Chapter 6

Electricity Tariff

6. Electricity Tariff

6-1. Tariff Structure Reform

6-1-1. Tariff System

In Oman, a single electricity tariff system is applied in the whole country. The tariff system has only consumption charge (kWh charge). Capacity charge (kW charge) is not introduced. There are several customer categories in the system; residential and government, commercial, agriculture and fishery, hotel and tourism, and industrial. Total accounts in Oman are about 380,000 and the biggest segment is the residential and government users whose electricity consumption (kWh) accounts for 80% of the total consumption. The second largest segment is the commercial users whose share is about 14%. In contrast, the industrial sector's consumption is only 3% of the total.

Table 6-1-1 Electricity Tariff in Oman

	Monthly Consumption	Tariff
Residential & Government	0-3000kWh	10Bz/kWh
	3001-5000kWh	15Bz/kWh
	5001-7000kWh	20Bz/kWh
	7001-10000kWh	25Bz/kWh
	10000kWh over	30Bz/kWh
Commercial		20Bz/kWh
Agriculture & Fishery	0-7000kWh	10Bz/kWh
	7000kWh over	20Bz/kWh
Hotel & Tourism	0-7000kWh	10Bz/kWh
	7000kWh over	20Bz/kWh
Industrial	Summer (May—August)	24Bz/kWh
	Other seasons (Sept.—April)	12Bz/kWh

Not charged : Desalination and Mining

Table 6-1-2 Customer Distribution Profile

	Residential	Government	Commercial/ Others	Industrial	Total
Consumption (mil kWh)	3,246(57.7%)	1,264(22.5%)	930(16.5%)	181(3.2%)	5,623
Accounts	290,689(76.9%)	20,442(5.4%)	66,780(17.7 %)	35(0.0%)	378,046

In Japan, the electricity tariff system consists of capacity charge and consumption charge to reflect actual cost structure more accurately. Many countries have such a tariff system. With a capacity charge, the amount of electricity demand (kW) needs to be measured and monitored. In case the kW demand exceeds the limit which is set by contract, the electricity supply may be disconnected or a surcharge is imposed. Electricity users naturally pay attention to how much they are using and try to keep the kW demand within the limit. Without a capacity charge, it is difficult to expect that people would manage their electricity consumption under a preset limit. It is recommended to introduce a capacity charge to large-scale customers, in particular, which will evoke people's consciousness toward efficient use of electricity.

6-1-2. Residential Tariff

In Oman, the largest segment in electricity tariff is residential tariff. The residential tariff, which generates more than 80% of electricity revenue in Oman, is applied not only to households but also to government and corporate offices. It is, therefore, first priority to consider a reform of residential tariff in order to increase revenue.

A progressive tariff system, which has higher rate for larger consumption, is adopted for the residential tariff. In principle, this system aims at providing lower income households with minimum but necessary amount of electricity at a discounted rate to sustain their living (lifeline tariff). In return it charges affluent families, who always use more electricity than average people, higher rates to offset the discount. It works to rectify the income disparity and also to discourage overuse of electricity by the upscale families.

The progressive tariff system is also used in Japan. The residential customers in Japan are charged based on the formula shown below (Figure 6-1-1). With the three-stage rates, wealthy families pay more for their more-than-average consumption. The premium margin of the most expensive rate covers the foregone revenue caused by the discounted rate. In Japan's system, the limit for the first stage rate is only 120kWh per month. This number is determined by a statistical survey on basic electricity consumption for TV, refrigerator and so on.

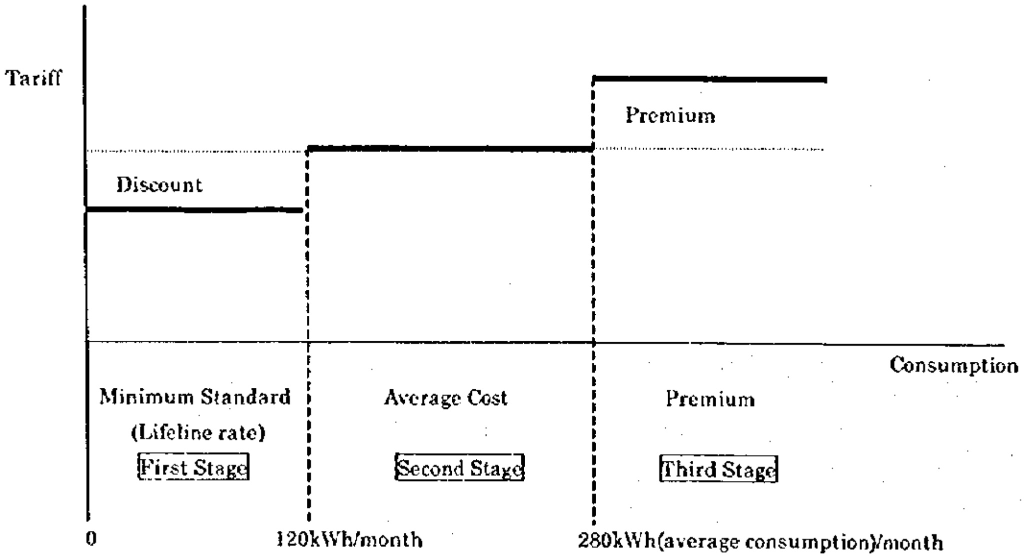


Figure 6-1-1 Residential Tariff in Japan

Before making any decision to modify the current residential tariff, it is required to examine the actual consumption pattern of average household. By analysing this data, the impacts of tariff reform to customers can be predicted. Also, it would be possible to estimate the amount of revenue increase.

In Oman, an average household consumes 12,000kWh per year, which is extremely large compared to Japan. A data set is collected to identify monthly consumption profile of middle income families, who use approximately 12,000kWh per year. It includes more than 30 data samples gathered in the Muscat area. The result is shown in Figure 6-1-2.

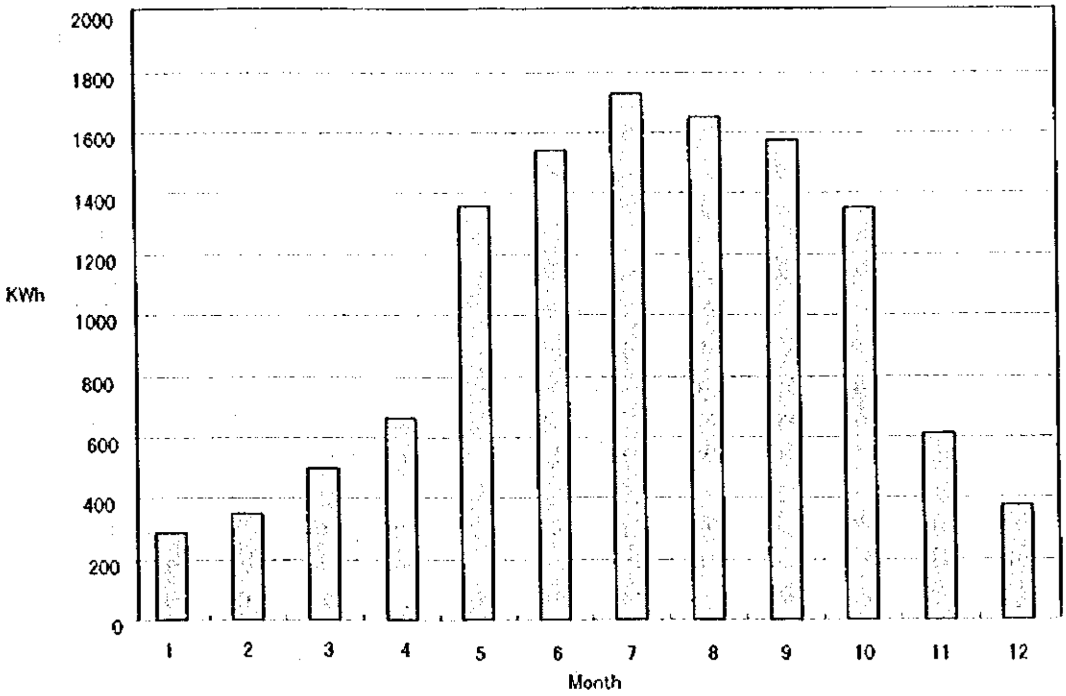


Figure 6-1-2 Annual Electricity Consumption by Standard Household (model)

It is clear from the above graph that in the off-peak season, when air conditioning is basically not necessary, the monthly demand is only around 300kWh. In contrast, from May to October air conditioners are in full operation pushing up the monthly consumption to 1,500 to 2,000kWh level. This can be interpreted that the basic electricity demand of average family other than air conditioning is around 300kWh, which includes lighting, TV, refrigerator, washing machine and so on. On top of this, an extra demand for air conditioning is added during the peak season.

An important finding is that even in the peak season average household does not consume more than 2,000kWh per month. As a result, the discounted first stage rate is applied to those families throughout a year fulfilling the policy objective of social welfare. Even higher income families who are using 2,000kWh to 3,000kWh per month enjoy the discounted price. When the residential tariff reform is planned, it is necessary to consider this point. Lowering the limit of 3,000kWh should be viewed as easy to justify, because this change does not affect average families. Also, it is important to introduce fixed charge system like the telephone tariff schedule which has a constant charge per month. There is a rationale for the introduction of fixed charge because electricity distribution cost such as low voltage network takes a significant part of total electricity supply cost.

Other issues to be examined are as follows:

a. During the summer season, monthly bills go up significantly; seven to ten times higher than that of off-peak season. For example, an average family needs to pay about 20RO in the summer season, which is substantially big in their monthly household expenses. In winter they only pay about 3RO. The big monthly bill may trigger meter tampering and other illegal practices in which the consumers willfully steal electricity. In order to cope with this problem, accepting deposits may be effective. When the customers pay some deposits during the off-peak season, they should be given some discounts. This program would be fairly easy to implement, because a computerized customer data base has already been operating.

b. In Oman the seasonal fluctuation of electricity consumption is very large. There may be an argument whether or not a single residential tariff throughout a year is appropriate. In the winter season when the electricity consumption level is low and a significant part of generation facilities are being idle, the premium rate may not be necessary because it works to discourage electricity consumption. Rather, it would be more beneficial if MEW promotes electricity consumption during the off-peak season by lowering the overall electricity rate.

Figure 6-1-3 indicates the distribution profile of monthly residential consumption. In this graph all the monthly consumption data from January to December are included. It should be noted that 86% of monthly residential consumption falls in the first stage rate. More precisely, 42% of residential consumption is in the range from 0 to 1,000kWh, 28% from 1,001 to 2,000kWh and 16% from 2,001 to 3,000kWh accordingly. There will be a substantial revenue increase if the limit of 3,000kWh is lowered because most of the residential consumption falls in the current first stage rate. As is clear from the previous analysis, the average household consuming 12,000kWh per year gets no impact even if the threshold is lowered to 2,000kWh.

After considering these issues, it is recommended to lower the threshold of 3,000kWh for the first-stage rate to 2,000kWh per month. By this change, the current rate of 10Bz/kWh would go up to 15Bz/kWh for 16% of the total residential demand, which is 520 million kWh. The expected revenue increase will be about 2.6 million RO per year. If this tariff revision is implemented, those who are using more than 2,000kWh per month will be more or less affected. For example, those who are consuming 3,000kWh per month during the summer season will have to pay 5 RO (5Bz/kWh x (3,000-2,000)kWh) more, from 30RO to 35RO, in a month. The number of wealthy households and government offices who will be affected would be approximately 50,000 to 60,000, depending on many conditions such as the summer time temperature.

Changing other thresholds is not recommendable. It would only generate minimal revenue increase, because the electricity consumption in higher slabs is very small. (See Figure 6-1-3)

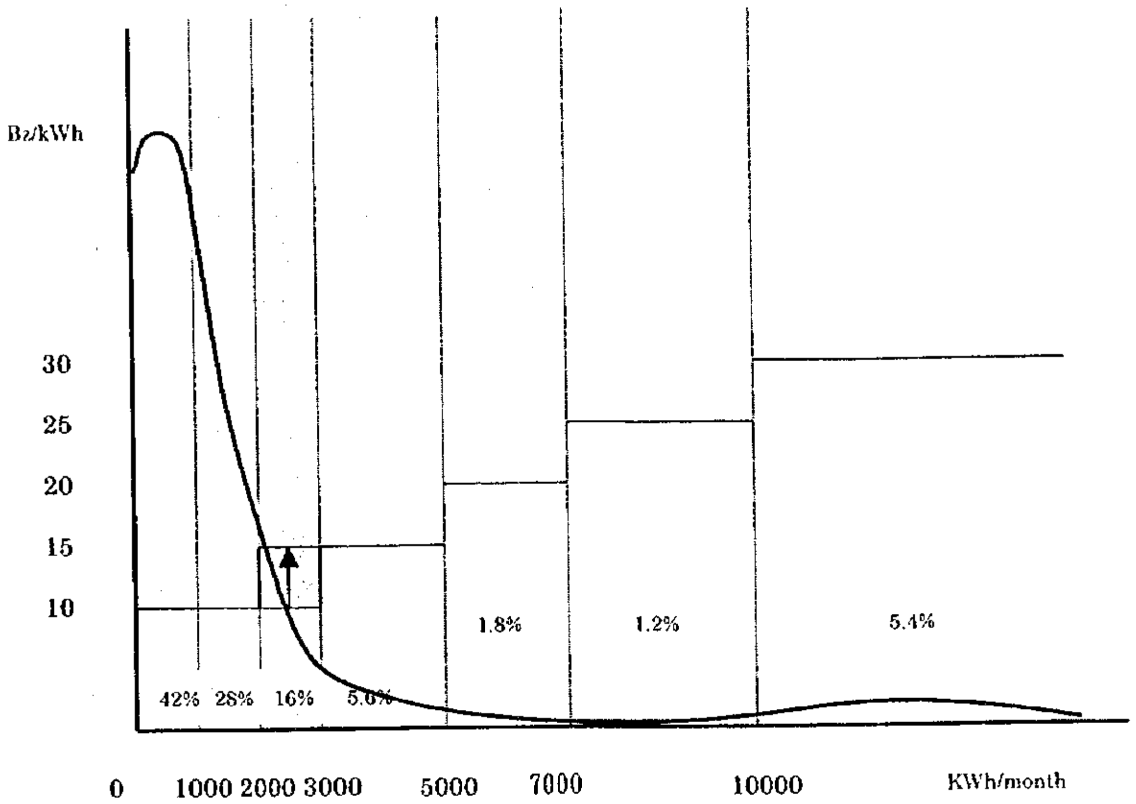


Figure 6-1-3 Consumption profile and overview of proposed tariff

In addition, a small fixed charge of 1RO per month is also recommended. This fixed charge will be applied to all the customers. For the long run, it is advisable to raise the fixed charge and, in return, to lower the consumption charge in order to reflect actual cost structure. This would also contribute to making the fluctuation of monthly payment smaller, which will be well received by the public. The expected revenue increase by introducing a 1RO fixed charge will be 4.5 million RO. If this fixed rate is applied only to households, the revenue increase would be 3.5 million RO. Given all these considerations, a new residential tariff is proposed as follows. (See Table 6-1-3)

Table 6-1-3 New Residential Tariff (draft)

Proposed Tariff		Current Tariff	
Fixed Charge	1 RO/month		
Consumption Charge			
0-2000kWh	10Bz/kWh	0-3000kWh	10Bz/kWh
2001-5000kWh	15Bz/kWh	3001-5000kWh	15Bz/kWh
5001-7000kWh	20Bz/kWh	5001-7000kWh	20Bz/kWh
7001-10000kWh	25Bz/kWh	7001-10000kWh	25Bz/kWh
10000kWh over	30Bz/kWh	10000kWh over	30Bz/kWh

As a result of lowering the first-stage threshold, the payment of those who use more than 2,000kWh per month will increase. Such families are regarded to be in the rich segment and can afford higher bills. In principle, the second-stage tariff should be applied to those who consume more than average. At the same time, this change would further accelerate the energy conservation among wealthy households.

Another important issue regarding the residential tariff is the fact that government and corporate offices are applied the same tariff. They are charged in the same way as residential customers. The monthly electricity consumption by these offices is far more greater than family use. Consequently, those offices are mostly charged the highest rate of 30Bz/kWh. It is difficult to find a good reasoning for the extremely high pricing to government and corporate offices. They should be separated from the residential customers and charged by a different tariff which is tailored for large-scale users.

6-1-3. Large-scale Customers

Commercial and industrial tariff should be analyzed not only from financial viewpoint but also from the considerations of industrial development and international competition. The electricity charge for commercial and industrial users in Oman is relatively high compared with other Gulf counties (See Table 6-1-4). Because of this, it is difficult to raise the industrial/commercial tariff for the time being. Furthermore, it cannot be explained why industrial users have to pay more than residential users. Based on the marginal cost theory, the current tariff system cannot be justified and residential users should pay more. This consideration does not also support any attempt to raise the industrial/commercial tariff.

Table 6-1-4 Industrial Electricity Cost in the Gulf Region

cent/kWh

Bahrain	0.030
Kuwait	0.005
Oman	0.030-0.060
Qatar	0.020
Saudi Arabia	0.030
UAE	0.020

The most important revision to be made for large-scale customers is setting up a special tariff for government and corporate offices. As stated earlier, they are now charged with the residential tariff, which is difficult to justify. Comparing with the industrial and commercial customers, who are paying about 16Bz/kWh and 20Bz/kWh respectively, the average rate for government and corporate offices, about 30Bz/kWh, is extremely high. Of course, the demand for electricity in office, mostly during office hours, is undoubtedly contributing to the summer daytime peak. For this reason, office use should be charged a higher rate compared with other consumers. All these considerations would suggest that it is strongly recommended to establish a new tariff system for offices and lower the current rate to around 25Bz/kWh, which seems to be quite reasonable. At the same time, it is necessary to consider how to depress the summer time consumption. Lowering the tariff might have an adverse impact of increasing electricity consumption even in peak hours. In this regard, seasonal tariff system, which is already applied to industrial users, may be a good solution. As MEW would face revenue decrease because of this revision, the new office tariff should be gradually implemented along with the improvement of cost structure to avoid worsening the financials of MEW.

6-1-4. Tariff System for Load Leveling

(1)Time-of-Use (TOU) tariff

In Oman there are two peaks of electricity demand in a day during the summer season, which occur around 3 p.m. and 11 p.m. respectively. The afternoon peak is slightly higher than the midnight peak. With this unique load curve (See Figure 2-1-1), it seems difficult to establish a TOU tariff system. In theory, two peak time zones and two off-peak time zones should be established in a day. But this is too complex and consumers would have difficulty in managing their electricity consumption.

Introducing a TOU tariff for load leveling requires in-depth considerations on target segment and their way of using electricity. In general, only large-scale customers can take advantage of TOU tariff because they can change operation mode in a day or invest in special equipment to utilize cheap electricity during the off-peak hours. It is difficult for residential customers to shift their peak-time electricity consumption to off-peak hours. It is, therefore, recommended to introduce a selectable TOU tariff system for the large-scale customers as a first step. It is expected that some large-scale customers will choose the TOU tariff and start using heat storage technology or switching to other energy sources to reduce their expense on energy.

The time zone of TOU tariff should be structured as simple as possible. One idea is to set a peak time zone only in the daytime of summer season. MEW would benefit if the daytime demand growth in the summer is squeezed, because the highest peak demand appears in the daytime and will grow more rapidly than the second peak at midnight. The most important issue is how to cut down the daytime peak demand for electricity. The electricity consumption of large-scale users during mid-night peak hours is not a big amount, which supports the idea of having only one peak time zone in the daytime. The TOU tariff should be tailored to maintain consistency with the current tariff system; with the industrial tariff (24Bz/kWh in summer and 12Bz in other seasons) in particular. The off-peak rate can be set as low as fuel cost per kWh. The current fuel cost is about 9Bz/kWh in case of gas turbines. Given this, it would be possible to set the off-peak rate at 10-11Bz/kWh taking transmission losses into account. In return, the peak rate should be set higher than the current rate.

There may be some customers who can take advantage of this new TOU tariff without changing their consumption pattern. In order to prevent these customers from using the TOU tariff, a special checking mechanism should be developed. For example, an application form should be filled out and checked by MEW officer. MEW needs to review the customers plan to use TOU tariff before making a decision to accept the application for TOU tariff. If there is no DSM effort, MEW should turn down the application.

One example of TOU tariff is shown in Table 6-1-5.

Table 6-1-5　TOU Tariff (draft)

Industrial TOU		Office Building TOU	
New Tariff	Current Tariff	New Tariff	Current Tariff
May to October 10am-5pm　30Bz Other period 10Bz	May to August 24Bz Other months 12Bz	May to October 10am-5pm　50Bz Other period 10Bz	KWh per month -3000　10Bz/Kwh -5000　15Bz -7000　20Bz -10000　25Bz 10000 over　30Bz

(2)Special contract system for load leveling

Apart from the TOU tariff, special contract programs can be introduced to improve the load factor, and to reduce the costs of power supply eventually. Electricity price discount will be rewarded for users who can contribute to load leveling. These programs, which are common in developed countries, would be also applied to large-scale users (cement, chemical, textile, etc.). The rationale here is to give financial incentives to customers who will contribute to peak shaving and/or peak shifting. The load leveling effort will help MEW reduce their future investment as well, but at the same time the customers will benefit from the discount. Both MEW and customers will share the benefits.

In Oman, there are few large-scale customers. It would be easy to pick out potential large-scale customers who will be able to change their consumption pattern. The detailed examination on how they use electricity is required before formulating contents of new contract. There will be various ideas on the form and amount of financial incentives. Some basic ideas for the special contract system are shown below:

- Discount for high load factor users
- Discount for changing operation hours
- Discount for accepting load shedding in case of power shortage

6-1-5. Long-run Marginal Cost

Long-run Marginal Cost (LRMC) can be calculated from the value of future demand growth and necessary investment for power supply facilities. Namely, long-term (five to ten years) demand growth, both in terms of kW and kWh, and corresponding fixed cost and variable cost of new power facilities need to be estimated. The estimated numbers are discounted to the present value. The present value divided by the cumulative kW and kWh represents approximated value of LRMC. Based on the investment plan in this report, which addresses demand growth and investment projects, a preliminary study on the rough estimate of LRMC was conducted. In this study, it is assumed that a constant level of investment to meet demand growth will be executed every year. Financial data such as construction costs, fuel costs and losses in the Fichtner report are reviewed and updated as much as possible. Other assumptions are shown in Table 6-1-6.

Table 6-1-6 Assumptions for LRMC Calculation

Period	From 1998 to 2006	Gas Turbine Generation	160RO/kW
Demand growth	5%/year	Diesel Generation	250RO/kW
Load factor	50%	Transmission & Distribution	240RO/kW
Power Station use	5%	Discount rate	8%
Total loss	17%		

Based on these assumptions, the Long-run Marginal Cost of electricity in Oman is calculated to be 25.5Bz/kWh. This is about 70% higher than the current average sales price of 15.06Bz/kWh. The high LRMC attributes to the dependence on expensive diesel generation in the local networks, the low plant factor, and the high loss ratio. However, the recent trend of falling gas turbine price mitigates these problems. If the electricity tariff in Oman is going to comply with the principle of adjusting to LRMC, the average tariff would be raised by more than 50%. In particular, the residential tariff should be raised much higher because residential customers are supposed to bear the low voltage distribution cost which is an additional cost in case of low voltage connections. It would be difficult to get the acceptance of general public. The tariff adjustment to LRMC, therefore, is very unlikely from the political viewpoint.

The Long-run Marginal Cost in different time zone can be also calculated. This will be a good benchmark for designing a TOU tariff structure. In order to calculate LRMC in the peak hours, for example, the demand growth during the peak time and also the required amount of investment should be clearly defined. There may be many ideas on how to allocate the investment costs into peak and off-peak hours. One idea is to allocate all fixed costs to peak time demand. This, however, leads to huge difference between peak and off-peak LRMC. In this study, therefore, a moderate idea that fixed cost is to be proportionally borne between peak and off-peak is adopted. Assuming that peak hour represents one-fourth of total hours, six hours in a day, 75% of total demand (kW) growth is allocated to the peak hours. The remaining 25% of demand growth is regarded as base load growth. As for the variable cost, the fuel consumption mode in peak and off-peak hours should be studied. In Oman, however, there is no clear difference in the plant operation between peak and off-peak hours. Either gas turbine or diesel generator, depending on electricity network, is used for both peak and off-peak hours. Hence, it can be concluded that variable cost (per kWh) would be equal in the two time zones. Given all these considerations, peak time LRMC and off-peak time LRMC are calculated to be 46.0Bz/kWh and 14.8Bz/kWh respectively.

6-2. Electricity Metering

The electricity losses in Oman are large, reaching around 17% in the Muscat system for example. The non-technical losses including meter tampering and measurement errors due to wear are regarded to be as high as 9%. MEW should recognize the problems related to metering and take appropriate counter measures to reduce losses and increase electricity revenue.

In Oman, electricity meter belongs to house owner, not to MEW. Newly built house or apartment is equipped with electricity meter at owner's expense. MEW engineer will visit and check the new meter before using. A seal is placed to prevent tampering. Once installed, electricity meter is used for many years unless any problem is identified by MEW engineer or meter-reader. As a result, many old meters, used for more than twenty years, can be found in old districts. In Japan, utility companies install meters and replace with new meters every ten years to maintain the accuracy of measurement.

Meter reading is conducted every month. Oman Investment and Finance Company (OIFC) has been working for MEW to read meters, to record consumption data, to send out monthly bills and to collect monthly payments. One meter reader is assigned to one district which has about 750 customers. Each customer has a code number and consumption record is kept in a computer data base. When a questionable record is found, the meter reader will check the past record and may visit again to find out the cause of problem. There are many advantages in this practice; the same meter reader working in his district for many years. He becomes aware of the people in his district, and can find a problem easily based on his long experience. This practice, however, may have shortcomings. A meter reader can collude with his customers to cover up problems.

6-2-1. Remote Metering System

Owing to the development of electronics technologies, remote metering system has been put in actual operation where the labor cost for meter reading is high. This technology is often used in the United States, because visiting each customer in a less populated area is more expensive than investing in the remote metering system. In Japan, the system is also used, but in special cases such as remote island or auto-lock condominium. The labor cost in meter reading is still low compared to the cost of remote meter reading system. As a result, the large-scale introduction of remote metering system is limited. Furthermore, the special meter has electronic parts and their durability is not as good as mechanical parts. Proper maintenance is a prerequisite of this system.

In Oman, the remote metering system is considered as a means to prevent meter tampering. If it is to be used to monitor meters to find out unidentified tampering cases, the remote metering system should be installed at each household. This would require huge amount of up-front investment and special maintenance work afterwards. In addition, the low labor cost in Oman will not justify the idea of cost reduction by remote metering.

6-2-2. Maintenance and Monitoring

The potential problems associated with electricity meters are illegal tampering and measurement errors. Both forego electricity revenue, and hence MEW must take appropriate measures to deal with them.

(1)Tampering

There are several different ways of meter tampering which have been all identified by MEW. Most of them are simple, and easily found by checking meters cautiously. In most cases, tampering seems to be suspended a few days before the day of meter reading. To cope with this problem, it is recommended to make a surprise visit to customers occasionally and also to develop computer software which can pick out suspected cases. MEW and OIFC should discuss these issues and revise the current contract as needed.

(2)Error due to wear

In order to identify errors of old (being used for more than twenty years) meters, samples were tested. (See Table 6-2-1)

Table 6-2-1 Results of old meter testing

No.	Manufacture/country	Years in service	Error(%)
1	Mitsubishi/Japan	18	-8.1
2	Ferrnti/England	20	-1.0
3	Landis&GYR/England	20	
4	Floton/England	20	-4.3
5	Landis&GYR/England	26	-12.0
6	Siemens/Germany	26	-4.5
7	Siemens/Germany	26	-1.4
8	English Electric/England	23	
9	GEC/England	21	-0.6
10	Siemens/Germany	29	-0.5

It is premature to draw a conclusion from this small size of samples, but it can be said that many old meters still show good record. On the other hand, some meters have more than 10% negative error. It is estimated that there are about 50,000 meters, 15% of total accounts, which are used for more than twenty years in Oman. If we assume that those old meters have 4% negative error on average, the foregone revenue every year would reach 500,000RO; 0.6% of the total revenue.

It is not feasible to check every old meter because a lot of time and money are required. The only viable solution is to replace all old meters with new ones. If MEW is going to replace 10,000 old meters every year at their expense, annual budget of 200,000RO is needed. After five years, the foregone revenue will be fully recovered. This project, replacing old meters, is strongly recommended because its Net Present Value (NPV) over the next twenty years is 2.85 million RO. (See Annex 3-3-v)

Chapter 7

Optimal Promotion Program

7. Optimal Promotion Program

7-1. Optimal SSM Promotion Program

Recently in Oman, the Muscat and Wadi Jizzi systems have been confronting a shortage of power supply because of substantial growth in demand for electricity, especially air-conditioning. Accordingly, the systems are forced to do load shedding at the summer peak. During the 1997 summer peak, the Wadi Jizzi system did load shedding 10 times at a maximum of 50MW. But in 1998, power supply shortages became worse and load shedding occurred almost everyday. More power supply needs to be secured immediately in preparation for the next summer.

Measures for coping with this situation, on the supply side, have been considered resulting in the following discussions.

7-1-1. Measures for Present Situation

(1) Gas Turbine Output Improvement by Water Injection

Injecting water directly into the gas turbine (GT) fuel chamber increases output. Injection water equal to 2.5% of air volume at the compressor inlet provides about 13% increase in output.

Table 7-1-1 Output increase and water tank capacity

Object Units		Output Increase (MW)	Tank Capacity (t)
Ghubrah PS	GT 1~11	29.1	800
Rusail PS	GT 1~6	93.8	2,200
Wadi Jizzi PS	GT 3~11	29.1	800

Extra supply capacity can be secured for the 1999 summer peak by completing construction of water injection system during the 1998 off-peak season.

Increasing Output ; 152 MW
Investment Cost ; 7.33 mil RO
NPV of water injection ; 15.4 mil RO (1999-2018)

(2) Preventative Counter-Measures against Voltage Swing due to Load Drops

Occasionally, the load has dropped out on long, rural transmission lines during the summer peak. Examinations concluded that this problem was caused by a shortage of reactive power, not by a collapse in voltage stability or by reaching transmission limits. Preventative measures call for the immediate installation of static capacitors (SC) to improve the power factor and increase the voltage of the 132KV transmission system. The conclusions are as follows.

Total Investment for voltage problems ; 0.6 mil RO

Table 7-1-2 Problems and Measures for 132KV System

Name	Problems	Measures
Barka SS 33kV Bus	Low Voltage	Install 10MVA SC
Musanna SS 33kV Bus	Low Voltage	Install 40MVA SC

Table 7-1-3 Problems and Measures for 33KV System of Musanna SS

Name	Problems	Measures	Remarks
Khaborah fdr-2	Limit of transmission	Introduction of 132kV transmission line	Already planned (132KV transmission line)
Rustaq-2 SS 11kV Bus	Low Voltage	Install 5MVA SC	
Sana Bani Gafar SS 11kV Bus	Low Voltage	Install 3MVA SC	
Suweiq-2 SS 11kV Bus	Low Voltage	Install 5MVA SC	
Marble Factory SS 11kV Bus	Low Voltage	Install 3MVA SC	
Wadi Jawahir SS 11kV Bus	Low Voltage	Install 3MVA SC	

7-1-2. Securing Mid- Long Term Power Supply and Measures for Cost Reduction

(1) Interconnection between the Muscat System and the Wadi Jizzi System

①Benefits of interconnection

a. Reduction of spinning reserve

After interconnecting both systems, the spinning reserve, equivalent to the capacity of the largest unit, can be shared and generation capacity can be reduced. Also, the total capacity can be reduced due to the diversity of the two systems.

Reduction of generation capacity ; 176 MW (2001~2018)

b. Construction investment for the interconnection line

Investment in interconnection line and sub stations ; 7.53 mil RO

NPV of net reduction of investment costs ; 15.29 mil RO(2001~2018)

c. Reduction of fuel expenses by GT operation at higher efficiency

With this interconnection, the gas turbines in the Wadi Jizzi system can be operated at a higher load factor corresponding to the elimination of spinning reserve. Interconnection also leads to remarkable reductions in fuel expenses.

NPV of reduction of fuel expenses ; 15.54 mil RO (2001~2018)

NPV of Interconnection ; 30.82 mil RO (1998 price)

Relief power can be interchanged between both systems in case of emergency.

②Timing of Interconnection

Interconnection should be done quickly. But no relief power is available now because both systems face a shortage of supply power. We recommend to interconnect the two systems by 2001, when enough power supply can be secured. It is also recommended to introduce the central load dispatching center at the same time.

(2) Fuel Cost Reduction by Economical Operation and Central Load Dispatching Center

①Reduction of annual fuel expenses by economical load dispatching

The economical operation program has been developed and transferred. Principles of the operation are summarized below.

a. More efficient base units (Ghubrah PS 12,13 & Rusail PS 4~6,1~3) operate at full output one-by-one to meet the hourly demands.
b. Next to them, peak units (Ghubrah PS 10,11,1~9) operate at higher output as much as possible, securing a spinning reserve equal to the capacity of the largest unit.

Compared with the current operation during a typical summer day, the Muscat system can reduce fuel expenses by 3.5% using the economical operation program.

Table 7-1-4 Comparison between economical and actual operation (1-8-1997)

		Actual Operation	Economical Operation
Base Units Average Output (MW)	Ghubrah PS(1213)	90 MW	94 MW
	Rusail PS (1~6)	62	69
	Average	69	75
Average Spinning Reserve		201	159
Gas Fuel Cost / Day (1000 OR)		107.4	103.6

Savings of fuel expenses after the introduction of the economical operation program have been estimated using the load curve for a typical year. The result is as follows:

During the peak season, there is no room to change the operational pattern. Almost all units operate at full output in order to meet the high loads. The amount of saving is about 3.5%.

During the off-peak seasons when the load is fairly low or load fluctuation is large, economical operation results in a savings of 6~14% because more efficient units can be selected to work in parallel. Average fuel savings per day for one year are about 7%.

②Introduction of central load dispatching center

The further system capacity increase requires improved supply reliability and more economical operations. Introducing a central load dispatching center is recommended when the system interconnection between the Muscat and Wadi Jizzi systems is completed. Benefits of introducing the central load dispatching center are shown below:

Reduction of fuel expenses (7% of gas fuel)	**1.8 mil RO / year**
Investment cost of CLDC	**4 mil RO**
NPV of central load dispatching center ;	**20.9 mil RO (2001-2018)**

Table 7-1-5 SSM Summary Table (Muscat/Wadi Jizzi System)

( ) Investment: 1000 RO

			1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Peak Demand (MW)			1596	1773	1843	1946	2046	2122	2197	2271	2344	2416	2489	2563	
Supply Capacity (MW)			1806	1930	2024	2118	2160	2243	2337	2431	2507	2595	2628	2705	
Project	Generation Expansion	Rusail PS	·GT7 (13,850) ·Water Injection (2,420)						·GT8 (13,850)			·GT9 (13,850)	·GT10 (13,850)	·GT11 (13,850)	71,670
		Ghubrah PS	·Water Injection (2,630)				·GT14 (13,850)	·GT15 (13,850)					·GT16 (13,850)	·GT17 (13,850)	58,030
		Manah PS		·GT4,5 (-----)											-
		Barka PS				·GT1 (37,400)		·GT2 (13,850)		·GT3 (13,850)	·GT4 (13,850)				78,950
		Wadi Jizzi PS	·GT12,13 (13,320) ·Water Injection (2,280)	·GT14 (6,660)	·GT15 (13,850)							·GT16 (13,850)			49,960
	·Interconnection Line ·Central Load Dispatching Center (*CLDC*) etc.		·Static Condenser (600)		·Interconnection (7,530) ·CLDC (4,000)									Battery Storage (2,500)* (not included)	12,130
Total Investment			35,100	6,660	25,380	37,400	13,850	27,700	13,850	13,850	13,850	27,700	27,700	27,700	270,740

Table 7-1-6 Introduction of Central Load Dispatching Center

	First Step	Second Step
Timing of introduction	At the time of Muscat system and Wadi Jizzi system interconnection	Future
Central Load Dispatching Center	Introduction of demand-and-supply operation program ・ Economical load dispatching ・ Power flow monitoring Introduction of system monitoring panel (132kV system) Introduction of automatic record- keeping program.	Introduction of the system control program ・ Automatic frequency control ・ Control of voltage and reactive power ・ Emergency control
Regional Control Center	Reinforcement of regional control center	Introduction of system monitoring panel (33kV system) Introduction of automatic record keeping program. Introduction of remote switching system Introduction of automatic recovery operation system
Others	・ Organizational set up ・ Operator training	

7-2. Optimal DSM Promotion Program

(1) Objective of DSM Promotion

Promotion of DSM is to encourage customers to implement certain power utilization pattern for rationalizing power consumption pattern. DSM is also desirable to both the electric utilities and the customers or to the country as a whole. The measures for this DSM are as follows:

- Reduction of power load through the use of alternative energy sources;
- Load leveling on the customer side(peak cutting, peak shift and bottom up of off peak load);
- Introduction of higher-efficiency energy utilization (energy-saving) systems;

New tariff system, special contract system and promotion organization (support organization and subsidy system etc.) are good measures for inducing customers.

(2) DSM Technologies

Technical measures applicable in Oman for accomplishing the above-mentioned objective are as follows:

①Reduction of power load through the use of alternative energy sources (peak cut)
Gas cooling and photovoltaic power generation.

②Load Leveling (peak shift)
Ice thermal storage cooling, battery energy storage, and demand and supply adjustment contract (one of tariff contracts).

③Introduction of energy saving systems

Higher-efficiency appliances(air conditioner), co-generation systems and thermal insulation of buildings.

(3) Specific Promotion Program

In Oman, the cooling demand accounts for a large percentage of power demand. Of the above mentioned DSM technologies, we mainly examined technologies that have attained a high level of technical maturity and have been disseminated in foreign countries in recent years, and technologies for using natural gas and solar light that are abundant in Oman. In particular, we examined design conditions of the following, by making case studies of some existing buildings, and assessed economic effects:

Gas cooling and co-generation with gas;
Ice thermal storage cooling system;
Photovoltaic system.

Moreover, the promotion organizations were also studied. The findings are as follows.

(4) Gas Cooling and Co-generation System

Effects of introducing a gas cooling system, using natural gas as energy source, are expected to be energy conservation and reduction in energy cost at the demand end. At the supply side, too, improvement of plant factor and deferral of constructing generating equipment are expected to reduce electricity supply cost. By these merits, the systems using natural gas are themes to be coped with. The results concerning the model buildings show that the gas cooling system would be more economical than the electrical system in large scale buildings.

However, in Muscat, there are high pressure natural gas supply pipelines only for the power generation plants and other limited sites. There is neither city gas supply network nor a plan for that. Therefore, in order to facilitate gas cooling in Oman, it is desirable to have a project for developing a town gas supply network in the area where electricity load density is high; office building districts and shopping centers.

Promotion program

In the Royal Hospital, the economic effect of introducing gas cooling through co-generation is large. In addition, the hospital is located very close (less than 1 km away) to the existing high pressure natural gas pipeline. Hence, the introduction of gas cooling system is easy to be introduced, and it is desirable to promote the project of Royal Hospital prior to the development of the town gas supply network. Proposed financing plan, only for gas supply, is as follows.

- Construction of a gas line from a high pressure gas pipeline branch station to Royal Hospital: 60,000 RO (budge of Royal Hospital)

- Construction of the high pressure gas pipeline branch station: 1,500,000 RO ~ 1,900,000 RO (budge of MOG)

(5) Ice Thermal Storage Cooling System

Through load leveling by the introduction of ice thermal storage cooling systems, construction of new power supply facilities can be controlled. At the same time, the capacities of power receiving facilities can be reduced. IF the TOU tariff is introduced, customers can take advantage of inexpensive electricity during off-peak period.

The results of economic evaluation are as follows.
Case 1: The construction costs per kW of a gas turbine is subsidized by MEW for rewarding power (kW) reduction.
Case 2: Load leveling operation is conducted, and as for the rate for ice thermal storage operation, the time of use (TOU) rate system is applied. In both cases, the NPV were slightly negative and they were not economically feasible. The reason for this economic difficulty with the ice thermal storage cooling system is as follows.

The load fluctuation is about 68 % between the peak period and the off-peak period of summer. It is not very large. Both the peak period and the off-peak period occur twice a day, and the resulting load fluctuation is complicated. As a result, the period of ice thermal storage operation for making ice is limited. In Case 2 where the TOU rates system is introduced, the period of ice thermal storage operation was assumed to be eight hours. Considerable efforts are needed for proper operation management. Furthermore, the construction cost of gas turbine power plant is as low as 160 RO per kW. The electricity rate is also low. Hence potential measures for promoting the ice thermal storage cooling system are limited.

<u>Promotion program</u>
As described above, it is concluded that the introduction of ice thermal storage cooling system is not economically feasible at the moment. However, the results in Case 2 are very delicate. Depending on promotional measures, Case 2 may become feasible in the future. It is recommended, therefore, to reconsider the implementation plan in the future when electricity tariff is revised and other policy measure are prepared for load leveling.

(6) Photovoltaic System

Generally the daily load peak occur during the period of maximum output of photovoltaic system. Hence, it is possible to achieve load leveling through photovoltaic (peak shaving). Furthermore, fossil fuels is substituted by energy of solar radiation, a renewable energy source. Energy resources available on earth can be saved.

The results of economic analysis as follows.
With the current cost level of 3,000 RO/kW, photovoltaic system is not economical. Even when the construction cost is lowered to 500~800 RO/kW, which is the target for the near future, the investment cannot be recovered from electricity cost saving alone. However, in case of long and expensive distribution line is needed for rural electrification, off-grid photovoltaic system may be economical. For the present, if the diffusion of photovoltaic systems is to be promoted as measures for environmental protection, it will be necessary to grant a considerable amount of subsidies.

<u>Promotion program</u>
Early introduction of the photovoltaic systems in cities is unjustifiable and unadvisable. We, therefore, propose the following policy of introduction.

- As for introduction of photovoltaic systems in near future, rural electrification may provide an opportunity. If a long-distance distribution line is required relative to the scale of the demand, the cost will be higher. In such a case, photovoltaic systems may be used.

- In the distant future, the construction costs of photovoltaic system will be reduced. Environmental benefits will be added. At that time, introduction of photovoltaic systems may become feasible even in cities. Hence, the diffusion of photovoltaic systems in electrified areas for the sake of energy conservation and environmental conservation should be studied continuously.

(7) Organization for DSM Promotion Program

To facilitate and accelerate individual DSM promotion program with the objective of optimal DSM promotion, an organization dedicated to promote DSM is necessary. The more DSM is implemented, the more the whole country benefits. The point is how to educate consumers and provide incentives. The organization will play a major role in public relations, education and consulting.

Chapter 8

Policy Recommendations

8. Policy Recommendations

The stable supply of electricity is essential to industrial development and better life in every country. In Oman, electricity consumption is expected to grow by 5% annually due to the strong and growing economy. Investments in power generation and transmission should be made continuously without interruption. There are, however, some problems in the electricity supply such as shortage of generation and transmission capacity, and revenue shortfall, which need to be resolved as soon as possible. With a fundamental understanding on the importance of electricity supply for the future development of Oman, MEW is recommended to implement the following plans and programs to improve both demand and supply of electricity.

(1) Power Development Plan

The power development plan should be disclosed to the public. It should be revised annually considering the demand growth and big development projects. The plan serves as a basis for investments which must be made in a timely manner to secure enough capacity. At the same time, private investment projects will be accelerated because the prospects of electricity supply, which is an important factor in large-scale industrial projects, would become clear.

(2) Energy Conservation Center

Among DSM measures to curtail electricity demand for air conditioning, energy conservation cannot be ignored. Moreover, it is the only item which can be started immediately, The ideas for energy conservation include not only raising room temperature, but also some technical measures such as improving efficiency of equipment by providing adequate maintenance or replacing old units. These measures, if applied nationwide, would significantly contribute to the electricity supply by cutting down peak demand. In order to undertake the measures, an organization which specializes in educating the public and also in providing the technical services. At the same time, this organization should oversee some mid-term issues such as gas cooling or ice thermal storage.

(3)Cost Reduction Effort

In the long run, raising electricity tariff would be inevitable. It is, however, important to make utmost efforts on cost reduction. For this, the consciousness on costs should be stressed among the people working for the electricity service. Furthermore, it is advisable to introduce incentive measures to operators and other related entities to reward them when they generate ideas and achieve significant cost reduction.

(4)Building Database

It is necessary to monitor actual electricity consumption at many sample customers to accumulate data for tariff reform and DSM promotion. By using such a database, it would become possible to develop concrete programs and also to make an assessment on their effects.

(5)Technical Training

Development of technical capabilities within MEW is important to reduce reliance on outside consultants. With sufficient technical knowledge, MEW staff can make decisions very quickly. Overseas technical training program may be effective as a short-time capacity development.

(6) Comprehensive Energy Planning

Coordination between electricity and natural gas is important to achieve "Best Mix" in comprehensive energy planning in Oman. For example, district cooling system or co-generation, which use natural gas directly, is more efficient, and hence, such projects should be promoted where feasible. To facilitate these projects, it is strongly recommended that MEW and MOG (Ministry of Oil and Gas) regularly discuss on various energy issues.

Chapter 9

Electric Power Analysis Programs

9. Electric Power Analysis Programs

9-1. Outline of Technology Transfer

Technology transfer of computer programs that are useful in rationalizing demand supply operation is considered to have great merits for the counterpart because these programs can be used directly in developing their power equipment plan. We, therefore, made technology transfer of three kinds of programs for load flow calculation, system fault calculation and demand and supply operation, that can be directly used in solving various problems of demand and supply of electric power. As for the actual contents of the transfer work, programs, input data, instruction manuals, etc. were developed in Japan. These programs and data were designed to run on the computer systems of the counterpart. We installed these programs in Oman and gave guidance on the operating methods. In response to the requests of the counterpart, we improved the programs and added some functions to them. In the following, the technology transfer will be outlined.

(1) Programs Transferred

① **Load flow calculation program**

The program analyzes power flows, voltages, etc. in an electric power system, and provides data essential to planning of substation facilities and transmission lines.

② **System fault calculation program**

The program analyzes currents, voltages, etc. in case of a fault. Such data are indispensable in system operation when the scale of the system gets large.

③ **Demand and supply operation program**

The program is used to determine an economical operation pattern of power generating facilities.

(2) Preparatory Work in Japan

① **Load flow calculation program**

- Development of an analytical program (English version).
- Development of an instruction manual (English version).
- Development of a program installation procedure (English version).
- Development of data on power systems (Muscat, Wadi Jizzi System).

② **System fault calculation program**

- Development of an analytical program (English version).
- Development of an instruction manual (English version).
- Development of a program installation procedure (English version).
- Development of sample data for analysis.

③ **Demand and supply operation program**

Development of a program for determining optimal operation patterns of power generating facilities and calculating costs.

(The program can calculate costs of actual operation patterns.)

(3) Counterparts :

①	Ministry of Electricity and Water	Transmission & Control Section
②	〃	Planning Section
③	〃	Control Center

(4) Work in Oman

① **Load flow calculation program**

Formats of input and output data of the analytical program and its method of use were explained.

Instruction was provided about effective use of the program by taking an example of developing a P-V curve of Musanna SS.

② **System fault calculation program**

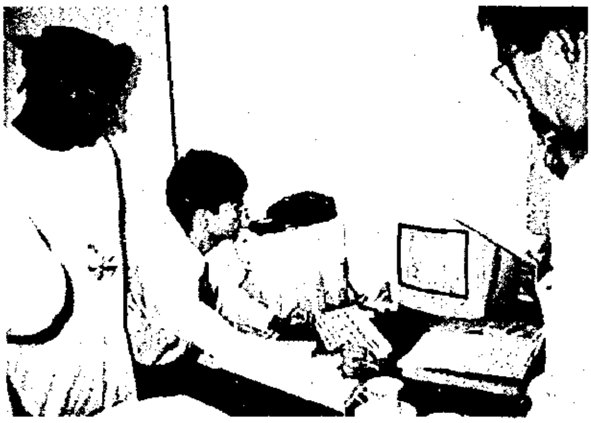
Formats of input and output data of the analytical program and its method of use were explained.

Instruction was provided about effective use of the program by using sample data.

③ **Demand and supply operation program**

Methods of cost calculation for optimal operation and actual operation were explained.

- The algorithm of determining an optimal operation pattern was explained.
- The overall accuracy of the program was verified.
- Upon the requests of the control center, the program was improved as follows:
  - a. As the output of a power generating facility change with atmospheric temperature, the program was improved so that atmospheric temperature can be specified.
  - b. The lowest output of a power generating facility was changed to 40 % of the rated output.
  - c. The number of startup and shutdown of a power generating facility was limited to once a day each.
  - d. The program was improved so that the shortest shutdown period of a power generating facility can be specified freely.
  - e. The order of parallel operation of the power generating facilities were changed to the conditions specific to the respective power stations.
  - f. The program was improved so that it can cope with addition of power generating facilities in future.
  - g. Demand forecasting functions were added to the program.



Picture 9-1-1 Training Session (MEW)

9-2. Load Flow Calculation Program

9-2-1. Purpose of Load Flow Calculation

Electric power that are generated in many power stations is supplied to the customers via transmission lines, substations, distribution lines, etc. A system that controls the train of these processes is called an electric power system. Calculation of power flows through the respective transmission lines and transformers and voltages at various points is called load flow calculation. Load flow calculation is required in examining the operating method of an electric power system when a change occurred in the load, generated output, state of operation of transmission line, etc. of the system, and in planning for new power station, transmission line, substation, etc. of a system of the future.

9-2-2. Input & Output Data of Load Flow Calculation

The following data are required for load flow calculation.

> Electric power system diagrams that indicate how electric power facilities such as generators, transformers and loads are connected with each other. The electric power system diagrams are comprised of "branch" that indicate state of connections of transformers and transmission lines and "node" that indicate connecting points of branches such as substation buses. The respective elements of the system are treated by assigning numbers to them.
>
> Tables of equipment constants that indicate impedances, admittances, tap ratios, etc. of transmission liens and transformers. They are expressed in per-unit method (pu) in many cases.
>
> Data that give operating conditions of the electric power system, such as outputs and target voltages of generators, active and reactive powers of loads, and capacity of reactive power supply equipment.

To ensure the reliability of analytical results of load flow calculation and any other analyses, it is essential to have accurate basic data. Hence it is desirable to control accurate data in a centralized manner.

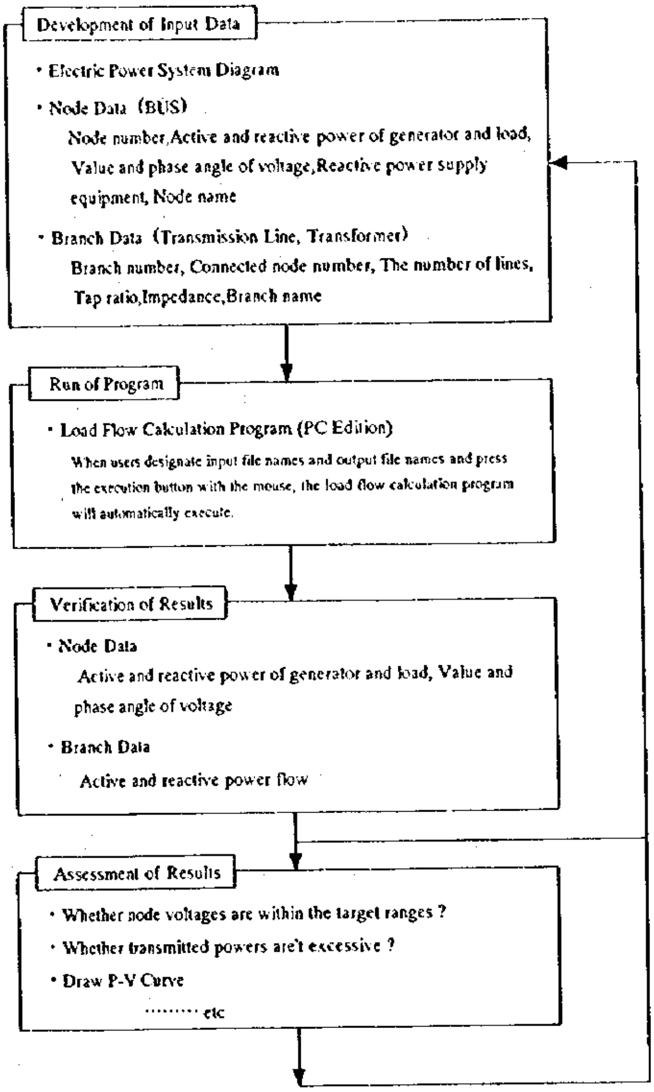
Load flow calculation reveals, for example, active and reactive powers that flow in transmission lines and transformers, active and reactive powers of loads, values and phase angles of voltages, and transmission loss of the entire power system. An example of input data and output data for load flow calculation is shown in Table 9-2-1. For example, as for the power station bus, when the active powers and voltages of generators are inputted, reactive powers and phase angles of voltages will be determined.

Table 9-2-1 Example of Input and Output Data for Load Flow Calculation

Power Station BUS	· Active Power · Voltage	· Reactive Power · Phase Angle of Voltage
Substation (Load) BUS	· Active Power · Reactive Power	· Voltage · Phase Angle of Voltage
Transmission Line	· Power System Diagram · Impedance · Tap-Ratio of Transformer etc.	· Active Power · Reactive Power · Transmission Current · Transmission Loss

9-2-3. Procedure of Load Flow Calculation

When the input data that were described in 9.2.2 are completed, load flow calculation can be made by following the flowchart of Figure 9-2-1. Here the procedure of load flow calculation will be described briefly by taking an example, examination of measures concerning voltages in Muscat system. First, its electric power system diagram is developed (Figure 9-2-2). The diagram shows the configuration of the system, such as generators, substation buses, loads, transmission lines and transformers. All the components in the system diagram are numbered to avoid duplication.



- Electric Power System Diagram
- Node Data (BUS)
  Node number,Active and reactive power of generator and load, Value and phase angle of voltage,Reactive power supply equipment, Node name
- Branch Data (Transmission Line, Transformer)
  Branch number, Connected node number, The number of lines, Tap ratio,Impedance,Branch name

- Load Flow Calculation Program (PC Edition)
  When users designate input file names and output file names and press the execution button with the mouse, the load flow calculation program will automatically execute.

- Node Data
  Active and reactive power of generator and load, Value and phase angle of voltage
- Branch Data
  Active and reactive power flow

- Whether node voltages are within the target ranges ?
- Whether transmitted powers are't excessive ?
- Draw P-V Curve
  ·········· etc

Figure.9-2-1　Flowchart of Load Flow Calclation

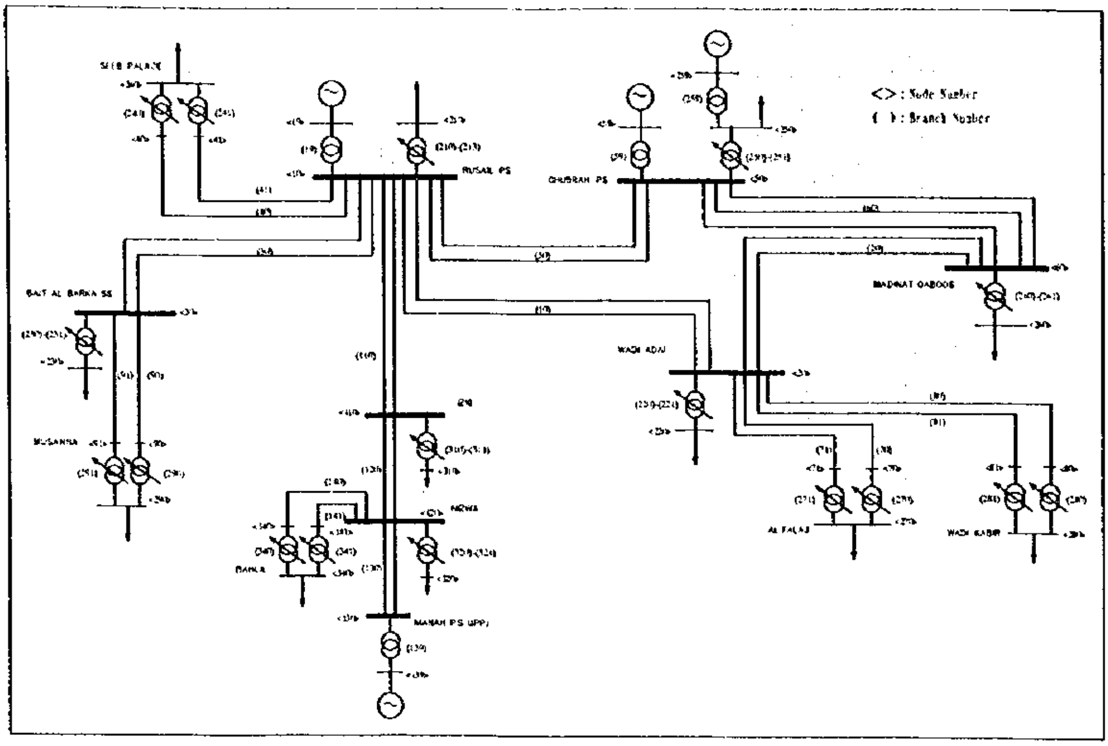


Figure.9-2-2 Electric Power System Diagram of Muscat System

Next, from the system diagram and the table of equipment constants, are prepared electric power system data or input data for the load flow calculation program (Figure. 9-2-3). The first half of the input data is the node data, and the latter half is the branch data. The elements or components are identified by numbers given when the system diagram was developed. In the node data, active and reactive powers of generators, active and reactive powers of loads, voltages, reactive power supply equipment, etc. are inputted. In the branch data, impedances, tap ratios of transmission lines and transformers are inputted. In the example of Figure. 9-2-3, an SC of 20 MVA is connected to a 33 kV bus of Musanna SS.

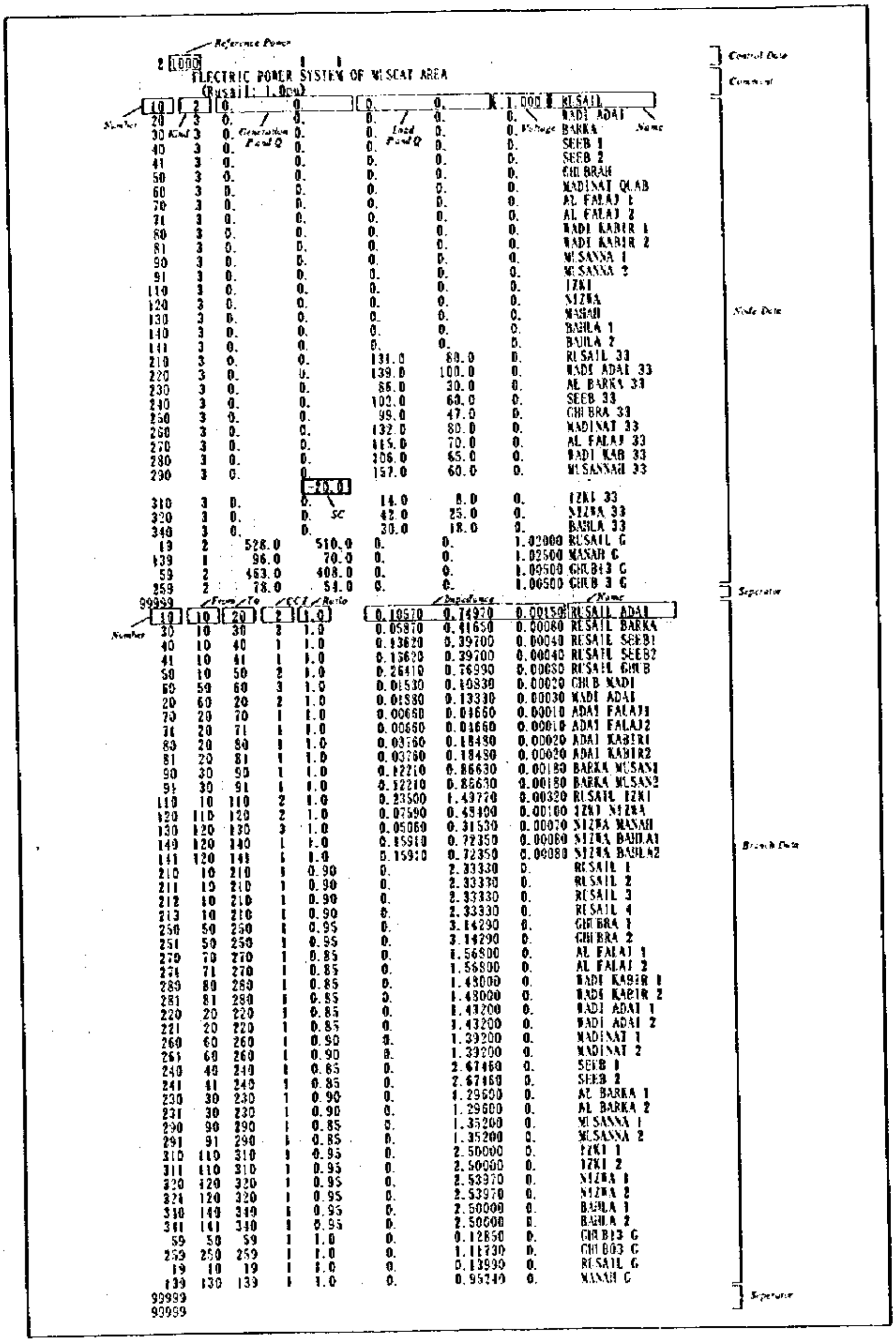
When the input date are completed, next step is to run the load flow calculation program. The load flow calculation program runs on Microsoft Windows. When users designate input file names and output file names and press the execution button with the mouse, the program will automatically execute the load flow calculation. And the results will be written in the output files.

The voltage values and phase angles of all the nodes, flows of the active powers and reactive powers of all the branches are outputted in the output files (Figure. 9-2-4). By checking these values, one can assess whether node voltages are within the target ranges, whether transmitted powers are excessive, etc. In the present case, the voltage of the 132 kV bus of Musanna SS is 0.926 pu. If the lower limit of the target is 0.95 pu, it is lower by about 2.5 %.

Then the SC capacity of the 33 kV bus of Musanna SS is increased to 40 MVA and the load flow calculation is executed again, the voltage of the 132 kV bus of Musanna SS will become 0.948 pu (Figure. 9-2-5). This shows that to keep the voltage of the 132 kV bus of

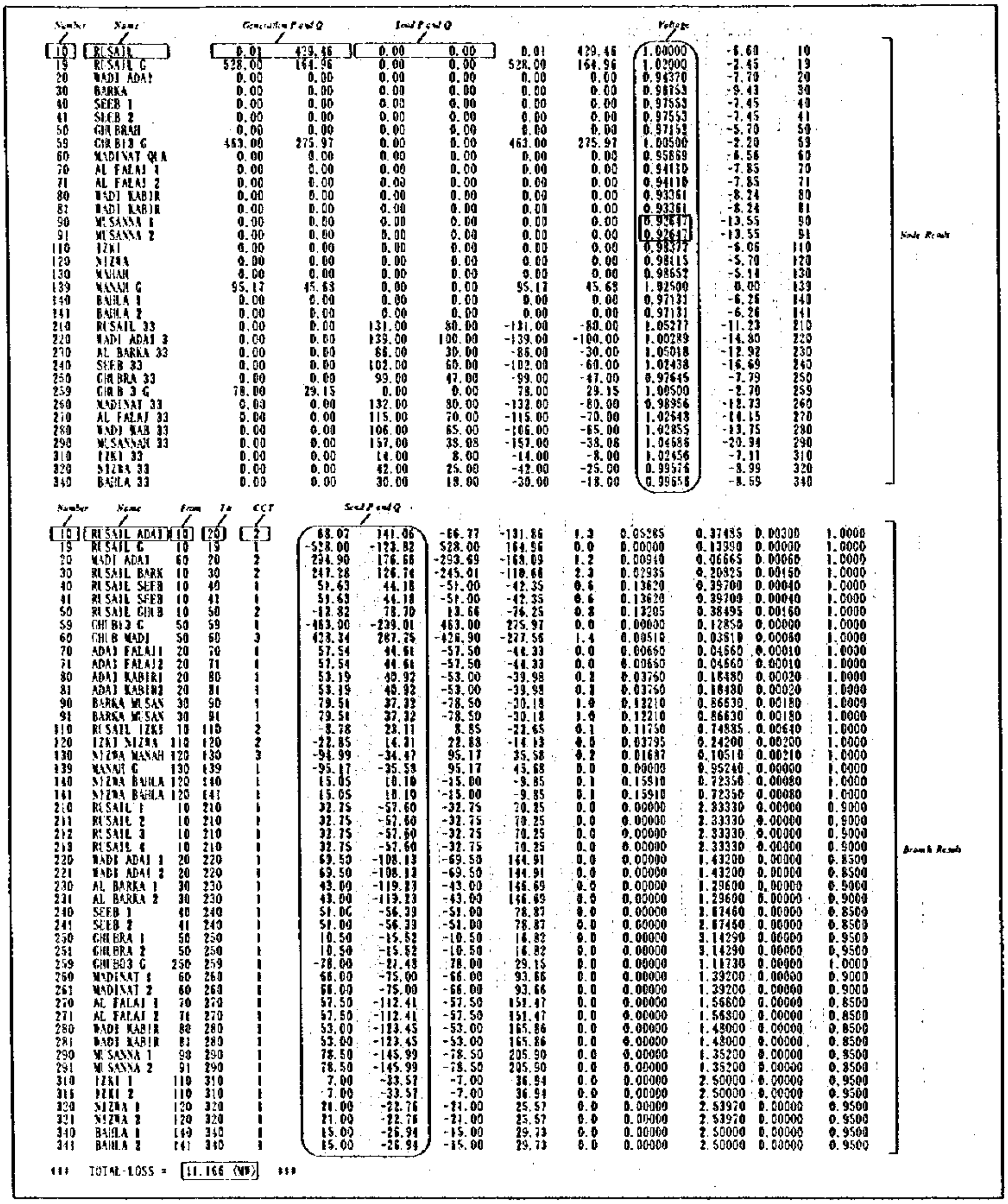
Musanna SS within the target range, it is necessary to install an SC of 40 MVA or over on the 33 kV bus.

In this way, P-V curves can be drawn by changing conditions and repeating the flow load calculation (Figure. 9-2-6). One can instantly read out from the P-V curves a voltage drop when a load is increased, a capacity of an SC required to maintain the voltage, etc. Thus P-V curves can be used in operating the facilities and in developing a future plan.



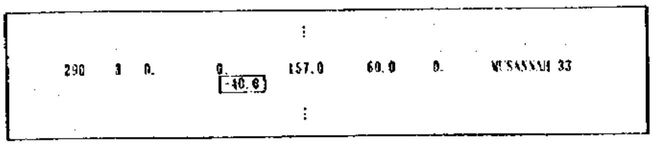
```
2 1000
  ELECTRIC POWER SYSTEM OF MUSCAT AREA
   (Rusail: 1.0pu)
   10  2  0.       0.       0.       0.       1.000  RUSAIL
   20  3  0.       0.       0.       0.       0.     WADI ADAI
   30  3  0.       0.       0.       0.       0.     BARKA
   40  3  0.       0.       0.       0.       0.     SEEB 1
   41  3  0.       0.       0.       0.       0.     SEEB 2
   50  3  0.       0.       0.       0.       0.     GHUBRAH
   60  3  0.       0.       0.       0.       0.     MADINAT QLAB
   70  3  0.       0.       0.       0.       0.     AL FALAJ 1
   71  3  0.       0.       0.       0.       0.     AL FALAJ 2
   80  3  0.       0.       0.       0.       0.     WADI KABIR 1
   81  3  0.       0.       0.       0.       0.     WADI KABIR 2
   90  3  0.       0.       0.       0.       0.     MUSANNA 1
   91  3  0.       0.       0.       0.       0.     MUSANNA 2
  110  3  0.       0.       0.       0.       0.     IZKI
  120  3  0.       0.       0.       0.       0.     NIZWA
  130  3  0.       0.       0.       0.       0.     MANAH
  140  3  0.       0.       0.       0.       0.     BAHLA 1
  141  3  0.       0.       0.       0.       0.     BAHLA 2
  210  3  0.       0.     131.0     80.0      0.     RUSAIL 33
  220  3  0.       0.     139.0    100.0      0.     WADI ADAI 33
  230  3  0.       0.      86.0     30.0      0.     AL BARKA 33
  240  3  0.       0.     102.0     60.0      0.     SEEB 33
  250  3  0.       0.      99.0     47.0      0.     GHUBRA 33
  260  3  0.       0.     132.0     80.0      0.     MADINAT 33
  270  3  0.       0.     115.0     70.0      0.     AL FALAJ 33
  280  3  0.       0.     106.0     65.0      0.     WADI KAB 33
  290  3  0.       0.     157.0     60.0      0.     MUSANNAH 33
                -20.0
  310  3  0.       0.      14.0      8.0      0.     IZKI 33
  320  3  0.       0.      42.0     25.0      0.     NIZWA 33
  340  3  0.       0.      30.0     18.0      0.     BAHLA 33
   19  2    528.0    510.0  0.       0.       1.02000 RUSAIL G
  139  1     96.0     70.0  0.       0.       1.02500 MANAH G
   59  2    463.0    408.0  0.       0.       1.00500 GHUB13 G
  259  2     78.0     54.0  0.       0.       1.00500 GHUB 3 G
99999
   10   10   20  2  1.0     0.10570  0.74970  0.00150 RUSAIL ADAI
   30   10   30  2  1.0     0.05870  0.41650  0.00080 RUSAIL BARKA
   40   10   40  1  1.0     0.13620  0.39700  0.00040 RUSAIL SEEB1
   41   10   41  1  1.0     0.13620  0.39700  0.00040 RUSAIL SEEB2
   50   10   50  2  1.0     0.26410  0.76990  0.00050 RUSAIL GHUB
   60   59   60  3  1.0     0.01530  0.10830  0.00020 GHUB WADI
   20   60   20  2  1.0     0.01880  0.13330  0.00030 WADI ADAI
   70   20   70  1  1.0     0.00650  0.04660  0.00010 ADAI FALAJ1
   71   20   71  1  1.0     0.00650  0.04660  0.00010 ADAI FALAJ2
   80   20   80  1  1.0     0.03760  0.18490  0.00020 ADAI KABIR1
   81   20   81  1  1.0     0.03760  0.18490  0.00020 ADAI KABIR2
   90   30   90  1  1.0     0.12210  0.86630  0.00180 BARKA MUSAN1
   91   30   91  1  1.0     0.12210  0.86630  0.00180 BARKA MUSAN2
  110   10  110  2  1.0     0.23500  1.49770  0.00320 RUSAIL IZKI
  120  110  120  2  1.0     0.07590  0.49400  0.00100 IZKI NIZWA
  130  120  130  3  1.0     0.05060  0.31530  0.00070 NIZWA MANAH
  140  120  140  1  1.0     0.15910  0.72350  0.00080 NIZWA BAHLA1
  141  120  141  1  1.0     0.15910  0.72350  0.00080 NIZWA BAHLA2
  210   10  210  1  0.90    0.       2.33330  0.      RUSAIL 1
  211   10  210  1  0.90    0.       2.33330  0.      RUSAIL 2
  212   10  210  1  0.90    0.       2.33330  0.      RUSAIL 3
  213   10  210  1  0.90    0.       2.33330  0.      RUSAIL 4
  250   50  250  1  0.95    0.       3.14290  0.      GHUBRA 1
  251   50  250  1  0.95    0.       3.14290  0.      GHUBRA 2
  270   70  270  1  0.85    0.       1.56800  0.      AL FALAJ 1
  271   71  270  1  0.85    0.       1.56800  0.      AL FALAJ 2
  280   80  280  1  0.85    0.       1.48000  0.      WADI KABIR 1
  281   81  280  1  0.85    0.       1.48000  0.      WADI KABIR 2
  220   20  220  1  0.85    0.       1.43200  0.      WADI ADAI 1
  221   20  220  1  0.85    0.       1.43200  0.      WADI ADAI 2
  260   60  260  1  0.90    0.       1.39200  0.      MADINAT 1
  261   60  260  1  0.90    0.       1.39200  0.      MADINAT 2
  240   40  240  1  0.85    0.       2.67460  0.      SEEB 1
  241   41  240  1  0.85    0.       2.67460  0.      SEEB 2
  230   30  230  1  0.90    0.       1.29600  0.      AL BARKA 1
  231   30  230  1  0.90    0.       1.29600  0.      AL BARKA 2
  290   90  290  1  0.85    0.       1.35200  0.      MUSANNA 1
  291   91  290  1  0.85    0.       1.35200  0.      MUSANNA 2
  310  110  310  1  0.95    0.       2.50000  0.      IZKI 1
  311  110  310  1  0.95    0.       2.50000  0.      IZKI 2
  320  120  320  1  0.95    0.       2.53970  0.      NIZWA 1
  321  120  320  1  0.95    0.       2.53970  0.      NIZWA 2
  340  140  340  1  0.95    0.       2.50000  0.      BAHLA 1
  341  141  340  1  0.95    0.       2.50000  0.      BAHLA 2
   59   50   59  1  1.0     0.       0.12850  0.      GHUB13 G
  259  250  259  1  1.0     0.       1.11730  0.      GHUB03 G
   19   10   19  1  1.0     0.       0.13990  0.      RUSAIL G
  139  130  139  1  1.0     0.       0.95740  0.      MANAH G
99999
99999
```

Figure.9-2-3 Input Data of Load Flow Calculation Program



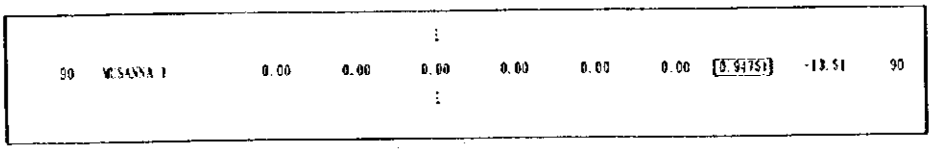
```
 10  RUSAIL             0.01   429.46     0.00     0.00     0.01   429.46  1.00000   -6.60   10
 19  RUSAIL G         528.00   164.96     0.00     0.00   528.00   164.96  1.02000   -2.45   19
 20  WADI ADAI          0.00     0.00     0.00     0.00     0.00     0.00  0.94370   -7.70   20
 30  BARKA              0.00     0.00     0.00     0.00     0.00     0.00  0.98153   -9.43   30
 40  SEEB 1             0.00     0.00     0.00     0.00     0.00     0.00  0.97553   -7.45   40
 41  SEEB 2             0.00     0.00     0.00     0.00     0.00     0.00  0.97553   -7.45   41
 50  GHUBRAH            0.00     0.00     0.00     0.00     0.00     0.00  0.97152   -5.70   50
 59  GHUBI3 G         463.00   275.97     0.00     0.00   463.00   275.97  1.00500   -2.20   59
 60  MADINAT QLA        0.00     0.00     0.00     0.00     0.00     0.00  0.95869   -6.56   60
 70  AL FALAJ 1         0.00     0.00     0.00     0.00     0.00     0.00  0.94130   -7.85   70
 71  AL FALAJ 2         0.00     0.00     0.00     0.00     0.00     0.00  0.94110   -7.85   71
 80  WADI KABIR         0.00     0.00     0.00     0.00     0.00     0.00  0.93361   -8.24   80
 81  WADI KABIR         0.00     0.00     0.00     0.00     0.00     0.00  0.93361   -8.24   81
 90  MUSANNA 1          0.00     0.00     0.00     0.00     0.00     0.00  0.92647  -13.55   90
 91  MUSANNA 2          0.00     0.00     0.00     0.00     0.00     0.00  0.92647  -13.55   91
110  IZKI               0.00     0.00     0.00     0.00     0.00     0.00  0.98377   -6.06  110
120  NIZWA              0.00     0.00     0.00     0.00     0.00     0.00  0.98115   -5.70  120
130  MANAH              0.00     0.00     0.00     0.00     0.00     0.00  0.98652   -5.14  130
139  MANAH G           95.17    45.63     0.00     0.00    95.17    45.63  1.02500    0.00  139
140  BAHLA 1            0.00     0.00     0.00     0.00     0.00     0.00  0.97131   -6.26  140
141  BAHLA 2            0.00     0.00     0.00     0.00     0.00     0.00  0.97131   -6.26  141
210  RUSAIL 33          0.00     0.00   131.00    80.00  -131.00   -80.00  1.05277  -11.23  210
220  WADI ADAI 3        0.00     0.00   139.00   100.00  -139.00  -100.00  1.00289  -14.80  220
230  AL BARKA 33        0.00     0.00    86.00    30.00   -86.00   -30.00  1.05018  -12.92  230
240  SEEB 33            0.00     0.00   102.00    60.00  -102.00   -60.00  1.02438  -16.69  240
250  GHUBRA 33          0.00     0.00    99.00    47.00   -99.00   -47.00  0.97645   -7.79  250
259  GHUB 3 G          78.00    29.15     0.00     0.00    78.00    29.15  1.00500   -2.70  259
260  MADINAT 33         0.00     0.00   132.00    80.00  -132.00   -80.00  0.98956  -12.73  260
270  AL FALAJ 33        0.00     0.00   115.00    70.00  -115.00   -70.00  1.02643  -14.15  270
280  WADI KAB 33        0.00     0.00   106.00    65.00  -106.00   -65.00  1.02855  -13.75  280
290  MUSANNAH 33        0.00     0.00   157.00    38.08  -157.00   -38.08  1.04686  -20.94  290
310  IZKI 33            0.00     0.00    14.00     8.00   -14.00    -8.00  1.02456   -7.11  310
320  NIZWA 33           0.00     0.00    42.00    25.00   -42.00   -25.00  0.99576   -8.99  320
340  BAHLA 33           0.00     0.00    30.00    18.00   -30.00   -18.00  0.99658   -8.59  340

 10  RUSAIL ADAI  10   20  2     68.07    141.06    -66.77  -131.86  1.3  0.05285  0.37455  0.00300  1.0000
 19  RUSAIL G     10   19  1   -528.00   -123.82    528.00   164.96  0.0  0.00000  0.13990  0.00000  1.0000
 20  WADI ADAI    60   20  2    294.90    176.66   -293.69  -168.09  1.2  0.00940  0.06665  0.00060  1.0000
 30  RUSAIL BARK  10   30  2    247.28    126.74   -245.01  -118.66  2.3  0.02935  0.20825  0.00150  1.0000
 40  RUSAIL SEEB  10   40  1     51.63     44.18    -51.00   -42.35  0.6  0.13620  0.39700  0.00040  1.0000
 41  RUSAIL SEEB  10   41  1     51.63     44.18    -51.00   -42.35  0.6  0.13620  0.39700  0.00040  1.0000
 50  RUSAIL GHUB  10   50  2    -12.82     78.70     13.66   -76.25  0.8  0.13205  0.38495  0.00160  1.0000
 59  GHUBI3 G     50   59  1   -463.00   -239.01    463.00   275.97  0.0  0.00000  0.12850  0.00000  1.0000
 60  GHUB WADI    50   60  3    428.34    267.25   -426.90  -277.56  1.4  0.00510  0.03610  0.00060  1.0000
 70  ADAI FALAJ1  20   70  1     57.54     44.61    -57.50   -44.33  0.0  0.00660  0.04660  0.00010  1.0000
 71  ADAI FALAJ2  20   71  1     57.54     44.61    -57.50   -44.33  0.0  0.00660  0.04660  0.00010  1.0000
 80  ADAI KABIR1  20   80  1     53.19     40.92    -53.00   -39.98  0.2  0.03760  0.18480  0.00020  1.0000
 81  ADAI KABIR2  20   81  1     53.19     40.92    -53.00   -39.98  0.2  0.03760  0.18480  0.00020  1.0000
 90  BARKA MUSAN  30   90  1     79.51     37.32    -78.50   -30.18  1.0  0.12210  0.86630  0.00180  1.0000
 91  BARKA MUSAN  30   91  1     79.51     37.32    -78.50   -30.18  1.0  0.12210  0.86630  0.00180  1.0000
110  RUSAIL IZKI  10  110  2     -8.78     23.11      8.85   -22.65  0.1  0.11750  0.74885  0.00640  1.0000
120  IZKI NIZWA  110  120  2    -22.85     14.31     22.88   -14.13  0.0  0.03795  0.24200  0.00200  1.0000
130  NIZWA MANAH 120  130  3    -94.99    -34.47     95.17    35.58  0.2  0.01687  0.10510  0.00210  1.0000
139  MANAH G     130  139  1    -95.17    -35.58     95.17    45.68  0.0  0.00000  0.95240  0.00000  1.0000
140  NIZWA BAHLA 120  140  1     15.05     10.10    -15.00    -9.85  0.1  0.15910  0.72350  0.00080  1.0000
141  NIZWA BAHLA 120  141  1     15.05     10.19    -15.00    -9.85  0.1  0.15910  0.72350  0.00080  1.0000
210  RUSAIL 1     10  210  1     32.75    -57.60    -32.75    70.25  0.0  0.00000  2.33330  0.00000  0.9000
211  RUSAIL 2     10  210  1     32.75    -57.60    -32.75    70.25  0.0  0.00000  2.33330  0.00000  0.9000
212  RUSAIL 3     10  210  1     32.75    -57.60    -32.75    70.25  0.0  0.00000  2.33330  0.00000  0.9000
213  RUSAIL 4     10  210  1     32.75    -57.60    -32.75    70.25  0.0  0.00000  2.33330  0.00000  0.9000
220  WADI ADAI 1  20  220  1     69.50   -108.13    -69.50   144.91  0.0  0.00000  1.43200  0.00000  0.8500
221  WADI ADAI 2  20  220  1     69.50   -108.13    -69.50   144.91  0.0  0.00000  1.43200  0.00000  0.8500
230  AL BARKA 1   30  230  1     43.00   -119.23    -43.00   146.69  0.0  0.00000  1.29600  0.00000  0.9000
231  AL BARKA 2   30  230  1     43.00   -119.23    -43.00   146.69  0.0  0.00000  1.29600  0.00000  0.9000
240  SEEB 1       40  240  1     51.00    -56.39    -51.00    78.87  0.0  0.00000  2.67460  0.00000  0.8500
241  SEEB 2       41  240  1     51.00    -56.39    -51.00    78.87  0.0  0.00000  2.67450  0.00000  0.8500
250  GHUBRA 1     50  250  1     10.50    -15.52    -10.50    16.82  0.0  0.00000  3.14290  0.00000  0.9500
251  GHUBRA 2     50  250  1     10.50    -15.52    -10.50    16.82  0.0  0.00000  3.14290  0.00000  0.9500
259  GHUB03 G    250  259  1    -78.00    -27.48     78.00    29.15  0.0  0.00000  1.11730  0.00000  1.0000
260  MADINAT 1    60  260  1     66.00    -75.00    -66.00    93.66  0.0  0.00000  1.39200  0.00000  0.9000
261  MADINAT 2    60  260  1     66.00    -75.00    -66.00    93.66  0.0  0.00000  1.39200  0.00000  0.9000
270  AL FALAJ 1   70  270  1     57.50   -112.41    -57.50   151.47  0.0  0.00000  1.56600  0.00000  0.8500
271  AL FALAJ 2   71  270  1     57.50   -112.41    -57.50   151.47  0.0  0.00000  1.56800  0.00000  0.8500
280  WADI KABIR   80  280  1     53.00   -123.45    -53.00   165.86  0.0  0.00000  1.48000  0.00000  0.8500
281  WADI KABIR   81  280  1     53.00   -123.45    -53.00   165.86  0.0  0.00000  1.48000  0.00000  0.8500
290  MUSANNA 1    90  290  1     78.50   -145.99    -78.50   205.90  0.0  0.00000  1.35200  0.00000  0.9500
291  MUSANNA 2    91  290  1     78.50   -145.99    -78.50   205.90  0.0  0.00000  1.35200  0.00000  0.8500
310  IZKI 1      110  310  1      7.00    -33.57     -7.00    36.94  0.0  0.00000  2.50000  0.00000  0.9500
311  IZKI 2      110  310  1      7.00    -33.57     -7.00    36.94  0.0  0.00000  2.50000  0.00000  0.9500
320  NIZWA 1     120  320  1     21.00    -22.76    -21.00    25.57  0.0  0.00000  2.53970  0.00000  0.9500
321  NIZWA 2     120  320  1     21.00    -22.76    -21.00    25.57  0.0  0.00000  2.53970  0.00000  0.9500
340  BAHLA 1     140  340  1     15.00    -26.94    -15.00    29.73  0.0  0.00000  2.50000  0.00000  0.9500
341  BAHLA 2     141  340  1     15.00    -26.94    -15.00    29.73  0.0  0.00000  2.50000  0.00000  0.9500

***   TOTAL-LOSS =  11.166 (MW)   ***
```

Figure. 9-2-4 Output Data of Load Flow Calculation Program



```
                                     :
  290    3   0.        0.          157.0      60.0     0.        MUSANNAH 33
                      [-40.6]
                                     :
```

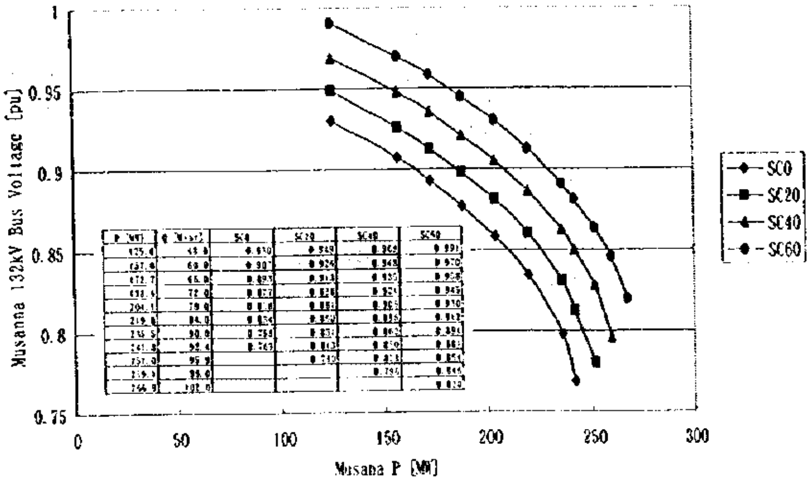
(a) Input data



```
                                          :
  90   MUSANNA 1          0.00     0.00     0.00     0.00     0.00     0.00  [0.94751]   -13.51     90
                                          :
```

(b) Output data

Figure.9-2-5 Input and Output Data (increase SC capacity)



P [MW]	Q [Mvar]	SC0	SC20	SC40	SC60
125.0	45.0	0.930	0.949	0.969	0.991
157.0	60.0	0.907	0.926	0.948	0.970
172.7	65.0	0.893	0.913	0.935	0.958
188.6	72.0	0.877	[illegible]	[illegible]	0.945
204.1	79.0	[illegible]	[illegible]	[illegible]	0.930
219.0	84.0	0.834	0.859	0.885	[illegible]
235.5	90.0	0.789	0.834	0.862	0.890
241.8	92.4	0.769	0.813	0.850	[illegible]
251.0	95.9		0.780	0.823	0.851
259.5	98.0			0.795	[illegible]
266.9	102.0				[illegible]

Figure.9-2-6 P-V Curve

9-3. System Fault Calculation Program

9-3-1. Applications of System Fault Calculation

Various faults, such as single line-to-ground fault and line-to-line short circuit, may take place on transmission lines and in power stations and substations. System fault calculation determines voltages and currents at a fault point and other points in the electric power system. The voltages and currents determined by system fault calculation are used extensively in assessing breaking capacities of circuit breakers, overvoltages and over currents on transmission lines and transformers, and induced voltages on adjacent communication lines.

9-3-2. Input and Output Data of System Fault Calculation

The input data are highly similar to those of load flow calculation. As system fault calculation covers unbalanced faults in its scope, it is necessary to input impedances such as line constants as values of symmetrical components. The program is designed so that, to suit the purpose of analysis, mutual induction impedances of lines can be considered. Naturally, fault points and kinds of faults must be inputted in detail.

System fault calculation reveals voltages, currents and phase angles at various points of the system as well as the voltage and current at the fault point.

9-3-3. Procedure of System Fault Calculation

The procedure of system fault calculation is also similar to that of load flow calculation; development and modification of input data → run of system fault calculation program → verification and assessment of results. The conditions are modified whenever needed and the program is run repeatedly (Figure. 9-3-1).

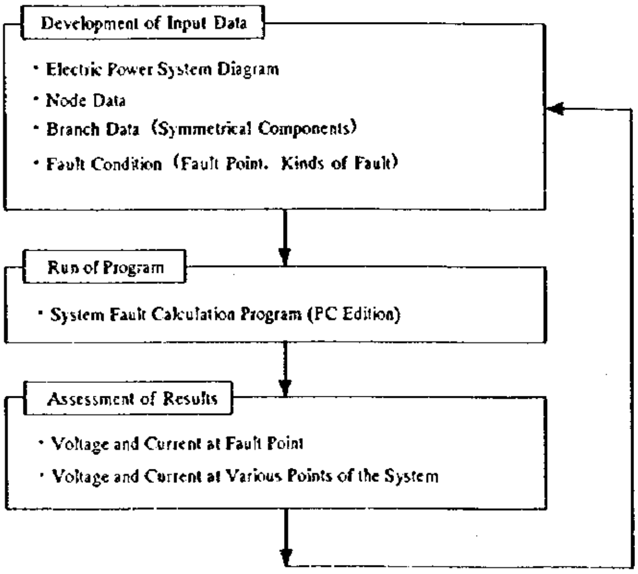


Figure.9-3-1 Flowchart of System Fault Calculation

9-4. Demand and Supply Operation Program

9-4-1. What is Economical Operation?

Economical operation seeks to minimize the annual fuel cost of an electric power system by adjusting outputs of many power generating facilities in the system to meet constantly changing power demand. It is based on economical load dispatching. In economical load dispatching, unit cost of power generating facility and costs of startup and shutdown of every individual power generating facility and other restraints are considered, and the number of power generating facilities to run in parallel and their respective outputs are determined so as to minimize the total cost.

9-4-2. Factors in Determining Economical Operation

(1) Fuel Costs of Power Generating Facilities

Fuel cost varies significantly from facility to facility, depending on the kind of fuel, the type of power generating facility, etc. Every power generating facility is designed to operate most efficiently at the rated output. The smaller the output, the lower the efficiency. The relationship of output and fuel cost of a typical gas turbine power generating facility used in Oman is shown in Figure. 9-4-1. In the diagram, fuel cost is 1 when the output is the rated one. Then, when the output is 70 %, the fuel cost is about 1.12. When the output is 50 %, the cost is 1.25. It is characterized in that as the output gets smaller, the fuel cost increases exponentially. Thus when each power generating facility is operated at the rated load rather than at a partial load, the fuel cost can be economized. In general, power generating facilities of higher efficiencies are constantly operated at their rated outputs to meet the base loads. And facilities of lower efficiencies are operated only during time zones of larger demand to meet peak loads. In this way, the total fuel cost is saved.

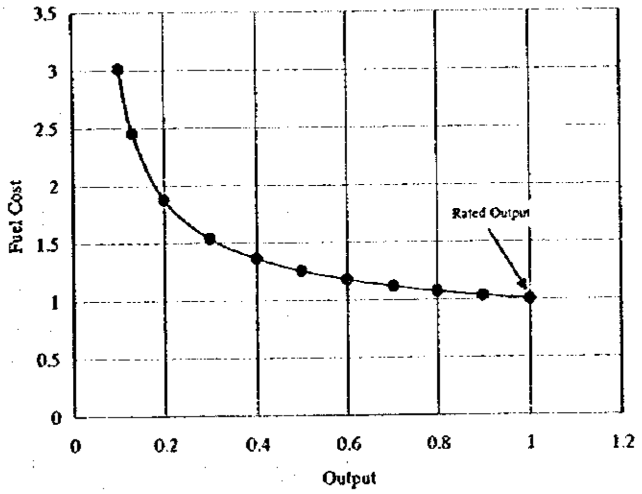


Figure.9-4-1 Relationship of Output and Fuel Cost

(2) Spinning Reserve

An estimation of power demand that changes all the time inevitably has an error of some size. Moreover, it is necessary to have a supply capability that is greater than the estimated demand so that power is stably supplied even if a fault is generated on a power generating facility. The difference between the supply capability and the demand is called spinning reserve. It is necessary to have such a spinning reserve that the load dispatching center can instantly increase the output by using, for example, a remaining capacity of a power generating facility that is operating at a partial load. However, it should be noted that failure of many power generating facilities at the same time is quite rare, and the greater is the spinning reserve, the greater is the cost. In Oman, it is a normal practice to have a spinning reserve that is equivalent to the output of the largest power generating facility among the power generating facilities in parallel operation.

(3) Startup and Shutdown of Power Generating Facility

If a power generating facility is shut down once, an extra amount of fuel is needed to restart the power generating facility. Hence, if the time from the shutdown to the restartup is short, the cost may be greater than that of continuous operation. Moreover, startup and shutdown of a power generating facility reduces the lifetime of the facility. It, therefore, is necessary to determine the number of startup and shutdown per day by considering this consumption of lifetime.

9-4-3. Economical Load Dispatching

The flowchart of economical load dispatching of power generating facilities is shown in Figure. 9-4-2. First, the calculation conditions are determined. They include the 24 hour load curve, power generating facilities that can be operated in parallel and their rated outputs and fuel efficiencies, atmospheric temperature, shortest shutdown periods of power generating facilities. As the maximum output of each power generating facility changes in proportion to the atmospheric temperature from season to season, it is necessary to correct the maximum output for temperature (Figure. 9-4-3).

Next, power generating facilities to be operated in parallel with each other are selected. Power generating facilities for parallel operation are selected in order of decreasing efficiency. This step is repeated till the total of outputs of the facilities selected exceeds the sum of demand and the spinning reserve. Here, the spinning reserve is defined as the output of the largest generating facility selected. This calculation is repeated to determine hourly sets of generating facilities for parallel operation for 24 hours.

Next, the status of startup and shutdown of every generating facility is checked. If the number of startup and shutdown is twice or over per day, the second and further startup and shutdown will be cancelled to operate the facility continuously. If the shutdown time of a generating facility to be shut down is shorter than an initially specified minimum time, the operation is continued to minimize lifetime consumption of the generating facility and cost increase.

When power generating facilities for parallel operation are selected, finally the outputs of the respective generating facilities are determined. As shown in Figure. 9-4-4, outputs of the generating facilities, starting from 100 %, are set in order of decreasing efficiency. Generating facilities of lower efficiency must be operated at least 40 % of the rated output. Outputs of intermediate generating facilities are adjusted so that the total output of the generating facilities meet the demand. In the actual calculation, all the generating facilities are operated at 40 % of their ratings. Next, the outputs of the generating facilities are increased in decreasing order of efficiency to balance the demand and supply. In this way, economical load dispatching of generating facilities is determined. The following two restraints were set to meet the requirements of the counterpart:

- The number of startup and shutdown of every generating facility is once a day

The minimum output of every generating facility is 40 % of the rating

When the outputs of the respective generating facilities are determined, the total fuel cost can be calculated from fuel efficiencies, unit costs of fuels, etc.

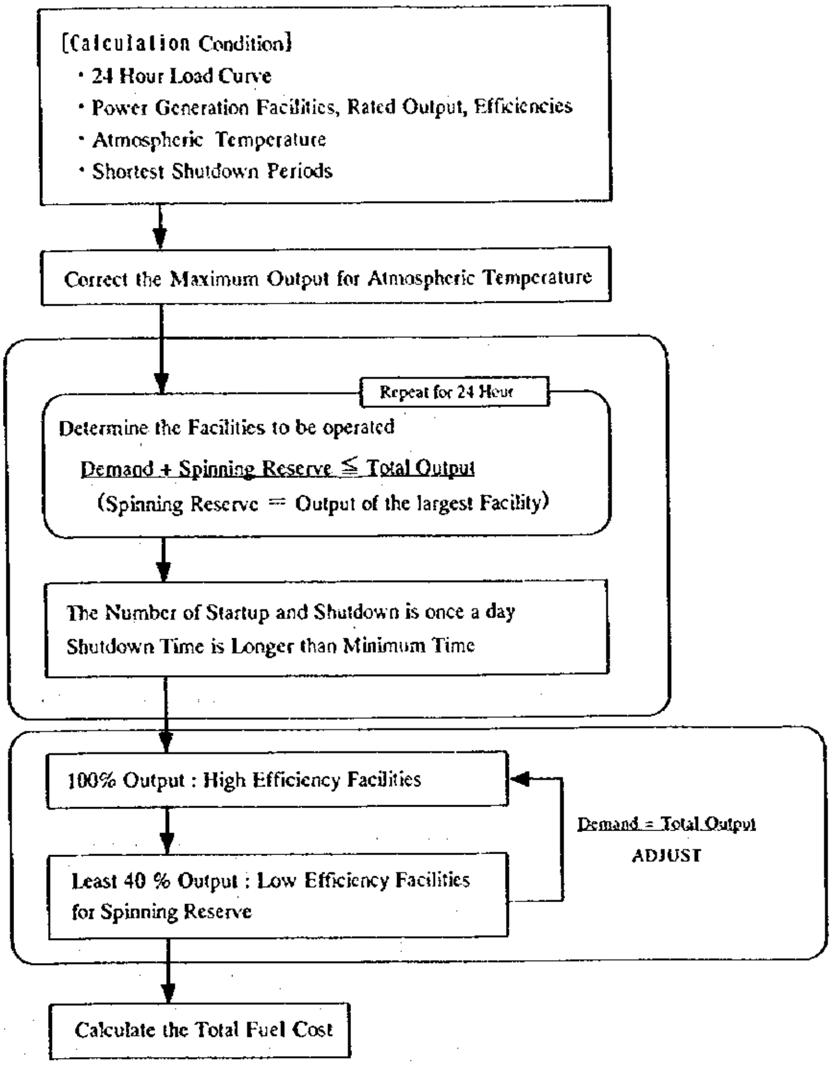


Figure.9-4-2 Flowchart of Economical Load Dispatching

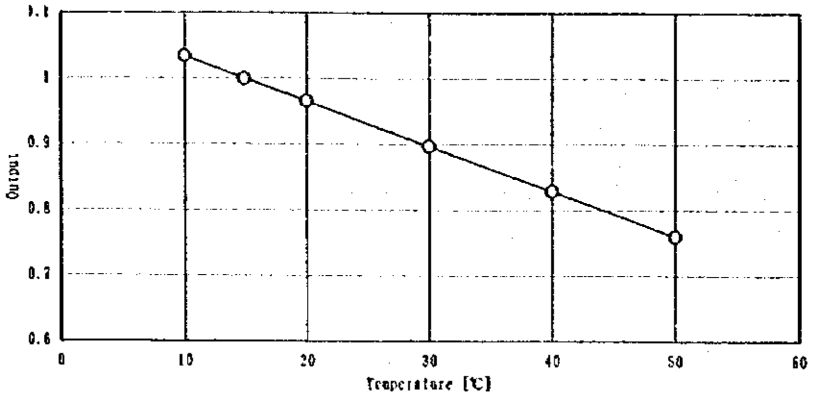


Figure.9-4-3 Relationship of Temperature and the Output of Generating Facility

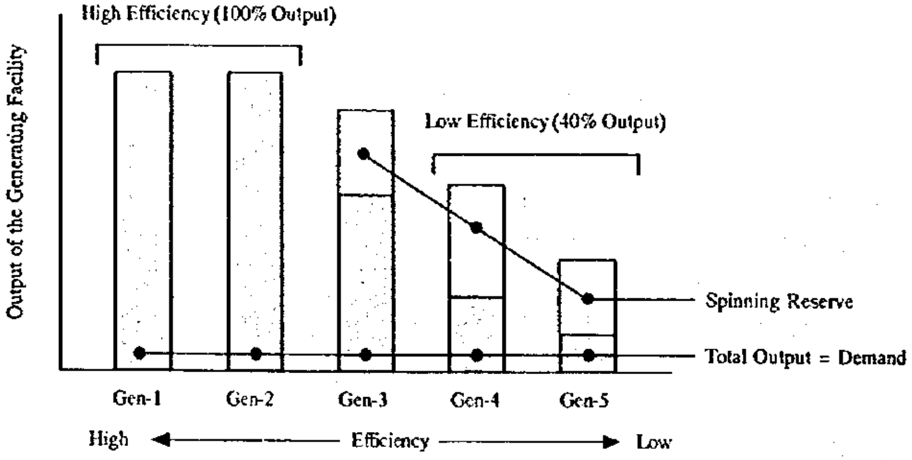


Figure.9-4-4 Determination of the Outputs of Generating Facilities

9-4-4. Demand Forecasting

To make an operation plan of the generating facilities, it is necessary to forecast demands for 24 hours. The daily electricity demand varies significantly with day of week, weather, atmospheric temperature, humidity, etc. It is a general practice to forecast the demand by adjusting past records of power demand for these factors. Proper treatment of these meteorological factors, however, requires many know-hows that can be derived only from accumulation of actual records of the area over many years and analyses of such data. It is not easy to develop a model of high overall accuracy. The flowchart of the most basic demand forecasting is shown in Figure. 9-4-5. First, the date of the day to be forecasted and the forecasted peak demand of the day are inputted. The forecasted peak demand of the day are determined by considering factors such as the meteorological factors. Next, a day, that is considered to be most appropriate, is selected as a reference day from, for example, the same day of the preceding year, the same day of the preceding week and the preceding day. The demand curve of the selected reference day is taken out of the actual demand database that has been inputted in advance. Finally, the demand curve of the reference day is corrected so that the peak value of the demand curve coincides with the forecasted peak value of the forecasted day. The resulting curve is the demand curve of the forecasted day.

One example of demand forecasting is shown in Figure. 9-4-6. This method is relatively simple and easy to understand, and is a practical method. The method fully satisfies the accuracy of forecasting that is practiced daily in Oman.

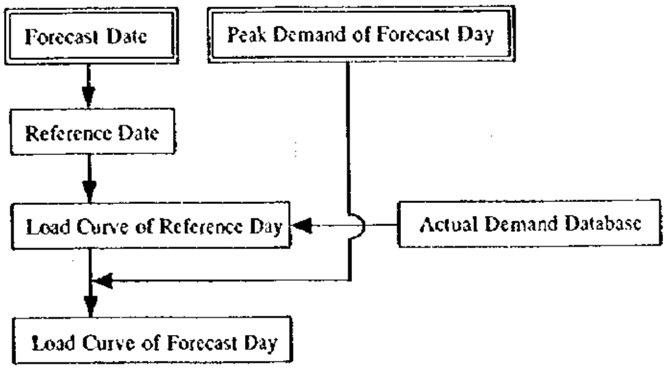


Figure.9-4-5 Flowchart of the Basic Demand Forecasting

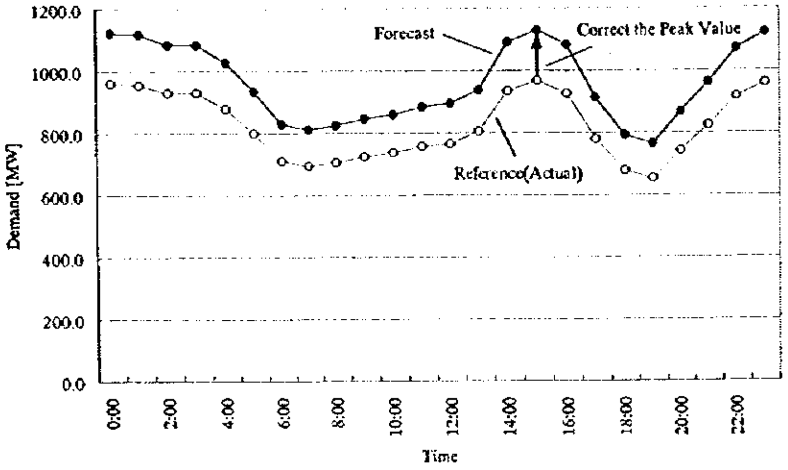


Figure.9-4-6 Example of the Demand Forecasting

9-4-5. Calculation Procedure of Demand and Supply Operation Program

The calculation flowchart of the demand and supply operation program is shown in Figure. 9-4-7. The demand and supply operation program is a combination of the demand forecasting program and the economical load dispatching program. When three items, namely, the date and a forecasted peak demand of a forecasted day and particulars of power generating facilities that can be operated in parallel, are inputted, the program will automatically calculate the demand curve, output of the respective generating facilities, cost, etc. and display them visually with tables and graphs. If the automatic calculation does not provide a satisfactory result, then the reference date, 24-hour demand curve, atmospheric temperature, spinning reserve, etc. of the demand forecasting can be modified.

When all the particulars of load dispatching of the generating facilities are inputted, costs of actual operation can be calculated by the program. The screen configuration and an example of calculation of the demand and supply operation program are shown in Figure. 9-4-8.

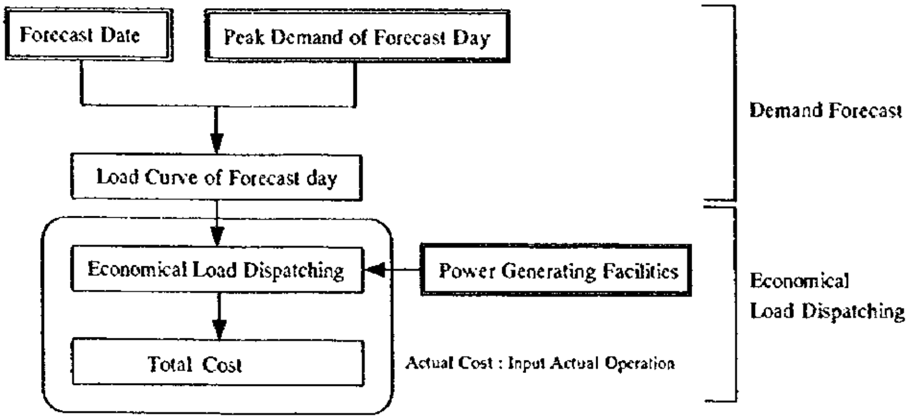


Figure.9-4-7 Flowchart of Demand and Supply Operation Program

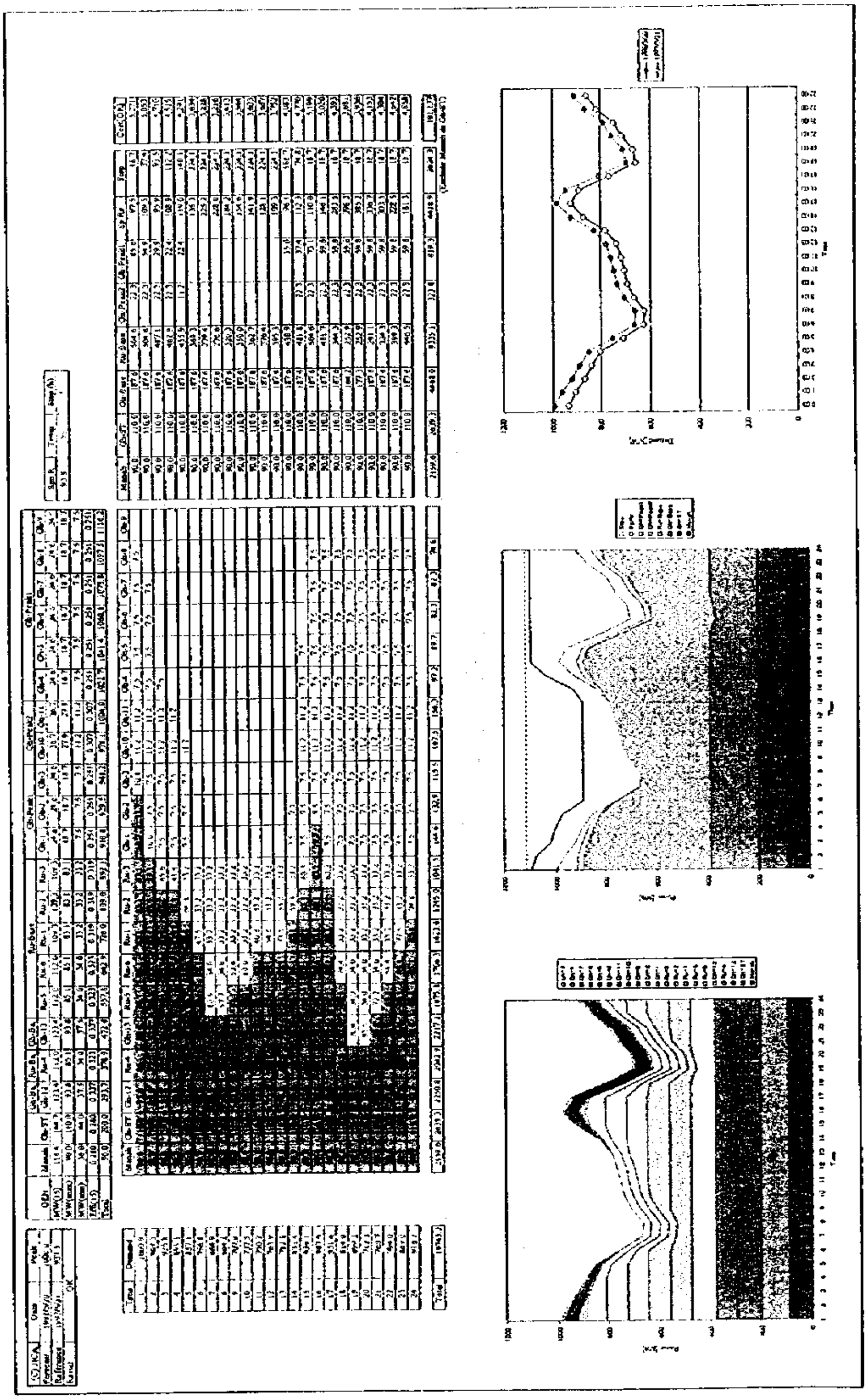


Figure.9-4-8 Example of the Demand and Supply Operation Program

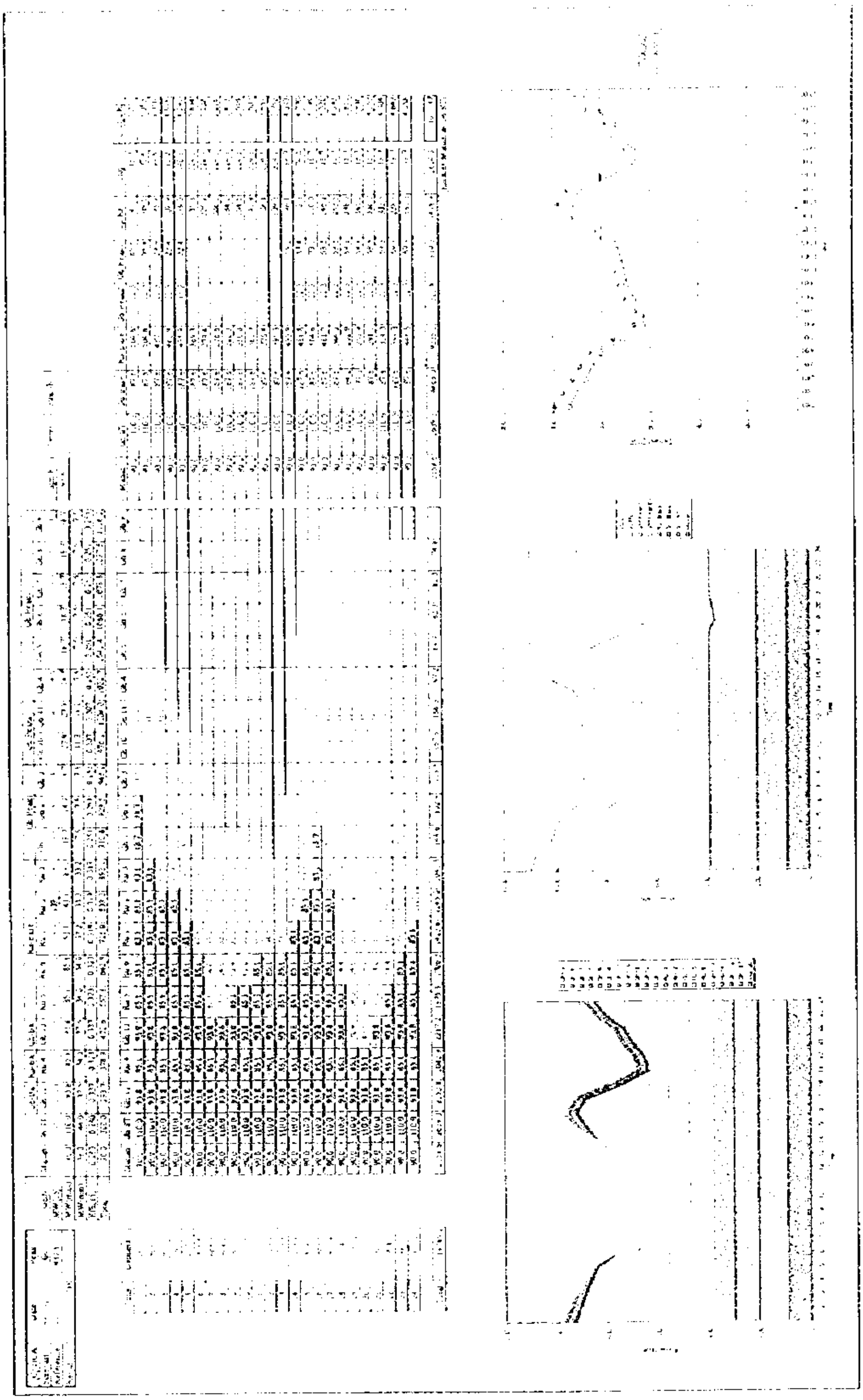
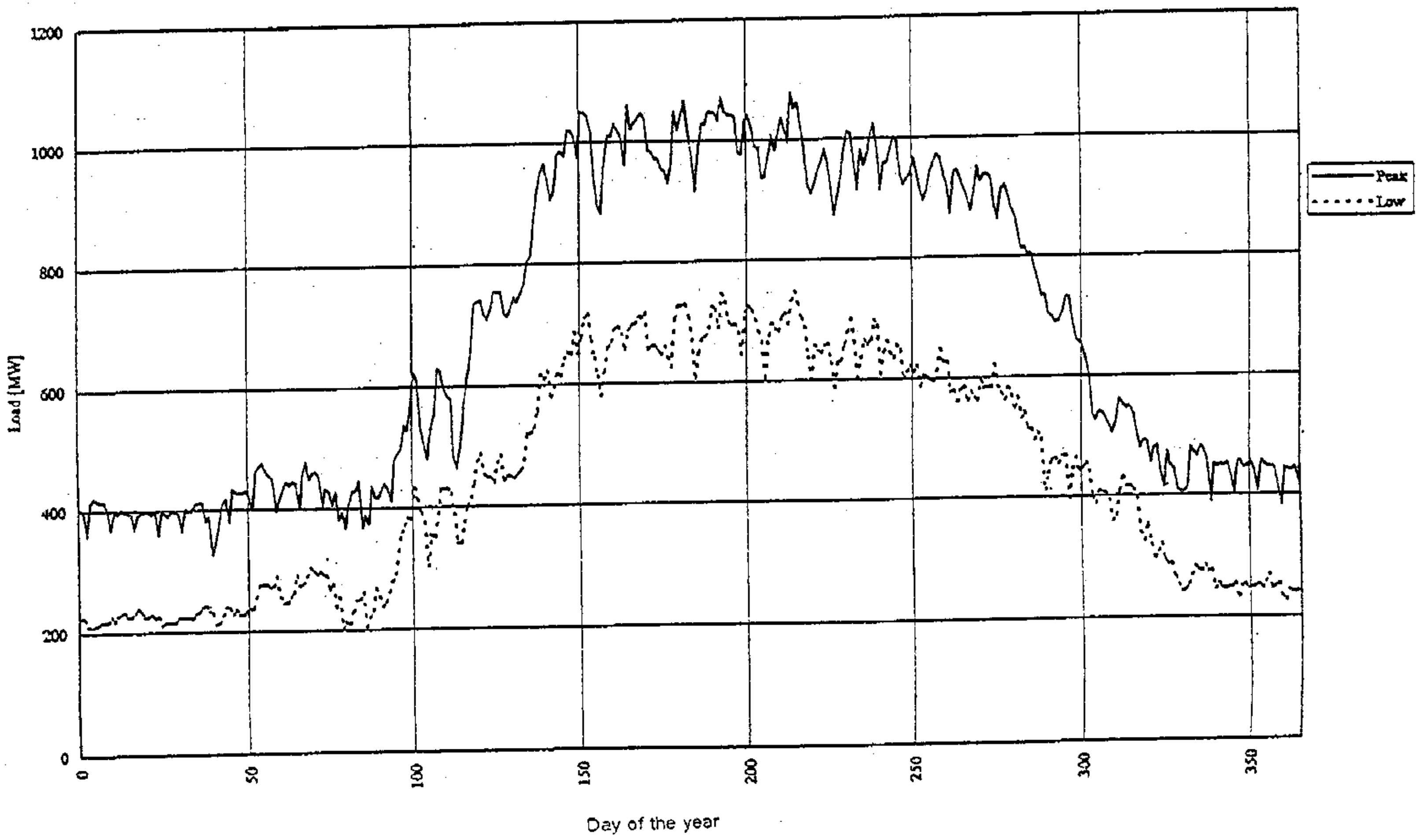


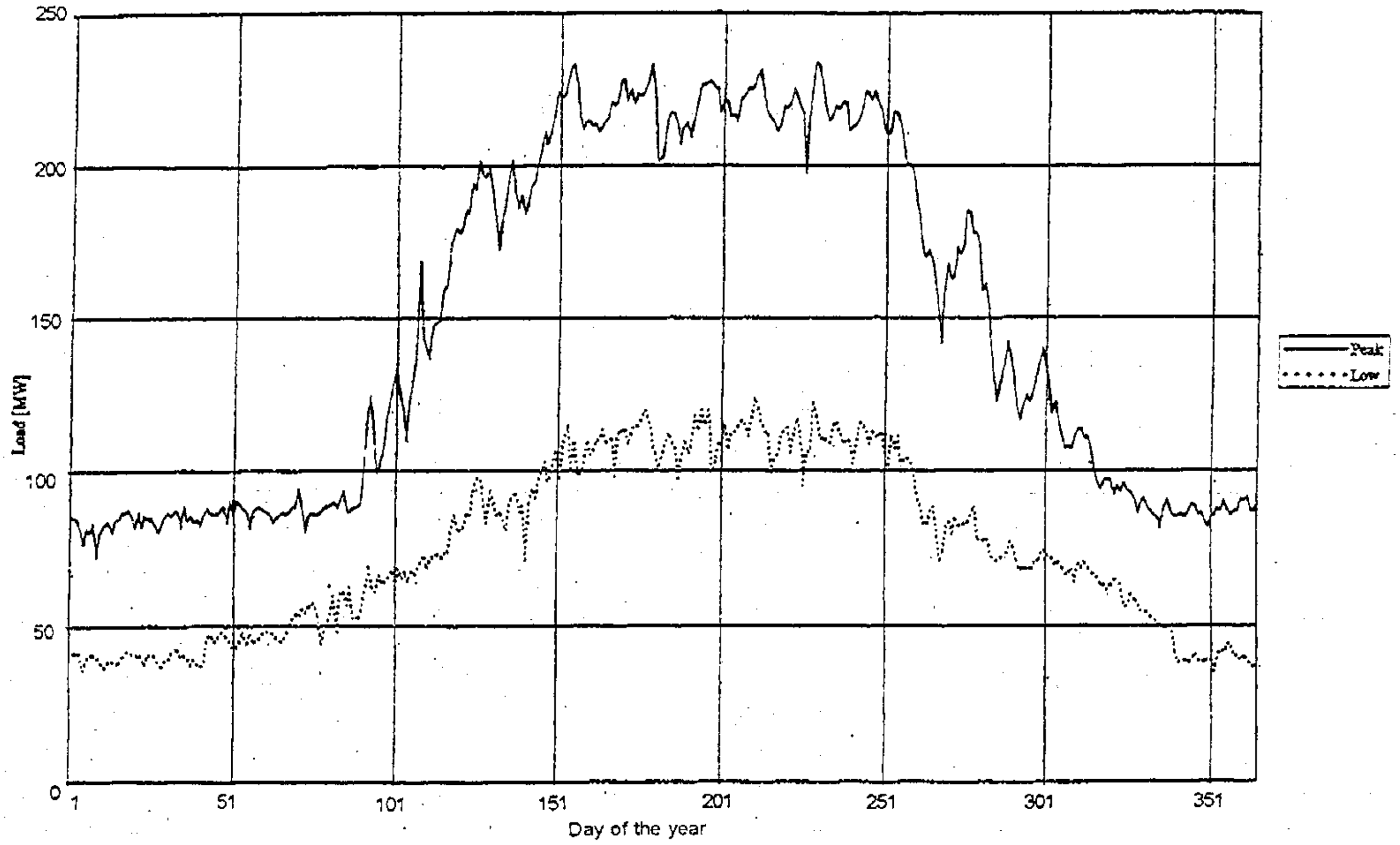
Figure.9-1-8 Example of the Demand and Supply Operation Program

LIST OF ANNEXES

2-1-a Daily Peak and Low Load in MW 1997 Muscat System



2-1-b Daily Peak and Low Load in MW 1994 Wadi Jizzi System



2-2-a Muscat System Maximum Demand Balance & Generation Expansion Planning

(MW)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Peak Demand	1210	1268	1423	1514	1605	1693	1756	1820	1880	1940	2000	2060	2120
Net Supply Capacity (*)	1124	1341	1529	1623	1717	1853	1936	1936	2030	2124	2135	2186	2291
Reserve Margin	95	95	95	95	95	95	95	95	95	95	95	95	95
Firm Generation	1029	1246	1434	1528	1622	1758	1841	1841	1935	2029	2040	2091	2196
Balance of Firm Generation to Peak Demand	-181	-22	11	14	17	65	85	21	55	89	40	31	76
Ratio of Reserve Margin	7.9%	7.5%	6.7%	6.3%	5.9%	5.6%	5.4%	5.2%	5.1%	4.9%	4.8%	4.6%	4.5%
(*) Net Supply Capacity													
Rusail PS	500.4	688.3	688.3	782.4	782.4	782.4	782.4	782.4	782.4	782.4	793.2	804	814.8
future expansion	(Water.In) (GT-7)	93.8 94.1		94.1 (GT-8)						(GT1~3) (GT9~11)	▲83.3 94.1	▲83.3 94.1	▲83.3 94.1
Ghubrah PS	537	566.1	566.1	566.1	566.1	607.7	596.8	596.8	596.8	690.9	690.9	731	825.1
future expansion		29.1 (Water.In)			(GT1~3) (GT14)	▲52.5 94.1	▲105 94.1	(GT4~9) (GT15)		94.1 (GT16)	(GT10~11) (GT17)	▲54 94.1	94.1 (GT18)
Manah PS	86.4	86.4	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6
future expansion			94.1*2 (GT-4,5)										
Barka PS	0	0	0	0	94.1	188.2	282.3	282.3	376.4	376.4	376.4	376.4	376.4
future expansion					94.1 (GT 1)	94.1 (GT 2)	94.1 (GT 3)		94.1 (GT 4)				
Expansion Total	0	217	188.2	94.1	94.1	135.7	83.2		94.1	94.1	10.8	50.9	104.9

2-2-b

Wadi Al Jizzi System **Maximum Demand Balance & Generation Expansion Planning** (MW)

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Peak Demand	310	328	350	367	381	395	409	422	437	452	465	480	496
Net Supply Capacity (*)	282	371	401	401	431	431	461	461	491	503	515	528	530
Reserve Margin	30	30	30	30	30	30	30	30	30	30	30	30	30
Firm Generation	252	341	371	371	401	401	431	431	461	473	485	498	500
Balance of Firm Generation to Peak Demand	-58	13	21	4	20	6	22	9	24	21	20	18	4
Ratio of Reserve Margin	9.7%	9.1%	8.6%	8.2%	7.9%	7.6%	7.3%	7.1%	6.9%	6.6%	6.5%	6.3%	6.0%
(*) Net Supply Capacity													
Wadi Al Jizzi PS	281.8	370.9	400.9	400.9	430.9	430.9	460.9	460.9	490.9	503.1	515.3	527.5	529.6
future expansion	(Water Inj) (GT 12,13)	29.1 30*2	30 (GT 14)	Note	30 (GT 15)		30 (GT 16)		30 (GT 17)	30 (GT 18) ▲17.8 (GT 1)	30 (GT 19) ▲17.8 (GT 2)	30 (GT 20) ▲17.8 (GT 3)	30 (GT 21) ▲27.9 (GT 4)
		89.1	30		30		30		30	12.2	12.2	12.2	2.1

Note: The capacity of new plant should be limited to about 15% of the total system capacity in order to avoid a large disturbance in case of unit trip. To prevent a supply shortage, it is needed to have a spinning reserve equivalent to the capacity of the largest unit. Thus, 30MW unit is the best in the Wadi Jizzi system before interconnection with the Muscat system.

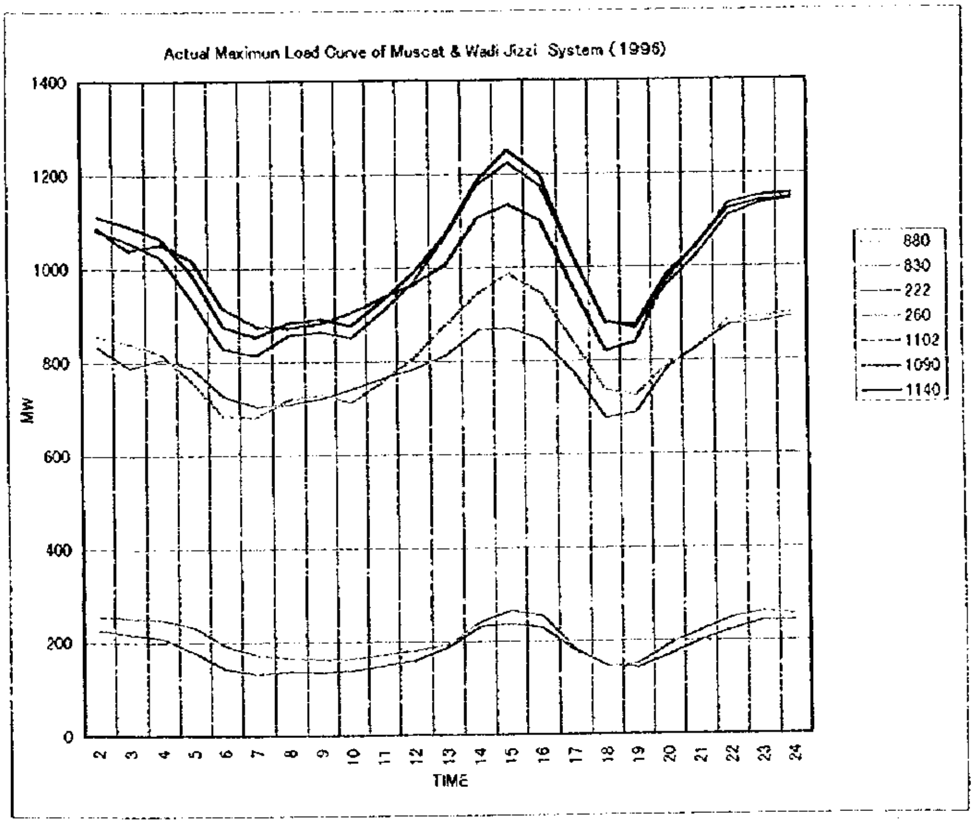
2-2-c

Diversity of Muscat & Wadi Jizzi System (1996)

	Muscat		Wadi Jizzi		Muscat +Wadi Jizzi		
	Mus 5-6	2-8	Wadi 5-6	2-8	M+W 5-6	M+W 2-8	M5-6+W2-8
1	880	830	222	260	1102	1090	1140
2	855	832	226	256	1081	1088	1111
3	840	788	217	251	1057	1039	1091
4	817	805	208	247	1025	1052	1064
5	756	786	177	232	933	1018	988
6	685	725	142	190	827	915	875
7	681	704	132	172	813	876	853
8	719	708	136	164	855	872	883
9	729	720	134	162	863	882	891
10	712	740	138	164	850	904	876
11	755	762	148	172	903	934	927
12	806	782	160	181	966	963	987
13	877	813	188	194	1065	1007	1071
14	945	866	231	241	1176	1107	1186
15	986	869	237	265	1223	1134	1251
16	945	845	228	254	1173	1099	1199
17	842	775	181	183	1023	958	1025
18	737	676	146	144	883	820	881
19	724	688	143	151	867	839	875
20	789	781	169	192	958	973	981
21	825	827	199	220	1024	1047	1045
22	886	874	223	248	1109	1122	1134
23	890	879	243	261	1133	1140	1151
24	899	890	244	256	1143	1146	1155

Diversity Factor ; (986+256)/1223=1.02

Coincidence Factor; 1/1.02=0.978



2-2-d

Interconnection case

Maximum Demand Balance & Generation Expansion Planning

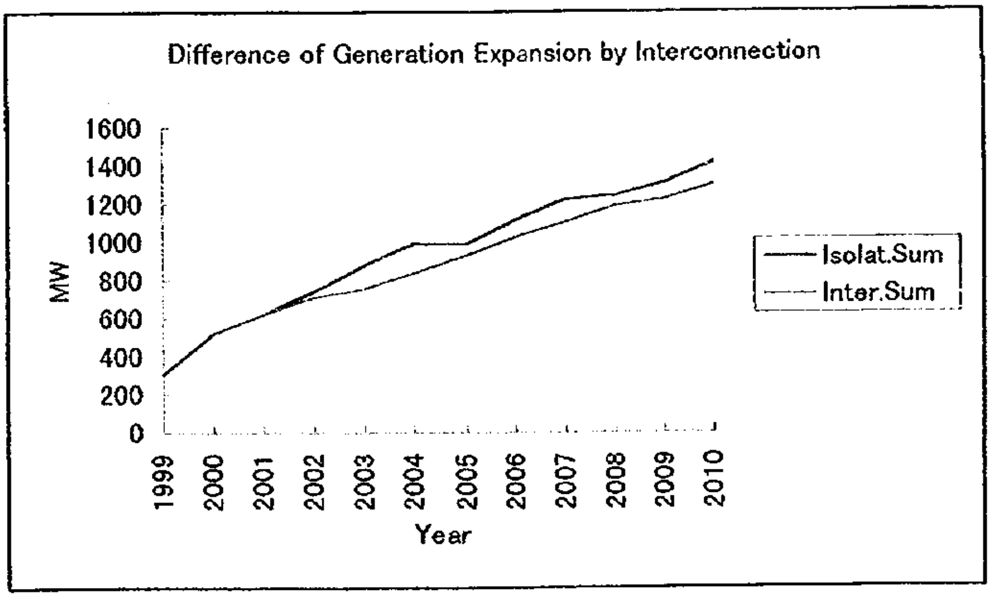
(MW)

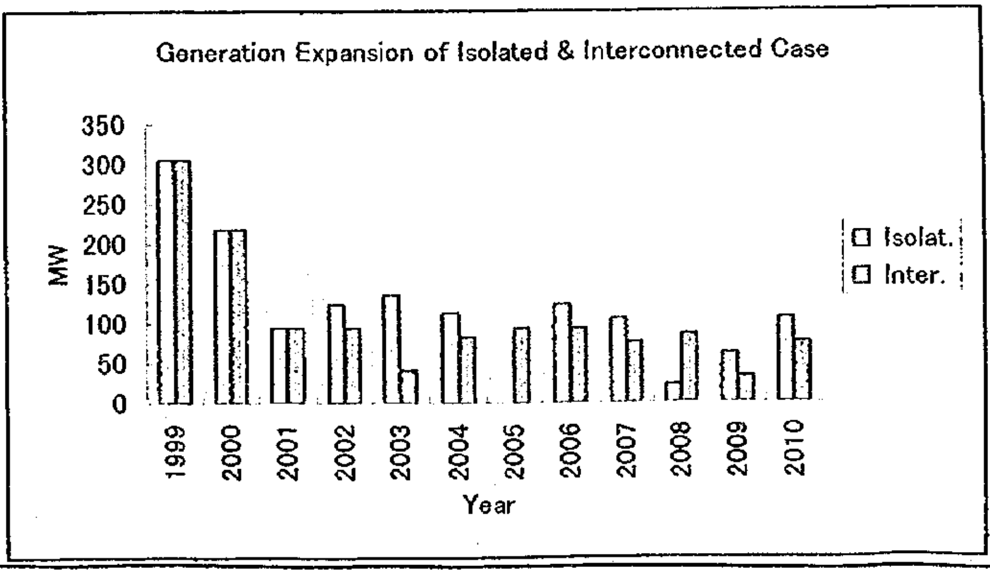
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Peak Demand	1520	1596	1773	1843	1946	2046	2122	2197	2271	2344	2416	2489	2563
Net Supply Capacity (*)	1406	1712	1930	2024	2118	2160	2243	2337	2431	2507	2595	2628	2705
Reserve Margin	125	125	125	95	95	95	95	95	95	95	95	95	95
Firm Generation	1281	1587	1805	1929	2023	2065	2148	2242	2336	2412	2500	2533	2610
Balance of Firm Generation to Peak Demand	-239	-9	32	86	77	19	26	45	65	68	84	44	47
Ratio of Reserve Margin	8.2%	7.8%	7.1%	5.2%	4.9%	4.6%	4.5%	4.3%	4.2%	4.1%	3.9%	3.8%	3.7%
(*) Net Supply Capacity													
Rusail PS	500.4	688.3	688.3	688.3	688.3	688.3	688.3	782.4	782.4	782.4	793.2	804	814.8
future expansion	(Water Inj) (GT-7)	93.8 94.1						94.1 (GT-8)		(GT1~3) (GT9~11)	▲83.3 94.1	▲83.3 94.1	▲83.3 94.1
Ghubrah PS	537	566.1	566.1	566.1	566.1	607.7	596.8	596.8	596.8	596.8	596.8	636.9	731
future expansion		29.1 (Water Inj)			(GT1~3) (GT 14)	▲52.5 94.1	▲105 94.1	(GT4~9) (GT 15)			(GT10~11) (GT 16)	▲54 94.1	94.1 (GT17)
Manah PS	86.4	86.4	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6	274.6
future expansion			94.1*2 (GT4,5)										
Barka PS	0	0	0	0	94.1	94.1	188.2	188.2	282.3	376.4	376.4	376.4	376.4
future expansion					94.1 (GT 1)		94.1 (GT 2)		94.1 (GT 3)	94.1 (GT 4)			
Wadi Al Jizzi PS	281.8	370.9	400.9	495	495	495	495	495	495	477.2	553.5	535.7	507.8
future expansion	(Water Inj) (GT 12,13)	29.1 30*2	30 (GT 14)	94.1 (GT 15)					(GT 1~4)	▲17.8 (GT 16)	▲17.8 94.1	▲17.8	▲27.9
Expansion Total		306.1	218.2	94.1	94.1	41.6	83.2	94.1	94.1	76.3	87.1	33.1	77

2-2-d(2)

Difference of Generation Expansion By Interconnection (Muscat & Wadi Jizzi System)

Year	Muscat	Wadi Jizzi	Isolat.	Isolat.Sum	Inter.	Inter.Sum	Differece
1998	0	0	0	0	0	0	0
1999	217	89.1	306.1	306.1	306.1	306.1	0
2000	188.2	30	218.2	524.3	218.2	524.3	0
2001	94.1	0	94.1	618.4	94.1	618.4	0
2002	94.1	30	124.1	742.5	94.1	712.5	30
2003	135.7	0	135.7	878.2	41.6	754.1	124.1
2004	83.2	30	113.2	991.4	83.2	837.3	154.1
2005	0	0	0	991.4	94.1	931.4	60
2006	94.1	30	124.1	1115.5	94.1	1025.5	90
2007	94.1	12.2	106.3	1221.8	76.3	1101.8	120
2008	10.8	12.2	23	1244.8	87.1	1188.9	55.9
2009	50.9	12.2	63.1	1307.9	33.1	1222	85.9
2010	104.9	2.1	107	1414.9	77	1299	115.9





2-2-d(3)

Saving Investment Cost of Generation Expansion by Interconnection (1998 ~2010)

	Generation Expansion			Investment(1000 RO)		Present Value(1000 RO)		
Year	Isolated	Interconn	Difference	Isolated	Interconn	Isolated	Interconn	Coefficient
1998	0	0	0	0	0	0	0	1
1999	306.1	306.1	0	34500	34500	31945	31945	0.92593
2000	218.2	218.2	0	6660	6660	5710	5710	0.85734
2001	94.1	94.1	0	13850	13850	10995	10995	0.79383
2002	124.1	94.1	30	20510	13850	15075	10180	0.73503
2003	135.7	41.6	94.1	27700	13850	18852	9426	0.68058
2004	113.2	83.2	30	34360	27700	21653	17456	0.63017
2005	0	94.1	-94.1	0	13850	0	8081	0.58349
2006	124.1	94.1	30	20510	13850	11081	7483	0.54027
2007	106.3	76.3	30	20510	13850	10260	6928	0.50025
2008	23	87.1	-64.1	20510	27700	9500	12830	0.46319
2009	63.1	33.1	30	34360	27700	14736	11880	0.42888
2010	107	77	30	34360	27700	13645	11000	0.39711
Total						**163451**	**143914**	

GT Investment Cost

Difference **19,538*1000 RO**

Frame9 (94.1MW) ; 13,850,000 RO
(30MW) ; 6,660,000 RO

2-2-e

Saved Fuel Cost for 10Years (2001~2010) (1000RO)

Year	Sav. F.C	Coefficie.	Pre.Value
1998	0	1	0.0
1999	0	0.92593	0.0
2000	0	0.85734	0.0
2001	1492	0.79383	1184.4
2002	1558	0.73503	1145.2
2003	1625	0.68058	1105.9
2004	1691	0.63017	1065.6
2005	1761	0.58349	1027.5
2006	1826	0.54027	986.5
2007	1891	0.50025	946.0
2008	1956	0.46319	906.0
2009	2022	0.42888	867.2
2010	2093	0.39711	831.2
		Total	**10065.5**

Interconnection at year 2001
Saved Fuel Cost of 1997 ; 7,988,000 *0.139 =1,110*1000 RO
Growth Rate of Power Demands
in Wadi Jizzi System; **5.0% /Year**
Saved Fuel Cost for 10 Years ; **10,065*1000 RO**

2-2-f

Interconnection case

Maximum Demand Balance & Generation Expansion Planning(2010-2020)

(MW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020			
Peak Demand	2563	2639	2718	2799	2882	2967	3057	3148	3241	3337	3436			
Net Supply Capacity (*)	2705	2789	2866	2913	3018	3084	3178	3272	3430	3495	3589			
Reserve Margin	95	95	95	95	95	95	95	95	95	95	95			
Firm Generation	2610	2694	2771	2818	2923	2989	3083	3177	3335	3400	3494			
Balance of Firm Generation to Peak Demand	47	55	53	19	41	22	26	29	94	63	58			
Ratio of Reserve Margin	3.7%	3.6%	3.5%	3.4%	3.3%	3.2%	3.1%	3.0%	2.9%	2.8%	2.8%			
(*) Net Supply Capacity														
Rusail PS	908.9	908.9	919.5	930.1	940.7	940.7	940.7	940.7	940.7	940.7	940.7			
future expansion	▲83.3 94.1	(GT3) (GT11)	▲83.5 94.1	▲83.5 94.1	▲83.5 94.1	(GT4～6) (GT12～14)								
Ghubrah PS	636.9	655.5	655.5	719.6	719.6	719.6	719.6	719.6	813.7	813.7	813.7			
future expansion	94.1 (GT17)	▲75.5 94.1	(ST1,4) (GT13)	▲30 94.1	(ST5) (GT19)				94.1 (GT20)					
Manah PS	274.6	274.6	274.6	274.6	368.7	368.7	368.7	368.7	368.7	368.7	368.7			
future expansion					94.1 (GT6)									
Barka PS	376.4	376.4	376.4	376.4	376.4	470.5	470.5	564.6	658.7	658.7	752.8			
future expansion						94.1 (GT5)		94.1 (GT6)	94.1 (GT7)		94.1 (GT8)			
Wadi Al Jizzi PS	507.8	574	640.1	612.1	612.1	584.1	678.2	678.2	648.6	713.1	713.1			
future expansion	▲27.9	▲27.9 94.1	▲28 94.1	▲23 (GT17,18)	(GT4,7)	▲28 (GT8)	94.1 (GT19)		▲29.6 (GT9,10)	▲29.6 94.1	(GT20)			
Expansion Total	77	84.8	76.7	46.7	104.7	66.1	94.1	94.1	158.6	64.5	94.1	2011～	884.4	

2-2-g

Isolated case

Muscat System

Maximum Demand Balance & Generation Expansion Planning(2010~2020)

(MW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020			
Peak Demand	2120	2181	2244	2309	2376	2445	2516	2589	2664	2741	2820			
Net Supply Capacity (*)	2291	2310	2414	2489	2500	2594	2688	2688	2782	2876	2970			
Reserve Margin	95	95	95	95	95	95	95	95	95	95	95			
Firm Generation	2196	2215	2319	2394	2405	2499	2593	2593	2687	2781	2875			
Balance of Firm Generation to Peak Demand	76	34	75	85	29	54	77	4	23	40	55			
Ratio of Reserve Margin	4.5%	4.4%	4.2%	4.1%	4.0%	3.9%	3.8%	3.7%	3.6%	3.5%	3.4%			
(*) Net Supply Capacity														
Rusail PS	908.9	908.9	919.5	930.1	846.6	846.6	846.6	846.6	940.7	940.7	940.7			
future expansion	▲83.3 94.1	(GT3) (GT12)	▲83.5 94.1	▲83.5 94.1	▲83.5 (GT13,14)	(GT4～6)			94.1 (GT15)					
Ghubrah PS	731	749.6	749.6	813.7	813.7	907.8	907.8	907.8	907.8	907.8	907.8			
future expansion	94.1 (GT17)	▲75.5 94.1	(ST1～4 (GT18)	▲30 94.1	(ST5) (GT19)	94.1 (GT20)								
Manah PS	274.6	274.6	274.6	274.6	368.7	368.7	368.7	368.7	368.7	368.7	368.7			
future expansion					94.1 (GT6)									
Barka PS	376.4	376.4	470.5	470.5	470.5	470.5	564.6	564.6	564.6	658.7	752.8			
future expansion			94.1 (GT5)				94.1 (GT6)			94.1 (GT7)	94.1 (GT8)			
Expansion Total	104.9	18.6	104.7	74.7	10.6	94.1	94.1	0	94.1	94.1	94.1			

2-2-h

Isolated case

Wadi Al Jizzi System   **Maximum Demand Balance & Generation Expansion Planning(2010-2020)**   (MW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020			
Peak Demand	496	512	529	547	565	583	603	623	643	664	686			
Net Supply Capacity (*)	530	562	628	694	694	760	760	760	825	795	795			
Reserve Margin	30	30	95	95	95	95	95	95	95	95	95			
Firm Generation	500	532	533	599	599	665	665	665	730	700	700			
Balance of Firm Generation to Peak Demand	4	20	4	52	34	82	62	42	87	36	14			
Ratio of Reserve Margin	6.0%	5.9%	18.0%	17.4%	16.8%	16.3%	15.8%	15.2%	14.8%	14.3%	13.8%			
(*) Net Supply Capacity														
Wadi Al Jizzi PS	529.6	561.7	627.8	693.9	693.9	760	760	760	824.5	794.9	794.9			
future expansion	30 (GT21) ▲27.9 (GT4)	30*2 (GT22,23) ▲27.9 (GT5)	94.1 (GT24) ▲28 (GT6)	94.1 (GT25) ▲28 (GT7)		94.1 (GT26) ▲28 (GT8)			94.1 (GT27) ▲29.6 (GT9)	▲29.6 (GT10)				
Expansion Total	2.1	32.1	66.1	66.1	0	66.1	0	0	64.5	▲29.6	0			

3-3-a

Production Cost at Consumer End, 1997: RO

Cost Within Plant

No	Cost Element	Ghubrah	Rusayl	Muscat Tota	Wadi Jizzi	Manah	Rural	Total	%	%
1	Fuel	14,930,156	13,531,167	28,461,323	7,993,343	4,428,976	26,095,840	66,979,482	61.2%	43.9%
2	Man Power	1,244,795	540,072	1,784,867	538,522	784,000	1,923,118	5,030,507	4.6%	3.3%
3	Spare Parts	782,375	487,251	1,269,626	662,270	292,304	2,212,657	4,436,857	4.1%	2.9%
4	Depreciation	3,759,820	2,306,860	6,066,680	1,806,420	0	2,503,952	10,377,052	9.5%	6.8%
5	Financing Cost	3,995,660	2,451,039	6,446,699	1,919,321	7,933,071	2,660,449	18,959,540	17.3%	12.4%
6	Insurance	39,471	21,704	61,175	10,798	0	12,515	84,488	0.1%	0.1%
7	Others	620,949	366,016	986,965	55,731	1,205,315	1,163,702	3,411,713	3.1%	2.2%
8	Power Purchases						212,823	212,823	0.2%	0.1%
10	Sub Total	25,373,226	19,704,109	45,077,335	12,986,405	14,643,666	36,785,056	109,492,462	100.0%	71.7%
	Excluding Power Purchase						36,572,233	109,279,639		

Cost Outside Plant

No	Cost Element	Ghubrah	Rusayl	Muscat Tota	Wadi Jizzi	Manah	Rural	Total	%	%
11	Depreciation			3,926,575	2,166,913		1,884,358	7,977,846	18.5%	5.2%
12	Financing Cost			4,162,170	2,296,927	9,470,491	1,997,419	17,927,007	41.5%	11.7%
13	Spare Parts			1,174,763	648,303		563,767	2,386,833	5.5%	1.6%
14	Maintenance			1,028,098	567,364		493,383	2,088,845	4.8%	1.4%
15	Insurance			7,718	4,259		3,704	15,681	0.0%	0.0%
16	MEW Administration			3,391,472	1,871,612		3,623,753	8,886,837	20.6%	5.8%
17	Billing Charges			2,387,155	563,159	170,417	759,549	3,880,280	9.0%	2.5%
20	Sub Total			16,077,951	8,118,537	9,640,908	9,325,933	43,163,329	100.0%	28.3%
30	Total Cost			61,155,286	21,104,942	24,284,574	46,110,989	152,655,791		100.0%
40	Billed Amount			54,954,949	11,132,000	8,125,036	13,534,139	87,746,124	40/30	57.5%
	Actual Revenue							86,808,768		
50	Govt. Subsidy			6,200,337	9,972,942	16,159,538	32,576,850	64,909,667	50/30	42.5%
60	Electricity Generated	2,362,415	1,938,842	4,301,257	1,131,707	680,106	1,204,670	7,317,740		
	(MWh) Exclude OMCO				1,051,052		1,190,349			
70	Electricity Exported	2,126,661	1,906,445	4,380,135	1,121,460	327,927	1,118,996	6,948,518	70/60	95.0%
	(MWh)			−347,029		347,029				
80	Electricity Consumed : Billed			3,489,931	845,360	537,392	952,018	5,824,701	80/60	79.6%
	(MWh) Exclude Desali							5,623,045		
90	Consumed/Generated			81.1%	74.7%	79.0%	79.0%	79.6%		

Export to OMCO 80,656

Paid up Consumption 76.8% 5,600,336

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Unit Cost at Consumer End, 1997: baiza/KWh

Cost Within Plant

No	Cost Element	Ghubrah	Rusayl	Muscat	Wadi Jizzi	Manah	Rural	Total
1	Fuel			8.155	9.456	8.242	27.411	11.499
2	Man Power			0.511	0.637	1.459	2.020	0.864
3	Spare Parts			0.364	0.783	0.544	2.324	0.762
4	Depreciation			1.738	2.137	0.000	2.630	1.782
5	Financing Cost			1.847	2.270	14.762	2.795	3.255
6	Insurance			0.018	0.013	0.000	0.013	0.015
7	Others			0.283	0.066	2.243	1.222	0.586
8	Power Purchases						0.224	0.037
10	Sub Total			12.916	15.362	27.250	38.639	18.798

Cost Out of Plant

11	Depreciation			1.125	2.563	0.000	1.979	1.370
12	Financing Cost			1.193	2.717	17.623	2.098	3.078
13	Spare Parts			0.337	0.767	0.000	0.592	0.410
14	Maintenance			0.295	0.671	0.000	0.518	0.359
15	Insurance			0.002	0.005	0.000	0.004	0.003
16	MEW Administration			0.972	2.214	0.000	3.806	1.526
17	Billing Charges			0.684	0.666	0.317	0.798	0.666
20	Sub Total			4.607	9.604	17.940	9.796	7.410

30	Total Cost			17.523	24.966	45.190	48.435	26.208

40	Billed Amount			15.747	13.168	15.119	14.216	15.064

50	Govt. Subsidy			1.777	11.797	30.070	34.219	11.144

3-3-c

Unit Cost at Exported from Power Station, 1997: baiza/KWh

Cost Within Plant

		Ghubrah	Rusayl	Muscat	Wadi Jizzi	Manah	Rural	Total
1	Fuel	6.320	6.979	6.617	7.605	6.512	21.923	9.273
2	Man Power	0.527	0.279	0.415	0.512	1.153	1.616	0.696
3	Spare Parts	0.331	0.251	0.295	0.630	0.430	1.859	0.614
4	Depreciation	1.592	1.190	1.410	1.719	0.000	2.104	1.437
5	Financing Cost	1.691	1.264	1.499	1.826	11.664	2.235	2.625
6	Insurance	0.017	0.011	0.014	0.010	0.000	0.011	0.012
7	Others	0.263	0.189	0.229	0.053	1.772	0.978	0.472
10	Sub Total	10.740	10.163	10.480	12.356	21.531	30.724	15.130

3-3-d

Integral Investment Program (1999 – 2010) : unit RO1000

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
A Interconnection between Muscat and Wadi Jizzi System													
Investment to Gas Turbine													
1 Ghubrah						13,850	13,850					13,850	13,850
2 Rusayl		13,850						13,850			13,850	13,850	13,850
3 Wadi Jizzi		13,320	6,660	13,850							13,850		
4 Barka					37,400		13,850		13,850	13,850			
5 (Manah)			(27,700)										
10 Gas Turbine Total		27,170	6,660	13,850	37,400	13,850	27,700	13,850	13,850	13,850	27,700	27,700	27,700
20 Investment to T/D				7,530									
30 Total (10+20)		27,170	6,660	21,380	37,400	13,850	27,700	13,850	13,850	13,850	27,700	27,700	27,700
40 12 year total	258,810												
B Water Injection													
1 Ghubrah		2,630											
2 Rusayl		2,420											
3 Wadi Jizzi		2,280											
10 Total (1+2+3)		7,330											
40 12 year total	7,330												
C Central Load Dispatching Center													
1 Investment				4,000									
40 12 year total	4,000												
D Battery Energy Storage													
1 Investment													*(2,500) *not included
E Meter Replacement													
1 Investment		200	200	200	200	200							
40 12 year total	1,000												
F Total Investment													
1 Annual Investment		34,700	6,860	25,580	37,600	14,050	27,700	13,850	13,850	13,850	27,700	27,700	27,700
50 12 year total	271,140												

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With Water Injection, Interconnection, CLDC,
Meter Replacement and Tariff Restructuring

Preliminary Income Statement, Northern Oman Electricity Grid (Excluding Manah) in RO1000
(Muscat System + Wadi Jizzi System)

Year	Actual	Actual	0	1	2	3	4	5	6	7	8	9	10	11	12
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy															
1 Generated in GWh	5,395	5,433	6,032	6,416	6,866	7,312	7,728	8,145	8,416	8,778	9,088	9,394	9,694	10,000	10,316
2 Exported in GWh	5,163	5,154	5,743	6,108	6,537	6,961	7,357	7,754	8,055	8,356	8,652	8,943	9,228	9,520	9,820
3 Consumed in GWh	4,327	4,335	4,826	5,133	5,493	5,850	6,182	6,516	6,769	7,022	7,270	7,515	7,755	8,000	8,253
Fixed Cost															
11 O & M	7,899	9,182	8,963	9,028	9,770	9,592	10,099	11,096	11,089	11,288	11,487	11,520	11,424	11,673	11,844
12 Capacity Cost - PS	16,516	16,311	16,907	16,230	18,434	18,248	18,994	21,327	21,620	23,046	23,269	23,484	23,690	25,033	26,322
13 Capacity Cost - T/D	20,055	12,565	12,601	13,192	13,730	13,387	14,233	15,350	15,150	14,771	15,146	15,098	14,721	14,525	14,162
14 Capacity Cost - Meter			0	20	40	58	75	92	86	81	76	71	66	61	56
15 Billing Charges	2,602	2,950	3,237	3,443	3,685	3,924	4,147	4,371	4,540	4,710	4,877	5,041	5,202	5,366	5,536
16 Total	47,072	41,008	41,708	41,914	45,658	45,208	47,549	52,235	52,486	53,896	54,855	55,214	55,102	56,658	57,920
Variable Cost															
21 Fuel	36,275	36,454	40,399	43,200	46,218	45,447	48,021	50,598	52,556	54,511	56,432	58,323	60,178	62,073	64,022
22 Consumables & Others	5,841	4,798	5,731	6,095	6,523	6,947	7,342	7,737	8,038	8,339	8,634	8,924	9,209	9,500	9,800
23 Total	42,116	41,252	46,130	49,296	52,741	52,394	55,362	58,335	60,594	62,850	65,065	67,247	69,386	71,573	73,822
Expenses Total	89,188	82,260	87,838	91,209	98,400	97,602	102,911	110,570	113,080	116,746	119,921	122,461	124,488	128,231	131,742
Revenue															
31 Unit Price, baiza/KWh	15.528	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245
32 Revenue in RO1000	67,190	66,087	73,569	78,253	83,741	89,180	94,251	99,330	103,190	107,050	110,837	114,566	118,223	121,962	125,809
33 Meter Replacement				0	100	200	300	400	500	500	500	500	500	500	500
34 Tariff Restructuring				5,680	6,080	6,474	6,842	7,213	7,491	7,774	8,049	8,319	8,582	8,853	9,134
35 Total Revenue			73,569	83,933	89,921	95,854	101,392	106,943	111,182	115,325	119,386	123,385	127,306	131,314	135,444
Net Income	-21,998	-16,173	-14,269	-7,277	-8,479	-1,749	-1,519	-3,627	-1,899	-1,421	-535	925	2,817	3,083	3,701

Note

1 Energy	Generated: 100%, Exported: 84%, Consumed: 80%
2 O & M	Assets (PS + T/D) x 2%
3 Capacity Cost - PS	Assets x (Loan Repayment 4% + Interest 4.25% + Insurance 0.02% = 8.27%)
4 Capacity Cost - T/D	Assets x (Loan Repayment 2.5% + Interest 2.65% + Insurance 0.02% = 5.17%)
5 Capacity Cost - Meter	Assets x (Loan Repayment 5% + Interest 5.15% + Insurance 0.02% = 10.17%)
6 Billing Gharges	Consumption x 4.4% (Private 5.72%, Government 1.75%, compounded)
7 Fuel	Generation x 6.6bz/KWh(Muscat), 7.1bz/KWh(Wadi Jizzi)
8 Consumables & Others	Generation x 0.95bz/KWh
9 Revenue	Consumption x 15.245bz/KWh (1997 actual)

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Preliminary Income Statement, Northern Oman Electricity Grid (Excluding Manah) in RO1000
(Muscat System + Wadi Jizzi System)

Without Projects

Year	Actual	Actual	0	1	2	3	4	5	6	7	8	9	10	11	12
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Energy															
1 Generated in GW	5,395	5,433	6,032	6,416	6,866	7,312	7,728	8,145	8,461	8,778	9,088	9,394	9,694	10,000	10,316
2 Exported in GW	5,163	5,154	5,743	6,108	6,537	6,961	7,357	7,754	8,055	8,356	8,652	8,943	9,228	9,520	9,820
3 Consumed in GW	4,327	4,335	4,826	5,133	5,493	5,850	6,182	6,516	6,769	7,022	7,270	7,515	7,755	8,000	8,253
Fixed Cost															
11 O & M	7,899	9,182	8,963	8,955	9,476	9,230	9,433	10,477	10,687	10,950	10,804	10,914	10,891	10,936	11,190
12 Capacity Cost - PS	16,516	16,311	16,907	16,230	17,828	17,666	18,059	20,934	22,342	24,244	23,228	23,950	24,642	25,307	27,090
13 Capacity Cost - T/D	20,055	12,565	12,601	13,003	13,351	12,817	13,096	13,996	13,658	13,151	13,407	13,240	12,749	12,450	11,990
14 Billing Charges	2,602	2,950	3,237	3,443	3,685	3,924	4,147	4,371	4,540	4,710	4,877	5,041	5,202	5,366	5,536
15 Total	47,072	41,008	41,708	41,631	44,340	43,637	44,735	49,777	51,228	53,055	52,317	53,145	53,484	54,059	55,806
Variable Cost															
21 Fuel	36,275	36,454	40,399	42,979	45,997	48,987	51,763	54,544	56,665	58,787	60,869	62,918	64,929	66,984	69,100
22 Consumables & Others	5,841	4,798	5,731	6,095	6,523	6,947	7,342	7,737	8,038	8,339	8,634	8,924	9,209	9,500	9,800
23 Total	42,116	41,252	46,130	49,075	52,520	55,934	59,105	62,281	64,703	67,126	69,502	71,842	74,138	76,484	78,900
Expenses Total	89,188	82,260	87,838	90,706	96,860	99,571	103,839	112,059	115,931	120,181	121,819	124,987	127,621	130,543	134,706
Revenue															
31 Unit Price, baiza/KWh	15.528	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245	15.245
32 Revenue in RO1000	67,190	66,087	73,569	78,253	83,741	89,180	94,251	99,330	103,190	107,050	110,837	114,566	118,223	121,962	125,809
Net Income without Project	-21,998	-16,173	-14,269	-12,453	-13,119	-10,391	-9,588	-12,728	-12,740	-13,131	-10,982	-10,420	-9,398	-8,581	-8,897
Net Income with Project	-21,998	-16,173	-14,269	-7,277	-8,479	-1,749	-1,519	-3,627	-1,899	-1,421	-535	925	2,817	3,083	3,701
Difference(With-Without)			0	5,177	4,640	8,642	8,069	9,101	10,842	11,710	10,447	11,345	12,215	11,664	12,598
Accumulation of Difference			0	5,177	9,817	18,459	26,528	35,630	46,471	58,181	68,628	79,973	92,188	103,853	116,451

Note

1 Energy	Generated: 100%, Exported: 84%, Consumed: 80%
2 O & M	Assets (PS + T/D) x 2%
3 Capacity Cost - PS	Assets x (Loan Repayment 4% + Interest 4.25% + Insurance 0.02% = 8.27%)
4 Capacity Cost - T/D	Assets x (Loan Repayment 2.5% + Interest 2.65% + Insurance 0.02% = 5.17%)
5 Billing Gharges	Consumption x 4.4% (Private 5.72%, Government 1.75%, compounded)
6 Fuel	Generation x 6.6bz/KWh(Muscat), 7.1bz/KWh(Wadi Jizzi)
7 Consumables & Others	Generation x 0.95bz/KWh
8 Revenue	Consumption x 15.245bz/KWh (1997 actual)

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Income Statement. Northern Oman Electricity Grid (Excluding Manah) in RO1000
(Muscat System + Wadi Jizzi System + Barka System)

With All Proposed Projects
Case 1: Consumption/Generation 1% Improved from 16%

Year	Actual 1996	Actual 1997	0 1998	1 1999	2 2000	3 2001	4 2002	5 2003	6 2004	7 2005	8 2006	9 2007	10 2008	11 2009	12 2010
Energy															
1 Generated in GWh	5,395	5,433	6,032	6,416	6,866	7,312	7,728	8,145	8,461	8,778	9,088	9,394	9,694	10,000	10,316
1' Revised Generation			5,960	6,339	6,784	7,225	7,635	8,047	8,359	8,672	8,979	9,281	9,577	9,880	10,192
2 Exported . in GWh	5,163	5,154	5,743	6,108	6,537	6,961	7,357	7,754	8,055	8,356	8,652	8,943	9,228	9,520	9,820
3 Consumed in GWh	4,327	4,335	4,826	5,133	5,493	5,850	6,182	6,516	6,769	7,022	7,270	7,515	7,755	8,000	8,253
Fixed Cost															
11 O & M	7,899	9,182	8,963	9,028	9,770	9,592	10,099	11,096	11,089	11,288	11,487	11,520	11,424	11,673	11,844
12 Capacity Cost - PS	16,516	16,311	16,907	16,230	18,434	18,248	18,994	21,327	21,620	23,046	23,269	23,484	23,690	25,033	26,322
13 Capacity Cost - T/D	20,055	12,565	12,601	13,192	13,730	13,387	14,233	15,350	15,150	14,771	15,146	15,098	14,721	14,525	14,162
14 Capacity Cost - Meter			0	20	40	58	75	92	86	81	76	71	66	61	56
15 Billing Charges	2,602	2,950	3,237	3,443	3,685	3,924	4,147	4,371	4,540	4,710	4,877	5,041	5,202	5,366	5,536
16 Total	47,072	41,008	41,708	41,914	45,658	45,208	47,549	52,235	52,486	53,896	54,855	55,214	55,102	56,658	57,920
Variable Cost															
21 Fuel	36,275	36,454	39,914	42,682	45,664	44,902	47,445	49,991	51,926	53,857	55,755	57,623	59,455	61,328	63,254
22 Consumables & Others	5,841	4,798	5,662	6,022	6,445	6,863	7,254	7,644	7,941	8,239	8,530	8,817	9,098	9,386	9,682
23 Total	42,116	41,252	45,576	48,704	52,108	51,765	54,698	57,635	59,867	62,096	64,285	66,440	68,554	70,714	72,936
Expences Total	89,188	82,260	87,285	90,618	97,767	96,974	102,247	109,370	112,353	115,992	119,140	121,654	123,656	127,373	130,856
Revenue															
31 Unit Price, baiza/KWh	15.53	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25	15.25
32 Revenue in RO1000	67,190	66,087	73,569	78,253	83,741	89,180	94,251	99,330	103,190	107,050	110,837	114,566	118,223	121,962	125,809
33 Meter Replacement				0	100	200	300	400	500	500	500	500	500	500	500
34 Tariff Restructuring				5,680	6,080	6,474	6,842	7,213	7,491	7,774	8,049	8,319	8,582	8,853	9,134
35 Total Revenue			73,569	83,933	89,921	95,854	101,392	106,943	111,182	115,325	119,386	123,385	127,306	131,314	135,444
Net Income	-21,998	-16,173	-13,715	-6,685	-7,846	-1,120	-855	-2,927	-1,171	-667	246	1,732	3,650	3,942	4,587

Note

1 Energy	Generated: 100%, Exported: 84%, Consumed: 81%
2 O & M	Assets (PS + T/D) x 2%
3 Capacity Cost - PS	Assets x (Loan Repayment 4% + Interest 4.25% + Insurance 0.02% = 8.27%)
4 Capacity Cost - T/D	Assets x (Loan Repayment 2.5% + Interest 2.65% + Insurance 0.02% = 5.17%)
5 Capacity Cost - Meter	Assets x (Loan Repayment 5% + Interest 5.15% + Insurance 0.02% = 10.17%)
6 Billing Charges	Consumption x 4.4% (Private 5.72%, Government 1.75%, compounded)
7 Fuel	Generation x 6.6bz/KWh(Muscat), 7.1bz/KWh(Wadi Jizzi), Compounded 6.7bz/KWh
8 Consumables & Others	Generation x 0.95bz/KWh
9 Revenue	Consumption x 15.245bz/KWh (1997 actual)

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Income Statement, Northern Oman Electricity Grid (Excluding Manah) in RO1000
(Muscat System + Wadi Jizzi System + Barka System)

With All Proposed Projects
Case 2: Revenue 5% Increased

Year	Actual 1996	Actual 1997	0 1998	1 1999	2 2000	3 2001	4 2002	5 2003	6 2004	7 2005	8 2006	9 2007	10 2008	11 2009	12 2010
Energy															
1 Generated in GWh	5,395	5,433	6,032	6,416	6,866	7,312	7,728	8,145	8,461	8,778	9,088	9,394	9,694	10,000	10,316
2 Exported in GWh	5,163	5,154	5,743	6,108	6,537	6,961	7,357	7,754	8,055	8,356	8,652	8,943	9,228	9,520	9,820
3 Consumed in GWh	4,327	4,335	4,826	5,133	5,493	5,850	6,182	6,516	6,769	7,022	7,270	7,515	7,755	8,000	8,253
Fixed Cost															
11 O & M	7,899	9,182	8,963	9,028	9,770	9,592	10,099	11,096	11,089	11,288	11,487	11,520	11,424	11,673	11,344
12 Capacity Cost – PS	16,516	16,311	16,907	16,230	18,434	18,248	18,994	21,327	21,620	23,046	23,269	23,484	23,690	25,033	26,322
13 Capacity Cost – T/D	20,055	12,565	12,601	13,192	13,730	13,387	14,233	15,350	15,150	14,771	15,146	15,098	14,721	14,525	14,162
14 Capacity Cost – Meter			0	20	40	58	75	92	86	81	76	71	66	61	56
15 Billing Charges	2,602	2,950	3,397	3,443	3,685	3,924	4,147	4,371	4,540	4,710	4,877	5,041	5,202	5,366	5,536
16 Total	47,072	41,008	41,708	41,914	45,658	45,208	47,549	52,235	52,486	53,896	54,855	55,214	55,102	56,658	57,920
Variable Cost															
21 Fuel	36,275	36,454	40,399	43,200	46,218	45,447	48,021	50,598	52,556	54,511	56,432	58,323	60,178	62,073	64,022
22 Consumables & Others	5,841	4,798	5,731	6,095	6,523	6,947	7,342	7,737	8,038	8,339	8,634	8,924	9,209	9,500	9,800
23 Total	42,116	41,252	46,130	49,296	52,741	52,394	55,362	58,335	60,594	62,850	65,065	67,247	69,386	71,573	73,822
Expenses Total	89,188	82,260	87,838	91,209	98,400	97,602	102,911	110,570	113,080	116,746	119,921	122,461	124,489	128,231	131,742
Revenue															
31 Unit Price, baiza/KWh	15.53	15.25	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
32 Revenue in RO1000	67,190	66,087	77,213	82,128	87,888	93,597	98,918	104,250	108,301	112,352	116,326	120,240	124,078	128,002	132,040
33 Meter Replacement				0	100	200	300	400	500	500	500	500	500	500	500
34 Tariff Restructuring				5,680	6,080	6,474	6,842	7,213	7,491	7,774	8,049	8,319	8,582	8,853	9,134
35 Total Revenue			77,213	87,808	94,068	100,270	106,060	111,862	116,292	120,626	124,875	129,059	133,161	137,354	141,674
Net Income	-21,998	-16,173	-10,625	-3,401	-4,332	2,668	3,149	1,292	3,212	3,880	4,955	6,598	8,672	9,123	9,932

Note

1 Energy	Generated: 100%, Exported: 84%, Consumed: 80%
2 O & M	Assets (PS + T/D) x 2%
3 Capacity Cost – PS	Assets x (Loan Repayment 4% + Interest 4.25% + Insurance 0.02% = 8.27%)
4 Capacity Cost – T/D	Assets x (Loan Repayment 2.5% + Interest 2.65% + Insurance 0.02% = 5.17%)
5 Capacity Cost – Meter	Assets x (Loan Repayment 5% + Interest 5.15% + Insurance 0.02% = 10.17%)
6 Billing Charges	Consumption x 4.4% (Private 5.72%, Government 1.75%, compounded)
7 Fuel	Generation x 6.6bz/KWh(Muscat), 7.1bz/KWh(Wadi Jizzi)
8 Consumables & Others	Generation x 0.95bz/KWh
9 Revenue	Consumption x 16.00bz/KWh (1997 actual x 1.05)

3-3-i

Cash Flow Analysis – Interconnection between Muscat System and Wadi Jizzi System

RO1000

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
Interconnection	NPV																					
1 GT – Build (MW)		154.1	30	94.1	94.1	94.1	188.2	94.1	94.1	94.1	188.2	188.2	188.2	188.2	188.2	188.2	94.1	94.1	94.1	94.1	188.2	
2 Investment	154,952	27,170	6,660	13,850	37,400	13,850	27,700	13,850	13,850	13,850	27,700	27,700	27,700	27,700	27,700	27,700	13,850	13,850	13,850	13,850	27,700	-242,816
Residual Value of 2 in 2019		5,434	1,598	3,878	11,968	4,986	11,080	6,094	6,648	7,202	15,512	16,620	17,728	18,836	19,944	21,052	11,080	11,634	12,188	12,742	26,592	
3 Transmission Line				5,830																		
4 Grid SS				1,700																		
5 Total (3+4)	5,155	0	0	7,530	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4,142
6 Investment Total	160,107	27,170	6,660	21,380	37,400	13,850	27,700	13,850	13,850	13,850	27,700	27,700	27,700	27,700	27,700	27,700	13,850	13,850	13,850	13,850	27,700	-246,958
Without Interconnection																						
11 GT – Build (MW)		154.1	30	94.1	124.1	188.2	218.2	0	124.1	124.1	124.1	218.2	218.2	154.1	282.3	282.3	0	188.2	94.1	0	188.2	
12 Investment	175,392	27,170	6,660	13,850	44,060	27,700	34,360	0	20,510	20,510	20,510	34,360	34,360	27,170	41,550	41,550	0	27,700	13,850	0	27,700	-265,345
Residual Value of 12 in 2019		5,434	1,598	3,878	14,099	9,972	13,744	0	9,845	10,665	11,486	20,616	21,990	18,476	29,916	31,578	0	23,268	12,188	0	26,592	
Net Cash Flow																						
21 Investment Saving(12-6)	15,285	0	0	-7,530	6,660	13,850	6,660	-13,850	6,660	6,660	-7,190	6,660	6,660	-530	13,850	13,850	-13,850	13,850	0	-13,850	0	-18,387
22 Fuel Saving	15,537	0	0	1,492	1,558	1,625	1,691	1,761	1,826	1,891	1,956	2,022	2,093	2,162	2,233	2,307	2,383	2,462	2,543	2,627	2,714	
23 Total (21+22)	30,822	0	0	-6,038	8,218	15,475	8,351	-12,089	8,486	8,551	-5,234	8,682	8,753	1,632	16,083	16,157	-11,467	16,312	2,543	-11,223	2,714	

3-3-j

Cash Flow Analysis – Central Load Dispatching Center

RO1000

No	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
		NPV																					
1 Investment		2,953	0	0	4,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,120
Benefit																							
2 Fuel Saving		23,867	0	0	2,289	2,405	2,542	2,639	2,736	2,832	2,925	3,016	3,110	3,206	3,305	3,408	3,514	3,622	3,735	3,851	3,970	4,093	
Net Cash Flow																							
3 Benefit – Investment		20,914																					

3-3-k

RO1000

Cash Flow Analysis - Water Injection Project-Ghubrah

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
Water Injection	NPV																					
1 Water Injection, Ghubrah	2,331	2,630	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-526
2 Fuel	5,576	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	568	
3 Water	215	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	
4 Project Cash Flow Total	8,121	3,220	590	590	590	590	590	590	590	590	590	590	590	590	590	590	590	590	590	590	590	-526
GT Addition																						
5 Investment w/o Project	5,902	6,660	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,332
6 Fuel	5,297	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	
7 Project Cash Flow Total	11,199	7,200	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	540	-1,332
Net Cash Flow (7-4)	3,078	3,980	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50	-806

Note

1 Depreciation of Gas Turbine	25 years
2 LHV of Gas	8,900Kcal/CuM
3 Investment of GT	Frame6

3-3-1

Cash Flow Analysis – Water Injection Project-Rusayl

RO1000

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
Water Injection	**NPV**																					
1 Water Injection, Rusayl	2,145	2,420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-484
2 Fuel	11,990	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	1,221	
3 Water	599	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	
4 Project Cash Flow Total	14,733	3,702	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	1,282	-484
GT Addition																						
5 Investment w/o Project	12,274	13,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2,770
6 Fuel	11,322	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	
7 Project Cash Flow Total	23,596	15,003	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	1,153	-2,770
Net Cash Flow (7-4)	8,863	11,301	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-129	-2,286

Note

1 Depreciation of Gas Turbine	25 years
2 LHV of Gas	8,900Kcal/CuM
3 Investment of GT	Frame9

3-3-m

RO1000

Cash Flow Analysis – Water Injection Project–Wadi Jizzi

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
Water Injection	NPV																					
1 Water Injection, Wadi Jiz:	2,021	2,280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-456
2 Fuel	5,475	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	558	
3 Water	200	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
4 Project Cash Flow Total	7,695	2,858	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	-456
GT Addition																						
5 Investment w/o Project	5,902	6,660	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1,332
6 Fuel	5,260	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	
7 Project Cash Flow Total	11,162	7,196	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	536	-1,332
Net Cash Flow (7–4)	3,466	4,338	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-42	-876

Note

1 Depreciation of Gas Turbine	25 years
2 LHV of Gas	8,900Kcal/CuM
3 Investment of GT	Frame6

3-3-n

Cash Flow Analysis – Inlet Air Cooling–Rusayl

RO1000

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
Inlet Air Cooling	NPV																					
1 Inlet Air Cooling, Rusayl	9,004	10,160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2,032
2 Chiller Power	1,041	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	
3 Project Cash Flow Total	10,044	10,266	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	-2,032
GT Addition																						
4 Investment w/o Project	12,274	13,850	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2,770
5 Extra Fuel	481	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	
6 Project Cash Flow Total	12,755	13,899	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	-2,770
Net Cash Flow (6–3)	2,710	3,633	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-57	-738

Note

1 Depreciation of Gas Turbine	25 years
2 LHV of Gas	8,900Kcal/CuM (Until 19: 9,550Kcal/CuM
3 Investment of GT: Frame 9	13,850

3-3-o

RO1000

Cash Flow Analysis - Pumped Storage Plant

No	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
1 Investment - Civil Work	83,080																					-48,186
2 - Plant	27,700																					-4,432
3 - Transmission	1,220																					-580
4 - Overhaul of Plant								3,048								3,048						-762
5 Total (1 to 4)	112,000							3,048								3,048						-53,960
6 O & M Cost		3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	
7 Pumping Energy Cost		484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	484	
8 Total Cost	112,000	3,844	3,844	3,844	3,844	3,844	3,844	6,892	3,844	3,844	3,844	3,844	3,844	3,844	3,844	6,892	3,844	3,844	3,844	3,844	3,844	-53,950
9 Net Present Value	141,761																					

Without Pumped Storage Plant

No Investment	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Residual
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
1 GT-107,340kW	17,200																					-2,752
2 O & M Cost		516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	516	
3 Fuel Cost		225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	
4 Total Benefit	17,200	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	741	-2,752
5 Net Present Value	23,929																					
Benefit - Cost (NPV)	-117,832																					
Benefit / Cost	0.169																					

3-3-p

Cash Flow Analysis – Battery Energy Storage System

RO1000

No	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Residual
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Value
	Project Cash Outflow																						
1	Investment - Battery	11,000										11,000										11000	-9,900
2	Investment – Add. Facilities	25,600																					
3	Investment Total	36,600	0	0	0	0	0	0	0	0	0	11,000	0	0	0	0	0	0	0	0	0	11,000	-9,900
4	O&M		366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	366	
5	Cash Outflow Total	36,600	366	366	366	366	366	366	366	366	366	11,366	366	366	366	366	366	366	366	366	366	11,366	-9,900
	Project Cash Inflow																						
6	Investment Saving	13,850																					-2,216
7	O&M Saving		416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	416	
8	Fuel Saving		1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	
9	Cash Inflow Total	13,850	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	1,916	-2,216
10	Net Cash Flow (9–5)	-22,750	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	1,550	-9,451	1,550	1,550	1,550	1,550	1,550	1,560	1,550	1,550	1,550	-9,451	7,684
#	Net present Value	-13,465																					

Note

1 Life of Battery	10 years
2 Life of Additional Facilities	20 years
3 O & M (BES)	Investment x 1%
4 O & M (GT)	Investment x 3%

3-3-q

Cash Flow Analysis – Gas Cooling System – Royal Hospital

1. Gas Co-Generation

No		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
	Project Cash Outflow	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	Gas Co-Generation	1,860,000															
2	O&M		55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800	55,800
3	Natural Gas		146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880	146,880
4	Water		70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560	70,560
5	Cash Outflow Total	1,860,000	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240	273,240
	Project Cash Inflow																
6	Saved Electricity		720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000
7	Saved Fuel Oil		48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000
8	Cash Inflow Total		768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000	768,000
9	Net Cash Flow (8-5)	-1,860,000	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760	494,760
10	Net present Value	2,374,888															

2. Steam Absorption Chiller

No		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
	Project Cash Outflow	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	Steam Absorption	1,212,000															
2	O&M		36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000	36,000
3	Natural Gas		167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400	167,400
4	Water		169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320
5	Cash Outflow Total	1,212,000	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720	372,720
	Project Cash Inflow																
6	Saved Electricity		568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080
7	Saved Fuel Oil		48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000	48,000
8	Cash Inflow Total		616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080	616,080
9	Net Cash Flow (8-5)	-1,212,000	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360	243,360
10	Net present Value	871,035															

3. Gas-Fired Absorption Chiller

No		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
	Project Cash Outflow	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	Gas-Fired Absorption	1,174,000															
2	O&M		35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220	35,220
3	Natural Gas		126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960	126,960
4	Water		169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320	169,320
5	Cash Outflow Total	1,174,000	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500	331,500
	Project Cash Inflow																
6	Saved Electricity		568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080
7	Saved Fuel Oil		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Cash Inflow Total		568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080	568,080
9	Net Cash Flow (8-5)	-1,174,000	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580	236,580
10	Net present Value	851,001															

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Cash Flow Analysis – Gas Cooling System – Al Falaj Hotel

1. Steam Absorption Chiller

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Project Cash Outflow	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1 Steam Absorption Chiller	164,800															
2 O&M		4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940	4,940
3 Natural Gas		17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640	17,640
4 Water		10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560	10,560
5 Cash Outflow Total	164,800	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140	33,140
Project Cash Inflow																
6 Saved Electricity		61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800	61,800
7 Saved Fuel Oil		13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440	13,440
8 Cash Inflow Total		75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240	75,240
9 Net Cash Flow (8-5)	-164,800	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100	42,100
10 Net present Value	195,554															

2. GHP Chiller

No	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Project Cash Outflow	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1 GHP Chiller	258,270															
2 O&M		7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750	7,750
3 Natural Gas		13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040	13,040
4 Water		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5 Cash Outflow Total	258,270	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790	20,790
Project Cash Inflow																
6 Saved Electricity		63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840
7 Saved Fuel Oil		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8 Cash Inflow Total		63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840	63,840
9 Net Cash Flow (8-5)	-258,270	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050	43,050
10 Net present Value	110,216															

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RO1000

Cash Flow Analysis–Ice Thermal Storage–Peak Cut Operation

No	Year 0 1998	Year 1 1999	Year 2 2000	Year 3 2001	Year 4 2002	Year 5 2003	Year 6 2004	Year 7 2005	Year 8 2006	Year 9 2007	Year 10 2008	Year 11 2009	Year 12 2010	Year 13 2011	Year 14 2012	Year 15 2013
Royal Hospital																
Case 1: Investment Program – Ice Thermal System																
Investment																
1 Ice Thermal System	310,000															
2 Grant	-118,400															
3 Investment Total	191,600															
4 O&M		2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480
5 Electricity		9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810	9,810
6 Total Cash Outflow	191,600	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290	12,290
7 Net Present Value	295,796															
Case 2: Investment Program – Without Ice Thermal System																
Investment																
1 Conventional A/C	194,000															
2 O&M		1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940
3 Electricity		7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020	7,020
4 Total Cash Outflow	194,000	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960	8,960
5 Net Present Value	270,693															
Benefit – Cost (NPV)	-26,103															
Benefit / Cost	0.912															
MCS																
Case 1: Investment Program – Ice Thermal System																
Investment																
1 Ice Thermal System	267,000															
2 Grant	-98,240															
3 Investment Total	168,760															
4 O&M		2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320	2,320
5 Electricity		8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424	8,424
6 Total Cash Outflow	168,760	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744	10,744
7 Net Present Value	260,723															
Case 2: Investment Program – Without Ice Thermal System																
Investment																
1 Conventional A/C	170,000															
2 O&M		1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
3 Electricity		5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850	5,850
4 Total Cash Outflow	170,000	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550	7,550
5 Net Present Value	234,624															
Benefit – Cost (NPV)	-26,099															
Benefit / Cost	0.900															
Al Falaj Hotel																
Case 1: Investment Program – Ice Thermal System																
Investment																
1 Ice Thermal System	107,000															
2 Grant	-34,400															
3 Investment Total	72,600															
4 O&M		856	856	856	856	856	856	856	856	856	856	856	856	856	856	856
5 Electricity		1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890	1,890
6 Total Cash Outflow	72,600	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746	2,746
7 Net Present Value	96,104															
Case 2: Investment Program – Without Ice Thermal System																
Investment																
1 Conventional A/C	69,000															
2 O&M		690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
3 Electricity		1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
4 Total Cash Outflow	69,000	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070	2,070
5 Net Present Value	86,718															
Benefit – Cost (NPV)	-9,386															
Benefit / Cost	9,907															

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RO1000

Cash Flow Analysis-Ice Thermal Storage-TOU Tariff

Case 1: With Project - Royal Hospital

No	Year 0 1998	Year 1 1999	Year 2 2000	Year 3 2001	Year 4 2002	Year 5 2003	Year 6 2004	Year 7 2005	Year 8 2006	Year 9 2007	Year 10 2008	Year 11 2009	Year 12 2010	Year 13 2011	Year 14 2012	Year 15 2013
1 Ice Thermal System	274,000															
2 O&M		2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190	2,190
3 Electricity		34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740	34,740
4 Total Cash Outflow	274,000	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930	36,930
5 Net Present Value	590,102															
Without Project																
1 Conventional A/C	194,000															
2 O&M		1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940
3 Electricity		42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120	42,120
4 Total Cash Outflow	194,000	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060	44,060
5 Net Present Value	571,131															
Benefit - Cost (NPV)	-16,971															
Benefit / Cost	0.968															

Case 2: With Project - MCS

No	Year 0 1998	Year 1 1999	Year 2 2000	Year 3 2001	Year 4 2002	Year 5 2003	Year 6 2004	Year 7 2005	Year 8 2006	Year 9 2007	Year 10 2008	Year 11 2009	Year 12 2010	Year 13 2011	Year 14 2012	Year 15 2013
1 Ice Thermal System	234,000															
2 O&M		1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870	1,870
3 Electricity		31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590	31,590
4 Total Cash Outflow	234,000	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460	33,460
5 Net Present Value	520,400															
Without Project																
1 Conventional A/C	170,000															
2 O&M		1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
3 Electricity		35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100	35,100
4 Total Cash Outflow	170,000	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800	36,800
5 Net Present Value	484,989															
Benefit - Cost (NPV)	-35,411															
Benefit / Cost	0.932															

Case 3: With Project - AL FALAJ HOTEL

No	Year 0 1998	Year 1 1999	Year 2 2000	Year 3 2001	Year 4 2002	Year 5 2003	Year 6 2004	Year 7 2005	Year 8 2006	Year 9 2007	Year 10 2008	Year 11 2009	Year 12 2010	Year 13 2011	Year 14 2012	Year 15 2013
1 Ice Thermal System	95,000															
2 O&M		760	760	760	760	760	760	760	760	760	760	760	760	760	760	760
3 Electricity		7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690	7,690
4 Total Cash Outflow	95,000	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450
5 Net Present Value	167,328															
Without Project																
1 Conventional A/C	69,000															
2 O&M		690	690	690	690	690	690	690	690	690	690	690	690	690	690	690
3 Electricity		8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280	8,280
4 Total Cash Outflow	69,000	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970	8,970
5 Net Present Value	145,779															
Benefit - Cost (NPV)	-21,549															
Benefit / Cost	0.871															

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Cash Flow Analysis – Solar Energy System (1kW)

Unit: RO

No Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Solar System																					
1 Investment – Solar	2,980																				
2 O&M		29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8	29.8
3 Electricity Saving		49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9
4 Net Cash Flow	-2,980	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1	20.1
5 Net present Value	-2,577																				

Note

1 Life of Solar System	20 years
2 O & M (Solar)	Investment x 1%
3 Electricity Tariff	30 Bz/kWh

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Cash Flow Analysis – Meter Replacement

Unit:1000 RO

No	Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		NPV	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	Investment	799	200	200	200	200	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	Revenue Increase	3,650	0	100	200	300	400	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
3	Benefit – Investment	2,851	-200	-100	0	100	200	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500

Note

1 Life of Meter 10 years