MINISTRY OF WORKS POWER DIVISION 1954 - 1974

Forward

The New Zealand electricity system is rarely out of the news.Volumes have been written about the generation,transmission and distribution facilities, but not much about how it was planned and implemented. Electricity in N.Z.is not like other commodities. If there is a shortage we cannot "buy some in" from the neighbours, like they can in Europe or North America. We have to make it ourselves. New Zealand has been making its own electricity for over 100 years. This has not been done in a haphazard fashion. Plans have been drawn up by people skilled in the business. The following notes describe the efforts of the MOW Power Division which was set up after World War 2, and was associated with the New Zealand Electricity Department to expand and establish what is now the basis of the national system. Apart from the small number of personnel forming the "Head Office" of the Power Division,I have avoided names, for the simple reason that the numbers in the projects and design office were so large that some worthy members of the teams would inevitably be missed.

Post World War 2 Shortages

Following the great surge in demand for electricity after World War 2, the state agencies responsible for electricity and works were called upon by the government to set up programmes to overcome the shortages. The New Zealand Electricity Department was responsible for the generation and supply to the local distribution authorities. The Ministry of Works, the government's construction agency, established a division to work jointly with the NZED to deal with the situation.

My first contact with the MOW Power Division was in 1954, a transfer from senior engineer in the department's Invercargill office to the Roxburgh Power Project which was under urgent construction to relieve blackouts in the South Island. Apart from a 3 year period in the Auckland district office, I was employed in the Power Division for about 20 years , ie from about 1954 to 1974.

The Forward Programme

This was a period of intense development of the national power system. The installed capacity increased from 765MW to 4544MW. 13 new hydro stations and 5 new thermal stations were commissioned. The hydro stations were :
Whakamaru,Atiamuri,Waipapa,Ohakuri,Aratiatia,Maraetai 2, Tokaanu and Matahina in the North Island, and Waitaki extensions, Roxburgh, Benmore, Aviemore, Manapouri in the South.
Construction was underway on Tongariro Power Development in the North Island and Upper Waitaki in the South Island.
Control dams were constructed at Lakes Pukaki, Ruataniwha, Hawea, Te Anau, and Manapouri, in the South Island, and Moawhango in the North Island.
The thermal stations were:
Wairakei, Meremere, Marsden A, New Plymouth, and Otahuhu.

Relationship With Client Department

Throughout these notes, for convenience purposes, the operator of the NZ Electricity System has been called "NZED", even though the title changed from time to time. Likewise the works department has been called "MOW", even though its title also changed. The Power Division was not always known as such. In the 1950's it was a Hydro design and construction team under the Assistant Engineer in Chief (Mr J.T.Gilkison who in turn was responsible to the Engineer in

Chief,Mr C.W.O.Turner). Following reorganisation of the M.O,W,, the team was renamed the Power Division. It consisted of a Head Office group of about eight,located in the old wooden building on Lambton Quay, a Design Office of about 100, located in a cluster of ex-wartime sheds behind Parliament Buildings, and the Power Projects located in construction villages, such as Mangakino in the North Island and Roxburgh in the South Island. (Note: The projects' technical responsibilities were to the Power Division,but for administrative purposes they reported to other sections of the M.O.W.) A typical hydro project involved 5 to 7 seven years design and construction from project authorisation to first power. Peak labour force varied from 300 to 1000 depending on the size of the project. Construction villages were established to suit the location of the construction work. North Island locations were Mangakino,Wairaki, Turangi, and Te Mahoe. South Island were Roxburgh, Hawea,Otematata and Twizel. Earlier establishments had been located at Tekapo and Waitaki. Peak population varied according to project size and duration, reaching several thousand for the larger work.

The Power Division therefore comprised a large number of M.O.W.personnel dedicated to the power development programme. Except for a few in senior management, their salaries and expenses were funded from "vote electric supply". The MOW involvement did not end there. Services from other divisions of the MOW were called upon for special assignments as required. This large presence of MOW was most marked in the hydroelectric projects where many of the constructed features were civil engineering items (earthworks,heavy concrete and steel items, hydraulic structures, etc). The proportion of these items was still significant in the thermal stations, but much less than in the hydro stations. So, in order to serve the client's (i.e.NZED's) needs, the power development programme demanded a large input from the MOW power division. NZED ultimately had to operate the stations and run the power system, economically and efficiently.

Close communication between the Client (NZED), and the MOW was essential at all times, and most important during the planning and early design stages. Project authorisation called for cost estimates, manpower,plant and materials assessments and construction schedules to be documented for government approval, with inputs from both the NZED as client and MOW Power Div. Responsibility for items varied from project to project.

For hydro schemes NZED was responsible for the installation of all permanent generating equipment from scroll case and turbines through to the transformers and switchyard items connecting to the transmission system,and all control room equipment. MOW power div. was responsible for site establishment and all civil engineering and other items (e.g. dams,hydraulic structures, powerhouse structures,gates and screens) necessary for the completed work. During the period of reservoir filling and station commissioning, the MOW items were progressively handed over to NZED.

For the thermal projects NZED usually engaged a specialist electrical engineering consulting firm to manage the work through the design, construction and commissioning phases. The various items were then allocated to specialist companies for supply and installation. Site establishment, excavation, foundations, cooling water systems and powerhouse structural items were carried out by MOW Power Div. forces for the Wairakei, New Plymouth, and Otahuhu stations, also at Huntly which came later.

MOW Power Division around 1960

Photograph "A" taken in 1960/61 shows the group of 8 comprising the head office of the Power Division. They were (in order left to right):
Chief Construction Engineer - G.J.Hallewell
Inspecting Engineer - W.M Fisher
Chief Power Engineer - F.R.Askin

Chief Design Engineer - R.F.D.Ritchie
Inspecting Engineer - W.E.Sisson
Asst.Chief Design Engineer - L.S.James
Construction Engineer - W.M.Duncan
Geothermal Engineer - J.H.Smith

Messrs Hallewell, Fisher, and Ritchie had many years of hydro construction experience dating back to Arapuni, the Waikaremoana schemes, and the Waitaki schemes in the 1930's.

The Chief Power Engineer headed the division and was the main link with the Commissioner of Works, Minister of Works, and General Manager of NZED.

The Inspecting Engineer,W.M.Fisher, because of his background and qualifications in both electrical and civil engineering, was located in the NZED office, and was available to the General manager and staff for advice and assistance. He was also in charge of investigations into new sites for generating stations and for geothermal investigations.

The Chief Designing Engineer and Assistant Chief Designing Engineer headed the Power design office which comprised a team of about 100 engineers,architects, draughtsmen,and technicians. Reports,working drawings and specifications, test records, as built plans, and technical data were produced and kept here. Liaison with the projects was maintained by the Inspecting engineer,who also kept up to date data on materials of construction, standards and codes of practice. Close cooperation between designers and the MOW Central laboratories took place throughout the design process, particularly relating to hydraulic structures where modelling was essential to verify and if necessary modify geometric shapes and dimensions. The Power design office was the technical centre for the Division.

The Construction engineers were closely involved during the evaluation of design layouts, before projects were authorised and established on site. Negotiations with local authorities and land holders, access to the work, availability of construction materials, labour and plant requirements, all required attention and assessment before a firm plan and cost estimate could be completed. It was usual during this phase to establish a small team on site to gather additional information and undertake any special investigations which would be useful to the designers and project construction force. This advance group could be from a previously completed project,or from a local MOW office. The group was also the first contact point with the local community.

The Geothermal engineer worked closely with Inspecting engineer W.M.Fisher, and supervised investigations and development of the steam field at Wairakei where the project team had developed special drilling expertise in geothermal work. The Geothermal engineer was located in the Power design office. Geothermal investigations, and the control and development of steam wells and steam fields involved highly specialised engineering, outside traditional MOW civil engineering construction. The work was at times unpredictable and dangerous. This pioneering work by a dedicated team led to the world's first use of wet geothermal steam for power generation. The Wairaki station's contribution to the national grid supply has been continuous and reliable, and compares favourably with North Island Hydro Stations in output.

MOW Power Division Around 1968

Photograph "B" taken in 1968 indicates some changes to the earlier Head Office team, brought about by retirements and changing workload. Following retirement of Inspecting engineer,W.M.Fisher, responsibility for investigations was transferred to the Power Design Office, where the investigating team could have closer contact with the designers. The investigation section of the office had become, in association with the Water and Soil Division of MOW, the repository

of hydrological data for New Zealand rivers. It had also become clear that the large programme of design work was more than could be handled by the existing staff. Overseas firms, experienced in both hydro and thermal power engineering, had been engaged to undertake some of the design and management of the work. The British firms of Sir Alexander Gibb and Partners were assigned the Atiamuri and Tongariro design,
Merz and McLellan the Wairakei design and management, Preece Cardew and Ryder the design and management of Meremere, New Plymouth (and later Huntly), and the U.S. firm Bechtel Corporation the management and design of Manapouri and the Marsden stations. Contractual arrangements were necessary between these firms and the government, and also between any subsequent supply or construction contractors and the government. These contracts were large and involved international firms. Administration under New Zealand conditions called for the special skills of the Power Division's very experienced administration officer, Mr W.O.Waller. A further issue of growing importance was the public concern that environmental values were at risk. An extreme example was the Manapouri scheme which became a national issue, resulting in two enquiries by Cabinet committees, and an independent Commission of Inquiry. Additional efforts from both NZED and MOW Power Div. were required to deal with these issues, which at times were very contentious.. The Power Div.'s man was Mr V.C.Davies, an experienced engineer capable of explaining the complexities to concerned parties, and frequently resolving them, whether they were apprehensive M.P.'s, hostile environmental groups, or international corporates.

Power Planning

Orderly execution of the design and construction was critically dependant on the annual Power Planning procedures. These arrangements were set up in the early 1950's and underwent some changes until they settled down into a steady pattern around 1960. Two committees were established under the chairmanship of the general manager of NZED. They were : The Committee to Review Power Requirements (CRPR), and the Power Planning Committee (the PPC). Staff from NZED, Electricity Supply Authorities, and later Statistics Dept,were represented on the CRPR. The Power Planning Committee had representatives from NZED, Electricity Supply Authorities,MOW Power Div., and Treasury. The CRPR produced a forecast of electricity demand for the next 10 to 15 years, and the PPC produced a list of new generating plant and commissioning dates to meet the demand. Details of this proposed new plant followed studies of various options and evaluation of environmental, technical and economic factors, which were considered by the committee at its annual meeting. The Power planning report was tabled in Parliament each year and formed the basis for ensuing construction programmes. The report was published by the Government Printer, A5 size and usually no more than 30 pages, containing tables of proposed new stations, commissioning dates, and also reports on work under investigation or construction. The document was not a glossy brochure. Items listed toward the end of the forecast period, i.e. 10 to 15 years out, were often changed from year to year. Although some criticism resulted from this, there would have been no justification for slavish adherence to a plan which ignored changing circumstances, For example: Planning reports for the years 1968 and 1969 listed nuclear power as a long term solution to the country's fuel problem. The Maui Gas discovery in 1969/70 altered all that, and the nuclear option was deleted in the 1970 Power plan, Some hydro schemes(e.g.Kaituna and Motu), which had originally appeared attractive enough to be included on the Power plan, were on closer examination found to be too expensive or unsatisfactory from an environmental point of view. Errors in demand forecasting required adjustment of commissioning dates, almost always moving them forward in time,which could readily be accommodated with work under construction. (In the 1970's there was a gradual flattening off in the demand growth rate. It was imperceptible at the time, but became clear some years later.)

The Advantages of Hydro Electricity

The early investigations by Government engineers into sources for power supply had foreseen the

possibilities of hydroelectric development, and had achieved early success. The old hydroelectric branch of the PWD, and the MOW Power division carried this tradition on. The self replenishing nature of Water power and the robust simplicity of the turbines and generators had great appeal. The capital cost was financed from loans and revenue from electricity sales. Tax funds were not used. Fuel costs were zero, and operation and maintenance relatively small. Once the loans are paid off, the economics of hydro power become very attractive. Against this was the high capital cost which strained availability of loan money, and the cost of transmission from hydroelectric plants to load centres. (A special case was the inter-island link from Benmore to Haywards. This was conceived by NZED Chief Engineer W.Latta who saw the opportunity of using the most economical South Island hydro resources to meet the demand in the North. The 540 MW Benmore scheme was constructed for approximately $60 million. The D.C. transmission, including submarine crossing of Cook Straight and two converter stations cost approximately $39 million. The electricity from this compared favourably with cost of thermally produced power.) The Benmore - Inter Island link ensured continuity of supply to the North Island at a time when thermal stations were in the early stage of planning.

Hydro electric proposals were compared with fossil fired thermal stations of equal output in order to assess economic merit. To be "Commercial" the cost of electrical units had to be equal to or better than that from a thermal station.The calculations involved estimates of capital costs, operating and maintenance costs and fuel costs. The annual charges from these items were divided by the annual output to determine the cost per unit, at the station terminals. It was often argued that this basis of comparison was unfair to hydro because it took no account of the long life of hydro stations,their residual value, and inflation in fuel costs for thermal plants. The long term benefits of hydro were therefore not recognised. Apart from some marginal comparisons where hydro received preference, the line taken by the Treasury representative on the planning committee emphasised the government's tight financial stance by posing the question "What has posterity done for us?"

Transition to Thermal Power

Investigations for hydro schemes involved collection of topographical and hydrological data followed by draughting of alternative layouts, cost and feasibility assessments. It became clear in the mid to late 60's that North Island hydro resources would be insufficient to meet North Island demand, and medium to large scale fossil fired thermal plants would increasingly be used for grid supply. The Benmore - Inter Island link mentioned above provided time for the transition to thermal power.Sites were investigated at New Plymouth, Kaipara and Waitemata Harbours, Marsden, Otahuhu and Huntly. In due course stations were constructed and commissioned at New Plymouth, Marsden, Otahuhu and Huntly. Hydro potential in the major South Island Rivers(Waitaki, Clutha, and Waiau) would easily meet South Island demand.

The Future of Hydro

The transition from hydro to thermal generation in the North Island signalled a departure from renewable energy to the large scale burning of fossil fuels. This created considerable public debate, which is still raging some 35 years later.

In 1973 the New Zealand Economist requested an article entitled "Is The Hydro - Electric Age Really Over?" (See Appendix C). The prognosis was that for comprehensive developments on major rivers, the end was in sight for the North Island, and there could be 15 to 20 years more development on the Waitaki and Clutha Rivers in the South Island. There would however be a future role for local schemes as the price of fuel and grid power increased, and also for peak hydro power. A number of old local hydro plants in Otago and Southland have recently been refurbished by Pioneer Generation. The electrical units obtained from them will be as good as those from the latest combined cycle gas turbine plants. With grid power retailing for 15 cents per kwh or more

,these hydro plants should be highly profitable.

The establishment of Wind Farms in New Zealand creates opportunities for integrating wind energy into the hydro system, e.g. the use of hydro lakes for storing wind energy in dry years, and the possibility of pumped storage plants specifically dedicated to wind farm installations. These schemes are under active investigation overseas. Undoubtedly more will be heard here.

Beyond 1974

The foregoing notes cover aspects of the MOW Power Division's work during the 1954 - 1974 period. However,it did not end there. Construction programmes for the Upper Waitaki, Tongariro and Clyde hydro projects, the Ohaaki geothermal station, and 3 fossil fired thermal stations were completed. A further 2400MW was added to the system before the Power Division's existence ceased when the MOW was closed down on 1 April 1988.

W.M.Duncan

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August 2006 (Revised: March 2007)

Appendices:
A. H.O. Power Div - 1960/61
B. H.O. Power Div. - 1968
C. Article - "Is The Hydro Electric Age Really Over?"

References:
Power Planning Committee Reports 1961 - 1979
Annual Statistics Electric Power Development Up to 1989
People, Politics, and Power Stations John E. Martin
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POWER DIVISION. - MOW
HO STAFF
1968

Article published in "The Economist" August 1973 (Appendix C)

IS THE HYDR0-ELECTRIC AGE REALLY OVER?

New Zealand has 43 hydro-electric stations operating at the present time. The largest of these is the Manapouri station which first produced power in 1970 after 7 years of construction costing $122 million. The station has a capacity of 600 megawatts (600,000 kilowatts), and the cost of the electrical energy from the station is about .25 cents per kilowatt-hour.

Next to Manapouri, the largest hydro-stations are Benmore with a capacity of 540 Megawatts and Roxburgh, 320 megawatts. These stations were completed in 1964 and 1956. They also required 7 years for construction, and the energy from them costs about .3 cents per kilowatt- hour.

These top three hydro stations are capable of supplying over 40% of New Zealand's present electrical load. No other undeveloped hydro resources exist which can compare in size and cost with Manapouri and Benmore. There are one or two which are comparable with Roxburgh.

At the present time the Upper Waitaki development is under construction. This will produce 850 megawatts from 4 separate stations. The construction period will be about 13 years, and the cost of the energy will be about .4 to .5 cents per kilowatt-hour. Power from this development is not as economic as that which has been gained from the top three, but it is still good value when compared with power from fuel burning steam powerstations.

The Upper Waitaki will take care of the South Island's electrical load requirements until about 1982. A similar type of development on the Clutha River could follow the Upper Waitaki, and this would enable the South Island demands to be met from hydro electric stations for some years beyond 1982.

The developments which have been mentioned are all in the South Island, and they are all associated with New Zealand's three largest rivers, the Clutha, the Waiau and the Waitaki. The volume of water flowing from each of these lake fed rivers is relatively even and is over twice the flow of the Waikato, which is the largest river in the North Island. The high and well regulated natural flow is a major factor in the favourable economics of the schemes.

Large scale hydro-electric development in the North Island took place in the 1940's and 1950's with the dam building programme on the Waikato River. This was followed by the Tongariro scheme which is at present under construction and will augment the output of the Waikato powerstations. The final stage of the Tongariro development is under consideration now. This stage, known as the Rangipo scheme, will provide 100 megawatts of power, will take 7 years to build, and will produce energy for about 1c per kilowatt-hour.

It is clear therefore that we are running out of sizeable low cost hydro resources in the North Island. In the South Island, while we have probably built the best schemes, we still have 15 to 20 years of hydro-electric development before we reach the stage that at present exists in the North Island.

Some years ago, it became clear that North Island power demands could not be met entirely from North Island hydro resources. The situation was eased by the construction of steam powerstations of modest size at Wairakei, Meremere and Marsden, and by the installation of the submarine transmission line linking the North and South Islands. This enabled the output from the Benmore powerstation to be used in the North Island.

This transition from hydro power to steam power has been further accelerated by the adoption of a steady programme of development of large steam power-stations, the first of which is at New Plymouth.

New Plymouth will have a capacity of 600 megawatts (the same as Manapouri), will have taken 5« years to build and will produce energy for about .8 cents per kilowatt hour. The station will be capable of burning oil or natural gas. Similar steam stations are envisaged at Huntly and in the Auckland area, but with capacity of 1000 megawatts or more.

At the present time the total installed capacity of the New Zealand system is about 3500 megawatts. In 10 years time it will need to be 7000 megawatts, and in 20 years 14000 megawatts, assuming the present pattern of load growth continues.

If the best efforts of the skilled hydro construction forces which exist in the country at present were engaged on the most favourable remaining hydro-electric sites, it would be possible to add a little over one half of the required growth in the next 10 years, and less than one third of the

required growth in the next 20 years.

Thus a total capacity of 14000 megawatts in the 1990's cannot be achieved by a predominantly hydro construction programme. Thermal power stations using oil, gas, coal and uranium will take over the major role.

So far we have discussed the place of hydro-electric development in the total New Zealand system, and conclude that it may carry on for another 15 to 20 years in the South Island, but it appears to have little future in the North Island.

This conclusion is based on our experience of hydro-electric development as we know it at present, where the hydro stations are a large part of the electrical generating system, and they are seen as alternatives to thermal power-stations.

If we look at hydro stations as complementary adjuncts to a predominantly thermal system, the longterm outlook for hydro is not as bleak as it first appears.

At the present time thermal power-stations are competitive in energy costs with our more expensive remaining hydro resources. Oil, natural gas, and coal reserves are not inexhaustible and their cost will rise. The cost of electricity from thermal power-stations is strongly influenced by the cost of fuels. The electricity cost from hydro schemes is almost entirely due to the capital cost of construction. This means that the cost of electricity from a hydro station is practically constant over its life, and is unaffected by inflation in the cost of fuels (which may be indigenous or imported). Remaining hydro-electric resources, even though they may be small, may eventually become attractive because they will enable scarce and costly fuels to be saved. Local power boards which happen to have small hydro-electric resources in their areas may find that economies can be made by constructing their own stations rather than purchasing power in bulk from the national system. Successful examples of this have taken place over a number of years. Continued demand for electricity and the rising cost of power from the national system will provide additional incentive for more of this type of development.

Another factor which is likely to extend the hydro- electric age is the need for peak load power. The large thermal stations using fossil fuels (oil, coal and gas) or nuclear fuels, are not well suited for dealing with sharp changes in load, such as occur at peak tines during the day. Once the

boilers for the thermal stations are fired up, they need to be kept going at a steady rate.

Hydro turbines operating on stored water (including pumped storage schemes) are capable of being brought up to full load very quickly. When the peak has passed the hydro turbine can be shut down and water stored in readiness for the next peak.

Therefore, as the New Zealand system becomes more and more dependent on large thermal stations for its base load energy, it will also need more complementary peak load power. Large rivers are not so essential for peak load hydro schemes. Topography which permits the construction of reservoirs at high levels is well suited for peak load hydro stations. New Zealand is fortunate in having a number of sites which meet these requirements.

To sum up then:

Hydro-electric development on a large scale is likely to continue in the South Island for another 15 to 20 years. Large scale hydro development in the North Island is now giving way to the construction of thermal powerstations.

The construction of small hydro stations for local supply can be a continuing process for an indefinite period. These stations can be effective savers of oil, gas and coal as these fuels become scarcer and more expensive.

The construction of hydro stations for peak load purposes will become more attractive as the New Zealand system becomes more reliant on the large thermal stations for base load.

Any discussion on hydro-electric development automatically raises environmental issues. Water power is a clean, self replenishing source of energy. On the other hand the development of water power requires that uncontrolled or natural water flow is controlled. Great controversy can arise from such schemes.

These environmental conflicts and the cost of environmental protection will be important issues in all future hydro-electric proposals.

W.M.Duncan
Chief Power Engineer
Ministry of Works 13 July 1973