NEW ZEALAND ELECTRICITY SUPPLY

by

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INTRODUCTION

The purpose of this paper is to highlight those aspects of electricity supply in New Zealand that are unusual or unique. The New Zealand Electricity Department has a demand about the same as an average U.S. utility, yet it has one of the most diverse power systems in the world. This paper will begin with the basic organization and operational parameters, and will then describe environmental considerations in planning, the nuclear debate, prospects for new technology, geothermal generation, the d.c. transmission scheme, the tariff structure, and peak load control.

BASIC ORGANIZATION

Government, operating through the New Zealand Electricity Department (NZED) is responsible for the generation and bulk transmission of electricity to 51 electrical supply authorities who retail the energy to consumers.

The electrical supply authorities comprise several different types of local government organizations. Power Boards (39) have the sole responsibility for retailing electricity in a defined area while municipal electrical authorities combine this function with the provision of other amenities. The boards and councils are non-profit making, and members are elected public representatives.

Some Power Boards and Municipal Councils have their own generating schemes; these are generally small hydroelectric installations. The Government is encouraging more of these schemes through provision of loans because it would mean extra energy from schemes too small for Electricity Department involvement. The schemes must first be approved by the Electricity Department and must meet the condition that the generating pattern is the same as the demand pattern of the supply authority. The size of supply authorities varies considerably, with peak demands ranging from 5 MW to 500 MW. There have been several amalgamations between adjacent boards to achieve economies of scale and indeed a previous Administration made this a policy plank; but generally boards seek to preserve their identity!

The Government took responsibility for electricity generation in 1915 and has retained it since then, forming a separate department in 1945. The principal reason for heavy Government involvement was that this was the only source of funds in a young country without a large capital infrastructure. The General Manager of the Electricity Department is still responsible to a cabinet minister, and the minister presents an Annual Report of the activities of the Department to Parliament.
The Department does provide a channel for the Government to "nudge" the national economy when desired, as much of its capital equipment and all the fuel oil must be imported. A recent minister of Electricity stated that "... an adequate supply of electricity is a major factor in fulfilling the social and economic objectives of the Government." However, conservation is becoming a widely stressed theme, and recent years have seen electricity restrictions in order to reduce expenditure on imported fuel oil. In 1974 the reduction of thermal generation was followed by low hydraulic inflows and this caused more stringent restrictions.

The long term growth of installed capacity and energy generated is shown in Fig. 1. Drops due to economic recessions can be seen in the 1930's and the Second World War. The average growth rate has been in excess of 7%, and this rate is projected for the next decade; the effect will be to push the market share of electricity from 22% in 1972 to a predicted 29% in 1981. At present, about 49% of electricity supply is to domestic consumers, and this represents one of the highest rates of domestic consumption in the world (8000 kwh per consumer per annum).

The main reason for this is that a pure maximum demand bulk supply tariff which was in effect for many years encouraged the use of domestic electric storage water heaters. This was further facilitated by the almost universal use of peak load control systems allowing the heater to be turned off at time of peak. National standards for insulation were instituted to prevent heat loss from the cylinders during such periods. In 1972, hot water systems accounted for 43.6% of domestic consumption, while the figure for cooking was 12.8% and for space-heating, lights, and other appliances was 43.6%.

However, New Zealand has an abnormally low ratio of electricity consumption to gross national product which reflects the agricultural basis of the economy. Only in the last decade has industrial demand for electricity risen rapidly, with the establishment of a steel industry, an aluminum smelter, and a large wood-pulp and paper industry.

The Department functions through eight district or regional offices throughout New Zealand; these are not autonomous but are controlled and coordinated by a head office in Wellington. Corporate management comprises a General Manager with two Assistants in Administration and Engineering. At the head of each of the Technical Divisions are Chief Engineers, located in the head office. The Divisions are Development, Design and Construction, Operations, Technical Services, and Commercial. The latter deals with relationships with the supply authorities.

This head office structure is reflected in the districts with the exception of the Development and Commercial Divisions which are head office divisions only. Total staff levels are at 5600, with 2200 in the Operations Division and about 850 being construction wage workers. This total does not include those on new civil engineering works.
Approximately 80% of the present annual generation of 19,000 GWh (with a 4000 MW peak) is supplied by hydroelectricity. There are several large hydro schemes together with thermal plant under construction so this proportion will not change greatly in the next decade. To supplement the hydrogeneration there are coal fired (177MW), oil fired (238MW), and natural gas fired (600MW) steam stations; oil fired (132MW), and natural gas fired (220MW) gas turbines; and geothermal steam (159MW). This is all located in the North Island, and new thermal power stations are also located here, these being 1000MW of gas and coal fired steam, and 320MW of oil fired gas turbine.

The utilization of the onshore field at Kapuni and the large offshore Maui field have delayed the introduction of nuclear power, and a further 1000MW gas burning station is planned near New Zealand's largest city, Auckland. The plant margin or "over-capacity factor" in the New Zealand power system is 4%. This is the extra capacity over the anticipated maximum demand, and is much smaller than that required in all-thermal power systems because of the high reliability of hydro-generating sets. Another factor is the temperate climate in New Zealand. In general, the planning criterion for the system is avoidance of an energy deficit due to a dry year rather than a peak deficit.

Hydraulic inflows and storage considerations dominate the scheduling of the power system. Operating policy is set in Head Office and the two System Control Centers (in the North and South Islands) are responsible for daily operation. The only transmission link between the two islands is a 500kV direct current submarine cable which can transmit energy in either direction; generally the transfer is South to North to minimize thermal generation. The operating pattern of the South Island storage lakes is that they fill during the spring thaw and rains, are held full over the summer and drop to minimum levels during winter. In the North Island the biggest inflows occur in the winter.

Generation is at 50 hertz with the main transmission voltage at 220kV and 110kV. Distribution is at 66kV and 33kV with most supply authorities being supplied at the latter voltage. There are over 7000 miles of transmission line connecting the 32 power stations and 130 (approximately) substations. Figure 4 gives a map of the power systems.

Briefly, the planning procedure is as follows. The Power and Finance Utilization Committee comprising representatives from the Supply Authorities and one from the Electricity Department meets annually to estimate demand for 5 years ahead. This estimate is based on an aggregation from the individual supply authorities forecasts, considering local growth in their area.
The Committee to Review Power Requirements with representatives from Electricity Department (chairman), Supply Authorities, Treasury, Ministry of Energy Resources, and Department of Statistics (who provide an independent projection) modify the P.F.U. forecast in the light of national economic and energy policy, and make 10 and 15 year projections of generation.

The Planning Committee on Electric Power Development comprising representatives from Electricity Department (chairman), Supply Authorities, Ministry of Works and Development, Ministry of Energy Resources, and Treasury then propose construction projects to meet the projected demand over the 15 year period. It reviews existing plans and may advance or defer projects as economic conditions require. Both reports are presented to Parliament through the Minister. Cabinet approval must be obtained before any construction project may proceed.

While the Ministry of Works and Development is consultant for design and construction of the civil engineering works, the Electricity Department designs all electrical installations itself. World wide tenders are called for the supply of equipment and for services such as tunneling. NZED then maintains and operates these facilities, as it is charged with supplying "adequate electricity safety, continuously, reliably, and at minimum cost."

As well as generating and transmitting electricity, the NZED administers regulatory control over the electrical industry and operates the Rural Reticulation Fund. The levy payable by the supply authorities to the fund is 1/8 of 1% of the revenue from the sales of electricity, and was begun in 1946. It has subsidized supply authority extensions to the remote parts of the distribution system, and has undoubtedly raised the rural standard of living and agricultural development.

Having thus set the scene we may proceed to elaborate on some of those aspects which overseas utilities have been interested in.

ENVIRONMENTAL CONSIDERATIONS IN PLANNING

It would be fair to say that little real environmental damage has occurred so far in New Zealand as a result of electric power production. Present thermal power stations are too small to have affected the air or water to the extent where the natural ecosystem cannot cope. Mining operations and air emissions of the single 177MW coal burning station could not be classed as significant; the words "damage" and "significant" are of course value judgments depending on one's point of view.

Hydro schemes have definitely visually and socially enhanced some areas (e.g. Benmore), controlled flooding in others (e.g. the Tongariro/Waikato scheme), and protected wildlife in a few (e.g. Tongariro). Some areas of the country have been opened up by electricity schemes, although the price paid can be a transmission line through the area. There have been a few schemes (such as Monowai) in which the environmental requirements have been neglected, or where waterfalls and rapids have been lost. In these schemes the benefits are somewhat masked by the costs.
However, as the remaining hydro sites are developed and more thermal stations built, the environmental objections become more strident. The planned Clutha scheme for example will take farmland and long stretches of natural river and gorge. Auckland residents are objecting to both new transmission lines and a thermal power station which are required in that area. There is a growing feeling among some groups that the remaining smaller rivers should be left in the wild rather than developed en masse.

Probably the first time that environmental considerations in power planning became a matter for widespread public debate was in the mid 1960's, when the Lake Manapouri scheme became controversial. This is a large lake in a rugged area of the South Island. The first proposal was to raise the lake 100 feet, later modified to 27 feet above the natural level, and was to be New Zealand's largest scheme at 700MW. However, very active environmental groups successfully campaigned to keep the lake at its natural level, and with nearly natural patterns of levels throughout the year. This has resulted in the loss of about 340GWh per annum and about 50MW of peak capacity.

It was recognized that some mechanism was needed to notify the public of the consequences of planned schemes, and to collect and utilize the comments of vigilant environmental groups. Accordingly the Commission for the Environment was set up to perform this educative and coordinating function.

There are of course statutory requirements by appropriate authorities which must be complied with. For an electric power project, these are as follows:

1. Application for a change in land use zoning under The Town and Country Planning Act 1953. Obtained from territorial local authorities e.g. county council.
2. Application for water rights under the Water and Soil Conservation Act 1967. Applies to water use or discharge into water. Obtained from the National Water and Soil Conservation Authority through the Ministry of Works and Development.
3. Application for license for emissions into the atmosphere under the Clean Air Act 1972. Obtained from the Department of Health.

Concurrently with the statutory requirements there are mandatory "Environmental Enhancement Procedures" for all Government projects, and local authority projects using Government money; and they are recommended for other local authority projects. As mentioned their intention is education; and the basic process is as follows:

1. There is an initial Environmental Assessment which is a preliminary report by the Electricity Department or Supply Authority to the Commission for the Environment. If the Commission is satisfied with this, no further report is needed, but if the environment changes are significant:
2. An Environmental Impact Report is requested. This is automatic for all major public works, and is (or should be) a comprehensive document detailing all the environmental effects. As it takes some time to prepare, the situation has occurred that an Impact Report is not available until the project has practically started. The preliminary Environmental Assessment is designed to partially overcome this objection.

3. The Environmental Impact Report goes to the Commission for the Environment which calls for public submissions over a 2 month period; and the Commission produces an audit of the Impact Report and the public comments within a further 2 months.

4. The audit plus public comments go back to the authority proposing the development who considers the comments and modifies the scheme where practicable to accommodate the criticisms. However, there is no legal obligation to meet any of the objections.

5. If there is considerable local pressure brought to bear against a scheme, or aspects of it, Cabinet will make the final decision as to which option to follow.

There is general recognition in New Zealand that the country while having one of the highest standards of living in the world is still largely "unspoilt" by virtue of the small amount of industrial activity and the low population (presently 3 million). The procedures outlined have slowed power planning down of course and their robustness is constantly being tested.

THE NUCLEAR DEBATE

In the mid 1960's the Power Plans showed a nuclear power station coming into service in 1977/78. The discovery of the Maui natural gas field and the allocation of gas for electricity generation made it possible to defer the introduction of nuclear power. However, the 1975 Power Plan stated that by 1988 or a few years thereafter, a nuclear power station would be required in the North Island, as indigenous energy resources appeared unlikely to support the projected electrical demand. A decision to introduce nuclear power would be required by 1977, and a 2x600MW plant was proposed with the proviso that the station be deferred as long as possible.

However, there has been a steadily increasing public debate on this issue. A petition containing over 330,000 signatures against the use of nuclear power in any form, including ships, was presented to Parliament at the end of 1976. The debate is fostered by the news media.

The issue has not yet become a divergent policy plank for the two major political parties. Official Government policy is that "no decision has yet been made." The previous Labour administration set up a committee under the chairmanship of the President of the Royal Society to report in 1977 on the "Environmental Effects of Nuclear Power." The purpose of the committee was stated to be educational.
More recently the present National administration set up a Royal Commission on Nuclear Power Generation in New Zealand. The Commission, chaired by a judge of the Court of Appeal, is to report by 31 December 1977. The terms of reference of the Commission are: "To enquire into and report to the Government upon the likely consequences of a nuclear program. In so doing the Commission will consider such matters as siting, licensing, inspection, environmental effects, safety factors, transport of fuel and waste, disposal of waste, and any other matters which the Commission decides shall be brought to the attention of the Government."

So a decision on nuclear power will not be made until at least 1978. (It could be noted that a similar Royal Commission in Britain has urged a postponement of the expansion of nuclear power in that country.)

Recently announced Government policy is that the price of indigenous energy resources be pegged to the price of imported oil. All oil consumed in New Zealand is imported both in refined and crude form except for a 15% contribution from natural gas condensate. Present pricing policy effectively imposes a levy on coal and natural gas, both of which are produced by Government financed corporations, so that natural gas prices are about 15% below the price of imported oil, and coal about 35% below. This relationship is to encourage the use of appropriate quantities of indigenous fuel, and also to reflect directly to consumers the world price for oil. From a power planning point of view the uncertainty in the world price for oil adds another dimension of uncertainty to future electricity production costs.

PROSPECTS FOR NEW TECHNOLOGY

The New Zealand Energy Research and Development Committee was established in 1974 with the overall objective of supporting energy research and development. This objective is being pursued by undertaking contracts with Government departments, universities, research associations, industry, and consultants. These contracts are for R&D directed toward meeting New Zealand's future energy requirements and making the country more self-sufficient in meeting those demands. In addition the committee is the administering body in New Zealand for the Joint U.S./N.Z. Agreement for Scientific and Technological Cooperation, under which it has been determined that the initial emphasis will be given to energy research.

Funded projects must include consideration of environmental factors, and those which promote the use of indigenous resources are given a high priority. However, those projects involving substantial expenditure on demonstration plants, drilling, etc., are recommended for separate funding by Government. Thus at the Committee's discretion, research money is available to private enterprise for innovation in energy supply.

At the end of its second financial year the Committee had expended $918,000 on approximately 43 projects. The largest of these was some
$84,000 on a research project to produce automotive fuels from cellulose materials. There have been many small grants sponsoring visits to overseas research establishments. One important program undertaken by the Committee has been the formation of a workshop group to develop energy policy scenarios for New Zealand. The great value of this work is that it can catalyze development of a coordinated energy policy for New Zealand.

One area of interest of the Committee has been electrical generation by windpower. A recent survey of wind resources in New Zealand has concluded that it is a windy country by world standards and has considerable potential for the utilization of wind energy. Projects have been funded for R&D in this area. There have also been projects for assessment of coal technologies and district heating schemes of relevance to the electrical industry.

N.Z. GEOTHERMAL GENERATION

At Wairakei, near Lake Taupo in the North Island, the New Zealand Electricity Department operates one of the two biggest geothermal steam fields in the world (the other is at Larderello in Italy). The peak generation at present available from Wairakei is 159MW and the annual production is about 1250GWh with an annual capacity factor of 89.6% and an availability factor of 88.7%.

Two separate steam supply systems have been established at Wairakei. The high pressure system (H.P.) to which are connected the deep bores of good quality, had initial well head production pressures of 200-230psig, and supplies H.P. back-pressure turbines at 180psig pressure (380°F). The intermediate pressure (I.P.) system which is used to collect steam from the shallow bores and also from some deep bores of secondary quality, was initially 80-120psig, and supplies I.P. backpressure turbines at 50psig pressure (298°F).

Steam is produced from what is essentially a hot water aquifer, and flashes off from the water as the pressure is reduced on rising up the bore. This steam forms the H.P. supply, and the separated water is mixed with some water from the I.P. bores and piped back to the power house where the steam is flashed off. After passing through scrubbers to remove the salinity it is mixed with I.P. steam piped in from the field. There is a third pressure system internal to the station -- the low pressure system receiving steam from the I.P. sets at about 1-1/2psig. This is also fed by steam flashed from I.P. water.

A "typical" deep bore at 2000 feet in the early stages of development had the following production:

<table>
<thead>
<tr>
<th>System</th>
<th>Production from steam (220 psig)</th>
<th>Production from hot water (95 psig)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.P. deep</td>
<td>4.4 MW</td>
<td>4.6 MW</td>
<td>9.0 MW</td>
</tr>
<tr>
<td>bore (220 psig)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I.P. deep</td>
<td>2.7 MW</td>
<td>0.9 MW</td>
<td>3.6 MW</td>
</tr>
<tr>
<td>bore (95 psig)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Steam wells number 40 H.P. plus 20 I.P., and about 35 exploratory. Drilling began in 1950, and the power station built in two stages from 1956-1960, and 1960-1963. During the first stage a heavy water production plant was provided for, but this failed to materialize.

A summary of the installed capacity is as follows:

'A' station; 102.6MW comprising 2 x 6.5MW HP, 2 x 11.2MW HP, 2 x 11.2MW IP, 4 x 11.2MW LP.
'B' station; 90 MW comprising 3 x 30MW mixed pressure.

In addition there are 3 HP and 2 IP 20 inch dia steam transmission pipes from the steam field of total length 42,500 feet, with 2 HP and 1 IP 30 inch dia steam pipes of total length 27,650 feet. The center of the steam field is about 1/2 mile from the power station, and close nearby is the Waikato River from which the cooling water for the turbines is obtained, and into which all waste water is exhausted.

There is a general tendency for bore outputs to decline and steam to become drier as time passes, often at a rapid initial rate. According to McKenzie and Smith (World Power Conference 1968, C4/204) the main reactions of the hot water reservoir to exploitation have been

1) A fall in pressure at depth. This has fallen from 900 psig and appears to be stabilizing. It corresponds to a fall in the level of water in the liquid phase.

2) A fall of water temperature in the wells. This has dropped from a mean of 250°C in 1958/60 at a rate of up to 4.5°C per year in 1968. As a result of the falls in pressure and temperature, well outputs were declining by 16% p.a. for H.P. and 11% p.a. for L.P. in 1968. At present they are declining more slowly.

3) Subsidence of the ground surface over an area of about 2 square miles due to the considerable extraction of water. The maximum rate of sinking in one area (away from the pipes fortunately) has been 1 ft per year, but total sinking has been 2 to 3 feet.

It is now clear that for maximum life and return from the field the initial design was for too high an operating pressure. As a whole the station is performing satisfactorily, with the turbines remaining high maintenance items.

The total geothermal resource has been estimated as having a potential for development of up to 2000MW. It is probable that part of the steam and water resource will be used directly by the pulp and paper industry established on land around the geothermal area, or by other industry. Piping the energy away for other industry or for cities is being investigated.

The only field which is proved and ready for development at present is the Broadlands field, which will support a 150MW power station. The environmental problems of ground subsidence, disposal of dissolved salts, and disposal of surplus hot water have still to be solved, however,
THE D.C. TRANSMISSION SCHEME

The presence of major hydroelectric reserves in the South Island and principal load centers in the North Island motivated the Electricity Department to consider a direct current link across the 24 mile Cook Strait in 1950. Detailed planning began in 1961 and the 600MW 500kV 400 mile link between Benmore and Haywards was commissioned in 1965. Since then it has contributed more than 20% of the total energy required by the North Island over the same period. As this was one of the first major d.c. links in the world (the other being in the Soviet Union) there has been considerable interest in it, and the technology is now well established and well documented. The following is a brief description of the configuration before the operating experience is described.

The geographical route stretches north of Benmore, a 540MW hydro-power station, with 332 miles of transmission line. There are then three single conductor submarine cables (one being spare) under the 24 mile Cook Strait followed by a further 22 miles of transmission line to a converter station at Haywards. From 1965 to 1975 the link operated south to north only; it has now been modified to make it bi-directional.

The link has two poles operated at +250kV and -250kV, and if one pole is out of service, an earth return is available for the link to operate at half power. To facilitate the earth return, there is a sea electrode in the north consisting of 25 graphite electrodes buried in the shoreline; and in the south at Benmore a land electrode in the form of six pointed star made from steel rods in a trench and surrounded by granulated coke.

The layout of a converter circuit is given in Fig. 3, and a simplified layout of the scheme connections in Fig. 2. Each end has an a.c./d.c. converter station with 28 mercury arc valves in 4 valve groups. The converter circuit has a cascade arrangement with adjacent converter groups having a 30° phase displacement on the a.c. side to increase the pulsation number from six to twelve. This reduces harmonics in the a.c., ripple in the d.c., and also kilovar consumption.

Within each group there is a bypass valve to carry current while the group is temporarily blocked (or faulted due to arc back). For prolonged outages, a bypass switch is used so the link continues operating with reduced capacity. The link is usually operated in a constant power mode and reactive requirements to the converters are provided by the Benmore hydro machines at 260 MVAR of synchronous condensers in addition to the 100 MVAR capacitive filters at both locations.

The filters are needed for the harmonics generated in the converters. Originally filters were provided for the 5th, 7th, 11th, and 13th harmonics but it was necessary to add 9th harmonic and high pass filters to overcome widespread telephone interference.

The cost of the scheme was about $U.S. 52.2 million. Transmission losses are about 10% of power delivered to the link.
Performance over the years has been very satisfactory and the link has rapidly become an indispensable part of the power system. In early years the number of valve interruptions steadily increased and the ratio of arc-backs to consequential arc-back trippings was 2 or 3:1. It was necessary to replace the anode porcelains and carry out anode and grid modifications, and now the ratio is 10 or 12:1. The number of trippings per year is about 20.

The submarine cable itself has performed satisfactorily. Until 1976, problems only occurred in the cable joint at the seashore where the cable type changes to cater for different cooling of soil and water. However, in that year one cable developed a fault, necessitating lifting, and replacing of the appropriate section.

THE FINANCIAL AND TARIFF STRUCTURE

The primary source of finance for the New Zealand Electricity Department is the bulk supply tariff charged to the individual electric Supply Authorities. The contracts are renegotiated every 5 years or less. This tariff is designed to recover all operating costs including interest and depreciation plus a capital contribution from revenue to an upper limit of 50% of operating costs. The latter charge is made to reduce the loan liability of NZED to the National Development Loans account and to pay for a portion of capital works.

The National Development Loans account is financed by public subscription, and charges interest at 10% on funds advanced to NZED for capital works. For many years the interest rate was 5%. The other external sources of finance are loans from the World Bank or finance credits from countries from which equipment is purchased.

Internal NZED financing is obtained from two accounts, the depreciation account and the general reserve account. The first of these, the depreciation account, is built up in the following way. All completed revenue-earning works are added to the books, and a depreciation reserve is built up from revenue on these assets on a sinking fund basis. Hydroelectric power stations are charged for depreciation at 1% (41 years' life) of the asset value, thermal power stations at 2-1/2% (25 years) and geothermal stations at 3-1/2% (20 years). In addition there is a charge of 4% on the balance in the fund (which rises to the full asset value when the asset is theoretically written off). The balance of the depreciation account is used to assist in financing new capital works.

The second of the two accounts, the general reserve account is the one to which the capital contribution from revenue is placed after operating costs, interest and depreciation have been paid. The amount paid into this account fluctuates, and it has been zero at times when the Government of the day wishes to hold down electricity prices as a means of combatting inflation. The cash content of this account is used initially to repay loans and then as a contribution to capital works. At the same time as this policy was put into effect, the revenue from electricity sales was freed from income tax.
Interest on work in progress is not capitalized (i.e. added to the capital cost of the plant and equipment). Rather, work in progress (or "under construction") is treated as a capital asset and is financed from internal sources or the National Development Loans Account. Overall, the loan liability to capital outlay ratio for the NZED is around 73%, and this figure is projected for the next 10 years.

As at 31 March 1976, the total capital outlay (including sundry debtors) was $1733 million. A total of $240 million had been paid into the depreciation account and $164 million into the general reserve account, leaving a capital liability of $1329 million.

In summary, the NZED policy since 1957 has been to charge for bulk supply at such a rate that a substantial amount can be made available for financing capital works. This has the effect of increasing the cost of electricity and diminishing the need for capital to finance new capital works.

Individual supply authorities raise loans by public subscription and fix their own tariffs. The authorities are arms of local government, so the revenue is required to cover operating costs without being discriminatory, but there is provision for a margin of 50% over operating costs as a provision for capital work. The loan liability to capital outlay ratio averaged over all the authorities is 27%.

In 1967 the bulk supply tariff was changed from a maximum demand only tariff to a two-part tariff. Supply authorities are now charged $40.89 per kW demand at "peak," and 0.85 cents per kWh. They are sent quarterly bills, and the peak is reckoned as being the average of the six highest peaks per year. At a nominal 55% load factor, this tariff is designed to realize equal components of revenue to NZED from peak demand and from energy sales. There is no charge for reactive power, but instead there is a penalty payment if the power factor drops below 0.9.

The Supply Authorities charge domestic and commercial consumers on energy only, while most industrial consumers are charged on a two part tariff. Electricity use in the home has been encouraged by domestic tariffs lower than commercial/industrial tariffs, and peak control of hot water heating and space heating. Prices between supply authorities vary, but a non-interruptible kWh costs about 2.2 cents and an interruptible kWh costs about 1.7 cents.

However, the Government offers electricity at reduced cost in the interests of industrial development. These apply if the proposed industry will be beneficial to New Zealand in regard to overseas earnings, if the demand for electricity is nearly continuous and electricity is a significant proportion of the value of output.
PEAK LOAD CONTROL

Peak load control by individual supply authorities is now a very important factor for the whole supply system. It was initially encouraged by the maximum demand only tariff structure, but the gradual movement towards a greater energy component in the tariff has not made the schemes uneconomic.

In 1975, a total of some 500MW could be interruptible at any one time by individual supply authorities compared to the highest annual system peak of 4000MW. Peak reduction is thus about 10 - 15% in winter and higher (up to 25 - 30%) in summer. The benefit to the supply authorities is in reduction of the peak charge and improvement of load factor, and to NZED in construction costs, spinning reserve requirements, and occasionally relief in a prolonged plant or line outage. There is also spinoff in energy saving, although the latter means less hot water and space heating might be available in the domestic sector. Some industrial load is also interruptible under special arrangements.

Load control has been by d.c. bias or by pilot wire, but is now generally by voice frequency signal injection into the system. An injection plant might have a 20hp motor driving a 5kW 670 hertz generator, the latter feeding into an 11kV three phase line via an isolating transformer, capacitors and inductors. The signal voltages at the transmitting plant are approximately 20V between each low tension phase and neutral. In each house (say 4000 for a particular authority) would be an electromechanical relay tuned to respond to the 670 hertz signal and arranged to control the water or space heater.

Now multiple injection frequencies and solid state pickup relays are being used by some authorities. The system is commonly called ripple control, and as mentioned, there is a tariff concession to the consumer who has controllable load. Most authorities operate some form of load control, and the scheme has wide public acceptance, since the storage effect of water and space heating means the consumer does not notice when supply has been interrupted. However, during electricity restrictions supply authorities have an allocation of electricity from the NZED and load control has been used to help meet this allocation. In this case the consumer can detect the difference if a significant quantity of electrical heat is used.

CONCLUSION

This paper has outlined those aspects of the New Zealand power system which are thought to be most interesting or unusual. Aspects such as geothermal generation, the d.c. transmission scheme, and peak load control have been well documented and much more information is available on these.
Growth of Electricity Generation
1920 - 1981

Installed Capacity
Energy Generated

Megawatts
Gigawatt Hours

Years Ending 31 March

21.5% 8.5% 6.3% 7.7% 7.3%
8.1% (6.9%)

Actual Forecast

6.9% raised to 8.1% by special industrial load
Fig. 2—Main connections for inter-Island transmission.

Fig. 3—Typical terminal station converter connections.
FURTHER READING


