OPERATION OF THE PROPOSED UPPER CLUTHA POWER DEVELOPMENT

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INTRODUCTION

Before I deal specifically with the proposed utilization of the water resources of the Clutha Valley for power generation, I would first of all like to look quickly at the overall New Zealand generating system from the point of view of both how it has been in the past and what we can expect in the future.

Before the commissioning of the Cook Strait cable in 1964, generating plant had been installed and operated specifically to meet each island's individual requirements. In the South Island the demand for electricity was met almost entirely by hydro generation from a series of stations which, unfortunately, were not able to make full use of the available water resources. The major catchments in the South Island give a streamflow that reaches a maximum during the spring and early summer. The creation of controlled storage, mainly at Coleridge, Tekapo, Pukaki and Hawea, enabled much of these higher flows to be contained for use in the period of high electricity demand in winter. Significant quantities of water, however, were spilled and ran to waste during the summer periods.

The introduction of the Cook Strait power cable enabled stations such as Benmore and Aviemore to be installed and operated economically without increasing the amount of controlled seasonal storage available in the South Island. Although available and used for peaking duties in the winter, the principal use of the cable has been to increase the utilization of the high spring/summer streamflows by transferring this energy to the North Island where the period of maximum flow occurs during the winter months.

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At the present time the growth of electricity demand in both islands has been such that once again there is insufficient storage available in either island to ensure that the water available for hydro generation is used efficiently. The completion of the new Pukaki dam, scheduled for April 1977, will go some way towards relieving this position, but by the early 1980s the South Island will once again have insufficient storage to be able to operate successfully in supplying the winter energy requirements. At this time it will then be necessary to transfer significant quantities of electrical energy from north to south in the winter. This energy will be generated principally from thermal stations in the North Island operating at a significant cost, both economically and environmentally.

THE CLUTHA IN THE POWER SYSTEM

Before dealing with the details and implications of the power proposals contained in the Clutha Valley Development Commission's interim report it is worth looking at the broad operation of the power system in the future, particularly as it affects the South Island.

Considering a year about the turn of the century, i.e. shortly after the expected completion of the Commission's proposals, the situation in the South Island could be as follows:

1. *In megawatt or capacity terms* the amount of hydro-electric plant installed in the South Island could be about 80 percent of the South Island peak demand.

2. *In energy terms* (a) mean-year conditions – hydro power generation is expected to meet 70 percent of the annual South Island requirement but only 60 percent of the winter requirement; (b) dry-year conditions – the corresponding figures would be 60 percent of the annual requirement falling to 50 percent of the winter demand.

The significant factors inherent in the above figures are:

(1) The overall plant factor of all hydro plant in the power system, not just the Clutha development, will be less than the overall system factor (typically the Clutha, Waitaki and Waikato systems are all expected to operate in the range of 40–45 percent plant factor).

(2) There will be insufficient seasonal storage available to ensure that the higher winter energy demand can be proportionately supplied from the hydro systems.

(3) Under dry-year conditions the South Island will have to rely heavily not only on its own thermal stations but also on the transfer of energy from the North Island.

TABLE 1 — Approximate operational data for Clutha power stations (based on the recommendations contained in the interim report of the Clutha Valley Development Commission).

Station	Nominal station parameters			Lake operating data						Computed max. daily winter peaking			
										Assumed mean daily inflow (m^3/s)	Daily station outflows		Location of station discharge
	Plant capacity (MW)	Mean generation (GWh)	Head (m)	Long term mean flow (m^3/s)	Upper control level (m)	Lower control level (m)	Operating range (m)	Approx. vol. ($m^3 \times 10^6$)	Approx. lake area (km^2)		Max. (m^3/s)	Expected min. (m^3/s)	
Upper Clutha:													
Hawea outflow	–	–	$\leqslant$73.2	60	347.4	327.4	20.0	–	120	300	300	300	river
Wanaka outflow (incl. Cardrona)	–	–	–	200	–	–	–	–	200	150	150	150	river
Upper Pisa	250	750	42.7	270	273.7	271.9	1.8	12	6.7	450	700	$\geqslant$0	UC8 lake
UC8	220	645	36.6	270	231.0	229.8	1.2	1.9	1.6	450	700	$\geqslant$0	DG7 lake
Kawarau:													
Wakatipu outflow (incl. Shotover)	–	–	–	200	310.3	309.3	1.0*	–	280	200	200	200	river
K7/2	150	645	51.2	200	306.6	304.2	2.4	6.7	2.8	200	350	0	K9 lake
K9	260	820	50.3	200	255.4	253.0	2.4	5.5	2.3	200	600	5†	river
Main Clutha:													
DG7	365	1060	34.4	480	194.5	192.9	1.6	35	22	650	1350	150	DG3 lake
DG3	250	705	22.9	480	160.0	159.1	0.9	1.8	2.0	700‡	1300	150	river
Roxburgh	320	1500	46.3	500	132.0	129.2	2.8	17	6.0	750‡	800	500	river
	1815	6125											

* Restricted. † Nominal. ‡ Assumes weekday drawdown on DG7 lake.

Having looked at the general electricity generation system, let us now look at the Clutha proposals in detail. It has been said on many occasions in the past that the Clutha is being developed as a peak-load river system. Before going any further let us look at the individual plant factors of the stations proposed in the Commission's interim report. The average plant factor of the new proposals is 35 percent which, when combined with Roxburgh, will give an overall plant factor of the river system of about 40 percent. Individually the plant factors of the stations range from a minimum of 32 percent for DG3 to a maximum of around 45–50 percent for K7/2. The electrical and hydrological parameters of the individual stations are set out in detail in Table 1.

It will be noticed that a departure has been made from the traditional method of designing a river system to the extent that the full-load station discharge has not been set primarily by the natural mean river flow but by the requirement that the individual stations should operate as an integrated part of the river system. Use is made of both the individual lake storage and the lake inflow pattern of each station in the determination of the amount of machine capacity that could be installed in each station. The effect of this has been that in general terms the plant factor of each successive station on the river is lower than that pertaining to the station above. Expressed in terms of station outflow, a typical chain exists on the Kawarau where the maximum station outflow of K7/2 at present is scheduled at 350 m^3/s, followed by a maximum outflow from the next station K9 of 600 m^3/s.

The flows mentioned are the maximum that can be achieved when the station is required to operate at full output. Typically in winter this situation will only occur for several hours each day. During the night period of low electrical demand the station will be turned down to the lowest practicable level. In the case of K7/2, for example, the night load is expected to be zero, with the night load of K9 somewhere in the order of a nominal discharge of 5 m^3/s.

On the Upper Clutha, because of the existence of canals at both the Upper Pisa and UC8 stations, and the small storage lake associated with the latter, the principles just described for the Kawarau River cannot be applied, i.e. the UC8 station will essentially be operated in tandem with the Upper Pisa station, the maximum discharge being 700 m^3/s as shown in Table 1.

The DG7 lake with its significant amount of storage has two prime functions: (1) to allow the wide fluctuations in inflow from both K9 and UC8 to be partially smoothed to ensure that the flow out of DG3 is maintained within acceptable limits; (2) to provide sufficient weekday storage such that the lake can be successively drawn down at a rate of approximately 0.3 to 0.4 m per day during the winter to allow the DG7, DG3 and Roxburgh stations to generate additional energy on those days.

The main constraint on the river system has been assumed to be the variation in daily streamflow that can be sustained in the open stretch of river between Clyde and Alexandra. It has been assumed that maximum flow in this stretch should be limited to 1300 m^3/s. Under those circumstances which would require the DG3 station to operate during daylight hours at this high flow, the minimum streamflow at night would be 150 m^3/s. The operation of the DG7 station will essentially follow that of DG3 because the lake volume at DG3 is too small to adjust the inflow pattern significantly.

It is not expected that the full peaking capacity will be installed in both the DG7 and DG3 stations until the late 1990s. During the intermediate period from 1982 the full load station flow from DG7 and later DG3 will be of the order of 750 to 800 m^3/s. This period of about 15 years will enable the possible effects of the higher daily flows in this stretch of river to be evaluated with some accuracy.

So far I have been dealing specifically with the maximum potential of the river system. It must be emphasized that the flows previously discussed should not be regarded as typical of the daily operating pattern of the stations throughout the year.

Under normal operating conditions the lake range utilized will be significantly less than the maximum range recommended by the Clutha Valley Development Commission in its interim report. For example, the Kawarau lakes are expected to operate over a range of about 1.5 to 2 m, somewhat less than the maximum recommended range of 2.4 m. The full weekday facility of the DG7 lake is likely to be used only during the high-demand periods in winter under extremely dry inflow conditions. During the summer it is expected that the successive drawdown facility would not be used and that the daily lake fluctuation would be of the order of 0.5 m. A noticeable exception will be the DG3 lake, where it is expected that the full 0.9-m range will be utilized regularly. During the summer period, operation of the Clutha proposals will not normally utilize the full capacity of the installed plant. This will be of benefit for recreational use of the lakes.

In conclusion I would like to emphasize that the Clutha power proposals will perform a continuing vital function in the power system and are crucial to the well-being of the South Island. As a renewable energy source, taken over, say. 100 years the potential of the whole Clutha River has an electrical equivalent of a similar order of magnitude to the total measured, indicated and inferred coal resources in this country, and is significantly larger than the electrical equivalent of the Kapuni and Maui natural gas fields combined.