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# NATURAL GAS DEVELOPMENT AND UTILIZATION IN JORDAN*

Country Paper

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*ABSTRACT*

*IN THE COURSE OF THE LAST THREE DECADES NATURAL GAS HAS BECOME A MAJOR SOURCE OF ENERGY FOR MANY COUNTRIES OF THE WORLD . ITS THERMAL EFFICIENCY , CLEAN-BURNING AND LOW POLLUTING CHARACTERISTICS HAS MADE IT MORE VALUABLE THAN ITS CLOSEST COMPETITOR , FUEL OIL , IN THE REGION , THAT HAVE ACCESS TO BOTH FUELS DELIVERED TO THE USERS PREMISES AT SIMILAR COST PER BTU. JORDAN WAS ENTIRELY RELIANT ON IMPORTED OIL AND ITS PRODUCTS WHICH IMPOSE SIGNIFICANT BURDEN ON ITS ECONOMY. GOVERNMENT EFFORTS OVER THE LAST DECADE TO DEVELOP DOMESTIC RESOURCES , PARTICULARLY OIL AND NATURAL GAS , HAVE LED TO A NATIONAL PROGRAM FOR HYDROCARBON EXPLORATION . THE DISCOVERED NATURAL GAS IN RISHA AREA , HAS CONSTITUTED 3.55% OF THE TOTAL PRIMARY ENERGY SUPPLY. THIS PAPER FOCUSES ON THE FOLLOWING ISSUES .*

*1. THE EXPERIENCE OF JORDAN THROUGH NATURAL RESOURCES AUTHORITY (NRA) IN THE EXPLORATION AND DEVELOPMENT OF THE DOMESTIC ENERGY RESOURCES.*
*2. THE PROSPECTS OF NATURAL GAS UTILIZATION IN JORDAN.*
*3. THE POTENTIAL MARKETS FOR NATURAL GAS .*

***BACKGROUND***

Jordan stands at crossroads in the development of its energy resources , particularly with respect to oil and natural gas ,where as in the early 80s energy imports represented more than total earnings from commodity exports. At present such imports represents over 35% of total exports. Today ,Jordan has clearly much more diversified economy , making it less susceptible to sudden changes in international oil prices. As the country with heavy reliance on road transportation , the adequacy and cost of energy units are and will continue to be important determinant of prices prevailing throughout the country. In addition , the exploration , development and utilization of indigenous energy resources will be an important determinant of the level of economic activity. Such development and utilization of energy resources must run in a manner that provides the maximum benefits to the nation . The cost of imported energy in 1988 was J.D.150 million (US$ 450 million), or 14.8% of the total imports and 46.5% of the total exports , the cost of energy in relation to GNP in 1988 was 8.9% , while it was 8.7% in 1987 (table 1) . Its believed that the cost of energy is much higher for the period 1989-1992 due to the devaluation of the Jordanian Dinar.

Table 1

***COST OF ENERGY IMPORTS IN PERCENTAGES***

| YEAR | EXPORT% | IMPORT% | GNP% |
|---|---|---|---|
| 1980 | 102.0 | 17.00 | 12.4 |
| 1983 | 129.0 | 19.00 | 14.6 |
| 1985 | 76.0 | 18.00 | 12.1 |
| 1986 | 49.0 | 13.00 | 6.8 |
| 1987 | 59.6 | 16.10 | 8.7 |
| 1988 | 46.5 | 14.80 | 8.9 |
| 1989 | 35.2 | 16.20 | NA |

in spite of the relative decline in the price of imported oil since 1986 , the cost of energy still constitutes a large share of GNP. Realizing this fact the Ministry of Energy and Mineral Resources (MEMR )adopted a policy aimed at alleviating the burden of energy import costs on the economy by lowering imports through conservation on the one hand and the development of local sources of energy , traditional and alternative , on the other hand. The Jordan government launched country wide exploration program which has been executed by Natural Resources Authority ( NRA ) , the aim was to delineate oil and gas reservoirs in an attempt to minimize the country dependence on imported energy resources.

## *LOCAL ENERGY RESOURCES EXPLORATION BACKGROUND*

Jordan is approximately 90,000 $Km^2$. The sedimentary part of this area constitutes about 78% where oil and gas may have been accumulated. During the period 1946-1978 exploration activities by several foreign oil companies included geological and geophysical surveys and the drilling of 14 exploratory wells were carried out . Although oil and gas shows were observed in several wells , no commercial oil and gas discoveries were made. The companies who expected to find large , middle east size oil fields were disappointed and abandoned their concessions. The lack of interest by the foreign oil companies and in view of the increasing burden imposed by oil imports in the seventies , the government , through NRA remained convinced that past exploration efforts were inadequate . Consequently , the government decided to use its own technical and financial resources to explore for oil and gas . NRA has been in charge of all exploration activities since 1981. It first undertook a revision and assessment of all past geological , geophysical and well data . This was followed by additional seismic surveys , the drilling of 84 wells , and re-evaluation of the hydrocarbon resources . NRA's efforts during the last ten years proved the presence of oil and gas in Jordan by achieving small oil discoveries at Azraq and Sirhan basins and a gas discovery at Risha area. The natural dry gas was discovered in september 1986 in the Risha area north east of Jordan with the completion of well RH-3. A total of 24 wells were drilled to date 14 wells of these are concentrated in an area of 15 sq. Km. around the discovery well. Five wells tested commercial quantities of gas , and eight were non productive . The remaining 10 wells were exploratory wells in various location within the general Risha area . Fig. 1.

## *RISHA GAS COMPOSITION*

RISHA GAS COMPOSITION

| | | |
|---|---|---|
| Density (air=1) | | 0.634 |
| Methane ($CH_4$) | %vol | 90.792 |
| Ethane ($C_2H_6$) | %vol | 0.050 |
| Nitrogen($N_2$) | %vol | 1.302 |
| Carbon dioxide ($CO_2$) | %vol | 7.776 |
| $H_2S$ | PPM | NIL |
| RSH | PPM | NIL |
| Heat value (calculated) | | |
| (Net) | BTU/Cu.ft | 829.840 |
| (Gross) | BTU/Cu.ft | 919.700 |

*PLANING FOR NATURAL GAS UTILIZATION*

The new discovery of natural gas was the beginning of an important new energy option . Immediately after the discovery NRA decided to proceed with the assessment of the reservoir characteristics , the aerial extension and reserves. At the same time MEMR and NRA conducted preliminary studies , surveys and analysis in order to find out the best model of the natural gas usage plan. Initially ,we found ourselves in a situation of maximum uncertainty because of the unknown nature of the reservoir and the size of reserves. However this did not hinder our determination to formulate a strategy of gas utilization , taking into consideration that different probable reserves and deliverabilities could be achieved . Therefore four scenarios were envisaged for the Risha gas utilization depending on the estimated gas reserves and deliverability.

**FIRST SCENARIO :-GAS DELIVERABILITY OF UP TO 20 MMSCFD FOR A SHORT PERIOD.**

For this the gas will be used to generate electric power locally. The electricity is then transmitted to the national grid via a 180 MW transmission line (already constructed). Power generation capacity will be 2 x 30 MW gas generating sets.

**SECOND SCENARIO:-GAS DELIVERABILITY OF UP TO 60 MMSCFD OVER LONG PERIOD.**

For this local power generation of 2 to 6x30 MW gas turbine generating sets is envisaged . Transmission to the national grid will be via the 180 MW line already constructed.

**THIRD SCENARIO:GAS DELIVERABILITY OF UP TO 100 MMSCFD OVER A LONG PERIOD.**

For this local power generation of between 2 to 6x30 MW is envisaged with pipeline transport of excess gas (40 to 80 MMSCFD) to Amman area (Al-hussain thermal station)

**FOURTH SCENARIO:GAS DELIVERABILITY OF UP TO 200 MMSCFD OVER A LONG PERIOD .**

This is the same as scenario 3 with transportation of the excess gas through pipeline system to areas where the gas can be economically utilized as fuel or raw industrial material.

Before implementing any of these scenarios the following four main questions were to be answered.

1-What is the total potential gas market in Jordan and how dose it relate to Risha reserves production capability?

2-Should Risha gas be further developed and transported to these markets beyond the present limited power generation at the field itself ?

3-What are the priorities for the use of Risha gas based on present if limited reserves in relation to total market?

4-What is the maximum economic market for gas in the event that total supply from Risha or elsewhere exceeds potential markets in Jordan ?

Thus both valuing the natural gas i.e. setting its price and planing for its substitution of oil products in the economy are entirely dependent on the size of the reserves . large reserves would mean that gas has a number of potential uses when transported to customers such as electric power stations and large industrial users. Beyond these uses there may be scope for extending gas distribution to residential and commercial sectors. If large reserves were discovered sectorial modeling will be required to balance the costs and benefits for each use option. A comprehensive study of gas utilization has been prepared on the bases of large gas reserves supplied from Rish field or from neighboring Arab countries ,which could justify the construction of a pipeline from Risha to Zarqa area. The following section will summaries the gas demand of Jordanian consuming sectors , by which the above questions will be answered in economically justified manner .

*THE POTENTIAL GAS MARKET*

The prime targets of natural gas substitution are the large power generation and industrial consumers of heavy oil . On in-plant surveys of all industrial consumers , available data on residential and commercial potential , and a definition of possible future "developmental" markets in specified petrochemical facilities , and estimate of Jordan's total potential gas market was made in 1990. Table.2 provides a summary of potential gas market by type of consumer , which is projected annually at average energy growth of 6% . As indicated , the total power/industrial potential , representing conversion of existing facilities from their present fuel oil use to natural gas ,would amount to 54.9BCF in 1990 ,increasing to an estimated 87.8BCF by the year 2000. The residential/commercial and petrochemical demands are more speculative markets and are not necessarily economically justified.

*PRIORITY MARKET FOR RISHA GAS*

The total existing and potential market for Risha gas is well in excess of the field deliverability even in the most optimistic scenario. Our approach to the establishment of priorities for use of the limited reserves and deliverability are shown as follows:

a) initial screening of all potential consumers based on calculated gas net backs as a criteria.
b) More detailed selection among packages of large heavy fuel oil (HFO) consumers using rent as a criteria.

The initial analysis indicated that all the large power and industrial consumers have net backs in the range of \$2.2/MSCF to \$2.6/MSCF Table.3. Net backs for the residential/commercial network and the petrochemical projects are however , much lower (below \$.90/MSCF). The residential/commercial and petrochemical were eliminated from consideration under the present Risha gas reserve/deliverability profile.

The second phase in the establishment of priorities was an examination of the total economic rents for packages of power/industrial consumers , the total gas demand for which matched the deliverability profiles for the two reserves cases . As indicated ,in Table 4.a , there is insufficient gas available even in the 700 BCF case to supply all the large consumers at each location Zarqa/Amman or South /Aqaba. It was therefore , a question of choosing a package of consumers to use the assumed gas reserves . It was found that the rent per BCF for each of Zarqa consumers in both cases (500 ,700 BCF) is the same within the margin of error of assumptions . The total economic rent for this package was compared with similarly selected package in the South / Aqaba area . In both the 500 and 700 BCF cases it was found that the greatest economic rent would be earned by considering the Zarqa package . Table 4.b illustrates the average unit rent and net present value of total rents for the two selected packages .

*MAXIMUM ECONOMIC MARKET*

The maximum economic market at given additional large Risha supplies at similar cost structure as the present reserve cases , would only include all large power and industrial consumers. Residential/commercial consumers as well as petrochemical markets would be excluded. It is estimated that this would require a total average gas deliverability of about 200MMSCFD , with an annual growth of 6% for the coming years. Gas from neighboring countries would have to be available at no greater than $1.5/MSCF border price for all the large power/industrial consumers to be connected.

*PIPELINE*

Unless the Risha gas reservoir study yields very disappointing results concerning the reserves and deliverability , a pipe line , based upon the above reserves , from Risha to Zarqa was recommended . The pipe line should have a 20 inches diameter ,operating at a maximum operating pressure of a 54 bar . The total cost for the project was estimated to be $74 million US dollars.

*HISTORY OF NATURAL GAS DEVELOPMENT AND UTILIZATION TO DATE*

The first gas utilization study was conducted in 1987 before field development was initiated. At that time , very little information was known about the reservoir except data collected from RH-3 well which was already completed . Depending on well completion and testing results , this well was expected to deliver up to 22 MMSCFD of gas , sufficient to drive 2x30MW gas turbine for at least three to four years. On this basis and combined with optimistic forecasts of additional production wells being located in the vicinity of RH-3 well and for the utilization of this natural gas in power generation without flaring it during the long term testing period , NRA and JEA decided to install 2x30MW gas turbine generators and 23 MMSCFD glycol dehydration plant in the Risha area close to the producing wells. The study of this development plan considered future flexibility for field development and recommended the provision for tie-ins to be made at the plant in readiness for expansion if and when new gas supplies become available . However , this decision entails certain risks , namely , drops in reservoir pressure and the difficulty in sustaining gas production . If the long term test results confirm the commerciality and sustainability of the reserves , the plan is to increase the number of gas turbines until the transmission line capacity is reached. Fortunately well RH-6 was drilled nearby and was successfully tested and connected to the treatment plant.

The present status of the field development is as follows.

- 2 producing wells RH-3 and RH-6 are in operation for more than three years supplying adequate gas quantities for the 2x30MW gas turbines Fig.2 .
- 1x23MMSCFD glycol dehydration plant located 750m from RH-6 and 350m from RH-3 ,is in operation for more than 3 years discharging dry gas into 10" pipe line Fig.3 .
- 10" carbon steel API5L X42 pipe line 3.5 Km long supplying gas from the glycol plant to the power plant via a custody metering station located 300 m from the power plant.
- A power plant consisting of 2x30MW gas turbine generators with provision for expansion to 4x30MW generators.
- Three productive wells RH-16,RH-18 and RH-20 drilled , completed and tested , but not yet hooked up to the existing facilities.
- Plans for relocation of two additional 30 MW gas turbines from Amman to Risha and for installation of a second glycol plant.

*FUTURE RISHA GAS FIELD DEVELOPMENT*

The uncertainties associated , so far , with the delineation of the reservoir , the development drilling program and well performance make it impossible to prepare an optimized field development at this stage. There is however another possible development strategy which has been already considered by NRA , this strategy is called " Phased development " , it follows the principle of " explore and develop as you go " and ensure revenue is generated as quickly as possible after completing and testing the production wells . Based on this strategy , and since the infrastructure in Risha location for the expansion of dehydration plant and electrical power station is available , NRA and JEA decided to expand the existing facilities and to generate more electricity . This decision was made based upon the following assessment of field reserves and deliverability.

***RESERVES***

Production commenced in March 1989 and wells RH-3 and RH-6 produced 16 BCF through March 1992. Due to the uncertainties of the reservoir concerning aerial extent ,size and configuration , the material balance approach was used to estimate the original gas in place OGIP. The best estimate of (OGIP) , based on the production history and pressure behavior of the two producing wells is 215 BCF.

The following is a summary of different estimates of OGIP.

| | OGIP BCF |
|---|---|
| 1- The pessimistic view of reserves (RH-3 + RH-6 ). | 133 |
| 2- The optimistic view of reserves including RH-18 and RH-16 | 253-314 |
| 3- Best estimate December 91 most likely | 215 |

note :- Well Rh-24 has been just completed but not tested log analysis indicated positive results.

*DELIVERABILITY*

The deliverability of the gas field depends on the Absolute open flow (AOF) values of the producing wells Table 5. The deliverability was used to generate production forecasts for a wide range of gas development scenarios and operating strategies. The deliverability forecasts were generated using a minimum well head flowing pressure of 400 psi. A total of 4 deliverability cases were considered to cover different production rates to be maintained at steady rates and development scenarios. All four cases assume that the OGIP in the main pool is 215 BCF . Two steady production rates (46 MMSCFD and 35 MMSCFD ) against a number of additional wells have been considered in these cases . The production profiles are shown in figs .4 . A recovery factor of 70% was assumed 46 vs.35 & 20 MMSCFD , three deliverability cases were considered based on 168 BCF OGIP . The production profiles are shown in Fig.5.

*FUTURE GAS UTILIZATION OPTION.*

As indicated above , the estimated reservoir performance in relation to reserves and deliverability profiles , and based on economical indicators , the following options are proposed .

1-If pessimistic reserve of 133 BCF is considered then :
- * NO EXPANSION IS RECOMMENDED.

2-If optimistic reserve of 253 to 314 is considered then:
- * BUILD ADDITIONAL GAS PLANT OF 40 MMSCFD CAPACITY.
- * MOVE TWO TURBINES .
- * CONTINUE WITH RESERVOIR ASSESSMENT.

3-If the best estimated gas reserves of 168-215 BCF is proved then :
- *BUILD ADDITIONAL GAS PLANT OF 26 MMSCFD CAPACITY.
- *MOVE ONE GAS TURBINE .

The economics indicate that if a minimum of five years of steady production rates from the inception of the new facilities are required , then the average production rate should be 35MMSCFD. This production is capable of providing fuel gas for 3 turbines. It should be pointed out that the rate of 35 MMSCFD would be increased and a fourth turbine installed if the pool deliverability and pressure performance support a reserve base , that is larger than 215BCF. NRA and JEA have already taken all the necessary arrangements to move the third gas turbine to Risha gas power station , and expand the dehydration facilities for another 26MMSCFD daily production which will increase the dehydration capacity to 49MMSCFD. Such an expansion of facilities will enable the production of 35MMSCFD of gas , sufficient for the existing two gas turbine plus the additional third turbine generator to make a total of 90 MW electrical capacity . The expansion will allow for the fourth generator , if additional gas reserves are discovered.

In this case Risha natural gas will contribute significantly in Jordans electrical power generation . As the natural gas consumption represents 13.23% of the total electrical power generated by JEA in 1990 and 3.55% of the total primary energy demand , this contribution will increase to 25% of the total power generated by JEA and to 5% of the total primary energy demand .

I have to point out that if the gas turbine combined cycle technology is applied ,the contribution of Risha gas could reach 40% of the total power generated by JEA. High fuel gas utilization efficiency , with modern gas turbine units, efficiencies of 45-50% are achievable compared to 30-32% with simple cycle turbines or steam cycle. Table 6 represents the electrical energy generated in Jordan ( according to type of generation ). Table.7 represents the fuel consumption for electricity generation (thousand tons of oil equivalent).

*CONCLUSION AND RECOMMENDATION*

*1- NRA EXPLORATION EFFORTS DURING THE LAST DECADE HAVE ESTABLISHED THE POTENTIAL FOR OIL AND GAS IN JORDAN BY DISCOVERING A SMALL OIL FIELD IN AZRAQ A FAIR SIZED NATURAL GAS DISCOVERY IN RISHA AREA . THESE DISCOVERIES ATTRACTED FOREIGN OIL COMPANIES TO INVEST IN JORDAN IN OIL EXPLORATION IN DIFFERENT AREAS THROUGH SEVERAL PRODUCING SHARING AGREEMENT*

*2-THE RISHA GAS DISCOVERY IS OF VITAL IMPORTANCE NOT ONLY FOR THE ENERGY SECTOR BUT ALSO FOR THE JORDAN ECONOMY AS A WHOLE.*

*3- THE NATURAL GAS PRODUCTION/UTILIZATION REPRESENTS SO FAR 3.55% OF THE TOTAL PRIMARY ENERGY DEMAND AND 13.3% OF ELECTRICAL POWER GENERATION IN JORDAN .*

*4- IF LARGER RESERVES ARE TO BE DISCOVERED , THEN MORE EXPLORATION AND UTILIZATION OF NATURAL GAS ARE IS RECOMMENDED.*

*5- THE TOTAL POTENTIAL GAS MARKET IN JORDAN REQUIRES MORE GAS THAN RISHA FIELD CAN DELIVER.*

*6- IF A SOURCE OF IMPORTED NATURAL GAS CAN BE SECURED FROM NEIGHBORING COUNTRIES WITH THE BORDER PRICE LESS THAN $1.5/MSCF , THE PIPE LINE WOULD BE RECOMMENDED.*

**SUMMARY OF LARGE OIL CONSUMERS** **TABLE 2**

**AND GAS EQUIVELENT IN MMSCF** **(THOUSAND TONS OF OIL EQUIVALENT.)**

| YEAR / SECTOR | 1990 | | 1991 | | 1992 | | 1993 | | 1995 | | 2000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOE | N.G | TOE | N.G | TOE | N.G | TOE | N.G | TOE | N.G | TOE | N.G |
| ELECTRICITY (JEA) | | | | | | | | | | | | |
| ZERQA HTPS | 343 | 13720 | 364 | 14543 | 384 | 15366 | 405 | 16190 | 446 | 17836 | 549 | 21952 |
| Aqaba ATPS | 373 | 14920 | 395 | 15815 | 418 | 16710 | 440 | 17606 | 485 | 19396 | 597 | 23872 |
| RISHA G.T | 120 | 4800 | 127 | 5088 | 134 | 5376 | 142 | 5664 | 156 | 6240 | 192 | 7680 |
| INDUSTRIAL | | | | | | | | | | | | |
| REFINERY | 130 | 5200 | 138 | 5512 | 146 | 5824 | 153 | 6136 | 169 | 6760 | 208 | 8320 |
| CEMENT FACTORY | 301 | 5400 | 319 | 5724 | 337 | 6048 | 355 | 6372 | 391 | 7020 | 482 | 8640 |
| PHOSPHATE Co. | 86 | 3440 | 91 | 3646 | 96 | 3853 | 101 | 4059 | 112 | 4472 | 138 | 5504 |
| FERTILIZER Co. | 62 | 2480 | 66 | 2629 | 69 | 2778 | 73 | 2926 | 81 | 3224 | 99 | 3968 |
| POTASH Co. | 83 | 3320 | 88 | 3519 | 93 | 3718 | 98 | 3918 | 108 | 4316 | 133 | 5312 |
| GLASS Co. | 12 | 480 | 13 | 509 | 13 | 538 | 14 | 566 | 16 | 624 | 19 | 768 |
| IRON FACTORY | 28 | 1120 | 30 | 1187 | 31 | 1254 | 33 | 1322 | 36 | 1456 | 45 | 1792 |
| HOME & SERVECES | 399 | 15960 | 423 | 16918 | 447 | 17875 | 471 | 18833 | 519 | 20748 | 638 | 25536 |
| TOTAL | 1937 | 70840 | 2053 | 75090 | 2169 | 79341 | 2286 | 83591 | 2518 | 92092 | 3099 | 1E+05 |
| TOTAL- HOME & SERVECES | 1538 | 54880 | 1630 | 58173 | 1723 | 61466 | 1815 | 64758 | 1999 | 71344 | 2461 | 87808 |

JORDAN POTENTIAL FOR RISHA GAS AS FEEDSTOCK AND FUEL IN PETROCHEMICAL INDUSTRY SECTOR IS ESTIMATED TO BE 39.6 BCF/YEAR.

# TABLE.3

## RISHA GAS NETBACKS

| | $/MCF |
|---|---|
| **LARGE HFO CONSUMERS** | |
| Refinery - Zarqa | 2.22 |
| JEA - Zarqa | 2.20 |
| JEA - Aqaba | 2.57 |
| Cement - Fuhais | 2.30 |
| Cement - Rashadiya | 2.51 |
| Phosphate - Abiad | 2.37 |
| Phosphate - Al Hasa | 2.38 |
| Fertilizer - Aqaba | 2.57 |
| Potash - Safi | 2.44 |
| Arab I/Steel - Zarqa | 2.27 |
| Jord I/Steel - Zarqa | 2.27 |
| Nat Steel - Zarqa | 2.27 |
| Jord Glass - Ma'an | 2.53 |
| Jord Paper - Zarqa | 2.27 |
| Jord Ceramic - Zarqa | 3.37 |
| **RESIDENTIAL/COMMERCIAL** | |
| Amman Network | 0.55 |
| Zarqa Network | 0.06 |
| **PETROCHEMICALS** | |
| Ammonia for DAP | 0.88 |
| Ammonia for DAP/UREA | 0.01 |
| Methanol | 0.01 |

## TABLE 4.a

### RESERVES AND DELIVERABILITY FOR RISHA GAS

| ASSUMED RECOVERABLE RESERVE BCF | DELIVERABILITY MMSCFD | | | |
|---|---|---|---|---|
| | 1993 | 1998 | 2003 | 2007 |
| 500 | 51.5 | 58.7 | 67.9 | 50.7 |
| 700 | 81.5 | 93.5 | 107.9 | 70.8 |

## TABLE 4.b

### ECONOMIC RENT FOR PACKAGES OF LARGE CONSUMERS.

| | ZARQA | AQABA/SOUTH |
|---|---|---|
| 500 BCF | | |
| AVERAGE UNIT RENT MM$ | 0.29 | 0.11 |
| NPV OF TOTAL RENT MM$ | 20.5 | 10.4 |
| 700 BCF | | |
| AVERAGE UNIT RENT MM$ | 0.65 | 0.45 |
| NPV OF TOTAL RENT MM$ | 77 | 57.9 |

TABLE No.5

## DELIVERABILITY OF THE PRODUCING RISHA WELLS

| WELL | n | C | INITIAL AOF | | PRESENT AOF | |
|---|---|---|---|---|---|---|
| | | | AOF | 25% AO | AOF | 25%AOF |
| RH-3 | 0.811 | 9.11E-05 | 48.90 | 12.23 | 39.76 | 9.94 |
| RH-6 | 0.823 | 3.28E-05 | 21.42 | 5.35 | 17.35 | 4.34 |
| RH-20 | 0.997 | 3.36E-06 | 28.40 | 7.10 | 28.82 | 7.21 |
| RH-18 | 0.905 | 1.87E-05 | 45.13 | 11.28 | 36.87 | 9.22 |
| RH-16 | 1.000 | 2.16E-06 | 23.71 | 5.93 | 19.44 | 4.86 |

ELECTRICAL ENERGY GENERATED IN JORDAN TABLE 6
(ACCORDING TO TYPE OF GENERATION)

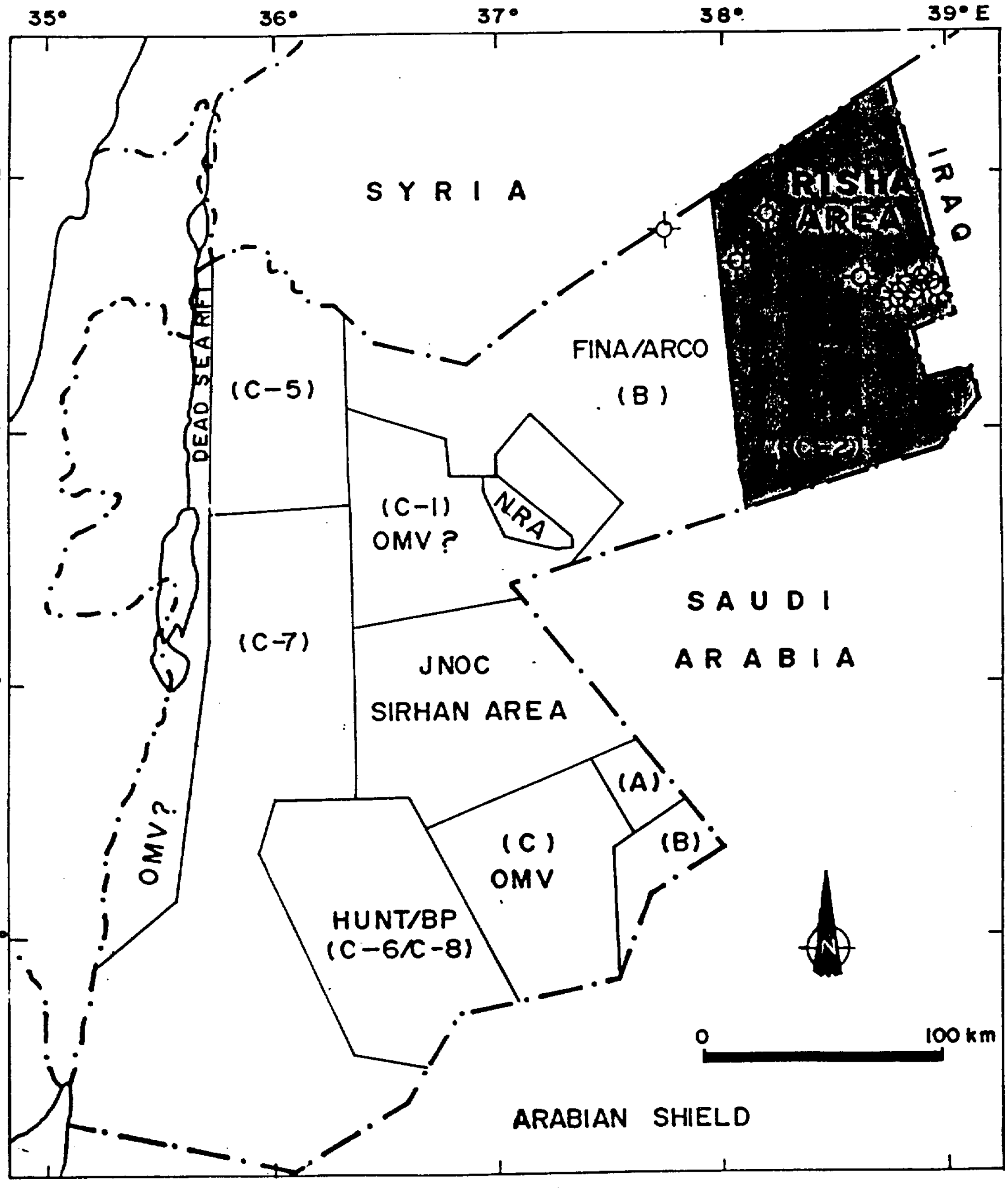
| | 1988 | | 1989 | | 1990 | |
|---|---|---|---|---|---|---|
| | GWH | % SHARE | GWH | % SHARE | GWH | % SHARE |
| SETAM HFO | 2719 | 94.51% | 2657 | 86.92% | 2751 | 84.08% |
| DIESEL HFO | 129 | 4.48% | 102 | 3.34% | 76 | 2.32% |
| GAS TURBINES- DIESEL | 2 | 0.07% | 1 | 0.03% | 1 | 0.03% |
| GAS TURBINES-NATURAL GAS | 0 | 0.00% | 281 | 9.19% | 433 | 13.23% |
| HYDRO UNIT | 27 | 0.94% | 16 | 0.52% | 11 | 0.34% |
| TOTAL | 2877 | 100.00% | 3057 | 100.00% | 3272 | 100.00% |
| INDUSTRIAL SECTOR | 385 | | 375 | | 365 | |
| TOTAL | 3262 | | 3432 | | 3637 | |

FUEL CONSUMPTION FOR ELECTRICITY GENERATION TABLE 7
(THOUSAND TONS OF OIL EQUIVALENT.)

| | | | | GROWTH |
|---|---|---|---|---|
| | 1988 | 1989 | 1990 | 1990/1989 |
| JEA | 740 | 773 | 839 | 8.5% |
| IDECO | 4 | 3 | 4 | 33.3% |
| INDUSTRIALCOMPANIES | 106 | 104 | 101 | -2.9% |
| TOTAL ELECTRICITY SECTOR | 850 | 880 | 944 | 7.3% |
| JORDAN FUEL CONSUMPTION | 3055 | 3189 | 3380 | 6.0% |
| TOTAL ELECTRICITY SECTOR TO TOTAL CONSUMPTION (%) | 27.8% | 27.6% | 27.9% | |

# FIG.1

## CONCESSIONS OF JORDAN



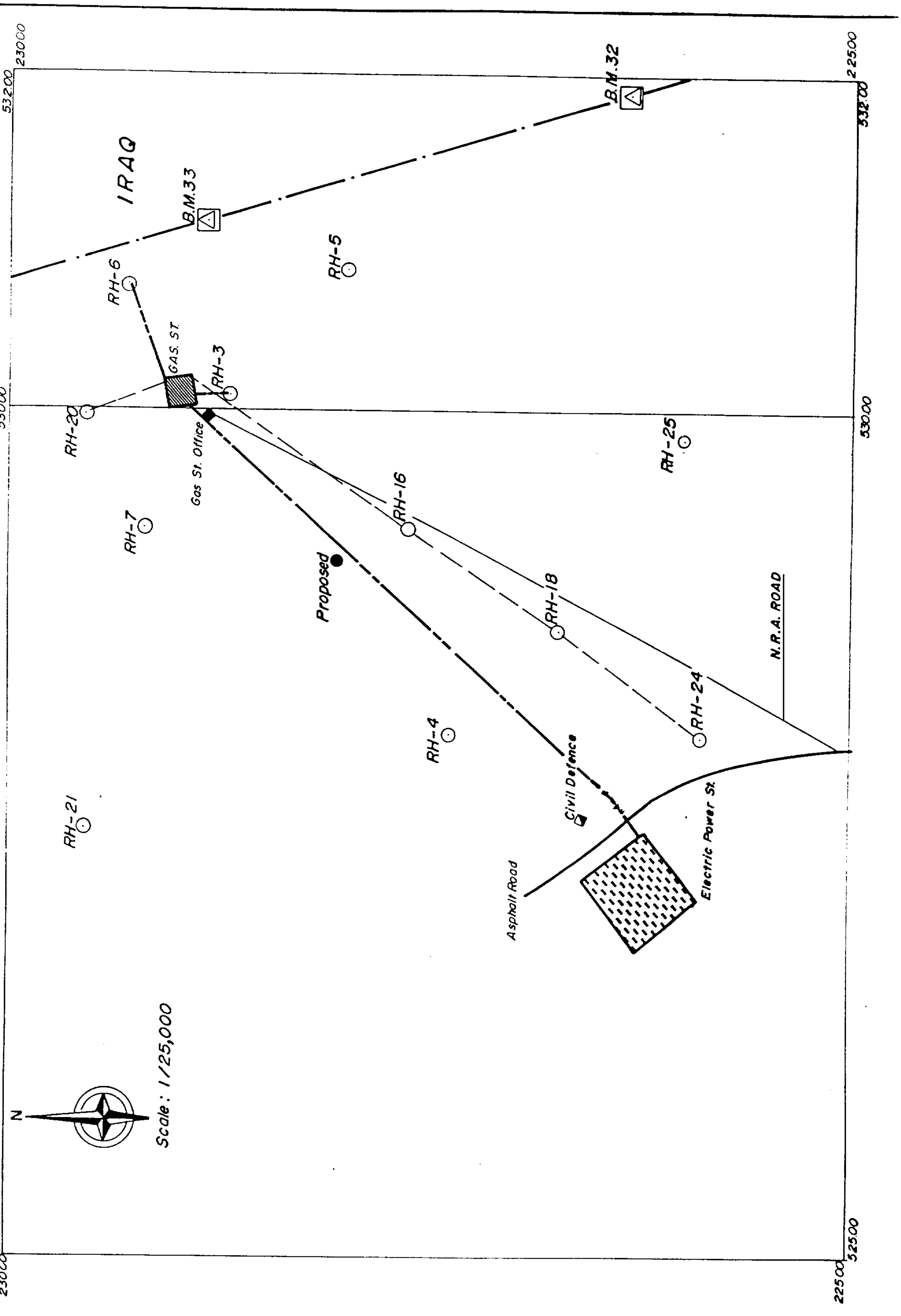
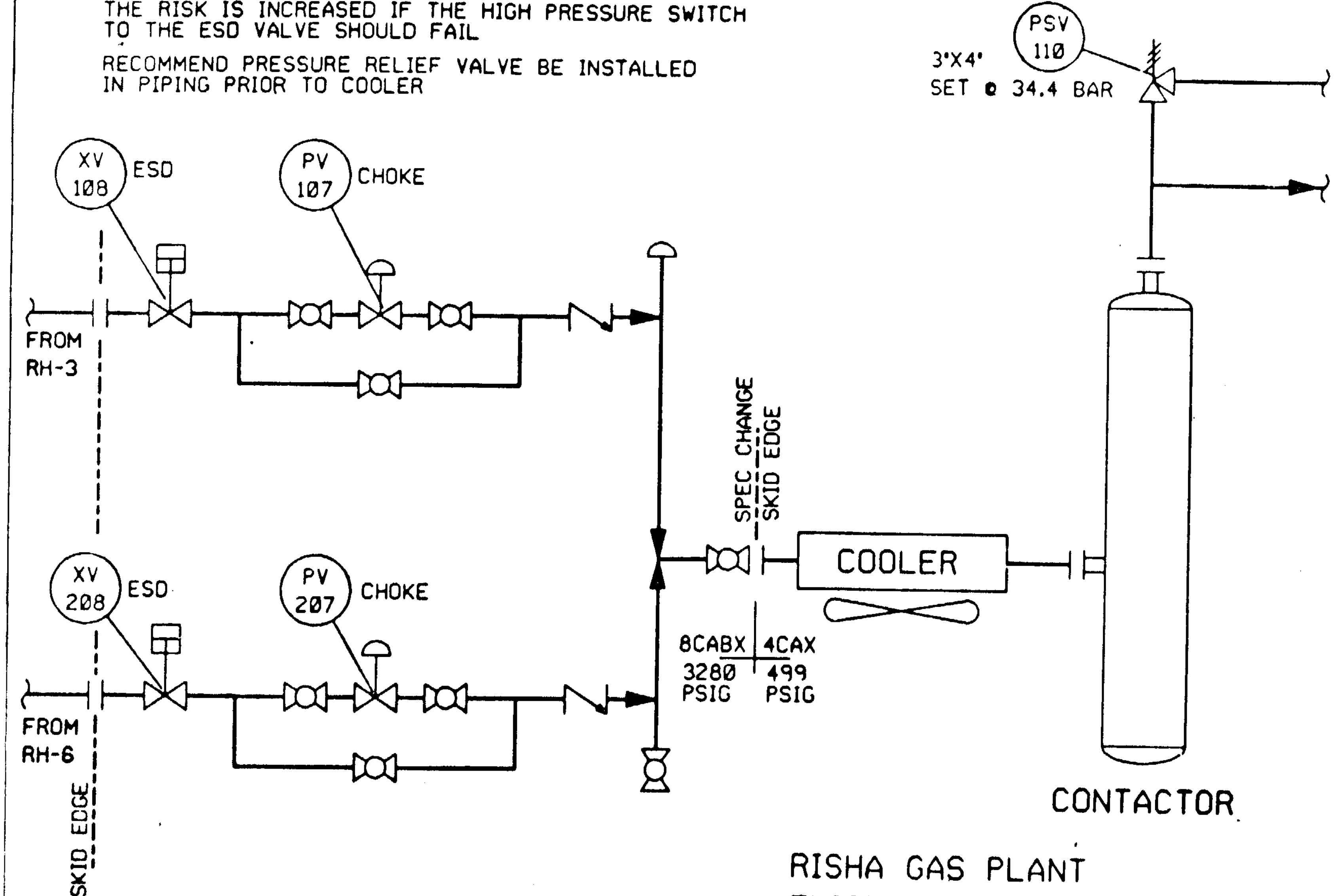

IRAQ
B.M.33
B.M.32
RH-6
RH-5
GAS. ST.
RH-3
RH-20
Gas St. Office
RH-25
RH-16
RH-7
Proposed
RH-18
N.R.A. ROAD
RH-24
RH-4
Civil Defence
Electric Power St.
RH-21
Asphalt Road
Scale: 1/25,000
N
23000
53200
22500
53200
53000
53000
52500
52500
23000
22500

FIG.2

FIG.3

NOTE :-
OVER PRESSURE OF THE COOLER MAY OCCUR
IF A HYDRATE CONDITION DEVELOPED IN THE COOLER
DURING START-UP WHEN GAS IS FLOWING TO THE PLANT
THROUGH THE CHOKE BYPASS.
THE RISK IS INCREASED IF THE HIGH PRESSURE SWITCH
TO THE ESD VALVE SHOULD FAIL

RECOMMEND PRESSURE RELIEF VALVE BE INSTALLED
IN PIPING PRIOR TO COOLER




RISHA GAS PLANT
EXISTING EQUIPMENT

FIG.4

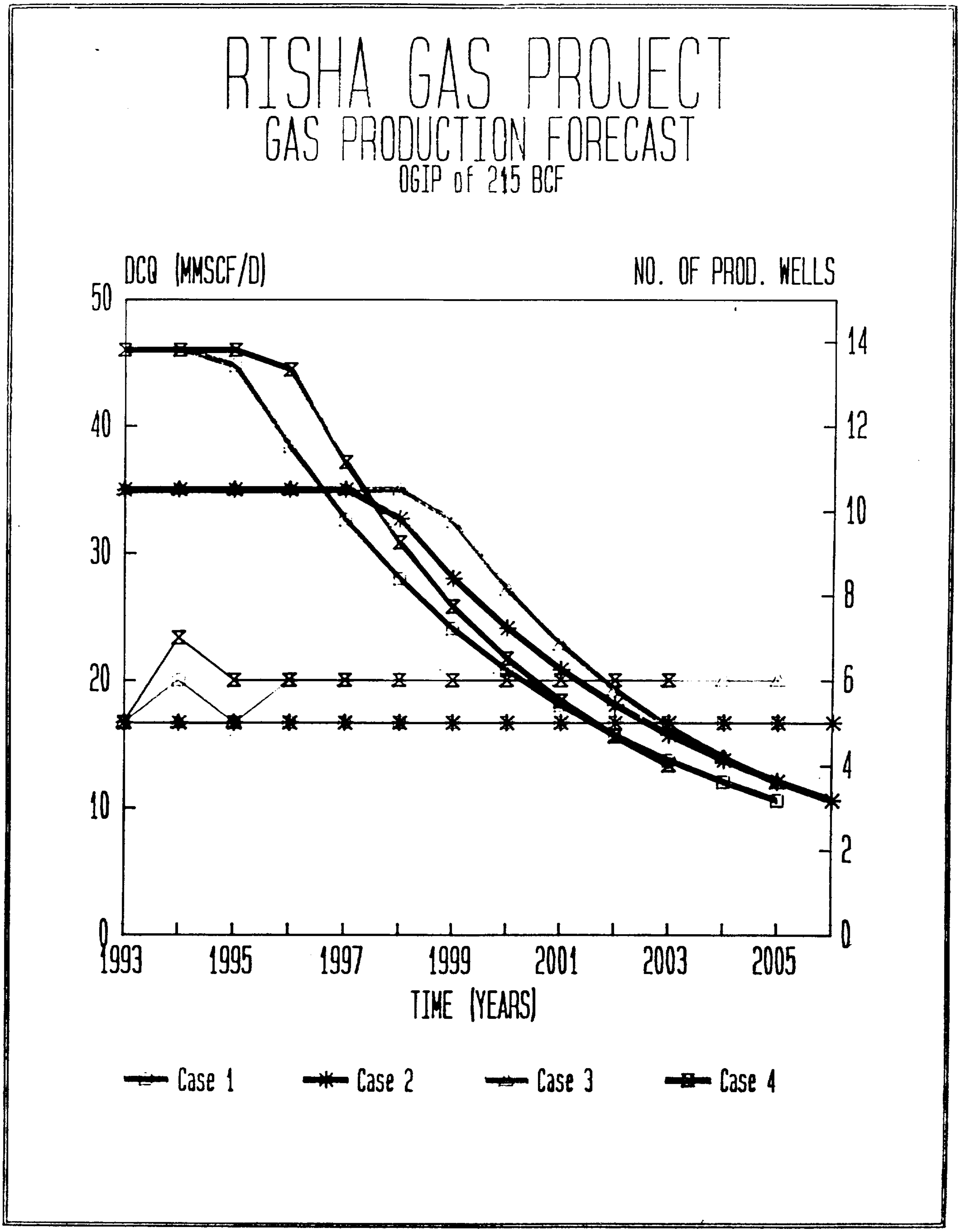
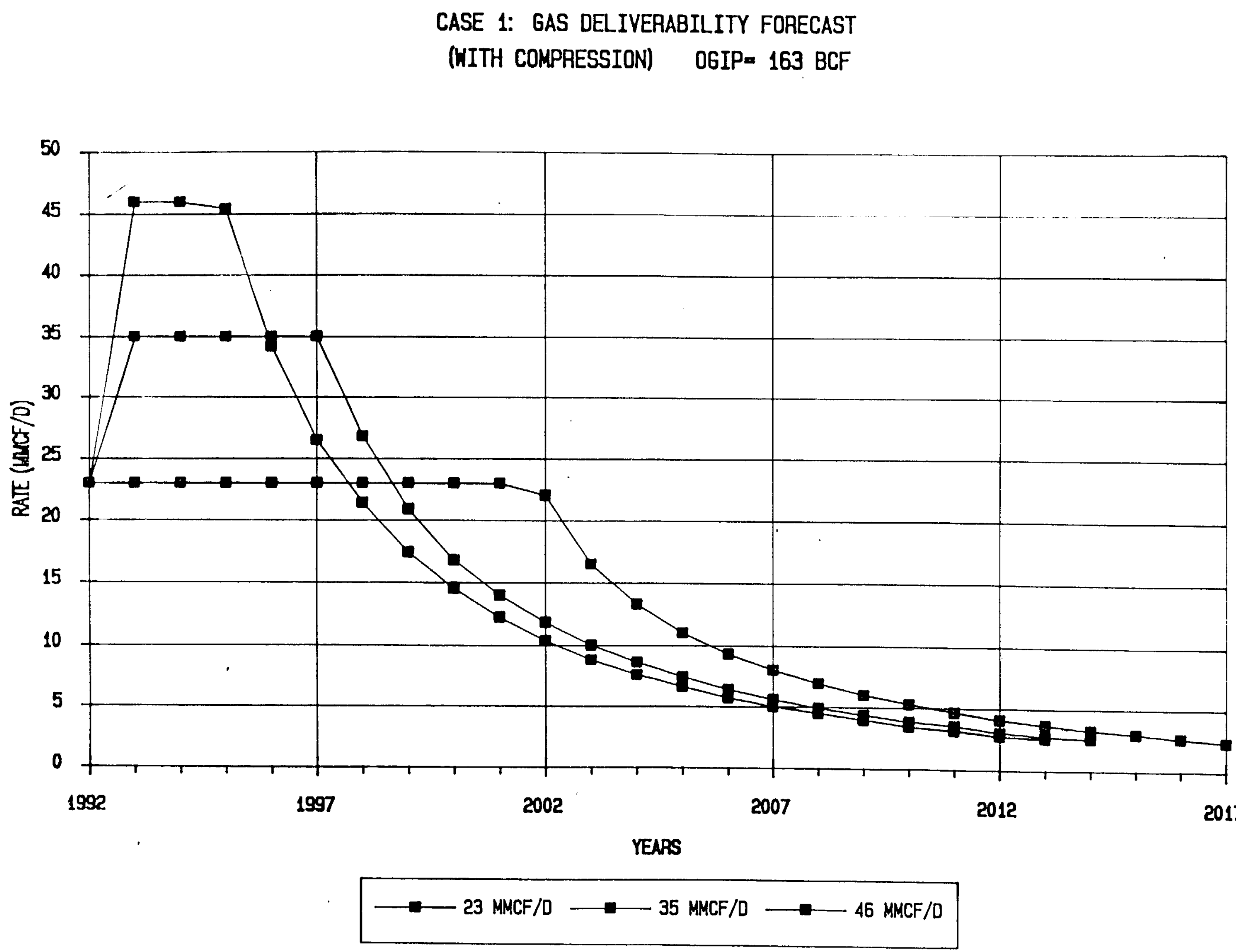

RISHA GAS PROJECT
GAS PRODUCTION FORECAST
OGIP of 215 BCF
DCQ (MMSCF/D)
NO. OF PROD. WELLS
50
40
30
20
10
0
14
12
10
8
6
4
2
0
1993
1995
1997
1999
2001
2003
2005
TIME (YEARS)
Case 1
Case 2
Case 3
Case 4

FIG.5



CASE 1: GAS DELIVERABILITY FORECAST
(WITH COMPRESSION) OGIP= 163 BCF
RATE (MMCF/D)
50
45
40
35
30
25
20
15
10
5
0
1992
1997
2002
2007
2012
2017
YEARS
23 MMCF/D
35 MMCF/D
46 MMCF/D