THE TREASURY
Kaitohutohu Kaupapa Rawa

17 March 2009
Reference: 20090058

M M Cosgrove
Advocates for the Tongariro River Inc → Brought to our attention by Mr A McNab
c/o 12 Wiremu St
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Dear Mr Cosgrove

Thank you for your letter which was received on 3 March 2009 concerning an Official Information Act request. You requested a duplicate copy of a letter Bernie Galvin, then Secretary to the Treasury, wrote to the Hon Roger Douglas, Minister of Finance, in 1985 about the costs of the various hydro electric generation projects of that period.

Please find attached a copy of the Treasury report, "Review of Electricity Planning and Electricity Generation Costs" dated 27th March 1985, which we believe is the document you are referring to. This fully covers the information you requested.

Yours sincerely

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for Secretary to the Treasury

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27 March 1985

The Minister of Finance

REVIEW OF ELECTRICITY PLANNING AND ELECTRICITY GENERATION COSTS

Introduction

1 Investment in capital projects by the public sector forms a significant part of the total capital investment in New Zealand. In 1983/84 $3.0 billion out of an estimated total of $7.68 billion was invested by the public sector. Over the last 30 years the state's share of capital investment has ranged from 30-45 percent. A major part of this investment has been in power station and allied construction projects. As a result the Electricity Division of the Ministry of Energy controls fixed assets of $3.06 billion (March 1983 book value after depreciation).

2 Some indication of the size and capital intensity of the energy sector can be obtained from a comparison of the above figures and the fixed assets and staff employed by Fletcher Challenge (excluding its Canadian subsidiary). Fletcher Challenge has fixed assets in New Zealand of $905 million and employs 17,300 people; NZE by contrast has fixed assets of $3.06 billion and employs 5,700.

3 The very size of the capital investment in this field when there is competition between the private and state sectors of the economy for capital means that inefficencies or errors of judgement can have a significant effect on New Zealand's long term prosperity.

ALL COSTS ARE IN $1983, UNLESS OTHERWISE STATED.

4 This report covers 11 of the 17 power projects, both hydro and thermal (gas, oil or coal burning), approved by the Government between 1953 and 1983. Hydro projects reviewed include Atiamuri, Tongariro, Upper Waitaki, Manapouri, Aviemore and Benmore: these were chosen to cover the range of project environments encountered in hydro construction. The thermal stations reviewed include New Plymouth, Huntly, the two Marsdens and Whirinaki. The Marsdens provide interesting examples of the design and build construction alternative available to the Ministry of Energy. Huntly underground mining is also reviewed as an important allied construction project. A brief commentary on each project, as reflected in Treasury files, is included in the Appendix.

5 The investigation reveals a less than satisfactory situation in this area of state investment as regarding the adequacy of advice presented to Ministers, the investigation, choice, and management of projects, basic precepts of power planning and the efficient administration of state resources.

6 The resultant unnecessary expenditure on Tongariro, Marsden B, and Whirinaki alone is estimated to be $0.8-1.0 billion in constant 1983 dollars, with a corresponding economic cost of $2.3-3.0 billion. The economic cost represents the present value of physical resources that would have otherwise have been available to the economy for consumption or investment. This is equivalent to the New Zealand economy being poorer by $230-300 million constant dollars a year for ever. The nature and calculation of the economic cost is discussed more fully in paragraphs 20-29.

Power Planning

8 Power planning requires three basic tools:

a a reliable demand forecast model;

b best practicable cost estimates of power costs from projects under investigation;

c a method of ranking projects in order of lowest economic cost.

9 Until 1957 forecasting future demand was the responsibility of the (then) New Zealand Electricity Department. Since that time this task has been carried out by a number of committees. Planning which new projects would be built, and when, rested initially with the Ministry of Works and NZED and after 1957 with Committees whose members were drawn from the above Ministries, or their successors, Treasury, Statistics and the Supply Authorities[1].

10 For the latter part of the period under review demand was considerably over-estimated by the committees which anticipated that the 7-8 percent annual growth rate in consumption that characterised the 1950's and 60's would continue into the 80's. Instead a combination of lower economic activity, decline in population growth and to a lesser extent the increasing availability of natural gas reduced demand growth to 2-3 percent per annum.

11 The situation that developed is set out in Table 1.

TABLE 1

Electricity Demand Forecasting

Year	Actual Consumption GWh	Predicted 10 Years' Previously GWh		Over Estimation %
1978/79	21,606	28,722	(1969)	33
1979/80	21,692	29,381	(1970)	35
1980/81	22,110	30,753	(1971)	39
1981/82	22,962	32,892	(1972)	43
1982/83	24,294	36,859	(1973)	52
1983/84	25,850	38,963	(1974)	51

Not until 1978 did the Planning Committee acknowledge that previous forecasts had been too high.

12 For New Zealand the error was costly indeed, resulting in the mothballing of Marsden B on completion and Whirinaki, a peak load gas-turbine station, being rarely used since its commissioning. However, its major damage was to assist in the creation of a climate which was not conducive to the optimal selection, planning and construction of power projects.

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1 Membership of the planning committees changed over the years in response to changes in Departmental structures and responsibilities:

a Committee to Review Power Requirements. This committee had the task of producing estimates of future power demand. Membership of the CRPR included:

Chairman G.M. NZED, 2 Electrical Supply Authorities, 2 NZED, 1 Department of Statistics, 1 Treasury, and (later) 1 Ministry of Energy Resources.

b Planning Committee on Electric Power Development. This committee had the task of deciding how the demand forecast figures produced by CRPR could best be met. Initially PCEPD was chaired by the Minister of Electricity, later by the General Manager, NZED. Its members included:

Chairman G.M. NZED, 2 NZED, 2 MWD, 1 Treasury, 3 ESA and later Ministry of Energy Resources or 1 Planning Division MOE.

From 1980 the roles of CRPR or PCEPD were taken over by the Electricity Sector Planning Committee.

The ESPC members comprise 4 representatives from the Electricity Division, 3 from the Electrical Supply Authorities, 2 MWD, 1 Mines Division, and 1 Planning Division (MOE).

13 Because of this, as this report shows, the cheapest power stations were not built first and there appears to have been inadequate investigations of projects prior to their recommendation: as a result Ministers were not fully informed of the potential for cost overruns and in some cases were provided with information of uncertain accuracy.

Analysis of Performance

14 In Table 2 calculated unit power costs based on submission data and those derived from actual construction costs are set out for a number of power projects. In addition submission and construction costs and commissioning times are set out. Power costs have been calculated using a 10 percent discount rate by discounting future operating costs and compounding past capital costs, and dividing this sum by the present value of the stations' output. An example calculation is shown in the Appendix. The figures are expressed in constant 1983 dollars.

TABLE 2
Construction Cost Data and Power Costs

	Construction Cost $m		Commissioning Date Year		Power Cost[2] /kwh		Overrun Factors[3]	
	Sub.	Act.	Sub.	Act.	Sub.	Act.	Capital Cost	Power Cost
Hydro Dams								
Atiamuri	183	292	59	59	7.5	11.8	1.6	1.7
Aviemore	417	273	68	68	6.1	4.2	0.7	0.7
Benmore	799	604	66	66	5.9	3.9	0.8	0.8
The Schemes								
Tongariro[4,5]	1162	1654	71/79	84	6.9	13.7 (21.1)	1.6	2.0
Upper Waitaki	1414	1460	81	86	3.8	5.7	1.0	1.5
Manapouri[6]	604	1096	70	70 [77]	1.9	3.0	1.8	1.6
Thermal Stations								
New Plymouth[4]	450	670	76	79	–	5.3	1.3	–
Huntly	941	1229	79	84	3.6	7.4	1.3	2.1
Marsden A[7]	204	229	67	67	–	–	1.1	–
Whirinaki[7]	90	78	76	78	–	–	0.9	–
Marsden B[8]	182	272	78	81	–	–	1.5	–

2 Both construction and power costs have been calculated in constant dollars, using the MWD Construction Cost Index, to convert dollars of a particular year to $1983 (CCI 2040). Power cost calculations, including the use of 10 percent discount factors, are set out in the Appendix.

3 The overrun factor is obtained by dividing the actual cost by the submission cost.

4 Scope changed after initial approval therefore submitted costs and actual costs do not give a real comparison. New Plymouth's submission cost is taken as that given in a letter to NZED by Preece, Cardew & Rider dated 10 April 1972.

5 Submission cost based on 1964 and 1973 submission costs with the project constructed, as orignally envisaged, by 1975. 21.1¢/Kwhr refers to Tongariro power costs without downstream benefits added.

6 The $604m for Manapouri was the estimate made by Bechtels after the project was approved and the contract with Comalco signed. 1977 indicates the construction completion date, power generation commenced in 1970. The submission power cost is based on Bechtels original submission expenditure distribution presented to Comalco.

7 Rarely run.

8 Mothballed on completion.

15 Examination of the data in Table 2 indicates:

i considerable construction cost overruns on most projects;[9]

ii delays in commissioning in 7 out of 11 projects;

iii considerable electricity cost overruns as a result of (i) and (ii).[10]

With the exception of Benmore and Aviemore considerable power cost overruns, in the order of 70 percent, were incurred on the hydro schemes, (Tongariro, Upper Waitaki and Manapouri). In the case of Huntly power station, the cost of power is likely to be about 100 percent higher than estimated at the time of submission through a combination of time and capital cost overruns and higher than expected coal prices.

16 The implication of Table 2 for future planning seems quite explicit. In the absence of any drive to counteract the deficiencies set out in this report currently predicted power costs of future stations are likely to be too low by a factor of about 1.5 with a standard deviation of 0.55. Thus power from the following stations quoted by the Electricity Sector Planning Committee in 1983:

Luggate	4.8 ¢/kwh
Queensbury	5.4
Kawarau	6.5
Lower Waitaki	8.7
NI Thermal	7.2

is likely to cost between 5 and 17 cents per kwh based on historical performance.

Ranking of Projects

17 Table 3 sets out the 11 projects in order of their commissioning dates as envisaged in the project submissions at the time the projects were approved together with the cost of power estimated using the appropriate discounting techniques on the basis of:

a the data provided in the project submission at the time of approval;

b the actual costs of the completed project.

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9 The construction cost overrun factors have a mean of 1.23 with a standard deviation of 0.36. The overrun factor as calculated, includes the contingency, which is generally of the order of 10-15 percent, but may be higher or lower depending on the project.

10 The electricity cost overrun factor is 1.5 with a standard deviation of 0.55. However, it should be noted the data are drawn from a very small sample. At a 95 percent confidence limit the overrun factor is $1.5 \pm 1.96 \times 0.55/\ 5 = 1.5 \pm 0.41$.

TABLE 3
Power Planning and Power Costs

Station	Commissioning Date as Submitted	Submission Cost ¢/kwh	Actual Cost ¢/kwh
North Island			
Atiamuri[11]	1958	7.3	11.8
Tongariro[12]	1971	6.9 (10.9)	13.7 (21.1)
New Plymouth	1976	(5.3	5.3
Huntly	1979	3.6	7.4
Rangipo	1980	6.2	7.7
South Island			
Benmore	1966	5.9	3.9
Aviemore	1968	6.1	4.2
Manapouri	1970	1.9	3.0
Upper Waitaki	1976	3.8	5.7
Clyde	1989	5.6	-

It is clear that even on the basis of submission costs projects were not undertaken in a cheapest-first basis. The actual outcomes after cost overruns diverge even further from what would have been the least cost schedule of construction.

The Basis of Evaluation

18 One factor influencing project evaluation in the earlier years was a general reluctance of planners to present submissions using costing procedures which used discounting techniques so as to provide the appropriate information to evaluate projects with different expenditure profiles. During the sixties the use of discount rate techniques for project evaluation and ranking was gradually developed. This was formalised by a 1971 Cabinet requirement that all projects with public sector involvement be analysed using a 10 percent discount rate. In spite of this requirement, assessments of the relative cost of power were not always submitted on this basis. Thus we find submission costs based on accounting capital charges being presented up until 1974. In some cases this may have been responsible for ranking errors. In others it may have resulted in projects being approved which should not have been submitted even on a simple undiscounted analysis but when evaluated using the discount rate technique were considerably more costly than existing alternatives. Rangipo is a case in point. NZE in its 1973 submission for approval of the station, chose to report costs based on accounting capital charges[13]. This, as

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11 Treasury report T529 July 1957 notes Atiamuri's cost as $298/kw ($1957) commissioning 1959 and Ohakuri's cost as $166/kw ($1957) commissioning 1961. The North and South Island transmission systems were linked in 1966 so that Atiamuri and earlier stations are not directly comparable with subsequent South Island stations.

12 Originally the Tongariro Power Project Stages I to V were to be completed by 1975. It was claimed to produce 670 Gwh pa in downstream benefits. As noted in the report these benefits appear to have been counted in the cost of the downstream stations and the cost of the power from TPD in their absence is given in brackets. The extra power generated at Atiamuri, for example, as a result of TPD, is captured in the cost of power for that station.

13 However during the Maui gas negotiations in 1971 NZED presented electricity charges calculated using the 10 percent discount rate.

Treasury argued at the time and as is clearly evident from the following table, did not provide appropriate information to enable Cabinet to obtain a clear picture of the economic cost of the alternatives. Thus in the example shown in Table 4 accounting capital charge costing calculations indicate a 32 percent difference in cost between Rangipo and the cheapest station while costs based on a 10 percent discount rate indicate a 97 percent difference in cost between the same two cases.

TABLE 4
Rangipo Cost Comparisons Based
on Different Estimation Procedures

	Estimated Cost Accounting Capital Charges ¢/kwh	Comparison with Cheapest Station %	Estimated Cost 10 Percent Rate of Return ¢/kwh	Comparison with Cheapest Station %
Rangipo	4.1	+32.0	7.1	+97.0
Coal-fired	3.1	0.0	3.6	0.0
Oil-fired	4.1	+32.0	3.9	+8.0
Auckland M2	3.3	+6.0	3.6	0.0

19 Despite the above rankings and the requirement of the 1968 Electricity Act that cheapest cost power must be developed first, Rangipo was approved.[14] The appropriateness of the 10 percent discount rate as a ranking tool for power projects appears still unresolved in the view of the Ministry of Energy with 5 and 10 percent rates being used for project evaluation.

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14 PECPD commented at the time (1973 Report page 5).

> "In retaining Rangipo in the power plan, this committee acknowledges the fairly high cost of the project but recognises that there are social and technical reasons for the inclusion. The technical reasons include the use of a self-replenishing fuel which is free, thereby avoiding the problem of escalating fuel costs, the absence of pollution and the simplicity of operating and maintenance ... As was mentioned in the 1972 report of this committee, the establishment and manpower are already in the area and the time is opportune to proceed with the construction of Rangipo if these resources are not to be lost."

In 1977, despite a Cabinet re-affirmation of the discount rate, the committee was still reporting (1977 Report page 4).

> "In the absence of any new technological development it is almost axiomatic to say that New Zealand's energy strategy must include a policy of developing indigenous, self-replenishing resources, first, followed by consumable resources to the extent that these resources can be made available."

The Economic Cost of these Shortcomings

20 The economic cost is a measure of the benefits the economy has forgone as a result of the choice of the higher cost alternative or the unnecessary construction of a power station. It is measured by the difference in the present value sums of the construction costs of the two projects, or, in the latter case, the present value sum of the station cost. What is forgone is the return (estimated at a 10 percent discount rate) on the extra or unnecessary resources put into the projects. If the cheaper alternative had been chosen or the station not constructed, these extra resources could have gone to other investment opportunities which would have yielded income and employment. If one were to correctly evaluate the economic cost to the nation of the somewhat haphazard approach reflected in the power station construction programme indicated above, one would re-cast the projects in terms of lowest submission cost first and calculate the present worth of that menu as against the present worth of the actual construction programme.[15] On the basis of the comparison of submission costs, Tongariro should not have been built before the rest of the menu. With a more accurate evaluation of the costs of Tongariro it is highly unlikely the Tongariro scheme as undertaken would have been constructed. Some idea of the magnitude of the unnecessary expenditure incurred as a result of the historic construction programme can be obtained by comparing the Tongariro scheme, which has just been completed, with Clyde, which is still under construction.

Tongariro

21 As the project was originally conceived, it consisted of five stages, which would be constructed over a period of 10 years.

Stage 1	:	Western diversion of water into Lake Rotoaira
Stage 2	:	Tokaanu power station
Stage 3	:	Moawhango diversion into the Tongariro River
Stage 4 and 5	:	Two power stations on the Tongariro River.

The Minister of Electricity in 1964 reported, based on a combined report of NZE and MWD, that power from this system would be cheaper than any other scheme which could be developed in the North or South Island.

22 In 1964 Cabinet approved the construction of Stages I, II and III of the Tongariro power project. This part of the scheme has two generation components:

a direct generation power (Tokaanu) amounting to 824 Gwh per annum (mean year production).

b indirect downstream benefits[16] amounting to 670 Gwh per annum from diverted water introduced into the Waikato system.

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15 "Least cost" has a range of meanings in power construction. In this report it refers to base-load stations. However the same concepts apply equally to firming or peaking requirements.

16 The downstream benefits were used as a major selling-point for the scheme, the implication being that the extra power generated downstream was essentially free as the Waikato dams were already in place. In fact if Atiamuri is anything to go by that power was very expensive indeed. In 1957, when the decision was made to install the fourth generating set at Atiamuri, its capital cost had risen to $298/kw, which was exceptionally high. It was justified on the grounds that the price would reduce to $232/kw on diversion of the Upper Waikato river, as the Tongariro scheme was then known. It thus appears that the downstream benefits from the Tongariro were double-counted.

23 In 1973 stages 4 and 5, producing 870 Gwh were replaced by a single power station (Rangipo producing 660 Gwh) and modified tunnel systems to give a completed cost based on the 1964 and 1973 submissions of $1,162 million. The scheme is now due for completion in 1984, after a construction period of 20 years, at a cost of $1,654m. The potential output for the scheme as finally approved and assuming the claimed downstream benefits are realised is 2154 Gwh.

Clyde

24 A potential alternative to Tongariro was the Clyde high dam designed to produce 1930 Gwh. Two sets of comparisons are presented in Tables 5 and 6. In the first, submission data for both projects have been compared assuming both stations produced full power by 1975. In the second, the current position is set out but with Clyde producing power by 1978 to meet the planning objective of supplying power to the Auckland area by the late 1970's.[17,18] It has been assumed, in accordance with paragraph 15, that a construction cost overrun of 20 percent would have been incurred at Clyde.

TABLE 5
Comparison of Tongariro and Clyde as Alternative Sources of Hydro Power: Submission Comparison
$m 1983

	Tongariro	Clyde
Capital cost, $m 1983[19]	1253	789
Construction period, years	10	13
Year of Full Power	1975	1975
Gwh, directly generated[20]	1640	1930
Gwh available at Auckland[21,22]	1640 (2310)	1800
Present value cost $m 1983, 1983 base year	5153	3160

The difference in capital costs incurred is $464 million in constant 1983 dollars and the corresponding difference in present value cost is $1,993 million. The present value cost is the present value sum, at a 10 percent discount factor, of the annual real ($1983) capital costs.

Current Construction Comparison

25 Tongariro was not constructed as originally submitted but was modified, as noted in paragraph 23. Full power has been produced at Tokaanu since 1975 and Rangipo was completed in 1983. This situation is now compared with Clyde assumed to be producing full power by 1978 but incurring a 20 percent cost overrun, as indicated by the analysis of previous stations' outturns, paragraph 15.

17 PCEPD 1964 page 6, 7 notes

Tongariro Power Development "... it is probable firm recommendations will be made to the Government soon".

Clutha River "... Between 4000 and 6000 Gwh annually should be available, but no costs are likely before May 1966".

18 PCEPD noted in reference to a report comparing nuclear generation to other forms of generation available in New Zealand, 1970 page 23:

"The specific terms of reference were to find a solution to the problem of supplying the load requirements of the Auckland area in the late 1970s over a 4 year period by the most economic means. ... The general conclusion reached is that the Clutha development would not be able to compete with other forms of generation."

TABLE 6
Comparison of Tongariro and Clyde as Actual and Estimated to completion construction costs

	Tongariro	Clyde (20%+)
Capital cost $m 1983	1654	947
Construction period, years	20	13
Year of Full Power	1983	1978
Gwh, directly generated[20]	1490	1930
Gwh available at Auckland[21,22]	1490 (2160)	1800
Present value cost $m 1983, 1983 base year	5173	2849
Cost of electricity delivered c/kwh[23]	21.1 (13.7)	7.7

26 The table indicates that the unnecessary costs incurred as a result of the construction of the Tongariro scheme are likely to be of the order of $700 million with a corresponding economic cost of the order of $2,130 million. The cost per unit of electricity delivered to Auckland is likely to be double or possibly treble the comparable cost if, rather than Tongariro, the Clyde high dam had proceeded as the alternative. With that cost of power, the Tongariro scheme would still not be appearing in current plans, which are projected to 1998.

Other Projects

27 Two oil-fired thermal stations, Marsden B and Whirinaki, were approved in late 1974. The stations were considered unnecessary by Treasury and the (then) Ministry of Energy Resources, who queried the demand forecasts and questioned the wisdom of installing oil-fired equipment. Marsden B was mothballed on completion, and Whirinaki has been used only rarely since it was commissioned. Their cost in 1983 dollars was $269 million for Marsden B and $78 million for Whirinaki.

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19 Clyde's current estimates includes infrastructure costs other than Cromwell re-development. The further $68m attributable to this cancels out the reduced cost resulting from the contractor's bid as compared with the MWD estimate which is included in the submission estimate. The Tongariro submission cost is that quoted in 1964 rather than the $1162m in table 2.

20 Tongariro Gwh's reflect two power stations in Stages IV and V.

21 The free downstream benefits appear in fact to have been included in the cost of power produced by the Waikato river stations and their inclusion would amount to double counting.

22 7 percent loss on transmission from Clyde (1983 Electricity Sector Plan).

23 The cost of electricity from Clyde includes 1.0¢/kwh estimated additional cost, covering transmission losses to the North Island and capital and operating costs. The figure in brackets is the Tongariro power cost if downstream benefits are included but ignoring downstream capital costs.

28 When Marsden B was first presented to Cabinet in 1973, it was as a dual coal/oil fired station. Following the 1973 oil shock Cabinet made the logical decision to attempt to minimise oil consumption. It then asked officials as to the feasibility of siting Marsden B on a Waikato coal field. It received the reply that a site was not immediately available and that any delay might give rise to electricity shortages in Auckland in late 1979, the year Marsden B was due to come onstream.

29 The total unnecessary expenditure incurred in these projects appears to be about $1,000 million dollars in constant 1983 dollars over the period of their construction. Some indication of the magnitude of the constant dollar costs can be gained by a comparison with the Mobil Synthetic Gasoline plant which had a capital cost of $886 million ($1980) in July 1980. Allowing for the time these resources were completely idle during the construction phase the total economic cost in terms of opportunities forgone was of the order of $3,000 million in constant 1983 dollars. If invested elsewhere these resources would have yielded $200-$300 million per annum (the approximate value of our horticultural products).

PROJECT APPROVAL AND MANAGEMENT

30 Successful management of construction projects requires that the planners and the construction managers have a common goal. That goal in the power industry can only be the supply of electricity at the lowest practicable cost, whether the power is designated base, firming or peaking. This analysis suggests that there have been very substantial economic costs associated with a construction programme that appears to have put to one side basic power planning criteria in favour of secondary issues such as the providing of a continuous supply of work for an apparently skilled workforce, as has often been the case. Also, the argument that the use of self-replenishing hydro resources, is preferable to the use of consumable thermal resources, on the grounds that lower operating costs are in some way preferable to lower capital costs incurred at the time of construction, has also contributed to the situation described above. The following technical and social issues, which have been identified in Appendix 1, have impeded the development of lowest practicable cost power:

- inadequate specification of project requirements
- inadequate investigation and project evaluation
- lack of accountability
- absence of reviews or monitoring
- employment opportunities and "skilled" workforce issues.

Project Evaluation and Submission Information

31 A number of projects encountered difficulties which might have been anticipated from a more rigorous evaluation prior to approval and which, had Cabinet been informed of the potential difficulties, may have resulted in it choosing a different course of action. In some instances information was supplied that was of uncertain accuracy. In a number of instances geological difficulties were greatly underestimated (Atiamuri, Tongariro, Manapouri and Huntly Mines). In others inadequate project specifications or investigation led to cost overrun, costly re-design or failure to meet performance or output requirements (Turangi township costs, Manapouri quantity surveying and design data, Huntly power station foundations and Huntly coal mines). In addition, a contract was removed from a contractor by Cabinet on information of uncertain accuracy (Bechtel's Huntly East Mine contract).

Project Supervision

32 The containment of costs is a significant component of project management. It presents a very real problem in power station construction due to the limited accountability that is a characteristic of State construction and the absence of financial incentives. Three separate areas can be identified:

a failure of the departmental system to communicate adequately its requirements with a multi-national consulting/constructing organisation. This has been the case with regard to Marsden A and the Huntly coal mines.

b conflicting roles of the MWD with regard to project construction and monitoring.

c problems relating to project management or contracting arrangements:

i Tongariro tunnelling contracts and consultants agreement;

ii Huntly coal mines development;

iii Manapouri tunnelling contracts.

33 The inadequacies in project management and control have led to considerable cost overruns before the matter has been brought to the attention of Ministers. This has resulted in directives by CEC and CWC for reviews of aspects of a number of projects and by Audit's expressions of concern at cost overruns or contract details. These reviews, detailed in the station data in Appendix 1, have covered aspects of:

a Manapouri cost overruns;

b Bechtels performance;

c Huntly mines;

d Tongariro power project;

i tunnelling contracts;

ii cost of Turangi township;

iii consultants fees.

Inadequate project management has also reflected a failure to appreciate the economic significance of cost overruns, particularly when seen in aggregate over a number of years.

Consultants

34 Three firms of consultants have undertaken the major share of consulting during the course of the work described in this report:

Sir Alexander Gibb & Partners – Waikato river dams & Tongariro power project
Bechtel Pacific Corporation – Manapouri, Marsdens, Huntly mines
Preece, Cardew and Rider – Meremere, New Plymouth, Huntly.

A factor common to all the consultants is that in one or more of their projects there has been either a CEC, CWC or Audit review of their work as a result of complaints of cost overruns or plant failure. The reviews drew attention to the following issues:

a Communication

Dealing with a multi-national consulting firm such as Bechtels is like dealing with a bureaucracy similar to our departments. High calibre staff are required in sufficient numbers to deal with the multitude of queries and voluminous paperwork which emanate from the consultant. It appears to have been departmental practice that one or two people have been given the task of liasing with the consultant.

b Specification of Requirements

Inadequate specification or the failure to anticipate needs have resulted in the costly redesign of consultants' proposals or the construction of plant that is not ideally suited to New Zealand conditions. Huntly coal mines stand out as a prime example of the problems encountered in this area. Redesign is costly irrespective of who is undertaking the project and proper specifications are still needed even if an international consultant is to undertake the work.

c Defined Tie-Points for Cost Comparison

The absence of pre-determined tie points, such as defined capital items, for the purpose of cost comparison obscures the identification or comparison of areas sensitive to cost increases. The client is thus disadvantaged by being unable to adequately control or evaluate the consultants' proposal. (The Synfuels GTG plant, like the Huntly mines, shows this characteristic while not exhibiting the same cost overruns).

d Monitoring of Consultants

When the consultant has been also responsible for project management there appears to have been some reluctance on the part of departmental engineers to monitor the consultants' performance. This appears to have been the case at Huntly mines (see Appendix). Monitoring of the consultant is clearly essential, if for example, the project involves the consultant, as project manager, in cost plus contracts.

e Fees

Sir Alexander Gibb & Partners were to receive 3 5/8 percent of audited cost of the Tongariro power project as their fee. The Auditor-General intervened in 1967 to request a fixed fee but this was not agreed to until mid-1977 which resulted in fees totalling $31 million $1983 being paid for their services.

Bechtel Pacific Corporation received a fixed fee plus reimbursibles for Marsden A and B. In the case of Marsden A their estimated fee of $21 million rose to $38 million while the Marsden B estimate of $33 million rose to $45 million.

Other Factors driving Project Planning

35 Two non-economic considerations have often been raised prior to the approval of new projects:

i Direct Raising of Workforce Issues

This has generally taken the course of retaining and existing "skilled workforce". This argument has been a common tool to justify the initiation of a new project or the extension of an existing one[25]. Areas where it has been used to argue for the initiation of a new project include the following (the project for which approval was sought is listed on the right):

a	Waikato river dams;	Tongariro
b	Tongariro Stages I, II and III;	Rangipo
c	Rangipo,	Ohaaki
d	Aviemore) Manapouri)	Upper Waitaki

ii Obtaining of Approvals in Principle

Political impetus appears to be given by this procedure to projects that have not been fully researched or documented. The clear danger is that this indirect blessing is taken as a political commitment:

a Atiamuri;

b Tongariro;

c Upper Waitaki.

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25 Commissioner of Works to August 1953 to GM State Hydro Electricity Department.

"The position now is that further work is required at Mangakino to help present forces employed. On this basis I would appreciate your seeking urgency to obtaining approval for the construction of Atiamuri with our own forces."

Treasury report on Aviemore 24 February 1968.

"In the attached paper the Minister of Works seeks Cabinet approval to retain the present Aviemore construction force for further work of the kind it has completed and recommends that the Minister of Electricity be asked what new works he could recommend to enable this to be achieved.

In our view the argument that the workforce possess construction experience gained over a period of 17 years or more is of doubtful validity."

Ministry of Works and Development on Ohaaki 4 October 1982 in response to a Treasury recommendation that it be deferred.

"The more important factor is maintaining a relatively steady load on, and thus high productivity from, the trained manpower resources presently available both in the field and in the design office."

Conclusion

36 The cost of the inefficiencies in project planning, evaluation, decision-making and management identified in this paper are of sufficient magnitude to have affected the performance of the economy as a whole as well as being a direct financial burden on taxpayer. The causes, including such things as the perception of responsibility between agencies, unnecessary claims of urgency, inadequate identification of costs or risks, as well as issues such as public sector accountability, all remain. Each of these should be addressed, if the Government's objective of producing least practicable cost power is to be achieved in a timely and efficient manner.

Recommendation

37 It is recommended that you note the information in this report.

B V Galvin
Secretary to the Treasury

APPENDIX 1

POWER STATION CONSTRUCTION HISTORICAL DATA

The Projects Investigated

a Atiamuri

b Tongariro

c Upper Waitaki

d Manapouri Power Project

e Benmore

f Aviemore

g New Plymouth

h The Marsdens

i Huntly Power Station

j Huntly Mines

k Whirinaki

Power cost calculation procedure example: Atiamuri

Unless otherwise indicated all costs have been converted to $1983 using the MWD Construction Cost Index.

The Stations Investigated

Hydro

In the North Island the Atiamuri power station and the Tongariro power scheme were chosen for examination. Atiamuri was considered typical of the Waikato stations while Tongariro provided an interesting example of a project involving a diverse range of construction requirements ranging from tunnelling to town planning.

South Island stations investigated included Benmore, Aviemore, Clyde and Manapouri and the Upper Waitaki power scheme. Benmore and Aviemore were chosen to compare with Clyde, while Manapouri and the Upper Waitaki scheme provide an interesting comparison with Tongariro.

Thermal

The peak load and firming stations Whirinaki and Marsden A were examined as well as the mothballed Marsden B. The two Marsdens provide interesting examples of the design-and-built construction alternative available to the Crown.

Huntly and New Plymouth were evaluated as the two major base load thermal stations.

a Atiamuri

Atiamuri was approved for construction in 1953 at a cost of $175m producing 63MW[1]. In 1957 Cabinet approved the addition of a fourth generating unit to increase output to 84MW which effectively increased the submitted cost to $183m.

Considerable cost overruns were incurred as the dam foundation material was found to be unsound and had to be excavated. The cost of the station on completion was $292.6m.

Treasury report T529, 19 July 1957 notes ($1957):

> "3 Investigation currently being carried out by the MOW at the southern end of Lake Taupo now indicates that it will be an economic propostion to direct a substantial quantity of extra water into the lake and thus increase the flow of the Waikato.
>
> 4 ... it is considered prudent to make provision at the station for the later installation of the fourth generator.
>
> 5 ... As regards costs the effect will be to bring total expenditure up to: Atiamuri $18.8 million and Ohakuri $1.86 million and as the power outputs will remain the same the initial costs per kw will rise to $298 and $166 respectively.
>
> 6 The installation of the fourth generator ... will reduce costs per kw to $232 and $142."

It thus appears that the downstream benefits of the Tongariro Power project for Atiamuri and Ohakuri, at least, were counted at the time of their construction.

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1 CM(53)43

Power Cost Calculation

The cost of power has been calculated using a 10 percent dicount rate. In such a calculation the stream of benefits over the life of the station are equated with the stream of capital and operating costs, all costs and benefits having been discounted or compounded (as the case may be) to the chosen base year.

Benefits = sum of $\frac{pi\ qi}{(1.1)^i}$

where q = yearly power output in Gwh
p = cost of power
subscript i = refers to ith year where at the base year i = 0
Costs = sum of $\frac{ci}{(1.1)^i}$

where c = yearly costs incurred both capital and operating

Thus $p\ \frac{qi}{(1.1)^i} = \frac{ci}{(1.1)^i}$

since p is constant over the life of the station.

Re-arranging for p, we obtain

$$p = \frac{ci/(1.1)^i}{qi/(1.1)^1}$$

An example calculation for Atiamuri is set out below

Atiamuri (Submitted Costs – NZE)

– Assumptions and Parameters

10 percent discount rate
1953 $ submission index
1959 year of first power

1971 first year of full power;
330 Gwh Output;
0.70 $m annual operating cost
50 year operating life

Year	Capital Cost $M Real 1953	Capital Cost $M Real 1983	Capital Cost Real Present Value 1983	Operating and Maintenance $M Real 1983	Operating and Maintenance $M Real Present Value 1983	Station Output Actual Gwh	Station Output Present Value 1983 Gwh
1953-54	0.60	7.65	133.49				
1854-55	1.86	23.72	376.19				
1955-56	4.50	57.38	827.40				
1856-57	4.50	57.38	752.19				
1957-58	2.00	25.50	303.91				
1958-59	0.80	10.20	110.51	0.7	7.55	153	1,658
1959-60				0.7	6.86	229	2,256
1960-61				0.7	6.24	305	2,731
1961-62				0.7	5.66	305	2,483
1962-63				0.7	5.15	305	2,257
1963-64				0.7	4.68	305	2,052
1964-65				0.7	4.26	305	1,865
1965-66				0.7	3.87	305	1,696
1966-67				0.7	2.51	305	1,542
1967-68				0.7	3.15	305	1,401
1968-69				0.7	2.90	305	1,274
1969-70				0.7	2.65	305	1,158
1970-71				0.7	2.41	305	1,053
1971-72						330	
Sum Over Life	14	182	2,504		82.46		34,513

Cost of Power = $\frac{\text{Present Value of Total Costs (\$)}}{\text{Present Value of Total Output (Gwh)}}$

= $\frac{(2{,}504 + 82.46) \times 10^6}{34{,}513}$

Cost of Power = 0.0745×10^6/Gwh

= 7.45 cents per kwh

The cost of Power is 7.45 c/kwh in $1983 and using 1983 as a base year at commissioning in 1959.

Atiamuri (Actual Costs – NZE)

Assumptions and Parameters

1975 first year of full power
330 Gwh Output

10.0 percent discount rate
1983 $ submission index
1959 year of first power

0.70 $m annual operating cost
50 year operating life

Year	Capital Cost			Operating and Maintenance		Station Output	
	Nominal $	$ Real 1983	Real Present Value 1983	$ Real 1983	Real Present 1983	Actual Gwh	Present Value 1983 Gwh
1951–52							
1952–53	1.10	14.03	269.20				
1953–54	1.30	15.88	277.10				
1954–55	3.08	36.53	579.48				
1955–56	5.40	61.20	882.56				
1956–57	5.43	59.55	780.76				
1957–58	6.77	72.31	861.78				
1958–59	2.29	22.55	244.35	0.7	7.55	153	1,652
1959–60				0.7	6.86	229	2,253
1960–61				0.7	6.24	229	2,048
1961–62				0.7	5.66	305	2,483
1962–63				0.7	5.15	305	2,257
1963–64				0.7	4.68	305	2,052
1964–65				0.7	4.26	305	1,865
1965–66				0.7	3.87	305	1,696
1966–67				0.7	3.51	305	1,542
1967–68				0.7	3.19	305	1,401
1968–69				0.7	2.90	305	1,274
1969–70				0.7	2.65	305	1,158
1970–71				0.7	2.41	305	1,053
1971–72				0.7	2.18	305	957
1972–73				0.7	1.98	305	870
1973–74				0.7	1.80	305	791
1974–75				0.7	1.64	305	719
1975–76				0.70		330	
1976–77							
1977–78							
Sum Over Life	25	282	3,895		82.37		33,549

The cost of Power is 11.81 c/kwh in $1983 at commissioning in 1959.

b Tongariro

Since its inception the Tongariro power project has raised strong emotions both on conservation grounds and cost overruns on construction. It was approved in principle in April 1964 at an estimated cost[2] of $1,254m. As the project was originally conceived it consisted of five stages:

Stage 1	-	Western Diversion of water into Lake Rotoaira
Stage 2	-	Tokaanu power station
Stage 3	-	Moawhanga diversion into the Tongariro River
Stage 4 and 5	-	Two power stations on the Tongariro River

and would be constructed over a period of 10 years. Mr T P Shand the Minister of Electricity at this time reported, based on a combined report of the Electricity Department and MWD, that power from this system[3] would be cheaper than any other scheme developed in the North or South Islands.

Sir Alexander Gibb and Partners in their report, "Tongariro River Power Development," April 1962, noted that other than hydrological measurements on the Tongariro, other flow estimates were based on either one or two years' observations of the major streams forming part of the scheme.[4] However it was on the basis of these measurements that the mean volume of water to be obtained from the diversions was calculated and hence the magnitude of the downstream benefits. This is surprising considering that the project had been under investigation prior to 1958.

Geological information appears to have been equally sparse. On the Tokaanu Tunnel, leading to the power station, Gibbs reported "Cores from the eight boreholes on the tunnel line show the tunnel can be expected to be in andesite, which, however, varies from very hard to soft where hydrothermally altered, the latter having little or no rock properties." No evidence of unusual heat has been found. Yet in 1970 PCEPD was to report to Parliament that delays in tunnelling would delay the commissioning of the Tokaanu power station due to heat and "squeezing" ground being encountered.[5]

Similarly on the Moawhanga tunnel Gibbs and Partners in their summary report noted that the rock through which the tunnel would be driven was expected to be greywacke with some argillite. "A few faults are believed to cross the line of the tunnel." Yet PCEPD was to report in 1973 that progress on the tunnel had been seriously affected as a result of water-bearing clay filled seam being frequently encountered.[6]

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2 CM(64) 13 7 April 1964

3 Dominion 24 April 1964

4 Tongariro River Power Development, Report of Investigation Vol 1, April 1962, Sir Alexander Gibb and Partners

5 Report of PCEPD 1970 page 7

6 Report of PCEPD 1973 page 5

7 CM(64) 37 22 September 1964

With respect to design detail the consultants noted in their report on the Maowhanga lower dam, for example, that the design was "based on preliminary consideration only" and that a significantly more detailed study would be required. While on the proposed Rangipo Power Station they noted that the site was "not restricted and a variety of layouts were possible but a more detailed consideration should be given prior to commencing construction."

Initially only stage 1, 2 and 3 were approved at an estimated cost[7] of $802m. In 1973 an amended stages 4 and 5, including a single power station and modified tunnel systems were added to give a completed cost of $1,162m. The scheme is now due for completion in 1984, after a construction period of 20 years, at a cost of $1,684m.

In a Cabinet draft of 26 August 1964 received by Treasury from MWD the construction of a town at Turangi was recommended. Ministry of Works and Development backed its case with a claim that the net cost of a permanent town ($38m) would be less than that of a works camp ($42m):

The figures supplied were clearly somewhat optimistic and by 1967 this was very obvious. Re-assessment indicated that a permanent town would cost $116.m compared with $72m for a works camp or temporary town.

In July 1966 the current estimate of the committed stages of the Tongariro power scheme had risen to $1,149m.

This information, like that supplied on Turangi township, was also to turn out to be an under-estimate. Problems were encountered with Maowhango tunnelling contracts concerning the amount of support required and water inflows.

By August 1968 a further revision of the project had been prepared. MWD reported "an independent estimate" of $1,263m and noted in its recommendation to CWC that the rearrangement of the Moawhango project would "include only those units that can be generated more cheaply here than elsewhere."

In July 1973 MWD submitted for approval the Rangipo power station at a cost of $328m. Their submission indicated that power from Rangipo (according to the 1970 Energy Plan) would be 0.85c/kwh ($1973) and as such would be no dearer than the estimated unit cost of the Tongariro development without Rangipo. However because of difficulties encountered in tunnelling the completion date was shifted back a year to 1980 and the cost was now restated as 0.95c/kwh ($1973). The modified Tongariro scheme would then cost $1,586.m based on the estimated cost to completion of stages I, II and III and Rangipo.

The statement that the units generated at Rangipo were cheaper than could be generated elsewhere was not supported by a Treasury analysis of alternative schemes (at a 10 percent discount rate). Treasury report T2685 21 September 1973 refers.

Station	Plant Factor	c/kwh (1973)	c/kwh (1983)
Rangipo	70	1.62	7.1
Clutha	55	0.6	2.6
Ohaaki	80	0.5	2.2
Huntly	55	0.95	4.1

7 CM(64) 37 22 September 1964

In a note to the Minister of Finance (23 November 1973) Treasury reported:

a Rangipo was said to be needed because of a possible power shortage in 1980/81. However, Treasury was not convinced that the additional margin was necessary;

b the economic analysis showed Rangipo to be 90 percent more expensive than a coal-fired station and 70 percent more expensive than an oil-fired station. It also noted that given the current uncertainty about future oil supplies that an oil-fired station was not an attractive alternative;

c the accounting technique used by Electricity Department was inappropriate as a means of making comparison between different forms of energy generation.

Despite all these objections the project was approved. Incidentally, the oil-fired power station referred to was later to be approved for construction as Marsden B.

However, this was not the end. Further problems were encountered with the construction of Rangipo headrace tunnel which increased $34m beyond the estimated, cost partly due to the method of payment being used on the contract, the contractor choosing top-heading rather than full-face tunnelling procedures.

The consultant, Sir Alexander Gibb and Partners, contracted on a percentage of audited cost (35/8 percent for most items) estimated fee of $27m rose to $31m before concern was expressed by Audit and a fixed fee plus reimbursibles was finally negotiated for their services.

c Upper Waitaki

The Upper Waitaki project includes the construction town Twizel, Pukaki high dam, five power stations and their associated canals. In September 1969[8] CWC agreed to the work on Twizel being extended to include Pukaki and Maryburn power stations and associated canals but deferred the construction of the Pukaki high dam. This was followed in December 1970 with approval to proceed on the Pukaki dam and Tekapo B power station (in place of Pukaki and Maryburn). Finally in 1972 CWC approved the construction of Ohau A power station and associated canals.

In February 1974 approval was given for construction of Ohau B and C power stations at which time the total cost of the project was estimated to be $1414 million. The current estimated completion cost is $1460 million.

While the project is likely to be completed near to its budgetted 1974 cost it has fallen considerably behind in its commissioning dates as is indicated below:

Upper Waitaki - Commissioning Dates

	Proposed 1974	Current 1983	
Ohau A	1977	1979 (2 units)	1980 (2 units)
Ohau B	1979	1983 (2 units)	1984 (2 units)
Ohau C	1981	1985 (2 units)	1986 (2 units)
Tekapo B	1976	1977	

8 Cabinet Works Committee Minute W(69) M23 Part I