CHAPTER 1

INTRODUCTORY SUMMARY

Although Saudi Arabia receives very substantial income from its oil operations, the Kingdom is making a major attempt to broaden the base of its economy. This study examines the economic and technical possibilities of two major programs which appear to offer considerable potential for development of the Western region of the country.

The first of these relates to steps that might be taken to utilize the very substantial amounts of natural gas (in excess of 2 billion cubic feet per day) which come to the surface with the oil. This gas represents a valuable source of energy for industry, for electric power generation, and for water desalination, and of feedstock for a variety of industrial processes. The second relates to the possibilities for electric power generation, improved transportation, industrial development and land reclamation which would result from the construction of a causeway from the east coast of Saudi Arabia, to Bahrain and from Bahrain to Qatar. This dam would isolate the Gulf of Bahrain from the Arabian Gulf and create an artificially made reservoir, the Dawhat Salwah. Solar evaporation would lower the water level within the reservoir and hydroelectric power could be generated utilizing the head thus created.

1.1 Utilization of Flared Gas

In order to appraise the possibilities for utilization of the gas now being flared an investigation was made of a number of energy intensive processes which it was felt might be viable in Saudi Arabia. These include the production of aluminum, magnesium and fertilizer primarily for export, and of steel, cement and glass for consumption within Saudi Arabia. In addition, the group considered utilization of the gas for electric power generation and for the desalination of water for irrigating a farm. In each case sources of any needed raw materials were examined, the capital and operating costs related to the process were appraised, and the size of the potential market for the product and the probable selling price were evaluated.

The attractiveness of individual projects and the relative attractiveness of the various projects were determined with the aid of a group of computer programs developed to determine the price which each industry could pay for gas and still break even, and the benefit/cost ratio for each project based upon a range of opportunity costs for the gas, selling prices for the product and discount rates.

This analysis showed the economic feasibility of a variety of industrial operations and of a modest agricultural activity utilizing desalinated sea water for irrigation. However, the size of the markets foreseen for the products investigated indicated that in toto they would utilize less than 20 percent of the gas available. The only possible means of utilizing the remaining 900 million cubic feet of gas currently being flared would be to ship it to the energy markets of Europe, Japan or the United States in the form of LNG (liquified natural gas). World demand for LNG is expanding rapidly and potential sales appeared to be limited by the availability of LNG tankers rather than the size of the market, providing the selling price is reasonable. Calculation of the opportunity cost of the gas indicated that as feedstock for an LNG operation the value of the gas would be approximately 26 cents per million Btu if the discount rate is taken as 8 per cent and about 18 cents for a discount rate of 12 per cent. This use therefore established a base price. Thus, if the decision were to be based on economic considerations alone, any activity which could afford to pay a higher price should be permitted to use as much gas as it could while projects capable of paying less should be ruled out.

Table 1.1 lists the projects which are recommended for implementation based on this analysis while Figures 1.1 through 1.5 give the net present value for each of the projects as a function of the discount rate, the price which each of these projects could afford to pay for gas and still break even, and the benefit/cost ratio for each project based on an opportunity cost for gas of 0, 30 and 50 cents per million Btu.

These results show that the combined LNG/Petrochemical operation has by far the largest net present value, because of its size, even though the opportunity cost of gas associated with the LNG activity is lower than for any of the other

Table 1.1

Proposed Projects: their location, capacity, costs, labor input requirements, and assumed market prices

Project	Location	Capacity	Capital Cost ($\$10^6$)	Labor Force	Annual Gas (10^{12} Btu)	Power (MW)	Water (10^6 gal/day)	Market Price
Citrus	Jubail	150 ha	2.9	65	0.35		1.45	¢17/kg
Tomatoes	Jubail	23 ha	0.36	10	0.04		0.2	¢10/kg
Vegetables	Jubail	168 ha	2.63	50	0.29		1.6	¢10/kg
Potatoes	Jubail	110 ha	2.2	25	0.15		1.3	¢ 9/kg
LNG	Jubail	740 MMcfd	1235.	2000	424			¢75/MMBtu
LNG and Petrochemicals	Jubail	540 MMcfd +4.94×10^9 lb/year	1410.	2500	424			¢75/MMBtu ¢ 4/lb
Magnesium	Dammam	23800 ton/year	60.	400	6	70	2.5	$726/ton
Aluminum	Dammam	100,000 ton/year	130.	900	13.6	300		¢28/lb
Steel	Dammam	10^6 ton/year	152.	1300	24.1	130	3.2	$100/ton
P_2O_5	Dammam	260,000 ton/year	37.	300	1.3	16		$60/ton TSP
N_2	Dammam	360,000 ton/year	115.	60	20	35		$80/ton urea
Cement	Abqaiq	1.4×10^6 ton/year	54.	800	10	40		$15/ton
Glass	Riyadh	20,000 ton/year	3.1	70	0.1			$180/ton
		Total	1969.19	6480	500	591	10.25	
		Based on LNG and Petrochemicals						

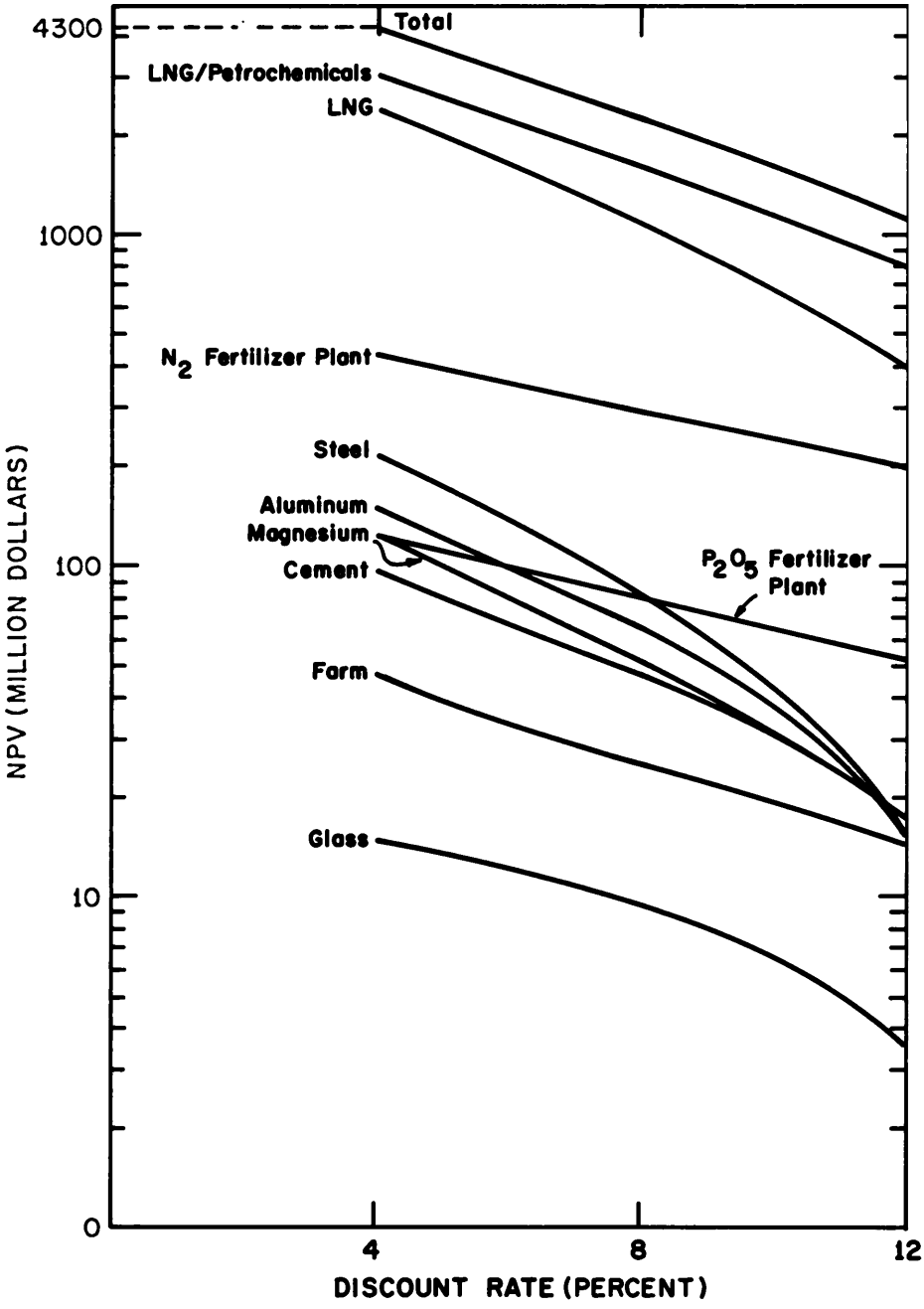

Figure 1.1 Net Present Value of Projects as a Function of the Discount Rate

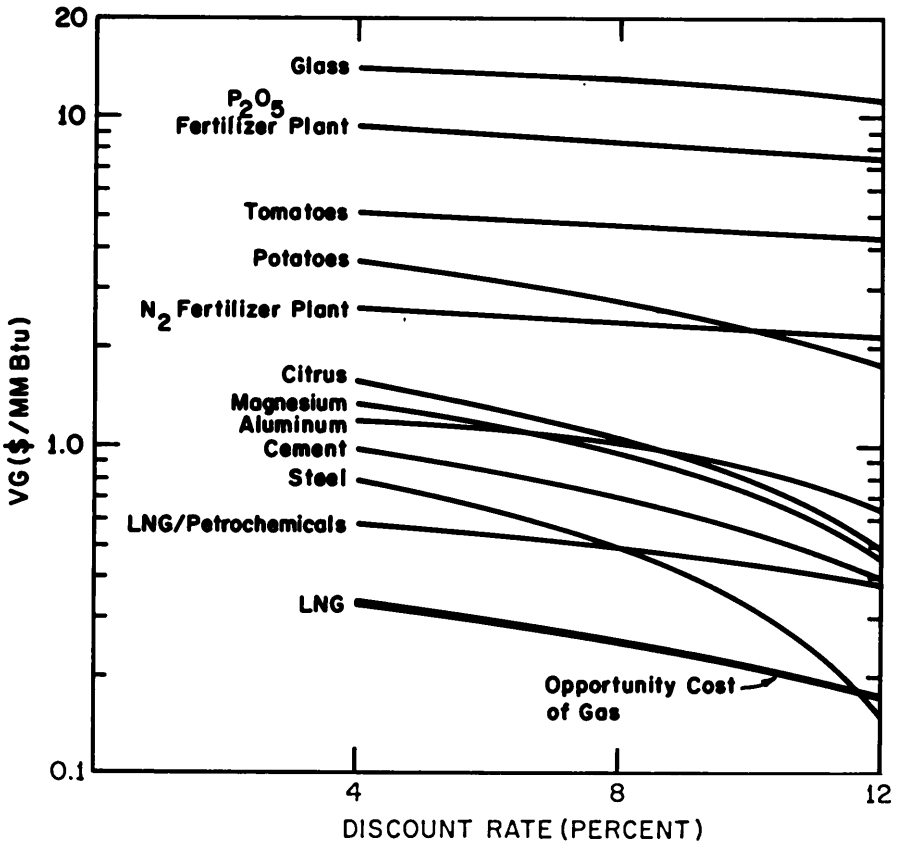

Figure 1.2 Break-Even Cost of Gas for Projects Proposed as a Function of the Discount Rate

projects recommended. On the other hand, while the glass plant has a low net present value it could afford to pay over 10 dollars per million Btu for the small amount of gas it would use. Basically this result indicates that the cost of gas would be a relatively minor component of the over-all cost of glass manufacture. However, taken with a relatively high benefit/cost ratio it indicates the economic desirability of establishing a modest glass producing facility. On the other hand, the economic attractiveness of a steel producing facility appears marginal. In fact, if the steel producer were to pay 30 cents per million Btu or higher for gas the benefit/cost ratio for the steel plant would drop below unity for discount rates

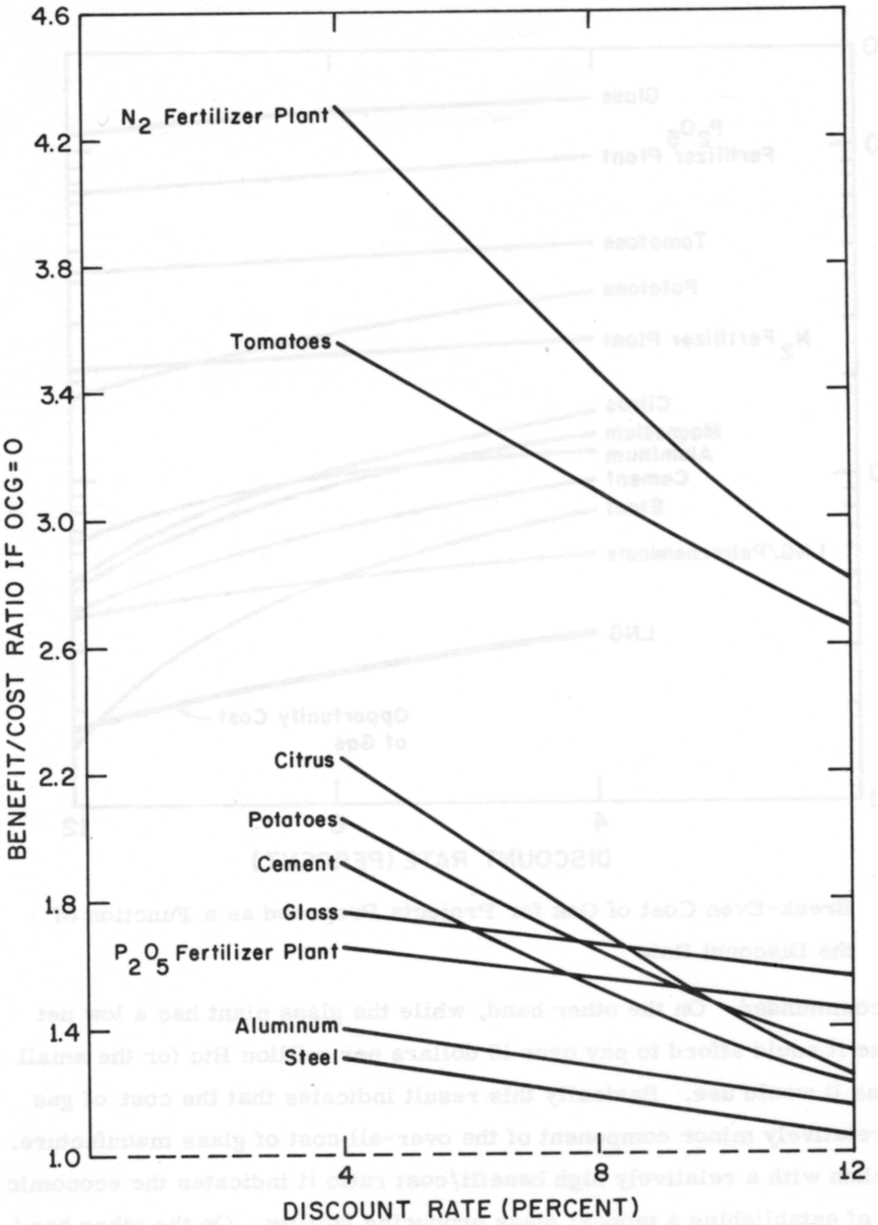

Figure 1.3 Benefit/Cost Ratio of Projects Proposed as a Function of the Discount Rate for OCG of 0

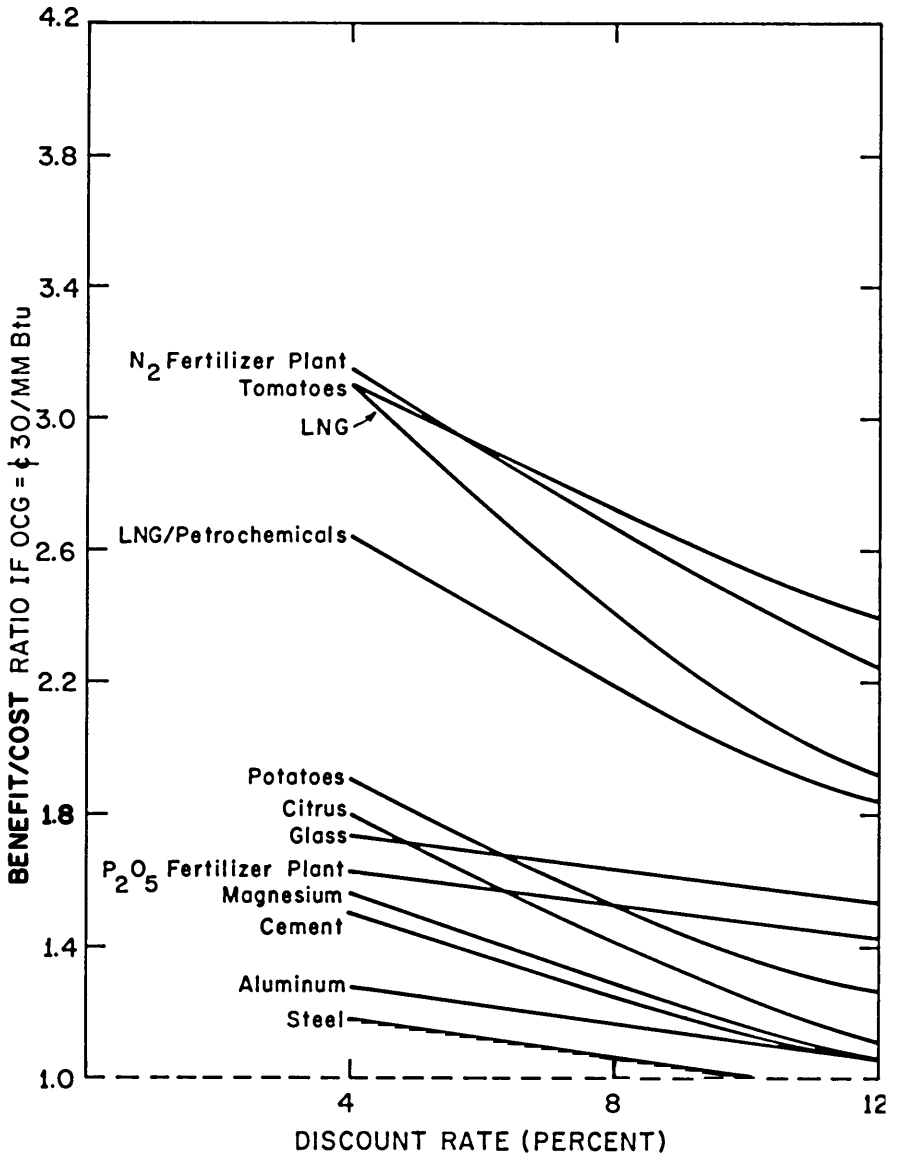

Figure 1.4 Benefit/Cost Ratio of Projects Proposed as a Function of the Discount Rate for OCG of 30 Cents per Million Btu

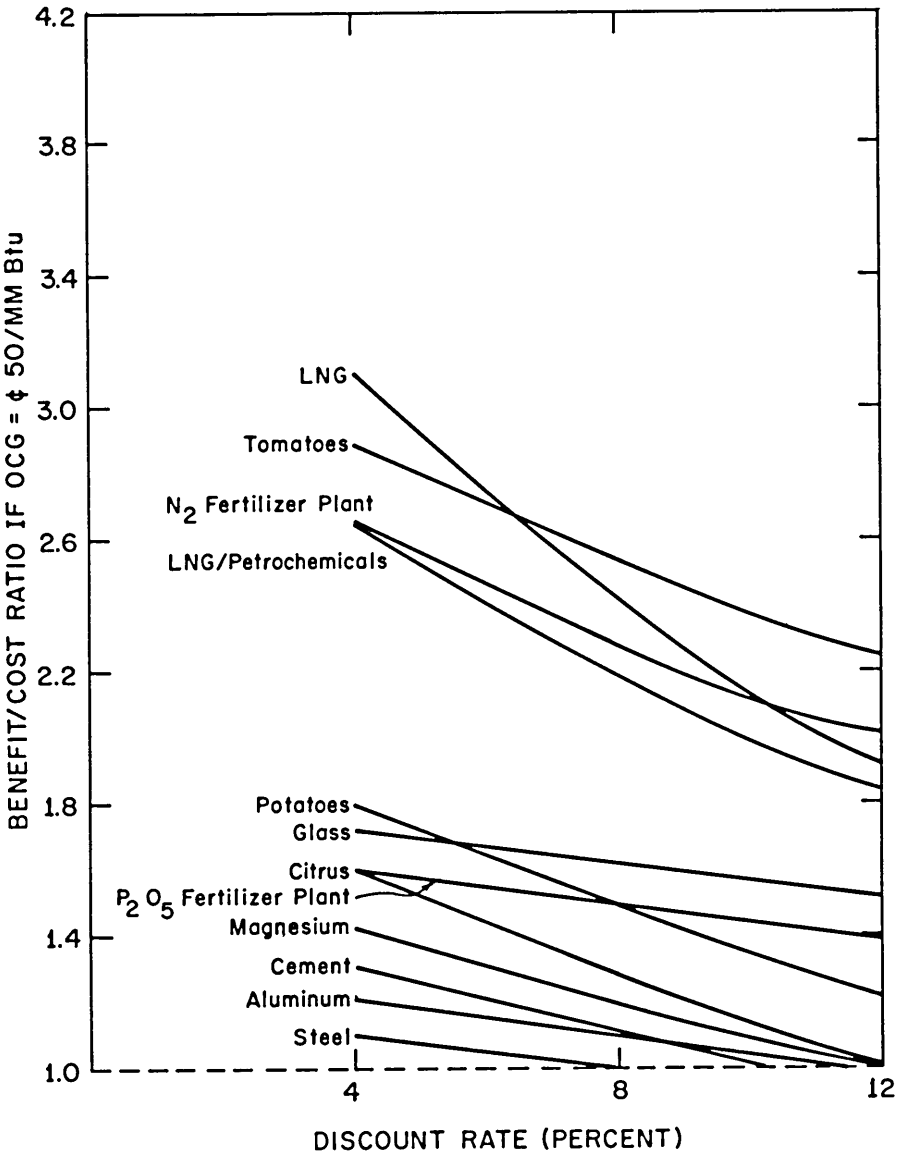

Figure 1.5 Benefit/Cost Ratio of Projects Proposed as a Function of the Discount Rate for OCG or 50 Cents per Million Btu

above 10 per cent.

Implementation of all the projects recommended would require a capital outlay of nearly 2 billion U.S. dollars. Their operation would provide direct employment for approximately 6500 workers. Many additional workers would be required during construction of the facilities but no attempt was made in this analysis to estimate the actual numbers nor to appraise the multiplier effect of the direct workers on the over-all economy.

Chapter 2 outlines the bases used for the economic analysis of these projects while Chapter 3 provides a brief overview of the Kingdom of Saudi Arabia for those not familiar with the area. The various projects for which the use of natural gas is proposed are analyzed in Chapters 4 through 13.

1.2 The Dawhat Salwah Complex

The principal components of the Dawhat Salwah Complex are two dams with an associated roadway, a hydroelectric plant, a magnesium plant, and an aquaculture facility. In addition, approximately 3,000 km^2 of valuable land would be recovered from the Gulf as a result of lowering the water level behind the dam.

Figure 1.6 illustrates the investment profile proposed for development of this complex. Construction of the dams would require a period of three years but construction of the hydroelectric plant could begin at the end of the second year. All construction would be completed in four years.

Use of the roadway connecting the eastern coast of Saudi Arabia with Bahrain and Qatar would begin three years after construction started but full operation of all of the facilities described would not be possible until the end of six years when the water in the Dawhat reached its steady state level.

Although the projects proposed for the Dawhat Salwah Complex could not be justified economically on an individual basis each one gains from the existence of the others and taken together they constitutute a very attractive development with a net positive cash flow of approximately 40 million dollars per year after full operation is reached. Figure 1.7 shows the net present value for the complex and Figure 1.8 the benefit/cost ratio, each as a function of the discount rate.

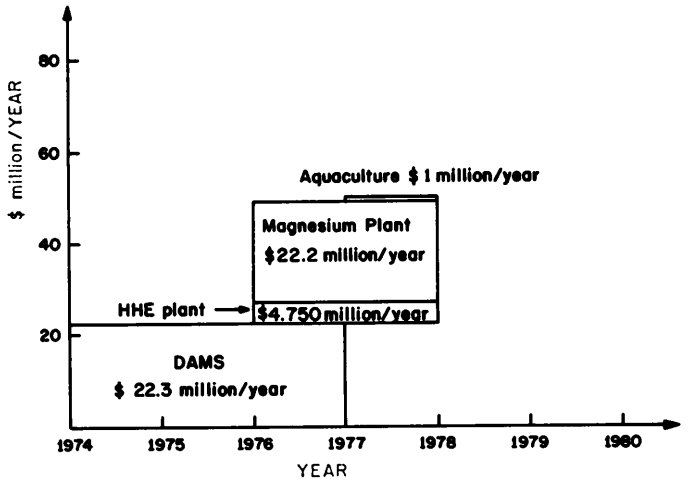

Figure 1.6 Investment Profile of the Dawhat Salwah Complex

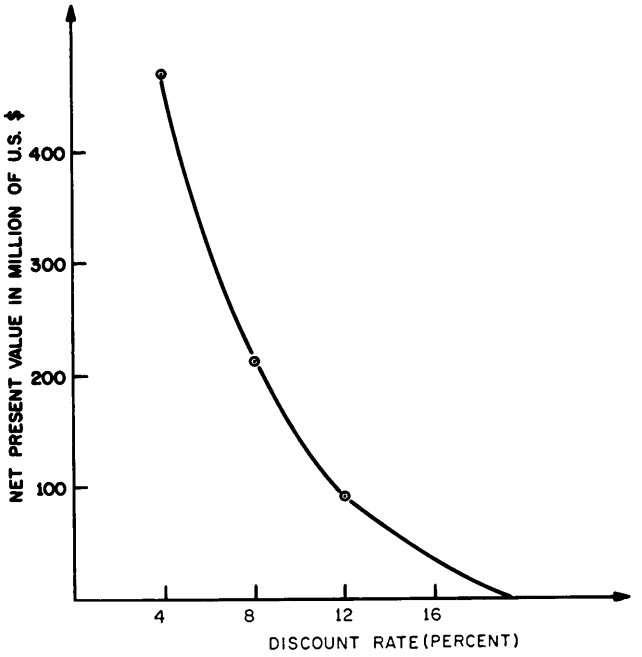

Figure 1.7 Net Present Value of the Dawhat Salwah Complex as a Function of the Discount Rate

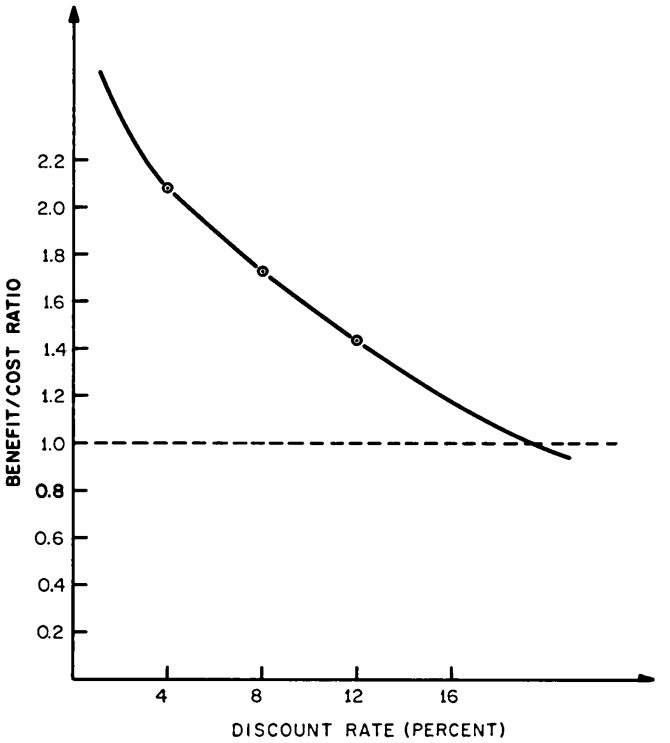

Figure 1.8 Benefit/Cost Ratio of Dawhat Salwah Complex as a Function of the Discount Rate

This preliminary analysis indicates that development of the proposed Dawhat Salwah Complex should be an effective means for economic and social development of the area. The first step toward realization of this potential would be securing the full cooperation of the three states involved. As soon as this cooperation is assured a research effort should be initiated to obtain additional "hard data" on the physical characteristics of the Gulf of Bahrain, on the manner in which salts would deposit in the proposed evaporation channel, and on the cost of producing the proposed products and on the markets for them.

1.3 Concluding Remarks

The analysis presented herein is obviously a first cut at a series of very complex problems. It would be foolish to believe that the projects proposed would be implemented in the form outlined or that actual operating experience would follow precisely the economic analyses herein presented. None the less, the method of analysis employed should be applicable in the further analysis of this particular situation or in the analysis of similar projects wherever they may be located. In addition, the analysis indicates a high potential for a diversified development in the area of the Arabian Gulf and further exploration of these possibilities is strongly recommended.