

SESSION II.
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NEW ZEALAND.

UTILISATION OF WATER-POWER

(REPORT ON).

Laid on the Table of both Houses by leave.

Public Works Department, Wellington, N.Z., 22nd October, 1906.

I HAVE the honour to report on the several proposed water-power schemes for which surveys have either been completed or are now practically so.

I have dealt in each case with the scheme as it would be if fully developed for full-time and for half-time working when storage is available. Each scheme can be partially developed at first where this course seems justifiable, but the works executed in each case should be parts of the completed scheme, as decided on. It is, however, an uncertain matter to determine years in advance how many hours per day any scheme will be worked in the future, and to proportion the size of the necessary conduit. It is improbable that any scheme designed to supply the general demands of a city or district for power will work either wholly full time, or a great part—say, eight hours per day. I have taken twelve hours per day, or 4,380 hours per year, as the average part-time working. This is, I think, as good an approximation as can be arrived at for the present.

ROTOITI, KAITUNA, ETC.

The schemes possible at Rotoiti appear to be more promising than the Huka or other Waikato schemes. Much higher falls are obtainable, and a much less quantity of water has to be handled. Their adverse feature is the longer length of conduit required, and the consequent increased cost of partial development. When fully developed any of the larger schemes on the Kaituna should be able to supply power to the Thames and Auckland districts at considerably less cost than at Huka.

There are quite a number of possible ways of taking a conduit from Rotoiti; these are given in the list below. It does not, however, appear possible, by taking a conduit along the Kaituna or Pokopoko, to get all the 914 ft. of fall available between the lake-level and the sea. Whether better results could be got by diversion to the Pongokawa has not been tried, but the conduit would be very much longer and more costly; and as nearly 800 ft. fall can be got on the Kaituna, it is not likely much better results could be got on the Pongokawa.

The country immediately to the east of Lake Rotoiti is very broken; this and wet weather has delayed the completion of the survey, which must necessarily be exhaustive in view of the magnitude of the issues involved.

It is not permissible to build a dam at Okere to store all the flood-water by raising the lake-levels. The intake can be put at about 20 ft. below the low-water level of Rotoiti; this will give a large storage-volume, and a further large quantity can be stored in Rotorua Lake between the ordinary fluctuations of the levels of that lake—about 3½ ft. Possibly the storage so got may generally be sufficient.

The best place found for the construction of an intake is in the bay opposite the head of the Pokopoko. The water in the bay leading to Okere is too shallow, though an intake at a suitable depth can be made. It would be more costly work than at the other point where the necessary depth is got in a very short distance.

The routes for conduits examined are as follows:—

Starting-point.			Distance Intake to Power- station.	Total Fall.	Power, Twenty-four Hours per Day.	Designation of Power-station.	Probable Cost.
			Miles.	Ft.	H.p.		£
Okere	...	...	2½	325	18,000	...	570,000
"	...	...	4	484	28,000	...	650,000
"	...	...	5½ (?)	530	30,500	Hururu	690,000
Pokopoko	...	...	6½	595	36,000	Te Akau	750,000
"	...	...	8	784	45,000	Kohangakairea	1,250,000
"	...	...	3	250	13,000	Pokopoko	400,000

The cost for any of these schemes for an average of twelve hours per day would be nearly double the cost given for twenty-four hours working.

The choice lies between a station at the 480 ft. drop—Hururu, with conduit starting from Okere; or Te Akau, with conduit starting from Pokopoko; and final decision awaits further information as to length of pipe-lines, it being necessary to have these as short as possible on account of the cost, and especially so in this case, as the lake-waters are said to induce corrosion on metals. Long lengths of pipes are required in all the Kaituna schemes—an unfavourable feature.

The Kaituna could best be utilised by two power-stations; the second conduit starting from the first power-station; the combined power obtainable would likely amount to 50,000 b.h.p. on turbine-shafts.

Any of the larger Kaituna schemes would deliver power in the Auckland, Thames, and Waihi districts at lower rates than the Huka schemes by 15 per cent. at Auckland, and by quite 20 per cent. at Waihi. For large and continuous supplies of power in Auckland a charge of £5 10s. per horse-power per year would give good returns, and about £4 10s. at Waihi. These are the extreme minimum rates. For small quantities of continuous supply somewhat higher rates would obtain, and for short-time supply proportionately higher rates would be charged.

HUKA.

At Huka there are two plans for dealing with the development of the available power.

First, a short channel may be cut on either side of the river to take the whole river low-water flow to a series of turbines located as near the edge of the pool below the falls as may be deemed safe. The present channel would be blocked sufficiently to send the necessary amount of water at all times to the turbines, and provision would be made for the escape of the surplus water at periods of high flow, or of the whole of the water when the turbines were not at work. No storage of the lake-water would be attempted. Turbines with vertical shafts would be necessary unless excessive excavations were made. The area is too limited to admit of the ready use of turbines with horizontal axis. In addition to the channels, the works required would be a concrete wall to protect the power-station from inundations, sluice-valves and gear, concrete and steel pipes, and chambers and tail-races cut below the level of the surface of water in the pool of sufficient sectional area to take the water freely from the draught-tubes. The power obtainable would be about 22,000 h.p.

This scheme completed with transmission-lines to serve the Auckland district only would cost about £615,000; but the whole need not be carried out at once—about half, costing about £325,000, could be done first, and additions made as required.

This scheme would not attempt to control the flow of water in the Waikato River, and perhaps less than the average minimum flow would have to be accepted at times owing to winds affecting the outflow of Lake Taupo.

Secondly, it is possible to build a dam across the river-valley just above the falls, and thereby control the waters of the lake. This scheme need not be taken as independent of the first one, but as a final development thereof if the power-station in the first place is put on the left bank of the river. If only the first development were to be final the best position for the power-station would be on the right bank of the river, but there is too little room here for the larger power-station required if the water is all conserved. The power-station being put on the left bank of the river at first and all works being suitably designed the dam could be completed at any time, and power developed up to 70,000 to 80,000 b.h.p. as may be deemed necessary. For continuous working 38,000 b.h.p. would be the probable limit of power from the Waikato flow at Huka. The cost for 76,000 h.p., all power delivered at Auckland, would be about £1,600,000.

The cost of the dam would not likely exceed £25,000. The Huka scheme is one for which the development may be continuous from 10,000 or 12,000 h.p. to, say, 80,000 h.p. without waste in any way or sacrifice of previous work. Part only of the canal-excavation might be saved by complete development at once, but this is so small a part of the total necessary expenditure that it need not be considered.

The fall available without a dam would be about 50 ft., and with the dam about 64 ft. The turbines and generators would all be designed to work at maximum efficiency for the 64 ft. head, so that if the additional development were made before the first units wore out they could be advantageously used.

The low fall available at Huka will entail much more expensive turbines and generators per horse-power than in the case of higher falls. This with the long-distance transmission will increase the cost of power obtained from there.

For the completed scheme, 38,000 h.p. at Huka, the cost for any large continuous supply of power (8,760 hours per year) may be taken as £6 10s. per horse-power year measured at the consumer's meter at Auckland, and for part-time supplies in smaller quantities higher rates, and for a partial scheme the rate would have to be 15 per cent. higher at least.

TAUHERENIKAU.

This is a rival scheme to the Hutt. The power-station would be in the Township of Feathers-ton, on a flat between the main road and Abbott's Creek.

The works required would be a dam, five miles of conduit (three miles of which would be in tunnel—the longest tunnel being 135 chains, and four tunnels in all). The pipe-line would be 33 chains long; the fall available from the end of the conduit to the flat would be about 430 ft.

There is a very large volume of flow in this river, in view of the fact that the drainage-area is only some twenty-seven square miles. The only possible site for a dam is not a very favourable one, the gorge being rather wide. A dam costing about £120,000 would probably store about 500,000,000 cubic feet of water, giving about one month or more reserve supply to supplement the lowest flow.

The drainage-area is one where excessively long droughts are not likely often to occur. The greater part of it is at present forest, and this forest should be carefully preserved.

The necessary works and a plant to develop up to 12,000 b.h.p. would cost £420,000, and while power could be sold in Wellington probably quite as cheaply as from the Hutt scheme, yet as the volume of storage only gives a reserve sufficient for about one-third of the time that the Hutt reservoir would give, the scheme is, I think, not quite equal in potential value to the Hutt one. This defect will be, to some at present unknown extent, counterbalanced by the probably greater and more frequent rainfall on the Tauherenikau basin than on the Hutt. Though highly probable, this point is not yet established by observation. Also there would be more danger of failure of transmission-line crossing the Rimutaka Range than for the Hutt line.

The power-station site is most favourably situated for the establishment of factories to use large quantities of, if not all, the power without conversion into electric energy. This is an end to be sought for in all cases.

HUTT.

The information obtained regarding this river shows that a very useful power scheme can be got.

The works required are a high concrete dam, a conduit about 4 miles 30 chains long, about 700 lin. ft. of pipes, and tail-race about 35 chains long, for the most part in drive.

The power-station would be situated near the junction of the Mungaroa Stream with the Hutt River, about four miles from the Upper Hutt Station.

In view of the physical conditions which obtain in the river-basin it will be necessary to store a large volume of water, as the low-water flow of the river is at times too small to warrant the construction of any works.

The volume of flow observed during the period for which the river has been closely observed varied from about 100 cub. ft. per second to 5,000 cub. ft. per second in flood. The mean flow during this period was equal to giving 8,000 b.h.p. on turbine-shafts at the power-station, and a surplus sufficient to supplement the observed low-water flow to give the above amount of power for a period of 100 days with probably some water running to waste. The period was probably a wet one—too much so to take as a fair average.

The rainfall records for a number of years past at the Summit and at stations not remote from the river-basin do not appear to give any ground for supposing that droughts will be so long-continued as to exhaust the storage-volume of the reservoir that can be obtained by constructing the dam described below.

The Hutt Gorge about half a mile below the junction of the Pakuratahi is narrow enough to enable a dam to be built, but there is a considerable fall in this distance. The best location for a dam would have been just below the junction, but the gorge is wider and a dam would be about three and a half times longer, though not so high. The height will be about 170 ft. from river-bed to the crest of the dam, and the length about 370 ft. along the crest. At water-level the river is only about 50 ft. to 60 ft. wide and the faces of the gorge show rock, and apparently solid foundations should be got without excessive excavation.

The faces along the river-bank below the dam are very steep, and it has been assumed that it would be the better course to construct the first mile and three-quarters, or rather more, wholly in tunnel, either in one length, or in two lengths by an adit to a gully about half-way. In addition to the tunnel there would be about 1,000 lin. ft. of fluming and about two miles and a half of channel in earth. From the end of the conduit to the Hutt River there is a distance of over half a mile, mostly flat, about 40 ft. above the river-level. The water can be taken across either in pipes to a power-station on the river-bank or the station can be put near the foot of the slope and the water taken away by a suitable underground conduit. This seems the cheaper plan. The conduit would be designed to carry about 700 cub. ft. of water per second.

The intake of the top of the conduit would be at a level of 611 ft. above the datum of the survey. At the junction of the Mungaroa and the Hutt Rivers the low-water level may be taken as 287 ft., giving a total fall of 324 ft. available. Deducting height lost by fall in race, friction in pipes, and fall necessary in tail-race, about 285 ft. of effective head should be obtainable.

The maximum power to which the scheme would work up to from the above data would be 17,000 b.h.p. on the turbine-shaft for machines of high efficiency. The corresponding continuous power would be 8,500 b.h.p. There would be little probability of continuous full-power service being required. The greater part of the demand at first would probably be for eight hours' service or longer, with no doubt some proportion of full-time service.

The power in use in Wellington, Petone, and the Hutt Valley at the present time does not probably exceed 19,000 h.p., and all of this would not be converted for some time to electric power, even if there were an electric supply of power available; but much of the probable increase of power installed would no doubt be electrical, and as this increase may likely amount to 1,500 to 2,000 h.p. a year, full use for all the energy developed should be got in a few years.

The power-station would be very favourably located, being rather less than four miles from the Upper Hutt Railway-station, sixteen miles from the Lower Hutt, seventeen from Petone, and twenty-four miles from the Wellington Railway-station. If not immediately, a large amount of power would ultimately be used in the Hutt Valley for lighting, tramways, suburban railways, and in numerous industries. A very safe route for a transmission-line could be got, and the risk of breakdown would be small for a properly constructed line.

It is somewhat difficult to form a definite conclusion as to the amount of power that should be provided. It clearly would be a mistake to instal only sufficient plant to utilise the water-power in continuous working. It is unlikely that full use would be made of such an installation and financial loss would result, while it would be equally inadvisable to provide for only an eight-hours service, as the conduit and plant would become too costly.

A plant and works to yield 8,500 b.h.p. on turbine-shafts for continuous working would cost, say, £350,000. Of this amount, £250,000 would be for dam, tail-race, conduit, buildings, &c., and £90,000 for electric plant, transmission-line, substitutions, &c.

For an installation to work up to, say, 17,000 b.h.p. on turbine-shafts the cost would be about £470,000. Of this, £286,000 would be for dam, conduit, tail-race, buildings, and minor engineering works.

No sums have been included in the above estimates for secondary distributing-lines in the towns; these would amount in time to a considerable sum—for these lines would year by year increase in number and length until the power was fully utilised.

To compete with steam and gas the power must be sold at a low rate to consumers. In this connection it is worthy of note that three electric horse-power are equal as a rule to displacing four steam horse-power owing to saving in losses due to belts and shafting, and in addition there is no doubt but that even on the above high costs for installation, power can be supplied at a profit if sold at the consumers' meters for £7 per horse-power year for continuous working, and for shorter-time service, eight hours per day, £5 per horse-power, and perhaps slightly higher rates for intermittent working. The probable revenue would be, at these rates, over £50,000 when all the energy was sold.

The Hutt scheme derives its importance from its very favourable situation. The cost per horse-power is high, but the working-costs will be lower than if an equal amount of money were expended in obtaining an equal amount of power from a long-distance-transmission scheme, and I have no hesitation in recommending its adoption in preference to any such scheme, on the grounds of probable lesser cost for power supplied, and the certainly much less risk of interruption of service by failures in the transmission-lines.

In Wellington City, Petone, and the Hutt Valley about 19,000 h.p. are in use exclusive of railway locomotives. The power obtainable at the Hutt would not supply all this demand, nor is it likely that all the existing power would be converted to electro-motive power.

A scheme that would now provide 10,000 to 15,000 h.p., and that could as time went on be gradually enlarged to double or treble the size would be preferable, but so far no such scheme has been discovered near Wellington, and, supposing one scheme started, additional power—so long as existing conditions obtain—would have to be got by adding future schemes, as Tauherenikau, Mangahao, &c., to supply the needs of the district.

The nearest large scheme is the Mangawhero—Wanganui—this would be 120 miles distant; then Waikaremoana, about 240 miles distant; and Huka, 250 miles distant by the east, and 210 miles by the west coast. If the Mangawhero scheme were to prove a good one, the cost for power might be about as low as the cost from the Hutt scheme, while for Huka and Waikaremoana the cost would be probably 40 per cent. greater than the Hutt costs, though this might be reduced if excessive voltages were found to be practicable under all New Zealand conditions—which would be severe, as the transmission-lines would be near the sea for considerable distances. There is, however, not enough power available at Huka to justify the construction of radiating transmission-lines to Auckland, Wellington, and other centres. Waikaremoana is the only scheme which could be considered in connection with any proposal to serve all the North Island from one power-station.

CLARENCE.

The surveys at Jollie's Pass and Jack's Pass show undoubtedly that Jollie's Pass is the better location for a power scheme, there being here more power available at less cost.

The works required are a weir across the Clarence River about half a mile above the junction of Jollie's Pass creek with the river, an intake to draw off all the low-water flow of the river through the shingle that must certainly accumulate to the level of the top of the weir, settling-basins sufficiently large to allow of the heavier grit being taken out of the water before it enters the tunnel. These works would be common to any works adopted. There are two alternative routes for the tunnel through the range—one leading to a spur down which the stock-track runs. On this route the tunnel would be 133 chains long in one length. Beyond this it would be advisable to continue the tunnel for a further length of about 59 chains, and excavate it from several drives in from the face of the spur. Open fluming, or perhaps a race in places, could be substituted for this length of tunnel, but the tunnel would involve practically no risks of breakdown. From the end of the second tunnel the ground falls very rapidly—in 40 chains, 966 ft.; in 60 chains, 1,071 ft.; and in one mile, 1,134 ft. Over any part of this section steel pipes must be used. The other alternative is to take the conduit along a ridge, the next on the south of the stock spur. The tunnel through the main range is 2 chains shorter than in the first case, being about 131 chains long. A prolongation of the tunnel in this case also would likely be advisable, but this length would only be about 32 chains long, or 165 chains of tunnelling against 192 chains on the other route. From the end of the tunnel the ground falls in the first half-mile 975 ft., and in 52 chains 1,037 ft.

By the construction of a dam across Lake Tennyson outlet to raise the water-level by about 35 ft. storage would be provided to give water enough to increase the power up to 31,000 b.h.p. at least. The cost of such a dam would not be very great; the most troublesome part would be the flood-water overflow. The area of the lake is about 0.91 square miles at low water, and about $1\frac{1}{2}$ square miles at 50 ft. above low-water level. The drainage-area above the lake is probably not more than twenty-six square miles. A high rainfall may be expected, as the elevation is high, and snow will help to maintain the river-flow at some seasons. The cost of this dam would be about £35,000. There are two periods of high flow in the river, and probably two fills or more of the reservoir would be had each year. Long-continued frosts might have some ill effects on the flow.

Without a dam the stock-spur project would give about 22,000 b.h.p. on the Pelton-wheel shafts, and 31,000 b.h.p. with the dam. The length of conduit would be—intake, 1,050 ft.; tunnels, 12,700 ft.; pipes, 4,500 lin. ft. The cost for the 22,000 h.p. would be £440,000, including a transmission-line to Christchurch; and for the 31,000 b.h.p. £590,000. The cost per horse-power would be about £20 and £19 respectively. For the two schemes this is very low.

For the other conduit-route, giving 21,000 b.h.p. or 30,000 b.h.p., the cost would be £380,000 and £535,000. There is little to choose between the two alternatives when the extra power is allowed for.

The cost of power from this scheme, measured at the consumers' meters at Christchurch, for continuous service may be taken at £4 10s. per horse-power per year, and for about half-time service £7 per horse-power per year. For intermittent service in small amounts the cost would be somewhat greater.

This scheme could be further augmented by increasing the height of the dam at Lake Tennyson, and perhaps by building a dam at the most favourable point between the weir and Lake Tennyson. It might also be possible to divert water from the most northerly branch of the Waiau-ua if this stream is higher than the Clarence; this is a point worth getting information on.

This scheme would give very cheap power if uses were found at first hand at the power-site. In the production of nitrate-of-lime fertilisers about 15,000 tons annually could be made. The selling-value of this quantity would be about £150,000. I have no information about the cost of the electric and other plant and works required for the production of nitric acid. The electric energy could easily be supplied for this purpose at £1 10s. per horse-power per year.

LAKE COLERIDGE.

The plans of further surveys and data for this scheme are not yet to hand, but on the fairly full information got at first, with subsequent information as to cost of electric plant, &c., the best alternative scheme at Coleridge for the generation of about 29,000 h.p. would cost £700,000, and the least cost in Christchurch of large supplies of power would be about £5 per horse-power per year.

OPIHI.

The surveys finished at Opihi show that the best way to utilise the power available is to build a dam at the upper end of the Opihi Gorge (this structure would be about 130 ft. high and 370 ft. long on the crest), and to construct a conduit from the dam to a point about 4 miles 16 chains lower down the river. The conduit will consist of about 120 chains of tunnel, about 7 chains of flume, and 209 chains of open tunnel, cut in rock or earth. The length of steel pipes from the end of the conduit to the power-house would be short—about 450 ft. long.

The fall obtainable from the end of the conduit to the power-house would be 260 ft. The reservoir would store 4,600,000,000 cub. ft. of water, and would be located in the Opihi Valley. To supplement the flow in the Opihi water can be diverted from the north and south Opuhas and creeks between at no great cost; and at considerable cost water could be diverted from the Tengawai Stream into the reservoir, but this is not considered as a present part of the scheme.

The works required for diverting the water from the Opuhas would be a weir across each river, with short levees at the South Opuha; a large channel from the South Opuha to the head of St. Michael's Valley, about one mile long; and a channel between the two rivers about two miles and three-quarters, for the most part in earth. There would be 2,000 lin. ft. in flumes over two creeks. The diversion of the South Opuha would be done first; then, when circumstances warranted, further water could be taken from the North Opuha.

There are extensive flats along the river-bank below the power-station favourable for the establishment of factories to utilise the power direct. The distance from the power-house to Timaru is about twenty-two miles, to Oamaru seventy-five miles, and to Christchurch about ninety-six miles, if a direct line were taken.

The flow of water in the Opihi and the Opuhas should give water enough for about 16,000 b.h.p. continuously on the turbine shafts, or a proportionately greater power for shorter-time working. The reservoir would store about four months' supply supplementary to the low-water flow of the rivers. The snowfall on the higher portions of the basins of the Opuhas would also help materially, the flow-off from melting snow not being so rapid as in the case of flood rainstorms.

The cost of works to give 16,000 b.h.p. on turbine-shafts continuously would be £610,000, and the cost of work for 35,000 b.h.p. would be £860,000.

It is a question whether a central power scheme should be established at Coleridge for Canterbury, or two schemes—one at Clarence and another at Opihi.

The two schemes would, for full-time working, have a capacity of 46,000 h.p., capable of extension to 70,000 h.p. for part-time working, costing for the 46,000 h.p. about £1,045,000. The two schemes would command a much greater area, and over this area would supply power at a lower average rate than the Coleridge scheme.

The Coleridge scheme would give, at a cost of £700,000, 29,000 h.p., against 46,000 h.p., at a cost of £1,045,000, and it would be capable of extension to 58,000 h.p. for half-time working, against 70,000 h.p. for the combined schemes; but there are also other and larger but costly schemes possible at Coleridge. Coleridge is more favourably situated for partial development than the two combined schemes taken together, though not more so than the Clarence alone. The relative cost of energy at Christchurch from the three schemes is given below:—

		Horse-power.	£	s.	d.	
Clarence ...	...	30,000	4	7	6	per horse-power year.
		22,000	4	13	0	
Coleridge ...	...	29,000	5	0	0	"
Opihi ...	...	16,000	5	10	0	"

As the bulk of the Christchurch power would naturally be taken from the cheapest source of supply, the dual scheme appears to be the better for this as well as for the reasons given above.

TEVIOT.

This is the largest scheme available near Dunedin, and is distant about seventy miles by the shortest route for a transmission-line; but the longer route *via* Beaumont, Lawrence, Milton, Mosgiel, and other smaller centres would probably be the better one to follow, as, in addition to facilities for carriage of materials for the transmission-line, considerable amounts of power might ultimately be sold along the route.

There are four separate schemes possible along this river between Lake Onslow and the junction of the Teviot River with the Clutha. The first starting from Lake Onslow would have a conduit about 5 miles 8 chains long, giving a fall of 230 ft. and about 7,000 b.h.p. A second conduit starting immediately from the first power-house would have a length of 7 miles 60 chains, giving about 300 ft. fall and 9,000 b.h.p. A third conduit would start from the second power-house, its length would be 5 miles 54 chains, the fall about 365 ft., giving about 11,000 b.h.p. The fourth conduit would start from the third power-station, its length would be 3 miles 45 chains, including 6,800 ft. of steel pipes, the fall obtainable clear of the Clutha flood-level would be 870 ft., giving about 27,000 b.h.p. at a power-station on the left bank of the Clutha, about one mile below the Roxburgh suspension bridge. It is also possible to adopt a smaller scheme for the fourth and a larger one for the third scheme.

All four schemes together would yield about 54,000 b.h.p. on the turbine or Pelton-wheel shafts. The configuration of the country would compel some such measure as outlined to be adopted to enable all the power in this river to be developed if ever it should be desired to develop it.

It would be necessary to increase the storage-volume of Lake Onslow by raising the present dam or perhaps building a new one a little lower down, where the gorge is narrower. A dam 90 ft. high would give a lake-area of about ten square miles, the dam probably would not require to be so high as this to store all the water available from the drainage-area, which is only sixty-six square miles. An investigation as to the possibility of diverting water from other areas into the Teviot basin was made, but, though possible, this appears to be too costly.

The fourth scheme of those outlined above is the only one having interest at the present time. The conditions are favourable for the economic development of power. The cost of works, plant, transmission-lines, &c., for 27,000 b.h.p. would be £550,000.

The cost at which power could be delivered in Dunedin from this scheme for large amounts of continuous supply would be £5 per horse-power year, and for part-time supply £6 to £7 and over for intermittent and small supplies.

The scheme would supply abundant power to the principal industrial interests of Otago for a long time to come.

For a scheme to utilise all the power over part-time work—say, twelve hours on an average per day—any amount of power could be developed up to 50,000 to 60,000 b.h.p. Taking a scheme of 54,000 b.h.p. the cost would be £870,000 or more, depending on where the power was used, the cost of transmission-lines being somewhat uncertain, depending on assumptions as to points of delivery of energy.

Partial developments may be made to start with as shown below :—

—	Power and Cost.		Power and Cost.		Power now used in Districts to be served.
	H.p.	£	H.p.	£	H.p.
Kaituna	36,000	750,000	18,000	590,000	37,000
Huka	38,000	790,000	15,000	345,000	
Tauherenikau	12,000	420,000	6,000	380,000	19,000
Hutt	17,000	470,000	17,000	470,000	
Clarence	22,000	440,000	11,000	340,000	21,000
Coleridge	29,000	700,000	14,500	440,000	
Opihi	16,000	610,000	10,000	500,000	18,000
Teviot	27,000	550,000	13,500	400,000	

The larger part of the power now in use in the various districts is only worked eight hours per day.

The Kaituna schemes would not be very favourable ones for partial development, as the cost of the full-power conduits would heavily load the partial scheme. It is not clear that any scheme there would remain long partially developed, as a large amount of power is used in the Auckland district.

The Huka is the best of all schemes for partial development at first, and any scheme can be carried to full development with hardly any loss.

The Hutt scheme should be completed in the first instance.

Coleridge is a scheme that is very favourably conditioned for partial development, and subsequent completion in successive stages as the demand for power justifies.

Opihi, on account of the cost of the dam and the expensive conduit through the gorge, would not be a very favourable scheme for partial development.

The Teviot scheme is one where the conditions are fairly favourable for partial development.

In partial developments it will be essential, to avoid future loss, to make the conduits full size at first, as they cannot subsequently be enlarged without stoppage in working for a considerable period.

The cost, so far as electric plant is concerned, in the above estimates is for the most part based on prices obtained by the consulting engineers in England from manufacturers of high standing. It will now be the best course to send full information to the consulting electrical engineers for the colony in London, and, through them, and on conditions to be laid down by them, to obtain from the leading companies manufacturing electric and hydraulic plant prices for the plant required in each case.

Tenderers would submit offers for the types of their own standard design of turbines, generators, and other machinery and appliances. It would be advantageous to select one type of machinery for all plants if possible to insure uniformity throughout as much as possible; the consulting electrical engineers in London to advise on offers.

There are two technical conditions which influence the cost of transmission-lines—the frequency of the alterations and the voltage of transmission, low frequency and high voltage being favourable to economy in the transmission-line. Low frequency increases the cost of the transformers, and greatly increases the capacity of a line for transmitting energy. As there are practically no restrictions here as in other places where power-installations have been made, the most favourable frequency and voltage should be adopted.

Until a transmission-line is actually located it is not possible to give more than a general average value for the cost; forming roads, clearing bush, &c., may in some cases increase the cost very materially, but generally very little bush would be traversed.

In most of the schemes the cost of the hydraulic works—weirs, dams, conduits, and pipes—much exceeds the cost of the electric plant.

A somewhat full investigation into the probable costs at which power can be got from many of our power schemes appears to show conclusively that it will be possible to supply power at relatively very low rates—sufficiently low to insure a certain sale for all the power which at present it appears prudent to generate.

A considerable amount of information has been obtained through the High Commissioner about the process now at work in Sweden for the manufacture of nitrate-of-lime fertilisers. This information has been got direct from one of the inventors, Professor Birkeland. He claims that the process is successful, and that about 0.4 of a ton of nitric acid may be got per horse-power year, giving about 0.52 of a ton of nitrate of lime per horse-power year. From Manapouri and Te Anau Lakes, diverted to the Sounds, about 600,000 tons of nitrates could be made a year, at present rates worth £6,000,000. Employment would be given to about four thousand men. The expenditure required would be about £10,000,000 to supply the electric energy; the cost of the works and plant for the manufacture of the acid I have no information about at present. The works would be situated near or alongside deep water. Similar factories could be established at other points on the West Coast Sounds and at numerous other places—Hauroko, Lake Hawea, Tekapo, Rotorua, Waikaremoana. It has been stated that within the next few decades the demand for nitrate fertilisers will greatly increase, while the only natural deposit at present known is being rapidly worked out. Most of the other hydro-electric chemical industries are of lesser apparent importance than the nitrate one, and the perfection of the process to insure its successful commercial working would make the full development of many power schemes possible in New Zealand with every prospect of profitable returns being obtained therefrom.

To illustrate the amount of money it is thought it may be profitable to spend on the development of water-power, out of 1,250,000 h.p., the estimated resources of Norway in water-power, concessions have been already granted for the development of 550,000 h.p. The estimated cost for development is stated to be £55 per horse-power—a high figure; and unless it includes more than providing the hydro-electric works, New Zealand power schemes would appear to be more easily developed than Norwegian, the cost per horse-power for the schemes herein dealt with varying from about £20 to £38 per horse-power.

Information has been obtained from England about suction gas and other plants likely to compete with hydro-electric power. Seeing that immense developments of electric power are now in progress at Niagara, it is a fair conclusion that for general industrial supplies of energy gas-engines as motive power are not at present able to supplant electric power when generated from economic water-power schemes.

The Hon. the Minister for Public Works.

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Engineer-in-Chief.

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