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STATE OF BAHRAIN
MINISTRY OF WORKS, POWER
AND WATER
ELECTRICITY DIRECTORATE



دولة البحرين
وزارة الأشغال والكهرباء والماء
إدارة الكهرباء

MINISTRY OF WORKS,
POWER & WATER
ELECTRICITY DIRECTORATE
ANNUAL REPORT 1987

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CENTRE FOR ARAB GULF STUDIES

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MINISTRY OF WORKS,
POWER & WATER

ELECTRICITY DIRECTORATE

ANNUAL REPORT 1987

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FOREWORD

The Directorate's work load in 1987 continued at a high level, although in comparison with earlier years the pace was perhaps a little easier. The last of the new plant completed in 1985 was taken over at the end of guarantee, and assimilated into Station maintenance programmes; all distillation plant was fully loaded for most of the year, supplying some 70% of Bahrain's desalinated water; transmission and distribution facilities were expanded to meet the increased demand; street lighting expansion continued at a high level both in existing districts and in new areas.

This continuing high workload has been sustained by the Directorate in the face of increasing budget restrictions and overtime constraints, and with a substantially higher level of Bahraini staff. Thanks are due to all concerned for their efforts throughout the year.

Although the Directorate has adequate production facilities for the next few years, the load growth continues. Peak load was up by 7%, energy supplied rose by 4% and the number of consumers rose by 4%. Thus, whilst working to meet this steady increase we must at the same time plan for the future. The predicted population increases and known new housing programmes will combine to ensure that these increases will be sustained for several years to come.

A major element of our planning during the year was the update of the Power & Water Feasibility Study, and this was substantially completed by year end. The plan envisages the addition of 500MW of generating plant between 1991 and 1996, and a doubling of desalination capacity to over 70 million GPD during the same period. All of the new generation facilities and a large part of the new desalination plant will be established at a new site south of Hidd.

Transmission facilities must also expand in order to handle the output from the new Station, and planning for this work has also largely been

completed. With such substantial increases in plant to be operated and maintained, Directorate strength is likely to grow by 25% or more during the period. It will be a major challenge to maintain our impetus towards full Bahrainisation whilst at the same time assimilating all the new plant into the system.

In summary, the work programme over the next ten years promises to be even more extensive and demanding than that completed in the last ten years. However, with the continued and unflinching support of His Excellency The Minister and the Assistant Under Secretary, the Electricity Directorate is ready to match the achievements of the last decade in the next.



Abdulla Juma
Director of Electricity

SUMMARY

1986 Key Facts

System Peak Demand	672 MW on 15th August at 1430hrs
Total Energy Supplied	2956 GWh
Total Water Production	29800 M ³ x 10 ³ (7567 MIG)
Number of Consumers	120200
Maximum Dependable Capacity - Power	991 MW
Maximum Dependable Capacity - Water	114 M ³ x 10 ³ /day (25 MIGPD)

The very large increases in demand which have been sustained over the last few years continued in 1987, and are forecast to continue for several years to come. As a consequence, although generating reserves are still adequate, the Directorate is already heavily involved in planning for future expansion. The number of consumers increased by 4.3%, a little less than in previous years, and the per capita consumption remained steady. Maximum demand at 672MW was up 7% on the 1986 level of 627MW and the 2,956 million units of energy supplied was 4% up on the 1986 level of 2,848 million units. In marked comparison to previous years the water production of 28.9 million cubic metres decreased by 16% as compared to the 34.4 million cubic metres produced in 1986. This was largely attributable to loss of production capacity consequent on end of guarantee inspections.

Net electrical efficiency remained unchanged at 29%, and it is unlikely that the substantial efficiency improvements of recent years will be repeated in the future until the advent of new plant. One consequence of the higher loads now prevailing is that older and less efficient plant is being used more often, thus restricting overall system efficiency.

Although final 1987 accounts are still in preparation, interim returns indicate that we have again achieved a small reduction in the cost of generating and distributing power, from 15.54 fils/kWh in 1986 to 15.08 fils/kWh in 1987. This is particularly pleasing as forecasts had indicated that unit costs were levelling out.

The consumption pattern remained almost unchanged from 1986, with industrial usage continuing at 7% of the total and commercial consumption at 32%, up slightly from 31% in 1986. However the market still remains predominantly domestic and 60% of demand was in this area, down slightly from 63% in 1986. Agriculture continues to account for less than 1% of the total market.

Production Department

Although not involved in the commissioning of new plant, nevertheless the Department have been heavily involved with guarantee work, particularly at Sitra. Major problems with the new distillers have presented the Station with a great deal of extra shutdown work. The new plant at Rifaa, which has much higher efficiency than our older gas turbines, has been used to cover all the increase in energy consumption. Thus major overhaul requirements at the Station remain at a very high level.

Sitra Power & Water Station is now predominantly concerned with water production, supplying two thirds of the desalinated water produced in 1987. Manama Power Station continues to supply a small but steady part of the generation, mainly from the base-loaded John Brown sets. The remaining operating life of the 'B' & 'C' sets is reserved for the early nineties. Rifaa Power Station supplies the bulk of the load, particularly in summer, with the more efficient BBC sets being loaded up as much as system security constraints will allow. System Operations developments during the year were concerned with improving their overall performance, particularly success being achieved in the programming area, where the bulk of development of the SCADA system is now handled in-house.

Distribution Department

The Transmission development programme continued, with six new 220kV installations being taken over during the year. The 220kV transmission system is now well established as the backbone of the island supply, although the 66kV system continues to play a very important role.

The consumer base continued to rise, although the 4% increase in the year is somewhat less than the 6% average annual increase established in previous years. Thus the distribution extension work is still of high priority. The extensive capital works programme continued throughout the year, with nearly 900 new connections being made at Madinat Hamad alone. Overall work connected with Ministry of Housing projects doubled in the year.

Street lighting networks again increased substantially during the year, with the 10% growth rate of previous years being maintained.

The number of LV faults dropped substantially during the year, but customer calls increased significantly. This would seem to indicate a shift in the type of failure from the distribution system to the customer installation. Many existing installations are marginal, but it is anticipated that overall standards will rise as the effects of the new Wiring Regulations filter through. These were introduced in 1986, and were in effect for all new installations in 1987.

Projects & Development Department

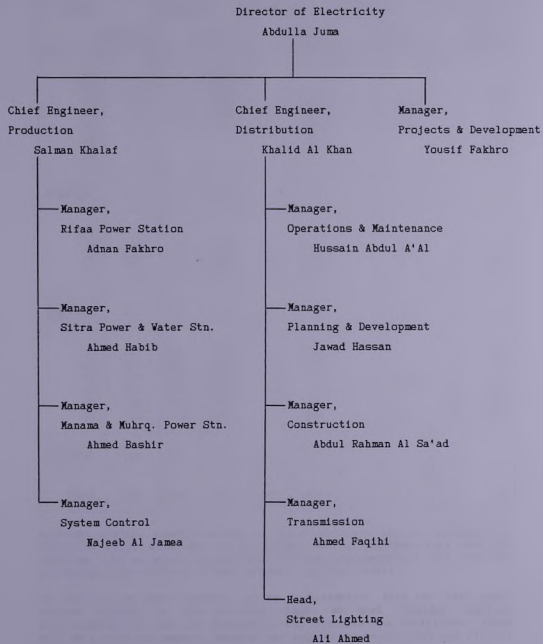
Although there are no individual major projects in progress the Departmental work load remains high, as most of the main contracts still have guarantee work pending, and transmission system expansion continues. During the year studies commenced on the 1987-1996 generation programme.

Both the Generation and Desalination sections were fully involved during the year with the resolution of problems or the completion of smaller jobs associated with past main contracts.

A substantial number of small and large Transmission projects are still in hand as work continues on the expansion of both the 66kV and the 220kV transmission systems. Parallel work also continues on the corresponding extensions to the SCADA system.

Civil section work expanded during the year with a number of medium projects being handled in-house. In addition to work funded from Major projects, the section now handle much of the civil work under the Minor Capital budget.

STAFF ORGANISATION



MANPOWER SUMMARY

GRADE	BAHRAINI		NON-BAH		CONTRACT		VACANCIES		
	APPROVED	PERCENT	PERCENT	PERCENT	PERCENT	PERCENT	PERCENT	PERCENT	
P8	2	2	100%					2	20%
P7	10	8	80%					2	11%
P6	18	8	44%	7	39%	1	6%	2	9%
P5	43	16	37%	21	49%	2	5%	4	11%
P4	91	34	37%	43	47%	4	4%	10	75%
P3	8			2	25%			6	100%
P2	2							2	
SUBTOTAL	174	68	39%	73	42%	7	4%	26	15%
G10	0	1						-1	
G9	96	24	25%	61	64%	7	7%	4	4%
G8	135	74	55%	32	24%	3	2%	26	19%
G7	182	95	52%	68	37%			19	10%
SUBTOTAL	413	194	47%	161	39%	10	2%	48	12%
G6	301	191	63%	38	13%			72	24%
G5	354	303	86%	45	13%			6	2%
G4	124	107	94%	9	7%	4	3%	4	3%
G3	177	196	111%	12	7%	17	10%	-48	-27%
G2	138	104	75%	5	4%			29	21%
G1	12	19	158%	3	25%	50	416%	-60	-500%
SUBTOTAL	1106	920	83%	112	10%	71	6%	3	
TOTAL	1693	1182	70%	346	20%	88	5%	77	5%

Although overall Bahrainisation in the Directorate has now reached 70%, there is still some way to go before we can achieve full national staffing, and we still require over 100 new engineers and well over 200 new technicians/fitters to meet present approved levels.

In addition we must consider future requirements. With our next power station already in the planning stage, we must consider staffing requirements for the new generation and distribution facilities. There will be a need for several hundred new engineers, technicians and fitters over and above present training commitments.

MONTHLY SUMMARY SHEET

MONTH	UNITS GENERATED GVH	MAXIMUM DEMAND MW	MINIMUM DEMAND MW	LOAD FACTOR %	NUMBER OF CONSUMERS
JANUARY	141.4	271	127	70.1	114585
FEBRUARY	131.3	268	142	72.7	114993
MARCH	150.6	283	145	71.5	115322
APRIL	181.8	419	148	60.3	115687
MAY	313.0	587	250	71.6	116004
JUNE	334.9	631	312	73.7	116424
JULY	383.8	667	370	77.1	116860
AUGUST	387.2	672	333	77.4	117274
SEPTEMBER	344.7	613	338	78.1	117726
OCTOBER	293.3	589	240	66.9	118120
NOVEMBER	176.7	434	159	56.5	118584
DECEMBER	157.2	297	151	71.1	119026
YEAR	2996.1	672	127	50.9	119026

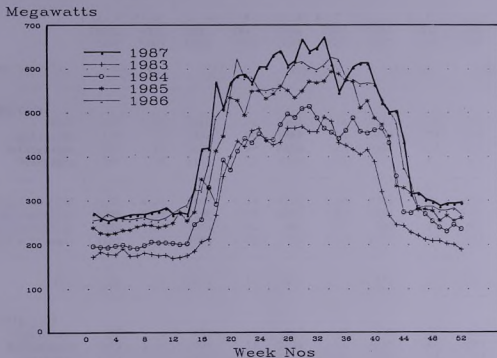
The table illustrates a consumption pattern typical of recent years, with a very sharp load increase in May, to a level which is sustained throughout the summer. Loads then drop almost as sharply back to winter levels in October. Also of note is the steady increase in the number of consumers, reflecting the continued Distribution programme, with over 100 new connections being made every week.

ANNUAL PEAK COMPARISON

YEAR	1980	1981	1982	1983	1984	1985	1986	1987
WEEK	29	32	29	33	31	34	34	33
DAY	THU	MON	TUE	MON	TUE	WED	TUE	SAT
DATE	24/7	10/8	20/7	15/8	31/7	28/8	26/8	15/8
TIME	1400	2200	1400	2200	2300	2300	1400	1430
TEMP °C		33.9	39.0	34.8	34.7	33.5	37.3	36.6
REL. HUM %		91	40	71	83	83	58	70
PEAK MW	375	414	441	490	514	594	627	672
% INC	22.5	10.4	6.8	11.1	4.9	15.6	5.6	7.2
MIN MW	279	281	308	318	339	426	446	474
% INC		0.7	9.6	3.2	6.6	25.7	4.5	6.3

The table above summarises the timing and conditions of the annual peak load for the last eight years. It is of interest that at the time of peak load the temperature is not as high as one might expect, and the humidity is often not excessive. Normally the daily load profile shows an afternoon and an evening peak which are roughly equal, and it seems a matter of chance as to which is the higher. There is normally no strong weekly pattern to the peaks, but Monday & Tuesday do seem particularly favoured.

WEEKLY DEMANDS



The curves of weekly demands above cover the last five years of operation, and illustrate the sustained high growth in system demand over this period.

Of note also is the change in duration of the peak, as the 'shoulder' periods extend further into the spring and autumn each year. The effect of this is to significantly reduce the opportunity for maintenance work during the low load period, whilst at the same time the increased running consequent on the higher loads increases the maintenance requirement. This places severe restraints on our maintenance organisation, as it means that the bulk of our plant overhauls must be completed within an 18 week period.

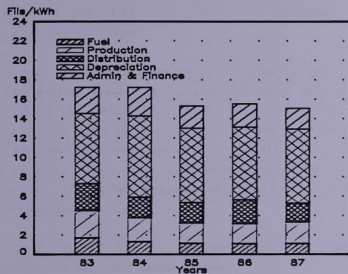
ELECTRICITY UNIT COSTS

	1 9 8 3		1 9 8 4		1 9 8 5		1 9 8 6		1 9 8 7	
	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST	TOTAL COST	UNIT COST
UNITS SUPPLIED	1952 GWH		2142 GWH		2595 GWH		2848 GWH		2956 GWH	
PRODUCTION										
Fuel	3341	1.71	2815	1.31	2953	1.14	3113	1.09	3262	1.10
Operations	1428	.73	1462	.68	1569	.60	1683	.59	1828	.62
Maintenance	2323	1.19	2073	.97	2189	.83	2394	.84	3149	1.07
Overheads	1249	.64	1117	.52	1015	.39	1171	.41	964	.33
PRODUCTION COST										
Depreciation	8341	4.26	7467	3.49	7726	2.98	8361	2.94	9203	3.11
System Control	6205	3.17	8196	3.83	9375	3.61	9361	3.29	9163	3.10
Admin & Finance	550	.28	674	.31	690	.27	690	.24	680	.23
Admin & Finance	1980	1.01	2564	1.20	2370	.91	2757	.97	2448	.83
TOTAL	17076	8.71	18901	8.82	20161	7.77	21169	7.43	21494	7.27
DISTRIBUTION										
Operations	175	.09	201	.09	177	.07	198	.07	200	.07
Maintenance	2699	1.38	2522	1.18	2799	1.08	4055	1.42	3689	1.25
Overheads	1979	1.01	1114	.52	1772	.68	2104	.74	1170	.40
DISTRIBUTION COST										
Depreciation	4853	2.48	3837	1.79	4748	1.83	6357	2.23	5059	1.71
System Control	7907	4.03	9772	4.56	10574	4.07	12003	4.22	13453	4.55
Admin & Finance	551	.28	674	.31	690	.27	689	.24	680	.23
Admin & Finance	3256	1.66	3697	1.73	3534	1.36	4042	1.42	3880	1.31
TOTAL	16567	8.45	17980	8.39	19546	7.53	23096	8.11	23072	7.81
DEPARTMENTAL BREAKDOWN										
Fuel	3341	1.70	2815	1.31	2953	1.14	3113	1.09	3262	1.10
Production	5000	2.55	4652	2.17	4773	1.84	5248	1.84	5941	2.01
Distribution	4853	2.48	3837	1.79	4748	1.83	6357	2.23	5059	1.71
PROD & DIST COST										
Depreciation	13194	6.73	11304	5.28	12474	4.81	14718	5.16	14262	4.82
System Control	14112	7.20	17968	8.39	19949	7.69	21369	7.50	22616	7.65
Admin & Finance	1101	.56	1348	.63	1380	.53	1379	.48	1360	.46
Admin & Finance	5236	2.67	6261	2.92	5904	2.28	6799	2.39	6328	2.14
TOTAL	33643	17.16	36881	17.22	39707	15.30	44265	15.54	44566	15.08

NOTES 1) 1983 fuel costs include a notional cost of 3.03 fils/Mm³ = BD 3,333,000
 2) TOTAL COSTS in BD 000's & UNIT COSTS in fils/kWh

UNIT COST TRENDS

The plot below and the table on the previous page illustrate the costs of producing and distributing a unit of electricity over the last five years. The costs for 1983 include a notional charge for electricity, in order to provide a direct comparison with 1984 onwards, when gas costs were charged to our recurrent budget. In broad terms the trend has been steadily downwards, with reductions in almost every year. It is pleasing to report that the drop has been sustained in 1987, although forecasts were for a steady unit cost.



Production costs actually increased in 1987, due largely to the maintenance takeover of new generation plant. However this has been more than offset by substantial reductions in Distribution costs, and a significant reduction in Admin & Finance costs.

PRODUCTION DEPARTMENT

Manama & Muharraq Power Station

The pattern of running at Manama continued as in previous years, with the John Brown sets being base loaded throughout the year, and the 'B' & 'C' Station sets held in reserve to conserve running hours.

Production, at 261 GWH, was virtually unchanged from 1986, as was the capacity factor of 18%. Both availability and efficiency increased marginally to 94% and 23% respectively.

Early in the year the Station plans for life extension until 1995 were finalised. An important element in the planning was an agreement by the manufacturers that the operating life of the 'C' set rotors could be extended from 100,000 hours to 140,000 hours. The recent reversal of this position by ABB therefore necessitated further reviews. A committee was established to study future load requirements from Manama P.S. in the light of this new information; management approval was given to proceed with their recommendations, namely :-

- A) Declare C1, C2 and C3 machines operational for extreme emergencies only, and mothball them.
- B) Review the position at the end of 1989 in the light of actual 88/89 peaks.
- C) Prepare for running the AEG sets at Muharraq on diesel firing during the peak periods starting from 1990/1991 through until commissioning of new capacity.

There are inevitably substantial cost implications to this change in projected running patterns, and it may be that a further review of the future of Manama is required. It is obvious, however, that the life of the Station is now even more limited.

Ahmed Habib, the Station Manager, left during the year to take over as Manager, Sitra, following the promotion of Salman Khalaf to Chief Engineer, Production. Ahmed Basbeer, Sitra Head of Maintenance, has been appointed as Acting Manager effective the year-end.

Of considerable concern throughout the year, as it was also in 1986, was the operation and maintenance of Dalil Power Station. The split responsibility for maintenance means that schedules are even more protracted than would normally be expected, and a high-level resolution of these problems with EDF is long overdue.

Sitra Power & Water Station

Sitra production figures for 1987 were substantially lower than in 1986 as a result of the Station outage, the first major overhaul on GTAS, Unit 5 gas line failure, the extensive repairs on the new distillers, the rehabilitation of Distillers 1A & 1B and the extensive remedial works on the 66kV switch-house building. Nevertheless a 76% availability was recorded for generation plant, and during the critical summer months availability was 100%. Efficiency was down somewhat, from 41% to 39%, mainly as a result of extensive distiller outages; these also resulted, for the first time in many years, in a 12% drop in water production.

During the Station outage at the beginning of the year a great deal of work was done over and above the maintenance required, with a view to unitising the plant. This programme continues with the intention of substantially reducing, if not eliminating, the need for regular total Station outages.

Although we have managed to maintain good availabilities at Sitra to date, failures are on the increase, and it is only a matter of time before forced outage rates are significantly affected. Additionally the new distillation plant has presented a requirement for life extension on the older plant so that steam supplies are available throughout the distiller life. A combined Production and Projects committee has been

established to formulate requirements for a mid-life rehabilitation on the Phase I plant. Such rehabilitation is essential if we are to operate the Station reliably up to the year 2010.

It was evident from the start that there were major design deficiencies on the Abu Dhabi project. During the major overhaul on G1A5 and the associated plant many of the smaller deficiencies were rectified, improving the forced outage rates considerably. However several other very substantial problems were revealed, particularly concerning accessibility and maintainability of the plant. We must make provision for the rectification of these and previous deficiencies, either as part of the overall rehabilitation or as separate items under the Minor Capital Works programme.

Problems continued with Distillers 2, 3 and 4, particularly with reject section tube failures, brine pump failures and sea water pump casing damage. The consultant's investigations continue, but a solution is not foreseen in the near future.

Rifaa Power Station

Utilisation of the sets at Rifaa, particularly the ABB units, is now very heavy during the summer, with 5 ABB and 3KWU units on load for much of the time. The Station supplied 75% of the peak load, the energy supplied was up 12% on 1986 and capacity factor rose by 3 points to 32%.

In the 1986 Production report concern was expressed over the forced outage rate and the start failure rate, as with increasing loads these would eventually result in system problems. After considerable investigation in the early part of the year, these problems have been overcome. Forced outage rates dropped from 2.9% to 0.9% and the start failure rate dropped from 24.3% to 4.4%. If the low rates of 1987 can be maintained then we have a reasonable chance of meeting demand during the peaks of 1990-1991. It is envisaged that base loading at Rifaa will

increase substantially over the next few years and hence the reliability of this plant will play a big part in determining system reliability.

The control elements of the Rifaa II gas reducing valves have given problems ever since commissioning, despite the trial of several different types of expanding plug. During 1987 one line was fitted with a completely different design of valve, and this has proved very successful. The other lines will be converted to the same type of valve.

The 220kV sub-station, although not under Station control, has been a cause of concern in the past, as it constitutes the Station busbar, and the high level of outages reflected badly on Rifaa II availability. However the reliability of the 220kV GIS switchgear seems to have improved in the past year, which also has improved availability.

System Operations

The operation of the transmission system continued smoothly throughout the year, with no major failures of generation or operation. There were 97 system disturbances during the year, down from the high of 105 in 1986. Eight of these disturbances resulted in loss of supply to consumers. Nine were on the GPIC supply, which seems particularly sensitive to ED switching transients, and this problem is being investigated.

The drive towards self-sufficiency in the section continues, particularly on the all important software side. System staff are now completing substantial modifications, improvements and extensions to the SCADA programs in-house. These have resulted in considerable savings in contractor costs, but more importantly have resulted in substantial life extensions for the system.

PRODUCTION STATISTICS - 1987

System Peak Demand	672 MW on 15th August at 1430hrs		
Total Energy Supplied	2956 GWh		
Total Water Production	29.8 MM ³ (6557 million imp gal)		
Maximum Dependable Capacity - Power	991 MW		
Maximum Dependable Capacity - Water	25MIGPD		
	RIFAA	MAWAMA	SITRA
Installed Capacity (MW)	700	127 **	125
Output at Peak (MW)	498	47	117
Availability at Peak (%)	100	100	100
Plant Restriction at Peak	None	None	None
Spare Plant Margin at Peak	202	80	8
Total Production (GWh)	2003	261	729
Staffing Level (%)	92%	87%	93%
Bahrainisation (%)	73%	80%	67%

** Muharraq (39MW) excluded (diesel fired & not avail. for normal ops.)

ANNUAL COMPARISON

YEAR	R I F A A					M A N A M A				
	83	84	85	86	87	82	84	85	86	87
CAPACITY (MW)	400	700	700	700	700	127	127	127	127	127
UNIT AVAIL (%)	82	89	90	89	90	92	93	93	93	94
CAPACITY FACT (%)	26	28	25	29	32	43	26	22	18	18
EFFICIENCY (%)	21	24	27	27	27	17	19	22	22	23
PRODUCTION (GVH)	918	1245	1622	1786	2003	479	290	247	267	261
GAS CONS (Mm ³)	501	597	685	772	843	357	174	132	137	133

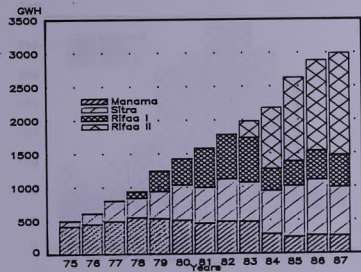
YEAR	S I T R A P O W E R					S I T R A W A T E R				
	83	84	85	86	87	83	84	85	86	87
CAPACITY (MW/MGPD)	120	120	120	125	125	5	10	25	25	25
UNIT AVAIL (%)	75	78	77	84	76	82	82	86	80	63
CAPACITY FACT (%)	58	59	70	76	67	80	81	75	83	72
EFF (%) or PROD RAT.	28	30	40	41	39	.07	.076	.09	.09	.09
PROD (GVH/Mm ³)	587	648	763	835	729	7	10	28	34	30
GAS CONS (Mm ³)	242	245	218	233	211	96	137	315	382	326

YEAR	T O T A L S				
	83	84	85	86	87
INSTALLED CAP (MW)	627	947	952	952	952
MAXIMUM DEMAND (MW)	490	514	594	627	672
PERCENT INCREASE	11	5	16	6	7
ENERGY SUPPLIED (GVH)	1952	2142	2595	2848	2956
PERCENT INCREASE	12	10	21	10	4
EFFICIENCY (%)	21	25	29	29	29
WATER PROD (Mm ³)	7	10	28	34	30
PERCENT INCREASE	19	55	173	21	-12
TOT GAS CONS (Mm ³)	1196	1153	1350	1524	1513
MV AVAILABILITY (%)	84	89	89	89	89
LOAD FACTOR (%)	46	48	51	54	51

NB - Mubarraq (39 MW) excluded (diesel fired & not available for normal ops.).

ANNUAL GENERATION PATTERN

The plot shows the contributions of the various stations to the grid for the past thirteen years. The effects of base-loading Sitra Power & Water Station can be seen clearly in the virtually constant annual contribution of the Station. This base load regime results from the requirement to maximise water production. It also allows full utilisation of the more efficient steam sets there.

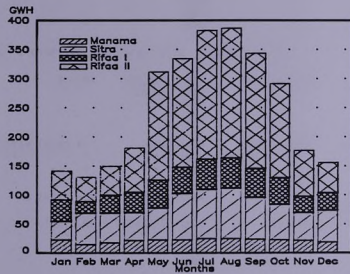


Also to be noted is the heavy reliance placed on the more efficient ABB sets at Rifaa II in the last four years. Five out of the six ABB units are on load for the greater part of the high-load period, with all six sets running for some peaks.

In future years, the contributions from the Rifaa I KWU sets and the Manama machines will increase as loads rise.

MONTHLY GENERATION PATTERN

The changing pattern of generation throughout the year is well illustrated by the plot below, which shows the load distribution during 1987. Both Manama and Sitra Power Stations maintain a steady contribution to the system, apart from a small drop in the winter months to cover planned maintenance outages. The bulk of the change in production is taken by the gas turbines at Rifaa Power Station, particularly the ABB sets at Rifaa II.



It is anticipated that this pattern will be even more marked in future years, as although winter loads are increasing, the absolute increase is far higher over the summer period, when air-conditioning consumption constitutes over 60% of the load.

MAIN PRODUCTION UNITS

UNIT	TYPE	RATING	INST	MANUFACTURER	REMARKS
RIPPA POWER STATION					
GT1	GAS TURBO ALT	50KW	1978	KRAFTWERK UNION	OPEN CYCLE
GT2	" " "	"	1978	"	"
GT3	" " "	"	1979	"	"
GT4	" " "	"	1980	"	"
GT5	" " "	"	1980	"	"
GT6	" " "	75KW	1983	BROWN BOVERI	"
GT7	" " "	"	1983	"	"
GT8	" " "	"	1984	"	"
GT9	" " "	"	1984	"	"
GT10	" " "	"	1984	"	"
GT11	" " "	"	1984	"	"
SITRA POWER & WATER STATION					
BLR1	BOILER	450,000	1975	VAAGNER BIRO	625psig
BLR2	"	1b/hr	1975	"	& 865°F
BLR3	"	"	1977	"	"
BLR4	"	"	1977	"	"
TA1	STEAM TURBO ALT	25KW	1975	FRANCO-TOSSI	PASSOUT TO
TA2	" " "	"	1975	"	DISTILLERS
TA3	" " "	"	1977	"	"
TA4	" " "	"	1977	"	"
GT45	GAS TURBO ALT	25KW	1984	BROWN BOVERI	EXHAUST TO
					HEAT RECOVERY
DIST1A	MSF DISTILLER	2.5MMGPD	1976	ITALIANA	"
DIST1B	" " "	"	1977	"	"
DIST 2	" " "	5 MMGPD	1984	ITALIMPIANTI	"
DIST 3	" " "	"	1985	"	"
DIST 4	" " "	"	1985	"	"
DIST 5	" " "	"	1984	"	"
MANAMA & MUHARRAQ POWER STATION					
B5	GAS TURBO ALT	6KW	1958	BROWN BOVERI	OPEN CYCLE
B6	" " "	"	1959	"	"
B7	" " "	"	1960	"	"
B8	" " "	"	1961	"	"
B9	" " "	"	1964	"	"
B10	" " "	"	1965	"	"
C1	" " "	13KW	1966	"	"
C2	" " "	"	1967	"	"
C3	" " "	"	1970	"	"
C4	" " "	"	1972	"	"
JB1	" " "	19.5MW	1975	JOHN BROWN	"
JB2	" " "	"	1975	"	"
ABG1	" " "	"	1976	ABG-KANIS	DIESEL FIRED
ABG2	" " "	"	1976	"	OPEN CYCLE

ALL RATINGS AT 40°C.

DISTRIBUTION DEPARTMENT

Planning & Development Division

The overall volume of project work declined slightly during the year. This has, in many ways, been of advantage, in that more time can now be devoted to individual projects. Such increased care and attention to detailed planning often results in a better scheme at a lower cost.

Two significant studies during the year were both aimed at improving distribution efficiency. The first was a full study of our substation practice with regard to layout, size, internal wiring, ventilation, earthing and fire & safety. Recommendations were made for upgrading and improving existing stations, and a standard set for future installations.

The second study was a complete review of cable loading practice, which will contribute to reduced cabling costs in the future. The report contained several recommendations with regard to use of PILC and XLPE cables.

The Spatial Database Project has progressed only slowly, as there are numerous software and hardware problems still to be overcome. Digitising of all services records is well in hand, and should be completed by mid 1988. Until all problems are resolved, the system will be used for mapping applications only.

Construction Division

Construction activity also registered a small reduction in work volume, again permitting increased attention to quality of output. The Divisional computer facilities were expanded to cover full computerisation of all applications and invoices.

There are now a total of 20 contractors working under the Measured Term Contract system, as compared with 19 in 1986. Working standards remained at a very high level, with very few instances of third party damage or of public complaint.

Cooperation with other authorities also assisted in the smooth flow of work. Monthly coordination meetings continued with PWA Roads Section and with the Ministry of Housing. These helped to minimise problems with cable routings, and ensured timely completion of ongoing projects, particularly at Madinat Hamad.

The tables indicate the volume of work completed in comparison with previous years.

Operation & Maintenance Division

In this Division, work volume is still on the increase, and will continue to increase in the future, in line with the customer base. There are now nearly 2100 substations in service, so even annual maintenance requires 40 substations to be serviced each week, or more than one every hour. In addition there is the work involved in fault repair, new connections and system additions.

Fault levels continued to decline, with a 20% reduction in 1987. Even at this level, though, crews attended an average of 160 faults a week, in addition to handling over 630 consumer calls a week. In this regard the continued restrictions on overtime make it very difficult to provide the necessary response to calls. This applied particularly during the peak, when over 150 calls a day were being received.

The Damage Prevention & Control Unit continued with it's role of coordination of contract work in order to minimise plant damage. It's success is reflected in the statistics, which continue to show a very low level of third party damage to our installations.

Transmission Division

The continued expansion of the transmission system, particularly of the 220kV network, places an ever-increasing demand on the section, and there is consequently a tendency for the level of maintenance to fall below the optimum. However all preventive maintenance checks were carried out on the network and on all protection systems.

All major repairs were carried out in-house, with obvious savings in contract costs. This included the temporary and permanent repairs to the Sitra-Dry Dock 66kV No 1 submarine cable, which was damaged by a ship's anchor on the 1st May. All jointing, testing and commissioning work was carried out by ED staff. Other work included the replacement of the oil filled cables at the Sitra 66kV switch-house as part of the fire-damage rectification work.

Streetlighting Section

As in previous years, a growth rate of over 10% was sustained, and this growth is forecast to continue for several years to come.

Significant construction schemes included Phases 2 and 3 of the National Loop Road, sections of Sheikh Sulman Highway and a number of major avenues. Nearly 3400 new luminaires were installed, supplied by 118 kilometres of new cable.

Maintenance work continued to rise in line with the expansion of the system. The section responded to over 10,000 calls from the public, cleared nearly 35,000 faults, and serviced almost 50,000 luminaires, or over 150 every working day.

ANALYSIS OF CONSUMER PATTERNS

CONSUMPTION TRENDS

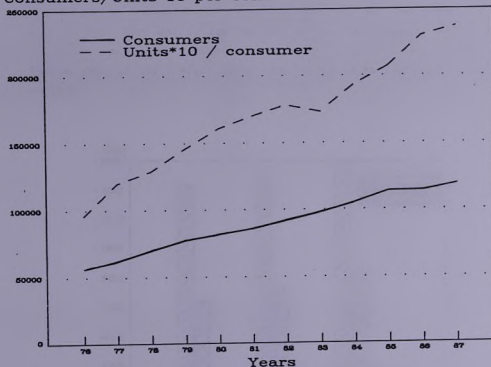
YEAR	PEAK	PCNT	UNITS	PCNT	NO OF	PCNT UNITS/	PCNT	PEAK/	PCNT	
	LOAD	INC	SOLD	INC	CONSUMES	INC CONSUMER	INC CONSUMER	INC	INC	
	MW		GWH			KWH		KW		
1976	171		544		56500	9628		3.03		
1977	223	30.4%	752	38.2%	62600	10.8%	12013	24.8%	3.56	17.7%
1978	269	20.6%	911	21.1%	70566	12.7%	12910	7.5%	3.81	7.0%
1979	306	13.8%	1135	24.6%	77849	10.3%	14580	12.9%	3.93	3.1%
1980	375	22.5%	1327	16.9%	82157	5.5%	16152	10.8%	4.56	16.1%
1981	414	10.4%	1468	10.6%	86152	4.9%	17040	5.5%	4.81	5.3%
1982	441	6.5%	1641	11.8%	92355	7.2%	17942	5.3%	4.78	-6%
1983	490	11.1%	1705	3.9%	98469	6.6%	17768	-0.7%	4.98	4.2%
1984	514	4.9%	2024	18.7%	105127	6.8%	19253	8.4%	4.89	-1.8%
1985	594	15.6%	2358	16.5%	113670	8.1%	20744	7.7%	5.23	7.0%
1986	627	5.6%	2629	11.5%	114118	3.9%	23038	11.1%	5.49	5.0%
1987	672	7.4%	2819	7.3%	119026	4.3%	23684	2.8%	5.65	2.9%

CONSUMPTION DISTRIBUTION

	DOMESTIC		COMMERCIAL		INDUSTRIAL		AGRICULTURAL	
	GWH	PCNT	GWH	PCNT	GWH	PCNT	GWH	PCNT
	OF TOT		OF TOT		OF TOT		OF TOT	
1985	1434	65.5%	644	29.4%	85	3.9%	26	1.2%
1986	1509	62.6%	735	30.5%	158	6.6%	7	.3%
1987	1583	60.5%	841	32.1%	184	7.0%	11	.4%

CONSUMPTION TRENDS

Consumers/Units*10 per cons

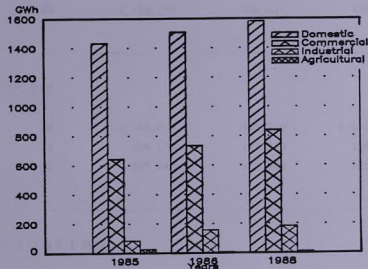


The tables on the previous page and the plot above illustrate the continued upward trend in consumption. All our indicators continue to rise. There are more consumers each year, the average consumer uses more energy, and the average consumer has a higher load during peak periods.

Rates of increase were a little lower in 1987 than in some previous years, but a substantial part of our load is air conditioning, so is very temperature dependent. It is thus too early to predict if this slowing of system expansion is likely to continue.

CONSUMPTION DISTRIBUTION

The change in consumption distribution over the last two years can be seen in this plot and in the earlier tables. The domestic sector has increased every year in absolute terms, but is nevertheless becoming a smaller part of the overall market due to the large increases in other sectors.



The commercial sector, although only half the size of the domestic market, has registered much larger increases in recent years, and as a consequence is increasing its market share. Industrial consumption has more than doubled in two years, probably as a result of the very large increase in the use of power in desalination plants. The consumption in this sector does not, of course, reflect its true size, as the two biggest energy consumers on the island (ALBA & BAPCO) are both self-sufficient for power production, and BANAGAS uses gas-turbines to power all major equipment. Despite these changes it can be seen that the market still remains predominantly domestic.

CAPITAL EXPENDITURE

		1985	1986	1987
11kV PROJECTS				
New works	BD	4,613,071	4,152,276	2,600,271
Ministry of Housing	BD	1,570,153	124,408	321,788
Reinforcements	BD	2,125,181	1,891,036	1,865,399
Diversions	BD	1,186,763	369,417	405,069

LV PROJECTS

New works	BD	2,046,599	855,299	1,038,308
Reinforcements	BD	329,189	201,319	190,381
Diversions	BD	315,146	345,683	263,191

STREET LIGHTING

Projects	BD	995,610	833,085	985,234
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Works to contractors

- New	BD	4,151,497	3,540,511	3,017,062
- Maintenance	BD	app 6,000,000	1,016,081	914,700

WORK SUMMARY

		1985	1986	1987
Applications received	No	5,165	4,875	3,902
Installed load	KV	302	256	236
Max Demand	KVA	175	145	119
Projects designed	No	1,359	769	612
Value	BD	15,067,177	7,466,234	5,517,740
Trans S/S commissioned	No	3	5	0
GM S/S commissioned	No	175	188	140
PM S/S commissioned	No	32	34	33
11kV cable installed	km	134	105	107
11kV line installed	km	18	10	13
LV cable installed	km	209	171	155
LV line installed	km	15	11	11
U/G services installed	No	1,303	1,110	1,162
O/H services installed	No	3,751	2,845	2,092
Installations inspected	No	9,447	6,837	5,806
Installed load (new)	KV	227	171	148
Installed load (add)	KV	21	18	23
New consumers connected	No	7,773	6,580	5,176
SL cable installed	km	96	140	118
SL columns erected	No	2,530	2,902	2,022
Luminaires installed	No	5,557	5,042	3,766
Trans transform maint	No	82	98	125
Trans 66kV sw/gr maint	No	124	168	201
Trans 33kV sw/gr maint	No	53	40	37
Trans 11kV sw/gr maint	No	141	216	294
GM S/S maintained	No	409	364	366
PM S/S maintained	No	14	57	61
Luminaires maintained	No	NA	36,121	34,638
Third party damage	No	350	364	340
66kV faults	No	5	2	1
11kV faults	No	344	219	168
LV faults	No	17,304	10,413	8,186
Consumers calls	No	23,741	25,509	32,846
mVA-hours lost	mVAh	2,361	481	598

PROJECTS & DEVELOPMENT

Studies commenced during 1986 for the 1987-1996 Generation Programme, and site work also commenced on some of the projects associated with the corresponding Transmission Programme.

During the year a great deal of effort was put into identifying areas where substantial cost savings could be made on project work. As a result, the Department have now started undertaking a much greater volume of design and management work in-house, particularly for civil works and SCADA applications. Savings have also been realised by introducing a system of split contracts, initially on cable projects.

Both these measures offer, in addition to substantial cost savings, a much greater degree of project control, enhanced flexibility in the award of contracts, more control over the selection of suppliers and more scope for the inclusion of local sub-contractors. They do introduce, however, a much greater administrative element into the task, and require a high level of expertise from our engineers.

The Generation Section were involved for much of the year in the update of the Electrowatt Feasibility Study. In addition the Rifaa canteen was completed and planning progressed on other work at Rifaa including the Security Improvements, the Emergency Diesel Supply and the Rigging Store. At Sitra tender negotiations were completed for the Gas Related Works.

The Distillation Section were, as in 1986, extensively involved with the contract problems concerning brine pumps, sea water pumps and evaporator tubes on all the new distillers at Sitra. Steady progress was achieved, with substantial retubing, and replacement of all brine pump casings. However long term reliability is still not established. Additionally a major rehabilitation of Distillers 1A and 1B was completed. This work included substantial civil repairs and cladding treatment.

The Transmission Section are still heavily involved with what is virtually a continuous expansion of the 220kV system. The introduction of split contracts for all cable work, although of great potential benefit, inevitably places a substantially increased workload on the section. Two cable circuits, three reactors and one 220/66 kV transformer were completed during the year. Enquiries were also issued for the ED/ALBA link and the Sheikh Isa Airbase supply.

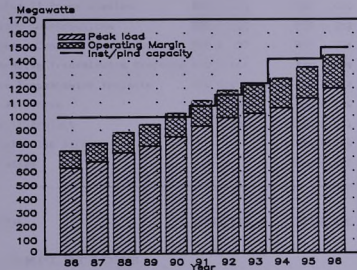
System Control Section work in the period included all the SCADA extension for the main Transmission Programme, enhancements to the SCC control system and completion of the design of the mobile radio system.

The Civil Section dealt with ten major projects during the year, some of these being extremely extensive. A number of minor tasks were also handled. Additionally the work load for each project increased substantially, as virtually all design, tender preparation and contract supervision is now handled in-house. Work at the design or tender stage includes the Transmission Maintenance Depot, the additional Distribution Offices, the Juffair Canteen and the Manama Chemical Store. Work being supervised includes the Sitra Drainage Improvements, the Juffair Yard Improvements and the Consumer Affairs building alterations.

The Projects Planning Section finalised the studies of power requirements during the decade from 1987 to 1996, and presented proposals for a new programme of plant construction to meet the forecast demands. Work is now in hand on detailed planning for the new power & water station.

LOAD FORECAST / PLANNED CAPACITY

YEAR	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
LOAD INCR		7.2%	9.5%	6.4%	8.6%	7.2%	6.0%	3.4%	4.8%	5.8%	5.8%
PEAK FCST	627	672	736	783	850	911	956	984	1025	1094	1158
+ NEW DESAL	627	672	736	783	850	927	988	1018	1059	1128	1200
+20%			883	940	1020	1112	1185	1222	1271	1354	1440
PLND CAP	993	993	993	993	993	1073	1153	1235	1413	1413	1495



The plot and table above show the current load forecasts for the planning decade, based on the latest population data and network studies. Also shown is a 20% plant margin to cover system security requirements.

Superimposed on this is a line showing the planned plant capacity for the decade 1987 to 1996. This new plant will be installed at a new power station for which planning is in hand.

EXPENDITURE & WORK SUMMARY

EXPENDITURE

PROJECT	1986	1987
Sitra Desalination	MED 5.891	MED 2.410
Rifaa II Power Station	MED 0.954	MED 0.014
Minor Constructions	MED 0.620	MED 0.282
System Control Development	MED 0.197	MED 0.074
On-going Transmission Projects	MED 5.684	MED 8.164
New Transmission Projects	MED 6.050	MED 7.454
Civil Works	MED 0.200	MED 0.120
Dalil Project	MED 0.030	MED 0.011
Sheikh Isa Airbase		MED 0.040
Studies		MED 0.048
TOTAL	MED19.626	MED18.626

KEY COMPLETIONS

Rifaa - Madinat Hamad No 2 220kV circuit.
 Isa Town North - Waterfront 220kV circuit.
 220/66kV 150 MVA transformer at Waterfront.
 Reactors at Madinat Hamad, Um Al Hassam and Rifaa.
 Remedial works at Sitra 66kV switch house.
 Rehabilitation of Distillers 1A and 1B.
 Canteen at Rifaa PS.
 Security improvements at Manama PS and Distribution.
 Repairs to Muharraq C substation.
 Alterations to PWA Head Office.
 System dynamic studies and SCC improvements.

STATEMENT OF FINANCIAL POSITION

ASSETS

2001	2000	Description
100,000	100,000	Investment in ABC
200,000	200,000	Investment in DEF
300,000	300,000	Investment in GHI
400,000	400,000	Investment in JKL
500,000	500,000	Investment in MNO
600,000	600,000	Investment in PQR
700,000	700,000	Investment in STU
800,000	800,000	Investment in VWX
900,000	900,000	Investment in YZ
1,000,000	1,000,000	Investment in ABC

LIABILITIES AND EQUITY

LIABILITIES

Accounts payable - 100,000
 Notes payable - 200,000
 Bonds payable - 300,000
 Other liabilities - 400,000
 Total liabilities - 1,000,000



