This report *Electricity in New Zealand is there a surplus to sell?* has been prepared by Geoffrey Bertram and Keith Johnston for the Development Information Group.

WE CONCLUDE:

1) We have built more power stations than we need.

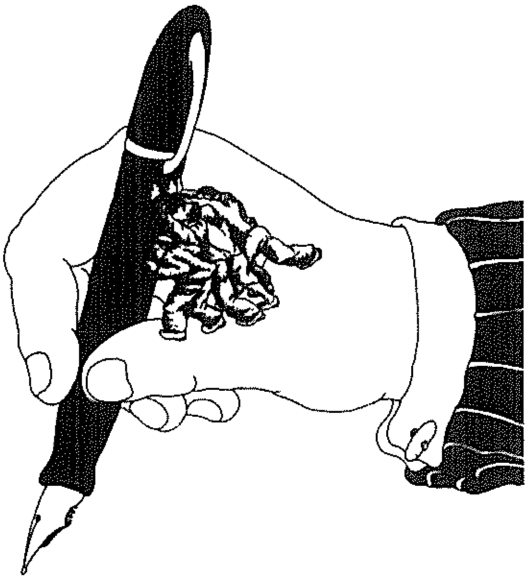
2) Only a small part of this extra capacity is in South Island hydro stations. Most of it is in North Island stations which burn coal, gas, and imported oil.

3) The Government proposes to sell off large amounts of electricity at low prices and under long-term contracts. The cost of supplying this power will treble in real terms between 1988 and 1994.

4) An electricity price which rises to cover the cost of supplying the power is unlikely to attract aluminium companies to New Zealand. Only prices which are subsidised by the New Zealand community are likely to be attractive.

5) The Government has yet to provide the public with good, substantiated, reasons for using our scarce resources to subsidise multinational aluminium companies.

The Development Information Group



The Development Information Group has been formed as a part of the Coalition for Open Government, the organisation which actively fought the passage of the National Development Act.

We aim to research and publicise the national economic, environmental and social impacts of development strategies available to New Zealand. This information is essential if New Zealanders are to participate in their government.

We are seeking a development strategy that will: provide employment and purpose for people, respect natural systems, and use resources wisely.

There is much to be done. Our society and our economy are going through a period of rapid change. If we are to have control over these changes and how they will affect our lives then we will need relevant information. The Development Information Group hopes to provide this information. To do this we will produce a regular newspaper and prepare special reports such as this one.

We will need your support. You can contribute your time, information on what is going on in your area, and/or money to publish reports and newspapers or to keep our wage pool solvent.

Write to us at: The Development Information Group,
P.O. Box 6133,
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Acknowledgements

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Introduction

To most people, electricity is lights and switches, three-point plugs, bar heaters and TV, fridges, hot water, and six-weekly bills. Bills that are getting bigger.

Rising bills reflect the rising cost of generating electricity. The rising costs: building new stations, operating them, and buying the fuel for thermal stations.

Yet now New Zealanders are being told that there is a surplus of electricity. That we will not be needing the electricity generated at the new stations - paid for from our power bills. Instead, this power is being offered at cut-price rates to large industries prepared to establish in the South Island.

Is there an electricity surplus? How did it occur? How big is it, really? What will it cost to sell the electricity cheaply? What effect will this have on New Zealand's future development?

In this report we try to answer these questions. The choices involved will shape our society and economy for the next two decades. The public interest demands that these choices be made properly, on the basis of the best available evidence and advice, and in the open view of the public at large.

These questions and their answers are not the preserve of technocrats. They are political, moral and social issues, which should be debated freely and openly. If the Government wishes to carry New Zealanders with it in its development policies it must not only make the right choices - it must be seen to make the right choices. Where citizens encounter secrecy and evasion on these issues, they are entitled to suspect bad planning and bad conscience.

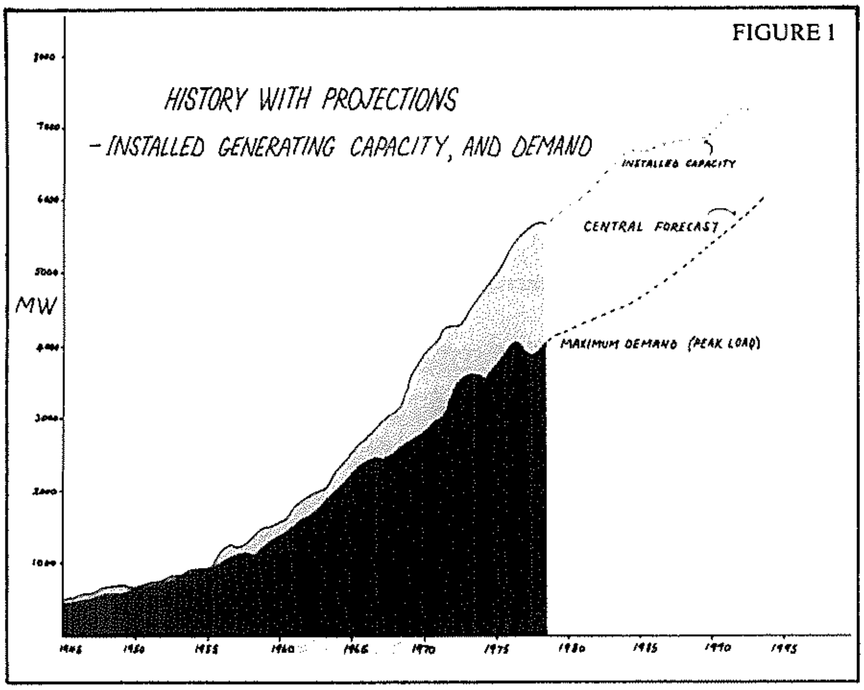


FIGURE 1

History With Projections

NEW ZEALAND has built hydro-electric power stations based on four major river systems and a string of thermal stations, fired by oil, coal, natural gas and geothermal steam.

At present, in a mean year, the hydro stations supply more than 85% of the electricity consumed in New Zealand. 6% is generated by the Wairakei geothermal station, and the remainder from fossil fuels, both local and imported.[1] In a dry year, hydro generation drops to less than 74% and the fuel stations' share increases accordingly.[2]

Virtually all major electricity generating stations in New Zealand have been built and operated by the Government, and the growth of the system has been planned by officials of the NZ Electricity Department, now the New Zealand Electricity Division of the Ministry of Energy. The history of our electricity system since 1945 is the history of their decisions and the construction work which resulted from them.

The period divides naturally into two: the years of power shortages and planning for growth, from 1945 to 1973; and the present era of coming to terms with excess capacity.

In the first period, power planning was dominated by the quest for an end to shortages and power cuts. The dominant attitude was summed up by the Hon. Hugh Watt (then Minister in Charge of the State Hydro-Electric Department) in 1958:

"The provision of adequate amounts of electric power has proved to be a very difficult matter over a long term of years. Since the early days of the last war, there has been a constant struggle to provide sufficient materials, manpower and money, and periods of sufficiency have alternated with periods of shortage. The rate of growth in the demand for electric power is such that the supply has to be doubled every eight years and this calls for a high rate of expenditure on capital works year by year."[3]

By the early 1970s, this race between growing demand and expanding generating capacity had begun to move decisively in favour of capacity. New power stations continued to be planned and built at a rapid rate, but the growth of demand was falling below the planners' predictions.

By the late 1970s, the conventional wisdom had swung away from the "shortage" view, and energy planning was proceeding on the basis that New Zealand now had an "electricity surplus" which should be disposed of by cut-rate sales and a search for new large-scale buyers.

The transition from the first to the second era has taken about seven years (since the 1973 oil crisis).

The key people in the previous era were the power planners of the NZ Electricity Department. Despite their weaknesses they published, and continue to publish, reasonably fully-documented annual reports.

In the new era, the key planning is being conducted in a less formal manner, out of public view and less open to public scrutiny. Decisions to sell huge amounts of electricity on a long-term basis are being made, and the commitments undertaken, secretly by officials in the Department of Trade and Industry, the Department of Energy, and the Treasury.

Our main object in this paper will be to provide some of the essential background to these decisions.

Mean and Dry Years

When farmers say that it has been a 'mean year', they usually mean that there has not been much rain. Power planners have a different meaning for 'mean year'. Their mean year occurs when river flows are normal. Historically river flows have been normal, or heavier than normal, for 42% of the time. One fifth of the time river flows are at least 10% less than normal and for about one year in twenty rivers carry only 85% of their normal flow. This 'one-in-twenty-year' is what power planners officially call a 'dry year'. The electricity system has to be designed to have enough spare capacity to ensure electricity supplies in these 1-in-20 dry years.

The Electricity Surplus: Where And What Is It?

The Government's development strategy for the coming decade is based on the idea of an electricity "surplus" which can be sold off cheaply to attract new large-scale industries.

On this page, we reproduce material from page 58 of the Government's recent publication *Growth Opportunities in New Zealand.* The main feature is a graph comparing predicted demand with potential minimum (that is dry year) electricity generation. All the figures used in constructing the graph are national totals.

Such overall totals are very misleading. In this section, we shall look in detail at the actual composition of the "surplus".

The key conclusion of this section is

Day by Day

The milkman is not the only thing moving at four o'clock on an average New Zealand morning. Metal is being smelted, wood pulped, food processed, essential services maintained, and in homes, water heaters and home freezers are operating. All these activities are consuming electricity. Yet this is the low point of the daily demand of our electricity system.

Electricity demand at this point is called baseload demand. Baseload electricity stations are used to generate electricity at a constant rate. The geothermal station at Wairakei is our most constant electricity producer. Most of baseload power is generated by downstream dams which must pass an even flow of water to prevent erosion, silting and damage to fish and scenery. Large fuel station such as New Plymouth and Huntly are also designed to be 'baseloaded' as continual stopping and starting reduces equipment life.

By 7 am, people are waking and the power goes on. In three hours, demand has doubled. Hydro station gates open automatically to follow this demand. Thermal stations are fired up.

This extra demand is the intermediate load. Apart from a dip in the early afternoon, the system must generate at least this amount until 11 pm, when demand gradually declines to the 4 am low. Intermediate load stations follow the daily rises and falls in demand. Most of the hydro stations are operated in this way.

Demand peaks between 6 and 7 pm, when dinners are cooking and in winter when heaters are also on. Peak load stations, which can be switched on quickly, are fired up and the gates opened on the hydro peaking turbines. On the very coldest days thermal peaking stations such as Otahuhu and Whirinaki may run for an hour or two.

(Sources: S. Wong & M. Hewlett, *The Comparative Economics of the Principal Forms of Electricity Generation;* and M. Melhuish, CNNF, *Second Submission to the Royal Commission on Nuclear Power in NZ* 6/77 p.4)

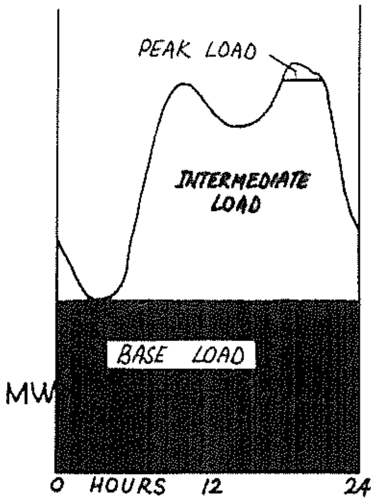


FIGURE 2 A typical daily electricity demand curve with the conventional division into base-intermediate- and peak- loads.

Peak Load Plant

(annual plant factor up to 15%)
Can be started up very quickly for short periods of running. Examples are the Maraetai and Waipori Hydro Stations and the Otahuhu and Whirinaki gas turbine stations which are only used as a last resort.

Intermediate Load Plant

(annual plant factor between 15-55%)
Built to follow the rises and falls in daily demand shown on the graph ('load cycling'). Examples are most hydro stations and Meremere and Marsden thermal power stations.

Base Load Plant

(annual plant factor 55% or greater)
This category of plant may be relatively inflexible unless designed, at extra cost, to be capable of load cycling. Examples are New Plymouth, Huntly and Wairakei thermal power stations and some turbines in the lower dams in the river systems such as Karapiro, Manapouri and Roxburgh.

that **the Government's claim that the 5,000 GWh surplus is "largely made up of hydro power in the South Island" is false. The so-called surplus does indeed have a definite regional character, but only a small part of it consists of power from renewable South Island sources. The great bulk of it is excess generating capacity in North Island fuel-burning stations.**

As an introduction to the anatomy of New Zealand's electricity surplus, we set out below some figures taken from the official statistics, but rearranged in order to show the balance between supply and demand in the North and South Islands separately, and to distinguish among the various sources of supply.

We have taken the central forecast of demand (the same as that used for the *Growth Opportunities* booklet) and the "mean year" level of electricity generation rather than the dry-year level, since (1) over longish periods of time, this represents the average situation to be expected (with a true dry year only once every two decades), and (2) if we were to use the dry-year electricity generation figures there would be no electricity surplus in the South Island at all (except for 47 GWh in 1984/85, an amount so small that it can be ignored). This would leave the Government without a leg to stand on, and us with nothing to discuss.

FIGURE 3

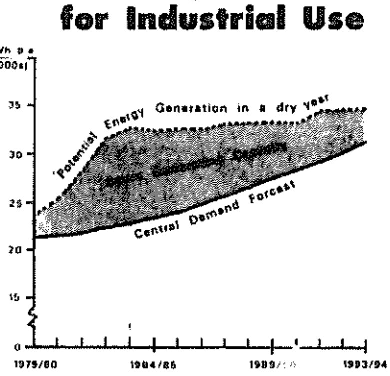
New Zealand is fortunate in having, at present, a surplus in generating capacity—largely made up of hydro power in the South Island

The capacity available and its price

At least 5000 GWh per annum of electricity could be available. The Government has decided that during the time of spare capacity electricity will be made available for certain industrial developments at a concessional price.

The concessional rates are negotiable having regard to the national and regional benefits involved, and will be available to companies that locate in the South Island and that install new plant which uses more than 25 GWh of electricity per annum. This will tend to limit the scheme to electricity intensive processes.

Electricity Available for Industrial Use



To construct our table, we have added up the total flows of energy (measured in GWh) for the fourteen years from 1980/81 to 1993/94. (This is the period from now until the end of the forecasts published in the 1979 Power Plan.) The **average** annual flows for the period can then be found simply by dividing by fourteen. The result is a rough, but not too misleading, picture of the overall situation for the 1980s and the early 1990s.

Since the NZED will run its fuel-burning stations at whatever level is necessary to meet North Island demand, and since these stations have plenty of generating capacity in hand, a balance of supply and demand can be expected in the North Island.

The only surplus in our table is thus the 17,823 GWh of uncommitted South Island hydro power which cannot be sent north because of the limited capacity of the Cook Strait cable, and which therefore must be either used in the South Island, or spilled to waste.

Now 17,823 GWh over fourteen years is an average of about 1,270 GWh per year, and that is the full extent of New Zealand's true surplus of renewable electricity. All of the so-called "surplus" over and above this excess electricity trapped in the South Island consists of idle generating capacity in fuel-burning stations in the North Island. It must be remembered that these cost money to run. To bring this power into existence, the NZED would have to buy gas, coal, and imported oil.

Most of the Government's expected "surplus" is thus a mirage - it is not free hydro-electricity at all, but relatively costly thermal power.

In a "dry year", when there is less water available for generating hydro-electricity, there will be no South Island surplus power, once local demand and the Cook Strait cable have taken their share. In most years, between now and 1994, a drought will not only eliminate the uncommitted South Island surplus, but also reduce the amount of power available for transmission over the cable. This will mean that fuel-burning stations in the North Island will have to take up the slack.

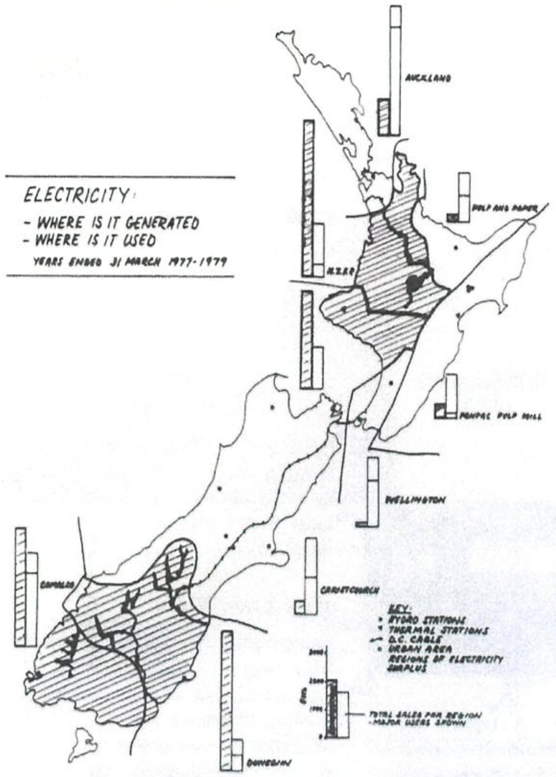
Large-scale sales of power to new industries in the South Island will simply increase the amount of power which must be produced from North Island thermal stations in any dry year.

We can thus suggest the following two general conclusions:

1. On mean-year figures, and using annual averages over the next fourteen years, New Zealand has a hydro-electricity surplus averaging less than 1,300 GWh per year. There is, in addition, a considerable amount of idle fuel-burning generating plant in existence, but this is not the same as "surplus electricity" since fuel must be bought to run these plants. (Building the Clutha scheme would add 1,800 GWh per year in the early 1990s but at a cost of more than 3c per kWh.)

2. In a one-in-twenty dry year, the central forecast shows no surplus at all.[4] In planning to use up the surplus, it is important to make allowance for dry years, remembering that in such years the shortages of power from renewable

FIGURE 4



The National Grid

More than 86% of our electricity is generated in two areas of the country: Otago-Southland, and Waikato-Taranaki. Power from each of these producing regions is transmitted northwards to the main consuming areas: to Canterbury, Nelson, and the southern North Island in the case of power from Waikato-Taranaki. The map on this page shows the amounts of power produced and consumed in the major producing and consuming regions, and the inter-regional flows in a typical year.

The Otago-Southland electricity producing region is dominated by the hydro electric stations on the Waitaki and Clutha Rivers, and at Lake Manapouri. On the basis of figures for the three years to 31 March 1979, about one-quarter of total South Island electricity output was consumed by the Comalco smelter at Bluff. Another 20% was taken by domestic and industrial users in Otago and Southland. A further 13% went to Christchurch, 15% to the rest of the South Island. More than one-quarter of electricity produced in the South Island was sent up the transmission line from Benmore, across the Cook Strait cable to the North Island.

Of total North Island electricity demand, the Wellington urban area accounts for one-eighth, and the rest of the southern half of the island (supplied basically from the Cook Strait cable) accounts for a further 22%.

Almost one-third of total North Island demand comes from Auckland urban area, and another 12% or so comes from the five major pulp and paper mills.* Consumers in the northern North Island are supplied from the Waikato-Taranaki producing area.

The core of this power generating area is the eight hydro stations and one geothermal station along the Waikato River, together with a set of large fuel-burning thermal stations. The New Plymouth gas-fired station provides baseload power, while the Stratford gas-fired station, the Meremere coal-fired station, and the oil-fired Marsden station are used to meet intermediate loads, supplementing Waikato hydro in both cases.

* The five pulp and paper mills are: Tasman; NZ Forest Products at Kinleith and Whakatane; Carter-Oji Panpac; and Caxton. The sixth mill at Karioi commenced operations only in late 1978 and has been excluded from our three year calculations here.

TABLE 1

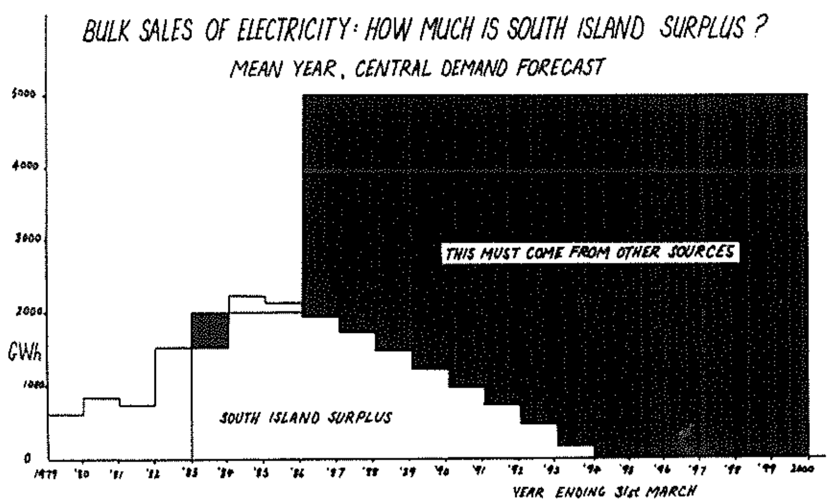
South Island	GWh fourteen year totals 1980/81 to 1993/94
South Island mean-year generating capacity (all renewable)*	198,823
minus South Island projected demand (without new smelters) central forecast	122,200
Gives total South Island excess supply	76,623
minus exports to the North Island via the Cook Strait cable @ 4.200 per annum	58,800
gives UNCOMMITTED SOUTH ISLAND SURPLUS	17,823

*Excluding Clutha, since this is yet to be finally approved, but including the Upper Waitaki stations.

North Island	GWh fourteen year totals 1980/81 to 1993/91
North Island mean year generation from renewable sources (hydro and geothermal)	122,608
plus imports from South Island via Cook Strait cable (minus 10% transmission loss)	52,920
gives total electricity from renewable sources available for North Island	175,528
Compare this with projected North Island demand, which is:	235,800
and we have the **deficit** of power from renewable sources (that is the amount that must come from fuel-burning stations)	60,272

Source: All data is drawn from the 1979 Report of the Planning Committee on Electric Power Development, with North and South Island demand dis-aggregated on the basis of information supplied by NZED.

FIGURE 5



sources have to be made up by burning fossil fuels.

The Government, nevertheless, is proceeding with plans to sell as much as 5,000 GWh per year to energy-intensive industries at concessional rates. On average, over the next fourteen years, only between one-quarter and one-third of this will be power from South Island hydro stations (even if Clutha is built). The rest will have to come from North Island fuel-burning stations.

Our figures so far have been averages over the full fourteen year period, and thus do not show the detailed story of what is likely to happen year by year if the Government proceeds with its planned sales. In Figure 5 we show the annual level of the South Island surplus, on the basis of the central official demand forecasts, mean year generation of electricity, and annual transfer to the North Island over the Cook Strait cable of 4,200 GWh. We exclude Upper Clutha power, which does not form part of the unavoidable South Island surplus.

On the same graph, we show the implications of selling off large blocks of power to smelters and other energy intensive industries. We assume that the first 2,000 GWh of cheap power would be taken up in 1983/84 and the rest of the 5,000 GWh would be taken up in 1986/87. These dates are chosen as being the most likely starting-up dates for the energy-intensive industries planned now.[5] There are three rather clear conclusions to be drawn from this graph;

1. The sale of 2,000 GWh will almost fully absorb the South Island surplus even at its peak in the mid 1980s. After 1985/86 it will require a steadily growing reduction in the amount of power available to be sent north over the Cook Strait cable (thereby increasing the amount of power which must come from fuel-burning plants in the North Island).

2. A commitment to supply a total of 5,000 GWh per year is enormously in excess of even the peak South Island surplus, which will never rise above 2,300 GWh in any year.

3. By 1992/93 the South Island surplus will have shrunk to less than 500 GWh. The total amount of power presently being sent up the Cook Strait cable is only 4,200 GWh, so that even ending **all** South Island electricity exports will not free enough power to make up the 5,000 GWh. At that stage, only the construction of the Clutha scheme would avoid a situation where the South Island would actually have to **import** North Island power over the Cook Strait cable throughout the 1990s.

How Will A 5000GWh Commitment Be Supplied?

In any discussion of the Government's plans to sell of 5,000 GWh of electricity at cheap rates, the key questions are where this power will come from, and what it will cost. In this section we consider the first of these questions; the next section will discuss the cost.

The problem which New Zealand will face, if the 5,000 GWh is promised, is already evident in Figure 5. Only a small, shrinking, part of the 5,000 GWh can be supplied from the surplus hydro electricity available in the South Island. Most of the power will have to come from the existing North Island fuel-burning stations, together with any new power stations which may be built during the next two decades. The Government has not yet explained how it proposes to supply this power, so the best we can do is try to work out what some possible answers might be, and what they would cost.

There are a number of fuel-burning stations with idle generating capacity already in existence; they are listed in Table 1 of Appendix III. Of the eight stations, four use imported oil and are an expensive source of electricity (more than 5 cents per kWh just to pay for the fuel, at today's oil prices). The other four stations use locally-produced fuels, but may not all be able to operate at full capacity because of specific problems:[6]

Gas from the Maui field will not be available in unlimited quantities once the methanol and synthetic-fuels plants are in operation in the late 1980s, so that the New Plymouth and Stratford stations are likely to be restricted to running only part-time.

The New Plymouth station can burn oil, but that would raise the fuel cost of its power from 1.1 to more than 5 cents per kWh.

Meremere is an old station due to be scrapped (unless a last-minute reprieve is decided upon).

That leaves only the new Huntly station free to expand its output of power to help supply the 5,000 GWh. We shall therefore assume that so long as there is some spare capacity available at the Huntly station, this will be used to provide part of the 5,000 GWh.

Once Huntly is committed, the only other excess capacity that can be brought in without technical problems is in the oil-fired stations, Marsden A and B. A decision to rely upon oil to provide a substantial, and growing, share of the 5,000 GWh would mean that the building of new power stations could be deferred until the mid-1990s, but the cost of running the oil-fired stations is so high that we assume the Government will in fact prefer to build some new stations based on hydro or coal resources.

In Figure 6 opposite we set out three possible options for supplying the 5,000 GWh sale. Detailed background to our calculations will be found in Appendix 5.

As Figure 6 shows, the utilisation of South Island surplus, plus extra output from Huntly and the saving of power which would otherwise have been lost in transmission on the way from the South Island to the North, would make it possible to supply a 5,000 GWh commitment only until 1988/89. After that, some other additional source of supply is required.

"We will be committing ourselves either to burning imported oil ... or to building a series of large new electricity stations, or both."

In Appendix 5 we explore the various possibilities, and conclude that a firm commitment to long-term bulk sales would almost certainly be accompanied by a final decision to proceed with the Upper Clutha hydroelectric development. If the timetable set out in the 1979 power plan is followed, this would bring the Clyde dam into operation in 1991/92, contributing about 1,800 GWh per year towards the 5,000 GWh target from then on. In the mid 1990s the Luggate dam would bring total Clutha output up to 2,550 GWh, but an unknown proportion of this would be needed to service the normal growth of South Island demand. In part (a) of Figure 6, we therefore show the Clutha scheme contributing a steady average of 1,800 GWh towards the target through the 1990s.

Alternatively, the construction of the Clutha dams might be brought forward, bringing Clyde into operation in 1989/90 and Luggate in 1991/92.[7] In part (b) of Figure 6 we show the Clutha dams contributing 2,550 GWh annually from 1992/93 on. (This assumes that growing South Island demand does not put competing pressure on Clutha power.)

As the South Island surplus shrinks to nothing and Huntly runs out of spare capacity in the early-mid 1990s, even bringing the Clutha scheme into our graph leaves a gap of between 2,000 and 3,000 GWh per year which must be filled from some other source, which we assume to be one or more North Island fuel-burning stations.

Options 1 and 2 in Figure 6 assume the construction of a new coal-fired station in the Waikato to meet this demand. Option 3 takes into account the possibility that the Government might decide to burn more oil in order to run the Marsden power stations at about 60% capacity.

Other less likely possibilities (such as building another Maui platform to supply gas for electricity generation, or embarking on some huge as-yet-unannounced new hydro-electricity project somewhere in New Zealand) appear to be of similar or greater cost than the two we have chosen, so that our conclusions later on will not be affected by excluding them.

Our essential conclusion from this section is that **supplying a 5,000 GWh commitment is not just a simple matter of turning on our existing excess capacity. We will be committing ourselves either to burning imported oil to supply part of the power, or to building a series of large new electricity generating stations, or both.**

Scarce New Zealand resources will have to be diverted from other uses in order to pay for the construction of new stations, just in order to keep supplying cheap power to giant energy-intensive industries.

Honouring our commitment, in other words, will cost us a lot of money. The next section asks whether we are likely to get a reasonable return on that money.

FIGURE 6

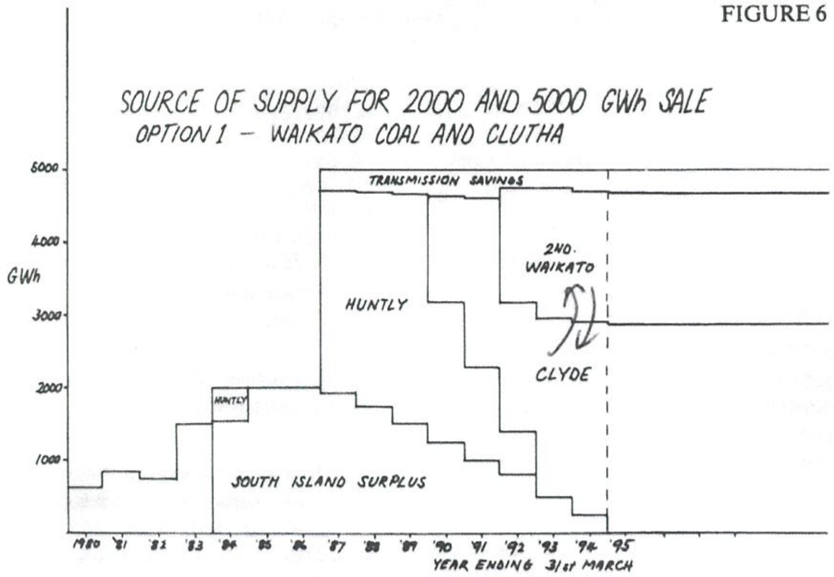


FIGURE 6

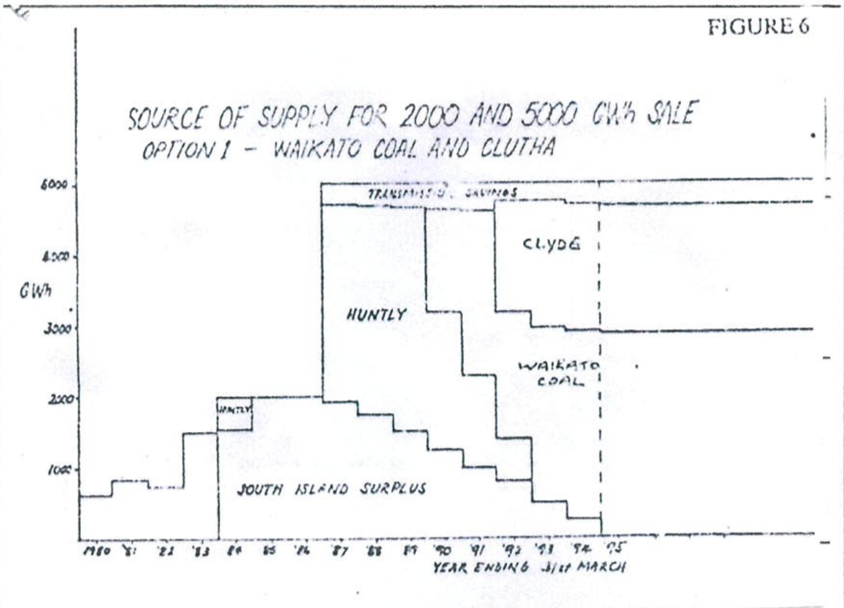
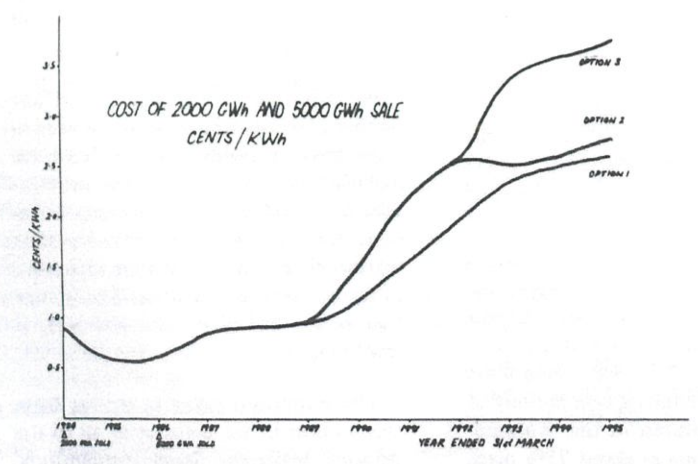


FIGURE 7



What Will It Cost To Supply the 5,000 GWh?

Not much to begin with, but a lot later on.

As Figure 6 demonstrates, a long-term contract made now to supply 5,000 GWh annually over the next couple of decades will commit New Zealand to supply somewhat different things at different times.

For two years in the mid-1980s we would be providing 2,000 GWh of surplus South Island hydro power. By the end of the decade, the commitment could work out as roughly 1,500 GWh of South Island surplus hydro, 3,000 GWh of power from the Huntly coal-fired station, and 500 GWh gained from the previous transmission losses on the Cook Strait cable.

Five years later less than ten percent of the 5,000 GWh would be coming from South Island surplus hydro and Huntly **combined.** By then, the main commitments would be to supply 1,800 to 2,500 GWh from the new and costly Clutha scheme, and most of the rest from either a new Waikato coal-fired station, or the oil-burning Marsden stations.

Obviously, as the resources which we must use to meet our commitments change, so too will the cost of meeting our commitments change. When negotiating power sales for very long periods of time (20 or 25 years) it is vital to ensure that the price which will be paid for the power will **at the very least** cover the cost to New Zealand of providing it.

As we move from surplus hydro-electricity into the generation of power from new hydro and coal-fired stations, the cost will rise sharply. If this increase in cost is not written into the supply contracts, it will have to be met by a subsidy from the New Zealand community.

The key cost to identify, from New Zealand's point of view, is what economists refer to as the "marginal cost" of supplying new consumers such as smelters. Marginal cost is the **extra** expenditure which the NZED must incur in order to supply **extra** power. If new users of electricity pay a price for their power which exactly covers this marginal cost, then existing consumers are left no better off and no worse off than they were before.

So far as existing generating stations are concerned, this means that the existing purchasers of power continue, as before, to pay the full capital charges (interest and depreciation) on these plants. While the new consumers pay only the extra operating costs involved in producing more power from the stations.

Where new power stations must be built to supply the new consumers, then the full construction costs, as well a the operating costs, of these stations must be charged to the new bulk purchasers. If these costs are not met by the users of the power, then they will fall on some other section of the community (presumably the taxpayer and/or the other electricity consumers).

Once calculated, the marginal cost of power gives us the **minimum** that should be charged to new users when the Government is negotiating contracts for long-term sales. Selling power at marginal cost confers **no benefit** on New Zealand - there is nothing in it for existing consumers (who will continue to pay the same prices as before), and nothing in it for NZED, which will make no profit whatever from the sales. The marginal cost is **not** the price we should aim for in negotiations - it is the **absolute minimum** below which we cannot afford to go.

Sales of power at marginal cost can be justified only if (a) there are no other potential buyers **at all** willing to pay a higher price for **any** of the power; (b) there are some net economic benefits to New Zealand other than income from electricity sales, since the net income from those sales is zero; and (c) there are no social, environmental, emotional, or political costs for the New Zealand community as a result of the contracts.

If we are going in for large-scale power sales, then, our negotiating aim must be to ensure a price for our power which is significantly **above** the costs which we calculate in the next part of this section.

In order to work out what it will cost to supply a 5,000 GWh block of electricity to new bulk users, we take the scenario set out in the preceding section and assume that the 5,000 GWh sale is negotiated as a single block. (This is equivalent to saying that all new users obtain their power on equal terms. An alternative assumption could be that

TABLE 2

Cost of Supplying Extra 2000 GWh and 5000 Gwh
cents/KWh

	Option 1 Clyde & New Baseload Coal Station	**Option 2** Advance Clutha & Baseload Coal	**Option 3** Advance Clutha & Oil
2000 GWh sold			
1983/84	0.89	0.89	0.89
1984/85	0.62	0.62	0.62
1985/86	0.64	0.64	0.64
5000 GWh sold			
1986/87	0.87	0.87	0.87
1987/88	0.90	0.90	0.90
1988/89	0.96	0.96	0.96
1989/90	1.33	1.58	1.58
1990/91	1.61	2.25	2.25
1991/92	2.13	2.66	2.66
1992/93	2.45	2.54	3.40
1993/94	2.50	2.67	3.58
1994/95	2.59	2.82	3.77

Option 1: Assumes that a new Waikato coal-fired station would be commissioned by 1989/90 and the Clyde dam would be commissioned in 1991/92. The feasibility of the coal station is uncertain. This casts doubt on the realism of this option.

Option 2: Assumes that the Government advances the Clyde dam completion date to 1989/90 and the Luggate dam is commissioned in 1991/92. A nWaikato coal-fired station is commissioned in 1992/93. Some oil-fired generation is required in mean years in 1990/91 and 1991/92.

Option 3: As for option 2, without a Waikato coal-fired station. Oil is burnt in mean years from 1990 onwards. Recent Government statements appear to favour this option.

See Appendix V for details.

some of the new users will pay more than others; if so, the **overall** average price received must come out to the figures set out below.)

The five sources of supply for our 5,000 GWh sale were set out in Figure 6. Two of them are virtually costless (once we take their capital costs as sunk cost), namely the South Island hydro surplus and the reduced transmission losses for the New Zealand grid system (as a result of scaling down the transfer of power over the Cook Strait cable from south to north).

The other three sources of supply are another matter. Huntly costs 1.2 cents a unit to run, **excluding** capital charges - this is just the cost of fuel, plus operating and maintenance costs incurred in order to step up the level of generation from the station.

Turning to the possible new stations that might be built to help supply the 5,000 GWh, the proposed Clutha scheme will produce power at a cost of 3.0-3.1 cents per kWh (depending upon the length of the construction period). A new coal-fired station in the Waikato, designed to operate at about 75% plant factor in mean years, would provide power at a somewhat lower cost - possibly as low as 2.5-2.6 cents per kWh. Power from the oil-burning stations at Marsden Point would cost at least 5 cents per kWh.

In Table 2 we show the overall marginal cost of supplying the 5,000 GWh, with the "gap" filled by a new coal-fired station, and with the alternative possibility of using oil to generate the power at Marsden. In both cases we have marked up the mean-year costs to allow for the extra cost of providing spare capacity for dry years.

We have not taken account of any further costs associated with the need to meet peaking needs, and we have not included the cost of providing transmission lines and other distribution infrastructure, nor the administrative costs for the NZED from such an expansion of its operations. In other words, our figures are biased on the low side, if anything.

The important point to emerge from this section is not sensitive at all to the detailed problems about assumptions, forecasts, and precise timing.* It will survive adjustments to our figures over quite a wide range. It is the key point to bear in mind when looking at any long-term power contract entered into by the Government. It can be summarised as follows:

During the next ten years we are capable of supplying 5,000 GWh of extra electricity at a cost below one cent per unit. Between 1990 and 1995, however, the cost rises from one cent to about three cents per unit. This escalation is over and above any inflation that may occur during the next twenty years - all our calculations are in 1980 dollars.

Any supply contract which is to last more than ten years must take into account the fact that the cost of supplying this block of power will treble in real terms between 1989 and 1995, and that thereafter the power will continue to cost three cents or more per unit, in 1980 dollars.

* Using a lower demand forecast than the central forecast used here does not eliminate the need for power from Waikato coal and Clyde — it merely defers some of it.

Long-term contracts, in other words, are very risky things which New Zealanders may come to regret. To indicate the risks involved, consider the case of an aluminium smelter such as has been proposed for the South Island.

Aluminium smelting companies would be delighted to obtain power at the sort of price which New Zealand can afford to charge during the mid-1980s, but there is not the faintest possibility of persuading them to commit themselves to pay what their power will cost to produce in the 1990s. Any long-term contract signed with aluminium companies is therefore likely to involve an initial price which favours New Zealand during the four or five years when the smelter would be utilising a large block of surplus power, but an escalation clause which utterly fails to keep pace with the rise in the true cost of power thereafter.

New Zealand in the 1990s would then face huge losses on its power sales to the smelter - losses which could dwarf any early gains. 0.1 cents per kilowatt-hour may not sound a great deal, but on a bulk sale of 5,000 GWh per year this adds up to $5 million per year — this means that an agreement to supply power at one cent per unit below its true cost would lose New Zealand $50 million annually.

In a world where other countries are signing long-term contracts to supply aluminium smelters with power at 1.5 cents per unit with no escalation,[8] we would suggest that **New Zealand cannot afford to offer long-term electricity supply contracts at a price that could be attractive to aluminium smelting companies.**

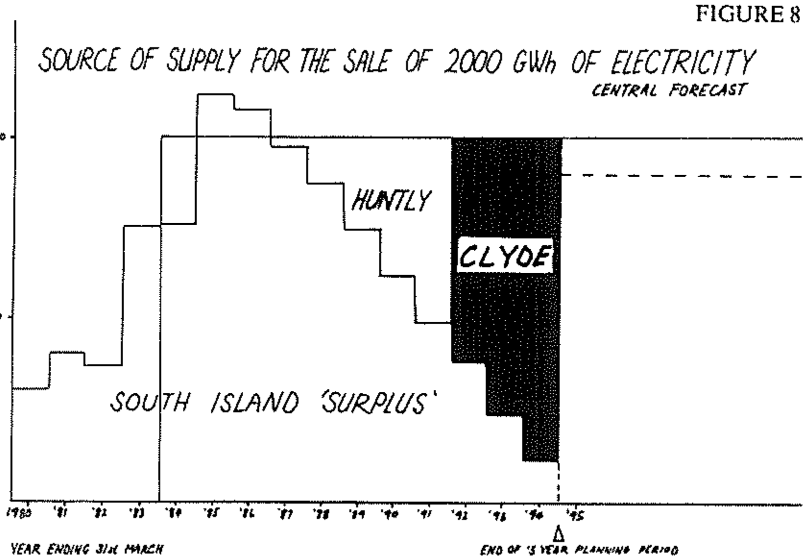
The fact that such companies are obviously attracted to New Zealand at present suggests that they are secretly being offered a price which we as a community cannot afford to offer. It is therefore imperative that the Government make public the terms of any proposed contract **before** final signature commits us irrevocably to a new Comalco saga (renegotiations and all).

In concluding this discussion of costs, we would emphasise that our analysis has been narrowly focussed and that we have ignored several very important categories of costs for New Zealanders at large if the proposed bulk sales go ahead. In addition to the financial costs of building giant new power stations to supply smelters, there are substantial environmental and social costs.

Along the Clutha, one of New Zealand's most beautiful river valleys would be flooded, with its scenic values destroyed and its productive land lost. In the Waikato, where the hot-water discharge from the Huntly power station is already threatening the river's ecology, there would be battles between those who insist on running the power station at full capacity and those (probably including the Waikato Valley Authority) who would wish to limit Huntly to 5,000 GWh per year in dry years in order to preserve the river.[9]

The need for a second large coal-burning station in the Waikato would become urgent as soon as any 5,000 GWh contract is signed, since the new station would then be required by 1988 if a dry-year power is to be ensured without resorting to oil-fired generation. Resolution of the problems with the siting of this station, and progress on its construction, would have to be very

FIGURE 8



A Footnote on Smaller Sales

In the preceding section we analysed the consequences of selling a 5,000 GWh block of power. In this section we shall briefly consider the possibility that the figure of 5,000 may prove a red herring, and that actual sales to new energy-intensive industries will be limited to 2,000 GWh per year (i.e. rather more than would be needed for the third potline at Comalco's Bluff smelter).[10]

This smaller sale would require the building of either another coal-fired station, or the Clyde dam, but not both. For the first seven or eight years the contract would be supplied mainly from South Island surplus hydro, with a steadily-increasing share from Huntly until the Clyde dam, if built, comes on in 1991/92. Thereafter the great bulk of the 2,000 GWh would be supplied from Clyde at a cost of over 3 cents per unit.

The need for steep escalation clauses is thus just as great for smaller bulk sales of power as it was for the 5,000 GWh option.

rapid if this deadline is to be met: we can probably look forward to the use by the Government of the National Development Act to prevent public debate and impose the project from above.

As further power stations and electricity-intensive industries are planned, more communities would be disrupted, and more of New Zealand's relatively scarce capital would be poured into large-scale capital-intensive projects offering few new jobs. Giant energy-intensive and capital-intensive growth poles can be expected to distort regional economies, while the promised "downstream developments" may never materialise.

Always in the background of any discussion of such development plans is the fact that the leading role will be assigned to foreign firms operating in New Zealand under special terms. The possibility that foreign control of the new commanding heights of the economy may weaken the autonomy of New Zealand's national economy is a very real one. Such an intangible thing as "loss of autonomy" is impossible to put a monetary value on, but it is undoubtedly a real cost of the sort of strategy now proposed by the New Zealand Government.

Some Concluding Remarks

Our analysis in this paper has indicated that an electricity surplus of moderate dimensions exists at present, and will remain available during the 1980s. The surplus will persist over a longer period if electricity demand grows less rapidly than planned by the NZED; on the other hand it will vanish overnight if the Government presses ahead with grandiose plans for huge bulk sale contracts.

The question now facing New Zealanders is what we want to do with this surplus. We have already committed ourselves, as a nation, to paying for the construction of the Upper Waitaki hydro stations and the Huntly coal-fired station, and these costs will have to be paid regardless of whether we use the stations or not. So there is no imperative need to use up all the power. Water spilling to waste, and boilers standing idle, do not cost us anything directly.

We thus have time to think, to take stock of our development priorities, and to consider how our energy resources can best be used to reach the economic and social goals which New Zealand may set itself for the 1990s.

Our Government does not seem to have worked out any such coherent set of priorities. Platitudes abound on the subject of sustainability and self-sufficiency, but government actions point in a different direction.

In the recent publication *Energy Strategy '79* the Minister of Energy, Bill Birch, heralded an era "in which New Zealand will move towards energy self-sufficiency through taking advantage of its own energy resources", on the basis of a "long-term planning concern for energy [which] brings with it a responsibility for careful husbandry of finite energy forms"[11] The booklet went on to set out energy goals which included reducing New Zealand's dependence on imported oil, increased diversity of energy supply, more efficient use of energy, and a long-term movement towards renewable, as distinct from depleting, sources for our energy.

These stated goals fit poorly with the Government's announced plans to sell off large blocks of electricity at cheap rates; indeed, such sales would obstruct the attainment of the goals. There would be a heavy capital cost to New Zealand both in supplying the power to new major users (almost $1 billion in the Clyde and Waikato power stations) and in providing infrastructure for the new industries.

Renewable energy resources would be pre-empted and our dependence on fossil fuels increased. Far from husbanding our resources, we would be exploiting them at an accelerated rate to supply industries which have not yet been demonstrated to offer any significant net benefits for New Zealand's development.

This is a strange situation, in the light of the history of our electricity planning since the Second World War. After struggling for thirty years to attain a position of abundant electricity, and having finally succeeded in that struggle, New Zealand seems about to plunge itself back into another era of scarcity by the hasty signing of secret contracts.

We cannot look to the power planners to save us from this, because the power planners themselves have a vested interest in continued rapid expansion; for them, the 5,000 GWh bulk sale would provide a welcome justification for otherwise-redundant projects such as the Upper Clutha and a second Waikato coal station.

Nor can we look to Cabinet Ministers whose political future is staked on the large energy-using projects; nor to civil servants who prefer the administrative convenience of dealing with a few large firms rather than a large number of small ones; nor to the impersonal working of market forces, since these have no opportunity to operate freely in the tightly-controlled and planned environment of energy policy.

At this moment the goal of a sustainable, self-sufficient energy system is within our reach. The short-term surplus means that New Zealand's economy can operate for the next decade free of the constraint which faces many other industrial nations, with considerable leeway to improve living standards **without** incurring the financial, social, and environmental costs of building new power stations.

"The goal of a sustainable, self-sufficient energy system is within our grasp."

Using the excess capacity as a reserve source of energy, while embarking seriously on a programme of increasing the efficiency of energy use, could free us indefinitely from the need to divert our resources from other uses back towards further expansion of our electricity system. (If we have no better use for those resources, of course, nothing will be gained - but this seems hardly likely.) As the Government notes in *Energy Strategy '79:* "... encouragement of energy efficient practices and investments in appropriate areas are likely to yield increasing benefits through time."[12]

Such a strategy, if pursued successfully, would leave our "surplus" free to be held in reserve. This would make possible the rapid adoption and installation of new industries and processes in the future as New Zealand enterprises expand. Small and medium-cale manufacturing development would be ıble to take up power as and when it was ıeeded, at concessional rates if the Government saw fit, especially for the development of new technology.

There are, in other words, substantial benefits to New Zealanders from retaining a reserve of unutilised generating capacity into which our economy can expand over time. Those benefits would vanish if the power is pre-empted by large energy-intensive industries.

Choices now being made about the use of our energy resources will shape our society and economy for the next two decades. The public interest demands that these choices be made properly, on the basis of the best available evidence and advice, and in the open view of the public at large. If the Government wishes to carry New Zealanders with it in its development policies it must not only make the right choices - it must be seen to make the right choices.

If the benefits to be gained from large-scale electricity sales to multinational enterprises are sufficient to outweigh the benefits that New Zealand would otherwise reap from a reserve of renewable energy resources, then the Government can have nothing to fear from a free and open debate. Where the citizens encounter secrecy and evasion on these issues, they are entitled to suspect bad planning and bad conscience.

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2. Report of the Planning Committee on Electric Power Development 1979 pp 13,23
3. Report of the State Hydro-Electric Department (D4) year ended 31st March 1958 p3.
4. See Appendix IV
5. This assumes a 2000 GWh sale to supply a 3rd potline at Comalco, plus some other industry (e.g. silicon carbide plant) in 1983/4; and 5000 GWh sale 1986/7. See NZ Engineering May 1980.
6. For fuel costs and supply see Appendix V.
7. Report of the Planning Committee on Electric Power Development 1979.
8. Metals Bulletin; November 2nd, 1979 p.23
9. Energywatch 1980 No. 4 May p.7
10. This is half of Comalcos present output as specified by Mark Rayner in a paper to the Australasian Institute of Mining and Metallurgy.
11. Energy Strategy '79 p3
12. Ibid p.23

SUGGESTED READING

Official Documents

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3) Report of the Ministry of Energy
4) NZED report of the Committee to Review Power Requirements (D6A)
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APPENDIX I

GLOSSARY

UNITS USED IN ELECTRICITY PLANNING:-

Watt (W) - Measurement of the amount of power passing through an electrical circuit e.g. a typical light bulb uses 100 watts.

Kilowatt (kW) - 1,000 watts. The amount of power needed to run 10 light bulbs of 100 watts each.

Megawatt (MW) - 1,000,000 watts. This is the measure commonly used in describing the capacity of power stations

Gigawatt (GW) - 1,000 million watts.

Kilowatt hour (kWh) - the amount of energy needed to run a 100 watt light bulb for 10 hours. This is the basic "unit" of electrical energy production and use.

Gigawatt hour (GWh) - 1 million kWh. The amount of energy used to run a 100 watt light bulb for a million hours (1140 years).

LOAD FACTOR - The ratio of the average hourly demand for the year, to peak demand for the year.

$$\text{load factor (\%)} = \frac{\text{electricity generated (GWh)}}{\text{8760 (hrs/yr)}} \times \frac{100}{\text{peak demand (MW)}} \times \frac{\text{1000 MW}}{\text{GW}}$$

or simplified load factor (%) =

$$\frac{\text{electricity generated (GWh/yr)}}{\text{peak demand (MW)}} \times 11.4$$

PLANT FACTOR - The ratio of the hourly production from a power station to its peak production.

MAXIMUM CAPABILITY - The greatest generation possible from the existing system; derived by aggregating the designed generating capacities of all stations.

PLANNED OUTPUT - Each year, power planners work out a scenario for electricity supply for the following fifteen years. This involves decisions such as which stations to use; appropriate load factors for different stations, and the need for new stations. Calculations are derived on the basis of both upper and lower demand forecasts (since 1976) and mean and dry years.

MEAN YEAR - Occurs when river flows are normal. Historically river flows have been normal or wetter than normal 42% of the time.

TRANSMISSION LOSS - There is some loss of energy during transmission from areas of generation to areas of use. Over the system, transmission losses account for about 8 - 11% of electricity.

TRANSMISSION SAVINGS - New bulk users located in the South Island will use power from South Island stations. At present the power from these stations is sent to the North Island. About 10% is lost in transmission. If this power is sold in the South Island, the North Island stations would only have to generate 9/10ths of the power normally sent north. Hence there is a transmission saving because there is not a transmission loss.

BULK TARIFF - The price at which the Government sells electricity to supply authorities and some large industries. For continuous power users e.g. an aluminium smelter, the charge is 2.34 cents per kWh; and for a 55% load factor (the average load factor for the New Zealand system) the charge would be 3.02 cents per kWh.

DRY YEAR - 1 IN 20 - Power Planners use the term 'dry year' meaning years when river flows are only 85% of the normal flow. This occurs about once every twenty years.
1 IN 5 - About once every five years, river flows are at least 10% less than normal flow.

DRY YEAR FIRMING - The reduction in hydroelectricity generation in dry years, necessitates extra thermal generation to make up the difference. This extra generation is dry year firming.

THERMAL POWER STATIONS - stations which burn oil, gas, or coal, and geothermal stations. All are located in the North Island. All except geothermal stations can also be called fuel burning stations.

RENEWABLE ENERGY - self replenishing. We define both hydro and geothermal electricity as renewable. Some geologists may disagree

NON RENEWABLE ENERGY - Produced from fossil fuels which are burnt up in the process, such as electricity produced by burning oil, gas, and coal.

CONSTRAINED ENERGY - Energy trapped in the South Island It equals South Island supply minus South Island demand minus 4200 GWh (the capacity of the Cook Strait Cable). This is New Zealand's only renewable 'surplus' electricity.

APPENDIX II

HISTORY WITH PROJECTIONS

The construction of our present generating capacity proceeded in three stages between 1945 and 1975. During the ten years after 1945, very few stations were completed but the ground work was laid for a new construction programme, which was carried out between 1955 and 1965. In those ten years, total generating capacity increased by almost 250%, with the completion of five dams on the Waikato river, a geothermal plant at Wairakei, and the Meremere coal-fired station. Electricity rationing, which had been instituted during the war, was finally lifted in the North Island in 1958. Restrictions in the South Island were ended with the commissioning of the first units at Roxburgh in 1956. This station spilled water for the subsequent decade while South Island demand caught up.

The next phase, beginning with the completion in 1965 of the Benmore Dam and the Cook Strait Cable, was the establishment of the national grid. By connecting the North and South Island, the cable made it possible to justify the building of large hydro stations in the South Island to meet North Island demand. At the same time, the Manapouri scheme was being built, and oil-fired stations were constructed at Marsden Point and Otahuhu. These thermal stations helped to assure continuity of supply in dry years.

The third stage came at the end of the 1960's when most of the easier hydro dam sites had been developed. To ensure baseload power supply the Government decided to build a series of giant thermal power stations to be fired by natural gas, coal, and nuclear fuel. Future hydro schemes were planned to meet intermediate and peak loads.

By 1975, gas-fired stations had been completed at New Plymouth and Stratford, the Tongariro hydro scheme was in operation, construction was underway on the Upper Waitaki and plans had been drawn up for four major thermal baseload stations: Huntly (coal), Auckland No 1 and No 2 (gas) and a nuclear station.

Of these last four schemes, only Huntly came to fruition. Already by 1975 it was becoming clear that the exponential growth of demand predicted by the power planners was not occurring. Demand for electricity was not in fact growing in a rising curve, as predicated by the planners. But power stations were being built to supply a rising curve - which meant that unnecessary excess capacity was being built.

Figures on demand for electricity were published by the Government in a form which concealed the true pattern of growth. This was done by including one-off developments such as Comalco, New Zealand Steel, and the three large pulp and paper mills in the North Island, along with the underlying growth of demand for domestic and industrial use.

Not until 1979 was a graph published which showed the growth of general domestic and industrial demand separately from the impact of these "big five" industries, and made it clear that unless several more huge projects came on the scene, power demand would fall far below the planners' projections.

Despite the inadequacy of official published information, the power planners had been under strenuous public criticism since the 1st Energy Conference in May 1974. Evidence presented to public hearings on the

SOURCES:

1. Report of the NZED for years ended 31st March 1946-78.
2. Report of the Ministry of Energy, year ending 31st March 1979.
3. Annual Statistics in Relation to Electric Power Development and Operation 1946 - 79. Section A - Condensed Statistics 1946 - 77. Section B - Condensed Statistics 1978 - 9.
4. Report of the Planning Committee on Electric Power Development in New Zealand (068) 1979 pp 12, 17.

Table 1.

HISTORY WITH PROJECTIONS (in MW)

YEAR	MAXIMUM DEMAND	INSTALLED CAPACITY	SURPLUS
1945-46	457	531	74
1946-47	477	551	74
1947-48	515	602	87
1948-49	575	675	100
1949-50	604	679	75
1950-51	642	675	33
1951-52	695	701	6
1952-53	718	787	69
1953-54	812	841	29
1954-55	919	940	21
1955-56	958	940	-18
1956-57	992	1205	213
1957-58	1122	1201	79
1958-59	1118	1360	242
1959-60	1277	1509	232
1960-61	1376	1566	190
1961-62	1554	1815	261
1962-63	1650	1945	295
1963-64	1874	2006	132
1964-65	2048	2336	288
1965-66	2261	2522	261
1966-67	2446	2749	301
1967-68	2410	2976	563
1968-69	2544	3137	593
1969-70	2690	3683	993
1970-71	2855	3909	1054
1971-72	2995	4209	1214
1972-73	3477	4209	732
1973-74	3558	4544	986
1974-75	3508	4784	1276
1975-76	3865	5038	1173
1976-77	4074	5366	1292
1977-78	3848	5634	1786
1978-79	4013	5623	1610
PROJECTIONS			
1979-80	4150	5620	1470
1980-81	4230	6104	1874
1981-82	4320	6357	2037
1982-83	4405	7063	2658
1983-84	4490	7191	2701
1984-85	4570	7132	2562
1985-86	4715	7238	2523
1986-87	4860	7238	2378
1987-88	5005	7278	2273
1988-89	5165	7318	2153
1989-90	5325	7318	1993
1990-91	5485	7318	1833
1991-92	5645	7518	1873
1992-93	5835	7718	1883
1993-94	6025	7718	1693

NOTES:

1. Maximum Demand - Years 1945/6 - 1955/6 are aggregated from totals of North Island, South Island, and Nelson/Marlborough. As peak demands for the three regions may not coincide, figures may underrepresent maximum demand. Between 1956/7 and 1964/5 figures are aggregated from a total of North and South Island's peak demands, and the same applies.

2. Restrictions on demand remained in force in the North Island until 1958, and in the South Island until 1956.

3. Some of the differences between installed capacity and maximum demand can be accounted for by transmission losses by the NZED; and for a built in margin of approximately 15% of installed capacity, for safety to ensure supply.

4. Projections of demand use the central forecast.

Auckland Thermal No 1 gas-fired station and the Royal Commission into Nuclear Power showed that the power produced from these stations would not be needed.

Both Auckland Thermal Nos 1 & 2, and the nuclear power programme were dropped from the power plan by the Government following these enquiries. Even with these stations deleted a widening gap continued to open up between the construction programme and the planned growth in demand.

The power planners were divided on their long-established vision of rapid expansion. However gradually, over a period of several years and with the publication of majority and minority forecasts, they revised their demand forecasts down to more realistic levels (the process is still continuing).

The advocates of more new construction took heart from temporary power shortages in 1973/74 and 1976/77, when sudden surges in demand due to the "big five" coincided with dry years and low levels in the hydro lakes; in 1976/77, the explosion in a boiler at New Plymouth made the situation worse.

The problems of these years, however, were short-term ones, not symptoms of any long-term shortage of capacity. By 1979, the hydro lakes were full again and the amount of obvious excess capacity in the system had become embarrassingly large. The Government put Marsden B (its newly-built oil-fired station) into mothballs, deferred the date for completion of the Clyde dam on the Clutha, and began to talk about an "electricity surplus" of 5,000 GWh per year which could be utilised only by cut-price sales of enormous blocks of electricity.

New Zealand has thus moved out of the era of planning to relieve power shortages and into an era of planning the disposition of power surpluses. Wrong decisions at this stage would throw us back to a new era of shortages within the next decade.

Table 2: SALES BY SECTOR (GWh)

YEAR	TOTAL SALES	DOMESTIC SALES	NON DOMESTIC	NON PRODUCTIVE	NON DOMESTIC SALES MINUS BIG 5	BIG 5 USERS
1958/59	5977					
1959/60	6371	3122	2152	1097	1932	220
1960/61	6835	3360	2324	1151	2087	237
1961/62	7299	3456	2513	1330	2281	232
1962/63	7951	3920	2764	1267	2451	313
1963/64	8953	4402	3169	1382	2699	470
1964/65	9718	4715	3474	1529	2968	506
1965/66	10578	5192	3813	1573	3265	548
1966/67	11319	5562	4042	1715	3514	528
1967/68	11605	5697	4196	1712	3617	579
1968/69	12185	5992	4462	1732	3917	545
1969/70	12926	6107	4882	1855	4225	655
1970/71	13706	6454	5292	1960	4566	725
1971/72	15194	6811	6301	2082	4787	1514
1972/73	17254	7389	7641	2223	5196	2445
1973/74	18114	7440	8508	2167	5399	3109
1974/75	18352	7554	8719	2079	5531	3188
1975/76	20071	8403	9248	2421	5683	3565
1976/77	20914	8398	10314	2202	6051	4253
1977/78	21268	8314	10595	2360	6419	4179
1978/79	21693	8181	10782	2730	6528	4254

NOTE 1: The 'Big 5' users are -

New Zealand Aluminium Smelters (Comalco); New Zealand Forest Products; Carter Oji Kokusaku Pan Pacific; Tasman Pulp & Paper; and New Zealand Steel.

SOURCES 1: Annual Statistics in Relation to Electric Power Development and Operation. Years ending 31st March 1959 - 1979 Table V.

2: M. Wigbout: Summary Report: The Annual Change in Non Domestic Electricity use. NZE Report No c/1 Table 1 p9.

3: Hugh Barr: Electricity Forecasting. Paper presented to the 15th National Conference of the Operational Research Society of New Zealand, Wellington 23 August 1979. Revised and Updated 12 September 1979 p 3.

Table 3: ELECTRICITY: WHERE IT IS GENERATED; WHERE IT IS USED (1977-79 Average in GWh)

DISTRICT	GENERATION	SALES	SURPLUS BY	MAJOR USERS	% USE OF REGIONAL SALES
AUCKLAND	1289.07	4631.3	-3342	NZ Steel Auckland UA	3.74 83.26
WAIKATO	8628.3	4902.7	3725.6	NZFP	25.78
BAY OF PLENTY	351.3	1768.5	-1417.2	Tasman, Whakatane Caxton	54.26
EAST COAST	576.7	1450.7	-874	Panpac	17.92
TARANAKI	3583.7	864.3	2719.4		
WELLINGTON/ PALMERSTON NTH	98.2	2481.3	-2382.1	Wellington UA	66.42
TOTAL NTH IS	11527.9	13098.8	-1570.9		
NTH OF STH ISLAND	488.4	2723	-2234.6	Christchurch UA	46.59
OTAGO/ WAITAKI	5060.5	1303.2	3757.3	Dunedin UA	45.62
SOUTHLAND	4192.3	3303	889.3	Comalco	78.25
TOTAL STH IS	9741.2	7329.2	2412.2		
TOTAL NZ	21269.1	20428			

Note 1: Sales figures include transmission losses by local supply authorities, but not those incurred by the NZE Division.

SOURCES 1. Report of the NZED years ending 31st March 1977 and 1978; Report of the Ministry of Energy, year ending 31st March 1979. Appendix A. Stations aggregated into geographical regions.

2. NZ Annual Statistics in Relation to Electric Power Development and Operation, years ending 31st March 1977 - 79. Table IV with Power Boards and Authorities aggregated into regions And Table VII (1977) and Table V 1978, 79.

APPENDIX III

MORE ON THE OFFICIAL PROJECTIONS:

Although we are using official projections as the basis for our analysis in this paper, it needs to be emphasised that the concepts of "supply" and "demand" used by the Government can be very misleading to the lay person. Predicting demand is notoriously difficult, and we have already discussed previous failures by the power planners in this regard.

Of immediate concern here is the definition of "supply" used by the planners and incorporated in the Growth Opportunities graph which we reproduced above. That graph shows a projection of "potential energy generation in a dry year", and the casual reader might be tempted to take this at face value, as an estimate of the amount of electricity which could be generated if all stations were operating at their maximum capability (within the constraint posed for hydro stations by shortage of water).

In fact, the supply projections set out by the Government are not based on full-capacity operation of the existing fuel-burning power stations. The Growth Opportunities graph understates the amount of power which the New Zealand system could possibly generate, while at the same time the accompanying text overstates the amount of surplus electricity available.

If we are interested in the amount of spare generating capacity available (regardless of the cost of using this plant to produce electricity) then there is undoubtedly a great deal.

In Table 1 we present the expected dry-year performance of the eight existing stations, dividing them into two groups - those which use imported oil fuel, and those which do not. As might be expected, the oil-burning stations are very expensive to run - their fuel cost is about four times greater than that for stations fuelled by coal or gas, per kilowatt-hour of electricity produced.

The planned capacity of the stations is represented in early power plans as dry year output. In fact, this high level of utilisation could not be sustained indefinitely because of the wear and tear on the plant; but for two or three years at a time, the thermal stations are capable of running at the levels shown in order to make up for a drought-induced shortage of hydro power.

The table shows that New Zealand could actually generate 18,000 GWh per year from gas, coal and oil. This assumes that the mothballed Marsden B station is used and that enough gas is available to run the New Plymouth and Stratford stations. Add this 18,000 GWh to the present dry year hydro capacity, which is roughly 17,000 GWh and we have a total dry-year generating capacity in New Zealand of 35,000 GWh per year.

With several more nearly completed hydro stations adding another 3,000 GWh, the total generating capability will reach 38,000 GWh by 1984/85.

Referring back to the Growth Opportunities graph, it can be seen that the estimated "potential energy generation in a dry year" in that diagram was only 25,000 GWh annually in 1980/81 (10,000 lower than our estimate) and raises to flatten out at roughly 33,000 GWh per year (still 5,000 GWh below our estimate*) when all power stations now under construction, except Clutha, are finished.

Thus the Government, at the same time as it has overstated the electricity surplus, has understated the amount of excess generating capacity. The difference between the two is that the surplus electricity is almost costless to generate once the dams are built, whereas the excess capability consists mostly of fuel-burning plant.

We conclude therefore that the available official figures indicate a large amount of excess generating capacity, which does not mean the same thing as an electricity surplus. If anyone were prepared to pay the full cost, we could produce a lot more power than we do now possibly 8,000 GWh or more. But notice that we are now talking about the amount of electricity which the New Zealand generating system would be capable of supplying, if there were buyers (local or foreign) willing to pay the full cost of producing the power. We are not talking about cheap surplus electricity - but then, neither is the Government, once it is realised that most of their proposed 5,000 GWh sale is to come from coal, gas and imported oil - not from cheaply-available renewable resources.

This appendix has been based on the official-published figures, and any errors or changes in those figures would modify our results somewhat, though it is most unlikely that our conclusion would be affected. In looking ahead over the next couple of decades, it is important to realise that there is quite a range of predictions of what will happen to demand (the official upper forecast is 22% higher than the lower forecast by 1993/94) even without any major policy change in favour of energy conservation; there is no official projection of the effects of a vigorously-applied energy-saving development strategy.

For the moment, suffice it to say that we are using the central forecast between the upper and lower forecasts offered in the 1979 power plan.

TABLE 1

Generating Capacity From New Zealand Fuel-Burning Power Stations as envisaged in the early 1970's

Station	Capacity in MW * net figs	Cost of fuel per KWh of electricity (cents)	Dry year planned output GWh (plant factor in brackets)
1. Stations using locally-produced fuel			
Meremere*	196	Coal 1.5	1,195 (70%)
New Plymouth	575	Gas 1.1	4,030 (80%)
Stratford	200	Gas 1.4	964 (50%)
Huntly	980	Coal 1.1	8,310 (75%)
Total, local-fuel stations	1,951		12499 (73%)
2. Stations using imported fuel			
Marsden A	240	Fuel Oil 5.0	1,680 (80%)
Marsden B	240	Fuel Oil 5.0	1,680 (80%)
Otahuhu	280	Oil Distillate 10.5	1,226 (50%)
Whirinaki	220	Oil Distillate 9.5	964 (50%)
Total, imported-fuel stations	980		5,550 (65%)
TOTAL, ALL STATIONS	2931		18049 (70%)

* The Meremere station is to be phased out during the period 1980 - 1984/85.

SOURCES: Information in this table has been collected from the Report of the Planning Committee on Electric Power Development 1970, p. 20; 1972, pp. 11 and 25; 1973, pp. 26-27; 1975, p. 25; and 1978, p. 21. The dry-year performance shown is that which was envisaged at the time of planning and/or commissioning the stations. It does not, therefore, coincide with the planned output from the stations as given in the recent power plans. Sources for costs are given in Appendix V.

* Our estimate includes 1,000 GWh from the Meremere coal-fired station, which the Government has planned to scrap because of lack of demand.

YEAR	(26) SOUTH ISLAND EXPORTS TO NORTH ISLAND Mean Year (4200)	(27) Dry Year Upper Demand Forecast 4200 + (18)	(28) Dry Year Lower Demand Forecast 4200 + (19)	(29) Dry Year Central Demand Forecast 4200 + (20)
1979/80	4,200	2,607	3,1[illegible]7	2,957
1980/81	4,200	2,963	3,263	3,113
1981/82	4,200	2,835	3,335	3,035
1982/83	4,200	3,421	3,921	3,671
1983/84	4,200	3,366	3,916	3,666
1984/85	4,200	3,947	4,200	4,200
1985/86	4,200	3,749	4,200	4,149
1986/87	4,200	3,490	4,200	3,940
1987/88	4,200	3,240	4,200	3,740
1988/89	4,200	2,940	4,040	3,490
1989/90	4,200	2,640	3,840	3,240
1990/91	4,200	2,340	3,690	2,990
1991/92	4,200	3,400	4,200	4,150
1992/3	4,200	3,270	4,200	4,030
1993/4	4,200	2,970	4,200	3,770
1980/81-1989/90 10 yr.	42,000	32,582	39,015	36,235
15 yr.	63,000	47,369	58,412	54,122

YEAR	(30) TOTAL RENEWABLE AVAILABLE IN NORTH ISLAND Mean Year (24)+(26)	(31) Dry Year Upper Demand Forecast (25)+(27)	(32) Dry Year Lower Demand Forecast (25)+(28)	(33) Dry Year Central Demand Forecast (25)+(29)
1979/80	11[illegible]17	[illegible]	[illegible]	9418
1980/81	11032	9591	9991	9841
1981/82	11949	9571	9971	9771
1982/83	12774	10519	11019	11055
1983/84	12724	10791	11311	11081
1984/85	12434	11435	11469	11085
1985/86	12334	11278	11509	11526
1986/87	12084	11025	11770	11516
1987/88	13154	11042	12003	11548
1988/89	1394[illegible]	10940	12040	11490
1989/90	13894	10830	11090	11230
1990/91	13334	10330	11740	11040
1991/92	13330	11450	12250	12200
1992/3	13336	11320	12250	12070
1993/4	13334	11020	12250	11020
1980/81-1989/90 10 yr.	127[illegible]24	107240	113781	110901
15 yr.	193025	[illegible]	171239	167449

Year	(34) THERMAL REQUIRED (NORTH ISLAND DEMAND - RENEWABLE) Mean Year Upper Demand Forecast (21)-(30)	(35) Mean Year Lower Demand Forecast (22)-(30)	(36) Mean Year Central Demand Forecast (23)-(30)	(37) Dry Year Upper Demand Forecast (21)-(31)	(38) Dry Year Lower Demand Forecast (22)-(32)	(39) Dry Year Central Demand Forecast (23)-(33)
1979/80	2293	1993	1993	4492	3932	4132
1980/81	2411	1411	1911	4752	3352	4009
1981/82	2901	1901	2201	5172	2572	4372
1982/83	3428	1028	1728	4334	2434	2384
1983/84	3488	1178	2098	4708	2808	3303
1984/85	3144	1510	2324	4548	2232	3612
1985/86	3540	1503	2746	5472	2812	3922
1986/87	4886	2082	3274	[illegible]	3172	4382
1987/88	5046	2846	3146	7102	3382	5282
1988/89	5954	2584	4104	9070	3260	5950
1989/90	6404	3004	4704	9110	4510	5010
1990/91	7504	3554	5254	10210	5210	7710
1991/92	6904	4054	6054	9950	5200	7250
1992/93	8904	4154	6794	10960	5980	9050
1993/94	9804	5554	7554	12190	6350	9050
1980/81-1989/90 10 yr.	2512[illegible]	17594	26224	59752	30059	45649
15 yr.	76375	37975	56325	107654	55251	91901

FOOTNOTE:

1. The Cook Strait Cable's rated capacity is 600 MW. In GWh this is 600 MW x 8760 (hours in a year) x 80% (load factor) = 4200 GWh.

   This figure is used in the 1979 PCEPD as the cable's capacity i.e. South Island Renewable Electricity minus South Island Demand minus constrained electricity = 4200 GWh. This is the amount of South Island surplus which can be sent to the North Island.

2. Negative constraint indicates that less than 4200 GWh was sent to the North Island. The difference has to be made up by thermal generation in the North Island.

SOURCES:

Report of the Planning Committee on Electric Power Development 1979 Col (1) to (3) p 15; Col (7) to (8) p 25; Col (24) to (25) p 22 and 23.

Information supplied by the Electricity Division of the Ministry of Energy - Cols (4) to (6).

APPENDIX V

Supplying a 5,000 GWh sale

In this appendix we set out the figures used to construct Figure 6 and Table 2 in the main body of the paper. The problem which we set out to answer is how it might be possible to fill the gap, shown in Figure 5, between a 5,000 GWh supply commitment and the amount of surplus power available for use in the South Island. The various sources of supply which we considered were the following:

1) New Hydro construction in the South Island. The next planned development in the South Island is the Upper Clutha scheme, beginning with the Clyde dam which is scheduled to begin operation in 1991/92, followed by the Luggate dam in 1995/96. As is pointed out in the main text, in the 1990s 5,000 GWh supply commitment could be met from South Island sources only if the Clutha scheme is built - otherwise power would have to be imported from the North Island across the Cook Strait cable. Power from the Clutha scheme will not be cheap. On the contrary, with the construction schedule set out in the 1979 power plan it will cost 3.1 cents per kWh,[1] and even shortening the construction period by two years (which would slightly reduce the capital charges incurred) would lower this only to 3 cents per kWh. It is clear, however, that the Clutha plans are intimately bound up with the proposed power sales, and we therefore assume here that any decision to supply 5,000 GWh on a long-term basis would be accompanied by a firm commitment to build the Clutha dams. The only question then would be the construction schedule for those dams. It seems possible that work on Clyde and Luggate could be speeded up to bring forward their completion dates to 1989/90 and 1991/92 respectively, and two of the three options we examine below take this path.

2) Existing coal-fired stations in the North Island. There are two of these: Huntly and Meremere. The latter is due to be scrapped in the mid-1980s, and even if it is not in fact scrapped the effect on our figures would be slight; we have therefore assumed that only Huntly is relevant in this category of supply beyond 1985. The Huntly station, we shall assume, can be operated on a steady plant factor of 65% during mean years, producing 5,466 GWh per year.

3) Existing gas-fired stations. New Plymouth and Stratford, it was seen in Appendix III Table I, have a dry-year maximum capability of 5,000 GWh provided the gas is available. In practice, nothing approaching that amount of generation will be possible because of competition for Maui Gas from other users. The best information we have been able to obtain on this issue is that only enough gas will be available to run these stations at a combined mean-year output of 1,180 GWh per year from 1989/90 on, with a certain amount of gas held in reserve for dry-year firming.[2] It will not be possible, without another Maui platform, to obtain more electricity from these stations without cutting into the gas supplies for petrochemicals industries in Taranaki, and/or other direct gas consumers. This means that much of the idle capacity in these stations will never be used, and that they will not be able to greatly increase their output unless residual oil is burned at the New Plymouth station to help supply the 5,000 GWh.

4) Existing oil-fired stations. There is ample generating capacity in the Marsden A and B power stations, which use residual oil from the Marsden Point refinery. There is no technical problem in stepping up generation at these stations to supply bulk sales. The problem is simply the intimidating cost of oil, which makes this electricity very expensive - over 5 cents per kWh at 1980 prices. Nevertheless, it is clearly feasible to supply a large part of the 5,000 GWh from this source through the 1990s, and the third of our options below is based on this possibility.

5) New coal-fired stations. In the Waikato, Westland, and Southland, there are considerable reserves of coal of various grades, which might conceivably be used to fuel new power stations. The most probable site for such a station is the Waikato, and we look here at a second large station of smilar type to Huntly as a possible source for some of the required power. Such a station we assume would be designed to produce baseload power, running at 75% plant factor, and would be of whatever size was needed to fill the supply gap. In the first of our options below we have assumed that such a station could be designed and built, together with the necessary coal mines, by 1989/90; this seems rather unlikely in view of the possibility of problems with siting, mine planning, labour-force recruitment, and teething troubles. In our second option we therefore consider, as an alternative, the situation if such a station were indeed built, but not completed until 1992/93, with the gap filled as necessary from oil-fired stations in the interim. The all-in cost per kWh of power from such a station completed at the early date would be around 2.5 cents at 1980 prices[3]; a longer construction period would raise this somewhat, but we have ignored this cost escalation in our figures (which are correspondingly conservative).

6) Transmission savings. A point easily overlooked is that if you do not have to transmit electricity then power is saved. This is equivalent to an actual increase in supply. Of all the electricity sent up the Cook Strait cable from Benmore to Wellington, we assume that about 10% is lost in transmission. If more of this power were used in the South Island rather than sent north, there would thus be a free addition to total New Zealand power availability of 10%. In constructing our tables below, we therefore take 10% of all power diverted from the Cook Strait cable to local use in the South Island as a free gain of electricity for the New Zealand system, in the sense that we have more power reaching bulk users without any extra cost.

Putting the same point in a different way, for every 10 kilowatt-hours of electricity used in the South Island rather than transmitted up the cable, there is a reduction of only 9 kilowatt-hours in the power available in the North Island; the remaining one kilowatt-hour is power which would have been lost on the way up the cable.

In Table I in this Appendix we set out the results of our exploration of three possible supply options for the 5,000 GWh, on a mean-year basis. The three options were chosen because they seemed to span a range of costs from the cheapest conceivable (but not necessarily feasible) to the one which the Government appears to favour (if recent statements are any guide). Several other possibilities fall within this cost range, and a number of other would lead to higher costs.

Our three leading contenders are:

Option 1. Here we assume a 500MW coal-fired baseload station would be built quickly in the Waikato, coming onstream in 1989/90 and reaching its full output by the mid-1990s. This we assume to be supplemented by power from the Clyde dam, which is assumed to start up in 1991/92 and reach full output the following year.

Option 2. Here we assume that the completion date for a second Waikato coal-fired station is deferred until 1992/93 but that construction of the Clutha scheme is speeded up, to bring the first dam at Clyde into production in 1989/90, and the second (at Luggate) in 1991/92. Deferral of the coal-fired station would mean a gap in supply for a couple of years in the early 1990s, which we assume to be filled bu the Marsden oil fired station.

Option 3. In this case we consider the possibility that (whether because of feasibility constraints of for other reasons) no new Waikato coal-fired station is built, but the Clutha scheme is pushed through on the speeded up schedule. In this case a substantial and growing share of the required power would have to come from oil-fired generation during the 1990s.

Constructing Table I, once the above material had been collated, was straightforward. The supply targets set were 2,000 GWh annually from 1983/84 to 1985/86, and 5,000 GWh annually from 1986/87 on. To meet these targets we allocated firstly all the available surplus electricity from South Island hydro stations, and secondly all of the power generated from the Clutha dams as these are assumed to come into production. We then worked out the extent of the reduction in South Island exports of power over the Cook Strait cable in order to meet the increased local requirement, and took 10% of this as a free "transmission saving" of power which would otherwise have been lost in transmission.

It then remained to allocate among various North Island supply sources the task of making up for the shortfall of North Island supply, resulting from the 5,000 GWh sale and its impact on electricity flows over the Cook Strait cable. In doing this we relied first upon the Huntly coal-fired station, since this is the cheapest source of extra power not otherwise committed to supplying predicted North Island demand. However, by the end of the 1980's the Huntly station will be increasingly needed to meet growing North Island requirements without a 5,000 GWh sale, and only the remaining margin of spare capacity in the station would then be available to supply extra commitments; this margin of spare capacity will shrink rapidly and vanish altogether in 1992/93, when Huntly disappears from our tables.

Having added up the electricity supplied from surplus hydro, Clutha, transmission savings, and Huntly, we were left with a gap between this and the 5,000 GWh requirement, which we filled with either a new coal fired station (Option 1), increased output from oil-fired stations (Option 3) or a mixture of the two (Option 2, where oil carries the lead until the coal-fired station comes onstream).

The cost of our three possible options for mean-year supply can readily be calculated from Table I once the cost of power from each of the sources is known. The cost figures which we have used are as follows:[4]

TABLE I

Possible Sources of Supply for a Long-Term Supply Commitment

All figures in gigawatt-hours

(a) Option I: Relying on Waikato Coal and Clutha

Year	South Island surplus	Clutha hydro	Transmission savings	Huntly coal-fired	Second Waikato coal-fired	Total mean-year supply
	Available mean-year supply from sources shown:					
1983/84	1,516	-	48	436	-	2,000
1984/85	2,000	-	-	-	-	2,000
1985/86	2,000	-	-	-	-	2,000
1986/87	1,936	-	[illegible]	2,758	-	5,000
1987/88	1,736	-	[illegible]	2,938	-	5,000
1988/89	1,486	-	35[illegible]	3,163	-	5,000
1989/90	1,236	-	376	1,942	1,446	5,000
1990/91	986	-	401	1,292	2,321	5,000
1991/92	786	1,600	261	592	1,761	5,000
1992/93	486	1,800	271	-	2,443	5,000
1993/94	236	1,800	296	-	2,668	5,000
1994/95	-	1,800	320	-	2,880	5,000

(b) Option 2: Relying on Earlier Clutha and Waikato Coal

Year	South Island surplus	Clutha hydro	Transmission savings	Huntly coal-fired	Second Waikato coal-fired	Oil-fired stations	Total mean-year supply
	Available mean-year supply from sources shown:						
1983/84	1,516	-	48	436	-	-	2,000
1984/85	2,000	-	-	-	-	-	2,000
1985/86	2,000	-	-	-	-	-	2,000
1986/87	1,936	-	306	2,758	-	-	5,000
1987/88	1,736	-	326	2,938	-	-	5,000
1988/89	1,486	-	351	3,163	-	-	5,000
1989/90	1,236	1,600	216	1,948	-	-	5,000
1990/91	986	1,800	221	1,292	-	701	5,000
1991/92	786	2,500	171	592	-	951	5,000
1992/93	486	2,550	196	-	1,768	-	5,000
1993/94	236	2,550	221	-	1,993	-	5,000
1994/95	-	2,550	245	-	2,205	-	5,000

(c) Option 3: Relying on Earlier Clutha and Oil

Year	South Island surplus	Clutha hydro	Transmission savings	Huntly coal-fired	Oil-fired stations	Total mean-year supply
	Available mean-year supply from sources shown:					
1983/84	1,516	-	48	436	-	2,000
1984/85	2,000	-	-	-	-	2,000
1985/86	2,000	-	-	-	-	2,000
1986/87	1,936	-	306	2,758	-	5,000
1987/88	1,736	-	326	2,938	-	5,000
1988/89	1,486	-	351	3,163	-	5,000
1989/90	1,236	1,600	216	1,948	-	5,000
1990/91	986	1,800	221	1,292	701	5,000
1991/92	786	2,500	171	592	951	5,000
1992/93	486	2,550	196	-	1,768	5,000
1993/94	236	2,550	221	-	1,993	5,000
1994/95	-	2,550	245	-	2,205	5,000

Background notes to table:

1) South Island surplus calculated using central demand forecast and mean-year generating capacity.

2) North Island gas-fired stations assumed restricted to a maximum output of 1,180 GWh annually from 1989/90 on due to allocation of Maui gas to other uses.

3) Huntly station assumed to operate in mean years at 65% plant factor, giving maximum output of 5,466 GWh from 1989/90 on.

4) In Option I the Clyde dam begins generation in 1991/92, as forecast in the 1979 power plan, and all electricity from this source is allocated to the bulk sale. A 500 MW coal-fired station in the Waikato comes on in 1989/90, avoiding the need to use oil to meet mean-year demand.

5) In Options 2 and 3 construction of the Clutha dams is brought forward, with Clyde starting up in 1989/90 and Luggate in 1991/2. All power from both schemes is allocated to the bulk sale. In Option 2 a new Waikato coal-fired station is opened to provide baseload power in 1992/3, avoiding the need to run oil-fired stations at more than 20% plant factor. In Option 3 the power is supplied by burning oil as required.

	Marginal cost per kwh
South Island surplus hydro	zero
Transmission savings	zero
Clyde dam if completed in 1992/93	3.1 cents
Clutha scheme with accelerated constructed schedule	3.0 cents
Huntly (cost of fuel, operation and maintenance only)	1.2 cents
New Waikato coal-fired station	2.5 cents
Marsden A and B oil-fired	5.0 cents

Low costs are shown for surplus hydro, transmission savings, and Huntly because the capital costs of these sources of supply have already been incurred, and are therefore sunk costs which are not affected by the level of operation of the station. The same is true of Marsden A and B, although there the very high price of imported oil makes the power expensive even with capital charges excluded. The Clutha scheme and the new coal-fired station are costed on the basis of capital charges as well as fuel, operating and maintenance expenses.

The calculation of mean-year costs per kilowatt-hour of power is straightforward: the costs of power from various sources, as shown above, are multiplied by the amount of power from each source in each year in Table I and the resulting total cost is then divided by 2,000 or 5,000, as appropriate, to give mean-year marginal cost of power per kWh under the three options. This gives the extra cost which New Zealand must meet in order to expand its mean-year generation to supply an additional 5,000 GWh over and above the expected growth of normal demand.

In order to meet the additional demand, however, there are two other categories of costs which will have to be met. One of these is the cost of installing and operating transmission lines, substations, and administration systems for the new sales. We have exluded these costs from our calculations here, which again has the effect of biasing our figures on the downward side.

The second category is the cost of providing enough spare capacity in the generating system to carry us through dry years and seasonal peak demand without the need for power blackouts. In one year in every five, river flows are 10% or more below the mean-year level; one in four of these years is a true "dry year" with river flows 15% below the mean. If all our hydro generating stations are fully committed during mean years, then in order to cover ourselves in dry years we shall need enough spare thermal stations to make up for a 15% fall in hydro generation.

This "dry-year firming" capability poses some problems in the context of the 5,000 GWh sale. Gas-fired stations will be limited in their ability to perform this role by the restriction on gas supply from Maui; while coal-fired stations can vary their output only to the extent that output of coal from the mines which service them can be varied. Underground coal mining is an activity which is unsuited to large fluctuations is output, and so we assume that coal-fired stations would be capable of not more than a 20% variation in their output of power to meet dry-year firming needs.[5]

What this means is that only part of the dry-year margin can come from gas or coal. With hydro and geothermal fully commited, this leaves only oil as the source of power to make up the dry-year shortfall.

The cost of building enough stations to provide insurance against dry-year shortages, plus the cost of actually operating those stations during dry years, must be taken into account in calculating the true marginal cost of supplying large long-term commitments. We have therefore worked out for each of our three options, year by year, the sources from which extra power would have to come in dry years to ensure meeting both normal demand and the 5,000 GWh. We have then allocated the highest-cost sources to the 5,000 GWh, since this is the marginal sale which pushes us into the more expensive sources of supply. This gives for each year the extra cost which would have to be met should the year prove a dry one. We have then weighted these costs by the probabilities of a 90% dry year (that is, 0.15) and of an 85% dry year (0.05) in order to obtain a series for the cost of providing for dry years, based on the probabilities of their occurrence.

This is not altogether a satisfactory method of making allowance for the dry-year problem, but we believe the results have the right orders of magnitude, and we therefore use them to adjust our mean-year-only costs upwards by an amount which covers the expected cost of dry-year firming as calculated above. The results are shown in Table 2.

TABLE 2

Marginal Cost of Supplying a Long-Term Commitment, in cents per Kilowatt-hour

Year	----- Option 1 ------			------ Option 2 ------			------ Option 3 ------		
	Cost of mean-year generation	Cost of providing for dry year firming	Overall cost	Cost of mean-year generation	Cost of providing for dry year firming	Overall cost	Cost of mean-year generation	Cost of providing for dry year firming	Overall cost
1983/84	0.26	0.63	0.89	0.26	0.63	0.89	0.26	0.63	0.89
1984/85	0.00	0.62	0.62	0.00	0.62	0.62	0.00	0.62	0.62
1985/86	0.00	0.64	0.64	0.00	0.64	0.64	0.00	0.64	0.64
1986/87	0.66	0.21	0.87	0.66	0.21	0.87	0.66	0.21	0.87
1987/88	0.71	0.19	0.90	0.71	0.19	0.90	0.71	0.19	0.90
1988/89	0.76	0.20	0.96	0.76	0.20	0.96	0.76	0.20	0.96
1989/90	1.19	0.14	1.33	1.43	0.15	1.58	1.43	0.15	1.58
1990/91	1.47	0.14	1.61	2.09	0.16	2.25	2.09	0.16	2.25
1991/92	2.01	0.12	2.13	2.59	0.07	2.66	2.59	0.07	2.66
1992/93	2.34	0.11	2.45	2.41	0.14	2.55	3.30	0.10	3.40
1993/94	2.45	0.05	2.50	2.53	0.14	2.67	3.52	0.06	3.58
1994/95	2.56	0.03	2.59	2.63	0.19	2.82	3.74	0.03	3.77

Mean-year generating costs calculated by multiplying per-unit cost for each source of supply by the appropriate volume of power from Table 1 of this Appendix.

Cost of providing for dry-year firming derived as explained in accompanying text, by estimating the cost of firming the national system with (as distinct from without) the 5,000 GWh sale commitment, and allocating these marginal firming stations to the 5,000 GWh sale.

Overall cost is the total of mean-year cost and dry-year firming cost.

REFERENCES

1) The costing method used involves the Present Worthing of the total flow of costs as done by S. Wong and M. Hewitt The Comparative Economics of the Principal Forms of Electricity Generation, a paper presented to the 3rd New Zealand Energy Conference, May 1977, Wellington, pp 14-22. The costing for the Clyde dam uses a construction cost of $320 million based on ($259M - Clyde Project EIR, 1977 dollars - increased by 35% for inflation - M Ellis - less $20M already spent at the Clyde site), a construction period if 13 years (PCEPD, 1979), and generation of 1800 GWh a year over 50 years. See also : M Ellis, Comments on "Aluminium Smelting in New Zealand, An Economic Appraisal," unpublished.

2) We have assumed a Maui gas offtake of 12PJ after 1989/90, with a further 6PJ available for dry year firming. Until 1986/87 the offtake for electricity generation would equal 22 PJ in a mean year. The average over the thirty year Maui gas contract is an allocation of 15PJ per year to electricity generation. Energy Strategy '79, Ministry of Energy. p 59.

3) Ellis, op cit, p.2.

4) Station costs:
For method and Clutha costs see (1).
Huntly: coal cost $1/GJ/Energy Strategy '79, p49. $1.15/GJ, Mr Smith/, Mines Division, 1/5/80. Heat Rate 10227, Molly Melhuish, Second Submission to the Royal Commission on Nuclear Power, 1977. Operations and Maintenance: 0.1c/kWh.
New Waikato, see (3)
Marsden A & B, $4.34/GJ (Arabian Heavy Crude $25 barrel and $1.20 per tonne shipping - large tanker average Oct 1979 - Jan 1980 - $184.97 tonne, 42.6 GJ/tonne Petroleum Economist March 1980 pp 39-40) Heat Rate 11430 Melhuish

5) Coal Plan, Mines Division and Ministry of Energy April 1979