1919.

VICTORIA.

ELECTRICITY COMMISSIONERS.

REPORTS

ON THE

UTILIZATION OF BROWN COAL AND WATER POWER

FOR THE

PRODUCTION OF ELECTRICAL ENERGY.

PRESENTED TO BOTH HOUSES OF PARLIAMENT PURSUANT TO THE PROVISIONS OF ACT No. 2996.

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ELECTRICITY COMMISSIONERS' REPORT.

The Honorable Arthur Robinson,

Attorney-General,

Melbourne.

SIR,

I.—SCOPE OF INQUIRY AND REPORT.

In accordance with instructions contained in section 10 of the *Electricity Commissioners Act* 1918, we beg to submit herewith a "scheme for coal mining and electrical undertaking to be undertaken in the neighbourhood of Morwell, and the distribution of electricity therefrom; and also a Report setting forth the results of an inquiry into the relative practicability of utilizing water power for electrical undertakings."

In considering the questions involved in the above instructions the Commissioners are satisfied that, having regard to "the ultimate co-ordination and unification of all State or other electrical undertakings within Victoria," it will be necessary to take a much wider view than section 10 of the Act expressly implies. Consideration has, therefore, been given to the ultimate requirements of the State as a whole, and while realizing the immediate pressing need of steps being taken to provide an adequate supply of electrical energy to the metropolitan area, any scheme to satisfy that requirement must be considered only as providing the nucleus of a system for the production of electrical energy from sources within Victoria, and its distribution in quantities sufficient to meet the future power requirements of the whole State, both for industrial and domestic purposes. The supply of cheap energy is as essential to industry as are labour and materials, and in the electrical form it is so flexible that it can be applied to nearly all kinds of machinery, whether used in transportation, in the mill, the workshop, the mine, or the farm, as well as to the many processes developed of late years that depend on the electric furnace, and on electro-chemical and electro-metallurgical action.

II.—NATIONAL ASPECT OF A POWER SCHEME.

In the Report (17.4.17) of the Coal Conservation Sub-Committee of the Reconstruction Committee of Great Britain the following passage appears:-

> In the industrial reorganization which must take place on the termination of the war the further development of power is of great importance. The present use of motive power per employee is only about half that in the United States of America. Large quantities of electrical power will be required for the development and carrying on of new processes not at present undertaken in this country. . . . It is only by largely increasing the amount of power used in industry (by two or more times) that the average output per head (and as a consequence the wages of the individual) can be increased.
>
> Power may be most efficiently applied to industry by the medium of electricity.
>
> The economical generation of the electrical energy so required is thus of great importance. . . . Technically, and economically, the electrical energy can be best provided by a comprehensive system, as may be amply proved from experience gained in those parts of the world where such systems are in existence, notably in Chicago (Illinois), on the north-east coast of England, on the Rand, and in certain industrial districts of Germany.

These opinions bear with even greater force on the situation in Victoria, and we feel that, in the light of experience in other parts of the world, the scheme for providing for the requirements in the metropolitan area in the year 1923 must be regarded as the first step of a greater scheme, having for its ultimate objective the linking together of all available sources of power supply, whether coal or water, for the benefit of the State.

III.—ESSENTIAL REQUIREMENTS OF A POWER SCHEME.

The essential requirements to be satisfied by any scheme selected as a first step in the inauguration of a State supply may be summarized as under :—

(*a*) Certainty and continuity of supply.
(*b*) Capability of early operation.
(*c*) Initial capacity,
(*d*) Capability of expansion.
(*e*) Economic soundness.
(*f*) Independence of sources outside Victoria.

(*a*) *Certainty and Continuity of Supply.*—The making available of a supply of electrical energy at a cheap rate must eventually result in almost the whole of the industrial activities of the State being dependent on that supply for their operation. Consequently, a cessation of operation from whatever cause would mean a corresponding interruption of all industrial activities. Such a disaster must be most carefully guarded against. It becomes, therefore, a matter for the most careful thought, when considering alternative schemes, that the scheme selected must be based on proved methods, and, as far as practicable, such as will guard against possible sources of trouble or breakdown in operation. The adoption of any process, or the installation of any plant which has not been proved economically satisfactory under continuous operation in undertakings of similar magnitude, or which are still in the experimental stage, would be unjustifiable.

(*b*) *Capability of Early Operation.*—The scheme selected must be capable of being put into operation early in 1923. The two undertaking authorities supplying Melbourne, viz., the Melbourne City Council and the Melbourne Electric Supply Company, have already made representations to the Government of the seriousness of the position that will arise should the matter of provision of an adequate supply of electrical energy be further delayed. The existing power-houses of the above-mentioned undertakings will reach the limit of their capacity in the year 1921, and, indeed, arrangements have already been made whereby a supply will, before then, be furnished by the Railway Commissioners from the Newport power-house. This arrangement, however, can only be regarded as a temporary expedient to relieve the position, as the Railway Department will require the whole of the present capacity of the Newport power-house to complete the electrification of the suburban railway system, possibly during 1923, or before.

(*c*) *Initial Capacity.*—The earliest date at which it will be possible to supply electrical energy will be the beginning of 1923. At this date it is estimated, on the basis of present expansion, that the power requirements in the metropolitan area alone will have reached 50,000 kw., of which the Newport power-house will be supplying about 10,000 kw. by agreement for five years from 1920.

In the event of any new scheme being capable of supplying energy to the existing generating authorities in the metropolitan area in sufficient quantity, and at a cost less than that at which these authorities are generating it, it may be assumed that they will readily avail themselves of the cheaper supply, and gradually shut down their own generating plants. In that case any new scheme must be judged by its ability to supply the 1923 requirements of the metropolitan area as mentioned above.

(*d*) *Capability of Expansion.*—The scheme adopted must be designed from the point of view of a probable steady and continuous growth in the use of electrical energy in Victoria, and must, therefore, be capable of ready expansion to meet that requirement, as well as any special demands created by the establishment of industries calling for comparatively large blocks of power. As stated in a former paragraph, the demand in the metropolitan area in the year 1923 will be about 50,000 kw. Natural growth of the demand may be expected to increase the requirements in 1925 to about 61,300 kw. The needs of country centres and outlying districts will yearly become more insistent, and, as the system is extended, the fact of adequate power being available at a reasonable charge will create a further demand. Any scheme entered upon at this stage, therefore, must be designed to take these factors into account. Neglect of this view would mean the raising of the same difficulties that have caused, and are at present causing, such grave concern in England, and to remedy which it is proposed to expend an enormous sum of money in the construction of power-generating stations on a large scale.

(*e*) *Economic Soundness.*—Any scheme entered upon must be able to furnish a bulk supply of electricity at a rate below that at which it is being generated at the existing power-houses in Victoria, due regard being had for the capital already expended on such power-houses.

(*f*) *Independence of Sources outside Victoria.*—Any scheme under consideration must, of necessity, be based upon a supply of energy from sources, either coal or water, entirely independent of those outside the State.

At the present time importations of New South Wales coal into this State for all purposes, except railways and gas making, may be stated at 450,000 tons per annum.

There is now no reason why the whole of this quantity should not be displaced by the use of electrical energy generated from brown coal, or by the direct use of such coal. By such a change the great bulk of the domestic and industrial requirements of the State would be met by the development of power or fuel sources within the borders of the State, with consequent financial benefit to the community.

The cost of New South Wales slack coal to the Melbourne City Council's electric supply undertaking has increased in the last four years from about 16s. to about 31s. per ton, partly on account of the increased mining costs, but due mainly to greatly increased cost of freight. The latter factor has placed Victoria at a great disadvantage industrially as compared with New South Wales, as can be seen by the fact that the electric supply undertakings in Sydney can obtain supplies of similar fuel at about 16/9d. per ton, which is about 5s. per ton increase above pre-war rates, whereas the increase to the Melbourne undertakings is about 15s. per ton. This state of affairs is reacting seriously on the industrial development of Victoria, and is correspondingly beneficial to New South Wales, a position which will be intensified by prospective increases in freights.

It would show an unjustifiable neglect of the interests of the State if the manufacturing industries were allowed to remain under this disability while we possess unlimited and comparatively unexploited areas of brown coal which, if utilized, would easily meet all possible power requirements.

It would be equally neglectful if no use were made of the water power resources of the State, as these, after careful investigation, are proved to be capable of being utilized economically.

IV.—SCHEMES CONSIDERED.

The possible schemes coming within the scope of our inquiries have been divided into two groups :—

1. Brown Coal.
2. Water Power.

Within these groups, and having in view the above-stated immediate requirements, we have considered—

1. (*a*) Morwell Brown Coal-field.
   (*b*) Altona Brown Coal-field.
2. Kiewa River.

V.—MORWELL COAL-FIELD.

The criteria already set out on which to judge the various schemes may now be applied to the proposed Morwell scheme.

(*a*) *Certainty and Continuity of Supply.*—Intensive boring by the Mines Department of an area of, approximately, 1 square mile adjacent to the power-house site has proved the existence of, approximately, 120,000,000 to 150,000,000 tons of coal which can be won by open-cut method of operation. These quantities are sufficient to provide for the continuous operation of a power-house with an output of 100,000 kw. for a period of 150 years, while outside that area there is an estimated quantity of over 20,000,000,000 tons of coal.

Mr. Lindesay Clark, in his report hereto attached, points out that the average thickness of the coal seam is 174 feet, with an average thickness of overburden of only 33 feet; that is to say, that each cubic yard of overburden covers on the average rather more than 4 tons of coal. It is interesting to note that in the Fortuna Brown Coal Mine, near Cologne, at which nearly 7,000 tons of coal are raised daily, the overburden is about 60 feet in thickness, while the coal seam averages 180 feet. The overburden and coal at this mine, as in several others in Germany and Austria, are both removed by the application of mechanical appliances which have been evolved over a long period of successful experience. The process of winning open-cut coal at Morwell will involve no serious problem that has not been satisfactorily solved in similar schemes on the European Continent, and the great extent to which powerful machinery, such as steam shovels, can be utilized to lighten the laborious nature of the operations usual in coal mining will be not the least interesting feature of the Morwell scheme. In addition, the conditions of working from the employees' point of view will be all that can be desired, as the whole of the operations will be on the surface, and contrast greatly with the conditions applying to deep mine operations, such as those that would be necessary at Altona.

The necessity to transmit the electrical energy over a considerable distance at high voltage does not, in our opinion, constitute a factor affecting appreciably the soundness of any proposal to establish a power-house at Morwell from the point of view of continuity of operation. In America a very large proportion of the power required to operate the public utilities in the main centres of population is conveyed thereto by means of long-distance transmission schemes, and in Great Britain the proposals to establish super power-houses must necessarily involve the introduction of such schemes in the near future. The practice of transmitting electrical energy at high voltage has been so perfected that there need be no apprehension as to the Morwell scheme being capable of rendering satisfactory service from this point of view. For the first 50,000 kw. it is proposed to erect one line of towers with two circuits thereon, and to duplicate this when the demands exceed this figure. With both tower lines in operation there will be a reserve to the extent of one circuit of 25,000 kw.

(*b*) *Capability of Early Operation.*—Subject only to present disabilities in regard to the purchase of plant—which disabilities apply equally to any scheme which may be put forward—there is no apparent existing cause to prevent an early start being made with the opening of the mine, the construction of the power-house, the transmission line, and distribution system to enable the necessary bulk supply being made available to Melbourne early in 1923.

(*c*) *Initial Capacity.*—The Morwell scheme fulfils the requirements set out under this heading. The scheme is designed to supply in the first stage the total requirements of the metropolitan area in the year 1923, namely, 40,000 kw., and on the assumption that the Melbourne City Council and the Melbourne Electric Supply Company will take their present and future requirements from such scheme.

The price at which a supply can be made available is such that these undertakers should readily avail themselves of the cheaper supply, and gradually shut down their own plants.

(*d*) *Capabiltiy of Expansion.*—The ability to meet the gradual growth in the demand for electrical energy, as well as any sudden call on its resources, is one of the outstanding favorable features in connexion with the Morwell project. The extent of coal deposits capable of being worked on the open-cut principle is such that by the provision of adequate machinery any increase in output above the proposed initial capacity can be provided.

(*e*) *Economic Soundness.*—This aspect is fully dealt with in the particulars of the Morwell scheme presented with this report, and estimates and particulars are given of capital expenditure and working costs.

The results of these estimates are indicated in Table I. of the Chief Engineer's Report on the Morwell Scheme hereto attached. This table is reproduced with additional information, and from it it will be seen that to deliver to Melbourne a given quantity of 20,000 v. energy with a load factor of 42 per cent. at one point, such as the Richmond Terminal Station, the total annual cost, including all capital charges of operating a scheme based on a power-house situated at Morwell with electrical transmission, would be £222,045.

To generate and deliver to a similarly situated point in the metropolitan area an equal quantity of energy at the same voltage and load factor, from power houses situated alternatively near Melbourne, using imported black coal, and on the Altona field, would cost annually £280,035 and £243,627 respectively—that is to say, the Morwell scheme would result in an annual saving of £57,990 and £21,582 in comparison with the two alternative schemes mentioned above.

TABLE I.—COMPARATIVE TOTAL ANNUAL COSTS, INCLUDING CAPITAL CHARGES, OF SUPPLYING TO MELBOURNE 43,960 KW. IN THE FORM OF 20,000 VOLT ENERGY FROM POWER-HOUSE SITUATED AT MORWELL, AND FROM ONE USING IMPORTED BLACK COAL SITUATED AT OR NEAR MELBOURNE (LOAD FACTOR 42 PER CENT.).

—		Morwell. Using Brown Coal with Electrical transmission.		Altona. Using Brown Coal with Electrical transmission.		Melbourne. Using Newcastle Coal (Sea-borne).	
Energy delivered Melbourne	units	161,700,000		161,700 000		161,700,000	
Energy generated at power-house	,,	183,960,000		168,350,000		167,326,000	
Maximum demand on power-house	kw.	50,000		45,760		45,490	
Coal consumption per unit generated	lbs.	3.81		3.81		1.59	
Coal consumption per annum	tons	312,900		286,350		118,800	
Coal cost per ton delivered power-house	..	2s. 3d.		7s. 1d.		25s. 3d.	
		Per annum.		Per annum.		Per annum.	
		£	£	£	£	£	£
Power-house—							
Variable Charges—							
Coal	..	35,200		101,400		150,000	
Wages, coal and ash handling staff	..	1,250		1,250		1,250	
Oil, water, and stores	..	1,000		1,000		1,000	
			37,450		103,650		152,250
Standing Charges—							
Wages, maintenance, &c.	..	26,585		24,330		24,185	
Capital charges	..	107,642		98,520		97,300	
			134,227		122,850		121,485
Transmission Line—							
Patrolling, maintenance, &c.	..	4,010		750		..	
Capital charges	..	19,558		1,717		..	
			23,568		2,467		
Terminal Station—							
Wages, maintenance, &c	..	3,585		3,585		..	
Capital charges	..	16,915		4,775		..	
			20,500		8,360		
Administration ..	..	..	6,300	..	6,300	..	6,300
Total annual cost	..	..	222,045	..	243,627	..	280,035
Cost per unit (pence)	..	..	.329	..	.361	..	.415

NOTE.—In this table the costs of 20,000 volt distribution within the metropolitan area are not included.

In the event of the load factor (ratio of average demand to max mum) increasing beyond 42 per cent., which, in the light of experience in other parts of the world may be expected, these differences of annual cost would be increased considerably in favour of Morwell. For instance, with a load factor of 60 per cent., the Morwell scheme would show an annual saving of £49,962 over that of Altona.

In the reports of the Advisory Committee on Brown Coal, and of Mr. Lindesay Clark respectively, the cost of winning coal was estimated at 2s. 3d. per ton delivered at the power-house. Mr. Clark has been engaged to revise his report in the light of more recent information, and in accordance with present prices of plant and materials. In this latter report, which is attached hereto—(Appendix "B")—he estimates that coal can be raised at Morwell for 2s. 2½d. per ton, based on an output of 2,000 tons per eight-hour day, the estimated capital expenditure being £221,000. The cost of coal to the power-house for the purpose of this report has been assumed at 2s. 3d. per ton.

(*f*) *Independence of Sources Outside Victoria.*—The independence of the scheme on any outside source of fuel supply requires no comment. In view of the quantities of available fuel mentioned above, Victoria is assured of a source of energy capable of satisfying all possible requirements of the State for many generations to come—a storehouse of wealth and power which any State must deem it not only a good fortune to possess but a duty to develop for the use of the community.

VI.—ALTONA COAL-FIELD.

The proximity of the Altona Coal-field to Melbourne naturally brings it into prominence as a possible site for a power-house. Situated about 11 miles from Melbourne, and adjacent to Port Phillip Bay, it offers one or two advantages not possessed in the same degree by any site situated inland. The cost of transmission of energy is reduced to a minimum, and the Bay offers unlimited cooling water supply for condensing purposes. In addition, its contiguity to Melbourne, with the essential low costs for freight, would be important in the event of brown coal in the future being utilized in a process of distillation, with the recovery of by-products. These are important advantages for any proposed schemes to start off with, and, therefore, very careful consideration has to be given to the merits which this site possesses.

Of the several criteria applied to the consideration of the Morwell field, several apply equally favorably to the Altona field. There are two, however, with regard to which the two fields differ considerably, and these are:—

(*a*) Certainty and continuity of supply.
(*e*) Economic soundness.

(*a*) *Certainty and Continuity of Supply.*—The Altona seam is about 72 feet in thickness and lies at a depth of about 349 feet. Hence, the method of winning the coal will greatly differ from that proposed with the Morwell seam, which has an overburden of only about 33 feet on the average, and can be worked on the open-cut principle.

Messrs. Klug and Broome, in their report on Altona, point out that "an artesian or sub-artesian water pressure obtains immediately under the coal bed, while the cover or roof over the seam is a swelling sandy clay. Such conditions as these clearly indicate that the proposition is beset with difficulties, and demands that a very safe method be adopted for mining the coal. The evidence we have collected reveals several instances of 'heating,' indicating that the coal is liable to fire by spontaneous combustion. Under the conditions the only methods of mining, in our opinion, that should be adopted are:—(*a*) that which depends upon bulk timbering and close filling; and (*b*) that of sectionally 'caving.' It is essential to keep weight on the bottom section of the coal seam to counteract the water pressure, and as only limited spaces can be opened owing to its friable nature, it will be necessary to mine sectionally. . . . ."

These observations indicate clearly that the difficulties likely to be met in mining at Altona are considerable in comparison with the simple open-cut method possible at Morwell, which is the method by which the Germans have so successfully developed their brown coal-fields on such an enormous scale. Briefly, it may be said that the tried methods of winning coal possible at Morwell will give a much greater certainty and continuity of operation than the more complicated, and, so far as brown coal mines are concerned, comparatively novel methods which are available for the winning of brown coal in a mine such as Altona.

In addition, the conditions of working in a mine are not those which would give the same labour efficiency and regularity of operation as could be expected amid the healthy surroundings of an open-cut scheme of operation.

(*e*) *Economic Soundness.*—The data as to the estimated cost of winning coal on the Altona field was of such a conflicting nature that it became essential for an authoritative opinion to be obtained on that all-important factor. Messrs. G. C. Klug (General Manager of Messrs. Bewick, Moreing, and Company) and G. H. Broome (General Manager of the State Coal Mine, Wonthaggi), were, therefore, engaged to report on this question in collaboration. Their report, copy of which is attached, shows that the cost of mining brown coal at Altona delivered into trucks at the present workings would be as follows :—

	Filling System. Per ton.	Caving System. Per ton.
	s. d.	s. d.
On a basis of 1,000 tons per shift of 8 hours per day ..	8 5	7 1
On a basis of 2,000 tons per shift of 8 hours per day ..	8 2	6 10
On a basis of 2,000 tons per two shifts of 8 hours each per day	7 8	6 4

It must be pointed out that the mine property is in the hands of private owners, who recently placed it under offer to the Government for £100,000. Consequently a charge to cover the interest and sinking fund on this amount must be provided, which, on the output required, will raise the cost threepence (3d.) per ton.

Reference to Table 1 of this Report will show that for equal quantities of energy delivered to Melbourne with a load factor of 42 per cent., the annual cost of operating a scheme with a power-house on the Altona field would be £21,582 greater than that of a scheme with a power-house at Morwell.

The load factor of the demand for energy (*i.e.*, the ratio of the average to the maximum demand) exercises a considerable influence upon the relative methods of the two schemes. In the event of this factor increasing, which undoubtedly will be the case, the difference in favour of Morwell will correspondingly increase. For instance, with a load factor of 60 per cent. the difference between the estimated annual expenditures of the two schemes would be increased to £49,962. To neutralize this difference, Altona coal costs would have to be reduced by 2s. 5d. per ton, or Morwell coal costs increased by 2s. 3d. per ton.

The respective annual expenditures have been based upon coal costs estimated upon present rates of wages. As the rates increase, as must be expected, they will have a greater influence on the winning cost at Altona than at Morwell, where labour-saving machinery can be operated to a much greater extent.

VII.—CHOICE OF BROWN COAL-FIELD TO BE DEVELOPED.

A careful study of the two alternative brown coal schemes has led to the conclusion that as the nucleus of a State supply scheme the opening up of the Morwell field should be proceeded with at once, leaving the development of the Altona field until the time arrives when its economic value will justify its utilization.

VIII.—WATER POWER.

In connexion with the utilization of water power the only known source of supply for production of electrical energy in bulk which shows a reasonable prospect of approaching the initial requirements is the Kiewa River, situated, approximately, 133 miles from Melbourne in a direct line.

To augment the limited data available, the Commissioners have had field parties engaged in the work of stream gauging and contour surveying in connexion with the river. No evidence, however, has so far been produced to justify the opinion that there is sufficient power available to supply even the initial requirements of the metropolitan area, while the probability is that there is much less.

Our hydraulic engineer, Mr. A. G. M. Michell, advises that present evidence points to there being at the outside not more than 35,000 kw. available at Kiewa for continuous supply. This in itself is not sufficient to meet the requirements set out under the heading of "Initial Capacity"; in fact, is far from being sufficient.

Further, it offers no hope of extension to meet the large demands that will continue to develop in other parts of the State as the scheme is extended, as well as demands that may reasonably be anticipated from the establishment of new industries requiring large blocks of cheap power as a basis of their operation. Hence, the Kiewa scheme, if proceeded with, would have to be supplemented immediately by another source of power.

In view of the comparatively high capital costs of hydro-electric works, it is necessary, in order that they may be economically successful, that such works should be operated almost continuously to their full capacity. Particularly is it so necessary where the source of energy is situated at so great a distance from the main centre of demand as Kiewa. The average demand to-day in the metropolitan area is less than half the maximum demand, and until this ratio improves, or the present average demand is greatly increased, it is extremely doubtful whether the Kiewa scheme could be proceeded with as a sound commercial proposition.

In view of the fact that –

1. All the data required on which a definite proposal should be based will take some considerable time to collect.
2. The definite limitations of capacity which our hydraulic engineer has advised is available ; and
3. The fact that a water-power scheme situated as far afield as Kiewa must be provided with a load much more continuous than can be offered for some time ;

we have come to the conclusion that any idea of developing Kiewa as a hydro-electric source of power should be deferred for the present.

We are, however, of the opinion that with the cultivation of the use of electricity, and the consequent expansion in consumption, the utilization of water power will become economically possible, and, indeed, an essential of any comprehensive State supply.

Investigations are also being conducted into the possibilities of other sources of water power, notably at the Rubicon River. Further, in conjunction with the State Rivers and Water Supply Commission, the probability of utilizing the flow from the Sugarloaf Basin at the Eildon Weir (now being constructed for irrigation purposes) is being inquired into.

A report will be submitted as to the possibilities of the Kiewa River scheme, with estimates of working costs and capital expenditure, as soon as possible after the investigatory work is completed.

The investigation of further possible sources of water power will be proceeded with as opportunity permits.

IX.—MORWELL ELECTRICAL SCHEME—ESTIMATED CAPITAL EXPENDITURE, ANNUAL COSTS, AND REVENUE.

Capital Expenditure.

The Chief Engineer in his report estimates the capital cost of establishing a power house on the Morwell field, of an initial capacity of 50,000 kw. with a transmission line to Melbourne and a terminal station thereat, as follows:–

Power house and plant	£1,442,927
Transmission line	323,102
Terminal station	226,755
	£1,992,784

To distribute the bulk supply of energy from the terminal station, to transform it from 20,000 v. to 6,000 v. or 4,000 v. and make it available to the electric supply undertakings in the metropolitan area at the several sub-stations proposed to be established, would require an additional expenditure as follows:—

Melbourne distribution cables	£272,550	
Melbourne sub-stations and equipment	251,058	
		523,608
The total capital expenditure, therefore, on the electrical scheme is estimated at		£2,516,392

This does not include the expenditure necessary to open up the mine, estimated by Mr. Lindesay Clark at £221,000, which has been taken into account in arriving at the estimated cost, 2s. 3d. per ton, of winning the coal at Morwell. Interest on capital during period of construction has not been allowed for in the above estimates.

No tenders have been called for the plant included in the above estimates, which are based on the most reliable information available, and our Engineer is of the opinion that they should cover the expenditure to be incurred.

Annual Costs.

As shown in Table I., the annual cost, including capital charges, of supplying to Melbourne 43,960 kw. (load factor 42 per cent.) in the form of 20,000 v. energy at the terminal station, Richmond, is estimated at £222,045

To this must be added the costs involved in distributing the 20,000 v. energy to the sub-stations in the metropolitan area, and making it available at a voltage of 6,000 or 4,000, estimated as follows :—

Annual cost of delivering 43,960 kw. to the terminal station, Richmond (load factor 42 per cent.)		£222,045
Additional cost of distribution to the sub-stations in the metropolitan area—		
Working expenses	£2,200	
Capital charges on cables and sub-stations	34,835	
		37,035
Total annual cost of delivering 6,000 and 4,000 v. energy to the undertakers at the sub-stations		£259,080

The item "Capital charges" in the above estimate includes interest calculated at $5\frac{1}{2}$ per cent. per annum and depreciation calculated on the sinking fund method at the above rate of interest, the assumed lives of the assets being as follows :

Power house, terminal and sub-stations	25 years.
Transmission line	40 years.
H.T. underground mains	50 years.

Costs per Unit.

The total annual cost, viz., £259,080, is equal to an average cost per unit of 0·359d. (load factor, 42 per cent.), equivalent to an annual cost of £5 3s. 6d. per kw. of maximum demand, plus 0·057d. per unit.

Possible Bulk Selling Price.

If to these figures is added a margin or profit of 10 per cent. on working costs, the result will be the price at which it will be quite reasonable to charge the undertakers in the metropolitan area for their supplies. Such a price would be 0·434d. per unit (load factor, 42 per cent.), or an annual charge of £5 13s. 10d. per kw. of maximum demand, plus 0·063d. per unit.

Annual Revenue and Profit.

Allowing for a margin of 10 per cent. over and above working costs, the annual revenue from the sale of energy to the undertakers in the metropolitan area, based on a demand at the terminal station, Richmond, of 43,960 kw. is estimated at £284,988, which, after providing for all working expenses, interest on capital and depreciation of assets as detailed above, will provide a profit of £25,908 to the State.

X.—EFFECT OF THE MORWELL SCHEME UPON PRESENT COSTS OF GENERATING ELECTRICITY.

It has been already shown that with the Morwell scheme it is possible to make available to the undertakers at the sub-stations in the metropolitan area a supply of 6,000 and 4,000 v. energy at an average price of 0·434d. per unit (load factor, 42 per cent.). While this price, the lowest that can be obtained from any of the alternative schemes under consideration, would undoubtedly be acceptable to the undertakers for all their future requirements, it does not follow that it would be so for the present requirements, unless it proved to be less than the present cost of generating such requirements, due allowance being made for the capital expended on the existing plants, which, for several years, will remain a fixed charge on the undertakers' cost of supply.

From the Chief Engineer's Report (Table V.) it will be seen that the present generating costs (excluding capital charges on the power house plant) of the Melbourne undertakings may be taken to be 0·561d. per unit sent out, while it is possible that by 1923 they may be higher owing to further increases in the price of imported fuel.

It is obvious that on this basis alone it will pay the undertakers to take all their requirements, present and future, from the State scheme. There is, however, a further item of cost, which will be affected, viz., the present cost of high tension distribution, a considerable portion of which will be eliminated by the proposed State scheme distribution in the metropolitan area. It is estimated that on these two items of cost, the Melbourne undertakings, by shutting down their own plants and taking in 1923 all their requirements from the State scheme, would be able to reduce their present working expenses by £80,000 in the first twelve months, with correspondingly greater savings thereafter as their requirements increase.

XI.—EFFECT OF THE MORWELL SCHEME UPON THE PRESENT RETAIL SELLING PRICES.

At this stage a question naturally arises as to what will be the effect of the Morwell scheme upon the present retail prices. It goes without saying that if the State pledges its credit to the extent of several millions of money, in order to make available to the existing undertakers a cheap supply of energy with resultant financial advantages, such advantages must be passed on to the public in the shape of reduced charges.

The Commissioners, however, have not the power to enforce these savings being secured to the consumer, but it is presumed that the Government will take such steps as will insure the benefit being equitably distributed. To remove any misconceptions on the part of the public, it should be pointed out that the reductions in the cost of supplying energy will have very little effect upon the charges at present in force to the average consumer for lighting purposes. Of the total consumption of energy for all purposes in the metropolitan area lighting accounts for not more than about 25 per cent. From a careful consideration of the economics of the Morwell scheme as set out in the foregoing sections of this Report, it will have been seen that the item of importance in the existing costs influenced by the proposed State scheme is the generating cost, viz., 0·561d. per unit, and that the saving thereon is about 0·127d. per unit for a load factor of 42 per cent. This saving is but a small fraction of the total costs incurred by the undertakers in supplying the average lighting consumer, who is charged from 4d. to 5½d. per unit. There is, however, this to be said, that in the absence of a scheme such as Morwell, and in the event of the undertakers having to purchase additional generating plant at present-day prices, it is certain that charges for all retail supplies in the near furure would advance considerably. The benefit of the proposed State scheme would mainly be felt by the large power consumer or factory owner, who, owing to the quantity of energy consumed, and the hours during which the supply is generally taken, obtains his supply at a much lower average cost than the lighting consumer. The power consumer to-day is paying an average price between 0·825 and 1·5 of a penny per unit, depending on the load factor of his demand and the quantity of energy consumed.

In the substitution of a State supply for that from existing power houses there is a considerable financial burden to be borne by the present undertakers in the shape of dead capital caused by the scrapping of plants. This will gradually disappear by the periodical writing-down of the assets, and when it does, the full effect of the cheaper State scheme will be demonstrated by the retail charges being substantially lower than would be possible if existing conditions were to continue indefinitely. The above can be illustrated by reference to the estimate at which energy from Morwell can be made available to the undertakers in Melbourne, viz., 0·434d. per unit, which, as already pointed out, includes not only working expenses but interest and depreciation charges and a 10 per cent. margin. The undertakers' present cost of generation is 0·561d. per unit, and if capital charges on their power house plants be added, the total cost of generating their supplies and conveying them to points in their areas similarly placed as the sub-stations at which the State supply may be made available, is probably not less than 1d. per unit.

Hence it may be safely said that in course of time the community will benefit very substantially by the establishment of a scheme which can make available a supply to the undertakers at approximately half the present cost, with the likelihood of still lower costs as the scheme develops.

XII.—RELATION OF PROPOSED SCHEME TO PRESENT METROPOLITAN UNDERTAKINGS.

It must be borne in mind that the Orders in Council granted to the Melbourne Electric Supply Company, covering a considerable portion of the metropolitan area, may come up for review in the year 1925. This matter, and the relation of the other metropolitan undertakings to the State supply, has not been overlooked, and will form the subject of a further report at a later date.

XIII.—POSSIBLE SELLING PRICES TO SPECIAL INDUSTRIES.

In the event of a cheap supply of energy being made available, there is reason to expect the establishment in Victoria of industries requiring very large quantities of energy for almost continuous use, that is to say, with a load factor from 80 to 100 per cent. Such industries would include the manufacture of alkalies, reduction of zinc concentrates, steel furnaces, production of nitrates, calcium carbide, white lead, &c., &c.

Assuming that such industries can be attracted to Victoria and settle outside the metropolitan area (as the Commissioners have not statutory authority to supply within that area consumers other than electric supply undertakings and public bodies), it will be interesting to indicate hereunder the approximate cost at which a supply of 20,000 volt. energy to such industries could be made available, at such a point as the Terminal Station, Richmond, and at the Morwell power house respectively :—

Terminal Station, Richmond ..	·188 pence per unit (100 per cent. load factor), equivalent to £4 2s. 10d. per electrical horse power year.
Power House, Morwell ..	·138 pence per unit (100 per cent. load factor), equivalent to £2 17s. 6d. per electrical horse power year.

The consumers in such cases would require to provide the necessary cable to convey the energy from the Commissioners' terminals or busbars to their establishments, and the cost of this would naturally depend upon the distance the energy has to be so conveyed.

XIV.—CO-ORDINATION OF OPERATION OF EXISTING AND PROPOSED POWER HOUSES.

Section 11 of the Electricity Commissioners' Act provides that one of the powers and duties of the Electricity Commissioners is to " inquire into and report as soon as practicable, and from time to time, as to the steps which in their opinion should be taken to secure the ultimate co-ordination or unification of all State or other electrical undertakings in Victoria."

It is essential that in the design and operation of any power houses to be erected in the future, particularly if owned by the State, due consideration should be given to the economies that will be effected by the electrical inter-connexion or linking up of such power houses with that at Newport. Such linking up would reduce to a minimum the amount of spare plant required to be held in readiness for emergencies, and decrease the risk of cessation of supply through failure of running plant.

Further, it would bring about a co-ordination of functions which would enable the combined plants to be operated at a maximum efficiency. As an initiatory step it would be necessary to bring Newport and the Morwell power houses under the control of a single authority.

XV.—BROWN COAL DISTILLATION PROCESSES.

The possibility of an economical utilization of brown coal in a distillation, or carbonization process, the use of the surplus gas in boiler furnaces and the marketing of the bye-products, has not been lost sight of.

At the present time there are several experimental plants in operation in various parts of the world, and a great deal of valuable research work has been done in this direction by officials of the Mines Department of our own State. There is no evidence, however, of any of the methods or processes experimented with having been proved a success with brown coal on a commercial scale.

We are, therefore, of the opinion that although a process of coal distillation cannot be recommended at present as a means of utilizing brown coal as a source of power, it is essential that research work should be carried out on a sufficient scale to prove the practicability or otherwise of any such process.

In the meantime developments in this direction in other parts of the world are being closely followed.

XVI.—BROWN COAL FOR GENERAL CONSUMPTION THROUGHOUT VICTORIA.

While not specifically called for in the instructions contained in section 10 of the Act, we feel that a brief reference should be made in regard to the use of imported fuel for purposes other than the public utilities of the State.

The present annual importation into Victoria of black coal may be stated to be in round figures 1,200,000 tons. Of this quantity about 912,000 tons are required at the present time for the most important public utilities, including gas undertakings, leaving a balance of 288,000 tons which is utilized for general purposes, both industrial and domestic.

From tests of Morwell brown coal under actual working conditions in Melbourne, it has been proved beyond doubt that this fuel can be economically burned under boilers, equipped with a suitably designed furnace, without a reduction of boiler capacity. In fact it has been repeatedly demonstrated that providing the furnace is equipped with ample grate area it is possible to obtain a capacity exceeding the normal rating of the boiler. This has been accomplished with a brown coal consumption in the ratio of less than two and a half to one of Newcastle coal for equal quantities of heat transferred to the steam in the boiler. On this basis the present cost of the two fuels for a given quantity of heat may be stated thus—

	Cost per ton.	For equal Heating Value. Cost.	Ratio.
	£ s. d.	£ s. d.	
Newcastle coal, *ex* Melbourne wharf (large) ..	1 12 9 ..	1 12 9 ..	1
Morwell brown coal, *ex* Melbourne siding, based on 2s. 3d. per ton at mine	0 7 8 ..	0 18 5 ..	·56

It is evident that with the opening up of the Morwell field on the lines proposed, so that coal may be won at 2s. 3d. per ton at the mine, and with Newcastle coal at present price, there is every reason to expect a considerable market for the use of brown coal for general purposes. The displacement of the 288,000 tons of imported coal referred to above would result in a demand of, approximately, 700,000 tons of brown coal. In view of the ever-growing scarcity and cost of wood fuel, the demand for brown coal would, doubtless, rapidly increase as the public became educated to the advantages resulting from the use of the cheaper fuel.

Among the advantages that would accrue to the State should the Mine be opened up for the supply of coal, must be included the additional revenue to be derived from increased freight and passenger traffic from the Mine to Melbourne. The railway receipts for carriage of coal, with an output of 500,000 tons, would amount in itself to over £135,000 per annum.

XVII.—BRIQUETTING.

Although it has been pointed out that there is a considerable market in the State for brown coal in its raw state for general purposes, it has not been overlooked that possibly this market, or a considerable portion of it, might be more satisfactorily catered for by a supply of brown coal briquettes.

In Germany a large percentage of the brown coal mined is briquetted without the use of any binding material. The syndicate controlling the Rhineland Brown Coal-fields turns out 20,000 tons of brown coal briquettes per day. Before the war the cost of producing these amounted to 3s. per ton, and at the present time the cost varies from 4s. 5d. to 5s. 6d. per ton on trucks at the works.

The moisture content of a briquette would be, approximately, 10 to 15 per cent., and the calorific value, approximately, 9,000 to 10,000 B.T.U's. per lb. The calorific value of Newcastle coal is, approximately, 13,000 B.T.U's. per lb. The difficulty of establishing a comparison with the German costs is very great, particularly at this juncture, with the abnormal rates of exchange, &c., but even should the cost of briquettes manufactured at Morwell be as high as 20s. per ton (and this is an outside figure) delivered at Melbourne sidings, there would be a big field for their sale for all heat producing purposes both industrial and domestic. The possibility of exportation of briquettes to States like South Australia dependent at present on imported supplies of coal should not be overlooked.

A sum of £30,000 has, therefore, been placed on the estimates herewith submitted for the provision for experimental purposes of a first unit of complete briquetting plant, having a capacity of 70 tons per day, this being the capacity of one press of the Zeitzer type. Should the operation of this unit prove successful it would be necessary to install at least four more units of the same capacity to provide for the household consumption of the metropolitan area alone, the probability being that the demand would prove very considerably greater than even the five units could cope with.

XVIII.—ESTABLISHMENT OF TOWNSHIP AT MORWELL.

In connexion with the proposed Morwell scheme, a matter which will call for attention at an early stage is the necessity of providing suitable accommodation for the housing of the employees.

The mine and power-house will be situated at too great a distance from the existing townships of Morwell and Moe to allow of the employees residing at such places. An excellent opportunity is, therefore, provided for planning a township on modern lines, insuring the employees comfortable and hygienic accommodation at a reasonable cost to them. Time has not permitted for details of such a proposal to be prepared, but from preliminary inquiries it would appear advisable to provide a sum of £150,000 for such purpose. It will be necessary, in the event of the Morwell scheme being proceeded with, to obtain an expert report on such a proposal.

XIX.—CUSTOMS DUTIES ON IMPORTATION OF MACHINERY.

In the preparation of a scheme such as the one presented herewith, we have had our attention drawn to the considerable effect that Customs duties will have upon the capital to be expended. On the electrical portion of the scheme these duties will probably amount to £180,000.

It may be assumed that duties are imposed upon the importation of machinery primarily to encourage local manufacture. While, therefore, it is necessary to assist in every reasonable manner the development of local manufacturing, it must not be overlooked that the imposition of substantial duties upon certain classes of heavy machinery required for the generation and supply of cheap electrical energy, and which cannot be manufactured in the Commonwealth under existing conditions, will react seriously on the industrial development of the State.

Existing industries, and those to be established, will depend for their existence upon a cheap supply of energy being made available. Heavy duties payable upon the importation of generating plant for proposed new power-houses will correspondingly increase the cost of energy, and, consequently, hamper the development or establishment of industries, the encouragement of which was, doubtless, the very object the framers of the Customs Tariff had in view.

Reference may be made particularly to one item, viz., "Electric generators for direct coupling to steam turbines," five of which, each of about 30,000 h.p., may be ultimately required for the Morwell scheme. The duty imposable on the first instalment of this section of the plant will amount to about £45,000, being at the rate of 25 per cent. for plant of British make and 30 per cent. for all other makes. The steam turbines, however, to which they are direct coupled, forming self-contained units of plant, are on the free list so far as those of British make are concerned, while those of foreign make are dutiable to the extent of 5 per cent.

It is evident that the Commonwealth authorities are of the opinion that the steam turbines cannot be made in this country, while the electric generators for coupling to such turbines, which present just as difficult a manufacturing problem as the turbines, are evidently considered plant, the local manufacture of which is practicable. This view is quite erroneous, as there is not the slightest hope that generators of the capacity required for a power-house such as Morwell will be manufactured in this country for many years to come. The Inter-State Commission, in their report No. 336, *re* "Tariff Investigation," dated 28th September, 1916, recommended that generators of a capacity of 500 h.p. or over, for direct coupling to steam turbines, should be admitted free of duty, if imported from Great Britain, and liable to 10 per cent. if from foreign countries.

We are of the opinion that representation should be made to the Commonwealth authorities with the object of endeavouring to have at least the recommendations of the Inter-State Commission above referred to adopted, although generally it may be said that the imposition of duties on turbine generators, boilers, and transformers and switch-gear of the capacities and voltages required in a scheme like that proposed for Morwell is nothing less than a direct and unfair burden on the industrial section of the community.

XX.—SUMMARY OF MAIN CONCLUSIONS.

After a careful survey of all the requirements in regard to an ample supply of electrical energy and fuel for use throughout the State, and the data available as to the possible sources of such supplies, the Commissioners, for the reasons set out in this Report, have arrived at the following conclusions :—

1. That the necessary steps should be taken to inaugurate a State scheme for the supply of electrical energy.

2. That with this object in view, and as the nucleus of such scheme, the Morwell brown coal-field should be opened up and a power house established thereon of an initial capacity of 50,000 kw., with the necessary transmission line, cables, and sub-stations, all as described in the Report, at an estimated cost of £2,737,392.

3. That the scheme be proceeded with immediately in view of the very serious position in which the electric supply undertakings in the metropolitan area and their consumers will be placed if such State scheme is not in operation early in 1923.

4. That the consideration of hydro-electric power schemes be deferred until further investigations now being carried out are completed.

5. That with a view to maximum economy the proposed Morwell and any other power house that may be erected in connexion with the proposed State electric supply scheme should be electrically linked up with the Newport power house and both operated under the control of a single authority.

6. That research work with brown coal should be continued on a sufficiently large scale to determine the commercial possibilities of its utilization in connexion with distillation or carbonization processes, gas production, by-product recovery, and as pulverised fuel.

7. With the object of providing brown coal as fuel at the cheapest price for industrial and domestic purposes, the necessary authority should be obtained to proceed at once with the opening up of the Morwell brown coal-field. This development, on the lines proposed, will involve the closing down of the present workings and a reduction in cost of winning coal to about one-third of the present cost. The capital required for this purpose is estimated at £221,000, which is included in the sum mentioned in Conclusion No. 2.

8. That in addition the sum of £30,000 be provided for the installation for trial purposes of the first unit of the necessary crushing, drying and briqetting machinery to be installed at Morwell for the purpose of manufacturing briqettes from brown coal for industrial and domestic purposes.

9. That in addition, authority should be obtained to proceed with the construction of suitable housing accommodation for the workmen to be employed in connexion with the scheme. Time has not permitted of a detailed estimate being prepared of the cost of such accommodation, but from preliminary inquiries it would appear advisable to provide the sum of £150,000 for the purpose.

10. That representations should be made to the Commonwealth authorities with the object of effecting a reduction of the Customs duties payable on many items of plant required for the Morwell scheme, which cannot be made in Australia, and particularly in reference to generators for direct coupling to steam turbines.

SUMMARY OF LOAN MONEYS REQUIRED.

	£
Opening up of Morwell Brown Coal-field	221,000
Electrical System	2,516,382
Township at Morwell	150,000
Briquetting Plant	30,000
Total	£2,917,382

We have the honor to be,

Sir,

Your obedient servants,

THOMAS R. LYLE, Chairman.
GEO. SWINBURNE, Commissioner.
ROBT. GIBSON, Commissioner.

R. LIDDELOW, Secretary.

Date—26th November, 1919.

APPENDIX A.

REPORT OF THE CHIEF ENGINEER ON THE PROPOSAL TO ESTABLISH AN ELECTRIC SUPPLY SCHEME IN CONNEXION WITH THE MORWELL BROWN COAL FIELD.

Electricity Commissioners' Office,
673 Bourke-street,
Melbourne, 3rd November, 1919.

ELECTRICAL ENERGY REQUIREMENTS IN THE METROPOLITAN AREA.

The Advisory Committee on Brown Coal, appointed in June of 1917 to advise the Government regarding the prospective use of brown coal for power and other purposes, in their Report, dated 25th September, 1917, assumed as a basis of their calculations that a demand of about 50,000 kw. would be required in the metropolitan area for light, power, and tramway requirements in the year 1921. Conditions arising out of the war have adversely affected the growth of the demand in this area, and a reconsideration of this matter has indicated that this demand is not likely to be reached until the year 1923, the earliest date by which any new scheme could be brought into operation.

Each of the two principal undertakers, namely, The Melbourne City Council and The Melbourne Electric Supply Company have recently entered into a five years' agreement with the Railway Department for a supply of 5,000 kw. from the Newport power-house. This will affect the demand to be met by the proposed new power-house scheme to the extent of 10,000 kw., reducing it to 40,000 kw.

By the year 1925 the Newport power-house plant may be fully required for railway purposes, and therefore it may become necessary to transfer this demand of 10,000 kw. to the proposed new scheme, which demand, with the growth expected in the Melbourne area between 1923 and 1925, will make the total demand in the latter year about 61,300 kw. These figures do not include any special demands that may arise from the establishment of new industries due to the existence of an ample supply of cheap energy. Such a development, to judge by the experience of similar schemes in other parts of the world, is most likely to take place.

A new power scheme such as is now under consideration, unless it be capable of supplying energy in bulk to the existing Melbourne undertakers at a cost less than their generating costs, will not be in a position to have transferred to it the task of generating and supplying the energy which such undertakers may be generating when the new scheme is brought into operation.

In such a case the demand available for the new scheme would be confined to the increase in business over and above the generating capacities of the two Melbourne undertakers. As, however, there is no doubt whatever that the proposed power scheme will be in a position to supply to the existing undertakers energy in bulk at a price considerably less than that at which it is being generated to-day, it may be taken for granted that they will readily accept the opportunity to purchase the whole of the requirements at present being generated by them, and by so doing gradually shut down their own plants.

CAPACITY OF POWER-HOUSE.

The proposed power-house, therefore, has been designed in the first stage to generate a supply of about 50,000 kw., with provision for extension ultimately to 100,000 kw., although it is possible, in view of the comparatively unlimited supplies of brown coal, to increase the plant capacity at Morwell beyond this figure should it become advisable at a later date. It is a matter, however, that can be left for future consideration in conjunction with the question of developing water power or brown coal fields other than Morwell.

CHOICE OF SITE.

Assuming ample supplies of fuel, the choice of a site for a steam power-house for supplying electrical power to Melbourne depends primarily on the cost of delivering to Melbourne a given quantity of electrical energy. This cost in itself depends on the price at which fuel can be made available at the power-house for a given quantity of heat energy and the cost of transmission of the electrical equivalent of such energy to Melbourne. In a less degree the choice is affected by the relative capital costs of the power-houses on the several alternative sites that may be under consideration, and the availability of cooling water, ample supplies of which are necessary in a modern power-house of large capacity. From a perusal of the Report of the Advisory Committee, it is evident that the possible sites for a power-house that claim serious consideration are limited to one on the Morwell field and one at or near Melbourne. In the former case the fuel to be used would be brown coal, and in the latter brown coal from the Altona field, or black coal from Wonthaggi or Newcastle.

In the Advisory Committee's Report it was clearly shown that assuming 2s. 3d. and 6s. 3d. per ton to be the respective costs of winning coal on the Morwell and Altona fields, a power-house on the former would supply to Melbourne cheaper electrical power than one situated on the Altona field. Recent detailed investigations, respectively by Mr. Lindesay Clark and Messrs. Broome and Klug, have resulted in confirming the above estimates of cost of winning coal.

Hence the Altona coal-field may be left out of any further consideration at present as a site for a steam power-house for the supply of electrical energy to Melbourne.

As regards the State coal mine at Wonthaggi, it is hardly necessary to point out that, apart from the price of such fuel being too high for any possible consideration in a problem of this kind, the supply is evidently of too irregular and limited a nature to justify its consideration for use in a power-house either on the Wonthaggi field or on a site near Melbourne.

There remains, therefore, to be considered the rival claims of a site at Morwell and one at or near Melbourne using Newcastle coal. A perusal of Table I., hereto attached, will show that the latter alternative is in no better position for the supply of cheap power than when the Advisory Committee on Brown Coal made its recommendation in favour of developing Morwell as a site for a power-house, for whereas the estimated cost of winning Morwell coal is still 2s. 3d. per ton, the cost of Newcastle slack coal delivered to a power-house situated as Newport power-house has risen from 21s. 5d., which was the price ruling at the time the Advisory Committee made its Report, to 25s. 3d. per ton. From inquiries made it seems extremely unlikely that the cost of such coal will be reduced in the near future. On the contrary, there is evidence to show that there will be a further rise before long.

TABLE I.—COMPARATIVE TOTAL ANNUAL COSTS, INCLUDING CAPITAL CHARGES, OF SUPPLYING TO MELBOURNE 43,960 KW., IN THE FORM OF 20,000 VOLT ENERGY, FROM A POWER-HOUSE SITUATED AT MORWELL, AND FROM ONE USING IMPORTED BLACK COAL SITUATED AT OR NEAR MELBOURNE (LOAD FACTOR 42 PER CENT.).

		Morwell. Using Brown Coal with Electrical transmission.		Melbourne. Using Newcastle Coal (Sea-borne).	
Energy delivered Melbourne	units	161,700,000		161,700,000	
Energy generated at power-house	,,	183,960,000		167,326,000	
Maximum demand on power-house	kw.	50,000		45,490	
Coal consumption per unit generated	lbs.	3·81		1·59	
Coal consumption per annum	tons	312,900		118,800	
Coal cost per ton delivered power-house	..	2s. 3d.		25s. 3d.	
Power-house—		Per annum.		Per annum.	
Variable Charges—		£	£	£	£
Coal	..	35,200		150,000	
Wages of coal and ash handling staff	..	1,250		1,250	
Oil, water, and stores	..	1,000	37,450	1,000	152,250
Standing Charges—					
Wages, maintenance, &c.	..	26,585		24,185	
Capital charges	..	107,642	134,227	97,300	121,485
Transmission Line—					
Patrolling, maintenance, &c.	..	4,010		..	
Capital charges	..	19,558	23,568	..	
Terminal Station—					
Wages, maintenance, &c.	..	3,585		..	
Capital charges	..	16,915	20,500	..	
Administration	..	..	6,300	..	6,300
Total annual cost	..	..	222,045	..	280,035
Cost per unit (pence)	..	..	·329	..	·415

NOTE.—In this table the costs of 20,000 volt distribution within the metropolitan area are not included.

The comparative costs of supplying energy to Melbourne from power-houses situated respectively at Morwell and at or near Melbourne are set out in Table I., and it can be safely said that the undoubtedly favorable position in which Morwell was placed in the Advisory Committee's Report is fully confirmed to-day as a result of a further careful investigation of the fuel situation and of the relative costs, both capital and annual, of power-houses on the two alternative sites under consideration.

The Advisory Committee also gave consideration to the question as to whether it would be cheaper to construct a power-house at or near Melbourne and transport the brown coal from Morwell or Altona to it for the production of energy required for the Melbourne area. The recommendations of such Committee, to the effect that it would be decidedly more economical under present conditions to transmit the energy electrically from Morwell than to transport the fuel to a power-house situated near Melbourne, holds good to-day notwithstanding an increase in the capital cost of the transmission line to Melbourne since the date of the Advisory Committee's Report.

MORWELL INVESTIGATIONS.

In anticipation that it would again be demonstrated that the Morwell field provided the most economical site for a power-house for the purpose mentioned, investigations have been made with a view to choosing a spot suitable for the erection of a power-house and to determining the quantity of cooling water that would be available from the River Latrobe for condensing purposes. A piece of elevated ground south of the River Latrobe and west of the present open-cut, as described in the Advisory Committee's Report, seems to offer the best position for the erection of a power-house.

The Mines Department are at present engaged in intensive boring of this ground to enable the location of the power-house site in relation to the mine to be definitely settled. There is every reason to expect that the site tentatively chosen will prove satisfactory from all points of view. It is contiguous to the proposed scene of mining operations, and which will enable transportation of fuel to be carried out at a minimum cost.

The State Rivers and Water Supply Commission have been for some time engaged on an investigation, with the object of choosing a suitable site for a weir across the River Latrobe, so as to provide storage of water to enable the maximum use of the river flow to be made for condensing purposes. The Commission has chosen a site for the erection of the weir and is submitting recommendations in regard to the design of such.

Fortunately, records have been kept by this Commission over a period of about twenty years of the flow of the River Latrobe at Rosedale, some miles below Morwell, and special observations made recently by the Commission have established the fact that the flow of water past Morwell may be taken in normal times to be 80 per cent. of that at Rosedale. It is the opinion of the stream-gauging expert of the Commission that in times of drought, when the flow of the river is at a minimum, the flow at Rosedale would be practically identical with that at Morwell, as the various streams feeding the Latrobe between Morwell and Rosedale cease altogether to flow during such times. On the basis of 80 per cent. of the minimum flow recorded at Rosedale during the last twenty years, it is estimated that the river would be capable of supplying sufficient condensing water to enable the power-house at Morwell to generate about 40,000 kw. without recourse to any special cooling arrangements. The erection of the weir, however, and the consequent storage of water will enable the power-house to meet a demand at times of minimum flow up to about 90,000 kw. (42% load factor). Hence, it appears that to the extent of this larger demand there will be no need to install special appliances for the cooling of the circulating water.

CAPITAL COST AND CAPACITY OF POWER-HOUSE.

The Advisory Committee in their Report in 1917 estimated that the cost of a power-house at Morwell, with an installed plant capacity of 75,000 kw., would cost £1,262,500, or £16·83 per kilowatt of installed capacity.

Owing to prices having risen 80 per cent. to 100 per cent. for machinery since pre-war days, a complete power-house containing 75,000 kw. of turbo-generating plant, with boilers, buildings, and other details, would cost to-day £1,442,927, as follows :—

TABLE II.—ESTIMATED CAPITAL COST OF POWER-HOUSE AT MORWELL.

1. Preparation of site, foundation, buildings, channels, &c.	£296,008
2. Turbo-generating plant and auxiliaries	581,538
3. Boiler-house plant, including coal and ash handling, storage, &c.	394,244
4. Switchgear, transformers, &c.	171,137
Total	£1,442,927

The above expenditure would provide for the supply and installation of the undermentioned plant, necessary to complete a power-house for the economical utilization of brown coal for an output of 50,000 kw. at the power-house, with provision for extension when necessary to 100,000 kw.—

- Three 25,000 kw. turbo-generators, complete, with surface condensing plant and pumps.
- Eight boilers, each of 14,010 square feet heating surface, generating steam at 275 lbs. per square inch at a temperature of 650° F., complete, with travelling grates and balanced draft equipment and stacks.
- Coal and ash handling and coal storage plant, with bunkers, conveyors, and elevators, crushers, weighing machines, &c.
- Four feed pumps of centrifugal type, turbine driven, each of 35,000 gallons per hour capacity.
- Two starting-up turbines and generators, each 500 kw., to operate non-condensing.
- The necessary steam, feed and other piping, evaporators, hotwells, and other auxiliary apparatus.
- Switchgear for three generators and auxiliaries, two outgoing 25,000 kw. circuits operating at 130,000 volts., with stepping-up transformers and control panels, wiring, instruments, &c.
- Buildings to house the above plant; also for offices, stores, &c.
- Fitting shop with machine tools.
- Railway siding and roads.
- Water channels and rotary screens.

SUITABILITY OF LARGE UNITS.

In the Advisory Committee's Report provision was made for the installing of five 15,000 kw. turbo-generators as the first instalment of plant. Since the date of their Report considerable progress has been made in the design and manufacture of larger units, even up to 45,000 kw., and in view of the appreciably less capital cost per kilowatt of capacity of such units, and the comparative simplicity of layout obtainable with the smaller number required of such units, it has been deemed desirable, for the purposes of this estimate, to prefer units of 25,000 kw. capacity. Further, by the adoption of the larger unit the steam economy of the power-house will be appreciably improved and operating expenses will benefit.

WEIGHTS.

Facilities in the Port of Melbourne for discharging heavy machinery are limited to weights not exceeding 35 tons. From inquiries made it appears that a line of steamers trading between Great Britain and this country have their ships equipped with derricks capable of discharging single pieces weighing up to 50 tons.

The stator of a 25,000 kw. generator, when completed, weighs considerably more than this, but it can be shipped in parts and assembled on the site. The heaviest single piece of such a generator would not exceed 46 tons. The fact that the Port of Melbourne is not equipped with lifting apparatus suitably situated and capable of discharging alongside a railway single pieces of greater weight than 35 tons is a matter that should be given careful consideration to by the authorities, in view of the likelihood of machinery of still greater weight being imported into this country in the near future.

STORAGE OF COAL.

Notwithstanding that it is proposed to erect the power-house alongside the coal mine, it will be advisable to provide for the storage of a certain amount of fuel which can be conveyed readily into the boiler-house in case supplies from the mine are interfered with. In a power-house being supplied with imported coal, there is always the risk of interruption due to failure of transportation. This risk will not have to be provided for in the case of Morwell, but there will always be the possibility of a suspension of mining operations due to inclemency of the weather, or serious breakdown of mining machinery. This risk will be sufficiently covered by storing about ten days' supply of coal. The cost of the necessary storage accommodation, together with conveyors and elevators, has been included in the estimates of capital costs for the power-house.

OUTDOOR SWITCH INSTALLATION.

The switchgear and transformers for stepping up the voltage at Morwell to 130,000 will be of the outdoor type, in accordance with the latest practice in America with high-tension transmission line schemes. The cost of the complete switchgear installation is estimated at £171,137, and has been included in the estimate of total cost of power-house.

TRANSMISSION LINE.

It is proposed to erect a single steel tower line with two transmission circuits, each capable of transmitting 25,000 kw. At a later date, as the power-house capacity is increased, it will be necessary to duplicate this line. It is estimated that the single-tower line, with conductors and accessories completely erected, will cost £323,102. Owing mainly to the increase in the price of copper cables, this estimate is £61,982 above that mentioned in the Report of the Advisory Committee for a line of similar capacity. The actual cost of the line will depend to a very large extent on the market rates for copper and steel at the time the contracts for the supply of material are entered into. There is, however, reason to expect that the actual cost of the line when erected will prove to be lower than the estimate, as the price of steel taken in the estimate (£23 per ton) is likely to fall to a less abnormal figure when the present conditions disappear. There is, however, little reason to expect lower prices for copper cables, as it is not likely that the price of electrolytic copper will be reduced much below the present price of £116 per ton, and the difference between this and the cost of the completed cable is mostly made up of labour and other costs of manufacture, and these are not likely to decrease to any appreciable extent. When the time arrives to place orders for materials, careful consideration will be given to the claims of aluminium, which has been used to a very large extent in the U.S.A. for the conductors of overhead transmission lines.

The leading features of the line on which the estimate is based, are as follows :—

Route length	82 miles
Voltage at generating end	130,000 volts
Frequency	50 cycles per second
Sectional area and material of conductor	·182 square inch copper
Number of towers per mile	8 approx.
Weight of towers	2·7 tons each
C.I.F. price of copper cable	£158 per ton
C.I.F. price of steel	£23 per ton

Carefully recorded data secured during a flying survey of the transmission line route by Messrs. J. M. and H. E. Coane, consulting civil engineers and surveyors, served as a basis for the estimated capital cost of such line.

A plan of the proposed route is herewith supplied. It will be noticed that the route of the line generally follows the Dandenong-road from Oakleigh as far as Drouin, and thence, owing to the road turning too far north, it proceeds across country in a straight line to Morwell.

The difficulties to be met in constructing the transmission line will be found to be extremely few, the territory passed through being on the whole gently undulating. In those cases where it passes through private property, provision has been made in the estimates for compensation to the owners.

In adopting a voltage of 130,000 volts at the generating end, the possibility of extension of transmission lines throughout the whole of Victoria was kept in mind.

TERMINAL STATION.

For the site of the terminal station land has been reserved at the quarries, Richmond, sufficient for the erection of the necessary switchgear and step-down transformers to transform the energy from the voltage of the transmission line to 20,000 volts, which is the voltage tentatively adopted for the purposes of distribution in the metropolitan area.

The capital cost of the terminal station, with its switchgear, transformers, and synchronous condensers, is estimated at £226,755. It may be of interest to point out that when the time arrives to erect a second transmission line from Morwell, such line would probably be taken round the north of Melbourne to the vicinity of Footscray and Williamstown, as it is expected that in these areas a large industrial demand will be developed. The two terminal stations then would be tied together by means of the 20,000-volt feeders, the first portion of which is provided hereunder.

MELBOURNE DISTRIBUTION AND SUBSTATIONS.

The Advisory Committee provided in their Report for the whole of the demand in the metropolitan area being met by laying two groups of 20,000-volt feeders from the terminal station, one to each of the power-houses of the two principal undertakers.

Bearing in mind that the object of the Advisory Committee was to establish a cost relationship between Morwell and the existing power-houses, no serious objection could be taken to this proposal for the demand above mentioned, but it must not be overlooked that the demands in the metropolitan area are growing steadily, and the time has arrived when a higher voltage than those at present in use (6,000 and 4,000) requires to be introduced for distribution purposes to efficiently deal with the growing business, particularly that of the Melbourne Electric Supply Company whose area is extensive, many parts of which cannot be efficiently served by 4,000-volt feeders. This company is at present considering a re-arrangement of its distribution system, with the introduction of a three-phase supply to meet the demands from factories and other power users. The moment is considered opportune to bring about in the interests of efficiency a change in the system of main distribution.

To postpone the matter and to deliver the whole of the energy from Morwell to the undertakers' power-houses will result in these undertakers having to provide for the laying of additional feeders at the low voltages in use in their areas. This would not be economical, and would not provide for an efficient service for all time.

Hence, provisions have been made in the estimate for supplying these undertakers at a number of points each located in accordance with the demand of the particular district. At these centres or substations there could be made also available the supplies for the dozen or so municipalities at present purchasing their power requirements in bulk from the City Council or the Melbourne Electric Supply Company.

These substations owned and controlled by the Commissioners would be served by feeders conveying the 20,000-volt energy from the terminal station at Richmond, and would be equipped with the necessary transformers to reduce the voltage to 6,000 or 4,000, as required by the undertakers.

By these means a standard and highly-efficient system of distribution of energy in the metropolitan area would be brought about, and the annual cost of same will naturally be included in the charges to the undertakers for the energy they receive. In the long run the consumer will benefit, as by this proposal the Commissioners will be carrying out, in a more efficient manner, a function at present performed by the undertakers.

Although the voltage of 20,000 has been adopted in the estimates as suitable for the main distribution in Melbourne, investigations are being made in regard to the economy of adopting a higher voltage, such as 33,000.

A plan of the proposed Melbourne 20,000-volt distribution system has been prepared and is supplied herewith. On it is indicated the approximate sites of the proposed substations, the demands in kilowatts expected at these substations by the year 1923, and the ultimate capacities of the substations.

It will be seen that the substations will be connected by a ring system of cables which will be laid underground, with the exception of that portion running between substations "G" and "C" supplying the western municipalities. These will be served by means of an overhead line, to be replaced at a later date when the growth of the demand justifies the expenditure on underground cables. The amounts to be spent on cables and substations for this purpose are as follows:—

Melbourne distribution cables	£272,550
Melbourne substations and equipments	£251,058

ESTIMATED TOTAL CAPITAL EXPENDITURE ON MORWELL POWER SCHEME.

The total capital expenditure of the proposed scheme to supply Melbourne with electrical energy in bulk, and to distribute same in the metropolitan area, is set out hereunder:—

TABLE III.—ESTIMATED TOTAL CAPITAL EXPENDITURE FOR AN OUTPUT OF 50,000 KW. FROM MORWELL.

Power-house	£1,442,927
Transmission line	323,102
Terminal station	226,755
Melbourne distribution cables and substations	523,608
Total	£2,516,392

ANNUAL COST OF 20,000-VOLT ENERGY AT THE TERMINAL STATION, RICHMOND.

From Table I. it will be seen that it is estimated that in the first stages of the Morwell development, and assuming an annual load factor of 42 per cent., the average cost of supplying power to Melbourne in the form of 20,000-volt energy at the terminal station, Richmond, will be 0·329 pence per unit, equivalent to an annual cost of £4 4s. per annum per kilowatt of maximum demand, plus 0·056 pence per unit. This is somewhat higher than the estimate in the Advisory Committee's Report, and is due mainly to the advances in prices of plant and materials and partly to higher rates of wages of operation staff, and to the smaller quantity of energy to be delivered to Melbourne, on which the estimate has been based. As the scheme develops and the demand increases above 50,000 kw., the average cost will be gradually reduced, for the spare plant capacity in proportion to the total capacity will be smaller and the annual load factor is likely to be improved. It will further be noted that the estimated cost of supplying energy from Morwell is 21 per cent. less than that possible in the case of a power-house that could be constructed at or near Melbourne in which imported black coal was to be used.

ANNUAL COST OF SUPPLYING 6,000 AND 4,000 VOLT ENERGY.

In order that a definite price can be arrived at, at which the existing undertakings should be charged for the supply of energy, it is necessary to add to the cost of the energy at the terminal station the cost of distribution to the substations and of conversion thereat. The total annual cost, including capital charges of supplying 6,000 volt and 4,000 volt energy at the substations in the metropolitan area, assuming the same load factor as previously, is estimated at 0·395 pence per unit, equivalent to £5 3s. 6d. per annum per kilowatt of maximum demand, plus 0·057 pence per unit.

In comparing these figures with the costs mentioned in the Advisory Committee's Report, it must be remembered that the former includes the whole annual cost of the main distribution system as already described, which cost, under the conditions on which the Advisory Committee's estimate was based, would be borne by the undertakers, but at a greater cost to themselves, and consequently to the public. It must also be borne in mind that underground cables have increased in price over 70 per cent. since the date of this Report (1917).

If to the costs above mentioned is added a margin of 10 per cent., the estimated charge to the undertakers, which could be made for 6,000 volts and 4,000 volts supplies at the Commissioners' substations, would be 0·434 pence per unit (load factor 42 per cent.), equivalent to £5 13s. 10d. per annum per kilowatt of maximum demand, plus 0·063 pence per unit.

GROWTH OF THE DEMAND AND ITS EFFECT UPON THE COST OF SUPPLY.

There is every indication that the demand for electrical energy in Victoria will rapidly increase as soon as the proposed power scheme is in operation. New industries for the production of manufactured articles at present imported are bound to arise under conditions that have come about as a result of the war, but such industries are likely to settle in other States than Victoria if the manufacturing facilities in the former are superior. An ample supply of electrical energy at cheap rates is one of the most important factors to be considered by the manufacturer in arriving at a decision as to where an industry is to be established.

Given a supply of cheap energy there is every reason to expect that Victoria will be looked upon with favour as an industrial centre, and in consequence the demand for power may be such that in about five years from the initiation of the scheme the output from Morwell will have reached 100,000 kw. Hence, it will be interesting to examine the effect of such a development upon the annual costs.

The increased output would require the installation of two additional 25,000 kw. turbo-generating units with the necessary boilers, switchgear, &c., a second transmission power line and terminal station, which at to-day's prices would increase the expenditure on the scheme to the following figures :—

Table IV.—Estimated Total Capital Expenditure for an Output of 100,000 kw. from Morwell.

Power-house	£2,381,518
Transmission lines	662,489
Terminal stations	453,510
Total	£3,497,517

Allowing for the increased anuual expenditure, and assuming the same load factor (although it would be reasonable to assume an improvement in the load factor as the output grows, with corresponding decrease in the average cost of supply), the cost of electrical energy delivered at the terminal station at Melbourne at the voltage of 20,000 would be 0·292 pence per unit, equivalent to £3 12s. 5d. per annum per kilowatt of maximum demand, plus 0·056 pence per unit.

PRESENT COST OF GENERATING AT THE UNDERTAKERS' POWER-HOUSES.

As already stated, unless the Morwell scheme is able to offer a supply of energy to the generating undertakers at less than their present generating cost, it would not be commercially possible for the proposed scheme to take over the business of generating the present requirements of Melbourne.

The cost of generation, *excluding all capital charges on the plant,* at the City Council's power-house for the year 1918 amounted to 0·519 peuce per unit sent out. For the year 1919, owing to an increase in coal prices, this cost will probably be 0·561 pence. Similar costs may be taken in the case of the Melbourne Electric Supply Company for the same periods.

A comparison of these figures with the cost at which 6,000-volt and 4,000-volt energy can be made available at the proposed Commissioners' substations, is as follows :—

TABLE V.

Melbourne Undertakings—	
Present generating cost (excluding capital charges on power-house plant) ..	0·561 pence per unit sent out from power-house
Morwell Power Scheme—	
Estimated cost of delivering 6,000-volt volt and 4,000-volt energy at Commissioners' substations, plus 10 per cent. margin	0·434 pence per unit at substation
Difference	0·127 pence per unit

On the estimated output of these two undertakings for the year 1923, viz., 108,000,000 units sent out, this difference of 0·127 pence is equivalent to a reduction in working expenses to these undertakings of about £60,000 per annum.

This, however, has not taken into account the saving due to the Commissioner's making available their supply at the substations scattered over the metropolitan area instead of concentrating such supplies at the two power-houses of these undertakers. This saving will be particularly marked in the case of the Melbourne Electric Supply Company, as under the scheme of distribution proposed, the bulk of their requirements will be taken at places other than their power-house.

It is estimated that the ultimate reduction in cost to the two undertakings, based on the output for 1923, will amount to nearly £80,000. This reduction. if passed on to the public in the form of lower charges will, in the eyes of the Melbourne citizens, prove to be the strongest argument for the immediate proceeding with the Morwell scheme. It must not be overlooked that the estimated annual costs of the proposed scheme have included a margin of 10 per cent. This should make the scheme attractive from a general taxpayers' point of view.

EFFECT ON COSTS OF IMPROVED LOAD FACTOR.

Although all costs have so far been calculated on the basis of a load factor of 42 per cent., a cheap supply of energy is likely to encourage the establishment of long-hour consumers, both at Melbourne and at Morwell. Hence, the costs at which a supply can be made available at these places, assuming the energy to be taken steadily throughout the 24 hours for each day of the year, *i.e.*, a load factor of 100 per cent., will be of interest. It has also been assumed that the supply is taken at the busbars of the terminal station, Richmond, and the Morwell power-house respectively.

COSTS (INCLUDING 10 PER CENT. MARGIN) OF SUPPLYING 20,000-VOLT ENERGY (100 PER CENT. LOAD FACTOR).

Melbourne	0·188 pence per unit equivalent to £4 2s. 10d. per electrical horse-power year
Morwell	0·138 pence per unit equivalent to £2 17s. 6d. per electrical horse-power year

MANNER OF UTILIZATION OF THE BROWN COAL.

The plant layout and estimates are based on the assumption that raw coal will be burned in the boiler furnaces without preliminary drying. These furnaces will be equipped with travelling grates, capable of burning up to 100 lbs. per square foot of grate area under balanced draft conditions.

The furnaces will be of special design and similar to one which has been under constant observation, and in which several thousands of tons of brown coal have been burned at the City Council's power-house during the past year or so.

This special furnace arrangement (see print attached) has been evolved since the date of the Report of the Advisory Committee, in which Report an average consumption of 4·57 lbs. of raw brown coal for every unit generated was adopted as the basis for arriving at the annual consumption of fuel. Subsequent experience has shown that this figure is too high, and coupled with the adoption of a higher steam pressure, enables the figure of 3·81 lbs. to be adopted for the design of the Morwell power-house.

This performance is equivalent to an average evaporation of 4·0 lbs. of water from and at 212° F. per lb. of raw coal. Bearing in mind that the heating value of this fuel in its raw state is only about 6,250 B.T.U.'s, this would appear to be a very satisfactory average result, as it is equivalent to a boiler and stoker efficiency of 61·8 per cent. On tests of short duration, an efficiency of about 70 per cent. has been obtained.

The estimated fuel cost per unit generated is 0·0459 pence, which is probably the lowest cost of any steam power-house in the world to-day.

Experiments are being made at the present time with a view to ascertaining whether on commercial lines the coal can be freed of a large proportion of its moisture before admission to the furnace. From inquiries recently made in Germany in this direction, where brown coal having even a larger percentage of moisture than the Morwell coal is used to a large extent in the production of electrical energy, it does not appear that preliminary drying of coal is resorted to.

Coal-drying apparatus to be commercially successful must be of low capital cost, as the waste heat available for the drying of the coal is of low monetary value. The type of coal-drying apparatus used in the German brown coal mines for briquetting purposes would be too elaborate and expensive to justify its adoption in the design of a large power scheme.

It is possible that in the course of time the burning of raw fuel under boilers may give place to the burning of gas obtainable from the brown coal by a separate distillation or gas-producer process; but in the complete absence of any information of coal being treated in this manner in power-houses of any importance, it can only be inferred that so far there has not been produced any distillation process which may be looked upon as a commercial success for application to the Morwell problem. Should the time arrive, however, when such a process, together with by-product recovery, can be regarded as commercially satisfactory as applied to brown coal, it would be comparatively simple to design future extensions of the Morwell power-house to utilize the gas as a fuel instead of the raw coal, and it would not be a difficult or costly matter to convert the existing furnaces to the use of gas for heating purposes should it be possible to supply the gas at a sufficiently low cost. At present it is wise to consider as practicable only the burning of the raw coal under the boilers.

INTERTOWN SUPPLY.

No provision has been included for any subsidiary transmission lines to supply towns *en route* of the main transmission line, but it must be expected that applications for such will be made as soon as the main operations commence. Such a development should be considered on its merits as a commercial proposition, and any additional capital expenditure incurred thereby must be justified by a sufficient revenue-earning capacity. Consideration of this development, therefore, can be left over until the main problem is decided on. Preliminary investigations indicate that it will be possible to convey power from Morwell to places as distant as Bendigo and Ballarat, and supply it cheaper than it is produced at those places to-day. Between these outlying points and the Morwell power-house are a large number of population centres that can be ultimately served by subsidiary lines giving a cheap supply of energy for all purposes.

H. R. HARPER, Chief Engineer.

TABLE VI.

MORWELL POWER SCHEME.

ANNUAL OPERATING AND CAPITAL COSTS (POWER HOUSE ONLY).

Maximum demand at Power House		50,000 kw.		
Units generated	183,960,000			
Units used on works	3,679,200			
Units sent out of Power House	180,280,800			
Load factor on Power House		·42 %		
Variable Charges—	£ per Annum.		Pence per Unit sent out.	
Coal	35,200		·0469	
Wages of Coal and Ash handling Staff	1,250		·0017	
Oil, water and stores	1,000		·0013	
		37,450		·0499
Standing Charges—				
Supervision and Clerical Staff	2,950		·0039	
Wages, Engine Room Staff	5,169		·0069	
Wages, Boiler House Staff	5,101		·0068	
Wages, Switch Room Staff	1,665		·0022	
Insurance	200		·0003	
Maintenance	11,500		·0153	
		26,585		·0354
Capital Charges—				
Interest and depreciation		107,642		·1432
Total		171,677		·2285

POWER HOUSE COSTS.

(20,000-Volt Energy).

Based on an output of 49,000 kws. (65,680 electrical horse power).

Costs.	*With 10 % added.*
1. £2 14s. 10d. per annum per kw. of M.D., plus 0·0499 pence per unit.	£3 0s. 4d. per annum per kw. of M.D., plus 0·0549 pence per unit.
2. With 42 % L.F. 0·2285d. per unit.	0·2511 pence per unit.
3. £2 12s. 3d. per annum per e.h.p.	£2 17s. 6d. per annum per e.h.p.
4. With 100 % L.F., 0·125d. per unit.	0·138 pence per unit.

TABLE VII.

MORWELL POWER SCHEME.

TOTAL ANNUAL COSTS OF DELIVERING 43,960 KILOWATTS TO MELBOURNE IN THE FORM OF 20,000-VOLT ENERGY.

At Terminal Station, Richmond—

Maximum demand .. .. 43,960 kw.

Energy delivered at 20,000 Volt .. .. 161,700,000 units annually.

		£ per Annum.	Pence per Unit 20,000 V.
Power House Costs—			
(See Table VI. for details) ..		171,677	·255
Transmission Line—			
Patrolling, maintenance, &c. ..	4,010		
Capital charges ..	19,558		
		23,568	·035
Terminal Station—			
Operation wages ..	2,195		
Maintenance ..	1,390		
Capital Charges ..	16,915		
		20,500	·030
Administration ..		6,300	·009
Total ..		222,045	·329

TERMINAL STATION COSTS.

(20,000-Volt Energy).

Based on an output of 43,960 kws. (58,930 electrical horse power).

Costs.	*With 10 % added.*
1. £4 4s. per annum per kw. of M.D., plus 0·056 pence per unit.	£4 12s. 5d. per annum per kw. of M.D., plus 0·062 pence per unit.
2. With 42 % L.F. 0·329 pence per unit.	0·362 pence per unit.
3. £3 15s. 4d. per annum per e.h.p.	£4 2s. 10d. per annum per e.h.p.
4. With 100 % L.F. 0·171 pence per unit.	0·188 pence per unit.

TABLE VIII.

MORWELL POWER SCHEME.

TOTAL ANNUAL COSTS OF DELIVERING 42,800 KWS. TO THE UNDERTAKINGS IN THE FORM OF 6,000-VOLT OR 4,000-VOLT ENERGY.

At Sub-stations within the Metropolitan Area—

Maximum demand .. .. 42,800 kw.

Energy delivered at 6,000 volts or 4,000 volts .. .. .. 157,420,000 units annually.

		£ per Annum.	Pence per 6,000 or 4,000 Volt Energy.
Terminal Station Costs—			
(See Table VII. for details) ..		222,045	·339
Distribution—			
Maintenance of Sub-stations, Cables, &c. ..	2,200		
Capital Charges, Sub-stations, Cables, &c. ..	34,835		
		37,035	·056
Total ..		259,080	·395

SUB-STATION COSTS.

(6,000 or 4,000 Volt Energy).

Based on an output of 42,800 kws. (57,370 electrical h.p.)

Costs.	*With 10 % added.*
1. £5 3s. 6d. per annum per kw. of M.D. plus 0·057 pence per unit.	£5 13s. 10d. per annum per kw. of M.D. plus 0·063 pence per unit.
2. With 42 % L.F. 0·395 pence per unit.	0·434 pence per unit.
3. £4 10s. 4d. per annum per e.h.p.	£4 19s. 4d. per annum per e.h.p.
4. With 100 % L.F. 0·199 pence per unit.	0·219 pence per unit.

APPENDIX B.

INVESTIGATIONS OF THE COST OF WINNING COAL ON THE MORWELL BROWN COAL FIELD.

Derby, Tasmania,
11th November, 1919.

The Electricity Commissioners,
Melbourne.

GENTLEMEN,

I have the honour, as instructed, to report to you on the probable cost of winning Brown Coal in the vicinity of the proposed power-house near Morwell, as follows :—

I visited the district on the 8th and 9th of December last, and was afforded every assistance in my inspection by officers of the Mines Department.

I attach a blue print supplied by the Director of Geological Survey (Appendix I.), which shows the results of boring carried out by the Mines Department on the site of the proposed operations.

Sections along lines of bores, which have been more particularly used for the present purpose, are shown in Appendix II. They are situated chiefly on blocks 38A, 38E, and 41, parish of Narracan.

GENERAL.

An inspection of Appendix II. shows the great depth and continuity of the Brown Coal, its comparatively *level surface and small amount of overburden, and, generally, the favorable conditions for open cutting.*

The surface of the ground is low lying, and subject to flooding by the Latrobe River on the north and Morwell River on the east, with rising ground on the south and west. Comparatively inexpensive earth embankments may be built along the higher ground on the southern bank of the Latrobe River, and thence along the western side of the railway line, which will protect the ground from flooding. A system of drains on the west and south will similarly divert surface water shed from the higher ground.

OVERBURDEN.

The bores show that, although there is a considerable amount of sandy material in the overburden, there is also much clay and clayey sand. The Boring Foremen inform me that the ground so described by them would correspond with the clay and clayey sand exposed in the Great Morwell Mine on the north side of the Latrobe River, and that some of it was very tough. An inspection of this ground convinced me that it would be unsuitable for hydraulicing, even if other necessary conditions existed. Most of the overburden may be easily worked by mechanical shovels and the tougher portion without much difficulty. It is proposed to win the coal by the same means assisted by explosives if necessary.

SCHEME.

It is quite evident that a suitable and convenient dump for the spoil cannot be obtained on non-coal bearing ground, as large quantities of coal at a shallow depth are proved in every direction in which such a dump might be sought. The most convenient site under the circumstances, and one involving a relatively small sacrifice of coal land, is situated to the north-west of a line through bores 83 and 64, and shown on sketch plan, Appendix III.

Assuming that the power-house will be situated in the most northerly portion of block 38A, this dump site should provide for 3,000,000 cubic yards of spoil, which will cover a few of the less important bores only. On the exhaustion of this site, it will probably be found advisable to start to fill in ground from which the whole of the coal has not been extracted, rather than cover a much greater area of ground containing a great thickness of coal.

Sketch plan, Appendix III., indicates in a general way what, I believe, will prove to be a convenient lay-out of the open cut. The coal will be delivered from the northern end of the excavation to (the stock pile at) the power-house, while the stripping will be led away to dump at the southern end, the parallel stripping and coal faces advancing in a southerly and south-easterly direction. An ideal cross-section of the workings, after dumping therein has been in operation some time, is given. On account of the clayey nature of the overburden, the spoil will be deposited in comparatively low banks as shown. As the extraction of the coal at this time will be proceeding at a much greater rate than the removal of overburden, there will be sufficient space to continue the deposit of spoil and take out the lower coal face, as indicated by the dotted lines, provided the initial spoil area on the surface is not very seriously curtailed.

It is assumed the power-house will be situated within the area shown. However, any moderate variation from this, necessitated by further information obtained later from bores or survey, should not seriously affect the above general arrangement.

Drainage.

Departmental records show that, so far, artesian water has been struck in nine bores. The drill foreman who put down the bores informed me that the main body of Brown Coal during drilling operations was perfectly dry, and that much water was not met with until a depth of 100 feet below the coal was reached. In Appendix II. the strata below the main body of coal are shown to consist to a considerable extent of clayey material. Although the coal in the open face of the Great Morwell Mine is traversed by a number of vertical joints, and similar jointing is to be expected on the south side of the river, which may permit percolation at a considerable rate, yet the favorable underlying strata, combined with the drilling foremen's experience, lead me to believe that the rate of percolation will not be excessive. It is impossible to say what amount of water will have to be dealt with, but I think it unlikely that provision will have to be made for greater quantities than have been dealt with in the large alluvial gold mines of the State (about 3,000,000 gallons per day). At any rate, this will be the case until the depth of the cutting has become considerable. It will be possible, under the conditions that will exist at Morwell, to pump such a quantity at a cost of 2d. per ton of Brown Coal on an output of 2,000 tons per day until the cutting reaches a depth of 200 feet. Provision for dealing with this amount is included in the estimate.

Cost of Extraction and Equipment.

Within the relatively small area B, C, D, E, F shown on the plan, Appendix III., *the average depth of coal is* 58 *yards*, and the amount of Brown Coal 76,000,000 tons. *The depth of overburden is* 11 *yards*, and each cubic yard of overburden covers on the average rather more than 4 tons of coal. In deciding the proportion of overburden expense that each ton of coal should bear, I think this ratio should be increased to 1 cubic yard of overburden to 3 tons of coal. The depth of coal for this purpose would be 40 yards. Coal below this depth would be relieved of any overburden charge, which would compensate for slight extra cost of winning due to increased depth, irregularity of bottom, &c.

I estimate cost of overburden removal, including maintenance, depreciation, and interest on plant, at one shilling and threepence (1s. 3d.) per cubic yard.

It is generally considered advisable to somewhat increase the charge on each ton of ore or coal for overburden removal during the earlier part of the life of a mine, while shallower levels are being worked. In order to provide interest on the money locked up in overburden removal, and allow a margin over the estimate, I suggest that a charge of 6d. per ton of coal be made during the earlier life of the mine. Any necessary adjustment can be made at a later stage.

Under the present conditions for an output of 1,500 tons of Brown Coal per day, I estimate the cost of delivering a ton of run-of-mine coal at the stock pile at the power-house, inclusive of the above charge of 6d., at two shillings and fivepence (2s. 5d.), and the cost of equipment at £152,500.

For outputs of 2,000 tons and 3,500 tons per day the working costs would be 2s. 2½d. and 2s. 2d. per ton respectively, and the cost of equipment £171,000 and £223,700 respectively. In addition to the above, it would be necessary to spend £40,000 in the preliminary removal of overburden, preparation of dumps, &c.

LINDESAY C. CLARK.

APPENDIX C.

INVESTIGATIONS OF THE COST OF WINNING COAL ON THE ALTONA BROWN COAL FIELD.

Melbourne, Victoria,
25th October, 1919.

To the Electricity Commissioners,
Melbourne.

Dear Sirs,

We respectfully beg to advise that, in accordance with your reqnest, we have examined the Altona coal-field with the view to determining the most suitable method of mining and the cost of winning brown coal.

The property owned by the Melbourne Altona Company comprises 2,269 acres, approximately 4 square miles.

From the information revealed by the Government bores Nos. 1 and 2, as per the blue print attached, apparently the depth of coal approximates 72 feet lying between the vertical depths of 349 feet and 421 feet. In the company's present shaft the thickness is 69 feet. We have taken the average thickness at 70 feet as a basis for our calculations. Before embarking upon an extensive scheme of mining we would recommend that these data be checked by further boring along the eastern and western boundary lines of the property to define more accurately the pitch of the seam, and as a test of its regularity. It would be advisable to keep the bores away from proposed workings to avoid flooding of same In outlining our schemes of operating we have combined the above data with those snpplied by Mr. Burman, the company's engineer. The estimated quantity of coal available by safe methods of mining is 100,000,000 tons.

The Altona Company has done a fair amount of work under difficult conditions, and we are indebted to their engineer, Mr. Burman, for much valuable information respecting the work already done. Further, we have collected similar data from other individuals who have had mining experience at Altona.

An artesian or sub-artesian water pressure obtains immediately under the coal bed, while the cover or roof over the seam is a swelling sandy clay. Such conditions as these clearly indicate that the proposition is beset with difficulties, and demands that a very safe method be adopted for mining the coal.

The evidence we have collected reveals several instances of "heating," indicating that the coal is liable to fire by spontaneous combustion.

Under the above conditions the only methods of mining, in our opinion, that should be adopted are: (*a*) that which depends upon bulk timbering and close filling, and (*b*) that of sectionally "caving." It is essential to keep weight on the bottom section of the coal seam to counteract the water pressure, and as only limited spaces can be opened owing to its friable nature, it will be necessary to mine sectionally for a height of 7 feet. In the case of (*a*), or filling system, these sections would approximate 100 feet x 100 feet.

We estimate that of the 70 feet of coal depth only 35 feet of it can be safely extracted. Starting at a point 20 feet from the bottom of the seam the coal would be first mined sectionally as above described for a height of 7 feet. It could be mined and the vacant spaces filled with sand filling until a considerable area of the 7 feet height had been extracted, when the second layer of 7 feet could then be attacked and so on until 35 feet of the coal depth had been extracted, leaving 15 feet of coal overhead as a protective cover.

In (*b*), or the "caving" system, narrow developmental headings, 7 feet in height, would first be driven, leaving 14 feet of roof coal overhead to timber to, a portion of which would subsequently be recovered in pillar extraction. The coal would be cut up by the headings into small panels or sections of work about 100 feet square, and provision would be made for readily sealing off a panel in case of spontaneons combnstion occurring. The coal in the panels would be worked back in 10-ft. wide lifts, each lift about 50 feet in length, in a similar manner to that adopted in working alluvial deposits. Actual experience gained in working the seam would demonstrate the safest and most economical dimensions for the panels and the lifts. As the panel pillars were extracted, as much of the timber as possible would be withdrawn and the top coal and roof allowed to cave.

From the nature of the strata overlying the coal, and the difficulty experienced by the Altona Company in maintaining their narrow drives near the roof, there is no doubt that the ground would cave immediately following the extraction of the pillars.

After the first layer of coal was worked out over the whole of the area to be mined, the method of procedure would be to start at the shaft pillar again and drive another set of developmental headings, leaving a certain thickness of top coal over the narrow work to form a roof, and then proceeding to work this layer as in the former instance. The thickness of the coal left on top of the drives would be arrived at from the experience gained in working the top layer—probably from 3 to 4 feet would suffice—and a portion of this coal would be obtained by caving in the extraction of the pillars.

Again, after the second layer was exhausted, a third layer would be exploited in a similar manner, and so on, till the whole seam was exhausted to within 20 feet of the bottom, namely, the depth of bottom allowed for in the filling system.

The caving method of mining would cause enormous surface subsidence, which could be lessened, although not entirely eliminated, by close filling with sand; and if it is necessary to maintain the surface level, it would be more economical to dump sand on the surface as the ground subsided. In any case it would be advisable to leave pillars of coal of adequate size under proposed building sites, railway lines, &c., and it would be a very necessary precaution to leave a large coal barrier adjacent to the sea beach.

These systems, allowing for an actual recovery of 30 feet, would yield 100,000,000 tons of coal, and on the basis of maximum extraction, *i.e.*, 2,000 tons of coal per day for 260 working days per year, this area would supply coal for over 190 years.

In either of the schemes of mining we would employ self-dumping skips operated in vertical shafts. At the bottoms of the shafts underground storage bins would be provided from which the skips would be filled by gravity.

The underground haulage would be by a rope system or by electric traction, either of which would be satisfactory. The hauling shafts would be operated by electric winders.

The shaft plats and storage bins would be constructed of reinforced concrete, thus providing good substantial structures necessary to take the weight of the overlying coal with its swelling clay roof. The accompanying drawings marked " No. 1 " and " No. 1A " show the lay-out of the filling scheme in plan and vertical section respectively, whilst " No. 1B " illustrates the caving scheme.

Sketch plan marked " No. 2 " shows the position of the present shaft and that of the proposed shafts. The present shaft might ultimately be used as a ventilating shaft, but as it is unfavorably situated as a site for permanent mining operations it would be necessary, for an output of 1,000 tons per eight-hour day, to sink the two shafts provided for in the attached estimates, one of which would be the winding and the other the ventilation shaft. This scheme would also apply to the basis of 2,000 tons output per sixteen-hour day. To produce 2,000 tons per eight-hour day would require two winding shafts. In this event the present shaft would be connected with the new shafts and converted into the ventilation shaft, making available both of the new shafts for winding.

We would answer the questions submitted to us in your letter of 22nd September last as follow :—

(1) (*a*) By filling system : Eight shillings and fivepence (8s. 5d.) per ton.
By caving system : Seven shillings and one penny (7s. 1d.) per ton.
As per statements attached.

(*b*) By filling system : Eight shillings and twopence (8s. 2d.) per ton.
By caving system : Six shillings and tenpence (6s. 10d.) per ton.
As per statements attached.

Alternatively, two shifts of eight hours each per day :—

By filling system : Seven shillings and eightpence (7s. 8d.) per ton.
By caving system : Six shillings and fourpence (6s. 4d.) per ton.
As per statements attached.

The coal seam would be penetrated to within a depth of 20 feet of the bottom of the coal by vertical shafts 14 ft. 6 in. x 7 feet, divided into three compartments, two for winding of coal and men and the third for timber and supplies.

The methods of mining, namely, (*a*) filling and (*b*) caving, have been outlined herein, and details as to costs are attached.

(2) The coal seam can, in our opinion, be safely worked to a thickness of 35 feet, perhaps in the caving system to a greater extent. We have, however, calculated upon an extraction of 30 feet only.

(3) From the company's land there can be obtained about two years' supply of sand filling, after which it would be necessary to obtain this filling by dredging the sea beach, which apparently contains an unlimited supply. We estimate the cost of sand at 9d. per ton, delivered on the mine.

(4) We are of the opinion that so long as the coal seam is not penetrated beyond a total depth of 50 feet, difficulties in respect to water need not be feared with either of the systems of mining recommended.

As a protective measure it would be necessary as mining operations progress to carry out a system of auger boring in the bottom 20-ft. layer of coal, and keep close records of the data obtained therefrom. It is essential that the depth of coal underfoot should be kept at the safe limit of 20 feet.

(5) The schedules attached set out the equipment required and the capital cost of same.

The capital cost of equipment to supply 2,000 tons per diem of eight hours would be about double that required to supply 1,000 tons of coal per eight-hour day.

(6) It would be necessary to build houses for the workmen. On the basis of 1,000 tons output per day we estimate about 200 workmen's cottages should be built. The cost of these would approximate £500 each, or a total of £100,000. The rents from these cottages should of course cover interest, depreciation, and redemption of capital.

In conclusion we would state that as the information we have obtained in connexion with our investigations shows a difference of opinion respecting the standing nature of the coal, it would be advisable to try out each of the proposed systems experimentally in the company's mine, in order to definitely determine the system best suited to the conditions.

We are, dear Sirs,

Yours faithfully,

GEO. H. BROOME.
G. C. KLUG.

ALTONA BROWN COAL FIELD.

STATEMENT OF CAPITAL EXPENDITURE.

Filling System.

Plant required for an Output of 1,000 Tons per Day of Eight Hours, or 2,000 Tons per Day of Sixteen Hours.

	£
Main shaft and ventilation shaft, each 14 ft. 6 in. x 7 feet x 400 feet, divided into three compartments ..	10,400
Main electric winder	5,000
Auxiliary electric winder for third compartment of main shaft	3,000
Winding ropes	300
Sinking and refitting existing shaft for pumping and ventilation purposes	1,500
Head gear and bins	3,000
Main shaft—	
Three self-dumping skips	900
Five cages	1,000
Plat and underground bins	7,500
Main shaft pump	1,000
Underground drives and cross-cuts to develop up to an output of 1,000 tons per day of eight hours; this includes drainage and ventilation drives	12,000
Underground rope haulage system	5,000
(Note.—If electric haulage decided upon this cost would approximate £10,000.)	
Ventilation fan, 160,000 cubic feet of air per minute, at water gauge of 4 inches, direct motor driven installed at existing shaft	3,000
Underground trucks—500 of 1-ton capacity, fitted with special oil bearings, estimated cost £12 each ..	6,000
Mine rails—150 tons 30-lb. and 20-lb. rails	3,000
Power substation—transformers, &c., 1,000 h.p.	3,000
Underground and surface electric lighting	900
Underground power transmission	1,100
Hydraulic stowage system, inclusive of bores, pipes, pumps, and pump column at existing or pumping shaft ..	5,300
Sand plant to supply filling for hydraulic stowage system, consisting of locomotive, hopper-bottom trucks, steam shovel, rails, &c.	10,000
Dredge, suction-pump type, 16-in. centrifugal, fitted with sand cutter, for dredging sea beach, capacity 1,300 tons of sand per day of eight hours	20,000
Stables and ponies	1,500
Railway sidings	3,000
Engineering and carpenters' shops	5,000
Changing house	3,000
Manager's house	2,000
Mine offices	2,000
	119,400
Add 10 per cent. for contingencies	11,940
Total	131,340

ALTONA BROWN COAL FIELD.

STATEMENT OF CAPITAL EXPENDITURE.

Caving System.

Plant required for an Output of 1,000 Tons per Day of Eight Hours, or 2,000 Tons per Day of Sixteen Hours.

	£
Main shaft and ventilation shaft, each 14 ft. 6 in. x 7 feet x 400 feet, divided into three compartments	10,400
Main electric winder	5,000
Auxiliary electric winder for third compartment of main shaft	3,000
Winding ropes	300
Sinking and refitting existing shaft for pumping and ventilation purposes	1,500
Head gear and bins	3,000
Main shaft—	
Three self-dumping skips	900
Five cages	1,000
Plat and underground bins	7,500
Main shaft and auxiliary pumps	3,700
Underground drives and cross-cuts to develop up to an output of 1,000 tons per day of eight hours: this includes drainage and ventilation drives	24,000
Electric haulage system	10,000
Ventilation fan, 160,000 cubic feet of air per minute, at water gauge of 4 inches, direct motor driven installed at existing shaft	3,000
Underground trucks—500 of 1-ton capacity, fitted with special oil bearings, estimated cost £12 each	6,000
Mine rails—300 tons 40-lb. and 20-lb. rails	6,000
Power substation—transformers, &c., 1,000 h.p.	3,000
Underground and surface electric lighting	900
Underground power transmission	1,100
Sand plant to supply filling for reclamation of surface; consisting of locomotive, hopper-bottom trucks, steam shovel, rails, &c.	10,000
Dredge, suction-pump type, 16-in. centrifugal, fitted with sand cutter, for dredging sea beach, capacity 1,300 tons of sand per day of eight hours	20,000
Stables and ponies	1,500
Railway Sidings	3,000
Engineering and Carpenters' shops	5,000
Changing house	3,000
Manager's house	2,000
Mine offices	2,000
	136,800
Add 10 per cent. for contingencies	13,680
Total	150,480

ESTIMATED MINING COSTS BY FILLING SYSTEM.

—	1,000 Tons per Eight-hour Day. Cost per Ton.	2,000 Tons per Eight-hour Day. Cost per Ton.	2,000 Tons per Sixteen-hour Day. Cost per Ton.
	s. d.	*s. d.*	*s. d.*
Mining	2 0	2 0	2 0
Filling	1 9	1 9	1 9
Timber and timbering for bulks and drives	2 0	2 0	2 0
Haulage and trucking	0 6	0 6	0 6
Pumping	0 2·5	0 1·25	0 1·25
Ventilation	0 2	0 2	0 2
Winding	0 1·5	0 1·5	0 1·5
Supervision clerical staff	0 6	0 4	0 4
Extra cost wages, afternoon shift	..	..	0 1·8
Interest, 5 per cent; depreciation, 7 per cent.	1 2	1 2	0 6·6
	8 5	8 2	7 8

ALTONA BROWN COAL FIELD.

ESTIMATED MINING COSTS BY CAVING SYSTEM.

—	1,000 Tons per Eight-hour Day. Cost per Ton.	2,000 Tons per Eight-hour Day. Cost per Ton.	2,000 Tons per Sixteen-hour Day. Cost per Ton.
	s. d.	s. d.	s. d.
Mining	2 0	2 0	2 0
Timber and timbering	1 6	1 6	1 6
Haulage and trucking	0 6	0 6	0 6
Pumping	0 2·5	0 1·5	0 1·5
Ventilation	0 2	0 2	0 2
Winding	0 1·5	0 1·5	0 1·5
Supervision clerical staff	0 6	0 4	0 4
Reclamation	0 9	0 9	0 9
Extra cost wages, afternoon shift	..	..	0 2
Interest, 5 per cent.; depreciation, 7 per cent.	1 4	1 4	0 8
	7 1	6 10	6 4

APPENDIX D.

BROWN COAL DEVELOPMENT IN GERMANY.

1. Through the efforts of the Agent-General (Sir Peter McBride) and Lieut.-General Sir John Monash, and by courtesy of the War Office, a party of engineers and draughtsmen was made available to report on the Rhineland Brown Coal-fields. This party has made a very thorough investigation into the methods employed in working these brown coal deposits, and a valuable report has been received as a result of their inquiries.

An examination of this report and the photographs and drawings accompanying it, bring out very clearly the similarity in many respects to the conditions obtaining at Morwell. The physical characteristics of the coal deposits show many like features, and the methods of working, particularly since the war conditions rendered the adoption of mechanical appliances imperative, could quite simply be adapted to the Morwell Brown Coal-fields should such a course be considered desirable after comparison with modern practice in other parts of the world.

The report shows that—largely as a result of the demand of men for the army—the breaking and handling of the coal by mechanical appliances has been developed very considerably during the war period. At the Fortuna Mine, Quadrath, near Cologne, Germany, 6,500 to 7,000 tons of coal are raised every twenty-four hours on the open-cut system. This method is employed where the ratio of the overburden to coal is as much as two to one.

2. The removal of the overburden is accomplished by means of land dredges in benches of about 33 feet each. These machines are set on rails, and slowly traverse the face, removing the material and loading into self-tipping trucks in the one operation. The material is then conveyed by locomotives to the dumping area, where it is dumped and distributed by means of a mechanical spreading machine. (Print 3.)

The tracks on which the various machines traverse the face are moved by means of a special machine invented during the war. Full details of this machine are also included in the report.

3. Various types of machines have been tried in winning the coal. Of these the machine which is described as ideal is illustrated herewith. (Print 4.) This machine travels on rails at the bottom of the face, and cuts and loads with a crew of two, one mechanic and one assistant. It may be constructed for any height of face up to 100 feet, and, briefly, consists of a body travelling on rails from which is suspended a framework supporting two link belts carrying the cutters. Underneath are suspended the loading buckets. The machine is worked and controlled electrically, and cuts and loads the coal in one operation.

The haulage of coal is done by means of endless chains operated by winding gear. The coal trucks are of standard size and are bridged in the centre. On this bridge is placed a fork which engages with the links of the endless chain.

4. At the Fortuna workings 6,500 to 7,000 tons of coal are raised daily. Of this quantity 800 to 1,000 tons per day of raw coal are sold direct to local factories, and the balance is utilized in the generation of electricity for industrial purposes and the manufacture of briquettes. The capacity of the electrical plant is 36,000 kw.

5. The syndicate controlling the Rhineland Brown Coal-fields produces 20,000 tons of briquettes per day, which are sold all over Germany for industrial and domestic purposes. The manufacture, briefly, consists of first screening and crushing the coal (any oversize and woody portions being conveyed to the boilers). The coal is then dried and fed to a special machine where it undergoes a pressure of 19,000 to 25,000 lbs. per square inch. No binding material is used.

By Authority: Albert J. Mullett, Government Printer, Melbourne.

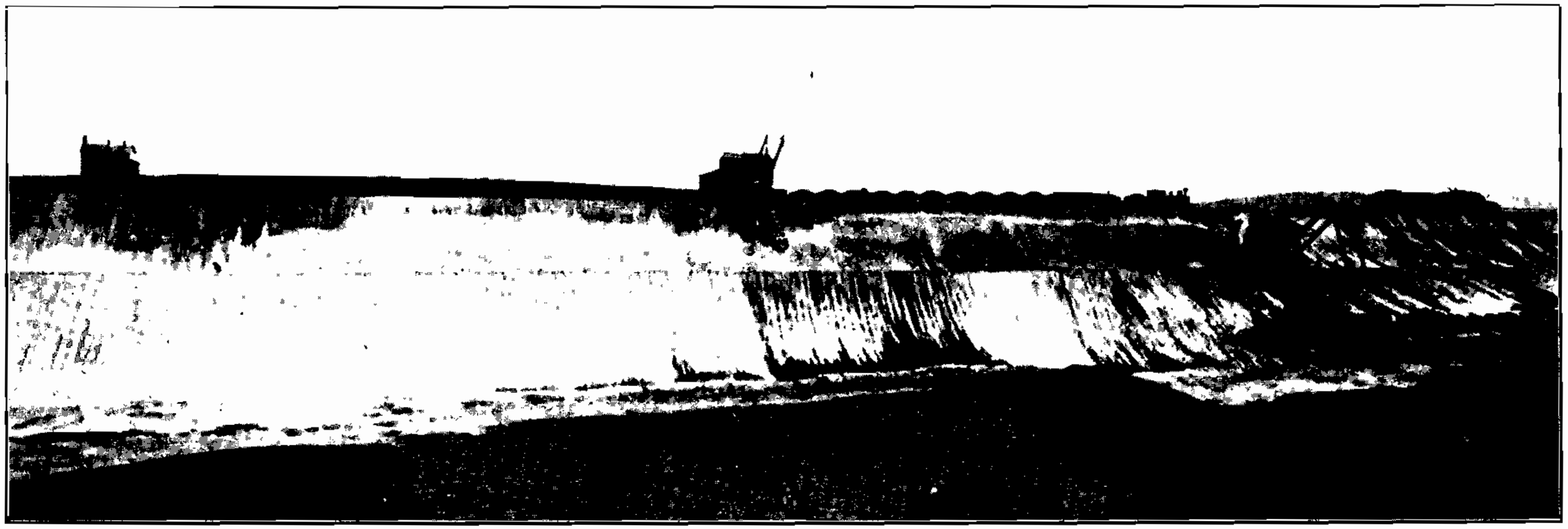

Fig. 15.—Overburden, Fortuna.

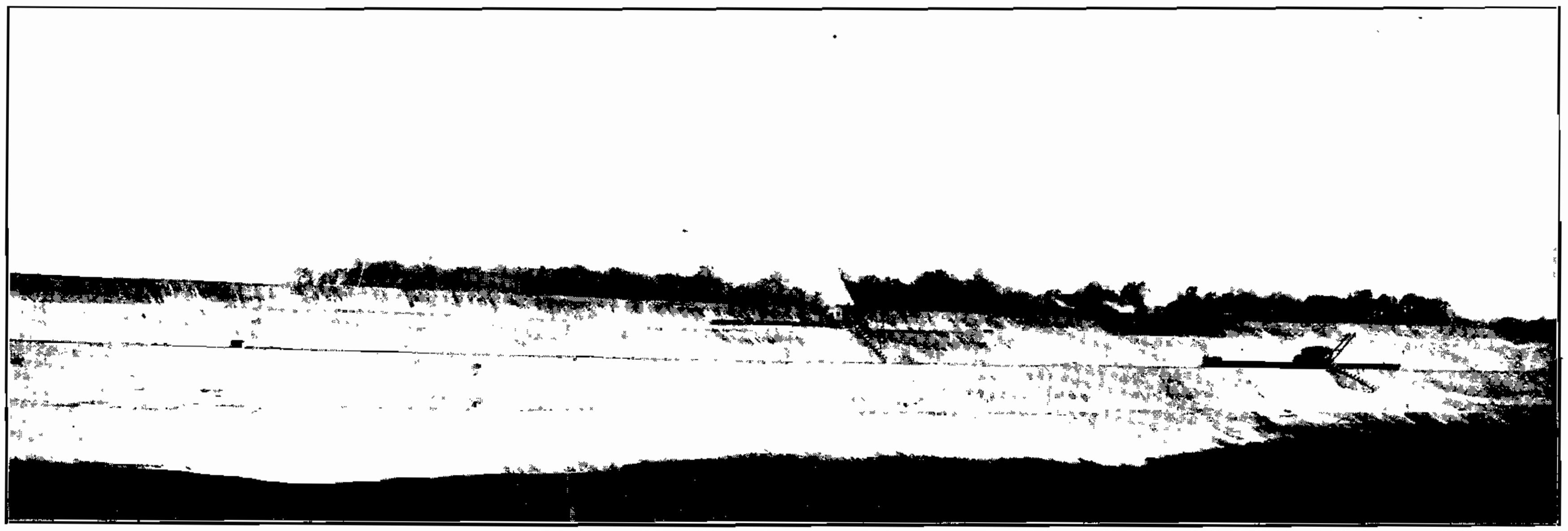

Fig. 16.—Overburden, Horrem.

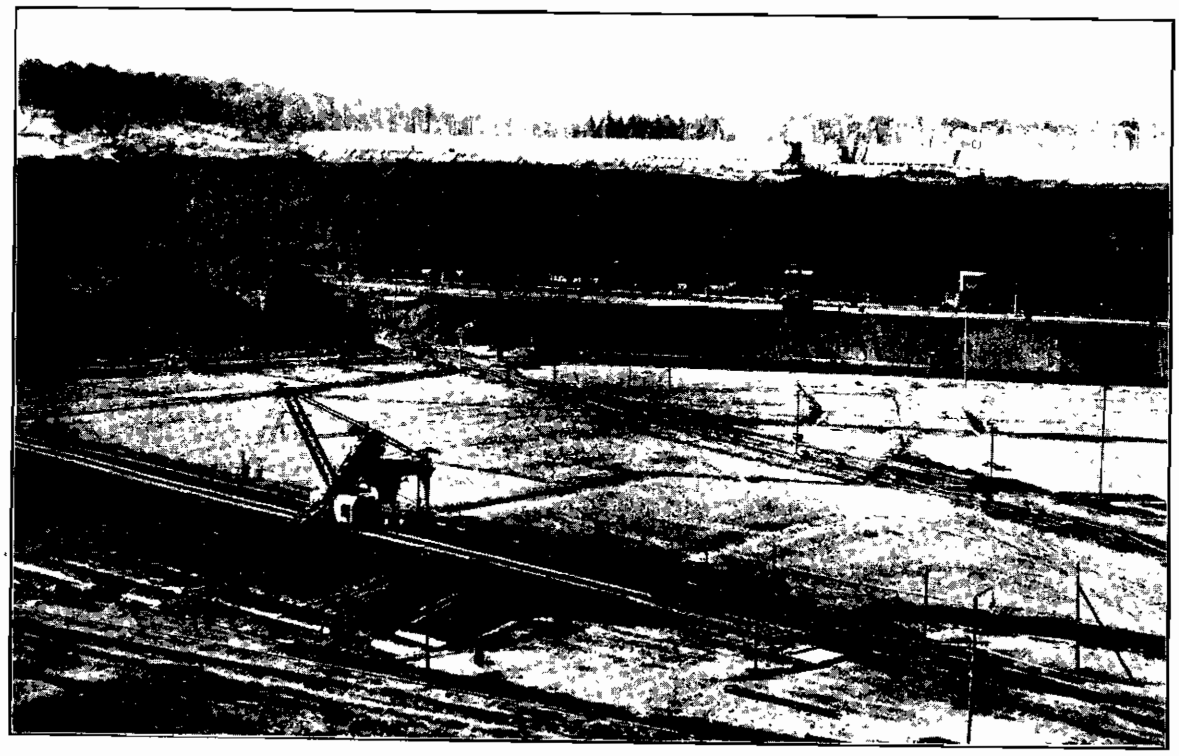

Fig. 17.—Brown Coal Open Cut.

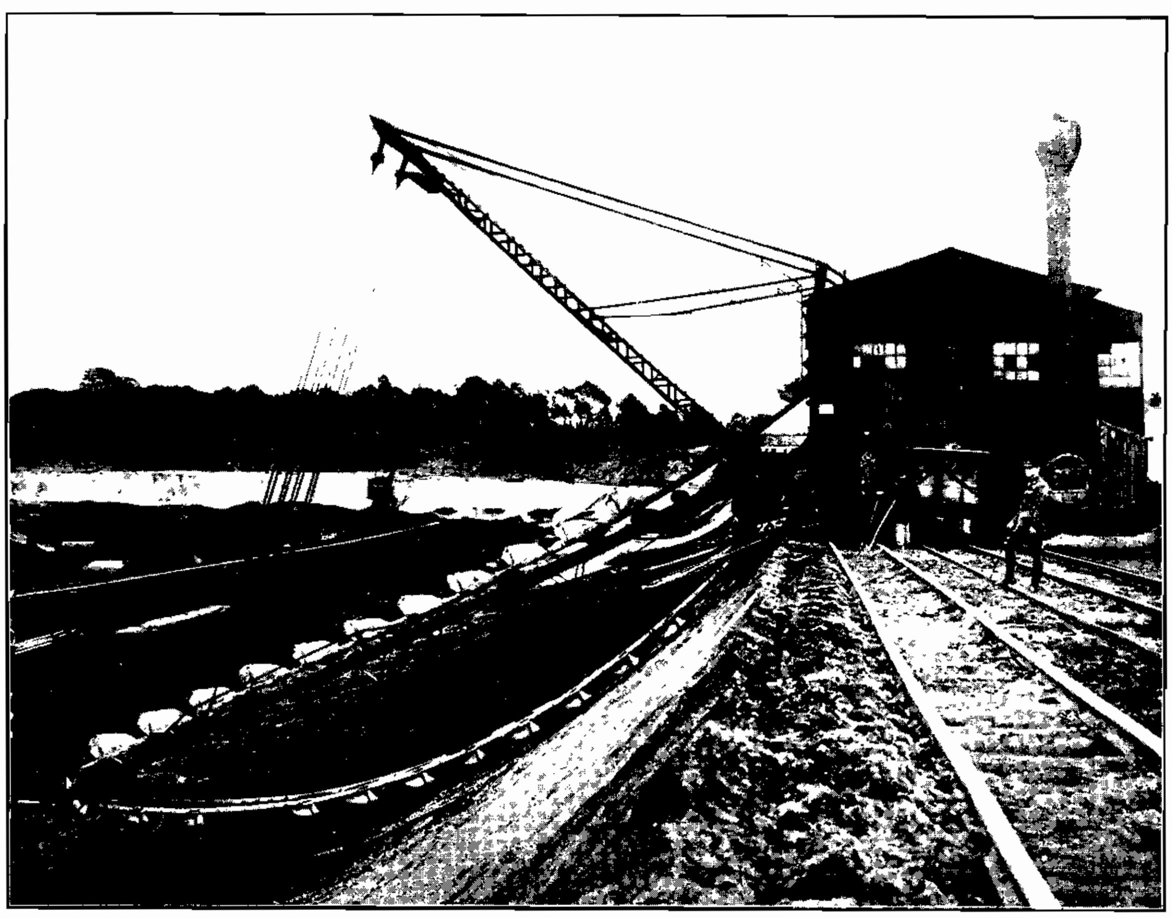

Fig. 20.—Underhand Machine on Overburden, Fortuna.

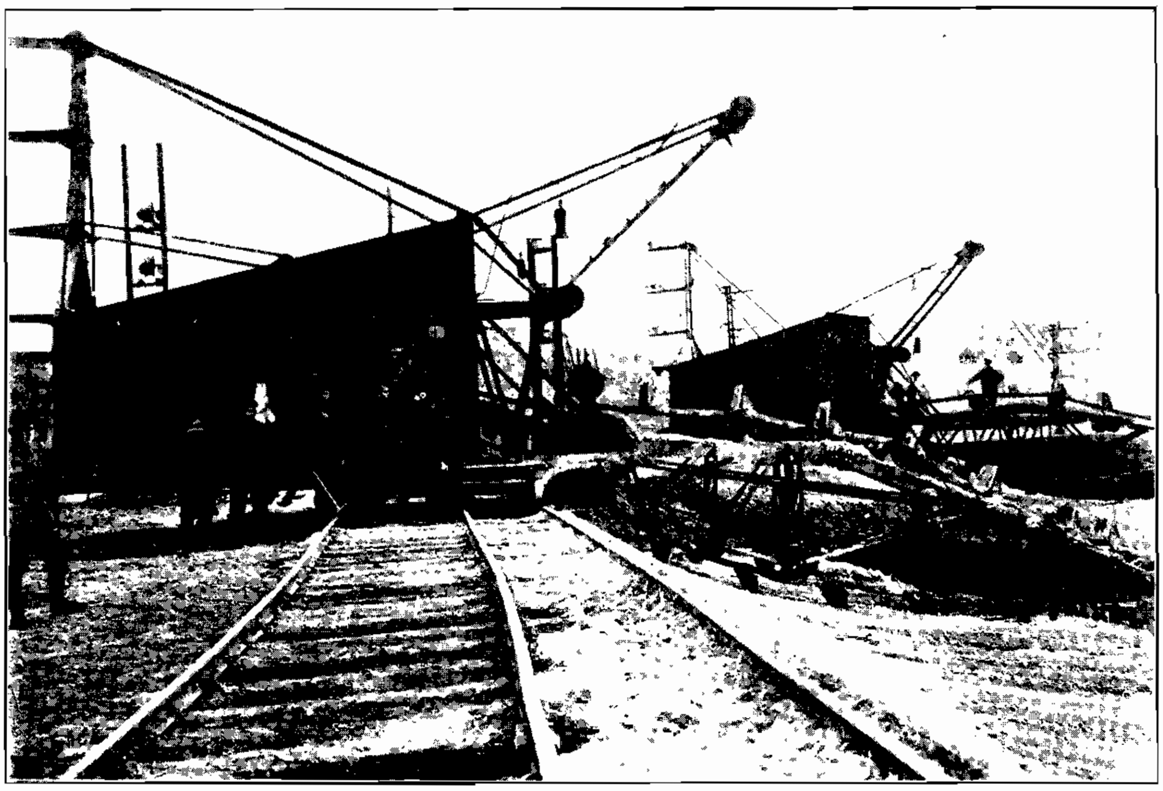

Fig. 26.—Mechanical Overburden Spreader, Fortuna.

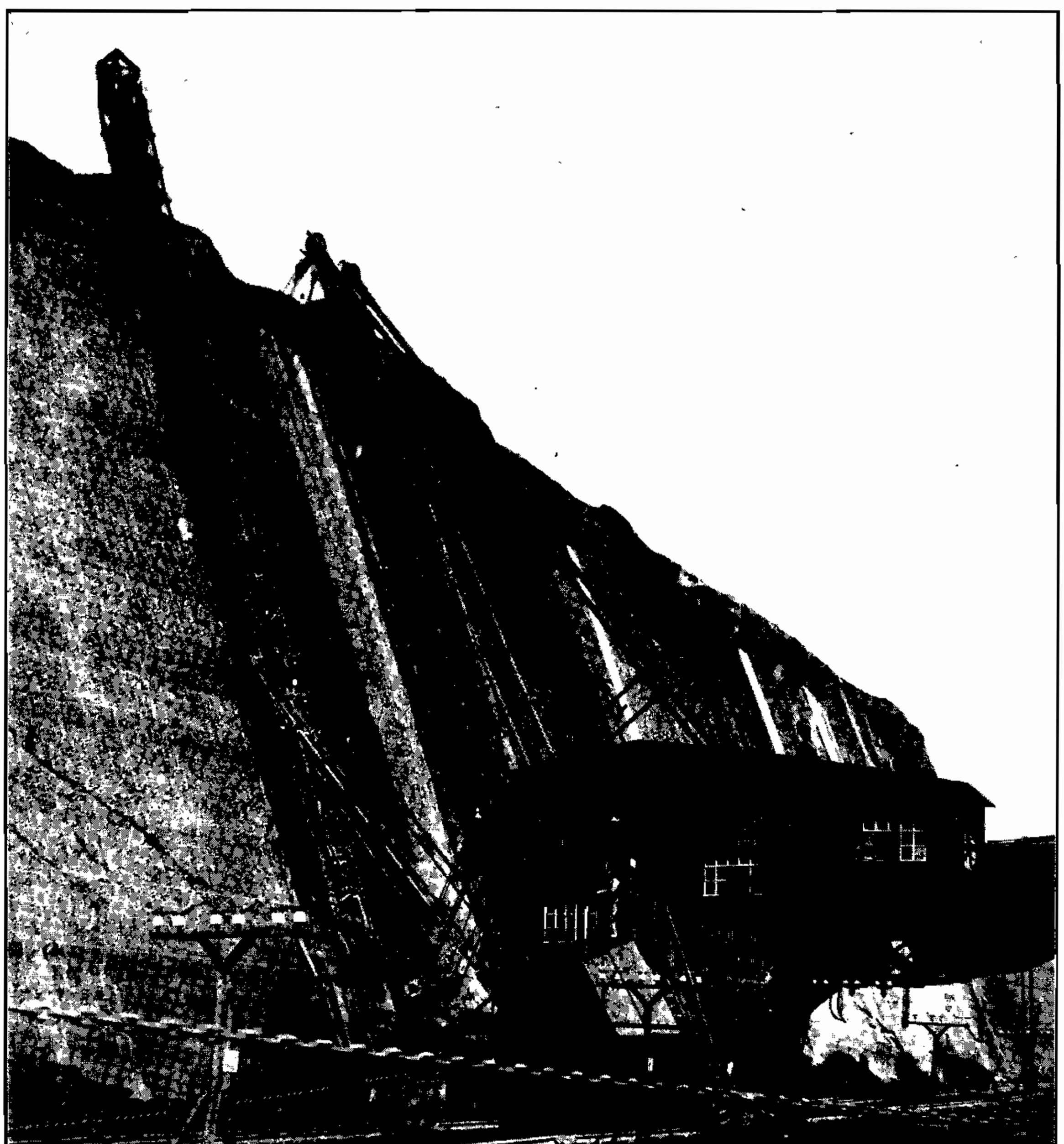

Fig. 40.—Overhand Coal Cutting and Loading Machine, Fortuna.