CHAPTER 7

The management of operations

Introduction

7.1. Within the financial framework described in Chapter 5 the South Board's main responsibilities are the long-term planning of its generation, transmission and distribution capacity in order to meet future demands upon it, and the day-to-day management of existing capacity and supporting facilities. Investment planning is dealt with in Chapter 8. In this chapter we are concerned with the operational management of existing capacity.

7.2. This chapter deals separately with the management of generation and of the transmission and distribution systems, the maintenance and other supporting services for generation, transmission and distribution, and finally the quality of service provided by the system as a whole.

The management of generation

7.3. The two Scottish Boards plan and operate the Scottish generating system as a single unit under the joint generating arrangement. The overall control of the Scottish thermal generating plant is exercised from the South Board's system control centre at Kirkintilloch. Advance scheduling of the operation of all Scottish generating units is conducted directly from Kirkintilloch, with the exception of the North Board's conventional hydro-electric plant which is scheduled from the North Board's control centre at Pitlochry. Control instructions (ie actual instructions to commence generating or to change output) are given directly from Kirkintilloch to all the South Board's generating stations and to one of the North Board's two pumped storage stations. Control instructions to the North Board's remaining stations are given from Pitlochry at the request of Kirkintilloch.

7.4. The joint operational planning cycle is based on a five-year rolling plan and starts in the autumn with proposals for generator outages for maintenance purposes, and these are evolved by February into an agreed plan of available plant capacity which is designed to meet all expected demands. The operation of available capacity is then planned on a day-to-day basis to meet expected variations in the demand upon the system. A computer program is used which forecasts from past data the half-hourly pattern of demand over the coming day and which then progressively modifies its forecast using current data as it becomes available.

7.5. Choice of the mix of plant to be operated to meet expected demand is determined by 'merit order' computations designed to minimise the total daily fuel cost. An on-line computer is used to derive the relevant costs for each generating unit from inputs supplied by its station which include, in the case of a conventional thermal generator, the results of current thermal efficiency monitoring together with the cost and calorific value of the fuel to be used. Costs are derived for a range of output increments from the generating unit's minimum operating level to its full output level. These costs together with generator start-up costs are input into a program which is used iteratively to derive operating schedules which give a near-optimum combination of running costs and start-up costs.

7.6. The merit order for thermal generating plant has normally placed nuclear, coal-fired and oil-fired cost in ascending order of incremental cost per unit of electrical energy generated. The special considerations governing the use of hydro-electric generating capacity have been described in our report on the North Board. The pumped storage units were designed to use some of the energy generated during the night-time demand trough to raise water to altitude, and for the energy thus stored to be used, together with hydro-electric generation, to meet peak demands during the day. Pumped storage capacity is scheduled, as has been noted, from Kirkintilloch, but its availability is the responsibility of the North Board.

7.7. The South Board has explained to us the theoretical advantages which would be obtained from running all the thermal generating plants which are used continuously at full load as indicated in Figure 7.1, thereby achieving their maximum thermal efficiency and avoiding start-up costs. The pumped storage and hydro-electric generating capacity of the Scottish systems is normally insufficient, however, to cope with all the peaks in demand above the 'flat steam line' shown on the diagram. It is consequently necessary to bring additional thermal generating capacity into use during the day as indicated in Figure 7.2 thus incurring start-up costs. Once these start-up costs have been incurred, it has been found more economic to use the additional thermal capacity to meet the major part of the peak demand, and to use pumped storage only to meet the extreme peaks.

7.8. Although the pumped storage stations were initially designed to pump during the night and generate during the day, it has often proved preferable to use high-efficiency thermal plant for day-time generation. The pumped storage stations have in recent years also been used to pump and generate alternately during the day in order to 'fine-tune' the operation of the generating system. This is more onerous than the regime for which the stations were designed because it requires more frequent reversals of flow.

7.9. The availability of the North Board's Cruachan pumped storage station has been low in recent times, as is illustrated by Table 7.1, and this is true to a lesser extent of its Foyers station. The North Board has explained that the age of the Cruachan station (which was commissioned in 1966) and the onerous operating regime to which the stations have been subjected are considered to be contributing factors.

TABLE 7.1 **Pumped storage availability**

per cent

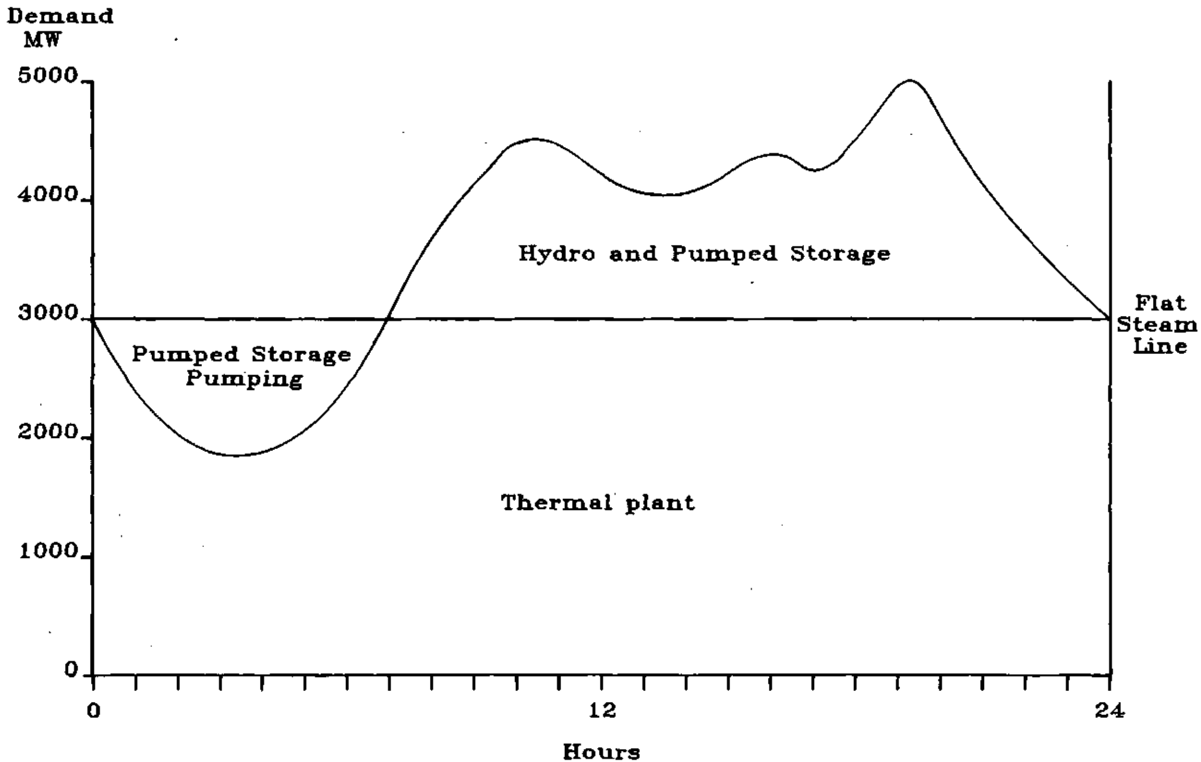
	Six-monthly periods starting			
	April 1984	*October 1984*	*April 1985*	*October 1985*
Cruachan	64·8	54·8	61·6	38·5
Foyers	60·6	95·9	71·7	57·1

Source: NSHEB.

Note: The October 1985 figures were affected by the refurbishment programme referred to in paragraph 7.11.

FIGURE 7.1

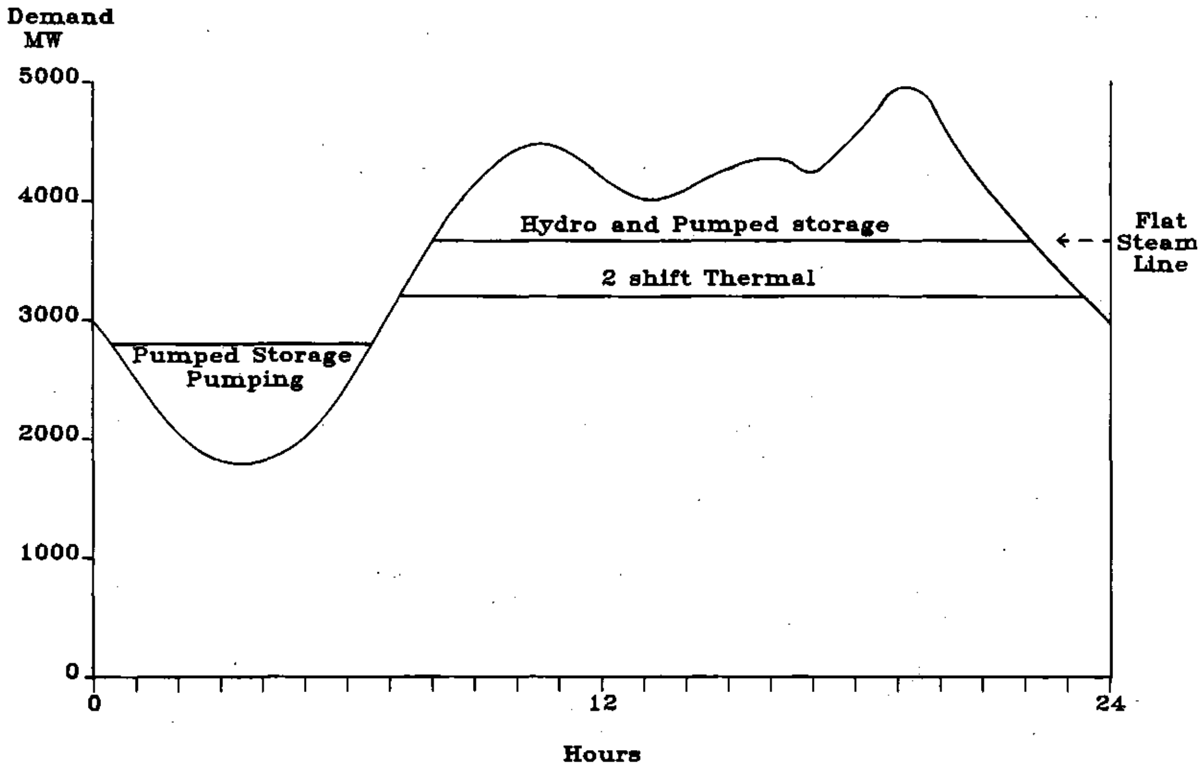
Flat steam line concept



Source: SSEB.

FIGURE 7.2

Modified flat steam line concept



Source: SSEB.

7.10. Simulations done at our request by the South Board have shown how the economic value of using pumped storage depends upon the difference between its production costs and the costs (including start-up costs) of the thermal generating plant which it displaces. With no differential production cost there is typically little benefit in using more than 43 per cent of the total pumped storage capacity and no benefit in using more than 57 per cent of that capacity. This, broadly, is the present position. The relatively low availability of the pumped storage plant has thus not presented any problems in the context of the generating capacity at present available. This is reflected in the utilisation figures shown in Table 7.2.

TABLE 7.2 **Pumped storage utilisation**

per cent

	Six-monthly periods starting			
	April 1984	*October 1984*	*April 1985*	*October 1985*
Cruachan	51·8	54·4	64·1	71·9
Foyers	45·9	45·1	60·3	78·1

Source: NSHEB.

7.11. The South Board's simulations show that the economic value of using pumped storage increases as the availability of low operating cost nuclear plant for overnight pumping increases, and that when the Torness nuclear station is in service substantial benefits would accrue from the full utilisation of all the Scottish pumped storage capacity. A major plant refurbishment programme has been in hand to improve pumped storage availability in readiness for that change.

7.12. In addition, the South Board is seeking ways to increase the economic utilisation of pumped storage, and has already initiated a plan to introduce a seven-day or longer scheduling procedure to take advantage of the differential costs of pumping on week-days and week-ends. It is not yet certain that a satisfactory procedure can be devised.

7.13. The two Scottish Boards have also commissioned a research project to develop procedures for the more effective planning and scheduling of a mixed hydro/thermal generating system. They are at present unable to quantify the likely benefits of introducing any new scheduling procedures for pumped storage.

7.14. The scheduling of generating plant for nine periods during each day's running begins on the previous day, and is refined during the course of the day in question. The output of plant not expected to be needed to meet Scottish demands is offered on the previous day to the CEGB in accordance with arrangements which are described in Chapter 10, and corresponding offers from the CEGB are considered at this time. The provisional arrangements for the export or import of electricity made at that time are also modified as the day proceeds.

7.15. Performance in the day-to-day scheduling of generation is normally to be judged by success in maintaining acceptable standards of security and quality of supply at minimum cost. The generating capacity of the Scottish system is, however, well in excess of what is required to meet peak demands, including the margin which is conventionally considered necessary to maintain adequate security of supply. Given adequate availability for use of existing plant, cost minimisation is the remaining criterion of performance. However, the South Board makes little use of retrospective analysis of scheduling performance to compare the costs achieved with the minima which would ideally be attainable. The South Board has told us that earlier investigations had confirmed the near-optimality of its scheduling procedures but that it nevertheless intends to introduce a form of post-operational analysis.

7.16. The performance of individual generating units is to be judged by their availability for use and by their operating cost, making allowances for their design characteristics and age, the demands placed upon them and, for thermal stations, the cost of the fuel which they use. Power station managers are required to manage against budgets which are set in terms of operating costs, although (since fuel purchasing is a headquarters responsibility) they have effective control only over the energy consumed per unit of electrical energy generated. Monthly reports go to headquarters comparing actual with historical and predicted values of thermal efficiency related to output, together with records of availability, planned outages and breakdowns. These reports are discussed at the Management Quarterly Results Meeting and at the Power Station Managers' Meeting. Discussions are also held with the managers of all major stations during the course of the year, and overall performance is assessed.

7.17. As a result of an analysis of power station performance we conclude that the management of generating units has been effective. The South Board has pursued a policy of installing new on-line plant monitoring facilities which enable central control room engineers to exercise tighter control over the operation of their generating sets, resulting in improved thermal efficiencies. A summary of results is given in Table 7.3.

TABLE 7.3 **Thermal efficiency by fuel type over 10-year period**

per cent

	1975–76	*1984–85*
Coal	33·06	31·28
Oil	14·7	35·16
Nuclear	23·10	33·74
Overall thermal	31·18	33·50

Source: SSEB.

The reduction shown in the efficiency for coal-fired stations is a result of reduced loading during the miners' strike.

7.18. For nuclear power stations our analysis showed how effective generation controllers had been in running the nuclear sets up to their maximum availabilities. This is shown in Table 7.4.

TABLE 7.4 **Utilisation of nuclear stations**

per cent

	1983–84	*1984–85*
Availability*	76·5	79·5
Generation plant running load factor†	95·5	95·4

Source: SSEB.

* Percentage of total station output which is made available for allocation.
† Percentage of total station output used over the period of running.

For the low cost base-load generation provided by nuclear units, we note the possibility of a conflict between high thermal efficiency and availability, and this was confirmed by the Board.

The management of the transmission and distribution systems

7.19. The Grid Control Centre at Kirkintilloch is responsible for the control of the high voltage networks which carry electricity from the generators to bulk supply points and to points of transfer to the English boards' network. This transmission system is operated independently of area boundaries and its maintenance is a headquarters responsibility. The control of the lower voltage distribution system is the responsibility of three distribution control centres in Glasgow, Hamilton and Edinburgh.

7.20. The South Board is planning to introduce improved on-line information systems which will initially affect the operational control of the 400 kV and 275 kV supergrid and the 132 kV grid. Extension down to the 11 kV networks is a future possibility.

7.21. Energy delivered from the transmission and distribution systems falls short of the energy delivered to these networks but present metering methods limit the extent to which the sources of those losses can be identified. The Board told us that an increase of approximately 12·5 per cent in the number of units not accounted for between 1983–84 and 1984–85 is under investigation but that a reduction in losses has been achieved in 1985–86. The Board is now introducing additional metering on circuits interconnecting its three areas, in order to give an increased awareness of where units which are not accounted for may be leaving the system.

7.22. Faults occurring in the transmission and distribution systems are compared with national figures in Table 7.5.

TABLE 7.5 **Summary of faults occurring in transmission and distribution system 1984–85**

	Faults per 100 km per year			
	132 kV and transmission	*Distribution*		
		22 kV and above	*Over 1 kV and below 22 kV*	*1 kV and below*
National	3·3	6·0	9·9	28·6
South Board	2·7	7·4	11·6	45·1

Source: NAFIRS.

The South Board's higher fault rate for its distribution system cannot be explained by any difference in the percentages of cable running underground, which for the South Board are similar to those of the national average.

7.23. We were told that experience elsewhere suggested that an extension of the South Board's facilities for the monitoring and remote control of its primary sub-stations offers the prospect of speedier restoration of supplies after distribution faults. We were told that a scheme has been approved by the Board but that replacement of some of the equipment would be sanctioned only as part of a policy of renewing time-expired assets, and would take up to 20 years to complete.

Maintenance and supporting services

7.24. The South Board is responsible for maintaining a wide variety of equipment and constructions which are necessary to ensure the continued availability of its generating stations, its transmission system and its distribution system. We examined its general monitoring and inspection procedures and found them satisfactory. However, our investigation raised several issues.

7.25. We were concerned to discover that the South Board has been obliged to abandon for the time being on-load refuelling of the R3 reactor at Hunterston B. A possible result arising from the cracks in the stand pipes at Hunterston B would be a prolonged shutdown of the station for repairs. There is an alternative of repairing the cracks on a section by section basis. The Board is continuing its investigations.

7.26. The South Board has initiated a comprehensive quality assurance programme which is to embrace initial design, procurement, manufacture, inspection, testing/delivery to site, site construction and erection, final inspection, testing and commissioning, operation, maintenance and final demolition. We were told that a significant number of quality assurance audits have been carried out in connection with Torness and the transmision/distribution system. No time-table has been set for implementing quality assurance throughout the business.

7.27. We noted that there had been an incident at Longannet power station resulting in a bent turbo-generator shaft with a consequential loss of 10 per cent of generating capacity for several months. This incident was the subject of a major Board of Inquiry, the final report of which is not yet to hand. The occurrence has undergone thorough investigation and new guidelines are to be issued, designed to avoid any repetition of this occurrence.

7.28. Purchasing is mainly controlled by the Headquarters Contracts and Purchasing Department following well-established procedures. The South Board operates a 'buy British' policy which it explained as meaning a preference for British products, all other things being equal. The Board believes that where higher capital costs have been incurred under this policy, they have been at least fully offset by subsequent savings in maintenance and other operating costs. The Board accepts that this policy requires it to take account of prices charged by overseas suppliers.

Quality of service

7.29. Table 7.6 shows a rising trend in the incidence of system faults but no corresponding deterioration in quality of service as measured by duration of supply interruption.

TABLE 7.6 **Standards of consumer service**

	System reliability faults per 100m			*Consumer minutes lost per connected consumer*
	22 kV and above	*Over 1 kV and below 22 kV*	*1 kV and below*	
1974–75	5·0	13·4	20·1	123·2
1975–76	5·9	15·4	21·0	100·8
1976–77	4·0	14·8	23·7	99·0
1977–78	4·6	14·9	24·8	118·6
1978–79	6·8	16·1	30·1	128·9
1979–80	5·7	14·7	28·8	101·2
1980–81	7·4	15·8	24·9	97·1
1981–82	8·0	15·9	25·7	110·6
1982–83	7·9	16·1	21·7	107·0
1983–84	9·4	18·4	26·1	135·2
1984–85	7·4	11·6	27·3	81·1

Source: NAFIRS.

The South Board attributes this mainly to measures which it has taken to anticipate and to improve its speed of response to faults in an ageing transmission and distribution system.

7.30. Table 7.7 indicates that the South Board's quality of service over the past five years has been not far different from the national average.

TABLE 7.7 **Five-year trend—average consumer minutes lost per connected consumer due to:**

	All outages (faults and pre-arranged)					
	1980–81	*1981–82*	*1982–83*	*1983–84*	*1984–85*	
National	81·5	193·8	95·4	142·9	82·6	
Board total	97·1	110·6	107·0	135·2	81·1	
Ayr	116·0	104·3	131·9	211·3	65·9	Central & SW Scotland
Coatbridge	103·9	170·5	112·3	119·5	67·2	Central & SW Scotland
Dumfries	294·4	360·2	355·2	412·6	224·3	Central & SW Scotland
Hamilton	65·7	63·2	67·9	71·0	46·7	Central & SW Scotland
Kilmarnock	97·1	88·0	172·6	96·6	54·9	Central & SW Scotland
Motherwell	90·3	135·8	122·4	146·9	74·4	Central & SW Scotland
Falkirk	135·2	160·7	164·1	138·9	100·7	Central & SW Scotland
Bathgate	149·0	113·4	148·9	205·4	118·3	Edinburgh Fife Borders
Borders	264·0	343·2	213·6	370·4	162·1	Edinburgh Fife Borders
Fife (West)	72·3	119·4	120·5	91·1	77·7	Edinburgh Fife Borders
Edinburgh	19·1	15·0	22·7	23·7	24·6	Edinburgh Fife Borders
Fife (East)	133·7	128·7	104·5	198·5	132·0	Edinburgh Fife Borders
Lothians	139·9	172·1	137·0	240·4	145·8	Edinburgh Fife Borders
Clydebank	67·9	71·7	50·9	63·6	44·0	Glasgow Clyde
Glasgow N	40·9	43·2	36·6	74·0	44·0	Glasgow Clyde
Glasgow S	34·1	35·8	28·8	32·9	28·9	Glasgow Clyde
Greenock	84·0	88·4	147·4	95·5	51·8	Glasgow Clyde
Paisley	48·9	83·9	88·1	79·2	56·3	Glasgow Clyde

Source: NAFIRS.

However, the data also show that in some locations, notably the rural districts of Dumfries, the Borders, and Lothian, performance in this respect has been far below national average. The Board told us that it proposes to introduce an individual security of supply target for each area.

Conclusions

7.31. In the report of an earlier inquiry, we concluded that the North Board's control of its own generating plant had been effective. In that inquiry we deferred examination of the arrangements between the two Scottish Boards for the joint control of their combined generating capacity. In this inquiry we have given particular attention to those arrangements. It has been clear to us from the outset that joint generation offers the potential of a substantial economic advantage, but that the full realisation of that potential requires close co-ordination of the generating activities of the two Boards. We have noted that the present arrangements retain some division of responsibility in this respect, and we refer to this further below. Our overall impression is nevertheless that the joint generating arrangements work well in practice, and that they probably result in a near-optimal use of Scottish generating capacity (paragraphs 7.3 to 7.15).

7.32. An important part of the economic advantage to which we refer arises from the use of the output of the North Board's hydro-electric and pumped storage stations to help to meet peak demands without incurring unnecessary start-up costs at the South Board's thermal stations. The North Board retains responsibility for the maintenance of its generating stations, and in recent years the availability of its pumped storage capacity has been low. We accept that there have been reasons for this, and that it has not presented problems in the context of present generating capacity. In the future, however, the non-availability of pumped storage could carry much larger penalties in connection with the planned increase in the South Board's nuclear generating capacity. We therefore attach considerable importance to the successful execution of the North Board's plans for the refurbishment of its pumped storage equipment in advance of the commissioning of the Torness nuclear power station (paragraphs 7.8 to 7.11).

7.33. We have found that the techniques used for the scheduling of the use of Scottish generating capacity work well in practice. Worthwhile benefits should nevertheless result from any further advances which could be achieved, particularly in the difficult task of increasing the utilisation of available pumped storage capacity. We note that the Boards are examining ways of improving their scheduling techniques. As they are examining the possibility of using the CEGB's GOAL program for the management of electricity trading, we suggest that they also consider the possibility of adapting that program for this purpose (paragraphs 7.13 and 7.14).

7.34. There is also a prospect that the practical implementation of existing scheduling techniques could be improved by systematic comparisons on a sampling basis between actual and optimal scheduling performances. We note with approval the Boards' intention to introduce a scheme of regular post-operational analysis (paragraph 7.15).

7.35. From our examination of the individual performance of the South Board's thermal stations, we conclude that good results are being obtained. We support the Board's initiatives in introducing modern and innovative control technology into its power stations (paragraph 7.17).

7.36. In its management of nuclear power stations, the Board recognises the dangers of attempting to increase thermal efficiency at the possible expense of availability. In view of the costs of temporarily losing the output of its lowest operating cost generating capacity, the Board is right to give priority to availability over thermal efficiency (paragraph 7.18).

7.37. The South Board has introduced a Quality Assurance programme which has been applied to the Torness project, and which is intended ultimately to cover all aspects of its operations. We accept that the further extension of this programme will make heavy demands upon scarce staff resources but we consider that its full implementation offers scope for considerable advantages (paragraph 7.26).

7.38. We found the South Board's transmission and distribution systems to be generally well managed. We have noted the occurrence of what may have been a temporary increase in system losses in 1984–85 and we support the actions which the Board is taking to monitor future system losses (paragraph 7.21).

7.39. Actions taken to protect consumers from the consequences of faults in the distribution system have in the main been successful. It is to be expected that the quality of service will be lower to remote communities than to urban areas, and we support the Board's action in setting targets which take this factor into account while seeking to raise the quality of service, particularly to remote areas (paragraphs 7.29 and 7.30).