0.33	6.48	1.25	12.1		
1983	2.44	1.01	1.06	0.30	5.09	1.15	11.0		
1984	2.17	1.21	1.16	0.39	4.66	1.15	10.7		
1985	2.25	1.43	1.02	0.30	3.39	1.19	9.6	17.5	
1986	2.04	1.69	1.42	0.31	4.87	1.33	11.7	19.4	
1987	2.30	2.08	1.59	0.29	4.27	1.54	12.1	19.5	
1988	2.24	2.69	1.49	0.35	5.09	1.57	13.4	19.0	
1989	2.81	2.90	1.78	0.38	5.06	1.86	14.8	20.1	
1990	3.09	2.04	1.18	0.41	6.41	2.12	15.2	18.6	
1991	3.31	0.31	0.19	0.40	8.12	2.39	14.7	16.2	
1992	3.43	0.45	1.03	0.40	8.44	2.33	16.1	17.7	17.7
1993	3.65	0.51	1.87	0.41	8.20	2.24	16.9	18.6	19.2
1994	3.60	0.55	2.03	0.41	8.15	2.23	17.0	19.6	20.7
1995								20.5	22.1
1996								21.5	23.6
1997								22.4	25.1
1998								23.3	26.6
1999								24.3	28.0
2000								25.2	29.5
2001								25.6	30.2
2002								26.0	31.0
2003								26.4	31.7
2004								26.8	32.5
2005								27.2	33.2
2006								27.8	33.9
2007								28.3	34.6
2008								28.9	35.2
2009								29.4	35.9
2010								30.0	36.6

Source: EIA *International Energy Outlook, 1995* (IEO), EIA *Annual Energy Review, 1993*, and EIA *International Oil and Gas Exploration and Development, 1991*.

Appendix A
Replacing Production with Additional Development

Table A1. Persian Gulf Oil Production Capacity and Development Cost Forecast with Additional Development to Replace Production

| | IEO/95 Production Capacity Projections | | | | Based on *Low-Case* Weighted Average Development Costs | | | | Based on *Mid-Case* Weighted Average Development Costs | | | | Based on *High-Case* Weighted Average Development Costs | | | |
| | | | | | Low Capacity | | High Capacity | | Low Capacity | | High Capacity | | Low Capacity | | High Capacity | |
Year	Low Capacity MMbbl/d	High Capacity MMbbl/d	Low Capacity Change MMbbl/d	High Capacity Change MMbbl/d	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$	Developed Reserves MMbbl	Annual Dev Cost MM$
1990	18.6	18.6														
1991	16.2	16.2	-2.4	-2.4												
1992	17.7	17.7	1.5	1.5												
1993	18.6	19.2	0.9	1.5	8,690	14,394	10,525	17,293	9,915	6,428	12,451	8,035	10,081	5,655	12,712	7,102
1994	19.6	20.7	0.9	1.5	8,981	14,888	10,982	18,071	10,206	6,620	12,908	8,337	10,372	5,821	13,170	7,363
1995	20.5	22.1	0.9	1.5	9,272	15,383	11,440	18,849	10,496	6,812	13,366	8,639	10,662	5,987	13,627	7,624
1996	21.5	23.6	0.9	1.5	9,581	15,908	11,917	19,661	10,806	7,016	13,844	8,954	10,972	6,163	14,105	7,897
1997	22.4	25.1	0.9	1.5	9,854	16,372	12,355	20,405	11,078	7,196	14,281	9,243	11,244	6,319	14,542	8,146
1998	23.3	26.6	0.9	1.5	10,145	16,866	12,813	21,183	11,369	7,388	14,739	9,545	11,535	6,485	15,000	8,407
1999	24.3	28.0	0.9	1.5	10,436	17,361	13,270	21,961	11,660	7,580	15,197	9,848	11,826	6,651	15,458	8,668
2000	25.2	29.5	0.9	1.5	10,748	17,892	13,753	22,782	11,972	7,787	15,679	10,166	12,138	6,829	15,940	8,943
2001	25.6	30.2	0.4	0.7	9,183	15,451	11,677	19,553	9,706	6,358	12,644	8,255	9,776	5,535	12,775	7,211
2002	26.0	31.0	0.4	0.7	9,307	15,662	11,907	19,943	9,830	6,440	12,873	8,407	9,901	5,606	13,004	7,342
2003	26.4	31.7	0.4	0.7	9,431	15,873	12,137	20,334	9,954	6,522	13,103	8,558	10,025	5,677	13,234	7,473
2004	26.8	32.5	0.4	0.7	9,578	16,123	12,394	20,771	10,101	6,619	13,360	8,728	10,171	5,761	13,491	7,620
2005	27.2	33.2	0.4	0.7	9,680	16,295	12,596	21,115	10,202	6,686	13,562	8,861	10,273	5,818	13,693	7,735
2006	27.8	33.9	0.6	0.7	10,350	17,369	12,621	21,181	11,081	7,246	13,509	8,834	11,180	6,320	13,629	7,705
2007	28.3	34.6	0.6	0.7	10,523	17,664	12,832	21,540	11,255	7,361	13,720	8,973	11,354	6,419	13,840	7,825
2008	28.9	35.2	0.6	0.7	10,722	18,001	13,073	21,950	11,453	7,491	13,961	9,132	11,552	6,532	14,081	7,962
2009	29.4	35.9	0.6	0.7	10,871	18,255	13,254	22,257	11,602	7,590	14,142	9,251	11,701	6,617	14,262	8,065
2010	30.0	36.6	0.6	0.7	11,045	18,551	13,465	22,616	11,776	7,705	14,353	9,391	11,875	6,716	14,473	8,186
Totals			12.3	18.9	178,397	298,307	223,008	371,465	194,461	126,844	247,691	161,158	196,638	110,912	251,037	141,276
Averages			0.7	1.1	9,911	16,573	12,389	20,637	10,803	7,047	13,761	8,953	10,924	6,162	13,946	7,849

Note: Production is assumed to be 85 percent of capacity.

Sources: Production Capacity Projections from EIA *International Energy Outlook, 1995* (IEO/95), Reserves and Costs from Petroconsultants *Estimator*.
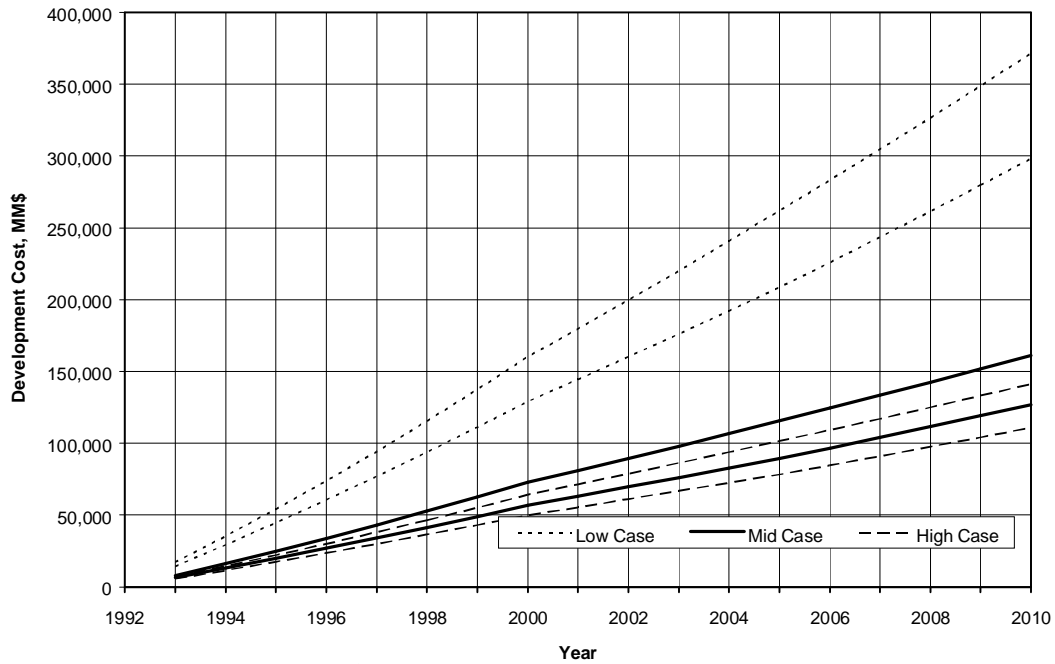
Table A2. Cumulative Persian Gulf Oil Production Capacity and Development Cost Forecast with Additional Development to Replace Production

	IEO/95 Production Capacity Projections				Based on *Low Case*-Weighted Average Development Costs				Based on *Mid-Case* Weighted Average Development Costs				Based on *High-Case* Weighted Average Development Costs			
			Low Capacity	High Capacity	Low Capacity		High Capacity		Low Capacity		High Capacity		Low Capacity		High Capacity	
	Low Capacity	High Capacity	Capacity Change	Capacity Change	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost	Developed Reserves	Annual Dev Cost
Year	MMbbl/d	MMbbl/d	MMbbl/d	MMbbl/d	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$	MMbbl	MM$
1990	18.6	18.6														
1991	16.2	16.2	-2.4	-2.4												
1992	17.7	17.7	1.5	1.5												
1993	18.6	19.2	0.9	1.5	8,690	14,394	10,525	17,293	9,915	6,428	12,451	8,035	10,081	5,655	12,712	7,102
1994	19.6	20.7	0.9	1.5	17,672	29,282	21,507	35,363	20,120	13,048	25,359	16,372	20,452	11,477	25,882	14,465
1995	20.5	22.1	0.9	1.5	26,944	44,664	32,946	54,212	30,617	19,860	38,725	25,011	31,115	17,464	39,509	22,090
1996	21.5	23.6	0.9	1.5	36,525	60,573	44,864	73,873	41,422	26,877	52,569	33,965	42,086	23,627	53,614	29,986
1997	22.4	25.1	0.9	1.5	46,379	76,944	57,219	94,278	52,501	34,073	66,850	43,208	53,331	29,946	68,156	38,132
1998	23.3	26.6	0.9	1.5	56,524	93,811	70,031	115,462	63,870	41,461	81,589	52,754	64,866	36,430	83,156	46,539
1999	24.3	28.0	0.9	1.5	66,959	111,172	83,302	137,423	75,530	49,042	96,786	62,601	76,691	43,081	98,614	55,207
2000	25.2	29.5	0.9	1.5	77,707	129,064	97,055	160,205	87,502	56,828	112,465	72,768	88,830	49,910	114,554	64,151
2001	25.6	30.2	0.4	0.7	86,890	144,514	108,732	179,758	97,207	63,186	125,109	81,023	98,606	55,445	127,329	71,362
2002	26.0	31.0	0.4	0.7	96,198	160,176	120,639	199,701	107,037	69,626	137,982	89,429	108,507	61,051	140,333	78,705
2003	26.4	31.7	0.4	0.7	105,629	176,049	132,776	220,035	116,991	76,148	151,085	97,988	118,531	66,728	153,567	86,178
2004	26.8	32.5	0.4	0.7	115,207	192,172	145,170	240,806	127,092	82,766	164,445	106,716	128,703	72,489	167,059	93,798
2005	27.2	33.2	0.4	0.7	124,887	208,467	157,765	261,921	137,294	89,452	178,008	115,577	138,975	78,307	180,752	101,533
2006	27.8	33.9	0.6	0.7	135,237	225,836	170,386	283,102	148,375	96,698	191,516	124,410	150,156	84,627	194,381	109,237
2007	28.3	34.6	0.6	0.7	145,760	243,500	183,218	304,642	159,629	104,058	205,236	133,383	161,509	91,046	208,221	117,062
2008	28.9	35.2	0.6	0.7	156,482	261,501	196,290	326,591	171,082	111,550	219,197	142,515	173,062	97,578	222,302	125,025
2009	29.4	35.9	0.6	0.7	167,353	279,757	209,544	348,849	182,685	119,140	233,338	151,767	184,763	104,195	236,564	133,090
2010	30.0	36.6	0.6	0.7	178,397	298,307	223,008	371,465	194,461	126,844	247,691	161,158	196,638	110,912	251,037	141,276

Note: Production is assumed to be 85 percent of capacity.

Sources: Production Capacity Projections from EIA *International Energy Outlook, 1995* (IEO/95), Reserves and Costs from Petroconsultants *Estimator, Table A1.*

Figure A1. Persian Gulf Projected Cumulative Development Cost with Additional Development to Replace Production Using High and Low Production Capacity Projections

Note: Each case is bracketed by a pair of lines.
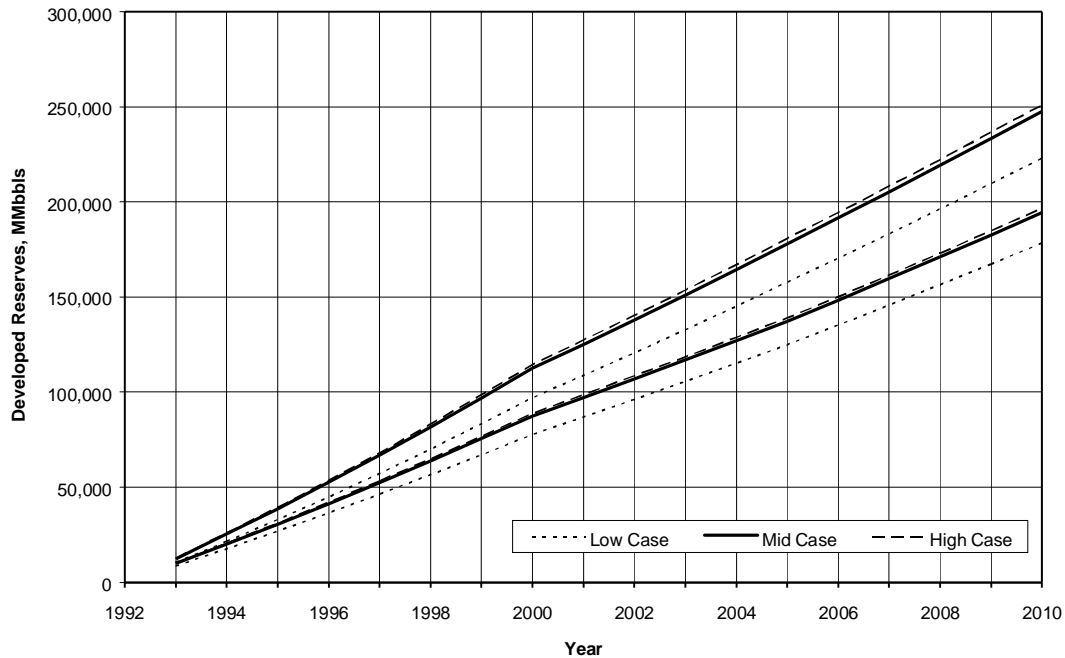Source: Table A2.

Figure A2. Persian Gulf Projected Cumulative Reserves Development with Additional Development to Replace Production Using High and Low Production Capacity Projections

Note: Each case is bracketed by a pair of lines.
Source: Table A2.

Appendix B
Development Costs for
Persian Gulf Geologic Plays

Table B1. Estimated Development Costs for Zagros Tertiary Play in Iran

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	30	200	1,500
Peak Production, % of Field Size	9	7	7
Production Plateau, yr	3.8	5	5.8
Peak Field Production, bopd	8,100	38,750	290,080
Peak Field Production, MMbbls/yr	2.916	13.950	104.429
Production Decline Rate, %	13	10	8
Well Productivity, bopd	810	1,550	2,590
GOR, scf/bbl	100	500	1000
Reservoir Depth, ft	2,500	6,000	12,500
Oil Pipeline, km	10	25	150
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	10	25	112
Dry Holes	3	3	6
Total Development Cost, $MM	24.943	88.591	651.181
Peak Operating Expense, $MM/yr	3.134	11.722	85.336
Capital Invest per Well, $MM	**1.92**	**3.16**	**5.52**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**8.55**	**6.35**	**6.24**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**3,079**	**2,286**	**2,245**
Capital Invest per bbl of Reserves, $/bbl	**0.83**	**0.44**	**0.43**
Peak Production Year Operating Expense per Well, $/mo	**26,113**	**39,074**	**63,494**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**1.07**	**0.84**	**0.82**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**270**	**194**	**193**

Source: Petroconsultants *Estimator*.

Table B2. Estimated Development Costs for Zagros Mesozoic Play in Iran

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	30	200	1,000
Peak Production, % of Field Size	9	7	7
Production Plateau, yr	3.8	5	5.8
Peak Field Production, bopd	7,470	39,520	192,510
Peak Field Production, MMbbls/yr	2.689	14.227	69.304
Production Decline Rate, %	13	10	8
Well Productivity, bopd	830	1,520	2,790
GOR, scf/bbl	100	500	1,000
Reservoir Depth, ft	2,500	6,000	12,500
Oil Pipeline, km	10	25	150
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	9	26	69
Dry Holes	3	3	4
Total Development Cost, $MM	24.464	95.862	551.002
Peak Operating Expense, $MM/yr	2.992	12.208	61.106
Capital Invest per Well, $MM	**2.04**	**3.31**	**7.55**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**9.10**	**6.74**	**7.95**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**3,275**	**2,426**	**2,862**
Capital Invest per bbl of Reserves, $/bbl	**0.82**	**0.48**	**0.55**
Peak Production Year Operating Expense per Well, $/mo	**27,706**	**39,127**	**73,799**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**1.11**	**0.86**	**0.88**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**249**	**198**	**193**

Source: Petroconsultants *Estimator*.

Table B3. Estimated Development Costs for Zagros Tertiary Play in Iraq

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	5	50	300
Peak Production, % of Field Size	7	6	6
Production Plateau, yr	5	5.8	7
Peak Field Production, bopd	960	9,020	50,540
Peak Field Production, MMbbls/yr	0.346	3.247	18.194
Production Decline Rate, %	10	8	7
Well Productivity, bopd	480	820	1,330
GOR, scf/bbl	100	250	1,000
Reservoir Depth, ft	3,500	4,000	6,500
Oil Pipeline, km	10	50	100
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	2	11	38
Dry Holes	1	2	2
Total Development Cost, $MM	9.444	31.986	124.105
Peak Operating Expense, $MM/yr	0.838	3.716	17.022
Capital Invest per Well, $MM	**3.15**	**2.46**	**3.10**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**27.29**	**9.85**	**6.82**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**9,838**	**3,546**	**2,456**
Capital Invest per bbl of Reserves, $/bbl	**1.89**	**0.64**	**0.41**
Peak Production Year Operating Expense per Well, $/mo	**34,924**	**28,151**	**37,329**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**2.42**	**1.14**	**0.94**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**192**	**180**	**168**

Source: Petroconsultants *Estimator*.

Table B4. Estimated Development Costs for Zagros Mesozoic Play in Iraq

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	5	50	300
Peak Production, % of Field Size	7	6	6
Production Plateau, yr	5	5.8	7
Peak Field Production, bopd	960	9,020	50,540
Peak Field Production, MMbbls/yr	0.346	3.247	18.194
Production Decline Rate, %	10	8	7
Well Productivity, bopd	480	820	1,330
GOR, scf/bbl	100	250	1,000
Reservoir Depth, ft	3,500	4,000	6,500
Oil Pipeline, km	10	50	100
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	2	11	38
Dry Holes	1	2	2
Total Development Cost, $MM	9.444	31.986	124.105
Peak Operating Expense, $MM/yr	0.838	3.716	17.022
Capital Invest per Well, $MM	**3.15**	**2.46**	**3.10**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**27.29**	**9.85**	**6.82**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**9,838**	**3,546**	**2,456**
Capital Invest per bbl of Reserves, $/bbl	**1.89**	**0.64**	**0.41**
Peak Production Year Operating Expense per Well, $/mo	**34,924**	**28,151**	**37,329**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**2.42**	**1.14**	**0.94**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**192**	**180**	**168**

Source: Petroconsultants *Estimator*.

Table B5. Estimated Development Costs for Arabian Mesozoic Play in Iraq

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	20	150	1000
Peak Production, % of Field Size	8	7	7
Production Plateau, yr	4.3	5	7
Peak Field Production, bopd	4,650	29,580	193,380
Peak Field Production, MMbbls/yr	1.674	10.649	69.617
Production Decline Rate, %	12	10	7
Well Productivity, bopd	930	1,740	2,930
GOR, scf/bbl	100	500	2,500
Reservoir Depth, ft	6,500	10,000	11,000
Oil Pipeline, km	5	10	50
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	5	17	66
Dry Holes	2	2	4
Total Development Cost, $MM	19.011	83.027	394.771
Peak Operating Expense, $MM/yr	2.159	9.958	74.152
Capital Invest per Well, $MM	**2.72**	**4.37**	**5.64**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**11.36**	**7.80**	**5.67**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**4,088**	**2,807**	**2,041**
Capital Invest per bbl of Reserves, $/bbl	**0.95**	**0.55**	**0.39**
Peak Production Year Operating Expense per Well, $/mo	**35,980**	**48,814**	**93,626**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**1.29**	**0.94**	**1.07**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**233**	**197**	**193**

Source: Petroconsultants *Estimator*.

Table B6. Estimated Development Costs for Arabian Mesozoic Play in Abu Dhabi

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	10	200	1000
Peak Production, % of Field Size	12	9	9
Production Plateau, yr	2.9	3.8	4.3
Peak Field Production, bopd	4,000	49,830	248,640
Peak Field Production, MMbbls/yr	1.440	17.939	89.510
Production Decline Rate, %	17	13	12
Well Productivity, bopd	1,000	1,510	2,240
GOR, scf/bbl	300	500	2,000
Reservoir Depth, ft	5,000	7,500	10,000
Oil Pipeline, km	10	25	75
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	4	33	111
Dry Holes	1	4	6
Total Development Cost, $MM	15.411	110.571	508.546
Peak Operating Expense, $MM/yr	1.902	14.395	84.970
Capital Invest per Well, $MM	**3.08**	**2.99**	**4.35**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**10.70**	**6.16**	**5.68**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**3,853**	**2,219**	**2,045**
Capital Invest per bbl of Reserves, $/bbl	**1.54**	**0.55**	**0.51**
Peak Production Year Operating Expense per Well, $/mo	**39,623**	**36,351**	**63,791**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**1.32**	**0.80**	**0.95**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**400**	**249**	**249**

Source: Petroconsultants *Estimator*.

Table B7. Estimated Development Costs for Arabian Mesozoic Play Offshore Abu Dhabi

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	10	50	200
Peak Production, % of Field Size	18	13	13
Production Plateau, yr	1.9	2.6	3.5
Peak Field Production, bopd	5,700	18,960	72,540
Peak Field Production, MMbbls/yr	2.052	6.826	26.114
Production Decline Rate, %	25	19	15
Well Productivity, bopd	950	1,580	2,340
GOR, scf/bbl	300	500	2,000
Reservoir Depth, ft	5,000	7,500	10,000
Water Depth, ft	50	100	150
Oil Pipeline, km	10	25	50
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	8	12	31
Dry Holes	2	2	2
Total Development Cost, $MM	61.720	93.631	259.567
Peak Operating Expense, $MM/yr	5.425	12.083	45.620
Capital Cost per Well, $MM	**6.17**	**6.69**	**7.87**
Capital Cost per bbl of Annual Production Capacity, $/bbl	**30.08**	**13.72**	**9.94**
Capital Cost per bbl of Daily Production Capacity, $/bbl	**10,828**	**4,938**	**3,578**
Capital Cost per bbl of Reserves, $/bbl	**6.17**	**1.87**	**1.30**
Peak Production Year Operating Expense per Well, $/mo	**56,509**	**83,911**	**122,634**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**2.64**	**1.77**	**1.75**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**570**	**379**	**363**

Source: Petroconsultants *Estimator*.

Table B8. Estimated Development Costs for Middle East Offshore Fields

Field Characteristics	Low Case	Mid Case	High Case
Field Size, MMbbl	25	75	500
Peak Production, % of Field Size	15	12	12
Production Plateau, yr	2.3	2.9	4.3
Peak Field Production, bopd	11,680	26,510	166,760
Peak Field Production, MMbbls/yr	4.205	9.544	60.034
Production Decline Rate, %	21	17	12
Well Productivity, bopd	1,460	2,410	3,790
GOR, scf/bbl	100	500	2,500
Reservoir Depth, ft	5,000	9,000	15,000
Water Depth, ft	50	150	150
Oil Pipeline, km	5	25	50
Gas Pipeline, km	(flared)	(flared)	(flared)
Producing Wells	8	11	44
Dry Holes	2	2	3
Total Development Cost, $MM	65.103	108.115	694.332
Peak Operating Expense, $MM/yr	7.823	15.394	111.920
Capital Invest per Well, $MM	**6.51**	**8.32**	**14.77**
Capital Invest per bbl of Annual Production Capacity, $/bbl	**15.48**	**11.33**	**11.57**
Capital Invest per bbl of Daily Production Capacity, $/bbl	**5,574**	**4,078**	**4,164**
Capital Invest per bbl of Reserves, $/bbl	**2.60**	**1.44**	**1.39**
Peak Production Year Operating Expense per Well, $/mo	**81,494**	**116,622**	**211,970**
Peak Production Year Operating Expense per bbl of Production, $/bbl	**1.86**	**1.61**	**1.86**
Peak Daily Production per Developed Reserves, bopd/MMbbl	**467**	**353**	**334**

Source: Petroconsultants *Estimator*.

Energy Information Administration
Oil Production Capacity Expansion Costs for the Persian Gulf

Glossary

Glossary

Bbbls   Billion barrels.

bbl   barrels

bbl/d   barrels per day

bopd   barrels of oil per day

developed reserves   volume of recoverable oil with the necessary infrastructure in place

development cost   includes the cost of wells, production facilities, pipelines, construction, management costs, and other infrastructure costs necessary to prepare a field for production. Does not include exploration costs (geophysical surveys, etc.)

field size   ultimate recovery from a field (typically, cumulative production plus remaining reserves)

geologic play   group of discovered and/or undiscovered fields with similar geologic, geographic, and temporal characteristics

gross revenue   oil price per barrel times oil production volume

MMbbl   million barrels

operating cost   cost to produce oil from a field (per well, per barrel, per year, etc.) not including development and/or exploration costs

peak field production   highest annual production volume in the life of a field

Persian Gulf countries   Iran, Iraq, Kuwait, Saudi Arabia, Qatar, and the United Arab Emirates (U.A.E.)

production capacity   maximum sustainable production rate

R/P ratio   remaining reserves divided by the annual production rate

remaining reserves   recoverable oil still in place in a field, country, region, etc.

undeveloped reserves   volume of recoverable oil requiring development and/or installation of infrastructure for production (such as wells, production facilities, and pipelines)

undiscovered resources   estimated volume of oil contained in fields projected to be discovered in the future

well productivity   maximum production rate from a single well