generally price and income inelastic, and thus domestic consumption in OPEC will continue to grow rapidly, even if domestic prices are raised closer to world levels in the near future".

* The "International Critical Event Occurrence", the time when OPEC's share of the global oil markets reaches the 50 % level will approximately take effect by the year 1386 (2007), in close concurrence with the identified "Domestic Critical Event Occurrence". If Iran is to maintain its OPEC production share of 14 %, the country's oil production has to be increased to about 6 Million barrels per day by 2007- 2008. The country's total production capacity, at a capacity utilization rate of 85 %, will have to be increased to about 7 Million barrels per day by such date.

* The stochastic analysis undertaken estimates an oil capacity expansion distribution with a Mean Value of 2.99 and a range of 2.87 to 3.12 Million barrels per day by 2008. This corresponds to a total oil production capacity range of 6.72 to 6.97 Million barrels per day by such date.

* The requisite capital investment distribution relevant to the aforementioned capacity expansion has a Mean Value of $ 15,872 Million with a range of $13,059 Million to $ 18,853 Million.

2. Implications

There are a number of findings that can be derived from the study, which may have practical importance and significant implications, specifically from a strategic planning viewpoint.

* First and foremost among the study findings is the observation that, based on the scenarios forecasted, the country's oil production capacity will have to be doubled from its 1377 (1998) levels within a decade.

* Secondly, an estimated capital investment of between $ 13- $19 Billion to implement such expansion has to be secured from the internal sources and/or global capital markets.

If Iran is to maintain its OPEC production share of 14 %, the country's oil production has to be increased to about 6 million barrels per day by 2007- 2008

* Thirdly, the tactical and operational plans to implement the expansion program will have to be initiated, devised and started long before the future target date of 2007-2008. The estimated lag time between the start of investments and the full target capacity realization, based on industry benchmarks, could be in the range of 2-4 years.

REFERENCES

1. Buresi, Georges Oil and Gas Technology in the Context of Investment Potential In the Middle East, Center for Global Energy Studies 9th Annual Conference-London 22 April 1999.

2. Bush, James and Daniel Johnston International Oil Company Financial Management In Non Technical Language, (Tulsa: PennWell Publishing Company, 1998) pp. 39-63.

3. Chakravorty, U., F. Fesharaki and S. Zhou Domestic Demand for Petroleum in OPEC Countries, OPEC Review, March 2000, pp. 23-52.

4. Grawdig, Dennis E., and Charles L. Hubbard Strategic Financial Planning with Simulation, (New York: Petrocelli Books, Inc. 1982).

5. Karbasian, Akbar Budget and Governmental Budgeting in Iran's Economy, Tehran: Central Bank of Iran- Advanced Banking Institute, 1999, p. 133.

6. Ministry of Energy - Energy Planning Office, 1998 Energy Balances of Iran: 1371-1377 (1992-1998), Ministry of Energy Publications.

7. Werckman, Carol, Terry Hardy and Eric Wainwright Crystal Ball 2000 User's Guide, Decisioneering Inc., Denver, 2000, pp. 27-115.

■

World Oil Forecasting Program (WOFP). This public domain program, developed and operated by the Institute on Energy and Man, of Seattle, Washington, U.S.A., uses the historic oil production data and predicts, by heuristic techniques, the future production for the world's top oil producing nations, grouped into seven regions, and the world (Duncan, 2000).

A complete description of the theoretical and technical aspects of the model structure and the detailed set of its latest findings and conclusions can be viewed and downloaded at the Internet site:

WWW.HALCYON.COM/DUNCANRC/

4.2 The World, OPEC and Non-OPEC Oil Production Lifecycles

Through the use of WOFP, the oil production curves for the aforementioned regions have been graphed for the years 1960-2004.

This graph is presented in Figure -10. The years 1960 to 1997 are historic data. As indicated from this graph:

* The non-OPEC production (curve 3) is expected to peak in 2003.

* The World production (curve 1) is expected to peak in 2006.

* OPEC production (curve 2) is expected to peak in 2009.

* The OPEC/Non-OPEC cross-over point (the 50- 50 market share) is expected to occur in 2007, with OPEC countries assuming the dominant position after 2007.

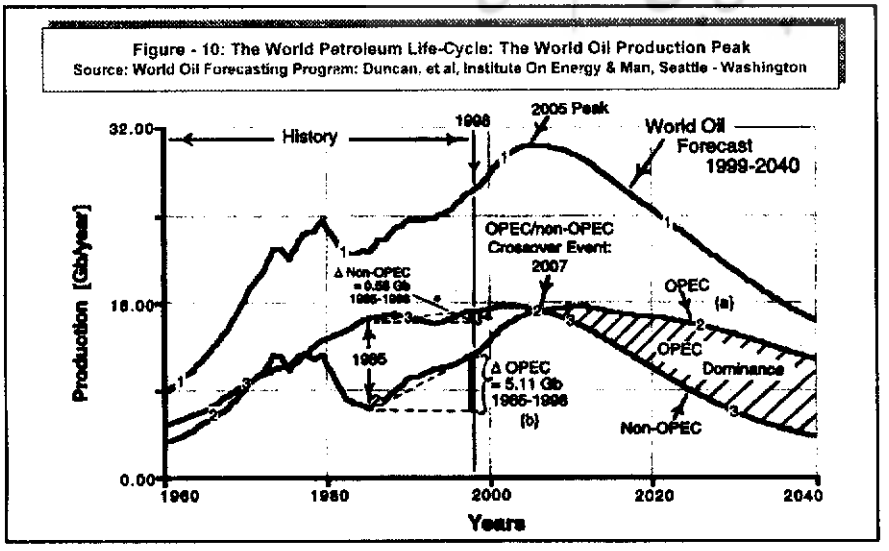
The audit of the WOFP graph is instrumental in assessing the other objective of the present study, namely the identification of an international "critical event occurrence". This event, the OPEC/Non-OPEC oil production cross- over point in 2007-2008 is identified as the "critical event occurrence" in the world oil markets, pertinent to the purpose and objectives of the present study.

Further analysis of the results of the aforementioned forecast indicates that at the world production peak, the global oil production rate is estimated to be about 31.6 Billion barrels (86.6 Million B/D).

The OPEC's share of this production, at the crossover point in 2007, is calculated to be equal to about 43.3 Million B/D.

If Iran is to maintain its current OPEC production share of about 14%, then it is expected that the country's oil production must be increased to around 6.1 million B/D by 2007-2008.

If, furthermore, it is assumed that the optimal oil production capacity utilization rate is around 85 %, then the country's total oil production capacity will have to be raised to about 7.2 million B/D by that date.



CONCLUSIONS AND IMPLICATIONS

1. Conclusions

The purpose of the study was to design and implement a set of algorithmically defined analytical-stochastic models to estimate the range and degree of certainty of Iran's expected oil production capacity expansion and the requisite capital investment needs.

The following conclusions were derived from the analysis of the results in achieving the study's objectives.

* Iran's domestic demand for petroleum products, driven primarily by the population and per capita oil consumption growth rates has resulted in a symmetric rate of decline of the country's oil exports.

* If a discernible strategy to revise and alter the historical supply-demand pattern is not devised and implemented, the "Domestic Critical Event Occurrence" (the time when Iran's total oil exports to production ratio will fall bellow 50 %), will take effect by the year 1386 (2007).

* The audit of the relevant literature and research on the subject tends to suggest that due to the demographic and structural exigencies, it is improbable, if not impossible to curtail the growth rate of demand for petroleum products in OPEC economies in the near future. Chakravorty, Fesharaki and Zhou (2000), in their study to estimate domestic demand for petroleum products by the major OPEC economies, under alternative economic growth and price de-regulation strategies concluded that "the product demand is

Figure - 8: Frequency Distribution of Iran's Estimated Oil Capacity Expansion in 2007-2008

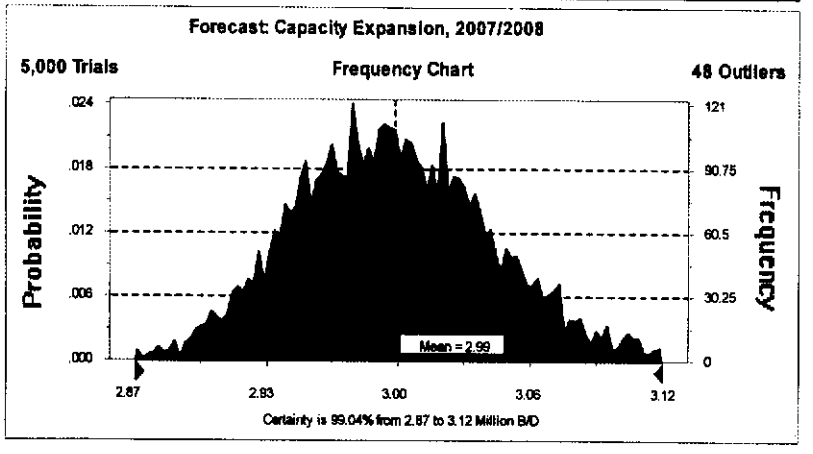
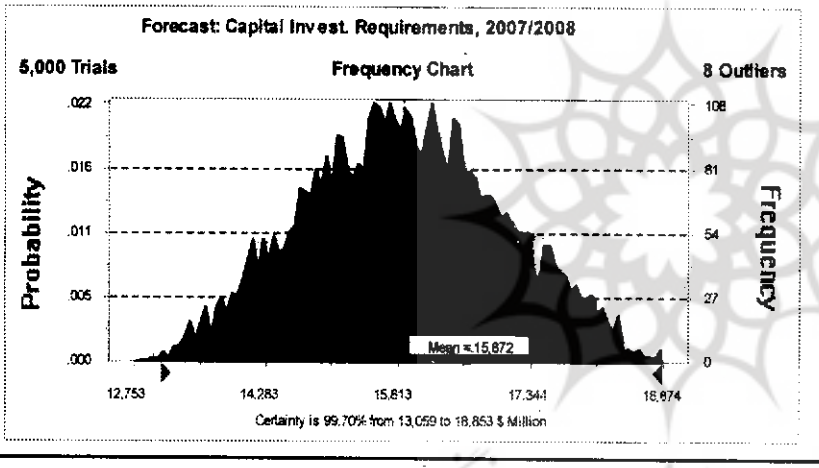


Figure - 9: Frequency Distribution of Iran's Estimated Capital Investment Requirements in 2007-2008



breakdown of Iran's off-shore/on-shore production capacity was estimated to be 10%, and 90%, respectively.

3.4.3 The Oil Capacity Expansion Distribution in 2007/2008

The simulated frequency distribution of the estimated oil capacity expansion after 5000 trials is presented in Figure-8. As indicated:

* The estimated Mean Value of the oil capacity expansion is 2.99 Million barrels per day.

* The mode has a frequency of 121, meaning that there are 121 values in the interval that contains the greatest number of forecast values.

* The mode also has a probability of 0.024 (2.4 %), meaning that there is a 2.4 % chance of value falling within this interval.

* The certainty level, one of the key parameters of a Stochastic analysis, is calculated to be 99.04%, meaning that there is a 99.04% certainty that the estimated value of the oil capacity expansion falls within the range of 2.87 to 3.12 Million barrels per day.

3.4.4 Capital Investment Requirements Distribution in 2007/2008

The frequency distribution of the estimated capital investment requirements after 5000 trials is presented in Figure-9. As indicated:

* The estimated Mean Value of capital investment requirements is $15,872 Million.

* The mode has a frequency of 108, meaning that there are 108 values in the interval that contains the greatest number of forecast values.

* The mode also has a probability of 0.022 (2.2%), meaning that there is a 2.2% chance of values falling within the interval.

* The certainty level, one of the key parameters of a Stochastic analysis is calculated to be 99.70%, meaning that there is a 99.7 % certainty that the estimated value of the capital investment requirements falls within the range of $13,059 Million to $18,853 Million.

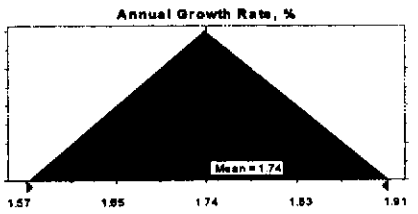
4. The International (External) Supply-Demand Perspective

4.1 Overview

The international demand for petroleum products and the subsequent call on OPEC oil is a significant factor influencing the OPEC member countries' production capacity expansion decisions. The purpose of the present study is not to assess the details of the underlying factors, performance characteristics or exigencies of the global oil supply and demand market. One of the stated objectives of the study, however, is to audit The World Petroleum Life Cycle and identify an international "critical event occurrence", which may indirectly, but most definitely will impact Iran's future oil capacity expansion requirements.

In delineating and appraising the future world oil supply situation, the present study exclusively and entirely relies on the extensive research and forecast scenarios generated by the

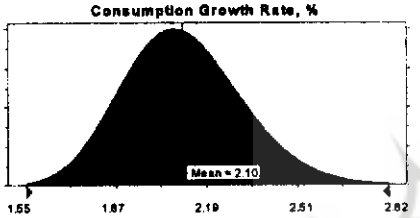
Figure - 5: Population Growth Rate & Oil Consumption/Capita Growth Rate Input Distributions Assumptions for the One-Dimensional Monte Carlo Simulation



Triangular distribution with parameters:

5% - tile	1.62
Likeliest	1.74
95% - tile	1.86

Selected Range is From 1.57 to 1.91

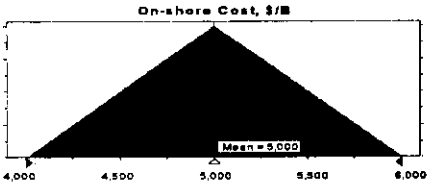


Log - normal distribution with parameters:

5% - tile	1.78
95% - tile	2.47

Selected Range is From 0.00 to Infinity

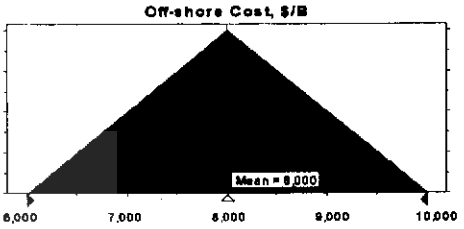
Figure - 6: The On-Shore & Off-Shore Capital Cost Requirement Input Distribution Assumptions for the One-Dimensional Monte Carlo Simulation



Triangular distribution with parameters:

Minimum	4,000
Likeliest	5,000
Maximum	6,000

Selected Range is From 4000 to 6000



Triangular distribution with parameters:

Minimum	6,000
Likeliest	8,000
Maximum	10,000

Selected Range is From 6000 to 10000

% and a 5 % - tile to 95 % - tile range of 1.62 % to 1.86 % was assigned to the population growth rate (Figure-5).

* A Log-Normal probability distribution with a Mean Value of 2.1 % and a 5 % - tile to 95 % - tile range of 1.78 % to 2.74 % was assigned to the per capita oil consumption growth rate (Figure-5).

* A Triangular probability distribution with the minimum, most likely and maximum values of $4,000, $5,000 and $6,000 was assigned to capital investments required to increase one barrel of on-shore oil production capacity (Figure-6).

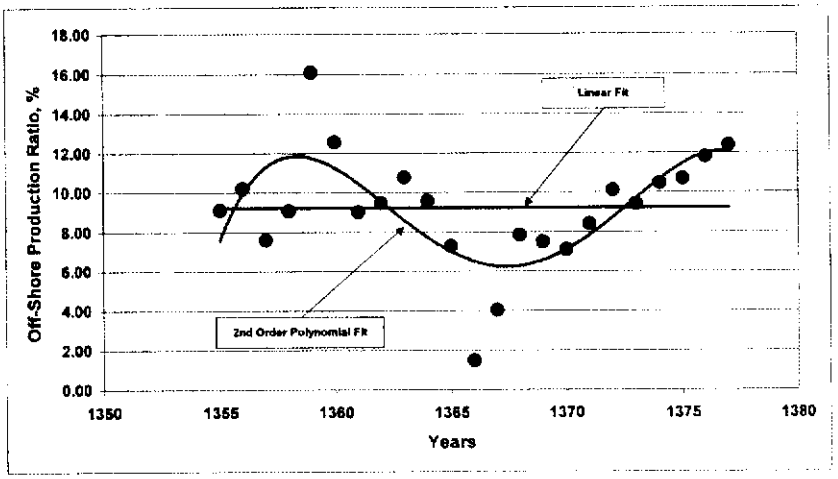
* A Triangular probability distribution with the minimum, most likely and maximum values of $6,000, $8,000 and $10,000 was assigned to capital investments required to increase one barrel of off-shore oil production capacity (Figure-6).

Based on actual historical production statistics (Figure -7), the

OPEC production will exceed non-OPEC production by 2007

By 2007, almost all OPEC production will be in the Persian Gulf Area

Figure - 7: Iran's Historical (1355-1377/ 1976-1998) Off-Shore Oil Production Ratio, % Total



The Assessment of Iran's Expected Oil Production Capacity Expansion and the Estimate of the Requisite Capital Investment Profile: A Stochastic Approach

No.	Macro Indicators	Years, Persian & Gregorian Calendars										
		1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387
		*1998	*1999	*2000	*2001	*2002	*2003	*2004	*2005	*2006	*2007	*2008
1	A. Oil Production Forecast	History	←				Forecast					→
2	Annual Growth Rate, %	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865
3	Oil Production, MMB	1,341.0	1,339.8	1,338.7	1,337.5	1,336.4	1,335.2	1,334.1	1,332.9	1,331.7	1,330.6	1,329.4
4	Oil Production, MMB/Day	3.67	3.67	3.67	3.66	3.66	3.66	3.65	3.65	3.65	3.65	3.64
5	B. Population Forecast											
6	Annual Growth Rate, %											
7	Population, Millions	61,900	62,977	64,073	65,188	66,322	67,476	68,650	69,845	71,060	72,296	73,554
8	C. Oil Consumption Forecast											
9	Consumption Growth Rate, %											
10	Per Capita Consumption, B	7.78	7.94	8.11	8.28	8.46	8.63	8.82	9.00	9.19	9.38	9.58
11	Total Consumption, MMB	481.6	500.3	519.7	539.9	560.8	582.6	605.2	628.7	653.1	678.4	704.8
12	Oil Consumption/Day, MMB	1.32	1.37	1.42	1.48	1.54	1.60	1.66	1.72	1.79	1.86	1.93
13	CAPITAL INVESTMENT ESTIMATION											
14												
15	Capacity Increase, MMB/D		0.90	0.96	1.02	1.28	1.52	1.78	2.06	2.36	2.66	
16												
17	On-shore @ 90%, MMB/D		0.81	0.87	0.92	1.15	1.37	1.61	1.85	2.12	2.40	2.70
18	Off-shore @ 10%, MMB/D		0.09	0.10	0.10	0.13	0.15	0.18	0.21	0.24	0.27	0.30
19	On-shore Cost, $/B											
20	Off-shore Cost, $/B											
	On-shore Costs, MM$		4,057	4,326	4,605	5,766	6,861	8,026	9,258	10,617	11,988	13,487
	Off-shore Costs, MM$		721	769	818	1,025	1,220	1,427	1,646	1,887	2,131	2,398
21	Estimated Capital Cost Profile, MM$		4,778	5,095	5,423	6,791	8,081	9,452	10,904	12,504	14,120	

Table-2: Stochastic Estimate of the Requisite Capital Cost Profile

The Impact of the Middle East/Caspian Oil on Global Energy Markets, Nov. 4-5, 2000- Tahran — M. Naraghi

increase for Scenario-3 + Scenario-4)/2 (Row-41)

The graphical representation of the oil production capacity expansion estimates for the outlined scenarios, along with the normalized estimates (the selected Base Case) is presented in Figure-4.

As indicated, the single value estimate of the expected oil production capacity expansion in 1387 (2007-2008) is in the range of 1.20 to 3.72 Million B/D.

3.4 The Stochastic Model/ Forecasting Module

A Stochastic process, according to Grawdig and Hubbard (1982), is "a time series with explicit inclusion of risk by means of probability distributions". As pointed out by Werckman, Hardy and Wainwright (1999), "Monte Carlo Simulation is an efficient technique that requires only Random Numbers, a mathematically selected value which is generated by a formula or selected from a table to generate a probability distribution on a computer. It is an iterative process that continues until the simulation reaches a stopping criterion".

3.4.1 The Model Structure

The requisite model capable of simulating the Stochastic attributes of the selected Base Case was conceptualized, designed and implemented as a combination of a Decision Support System (DSS), superimposed on a spread sheet template in an MS Office/Excel environment. The process and the specific DSS used was the application of One-Dimensional Monte Carlo Simulation capabilities of Crystal Ball 2000, a Stochastic Process Simulation software developed and marketed by Decisioneering, Inc. of Denver, Colorado, U.S.A. The program, an add-in module to the Excel spread sheet, is capable of estimating the range (distribution) and the degree of certainty of an uncertain (dependent) variable by assigning ranges (distribution) of values to the inputs (independent) variables.

The outline of the designed model, along with the parametric values of the selected Base Case is presented in Table -3. As indicated, the set of input (independent) and output (dependant) variables are highlighted in the table.

3.4.2 The Input Distributions

The following set of estimates and probability distributions were selected and assigned to the input parameters.

* Due to marginal rate of growth of recent history annual oil production rates (Table-1, Row-2), a single value estimate is assigned to this parameter.

* A Triangular probability distribution with a Mean Value of 1.74

that Iran's level of annual oil exports will be maintained at its 1372 (1993) levels. This criterion was selected based on two principal observations. First, the annual oil export level of 2.91 million barrels per day in 1372 was the highest level of exports attained during the audited historical time horizon (Table -1, Row-3). Secondly, the country's historical average annual level of the oil exports during 1346-1377 (1967-1998) time horizon is approximately about 2.95 million barrels per day (Iran Energy Balances, 1377 (1998).

As indicated in Table-2, the expected oil capacity increase during 1378 (1999) to 1387 (2008), under this scenario is in the range of 0.61 to 1.20 Million B/D.

3.3.2 Scenario-2

This scenario is identical with Scenario-1, except for the assumption that the country's oil production capacity utilization rate of 95 % (under the existing conditions) is reduced to a level of 85 %.

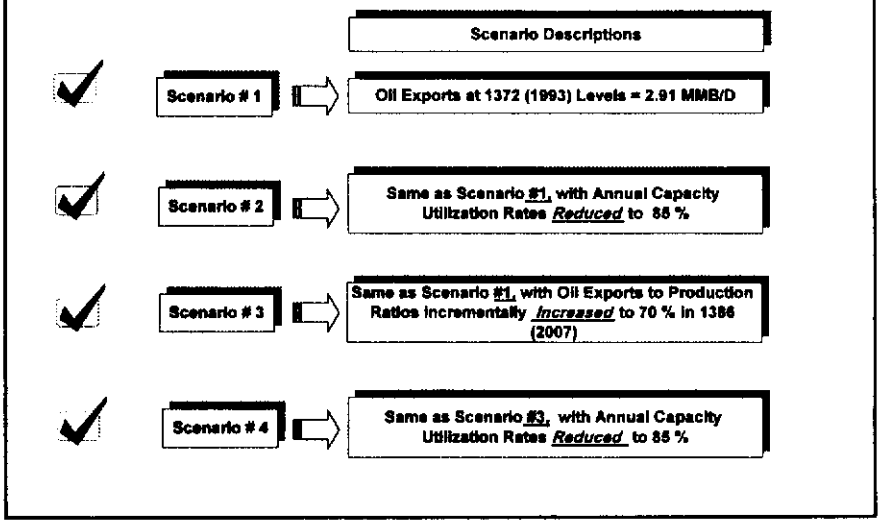
As indicated in Table-2, the expected oil capacity increase during 1378 (1999) to 1387 (2008), under this scenario is in the range of 1.19 to 1.85 Million B/D.

3.3.3 Scenario-3

This scenario is identical with Scenario-1, except for the assumption that the ratios of the annual oil exports to production be gradually increased (Table 2, Row-37) to around 70%, by 1386-1387 (2007-2008). As is reflected in Figure -2, the historical average annual value for this ratio during 1346-1377 (1967-1998) has been about 80 %.

As indicated in Table-2, the expected oil capacity increase during 1378 (1999) to 1387 (2008), under this scenario is in the range of 0.61 to 2.80 Million B/D.

Figure - 3: Scenario Generation Criteria in Forecasting (Estimating) Oil Production Capacity Expansion & the Requisite Capital Expenditure Distributions (1378-1387/1999-2008)



3.3.4 Scenario-4

This scenario is identical with Scenario-3, except for the assumption that the oil production capacity utilization rate of 95 % (in Scenario-3) is reduced to a level of 85 %.

As indicated in Table-2, the expected oil capacity increase during 1378 (1999) to 1387 (2008), under this scenario is in the range of 1.19 to 3.72 Million B/D.

The general outline and descriptions of the above four scenarios are presented in Figure -3.

3.3.5 The Normalized Estimate (The Selected Base Case)

For calculating a normalized estimate of oil production capacity increase (Table -2, Row No. 42), based on the aforementioned four scenarios, the following algorithmic relations were defined and utilized in the model:

NormEst (t) = ((MinVal(t) + 4*(MLVal(t) +MaxVal))/6

Where;

MinVal(t) = Capacity increase for time t in Scenario-1 (Row-23)

MaxVal(t) = Capacity increase for time t in Scenario-4 (Row-40)

MLVal(t) = (Annual Capacity

Figure - 4: Deterministic Projection of Iran's Oil Capacity Expansion Estimates for (1378-1387/ 1999-2008) For Various Scenarios

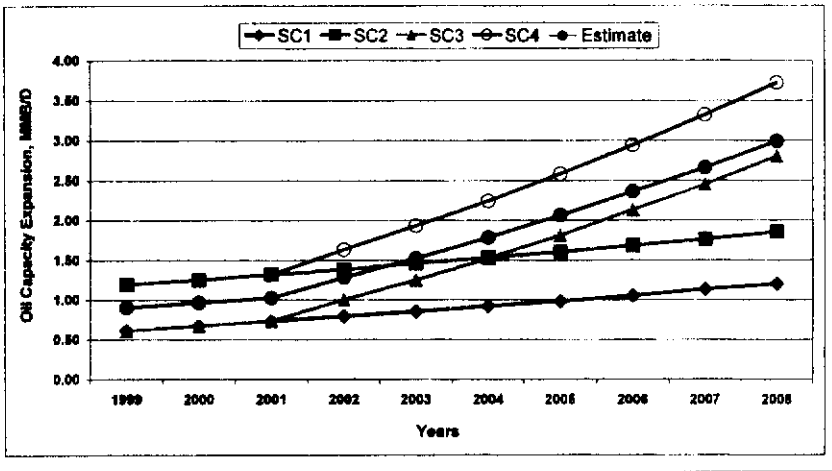
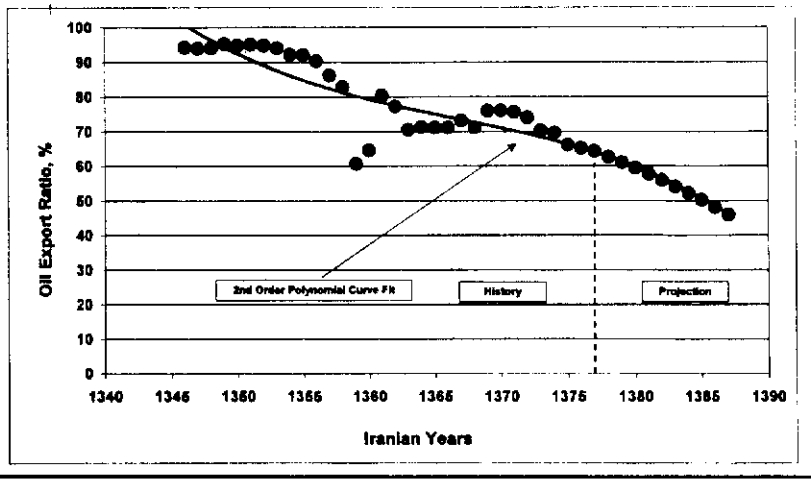


Table -1: Deterministic Model of Iran's Historical Oil Production/Export/Consumption Patterns and Energy Efficiency Indicators, 1371-1377 (1992-1998)

No.	Macro Indicators, Volumes in MMB	Years, Persian & Gregorian Calendars							Average Annual Growth Rate, %
		1371	1372	1373	1374	1375	1376	1377	
		*1992	*1993	*1994	*1995	*1996	*1997	*1998	
1	A. Total Oil Production								
2	Crude Oil Production	1,348.0	1,428.8	1,411.4	1,433.4	1,432.2	1,322.4	1,341.0	-0.09
3	Crude Oil Exports	1,026.5	1,063.3	887.9	934.1	916.5	773.2	752.8	-4.37
4	Change in Inventories	0.0	0.0	0.0	-11.8	-13.7	9.5	-0.6	0.00
5	Total Refinery Feeds	327.5	363.5	423.5	487.7	502.0	558.7	587.5	13.24
6	B. Total Oil Consumption								
7	Total Refinery Output	327.5	363.5	423.5	487.7	502.0	558.7	587.5	13.24
8	Finished Products Imports	61.5	54.0	39.0	25.8	38.7	22.9	7.5	-14.56
9	Finished Products Exports	0.0	0.0	0.0	-87.1	-89.5	-89.4	-109.3	-
10	Bunker & Marine Fuels	-1.7	-2.5	-2.9	-3.3	-4.4	-4.4	-4.4	26.47
11	In Storage	0.0	0.0	0.8	0.7	0.8	0.0	0.0	-
12	Total Domestic Consumption	387.3	416.0	461.3	443.8	467.6	487.8	481.7	4.08
13	B-1. End-Use Oil Consumption								
14	Industrial Sector	72.3	69.3	66.3	60.6	64.1	58.9	55.2	-3.71
15	Residential & Commercial	96.3	109.5	116.8	108.2	116.2	118.6	109.4	2.47
16	Transportation Sector	116.7	122.3	144.6	141.9	147.4	160.5	161.1	7.69
17	Agricultural Sector	31.0	28.8	28.8	27.7	29.3	26.5	28.2	-0.97
18	Non-Energy Usage	21.5	32.2	24.8	21.8	24.3	37.9	50.7	22.45
19	Total End-Use Consumption	330.9	351.9	371.3	350.1	378.3	391.4	405.6	3.81
20	Total Conversion Losses & Others	56.4	63.1	90.0	93.7	87.3	96.4	76.1	5.53
21	Total Domestic Consumption	387.3	416.0	461.3	443.8	467.6	487.8	481.7	4.08
22	C. Primary Energy Consumption								
23	Total Energy Consumption	613.3	664.3	708.5	729.6	763.4	819.3	844.2	6.27
24	End-Use Energy Consumption	485.8	512.8	554.1	555.1	595.3	632.6	661.2	5.78
25	Total Oil/Total Energy, %	63.2	63.4	65.1	60.8	61.3	59.5	57.1	-1.61
26	End-Use Oil/End-Use Energy, %	68.4	68.6	67.0	63.1	62.4	61.9	62.4	-1.48
27	D. Population, Thousands								
28	Source 1: Energy Balances, 1377	56,428	56,833	57,672	58,846	60,068	61,160	61,960	1.95
29	Source 2: Time Series, PBO,1378	56,681	57,624	58,388	59,212	60,066	60,900	61,900	1.63
30	Average:	56,056	57,029	58,029	59,029	60,068	61,030	61,930	1.74
31	E. Energy Efficiency								
32	Total Energy/Capita, BOE	10.9	11.5	12.2	12.4	12.7	13.4	13.6	4.11
33	End-Use Energy/Capita, BOE	8.5	9.0	9.6	9.4	9.9	10.4	10.6	3.68
34	Total Oil/Capita, Bbl	6.9	7.3	8.0	7.5	7.8	8.0	7.8	2.10
35	End-Use Oil/Capita, Bbl	5.9	6.2	6.4	5.9	6.2	6.4	6.5	1.86
36	F. Export Capacity								
37	Crude Oil & Products Exports	1,020.5	1,063.3	887.9	1,091.2	988.0	862.6	862.1	-2.59
38	Total Exports/Production, %	75.7	74.5	70.0	69.8	68.8	65.2	64.3	-2.51

The Assessment of Iran's Expected Oil Production Capacity Expansion and the Estimate of the Requisite Capital Investment Profile: A Stochastic Approach
The Impact of the Middle East/Caspian Oil on Global Energy Markets, Nov. 4-5, 2000- Tehran

Figure - 2: Iran's Historical (1346-1377/ 1967-1998) And Projected (1378-1387/ 1999-2007) Annual Oil Export to Production Ratios



The following algorithmic relationships are defined in the model:

Oil Prod (t) = (1+GR1) * Oil Prod (t-1)

Pop (t) = (1+GR2) * Pop (t-1)

O lCons (t) = (1+GR3) * PerCapC (t-1) * Pop (t)

Where;

Oil Prod (t) & Oil Prod (t-1) = Oil production estimates for years t & t-1

Pop (t) & Pop (t-1) = Population estimates for Years t & t-1

GR1 = Historical average annual growth rate of oil production

GR2 = Historical average annual growth rate of population

GR3 = Historical average annual growth rate of per capita oil consumption

It was further calculated that, based on published information the country's oil production capacity utilization rate in 1377 (1998) was about 95.4 % (Table-2, Row-19).

Subsequent to the analysis of the forecast results, the domestic "critical event occurrence" was identified and selected to be the date on which Iran's annual oil exports to production ratio falls below 50 %.

The historical graphical presentation of this ratio along with the forecasted statistics from Table -2 are presented in Figure -2.

As indicated, and assuming that no discernible policy is implemented to alter the recent history supply-demand pattern, the aforementioned "critical event occurrence" is forecasted to take place during 1385-1387 (2006-2008).

In assessing the boundary conditions for the potential range of the forecasted domestic oil production capacity increase and the resultant capital investment needs the following scenarios were identified and appraised.

3.3.1 Scenario-1

In this scenario, it was postulated

upon the appraisal of the domestic market.

3. The Domestic (Internal) Supply-Demand Perspective

Iran's recent historical statistics for the years 1371-1377 (1992-1998) on petroleum production, domestic petroleum consumption and exports and the relevant demographic measures and indicators were selected for the purpose of audit, establishing trends and pattern recognition.

3.1 Source of Data

The present assessment is entirely based on non-proprietary and unclassified public domain information. The primary sources of data are the annual "Energy Balances of Iran", for the years 1371 to 1377 (1992-1998).

3.2 The Deterministic Analytical Model/Historical Module

The analytical model, a spreadsheet template designed in an MS/Office-Excel environment and conceptualized to assess some of the historical trends of the critical supply and demand parameters of the domestic petroleum market is presented in Table -1.

Some of the salient aspects and the results of the assessment are outlined below:

* The historical time horizon of the model is from 1371 (1992) to 1377 (1998).

* The benchmarking criterion is calculation of the average annual growth rates of each macro-indicator.

* The macro-indicators targeted include; Iran's annual total oil production, total oil consumption, end-use oil consumption, primary energy consumption, population growth, energy efficiency and oil exports during the aforementioned time horizon.

Analysis of results indicate that for the aforementioned historical time interval, the average annual growth rate of:

* Oil production is about - 0.0865 %

* Crude oil export is about - 4.4 %

* Total oil consumption is about 4.1%

* The end-use oil consumption is about 3.8 %

* Population is about 1.74 %

* The total oil per capita consumption is about 2.1 %

* The exports to production ratio is about - 2.5 %

Table - 2 : Iran's Estimated Oil Production, Consumption, Export and Capacity Expansion Requirements for Various Projected Scenarios, 1378-1387 (1999-2008)

#	Macro Indicators	Years, Persian & Gregorian Calendars										
		1377	1378	1379	1380	1381	1382	1383	1384	1385	1386	1387
		*1998	*1999	*2000	*2001	*2002	*2003	*2004	*2005	*2006	*2007	*2008
1	A. Oil Production Forecast	History	Forecast									
2	Annual Growth Rate, %	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865	-0.0865
3	Oil Production, MMB	1,341.0	1,339.9	1,338.7	1,337.6	1,336.4	1,335.2	1,334.1	1,332.9	1,331.7	1,330.6	1,329.4
4												
5	B. Population Forecast											
6	Annual Growth Rate, %	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.74
7												
8	C. Oil Consumption Forecast											
9	Consumption Growth Rate, %	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10	2.10
10												
11	Total Consumption, MMB	481.6	500.3	518.7	539.9	560.8	582.6	606.2	628.7	653.1	678.4	704.8
12												
13	D. Net Oil & Product Exports											
14	Yearly, MMB	858.4	838.6	819.0	797.7	775.5	752.6	728.0	704.2	678.7	652.2	624.7
15	Daily, MMB	2.35	2.30	2.24	2.19	2.12	2.06	2.00	1.93	1.86	1.79	1.71
16												
17	E. Capacity Utilization											
18	Oil Production Capacity, MMB/D	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85	3.85
19												
20	Scenario Generation											
21	SC1. Exports = 1372 Levels, MMB		1,063.3	1,063.3	1,063.3	1,063.3	1,063.3	1,063.3	1,063.3	1,063.3	1,063.3	1,063.3
22	Daily		2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
23			0.61	0.67	0.73	0.79	0.85	0.92	0.98	1.05	1.13	1.21
24	Total Oil Production, MMB/Day		4.28	4.34	4.39	4.45	4.51	4.57	4.64	4.70	4.77	4.84
25	Total Capacity		4.49	4.56	4.61	4.68	4.75	4.82	4.89	4.96	5.04	5.12
26	Capacity Utilization, %		95.3	95.3	95.2	95.1	95.0	94.9	94.8	94.8	94.7	94.6
27	Total Exports/Production, %		88.0	87.2	86.3	85.5	84.6	83.7	82.8	81.9	81.0	80.1
28	SC2. Capacity Utilization @ 95%	History	95.00	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.00
29	Total Capacity		5.04	5.10	5.17	5.23	5.31	5.38	5.46	5.53	5.61	5.70
30			1.19	1.25	1.32	1.38	1.46	1.53	1.60	1.68	1.76	1.85
31	SC3. Exports = 1372 Levels, MMB		1,063.3	1,063.3	1,063.3	1,140.0	1,210.0	1,285.0	1,365.0	1,455.0	1,545.0	1,645.0
32	Daily		2.91	2.91	2.91	3.12	3.32	3.52	3.74	3.99	4.23	4.51
33			0.61	0.67	0.73	1.00	1.25	1.52	1.81	2.13	2.45	2.81
34	Total Oil Production, MMB/Day		4.28	4.34	4.39	4.66	4.91	5.18	5.48	5.78	6.09	6.44
35	Total Capacity		4.49	4.55	4.61	4.90	5.17	5.46	5.76	6.09	6.43	6.80
36	Capacity Utilization, %		95.3	95.3	95.2	95.1	95.0	94.9	94.9	94.8	94.7	94.6
37	Total Exports/Production, %		88.0	87.2	86.3	87.0	87.6	88.0	88.5	89.0	89.5	70.0
38	SC4. Capacity Utilization @ 95%		95.00	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.00
39	Total Capacity		5.04	5.10	5.17	5.49	5.78	6.09	6.45	6.79	7.17	7.57
40			1.19	1.25	1.32	1.63	1.93	2.24	2.58	2.94	3.32	3.73
41	Most Likely Capacity Increase		0.90	0.96	1.02	1.32	1.59	1.88	2.19	2.54	2.88	3.26
42	Normalized Estimate		0.90	0.96	1.02	1.28	1.52	1.78	2.06	2.36	2.66	2.98

The Assessment of Iran's Expected Oil Production Capacity Expansion and the Estimate of the Requisite Capital Investment Profile: A Stochastic Approach

3.3 The Deterministic Analytical Model/Forecasting Module

The analytical model, a spreadsheet template designed in an MS/Office-Excel environment and conceptualized to forecast some of the future trends of the critical supply and demand parameters of the domestic petroleum market is presented in Table-2.

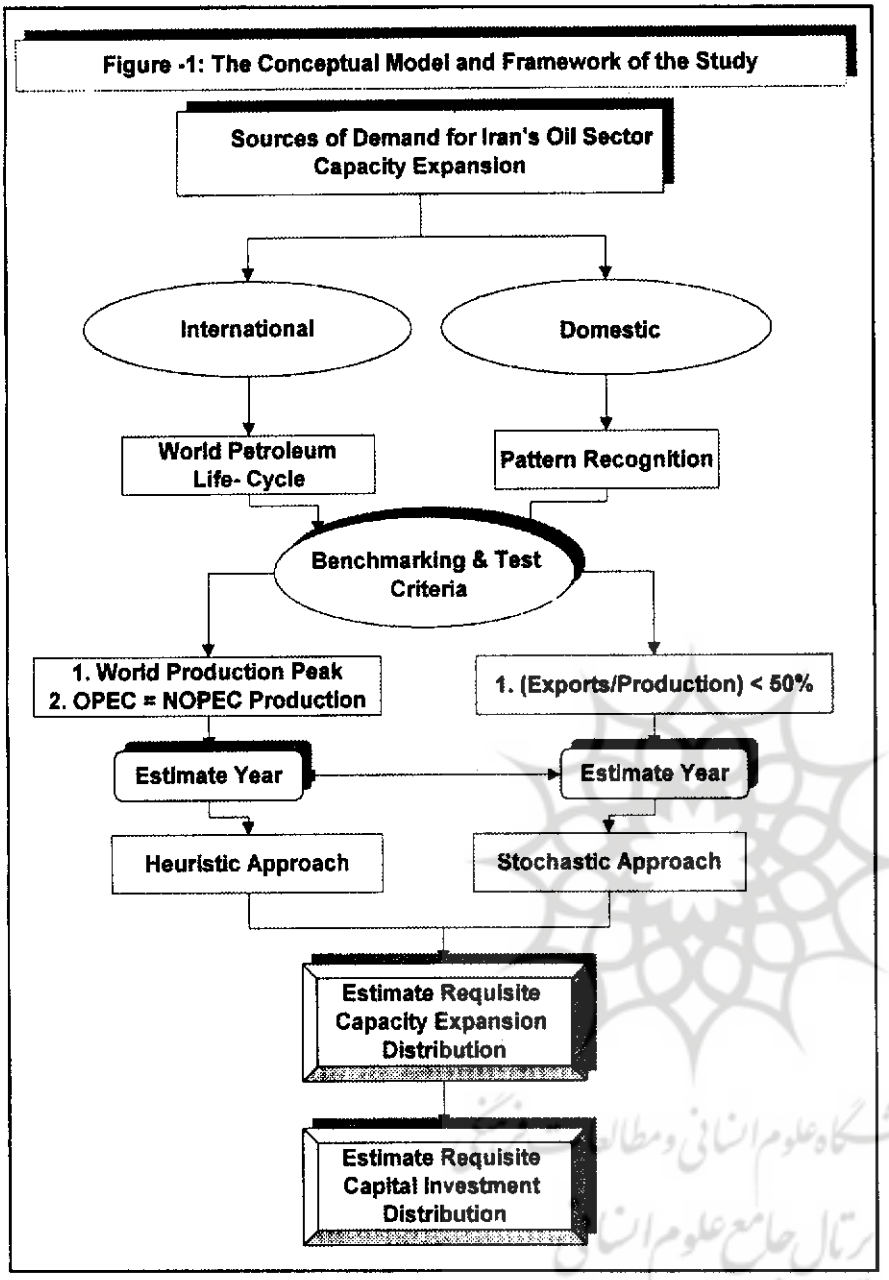
As indicated, the key parameters forecasted by the model for the projected time horizon of 1378 (1999) to 1387 (2008) include:

* The annual oil production rates.

* The annual population of the country.

* The annual per capita and the total oil consumption.

* The total annual oil exports to production ratios.



The pivotal role of Iran's petroleum sector revenues in financing the national development programs and current expenditures, the substantial rate of growth in domestic demand for petroleum products, and the country's prominent and historical role in OPEC mandates that, from a strategic planning viewpoint, the expected range and the degree of certainty of the country's anticipated oil production capacity expansion and the resulting capital investment requirements be appraised.

3. Purpose and Objectives

The purpose of the study is to design and implement a set of algorithmically defined analytical - stochastic models to statistically estimate the range and degree of certainty of Iran's expected oil capacity expansion and the requisite capital investment needs, at a target future date.

The specific objectives examined are:

1) To identify the recent history trends and patterns, pertinent to domestic oil production, consumption, exports, population growth, and oil efficiency measures.

2) To identify a future domestic critical event occurrence by analyzing the domestic petroleum life cycle.

3) To identify a future global critical event occurrence by auditing the world petroleum life cycle.

4) To identify the degree of proximity and/or concurrence of these two events in the future, and to establish a target date.

5) To stochastically forecast the country's expected oil capacity

Expansion and the required capital investment distributions by the Aforementioned target day.

DISCUSSION AND RESULTS

1. Overview

"Capacity increase is for the Middle East a logical strategy which will require significant capital investment: 60 billion US$, within the next 5 to 10 years (to increase production capacity from 23.6 million B/D - of which is 2.6 unused - to 30 Million B/D)", (Buresi, 1999).

The present discussion and the study results intend to address some of the salient aspects of the oil capacity expansion and the requisite capital investment, as it pertains to Iran.

2. The Conceptual Model and the Framework of Study

The "Conceptual Model" specifying the sequence of steps taken to accomplish the study's objectives, the inferences it has performed and the concepts and processes it has used is presented in Figure -1. Although the model has outlined the domestic, as well as the international market components of the demand for Iran's oil production capacity expansion, the primary emphasis of current assessment is placed

"Assessment of Iran's Expected Oil Production Capacity Expansion and the Estimate of the Requisite Capital Investment Profile: A Stochastic Approach"

Dr. M. Naraghi
Researcher, IIES

Presented at International Conference of

"THE IMPACT OF THE MIDDLE EAST/ CASPIAN OIL ON GLOBAL ENERGY MARKETS"
4th/5th Nov. 2000-TEHRAN

INTRODUCTION AND STATEMENT OF THE PROBLEM

1. Introduction

Since the beginning, the petroleum industry has experienced cycles of economic prosperity and depressions. Companies spend a good deal of time planning ahead so they can anticipate the future cycles. If they can not anticipate the future, at least they can consider alternate scenarios which might occur in the future and the Events that lead to the End State.

Events influenced by industry participants, affect the End State, or the snapshot of future industry conditions. The sum of the Events and the End State defines the Scenario, which embodies the driving forces of:

* Social changes affecting demand for petroleum products
* Technological changes resulting in improvement of productivity
* Economic changes in prices, oil financing and operating expenses
* Political changes affecting the continuity and risks of investments.

(Bush and Johnston, 1998)

The focus of the present study is to design a set of simplified analytical/ stochastic models which, by identifying the critical factors affecting Iran's historical oil consumption patterns, can estimate and forecast the country's expected oil capacity expansion and the resultant capital investment requirements, at a target future date.

Specifically and in view of the uncertainties and the degree of complexities associated with such parametric estimation, the study demonstrates the application of the One-Dimensional Monte Carlo Simulation (Stochastic) methodology in generating distributions rather than single value estimates of the aforementioned two entities.

2. Statement of the Problem

Production, marketing and the sales of petroleum products in Iran are under the sole management of the government and the revenues derived from the sales of these products constitute a significant share of the budgetary income of the government. It is estimated that up to 70% of the government's general budget is comprised of the revenues derived from these sources (Karbasian, 1999).

Iran has the largest demand and population of any country in the Middle East. Iranian product demand has grown rapidly for nearly a decade and a half, with the result that Iran has turned into a major product importer. The rapid increase in demand is the result of robust economic growth, coupled with extremely low domestic prices, (Chakravorty, Fesharaki and Zhou, 2000).

We assume that the peak of world oil production will be a watershed in human history. Based on the results obtained from the World Oil Forecasting Program, we believe that:

* Non-OPEC production will peak about 2003
* OPEC production will peak in 2009
* OPEC production will exceed non-OPEC production by 2007

(The OPEC cross-over point) and thereafter, OPEC will dominate World production

* By 2007, almost all OPEC production will be in the Persian Gulf Area. Some nations may drop out of OPEC when they're domestic demand exceeds production, with marginal surplus to export

(Duncan, 2000).