1928.

VICTORIA.

REPORT

OF

STATE ELECTRICITY COMMISSION OF VICTORIA

ON

EXTENSION OF ELECTRIC SUPPLY SYSTEM.

PRESENTED TO BOTH HOUSES OF PARLIAMENT BY HIS EXCELLENCY'S COMMAND.

[*Approximate Cost of Report*:—Preparation.—Not given. Printing (500 copies) £52.]

By Authority:
H. J. GREEN, GOVERNMENT PRINTER, MELBOURNE.
No. 10.—[1s. 9d.].—3035.

TABLE OF CONTENTS.

EXTENSION OF ELECTRIC SUPPLY SYSTEM.

The Hon. T. Tunnecliffe, M.L.A.,
Minister in Charge of Electrical Undertakings,
Melbourne.

SIR,

1. For the past twelve months this Commission has had under active consideration the question of making adequate provision, beyond that already approved by Parliament, for the steadily increasing public demand for electric services throughout the State. The Commission has, on several occasions, intimated to you that the time was approaching when this question would have to be dealt with.

2. The present Report, which sets out the considered recommendations of the Commission upon this important question, and a full statement of the reasons for same, is now submitted, pursuant to the requirements of section 11 of the State Electricity Commission Act No. 2996 of 1919.

3. Appended hereto are the following annexures :—

"A." Report of the Chief Engineer (Mr. H. R. Harper) setting out, in detail, the results of a comprehensive investigation into the economics and technicalities embraced in this inquiry.

"B." Report of the Power Advisory Board (Messrs. T. P. Strickland, Chief Engineer of the Melbourne and Metropolitan Tramways Board, H. P. Colwell, Chief Electrical Engineer of the Victorian Railways Commissioners, and H. R. Harper, Chief Engineer of the State Electricity Commission), reviewing the Chief Engineer's report, and expressing categoric approval of the data, results, and recommendations contained therein.

"C." Report of the Engineer i/c Briquetting and Research (Dr. H. Herman), dealing specially with the economics of the production of pulverized dried brown coal.

"D." Extracts from the Report of this Commission to you, of 20th May, 1927, describing, in full detail, the scheme already approved for the future development of the new open-cut workings at Yallourn in so far as this scheme is correlated with the main question dealt with herein.

4. The several technical questions involved will be found to have been exhaustively dealt with in the above-quoted annexures, which the Commission, after full consideration, has adopted and approved. It is therefore necessary and desirable to deal, herein, mainly with only the policy and financial aspects of these proposals.

PART I.—BASIC CONSIDERATIONS.

5. As a preliminary step to a closer analysis of the several alternatives which present themselves, it is desirable first to consider, in some detail, (*a*) the extent of the provision of further generating plant which should now be determined upon; (*b*) the bearing which the question of coal-winning costs has upon the choice to be made; (*c*) the question whether water-power or heat-power should be the source to be selected; and (*d*) the observations of Mr. W. H. Sawyer (in his report of 19th May, 1926), which deal with the general question of fuel supply and location of further power installations.

6. *Growth of Demand.*—The Commission has at its disposal statistical material and experience covering many years upon which to base conservative estimates as to the future, and upon which to make reliable forecasts of the probable load on the system for a series of years to come. As you are aware, similar forecasts made during the past seven years have been closely realized, the load having in no previous year fallen below the amount forecasted. The subjoined prospective figures have been based on identical data and assumptions.

7. The system load anticipated during the next ten years is as follows:—

1928	83,000	kilowatts
1929	92,000	,,
1930	100,000	,,
1931	119,000	,,
1932	129,000	,,
1933	139,000	,,
1934	149,000	,,
1935	160,000	,,
1936	172,000	,,
1937	184,000	,,

8. The generating capacity at present available, and shortly to become available, comprises:—

	Kw.
(*a*) Yallourn Power House—originally designed for 50,000 kw., but as the result of improvements in combustion conditions, now capable of producing	60,000
(*b*) Newport "B" Power House	16,000
(*c*) Sugarloaf–Rubicon Hydro-Electric Scheme (taking into consideration only that portion which can be relied upon as available during the winter months)	11,500
(*d*) Richmond Power House (to be ready in 1929)	15,000
	102,500

9. The comparison between "available" and "requisite" plant can, therefore, be seen from the following table:—

Year.	System Demand.	Total Available Capacity.	Surplus or Deficiency.
	Kilowatts.	Kilowatts.	Kilowatts.
1928	83,000	87,500	+ 4,500
1929	92,000	102,500	+10,500
1930	100,000	102,500	+ 2,500
1931	119,000	102,500	—16,500
1935	160,000	102,500	—57,500

10. It will thus be seen that further generating plant, beyond that already authorized by Parliament, must become available for the winter of 1931, and that the deficiency in plant, unless fresh provision is made, will, by 1935, exceed 50,000 kw. For reasons given elsewhere, any further installations should comprise generator sets of not less than 25,000 kw. capacity each. The Commission therefore proposes the provision of a total increment of 75,000 kw. of plant. Of this quantity, 25,000 kw. would represent one spare or reserve unit, leaving 50,000 kw. available for regular use. The first unit, of 25,000 kw., must be available for the winter of 1931, the remainder being installed progressively, in later years, as required, all to be available before 1935.

11. Lest it may be thought that large further investments in generating plant can be obviated or postponed, it should be explained in general terms that the growth of demand is beyond the control of an electric supply authority. Every tenement and every factory is free to draw current and to increase its consuming devices at its own will and pleasure. Consequently, when an existing system of supply has reached full-load conditions, the inevitable further increase of consumption cannot be prevented, with the result that the system becomes overloaded. The effect of sustained overload—apart from the risk of serious breakdowns of essential plant—is to render the service, in its entirety, irregular and unreliable, to the disadvantage and inconvenience of the whole body of consumers. It is, therefore, the paramount duty of every supply authority to ensure that its plant capacity is, at all times, available *in advance* of public requirements. Should the plant capacity of the State system be allowed to fall short of requirements in 1931, the results to the community would be very serious.

Brown Coal.

12. This Report embodies a recommendation that the extensions of power supply, herein dealt with, should be based on heat power, provided by the use of brown coal won from the Yallourn open cut. The results of the exhaustive investigation, appearing hereunder, demonstrate that at present actual coal-winning costs, the use of Yallourn coal, in a generating plant located at Yallourn, is economically superior to any other competitive proposal, involving either alternative fuels or alternative locations. Such a recommendation, if carried out, would, however, have far-reaching advantages altogether apart from the specific scheme of extension to which the above-mentioned investigation was directed. In a report to you of 20th May, 1927, the whole question of coal-supply development at Yallourn was very fully dealt with. The latter report has so important a bearing upon the present question that lengthy extracts from it are represented as an Appendix hereto. (See Appendix D.)

13. Briefly summarizing here the main conclusions of Appendix D, it is shown that the cost of coal, at per ton won, is closely related to the total output, that the cost per ton falls appreciably with every increment of output, and that, therefore, a substantial increase in coal output, such as would result from locating the power plant extension at Yallourn, will have the effect of reducing the present-day cost of coal, not merely for the benefit of the extension itself, but also for the existing plants at the Power House and the Briquetting Factory. Stated specifically, the existing plants consume, roundly, 6,000 tons of new-cut coal per day. The contemplated extensions will, by 1931, consume an additional 4,000 tons per day. Such an increase in the total coal production will reduce the cost, per ton of coal, not merely for the additional 4,000 tons, but also for the whole 10,000 tons. Thus, existing installations would be definitely advantaged by a decision to extend the coal-consuming activities at Yallourn. This is a policy aspect which strongly confirms the present proposals apart from the intrinsic merits of these proposals *per se*.

Water Power.

14. The Commission has not overlooked the possibility of developing the requisite increment of the present power supply in the form of hydro-electric power. In this context, however, it is only necessary to refer to the Commission's Report of November, 1920, on the then proposed Kiewa Scheme, and in particular to those passages which explain that, owing to the geographical, climatic, and meteorological conditions in this State, the capital cost of works of water conservation in our mountain regions is prohibitive as compared with heat power, unless and until there is available a load of sufficient high load-factor to earn, throughout every hour of every day, the revenues necessary to meet these capital charges. That stage in the development of the daily load upon the Victorian power system has not yet arrived, and until there is available a practically constant demand, throughout the 24 hours, of 30,000 kw. or upwards, any hydro-electric scheme involving extensive and expensive hydraulic storage works must be considered to be premature. For this reason, the full development of the Kiewa Scheme (of which the Sugarloaf–Rubicon Works now under construction form a part) must be postponed.

15. Serious consideration of the Kiewa and other hydro-electric schemes merely awaits the development of the requisite economic load conditions, and, therefore, the Commission is keeping this matter under close observation, both by systematic gauging of the streams and by the continuance of detailed surveys directed to perfecting the original proposals. In the same context, the Commission is devoting attention to the possibility of the economic development of power schemes both from the Mitta River and from the outflow from the Hume Reservoir when completed. In due course these alternative sources of hydro-electric power will receive close consideration in comparison with the Kiewa River.

Mr. W. H. Sawyer's Report.

16. The Royal Commissioner, Mr. W. H. Sawyer, in his Report to the Government, dated 19th May, 1926, dealt lengthily and specifically with the subject-matter of the present proposals. In the main, the Commission's present recommendations harmonize with the views so expressed.

On the question of the urgent necessity to take early steps to increase the generating capacity of the State system, Mr. Sawyer reported as follows :—

> "Data have been submitted to me showing the electrical load anticipated for an extended future period. These data show that, in the winter of 1929, with an output from Yallourn Station of 54,000 kw. and from Newport "B" of 16,000 kw., together with 11,500 kw. from Sugarloaf group (not including Snob's Creek Section), this available supply of 81,500 kw. will be slightly under the demand of 86,000 kw. estimated for that year. We have spent considerable time on checking the above demand, both as to kilowatts and as to kilowatt-hours, and as a result of this check, I estimate a somewhat higher demand than the data submitted indicated, and believe it is essential to provide for some additional supply in 1929 over the supply of 81,500 kw. referred to above, and also that appreciable additional facilities should be provided not later than the winter of 1930. Melbourne's electrical load is growing rapidly, and will continue to grow."
>
> "The indications are, therefore, that Melbourne will soon be, in effect, almost entirely dependent for industrial and commercial power and lighting supply upon the Electricity Commission, and it is most essential that the Commission take steps at an early date to provide additional facilities, looking toward giving sufficient service in 1929 and thereafter."

17. As to the nature and location of the new plant, Mr. Sawyer summarizes his recommendations as follows :—

1. Do not install another turbine of *less* than approximately 25,000 kw. capacity.
2. Use Old Cut coal to whatever extent advisable until studies and tests can be completed and Yallourn boiler plant brought up to 60,000 kw. capacity, using 65 per cent. moisture coal.
3. Proceed at once with installation of boilers at Newport "B," so that both turbines can be operated to full capacity.
4. Hold Richmond Power Station in reserve, as planned, but do not expect to operate it in an "emergency" unless it is kept under fire, carrying some load.
5. Proceed at once with practical tests at Yallourn to determine the economics of drying coal from 65 per cent. moisture to 15 per cent. moisture.
6. Proceed with studies of new plant, and, if indications are that new plant will not be in operation by the date needed, install an additional 25,000 kw. turbine at Newport "B" in space now available in the present turbine room.
7. Unless the economics are distinctly against it, locate the new plant capacity at Melbourne.
8. Include in the study of the plant at Melbourne a study based on this plant being normally operated as a peak load station.
9. Include in the study of a new plant at Melbourne a study of burning pulverized coal.
10. Outside competent engineers should preferably be employed in connexion with the study and construction of a new plant, and one or more men of the Commission's staff should be sent abroad at once to study the latest designs of large power plant.

18. The Commission desires to make the following commentary on these recommendations :—

(*a*) The several investigations mentioned have all been made. They have been prolonged, thorough, and exhaustive, and the results are embodied in Appendices A, B, and C hereof.

(*b*) The decision (already approved by Parliament) to re-equip the Richmond Power Station with a modern generating plant has justified the indefinite postponement of recommendation No. 3 above. The duplication of the Newport "B" boiler plant will not now be necessary for at least five years.

(*c*) The Commission's investigations have definitely established that, as regards Mr. Sawyer's recommendation No. 7, the economics are distinctly against locating the new plant in Melbourne, under the load conditions expected to obtain in 1935. As this would appear to be an important departure from the expectation formed by Mr. Sawyer, Part II. of this Report is specially devoted to a discussion of the reasons for locating the new plant at Yallourn.

(*d*) Outside competent engineers have endorsed the Commission's present proposals. (See Appendix B.)

(*e*) Of the Commission's staff, Mr. Briggs, Mechanical Engineer, and Mr. Roberts, Combustion Engineer, have made extensive studies abroad, in Europe and America, of modern steam-raising and combustion practice, while the Electrical Engineer, Mr. Bate, is at present abroad studying the electrical side of the proposed scheme.

PART II.—STUDY OF ALTERNATIVE PROPOSALS.

19. *What alternatives are available?*—The use of water power having been eliminated from consideration, for the reasons given in paragraphs 14 and 15 *supra*, attention must be directed to the various classes of fuel which are available, viz. :—

(*a*) Black coal from New South Wales or from Wonthaggi.

(*b*) Brown coal from Yallourn.

(*c*) Brown coal from other Victorian fields, such as Altona or Bambra (Otway Forest).

But, closely associated with the choice of the fuel, is the choice of the best location for the new plant. Clearly, if black coal is to be used, the plant must be located at a seaport (i.e., Melbourne or Geelong). If brown coal is to be used, there are the further alternatives of siting the plant on the coal-field, and transmitting the energy to Melbourne, or of siting the plant in Melbourne and railing the coal to it. Any proposal to place the plant at the source of fuel supply (e.g., Yallourn) must necessarily take into calculation the cost of transmitting the energy to the principal market (i.e., Melbourne). Again, if brown coal is to be railed to Melbourne, the study must include the alternative of railing wet raw coal, or partially dried coal, or fully dried coal, preferably pulverized. Furthermore, the type of grates and furnaces to be used furnish subsidiary alternatives which require consideration before finality can be reached.

20. *Load Factor.*—Superimposed upon above considerations is the question of the load factor at which the plant is to operate. Of any two alternatives, the advantage may lie with one or the other, according to the character of the available load. As a broad principle, the higher the load factor, the more does the advantage lie with the transmission of the energy as against the transport of the fuel. That amounts to saying that if the load factor is of a high order a transmitted supply can be more economically operated than one generated at the centre of demand (i.e., in the metropolis). Because of this consideration, the investigation by the Commission's technical staff covered a study of the economics of every one of above alternatives, in every practicable combination, under varying load factors, ranging from 35 per cent. to 55 per cent., these being respectively the lowest and highest probable load factors available to this plant. The range is conservative, seeing that the Yallourn Power Station is operated to-day at a load factor averaging 60 per cent. It may be mentioned that the distribution of the daily load cannot be forecasted with the same certainty as the total load (i.e., maximum demand), hence the desirability of considering a wide range of probabilities.

21. The whole investigation above described is set out, in great detail, in the report of the Chief Engineer, annexed hereto. (See Appendix A.) As the reliability of the fundamental data employed in the calculations is of importance, these data and all source material have been set out in full detail. Lest it may be thought that the Commission's staff would be influenced by an unconscious bias in favour of an extension of the Yallourn plant, it should be pointed out that, under instructions from the Commission, wherever, in the course of the study, more or less arbitrary assumptions were necessary, these were made to the disadvantage of Yallourn and in favour of one or other of the competing alternatives. Numerous policy considerations in favour of Yallourn referred to herein have been intentionally disregarded in the Chief Engineer's report. Every case investigated has been reduced to a " common denominator " by basing all estimates on the over-all cost of delivering 44,000 kilowatts of power at a receiving station in the metropolis. Thus all incidental costs, both capital and operating, such as transmission costs or coal transportation costs, have been duly taken into account in their respective contexts. Appendix A forms, in fact, a valuable and comprehensive thesis upon the economics of large heat-power stations in Victoria.

22. Page 22 of Appendix A contains the ultimate financial results of a study of no less than 130 alternatives, of which the following characteristic selections will indicate, sufficiently fully, the broad conclusions to be drawn from this inquiry :—

Location.	Coal.	Firing.	Total Annual Charges.	
			At 35 per cent. Load Factor	At 55 per cent. Load Factor
			£	£
Yallourn ..	New Cut, 65 per cent. moisture	Grates ..	333,550	374,040
Yallourn ..	New Cut, 15 per cent. moisture	Grates ..	346,390	395,940
Yallourn ..	New Cut, 15 per cent. moisture	Pulverized ..	351,270	403,810
Newport ..	Bambra, 50 per cent. moisture	Grates ..	368,370	454,120
Newport ..	Yallourn New Cut, 15 per cent. moisture	Grates ..	380,640	467,310
Newport ..	Yallourn New Cut, 15 per cent. moisture	Pulverized ..	381,610	469,480
Newport ..	Wonthaggi	Grates ..	397,330	508,050
Bambra ..	Bambra, 50 per cent. moisture	Grates ..	406,300	457,580
Newport ..	New South Wales	Grates ..	406,420	522,850
Altona ..	Altona, 54 per cent. moisture (600 lb.)	Grates ..	418,030	501,930
Newport ..	Altona, 54 per cent. moisture (280 lb.)	Grates ..	464,520	598,280

23. *Conclusions.*—The investigation has established that a scheme based on the use of raw brown coal from the new Yallourn cut, in a power station located at Yallourn, has substantial ecomonic advantages over every available competitor, even if operated at only 35 per cent. load factor. If, as is probable, this new plant (being necessarily of more modern design than the existing plant) be utilized on the basic portion of the daily load, and therefore on a high load factor (55 per cent. or over), these advantages will be still more pronounced.

In addition, such a scheme, as pointed out in paragraph 13 *supra*, will enhance coal production by, roundly, 4,000 tons per day, and will therefore effect savings in the cost of coal-winning to the extent of at least 3d. per ton. This will reflect itself in a saving of the cost of coal, to plants already in existence, to the extent of, at least, £20,000 per annum.

24. Even if the disparity in favour of brown coal won at Yallourn, as against brown coal from any other source within the State, were much less pronounced than proves to be the case, the Commission would have hesitated to adopt any scheme which would necessitate the development of a new coal-field in a different part of the State, involving as it would heavy capital expenditure in plant, equipment, and housing provision, as well as divided administration and supervision. Any expectation of having to face such a necessity has been dispelled by the certainty that the Yallourn field proves still to be the most economic source of fuel supply, thus fully vindicating the original selection of that field.

Transmission Line.

25. An integral part of the scheme above selected, and forming part of the computed capital cost of same, is the duplication of the main transmission line from Yallourn to the metropolis and the establishment in the latter of a second terminal station. In the original Morwell Scheme it was proposed to erect, for the transmission of the first 50,000 kw. of output, a single tower line carrying two circuits (i.e., six conductors). This has been done, and the line has operated successfully for three and a half years. Recently, however, owing to growth of demand, and to the fact that the Yallourn Power House has been found to be capable of generating up to 60,000 kw.—having actually done so for several months past—the important question of the security of supply along this single line has recently come into prominence. There is little doubt that, quite apart from any extension of the Yallourn Power House, the matter of duplicating the main transmission line would have had to be seriously considered in the very near future. The scheme of extension proposed in this report provides for such a duplication, and assures the future secure operation of the present line.

Existing Provision for Expansion at Yallourn.

26. A further policy aspect of the final choice of location for any extension of plant lies in the fact that a considerable investment has already been made at Yallourn, in anticipation of some future extension at that site. Thus, site preparation, circulating water systems, river barrage, switch-house, workshops, roads, railways, stores, drains, and numerous services have already been effected, and are available without material expansion to serve any increment of the existing Power House. All these services, facilities, and works would have to be brought into being anew at any new site.

Richmond Terminal Station.

27. The present metropolitan terminal of the Commission's system is at Yarraville. It is now proposed that the terminal of the second or duplication transmission line shall be at Richmond. When the first terminal was completed (in 1923) the greater part of the load was provided by the industries and consumers lying in and to the west of the City of Melbourne. In recent years, however, both residential and industrial load has been steadily spreading eastward—a trend which will undoubtedly continue. By establishing a second terminal station at Richmond, a more equably balanced distributory system can be put into operation than that which is at present based upon the single terminal at Yarraville.

PART III.—FINANCIAL.

28. *Capital Cost.*—As a result of a revision of the most economic alternative, it is now estimated that the complete scheme covered by this Report will cost £2,806,000. This estimate is based upon present-day world price levels and present-day cost of loan moneys, and includes provision for interest accruing during the construction period before the respective units of the plant come into commercial operation. The distribution of this sum over the various works comprised in the scheme is as follows :—

POWER STATION—		
1. Site works, buildings, foundations, &c. ..	£308,000	
2. Machinery and plant	1,511,400	
3. Switchgear and electrical equipment	200,000	
4. General and miscellaneous	24,000	
5. Interest during construction	156,600	
		£2,200,000
TERMINAL STATION—		
1. Land, buildings, structures, and crane ..	£48,000	
2. Transformers and switchgear	136,000	
3. Machinery and other equipment	58,000	
4. Overhead and contingencies	22,000	
		264,000
TRANSMISSION LINE (two circuits)		342,000
		£2,806,000

A more detailed distribution of above total sum will be found set out in the report of the Chief Engineer, Appendix A, page 17.

29. *Segregation.*—The segregation of the expenditure into the financial years in which the loan funds will be required, as the works proceed, is as follows :—

Year.	Power Station.	Transmission Line.	Terminal Station.	Total.
	£	£	£	£
1927–28	10,600	..	..	10,600
1928–29	157,200	150,000	72,000	379,200
1929–30	367,000	65,000	118,000	550,000
1930–31	733,200	..	..	733,200
1931–32	534,000	127,000	50,000	711,000
1932–33	292,900	..	..	292,900
1933–34	105,100	..	24,000	129,100
	2,200,000	342,000	264,000	2,806,000

30. *Economics of the Scheme.*—The total capital cost per kilowatt of plant capacity is given by the following table :—

Yallourn Power House, per k.w. installed of new generating plant	75,000 k.w.	= £29·3 per k.w.
Yallourn Power House, per k.w. available ..	50,000 k.w.	= £44 per k.w.
Complete scheme, per k.w. available	44,000 k.w.	= £63·7 per k.w.

31. *Comparison with Kiewa Scheme.*—It is interesting to note that the Kiewa Scheme as envisaged in 1920 was estimated to cost £3,715,000 and to provide 37,000 kilowatts. It is certain that this cost would be much greater at present-day price levels. Such a scheme would, therefore, apart from other considerations, involve, relatively, a much greater capital investment than the scheme submitted herein.

32. *Total Annual Cost.*—The estimated total *annual* cost of the completed scheme, including all capital, managerial and operating charges, is as follows, viz. :—

When operating at 35 per cent. load factor	£335,060 per annum.
When operating at 55 per cent. load factor	£366,660 per annum.

These charges represent the following costs of 22,000-volt energy at the Richmond Terminal Station, after allowing for line and other electrical losses, viz. :—

At 35 per cent. load factor	0·597 pence per k.w. hr.
At 55 per cent. load factor	0·415 pence per kw. hr.

33. The plant is proposed to be installed progressively, unit by unit, in sympathy with the growth of public demand. Thus, the first 25,000 kw. generator set, with appropriate boiler plant and accessories, should be ready for commercial operation early in 1931, and the last or third set in 1933. Thus the scheme will commence to produce revenue when about one-half of the total investment has been made.

PART IV.—RECOMMENDATIONS.

34. We have the honour to recommend to the Government as follows:—

(*a*) That approval be given to the increase of the existing generating capacity of the State Electricity Scheme by 75,000 kilowatts installed capacity or 50,000 kilowatts available capacity, the first unit of 25,000 kilowatts to be available for service early in 1931; the whole installation to be completed in 1933.

(*b*) That the generating plant be located at Yallourn, and be based upon the combustion of brown coal from Yallourn open cut.

(*c*) That the main transmission line from Yallourn to Melbourne be duplicated with two additional circuits, the first of such circuits to be ready for service by 1930; and that a Terminal Station be erected at the Richmond site.

(*d*) That immediate authority be given for the preparation of detailed designs and specifications and calling of tenders for the whole of the works embraced in this scheme.

We have the honour to be,

Yours obediently,

JOHN MONASH, Chairman.
THOMAS R. LYLE,
ROBERT GIBSON,
F. W. CLEMENTS,
} Commissioners.

R. LIDDELOW, Secretary.
4th April, 1928.

APPENDIX "A."

REPORT OF CHIEF ENGINEER (MR. H. R. HARPER) ON NATURE, LOCATION, AND CAPACITY OF PROPOSED EXTENSION OF GENERATING PLANT.

TABLE OF CONTENTS.

APPENDIX "A."

REPORT OF CHIEF ENGINEER (Mr. H. R. HARPER) ON PROPOSED MAJOR EXTENSION OF POWER SYSTEM.

GROWTH OF DEMAND.

1. The forecast of power requirements prepared towards the end of 1926, and on the basis of which the Commission decided to install a 15,000 kw. generator at Richmond, has been subjected to a complete revision as a result of the experience gained during last winter, when it was found that the system demand had actually exceeded the forecast by about 5,000 kw.

2. A graph has been prepared, and is submitted herewith (see Plan No. 1), showing the system loads expected during each of the next ten years. In this revised forecast allowance has been made for the extension of the State scheme to those parts of Victoria of which Ballarat and Bendigo are the chief centres, and to Geelong.

3. From this graph it will be seen that the position during the next four years (1928 to 1931) with regard to the expected demands on the system and the capacity of the plants, including the sixth generator for Yallourn recently ordered, is estimated as follows :—

Year.	System Demand.	Total Available Plant Capacity.	Surplus or Deficiency.
	Kw.	Kw.	Kw.
1928	83,000	87,500	+ 4,500
1929	92,000	102,500	+10,500
1930	100,000	102,500	+ 2,500
1931	119,000	102,500	−16,500

The total available plant capacity of 102,500 kw. in the above table comprises the following :—

Yallourn	60,000 kw.
Newport "B"	16,000 kw.
Sugarloaf–Rubicon Hydro ..	11,500 kw.
Richmond	15,000 kw.

4. The figure for the Sugarloaf–Rubicon Hydro Scheme does not include the plant now being installed at the Eildon Weir, as it is uncertain as to the extent to which the latter will be available during the months of June and July in each year, if at all. Therefore, the capacity of the Hydro Scheme has been taken as solely that of the Mountain Stream Power Plants, which, on account of the pondages being provided, can be relied upon to the extent of their maximum capacity during peak load hours. These plants, it is confidently expected, will be brought into operation in time for the winter load of 1928, and in July of the same year it is expected that the sixth generator (12,500 kw.) on order for Yallourn will also be available. These increments of plant capacity, together with the standby capacity of Newport "A," should enable the system demand of 1928 to be met with a reasonable margin of security.

5. The Richmond plant extension (15,000 kw.) is planned to be completed in time for the winter load of 1929, and this, together with the extensions abovementioned, should enable the several power houses to meet all demands likely to arise until the year 1931.

6. By the winter of that year, the demand is expected to be such that if no plant extensions further than those already mentioned have been provided, a shortage will be experienced of about 16,500 kw. To obviate such a result, it will be necessary to have ready not later than early in 1931, the first instalment of a comparatively large or major installation of plant, which in its complete form should provide for the growth of the demand for a number of years.

7. The new installation should be planned with an output capacity of not less than 50,000 kw., equal to that of the existing Yallourn plant. Judging by the estimated growth of the demand, the whole of this capacity will be fully absorbed within a period of four to five years from the date of coming into operation.

SITE OF NEW PLANT.

8. In determining the most economic site for such a large installation, the following considerations have been kept in the foreground :—

(*a*) Whether such an installation should be established in Melbourne, Yallourn, or one of the other brown coal-fields of the State.

(*b*) Whether the choice of location would be affected by the adoption as fuel of brown coal partially dried before introduction to the boiler furnaces, instead of the present method of burning raw brown coal.

(*c*) To what extent would variations of load factor influence the choice of location.

In the exhaustive investigation that has been undertaken on this aspect, the use of coal from the following fields has been considered :—

Field.		*Location of Plant.*
Brown coal-fields—		
Yallourn	.. ..	Yallourn.
Altona	Typical of other undeveloped fields	Altona or Melbourne.
Bambra (Otway Forest)	similarly situated	Bambra or Melbourne.
Black coal-fields—		
Wonthaggi ..	.. ..	Melbourne.
New South Wales ..	.. ..	Melbourne.

BASES AND DATA EMPLOYED IN INVESTIGATIONS.

9. The bases and data employed in this investigation are as follow :—

(i) *Plant Capacity.*—That plant located at Yallourn burning raw coal is to be capable of a commercial output of 50,000 kw. The capacities of plants in other alternative schemes are to be such as to provide the same amount of power for distribution from a terminal station in Melbourne as would be available from the Yallourn alternative.

(ii) *Basis for Installed Plant Capacity*—

Turbo-generators—

(*a*) *Melbourne (Newport* " B ").—That the required output is to be obtained without additional spare plant, on the grounds that Newport " B " Station has one spare 15,000 kw. set already, which would then serve as the spare unit for the extended plant. The margin of one spare set out of five sets is inadequate were it not legitimate to count upon Newport " A " (Railway Power Station) in an emergency.

(*b*) *Yallourn.*—That in addition to the plant that may have to be operated for an output of 50,000 kw. there is to be provided one spare generator unit.

(*c*) *Altona and Bambra.*—(Typical of others similarly situated.) That, in addition to the plant that may have to be operated at any time for the necessary output, there is to be provided one spare generator unit. Such an allowance in an isolated station is barely adequate, but was adopted in order to give such cases the advantage over Yallourn and Newport.

Boilers—

(*a*) *Newport " B."*—Four boilers steaming, plus one boiler spare in each boiler-house.

(*b*) *Yallourn.*—Ten boilers per boiler-house steaming, plus two boilers spare.

(*c*) *Altona, Bambra, or other typical plant.*—Ten boilers steaming, plus two boilers spare.

(iii) *Energy to be Delivered to a Terminal Station in Melbourne.*—In all cases the energy to be delivered to the Melbourne Terminal Station is assumed to be equal, and is calculated by applying the load factor to the power to be made available at the terminal station when derived from Yallourn.

Allowances have been made in the energy to be generated for that required for drying and pulverizing in such cases where the coal is dried or pulverized.

(iv) *Capital Cost.*—This includes land, buildings, plant, and preliminary work in each of the following sections :—

Section 1.—Power station extending from the coal-receiving station, including coal-crushing storage and conveying plant, boiler plant, turbo plant up to and including switchgear.

Section 2.—Drying plant, including additional coal-crushing and conveying plant, with additional bunker storage, also the drying plant, dust extraction, and accessories.

In the case of drying plant for 15 per cent. moisture coal, allowance has been made for a coal cooling-house similar to that at the briquetting factory, on the grounds that such plant would be necessary in view of the tendency of such dry coal to ignite elsewhere than in the furnaces, whereas with 35 per cent. moisture coal such provision is considered to be unnecessary.

For the same reason 15 per cent. moisture coal would be dried in a building detached from the main building, whereas the drying plant in the case of 35 per cent. moisture coal could be accommodated either in the boiler-house building or in a detached building. The cost of incorporation in the boiler-house building would be slightly less than in the case of a detached arrangement, but the difference is so small that no allowance has been made in the comparison.

Section 3.—Pulverizing plant costs have been subdivided into those attributable to pulverizing as distinct from those attributable to the firing equipment. The latter have been incorporated in the power station costs in the place of grate equipment, and the former have been included in a separate section designated " Pulverizing Plant."

Section 4.—Transmission line costs include—

(*a*) Newport : cable connexions to a terminal station at Richmond.

(*b*) Yallourn : transmission line to a terminal station at Richmond.

(*c*) Altona : similar to Newport.

(*d*) Bambra (or other similarly situated) : similar to Yallourn plus Newport as an approximation only.

Section 5.—Terminal station costs include—

(*a*) Newport " B " : a terminal station at Richmond.

(*b*) Yallourn : a terminal station with synchronous condensers at Richmond.

(*c*) Altona : similar to Newport " B."

(*d*) Bambra (or other similarly situated) : similar to Yallourn, as an approximation only.

All capital costs are estimated on previous experience relating to Yallourn and Newport " B " installations adjusted according to the latest available information.

(v) *Plant Design.*—

(*a*) Newport " B " is assumed to have the same steam conditions, voltage, and arrangement of boiler-houses and turbine plant as those in the existing station.

(*b*) Yallourn is assumed to have the same steam conditions, voltage, and arrangement of boiler-house and turbine plant as those in the existing station.

(*c*) *Altona.*—In order to give every reasonable advantage to this case, two alternatives have been set down—

(*a*) One having steam conditions and, therefore, specific heat economy similar to Yallourn Power Station.

(*b*) One having a greater steam range of pressure and temperature combined with reheat and other economizing devices, with a consequent better specific heat economy.

(*d*) *Bambra (or other typical plant).*—As in the case of Altona, it being desired to give every reasonable advantage to this case, the estimates are based on a greater steam range of pressure, temperature, &c.

(*e*) *Drying Plant.*—The location of the drying plant has in all cases been assumed to be adjacent to the existing power station at Yallourn whether the coal be transported to Newport or burned at Yallourn. In the case of coal being transported to Newport, allowance has been made for an extra storage bunker at the truck-loading station.

(vi) *Efficiencies.*—All efficiencies have been based on actual results usually obtained in practice—

(*a*) *Turbine Plant.*—Although there is no real justification, other than a desire to allay any suggestion that the case for Newport has not been sufficiently favoured, the steam results assumed for Newport have been taken to be 1·9 per cent. better than those for Yallourn or any other power station.

(*b*) *Boiler Plant.*—For the sake of simplicity, it has been assumed that all plants have economizing devices to the extent of air heaters only. At Newport "B" these have proved themselves to be moderately advantageous, and the cost is less than water economizers.

In the case of brown coal having a high moisture content, it is anticipated that apart from the measurable advantages in efficiency, air heaters may assist in the ignition and thus help the manipulation of the furnaces on a rapidly-rising load. It was, of course, impossible to represent this latter advantage in the comparative figures.

The assumed yearly boiler plant efficiencies have been based on what may reasonably be anticipated in the light of present data obtained in practice. These efficiencies with each class of coal are as follows :—

BOILER PLANT OVER-ALL EFFICIENCIES (AVERAGED THROUGHOUT THE YEAR).

—	Black Coals.	Moisture Content.					
		Raw Brown Coals.				Semi-dried Brown Coal.	
		65 per cent.	54 per cent.	50 per cent.	48 per cent..	35 per cent.	15 per cent.
Yallourn new cut coal—							
Grates	..	0·64	..	..	..	0·76	0·78
Pulverized	..	..	..	..	..	0·81	0·83
Yallourn old cut coal—							
Grates	..	..	..	..	0·74	0·76	0·78
Pulverized	..	..	..	..	..	0·81	0·83
New South Wales coal—							
Grates	0·785	..	..	..	..	..	..
Wonthaggi coal—							
Grates	0·765	..	..	..	..	..	..
Altona coal—							
Grates	..	..	0·705	..	..	..	..
Bambra coal—							
Grates	..	..	..	0·73	..	..	..

(vii) *Costs of Raw Coal*—

(1) *Yallourn New Cut and Old Cut.*—Prices estimated by Engineer for Coal Supply to the State Electricity Commission.

(2) *New South Wales Coal.*—Information taken from records over past year or so, and information supplied by Victorian Railways Commissioners, with adjustments to arrive at the anticipated price for the future.

(3) *Wonthaggi.*—Similarly as in (2).

(4) *Altona.*—Report of Messrs. G. H. Broome and C. C. Klug, dated 25th October, 1919, adjusted for present increased cost of labour and material.

(5) *Bambra.*—Prices based on those for Yallourn old cut, with adjustment for local railway facilities.

(viii) *Basis for Costs of Prepared Coal*—

Dried, pulverized—

(*a*) Performance of direct dryers based on information supplied by Büttner, Germany, and supported by German technical journals.

(*b*) Performance of steam dryers based on experience at Yallourn Briquette Factory, and supported by German authorities.

(*c*) Performance of pulverized coal plant based on various authorities as Fuller Lehigh, Raymond, Atritor, Continental Babcock, and various American plants. Also test carried out at Melbourne City Council's Spencer-street Power Station, and Dr. H. Herman's report on dried and pulverized brown coal, all revised and adjusted by estimates to suit the case under consideration.

(*d*) *Data for Coal Dryer Calculations*—

Raw Brown Coal and Moisture.	Moisture Content of Dried Product.	Raw Coal to be Dried per lb. of Product lb.	Direct Fired Dryers (Raw Coal Consumed in Dryer Furnace per lb. of Product).	Total Raw Coal required per lb. of Product.
	%	lb.	lb.	
New cut: 65 per cent. ..	15	2·55	1·005	3·56
	35	1·95	0·065	2·58
Old cut: 48 per cent. ..	15	1·71	0·27	1·98
	35	1·31	0·125	1·435

(*e*) Freights on semi-dried coal are based on information supplied by the Victorian Railways Commissioners.

(ix) *Operating Costs*—

A. Variable costs—

(*a*) All operating costs are based on those prevailing at Yallourn and Newport "B" with suitable adjustments, and allowances have been made for taking advantage of the existing supervisory operating staff in the case of Yallourn and Newport.

(*b*) The operating costs of the drying plant assume supervision under the Power Station Superintendent.

(*c*) The operating costs of unit pulverizers for 35 per cent. moisture coal are incorporated in the operation of the boilers, and thus no additional allowance has been made, whereas the central pulverizing plant for the 15 per cent. moisture coal requires an operating staff which, in the case of Yallourn, would come under the supervising officer in charge of the drying plant.

(*d*) Maintenance costs are based on existing conditions and similarly, in the case of Yallourn and Newport, take advantage of the existing supervisory staff, as well as of the existing workshop organization and equipment.

(*e*) In assessing the maintenance on a plant at Newport, much larger than the existing plant, conservative figures have been taken so as not in any way to prejudice the Newport case.

B. Capital charges—

These are based uniformly for all works on—	%
Interest on capital expenditure	5·125
Sinking fund at 4½ per cent. for a life of 25 years	2·240
	7·365

C. Sundry apportionments, &c.—

In all cases, except Bambra (or other similarly situated), there exist local facilities and services, the cost of which is already provided for, so that allowance only has been made for services directly chargeable.

INFLUENCE OF LOAD FACTOR.

10. Before studying the results of the investigations in detail, it is necessary to examine the load conditions likely to prevail when the major extension is in full operation, because such conditions, to a large extent, determine the location of the extension.

The importance of this factor is clearly indicated in a graph attached to this report, Plan No. 2, in which is plotted the comparative results of all the alternative schemes considered with varying load factors. It will be seen that at a load factor of about 20 per cent., the financial results of all the alternatives approach equality, whilst with improving load factors, they steadily diverge, some of the alternatives being in a predominantly superior economic position at a high load factor, such as 55 per cent.

11. The question as to the likely load factor of that portion of the future daily output which would be served by the proposed major installation has, therefore, received careful consideration, and it has been calculated that the load factor at which the proposed installation would operate in that year is 35 per cent., but the actual figure will depend on the location of the plant. If located at Melbourne, the load factor is not likely to be higher than 35 per cent., and probably during the greater part of the life of the extension would be even less, for the reason that so long as the new plant, if located at Melbourne, is operated up to its full kilowatt capacity, the highest interests of economy would be served by transmitting to Melbourne the maximum number of kilowatt hours from the existing Yallourn plant, because of the lower fuel cost per kilowatt hour applying to the latter plant.

12. On the other hand, if located at Yallourn, the load factor on the new plant starting at 35 per cent. would steadily improve beyond 1935, as the system output developed. In addition, if the new plant, as is certain to be the case, should prove to be more economical than the existing plant under the Yallourn conditions, the former would take the place of the latter in supplying the basic portion of the output from that station, and thus would operate at a much higher load factor than 35 per cent. This matter of load factor will be referred to again, but at this stage it will suffice to say that the comparison of the numerous alternative schemes is based on a load factor of 35 per cent.

WATER POWER.

13. Although the figures contained in this report deal with fuel power station alternatives, the claims of water power developments have not been overlooked. For several years the Commission's civil engineering staff has been engaged in exploring the potentialities of water power within the borders of the State, bestowing particular attention upon those areas where the power to be produced would be of such a magnitude as to constitute valuable adjuncts to the schemes already in operation. Such areas would include the watersheds of the Kiewa and Mitta Rivers, where large blocks of power await development. The time is not ripe for the prosecution of water-power schemes of considerable magnitude, even if the preliminary investigations had been sufficiently advanced to enable them to be considered as concrete propositions. The demand for energy throughout the 24 hours is not of sufficient continuity and magnitude to justify construction works being decided upon for some years to come.

Further power schemes based on hydro-electric development must, therefore, be held over until the demand conditions justify their prosecution, and cannot be considered at this stage as an alternative to the installation of fuel-power plant extension.

COMPARATIVE COSTS OF THE SEVERAL ALTERNATIVE SCHEMES.

14. The annexed table contains a summary of the estimated capital expenditures and annual charges of the several alternative schemes investigated, based on varying load factors :—

Alternative No.	Class of Coal.	Predried to.	Firing.	At 35 per cent. Load Factor.		At 40 per cent. Load Factor.		At 45 per cent. Load Factor.		At 50 per cent. Load Factor.		At 55 per cent. Load Factor.	
				Capital Expenditure.	Annual Charges.	Capital Expenditure.	Annual Charges.	Capital Expenditure.	Annual Charges.	Capital Expenditure.	Annual Charges.	Capital Expenditure.	Annual Charges.
				£	£	£	£	£	£	£	£	£	£
	PLANT LOCATED AT YALLOURN.												
1	Old cut, raw, 48 per cent. moisture ..	.. .. ..	Grates ..	2,466,800	324,570	2,470,100	335,080	2,473,400	345,790	2,476,500	356,380	2,479,800	367,250
2	New coal, raw, 65 per cent. moisture ..	.. .. ..	,, ..	2,691,600	333,550	2,696,400	343,330	2,701,500	353,180	2,706,900	363,310	2,712,400	374,040
3	New cut	35 per cent. moisture ..	,, ..	2,650,540	345,520	2,673,870	357,680	2,696,510	370,160	2,718,930	382,380	2,741,500	394,610
4	,, ...	,, ,, ..	Pulverized ..	2,783,945	353,440	2,807,190	366,660	2,828,765	379,630	2,850,940	392,800	2,873,285	406,190
5	,, ...	15 per cent. moisture ..	Grates ..	2,662,280	346,390	2,690,790	358,930	2,718,700	371,160	2,746,590	383,900	2,773,230	395,940
6	,, ...	,, ,, ..	Pulverized ..	2,763,910	351,270	2,801,280	364,410	2,833,180	377,310	2,866,010	390,510	2,897,790	403,810
7	Old cut	35 per cent. moisture ..	Grates ..	2,546,360	346,930	2,557,610	359,350	2,567,490	371,710	2,578,100	384,340	2,587,730	396,760
8	,, ...	,, ,, ..	Pulverized ..	2,686,255	354,140	2,696,410	367,520	2,707,125	380,880	2,717,090	394,130	2,727,115	407,570
9	,, ...	15 per cent. moisture ..	Grates ..	2,563,760	348,860	2,579,330	361,650	2,596,240	374,240	2,611,570	387,130	2,627,410	399,880
10	,, ...	,, ,, ..	Pulverized ..	2,673,520	352,900	2,693,680	366,260	2,714,420	379,440	2,734,990	393,180	2,755,490	406,660
	PLANT LOCATED AT NEWPORT.												
	Yallourn Brown Coal.												
1	New cut	35 per cent. moisture ..	Grates ..	2,249,430	408,850	2,275,920	434,050	2,300,480	459,340	2,326,030	484,490	2,352,850	510,230
2	,, ...	,, ,, ..	Pulverized ..	2,389,485	412,420	2,414,730	437,880	2,439,655	463,950	2,465,500	489,600	2,489,475	515,900
3	,, ...	15 per cent. moisture ..	Grates ..	2,235,740	380,640	2,264,130	402,080	2,293,820	423,770	2,322,840	445,360	2,350,560	467,310
4	,, ...	,, ,, ..	Pulverized ..	2,340,510	381,610	2,373,860	403,175	2,404,790	425,300	2,436,600	447,110	2,467,580	469,480
5	Old cut, raw, 48 per cent. moisture ..	.. .. ..	Grates ..	2,046,440	375,380	2,051,240	397,610	2,055,650	420,100	2,059,970	442,280	2,064,360	465,170
6	Old cut	35 per cent. moisture ..	,, ..	2,151,130	405,150	2,164,480	429,930	2,178,100	454,800	2,191,390	479,240	2,204,760	504,770
7	,, ...	,, ,, ..	Pulverized ..	2,295,840	408,400	2,309,715	433,660	2,322,870	459,100	2,336,285	484,330	2,349,800	509,420
8	,, ...	15 per cent. moisture ..	Grates ..	2,141,200	379,710	2,158,140	401,030	2,176,780	422,630	2,193,890	444,110	2,211,060	465,910
9	.. ..	,, ,, ..	Pulverized ..	2,252,360	380,710	2,272,660	402,440	2,293,220	424,230	2,312,650	445,930	2,332,260	468,180
	Black Coal.												
11	New South Wales	.. .. ..	Grates ..	1,841,000	406,420	1,843,200	435,650	1,845,500	464,230	1,848,000	493,380	1,850,750	522,850
12	Wonthaggi	.. .. ..	,, ..	1,860,400	397,330	1,862,800	424,800	1,865,100	452,480	1,867,200	480,150	1,869,000	508,050
	Altona Coal.												
13	Raw—54 per cent. moisture, 600 lb. sq. inch	.. .. ..	Grates ..	2,113,010	464,520	2,118,180	497,630	2,123,250	530,780	2,128,320	564,070	2,133,500	598,280
	Bambra Coal.												
14	Raw—50 per cent. moisture, 600 lb. sq. inch	.. .. ..	Grates ..	2,065,130	368,330	2,070,090	389,360	2,074,890	411,080	2,079,420	431,970	2,084,290	454,120
	PLANT LOCATED AT ALTONA.												
1	Raw—54 per cent. moisture, Altona, 600 lb. sq. inch	.. .. ..	Grates ..	2,558,200	418,030	2,560,900	438,780	2,563,900	459,760	2,567,000	480,630	2,570,000	501,930
2	Raw—54 per cent. moisture, Altona, 280 lb. sq. inch	.. .. ..	,, ..	2,350,600	434,930	2,354,100	459,940	2,357,600	485,040	2,361,100	510,080	2,364,600	536,200
	PLANT LOCATED AT BAMBRA (OR SIMILAR ALTERNATIVE).												
1	Raw—50 per cent. moisture, Bambra, 600 lb. sq. inch	.. .. ..	Grates ..	3,148,300	406,300	3,151,900	418,770	3,155,300	431,820	3,158,500	444,720	3,161,800	457,580

15. Considering for the moment those alternative schemes, based on a load factor of 35 per cent., it will be noted that they naturally fall into two main groups, as defined and set out below. The alternatives in the second group have been investigated on the assumption that the proposed plant, if situated in the vicinity of Melbourne, would be installed as an extension of the existing Newport "B" Station. No other site in the metropolis offers the facilities which exist at Newport for the construction and efficient operation of so important a power plant as the one now under consideration. The two main groups mentioned above are as follows :—

THOSE BASED ON GENERATION AT A SITE IN THE VICINITY OF ONE OR OTHER OF THE BROWN COAL-FIELDS OF THE STATE, AND THE TRANSMISSION ELECTRICALLY OF THE ENERGY TO MELBOURNE AS THE MAIN CENTRE OF DISTRIBUTION FOR THE STATE.

Power Station.	Coal.	Firing.	Total Annual Charges.	Capital Expenditure.
			£	£
Yallourn ..	Yallourn—			
	Old Cut, 48 per cent. moisture	Grates ..	324,570	2,466,800
„ ..	New Cut, 65 per cent. moisture	„ ..	333,550	2,691,600
Yallourn ..	Yallourn—			
	New Cut, 65 per cent. moisture, dried to 35 per cent. ..	Grates ..	345,520	2,650,540
„ ..	New Cut, 65 per cent. moisture, dried to 15 per cent. ..	„ ..	346,390	2,662,280
„ ..	Old Cut, 48 per cent. moisture, dried to 35 per cent. ..	„ ..	346,930	2,546,860
„ ..	Old Cut, 48 per cent. moisture, dried to 15 per cent. ..	„ ..	348,860	2,563,760
Yallourn ..	Yallourn—			
	New Cut, 65 per cent. moisture, dried to 15 per cent. ..	Pulverized ..	351,270	2,768,910
„ ..	Old Cut, 48 per cent. moisture, dried to 15 per cent. ..	„ ..	352,900	2,673,520
„ ..	New Cut, 65 per cent. moisture, dried to 35 per cent. ..	„ ..	353,440	2,783,945
„ ..	Old Cut, 48 per cent. moisture, dried to 35 per cent. ..	„ ..	354,140	2,686,255
Bambra ..	Bambra, 50 per cent. moisture	Grates ..	406,300	3,148,300
Altona (600 lb.) ..	Altona—			
	54 per cent. moisture	„ ..	418,030	2,558,200
Altona (280 lb.) ..	54 per cent. moisture	„ ..	434,930	2,350,600

THOSE BASED ON GENERATION AT A SITE WITHIN THE METROPOLIS OF MELBOURNE, SUCH AS NEWPORT, USING AS FUEL EITHER BLACK COAL (IMPORTED OR LOCAL) OR BROWN COAL.

Power Station.	Coal.	Firing.	Total Annual Charges.	Capital Expenditure.
			£	£
Newport ..	Bambra, 50 per cent. moisture	Grates ..	368,330	2,065,130
„ ..	Yallourn—			
	Old Cut, 48 per cent. moisture	„ ..	375,380	2,046,440
„ ..	Old Cut, 48 per cent. moisture, dried to 15 per cent. ..	„ ..	379,710	2,141,200
„ ..	New Cut, 65 per cent. moisture, dried to 15 per cent. ..	„ ..	380,640	2,235,740
„ ..	Old Cut, 48 per cent. moisture, dried to 15 per cent. ..	Pulverized ..	380,710	2,252,360
„ ..	New Cut, 65 per cent. moisture, dried to 15 per cent. ..	„ ..	381,610	2,340,510
„ ..	Wonthaggi	Grates ..	397,330	1,860,400
„ ..	Yallourn, Old Cut, 48 per cent. moisture, dried to 35 per cent. ..	„ ..	405,150	2,151,130
„ ..	New South Wales	„ ..	406,420	1,841,000
„ ..	Yallourn—			
„ ..	Old Cut, 48 per cent. moisture, dried to 35 per cent. ..	Pulverized ..	408,400	2,295,840
„ ..	New Cut, 65 per cent. moisture, dried to 35 per cent. ..	Grates ..	408,850	2,249,430
„ ..	New Cut, 65 per cent. moisture, dried to 35 per cent. ..	Pulverized ..	412,420	2,389,485
„ ..	Altona, 54 per cent.	Grates ..	464,520	2,113,010

16. The second group in the foregoing table includes alternative schemes, one involving the use of black coal from the State Coal Mine at Wonthaggi, and another, coal from New South Wales. Whilst the former has a greater claim upon our attention for the reason that it provides for the utilization of what is one of the natural resources of the State, the estimates indicate that the adoption of any of the alternatives under this group would result in comparatively high annual charges.

17. There is nothing to be gained by further consideration of this second group, and its elimination reduces the investigation to a consideration of alternatives placed upon the common basis of the utilization of brown coal, as the sole source from which the required power is to be produced.

18. Certain of the brown coal-fields, in addition to Yallourn, have received attention in this investigation, and their claims for exploitation have been considered. The fundamental data with regard to all fields, other than Yallourn, is uncertain, and based upon estimates which, while founded on reasonable assumptions, have to be accepted with considerable reserve, as no two fields are likely to be developed under precisely similar conditions. Nothing has been revealed which would suggest the advisability of starting operations on a field other than Yallourn, and the same result would apply to fields other than those mentioned in the investigation.

19. The main object in considering the claims of the Bambra and Altona fields was to ascertain whether either of the fuels therefrom would place a power station in Melbourne, such as Newport, in a position to compete economically with a Yallourn extension. For that purpose, these two fields were looked upon as being the most likely of all those available to produce the most economic results. The conclusions show that Bambra coal burned at Newport was

slightly more economical than Yallourn coal burned at Newport, while Altona coal, for the same purpose, was even less economical than the black coals (Wonthaggi and New South Wales). Neither of these brown coals, when used at Newport, could compete economically with Yallourn coal burned in the Yallourn power station, coupled with the transmission of the energy therefrom to Melbourne.

20. Since the completion of this investigation, an offer has been received from the owners of the Altona Mine to supply the Commission with coal at 6s. 3d. per ton at the pit. The cost assumed in the investigation is 10s. per ton at the pit, a figure considered to be the minimum cost likely under the exceptionally difficult mining conditions prevailing at Altona, and more in consonance with the results of the investigation carried out on behalf of the Commission in 1919 by Messrs. Klug and Broome, after allowing adjustments for increased labour costs since that date. The acceptance of the above-mentioned offer of the mine-owners, however, would have no further effect than placing the Altona alternative approximately level with the black coal alternatives at Newport, which, as already mentioned, are comparatively high in annual charges.

21. In view of the above, and the economic positions occupied by the alternative schemes based on the use of brown coals, there is nothing to be gained by further considering the claims of coal-fields, other than Yallourn, as a source of fuel supply for either a Melbourne station or one situated on the coal-field.

22. The elimination of all other brown coal-fields reduces the two groups of schemes for further consideration to one involving an extension of the present Yallourn Power Station with transmission to Melbourne, and the other an extension of Newport "B" Power Station, in each case using Yallourn brown coal, either from the new cut or the old cut.

23. Several of the alternative schemes considered are based upon the use of coal from the old cut at Yallourn. Consideration of such alternatives has been undertaken more as an academic study than from the point of view of practical propositions, for the Commission has definitely stated that coal from the old cut would not be available as fuel for future power station operations, owing to the limited quantity available.

24. From the estimates, it will be noted that with a load factor of 35 per cent. the estimated annual charges of an extension of power station plant at Yallourn, are as follow:—

Power Station.	*Yallourn Coal.*	*Annual Charges.*
Yallourn	Old Cut, 48 per cent. moisture	.. £324,570
Yallourn	New Cut, 65 per cent. moisture	.. £333,550

25. The difference in favour of old cut coal, for a Yallourn Power Station, is about £9,000 per annum, and is based on estimated coal costs per ton of 2s. for the new cut and 4s. 7d. for the old cut. This difference would be more than wiped out by a reduction in the new cut coal cost to 1s. 8d. per ton, which is the estimated cost of new cut coal on a daily output of 10,000 tons.

26. If that be the situation as regards the alternative use of old and new cut coal for a power station extension at Yallourn, what is the position as regards these two fuels in the case of a power station in Melbourne? With the same load factor, the lowest estimated annual charges of an extension of Newport with new cut and old cut coal respectively are as follows:—

Power Station.	*Yallourn Coal.*	*Annual Charges.*
Newport	Old Cut, 48 per cent. moisture	.. £375,380
Newport	New Cut, 15 per cent. moisture	.. £380,640

27. The difference in annual charges in favour of old cut coal is £5,260, which would be entirely eliminated by a reduction in new cut coal costs from 2s. to 1s. 9½d. per ton.

This is well within the possibilities of the new cut operating costs under the conditions of greater output likely to prevail within the next four years.

28. Yallourn old cut coal being thus eliminated, the alternative schemes remaining to be considered in the two groups are all found to rest on the common basis of the use of Yallourn new cut coal, one group involving an extension of the Yallourn power station, and the other an extension of Newport "B."

29. These remaining alternatives may now be set out as follows:—

GROUP OF ALTERNATIVE SCHEMES BASED ON GENERATION AT YALLOURN WITH NEW CUT COAL AND TRANSMISSION TO MELBOURNE (LOAD FACTOR, 35 PER CENT.).

Power Station.	Yallourn New Cut Coal.	Method of Firing.	Annual Charges.
			£
Yallourn	65 per cent. moisture	Grates	333,550
Yallourn	Dried to 35 per cent. moisture	,, ...	345,520
Yallourn	Dried to 15 per cent. moisture	,, ...	346,393
Yallourn	Dried to 15 per cent. moisture	Pulverized ..	351,270
Yallourn	Dried to 35 per cent. moisture	,, ..	353,440

GROUP OF ALTERNATIVE SCHEMES BASED ON GENERATION AT NEWPORT "B" WITH NEW CUT COAL.

Power Station.	Yallourn New Cut Coal.	Method of Firing.	Annual Charges.
			£
Newport "B" ..	Dried to 15 per cent. moisture	Grates	380,640
Newport "B" ..	Dried to 15 per cent. moisture	Pulverized ..	381,610
Newport "B" ..	Dried to 35 per cent. moisture	Grates	408,850
Newport "B" ..	Dried to 35 per cent. moisture	Pulverized ..	412,420

30. It will be noticed that alternative schemes in both groups have been worked out for Yallourn new cut coal reduced in moisture content from 65 per cent. to 35 per cent. and 15 per cent. respectively, and, in addition, in the first group, viz., the Yallourn Power Station alternatives, for Yallourn new cut coal used in the raw state (65 per cent. moisture content). This last mentioned is the most economical alternative of all, but it is interesting to note that all of the alternatives in the first group are more economical than any in the second group.

31. A comparison of the most economical alternative in each group shows that a saving of £47,000 in annual charges would accrue by adopting the scheme of extension of the Yallourn power station in preference to extending the Newport "B" power station, after allowing for the cost of transmission of energy from Yallourn to Melbourne. This result is based on an assumed load factor of 35 per cent.

32. In the event of the extension being located at Yallourn, it is estimated that owing to the probability of the more modern plant being higher in efficiency than that existing at Yallourn, a collateral advantage of about £5,000 per annum would accrue by utilizing the proposed new plant on the basic portion of the load curve.

33. The location of the extension at Yallourn would, therefore, show an advantage over an extension at Newport equivalent to £52,000 in annual charges. This advantage is so substantial that nothing would be gained by a further examination of the two rival schemes.

34. Although it has been shown that on purely economic grounds the supply of a 50,000 kw. block of power by transmission from Yallourn is the most favorable, the duplication of the transmission line has a distinct bearing on the question as to whether an extension at Yallourn should be preferred to one at Newport.

35. *Transmission Line.*—The present transmission line consists of two circuits, having a combined maximum capacity at the sending end of about 60,000 kw. within reasonable limits of regulation. The load at present being carried by this line is well over 50,000 kw., and with the extension of generating plant already arranged for, and improvements being effected in the boiler plant, the line will be called upon to transmit regularly loads equal to the maximum capacity of its circuits. In the event of failure of one of the circuits, it would be found impossible for this line to maintain other than a restricted supply to Melbourne during the period of failure, for the maximum that could be transmitted through one circuit under emergency conditions is 40,000 kw.

36. In the construction of this line, sufficient width of right-of-way was secured to enable a second steel tower line to be erected whenever the circumstances warranted it. This duplication would enable double the present amount of power being transmitted through three of the circuits, with the remaining circuit out of use.

37. The time has arrived when from the point of view of security of supply, the duplication of the line should be proceeded with. The economic factors weigh heavily in favour of an extension of plant at Yallourn, and the duplication of the line follows as a matter of course, but the need for duplication for the sake of security would have more than offset a considerable economic disability, had such existed in connexion with a Yallourn plant extension.

38. It may be argued, however, that a transmitted supply does not possess the same degree of reliability as one from a power station situated at, or near, the point of demand. This argument carried a great deal of weight in the early days of development of the art of electrical transmission, but experience has brought about such improvements in design and maufacture of insulating materials that this limitation has been almost entirely removed. Under the climatic conditions prevailing in Victoria, there should be no anxiety as to the reliability of transmission at the voltage employed on the Yallourn to Melbourne line.

CONCLUSIONS.

39. The conclusions that have been reached as the result of a careful study of the position with regard to the power requirements of the next few years, and the means whereby these requirements could be satisfactorily met, are :—

(1) That the estimated system demand during the winter of 1931 is 119,000 kw.

(2) That if no further generating plants be provided, other than those now under construction, or ordered, there will be a deficiency in plant capacity of the order of about 16,500 kw. in meeting the estimated system demand of the year 1931.

(3) That the estimated system demand of that year, and following years, warrant the Commission in undertaking an extension of generating plant having an available capacity of the order of 50,000 kw., the first instalment of which should come into operation not later than early in 1931.

(4) That this extension of plant should be located at Yallourn.

40. In arriving at these conclusions, the limitations of the Latrobe River for cooling purposes have not been lost sight of. A continuous record of river gaugings at Yallourn has been kept for several years, supplementing the records kept by the State Rivers and Water Supply Commission for a previous period of 40 years, and from these it is possible to state that there will be no difficulty in designing this extension plant so that the full power output is obtainable under conditions of minimum river flow. The circulating water situation would be definitely eased should it be decided to reduce the moisture content of the coal by the installation of steam driers.

41. A time programme of the works to be undertaken in connexion with this extension has been prepared, which indicates that, provided the authority to prepare and issue specifications for plant is furnished without delay, there is every reason to expect that the first instalment of the extension could be brought into operation in time for the winter load of 1931, subject, of course, to the additional coal being made available as and when required.

42. A number of alternative schemes based on various methods of firing the new cut coal have been examined. The one possessing the feature of lowest annual charges is based on the burning of raw coal on grates, which is the system in operation in the present power station at Yallourn. Alternative schemes provide for the predrying of the coal to 35 per cent. and 15 per cent. moisture content, and their utilization on grates and in pulverized form respectively. It is interesting to note that for an installation in the vicinity of the coal-field, the annual charges of a number of alternative schemes involving the drying of brown coal, are on an ascending scale, as the moisture content in the coal assumed is reduced from 65 per cent. to 15 per cent., whereas for an installation remote from the coal-field, such as at Newport, the reverse holds good. This is due to the influence of freight on the water content of coal transported over long distances.

43. It will have been noticed that several of the schemes have been based on the use of semi-dried fuel at Yallourn; the drying would be effected either by a direct drying or a steam drying method. These schemes are to be accepted at present only as an indication of their comparative commercial value, and not in the sense of a final estimate in any individual case. Whilst the steam method of drying indicates an economy over the other method, both of them are somewhat inferior in this sense when compared with the method of burning raw fuel on grates. The superiority of the latter at 35 per cent. load factor, however, is less than £12,000 a year in annual charges, and as this figure represents an estimated difference of about 3 per cent., it will be readily seen that such a margin might easily disappear in a comparison of final and detailed designs. The stage has not yet been reached when a definite recommendation can be made as to whether one system of fuel treatment or another should be adopted.

44. It is also of interest to point out that the alternative schemes dealing with Yallourn new cut coal have all been prepared on the assumption that the moisture content of the coal in its raw state, as it reaches the place of utilization, will be 65 per cent. This is the maximum moisture content found in the new cut coal as delivered to the boiler-house at Yallourn. At the present time it averages about 63 per cent., and when the cut is further developed there is every reason to expect a still lower moisture content. To show the effect of this factor on the annual charges of the proposed extension of plant, it has been calculated that on a basis of 62 per cent. moisture content, these charges would be reduced in the case of raw fuel being burnt on grates, by £14,000, with a load factor of 55 per cent., a reduction in total annual charges of 1·25 per cent., or in coal charges of 5 per cent. for every 1 per cent. reduction of moisture content. The less moisture in the coal from the new cut, the less advantage there is to be gained by adopting pre-drying methods in a plant situated at Yallourn, and in the event of an ultimate recommendation being made to install a system based on pre-drying, considerations other than financial will be found to have carried weight. In such considerations will be included the relative facilities with which steam can be raised quickly, and controlled, the reduced labour in the boiler-house, and the possibility of undertaking the supply of semi-dried fuel for the power station at Newport. These are matters which are still under consideration.

45. The estimates, particularly those for the most economic alternative, viz., the installation of the extension at Yallourn, burning raw fuel, provide for a generator plant of installed capacity of 62,500 kw.*, costing £2,100,000 approximately. The capacity to be finally adopted will depend on the size of unit chosen, either before or after tenders have been received. A decision thereon will depend to a very large extent on the maximum size of unit considered satisfactory at the speed of 3,000 revolutions per minute, and the corresponding spare plant capacity. It may also depend somewhat on the decision as to whether a coal pre-drying method is to be a feature of the design.

46. The estimates also provide for the duplication of the existing transmission line at a cost of £342,000, and a terminal station at Richmond costing £264,000. The transmission line will follow the route of the present line as far as a point near Wheeler's Hill, diverting thence on a right-of-way already acquired along Gardiner's Creek, to the site of the new terminal station, near the old quarries at Richmond.

RECOMMENDATONS.

47. I have, therefore, the following recommendations to make :—

1. That the Commission approve of the proposal to install an extension plant and switchgear at the Yallourn Power Station, capable of an output of 50,000 kw., the first portion of which is to come into operation not later than early in the year 1931.

2. That approval be given to the proposal to duplicate the existing transmission line and to install a terminal station with the necessary machinery therein, to be ready preferably by the winter of 1930.

3. That authority be given to proceed at once with the drafting of specifications, and the calling for tenders for the whole of the works mentioned.

H. R. HARPER,
Chief Engineer.

26th September, 1927.

* See Chief Engineer's Supplementary Report of 5th March, 1928.

SUPPLEMENTARY REPORT OF THE CHIEF ENGINEER (Mr. H. R. HARPER).

PROPOSED MAJOR EXTENSION OF POWER SYSTEM.

In my main report on the above subject, there were mentioned certain matters concerning the design of the proposed power station plant extension, which were left over for further consideration, viz. :—

A. The advisability of using partially dried brown coal in the boiler furnaces.
B. The unit capacity of the turbo-generator plant.

In this memorandum, not only are the above matters dealt with, but estimates of capital expenditure and annual charges are submitted, based upon the works which I recommended the Commission to undertake as a result of the decision to locate the major installation at Yallourn.

A.—It will be remembered that in the main report above referred to, a table is shown in paragraph 29, setting out the final group of alternative schemes based on generation at Yallourn. In this table the most economic alternative was the scheme which provided for the burning of raw coal in a plant to be situated at Yallourn and the estimated annual charges of this alternative, at 35 per cent. load factor, were approximately £12,000 less than those of the scheme in which partially dried fuel (35 per cent. moisture) was assumed to be used.

The plant that is intended for installation at Yallourn will probably operate at a load factor of at least 55 per cent., and under this condition the difference in annual charges between the raw coal and dried coal schemes will be increased to about £20,000 in favour of the former.

Consideration has been given to the question as to whether the use of partially dried fuel in the power station boilers would offer advantages of sufficient weight to more than off-set the higher annual charges involved. The greater fuel economy obtainable from the utilization of partially dried fuel was fully allowed for in estimating the annual charges of the numerous alternatives considered in the main report, in which this class of fuel was assumed to be used. There remained, however, questions as to the quality of service that might be expected from the use of dried fuel, as apart from economy, so the matter of a final decision as to the type of steam plant was held over pending further consideration.

Undoubtedly the use of dried fuel in the power station would facilitate the rapid raising of steam at peaks and other times when rapid increases of load have to be met. On the other hand, the simplicity of operation where the preparation of fuel has not to be undertaken, and the fact that the process of burning raw brown coal presents no serious uncertainties, make one loath to advocate a system introducing new problems, and at a considerably greater annual cost.

I have come to the conclusion, therefore, that the additional link in the process of fuel combustion that would be introduced if a drying plant were provided, and the consequential higher annual charges, are not justified by the results obtainable by using semi-dried fuel.

B. The original investigation as to the most economical scheme for the supply of 50,000 kw. was based, so far as the Yallourn alternatives were concerned, upon an installation of 62,500 kw. composed of five units, of which one was to be a spare.

The number and size of units mentioned were chosen, in this case, in order that the spare plant capacity ratio in all alternative schemes would be approximately the same.

Having decided as to the most suitable alternative scheme for adoption—namely, the extension at Yallourn—the question as to the number and size of plant units has received further consideration, and I now recommend that tenders be invited for three units, each of 25,000 kw. capacity, inclusive of one spare unit. My reasons for this may be stated thus :—

(i) The Yallourn Station has already six units, each of 12,500 kw., and to continue extending the station indefinitely with units of this capacity would result in a number of plant units unnecessarily great for the safe carrying of the station load, with consequential higher costs of supervision during operation than would be necessary if fewer and, therefore, larger units were installed.

(ii) The larger units of plant are likely to be more economical in steam consumption.

(iii) The increased capacity of the spare unit would increase the reliability of the whole station, and at a cost but slightly greater than that of the alternative. Actually, the cost per kw. installed will be lessened.

(iv) The unit size of 25,000 kw. is not too large for Australian manufacturers to handle.

Estimated Capital Expenditure and Annual Charges.—In view of the decision reached to recommend that tenders be invited for three 25,000 kw. turbo-generators, and the fact that the proposed plant extension at Yallourn will probably take the basic portion of the station load—that is to say, it will operate on a load factor of at least 55 per cent.—it has been necessary to slightly amend the estimate of capital expenditure previously submitted.

The revised estimate, which includes interest during construction, provides for an expenditure as follows :—

Power station (Yallourn)	£2,200,000
Terminal station (Richmond)	264,000
Transmission line (2 circuits)	342,000
Total	£2,806,000

This capital expenditure will be spread over a period of years as stated below :—

Year.	Power Station.	Transmission Line.	Terminal Station.	Total.
	£	£	£	£
1927-28	10,600	..	..	10,600
1928-29	157,200	150,000	72,000	379,200
1929-30	367,000	65,000	118,000	550,000
1930-31	733,200	..	..	733,200
1931-32	534,000	127,000	50,000	711,000
1932-33	292,900	..	..	292,900
1933-34	105,100	..	24,000	129,100
	2,200,000	342,000	264,000	2,806,000

Consequential upon the revision of estimated capital expenditure, a revised estimate of the annual charges has been prepared as follows :—

35 per cent. load factor £335,060
55 per cent. load factor £366,660

Details of the estimates of capital expenditure and annual charges are set out in attached Schedules Nos. 1 and 2.

Programme.—The following is submitted as the time schedule to which construction will be expected to conform in order that the future demands for energy can be safely met :—

Power Station—

Turbo-generators—

1st unit to be ready for service	January, 1931
2nd unit to be ready for service	March, 1932
3rd unit to be ready for service	May, 1933

Boilers—

1, 2, 3, 4 to be ready for service	January, 1931
5, 6, 7, 8 to be ready for service	June, 1931
9 and 10 to be ready for service	February, 1932
11 and 12 to be ready for service	February, 1933

Transmission Line—

1st circuit to be ready for service	March, 1930
2nd circuit to be ready for service	March, 1932

Terminal Station—

Initial stage to be ready for service	March, 1930
Final stage to be ready for service	March, 1932

H. R. HARPER,
Chief Engineer.

SCHEDULE No. 1.

PROPOSED MAJOR EXTENSION OF POWER SYSTEM.—SCHEDULE OF ESTIMATED CAPITAL EXPENDITURE.

	£	£
Yallourn Power Station (installed generator capacity, 75,000 kw.)—		
1. Land, site works, drainage, roads, fencing, and steel structural buildings	308,000	
2. Coal and ash handling	126,000	
3. Tanks, heaters, filters, evaporators, feed pumps, &c.	61,400	
4. Cranes and hoists	6,600	
5. Boilers, firing equipment, chimneys, flues and dampers, galleries and ladders, &c.	617,000	
6. Turbo-alternators and condensing plant	374,000	
7. Circulating water system	6,400	
8. Piping, valves and fittings, &c.	100,000	
9. Switchgear	200,000	
10. Auxiliary fixtures and fittings, preliminary work, investigations, tests, and general	24,000	
11. Interest during construction	156,600	
		2,200,000
Terminal Station (Richmond)—		
1. Land, buildings, structures, and crane	48,000	
2. Transformers and switchgear	136,000	
3. Machinery and other equipment	58,000	
4. Overhead and contingencies	22,000	
		264,000
Transmission Line **(2 circuits)**		342,000
Total		2,806,000

SCHEDULE No. 2.

PROPOSED MAJOR EXTENSION OF POWER SYSTEM.—SCHEDULE OF ESTIMATED ANNUAL CHARGES.

	Load Factor, 55 per cent.		Load Factor, 35 per cent.	
	£	£	£	£
Power Station—				
Variable Charges—				
Coal	78,200		51,000	
Coal and Ash Handling—Operation	7,860		7,860	
Operation Stores	2,900		2,700	
Standing Charges—				
Capital Charges	162,000		162,000	
Coal and Ash Handling—Maintenance	8,100		7,300	
Remainder of Plant—Operation	16,000		16,000	
Remainder of Plant—Maintenance	32,400		29,000	
Sundry Apportionments	1,200		1,200	
Total Generation Charges		308,660		277,060
Transmission Line—				
Operation, Maintenance, Salaries, Wages, &c.	3,300		3,300	
Capital Charges	25,200		25,200	
		28,500		28,500
Terminal Station—				
Operation, Maintenance, Salaries, Wages, &c.	10,000		10,000	
Capital Charges	19,500		19,500	
		29,500		29,500
Total Annual Charges		366,660		335,060

MEMORANDUM FROM THE CHAIRMAN OF THE STATE ELECTRICITY COMMISSION OF VICTORIA TO THE POWER ADVISORY BOARD.

The Board is asked to submit its views on the conclusions reached in the report of the Chief Engineer on a "Proposed Major Extension of Generating Plant," dated 26th September, 1927, and recommendations therein, and the accompanying investigation of the M./E. with regard to the location of major generating plant extensions, dated 26th July, 1927, particularly in regard to the following specific matters related thereto :—

1. The rate at which the demand for energy from the State scheme is likely to grow during the next five years or more.
2. The extent to which the Commission's generating plants, existing and under construction, will be able to satisfactorily cope with the demands estimated to arise in those years.
3. The date by which a further increment of generating plant must be constructed and brought into operation to maintain a satisfactory margin of security, and the ultimate capacity of such extension.
4. The most economic location of this extension with due regard to the point at which the energy will require to be delivered.

(Sgd.) JOHN MONASH,
Chairman.

28th September, 1927.

APPENDIX "B."

REPORT OF POWER ADVISORY BOARD

ON

PROPOSED MAJOR EXTENSIONS OF POWER SYSTEM.

APPENDIX "B."

The Chairman,

State Electricity Commission.

SIR,

In response to your request of the 28th ult. for the views of the Board on the conclusions reached in the Report of the Chief Engineer on "Proposed Major Extensions of Power System," dated 26th September, 1927, and the recommendations therein, &c., the Board has pleasure in complying therewith, and taking the specific matters mentioned in your memo., begs to reply thereto as follows :—

1. We have examined the Commission's records of the system demand over a period of several years, up to and including the winter of 1927, and the estimates of growth for future years as set out in the graphs accompanying the Chief Engineer's above-mentioned report.

It is always difficult to estimate correctly the demand, especially for several years ahead, notwithstanding the data collected in previous years as to the actual growth. We are of the opinion, however, that the estimates submitted to the Board may be taken as reasonable assumptions of the demands likely to develop during the next five years or so on which to formulate plans for extensions of generating plant. To take any lower estimate would be looking for trouble, particularly in view of the experience during the recent winter, when the demand was found to have much exceeded the estimate.

2. We have considered all the data and information available with regard to the capacities of the Commission's existing plants, and those under construction, and are satisfied that with these plants the Commission will be able to meet the estimated demands on the system that will occur up to, but not beyond, the winter of 1930. In reaching this conclusion, the Board has kept in mind the fact that for this period at least material assistance will still be available from the surplus plant capacity of Newport "A," in conjunction with the frequency changer plant at the Yarraville Terminal Station.

3. We are of the opinion that a substantial increment of generating plant capacity must be provided by the has Commission in anticipation of the winter demand of 1931. Judging by the rate at which the demand on the system grown, and the considerable increment of load that will accrue when the contemplated extension of the supply system in the direction of Bendigo, Ballarat, and Geelong is carried out, the Board has formed the opinion that the capacity of the generating plant to be provided should be of a major character, sufficient for the growth of several years. Assuming at this stage that the extension will be located at Yallourn, and taking into consideration the general layout of the plant, space reserved for extensions, and the capacity of the existing boiler-house, the proposed extension should provide for a plant capable of an output of at least 50,000 kw. Further, as the location of an extension plant at Yallourn of even much less capacity would involve the erection of another transmission line to Melbourne, there should be some correlation between the capacities of plant and line in order to obtain the most satisfactory return on the total investment. The present transmission line has a capacity of at least 50,000 kw. To construct a second line of less capacity would be uneconomic, and there are sound reasons for designing the second line as a duplicate of the original.

4. The Board has given particular attention to this question, which refers to the most economic site for the location of the proposed extension of generating plant, and, in so doing, has considered the results of the exhaustive investigation completed by the Mechanical Engineer, dated 21st July, 1927.

Speaking broadly, the problem resolved itself into an inquiry as to whether, for the delivery of a certain block of power to Melbourne, it would be more economical to generate at Yallourn or at a site in Melbourne—such as Newport "B"—in the latter case using black or brown coal.

Of the several factors entering into an investigation of this kind there are two of great importance, to which due attention has been given by the Board, and they are—

(*a*) The likely average annual loading which the proposed plant is expected to carry.
(*b*) The costs at which the fuel is likely to be made available.

(*a*) With regard to the load factor, we consider reasonable the Chief Engineer's assumption for the purpose of this report that the annual load factor likely to apply to the particular portion of the future load which will be served by the proposed extension of generating plant will be of the order of 35 per cent.

(*b*) As regards the likely fuel costs, it is to be noted that in the various alternative schemes prepared by the Mechanical Engineer, a price has been assumed of 2s. per ton for Yallourn new-cut coal delivered to the power station site. After a careful examination of the statements of coal-winning costs, both actual and estimated, submitted by the Commission, the Board is of the opinion that this price is a conservative estimate of future coal-winning costs. It has been noted with satisfaction that the latest cost sheets establish the fact that coal-winning costs are already down to 2s. 9d. per ton, inclusive of screening and transportation charges. This result is being obtained on the basis of a daily output of about 4,000 tons of coal from the new cut.

The fuel requirements for the proposed extension of power-station plant and for the enlarged briquetting factory, when added to the present output of the mine, will bring the daily output in the new cut to over 10,000 tons. After allowing for the considerably increased capital expenditure that is being incurred by the installation of modern coal-winning and overburden removal plant, and the introduction of the new electric loco. haulage system and providing for the amortization of the expenditure on all assets thrown out of use by the developmental changes resultant upon the introduction of new methods of operation, there is every reason to expect that the Commission's estimate of future coal-winning costs—viz., 1s. 8d. per ton—will be realized when the output reaches the maximum figure mentioned above. The higher figure of 2s. assumed for the purpose of the investigation is, therefore, considered to be on the safe side.

The assumed costs of all other fuels were either based upon market prices or estimates that appeared to be reasonable.

It was evident from the very superior economic position of the Yallourn alternative schemes that considerable adjustments to the estimated or actual costs of coal could be made before the relative positions of the alternative schemes concerned were affected.

For instance, in order that the black coal (New South Wales) alternative at Newport "B" could be put on an economic level with the Yallourn raw coal alternative, a reduction in the cost of New South Wales coal of 12s. 9d. per ton would be necessary, or, alternatively, with present price of black coal, the cost of Yallourn new-cut coal would have to increase from 2s. to 4s. 5d. per ton.

It is to be noted that in the final comparison of those alternatives deemed the most economic, there is little to choose between the claims of the old cut and the new cut at Yallourn as sources of fuel supply. It is understood, however, by the Board that the Commission has definitely pronounced against the development of the old cut for the purpose of power-station supplies. Regardless of such a decision, it is evident that the increased scale of operations foreshadowed in the new cut will bring the coal-winning costs down to a figure with which it would be impossible for the old cut, with its much less favorable disposition of overburden and coal, and smaller output, to compete.

The Board is therefore of the opinion that the question as to the utilization of old-cut coal is definitely and rightly settled by the Commission's intentions to concentrate its attention upon developing the new cut to the exclusion of the old cut for the present and future coal supplies to the power station and briquetting factory.

On the foregoing grounds, the Board has no hesitation in concurring with the recommendations in the Chief Engineer's report to the effect that the location of the 50,000-kw. extension plant now proposed should be at Yallourn as being the more economical alternative than an extension at Newport "B."

The Board also concurs in the consequential recommendation that a second transmission line should be constructed between Yallourn and Melbourne, with the necessary terminal station at Richmond, from which to distribute the energy for metropolitan and other requirements.

(Sgd.) T. P. STRICKLAND,

(Sgd.) H. P. COLWELL,

(Sgd.) H. R. HARPER,

Power Advisory Board.

5th October, 1927.

APPENDIX "C."

COST OF DRIED BROWN COAL FOR USE AT NEWPORT "B" POWER STATION.

REPORT OF H. HERMAN, B.C.E., M.M.E., F.G.S., D.Sc., ENGINEER IN CHARGE OF BRIQUETTING AND RESEARCH, STATE ELECTRICITY COMMISSION.

APPENDIX "C."

8th June, 1926.

COST OF DRIED BROWN COAL FOR USE AT NEWPORT "B" POWER STATION.

REPORT OF H. HERMAN, B.C.E., M.M.E., F.G.S., D.Sc., Engineer in Charge of Briquetting and Research, State Electricity Commission.

The Chairman,
State Electricity Commission of Victoria.

Sir,

I. GENERAL CONSIDERATIONS.

1. This is in reply to your memo. of 27th ult., asking for a comprehensive report on the general question of the drying of brown coal at Yallourn for the purpose of its transport to Newport, and its use there, preferably in pulverized form, for firing either the present Newport "B" plant or some further extension of that plant.

2. The fundamental data are those given by yourself, viz. :—

(*a*) Raw coal to be that mined from the new cut.

(*b*) Present known percentage of moisture in the raw coal is used. This I take at 65 per cent.

(*c*) The coal is to be dried down to 15% H_2O.

(*d*) The quantity of dried coal required per annum is 200,000 tons.

(*e*) The cost of raw coal delivered at the drying plant is taken alternatively at 2s., 2s. 6d., 3s., and 3s. 6d. per ton.

3. The problem of drying raw brown coal for pulverizing is almost precisely the same as the problem of drying raw brown coal for briquetting. After the drying has been effected, the cooling required for briquetting can probably be safely eliminated for pulverizing. I have not included cooling plant in my estimates herein. Briquetted coal has to be conveyed to the loading shed and loaded into trucks. Pulverized coal, or the coal merely dried without pulverizing, has to be conveyed to bunkers, and therefrom loaded into trucks. It will be seen therefore that, up to the point where the drying of coal has been completed, the costs are almost identical in the two cases. After that point, the cost for pulverized coal becomes somewhat less than for briquettes on account of the elimination of cooling costs (which are not very heavy), and on account of the somewhat lower costs of pulverizing than of briquette pressing.

4. I have made calculations of cost both by direct drying and by steam drying. The calculations for the direct-drying plant are more academic than practical. After going into the merits of direct drying in connexion with the proposed extensions of the briquetting factory, on the basis both of our experience at the Newport experimental plant and consultations with leading authorities in Germany, I have come definitely to the following conclusions :—

(*a*) That the net cost per ton of dried coal by direct drying, after taking into account revenue from sales of by-product electrical energy, is not likely to be much less than the cost by steam drying.

It has further to be borne in mind that data based on practical experience as to capacities and costs of direct drying plant, used in a large way, for very wet fuels are not obtainable even from Germany. The figures on which the calculations herein are made for direct drying are consequently based fundamentally on makers' guarantees unsupported by adequate data from commercial running.

In marked contradistinction to this, the capacities and costs of steam-drying plants are now known, not only from our own experience at Yallourn, but from performances from scores of similar plants that have been for years operating in Central Europe.

(*b*) Apart from the question of relative costs of drying, arises the question of the safety in operation with the two systems. It is a matter of common knowledge that the direct drying of brown coal was abandoned in Germany many years ago, primarily on account of disastrous explosions which occurred from time to time. The comparative immunity from danger of the steam plants is so widely recognized in Germany that direct drying for briquetting is practically prohibited by law.

Although the increasing use of pulverized fuel has led to renewed attention being given in Germany to direct drying of brown coal, very little progress has so far been made in introducing direct drying into commercial plants.

If a direct-drying plant were established by the Commission, either for briquetting or for pulverizing of brown coal, and a serious explosion occurred therein, the Commission would have no adequate defence to offer if it were charged with having adopted a system of operation which, on account of its danger, had been practically discarded in a country where a vast experience with drying systems had been obtained.

5. It appears, further, that even in the comparatively simple problem of drying black coal, the difficulty of drying with hot gases has not yet been overcome. During a visit last year by the Commission's officers to the Vitry power station near Paris, where pulverized black coal is burned, it was found that the flue gas-driers were not at the time functioning at all. The problem of drying the coal by such means had not, up to that date, been satisfactorily solved at this station.

The recently-deceased Dr. Klingenberg, probably the leading power-station engineer in Germany, and designer of the new Rummelsburg power station near Berlin, which burns pulverized black coal, installed for the drying of the black coal (containing as a rule from 2 per cent. to 12 per cent. of moisture) steam driers precisely similar to those used in the brown coal briquetting industry.

6. One of the alternatives that has been considered is the burning at Newport "B" of run-of-mine coal crushed, but not sieved, and then dried down to 15 per cent. moisture. The experience obtained at the Newport pulverizing plant was that great difficulty was met with in drying old-cut coal down to an average of about 20 per cent. moisture, unless the maximum size of grain was less than 1 inch diameter. With Yallourn coal, running two driers in series, the necessary drying could not be effected even with the maximum size of grain under an inch. To get even drying and a reasonable capacity out of steam driers in briquetting plants, it is found that the maximum grain passing to the driers, viz., about $\frac{1}{4}$ inch to $\frac{1}{8}$ inch, is quite large enough. Even with this maximum size of grain, one function of the cooling plant is to even up the moisture content throughout the mass of under-dried large particles and over-dried small particles.

In view of the experience obtained during the last two or three years at Newport, and of briquette factory experience at Yallourn and in Germany, I feel satisfied that the only rational assumption to be made at the present time is that, if 15 per cent. moisture content brown coal is to be used at Newport "B" power station, it will be used either pulverized or briquetted. For this reason I make pulverizing, whether effected at Yallourn or at Newport, an essential part of my calculations herein.

II. COSTS OF DIRECT DRYING AND STEAM DRYING PLANT RESPECTIVELY.

7. Although I have already stated that, in the light of present experience, direct-drying plant should not be used, I give hereunder estimated capital and operating costs of direct-drying as well as steam-drying plant, for purposes of comparison.

8. Savings in capital cost of a direct-drying plant compared with a steam-drying plant may be made principally in the following items :—

(*a*) Boilers and turbines can be entirely eliminated.
(*b*) The cost of the actual direct-drying plant, based on guarantees of the character described in 4 (*a*), is about four-fifths that of the actual steam-drying plant.

All other costs, such as clearing, levelling, surface drainage, water supply, railway connexions, coal receiving and conveying, wet crushing and screening, dust extraction and sundry plant, housing, repair shop, store, &c., are, on the whole, practically the same for either system.

9. I assume that for a steam-drying plant, high-pressure boiler plant (about 37 atm.) and turbines would be used.

10. The cost of a plant and its railway connexions varies, to some extent, with its location. As a special and possibly lengthy study would have to be made of various sites before making a definite choice, I shall assume that a site would be available for a drying and pulverizing plant with about the same conveniences and costs for plant layout and rail connexions as obtain with the present briquetting factory.

11. The following estimated costs respectively of a steam-drying and pulverizing plant to produce 15 per cent. moisture coal from raw coal with a moisture content of 65 per cent. are based, as to all operations up to pulverizing, on our experience of actual costs of the present Yallourn briquetting works.

In the following estimated costs of a direct-drying and pulverizing plant, the figures for the driers are based on information much less definite than those available for estimates of steam-drying plant. The information as to capacities and costs of direct-drying plant are based mainly on quotations received from the Buttner Works in Germany.

12. The estimates of capital cost do not include haulage lines, rolling-stock, motors, and driving gear for delivery of coal from the mine to the drying and pulverizing plant. The capital cost of the corresponding works for the Yallourn briquette factory was about £45,500.

13. In Table II. details are given of cost of coal, capital charges, and operating costs both for steam and direct drying, so that the total costs per ton at Yallourn of dried and pulverized coal, with variable costs for raw coal, may be obtained. In Item 3 (*q*) the figure 0·5d. is that used by the Electric Supply Branch for a similar calculation with coal at 2s. per ton. The figure 0·56d. allows for costs with coal at 3s. 6d.

14. If coal were to be only dried at Yallourn and pulverized at Newport, the costs would probably be slightly higher than shown, owing to having two separate organizations for drying and pulverizing respectively. This extra expense would probably be from 3d. to 6d. per ton.

Table I.—Estimated Capital Costs of Plant for Drying and Pulverizing Yallourn Brown Coal. Raw Coal 65 *per cent.* H_2O, *Dried Coal* 15 *per cent.* H_2O. *Output* 200,000 *tons Dried Coal per Annum.*

Item.	——	Method of Drying.			
		Steam.		Direct.	
		£	£	£	£
1	Preliminary expenses, preparation of plans and investigations	10,000		10,000	
2	Clearing, levelling, surface drainage, fencing, unloading and handling of plant and water supply	17,000		17,000	
3	Railway connexions	17,000		17,000	
4	Wet crushing plant, and plant conveying coal thereto from receiving hopper ..	70,000		50,000	
5	Drying plant (8 8-metre steam driers or 6 Buttner type direct driers)	144,000		116,000	
6	Dust extraction plant (apart from drying section)	7,500		7,500	
7	Pulverizing plant (1342—Fuller mills, or equivalent, with motors, pumps, pump motors, compressor, air receiver, conveyor plant	80,000		80,000	
8	Storage bins and loading equipment (1,000 tons storage)	10,500		10,500	
9	Boiler plant (37 atm.)	180,000		—	
10	Turbines (two 6,500 kw. sets, with housing and accessories)	75,000		—	
11	Repair shops, store, and office	12,000		10,000	
12	Temporary plant and building, erecting gear, sanitation and sewerage ..	15,000		10,000	
			638,000		328,000
13	Interest during construction		40,000		21,000
14	Contingencies, 5 per cent.		34,000		17,000
			712,000		£366,000

Table II.—Estimated Costs of Production of Pulverized Brown Coal. Raw Coal 65 per cent. H_2O, Dried Coal 15 per cent. H_2O, Output 200,000 tons per Annum.

Item.	—		Method of Drying.	
			Steam.	Direct.
			1.	2.
1	Raw coal required per ton of dried coal—			
	(*a*) For the dried coal	t.	2·55	2·55
	(*b*) Boiler coal, turbine full load 24 hours	t.	1·34	..
	(*c*) Boiler coal, turbine full load 17 hours	t.	1·30	..
	(*d*) For heating direct driers	t.	..	1·08
	(*e*) Total of (*a*) and (*b*)	t.	3·89	..
	(*f*) Total of (*a*) and (*c*)	t.	3·85	..
	(*g*) Total of (*a*) and (*d*)	t.	..	3·63
2	Cost of raw coal per ton of dried coal (Refer to 1 (*e*), (*f*), and(*g*))—			
	(*a*) Coal at 2s. per ton	s.	7·78– 7·70	7·26
	(*b*) Coal at 2s. 6d. per ton	s.	9·72– 9·62	9·07
	(*c*) Coal at 3s. per ton	s.	11·67–11·55	10·89
	(*d*) Coal at 3s. 6d. per ton	s.	13·61–13·47	12·70
3	Operating costs, per annum—			
	(*a*) Capital charges at 8 per cent. on £712,000	£	56,960	
	(*b*) Capital charges at 8 per cent. on £366,000	£	..	29,280
	(*c*) Operating staff, including maintenance crew and management	£	50,000	40,000
	(*d*) Administration	£	5,500	5,500
	(*e*) Common services	£	2,500	2,500
	(*f*) Operating and maintenance stores	£	10,000	7,000
	(*g*) Energy purchased, 4,800,000 kw. hr. at ·5d. to ·56d.	..	..	10,000 to 11,200
	(*h*) Totals of above	£	124,960	94,280 to 95,480
4	Operating costs per ton	s.	12·50	9·43 to 9·55
5	Energy generated and used by pulverizing plant—			
	(*a*) Normal output	kw.	6,400	..
	(*b*) Annual output, full load 24 hours	kw. hr.	46,080,000	..
	(*c*) Annual output, full load 17 hours	kw. hr.	34,300,000	..
	(*d*) Energy consumed by pulverizing plant per annum,	kw. hr.	5,700,000	4,800,000
6	Energy for sale by pulverizing plant, running as per 5 (*c*)—			
	(*a*) Annual Sales	kw. hr.	28,600,000	..
	(*b*) Valuation of E.S. Branch with raw coal at—			
	2s. 0d. per ton (·0882d. per kw. hr.)	£	10,510	..
	2s. 6d. per ton (·1076d. per kw. hr.)	£	12,810	..
	3s. 0d. per ton (·1271d. per kw. hr.)	£	15,110	..
	3s. 6d. per ton (·1465d. per kw. hr.)	£	17,410	..
7	Value of 6 (*b*) per ton of dried coal, with raw coal at—			
	2s. 0d.	s.	1·05	..
	2s. 6d.	s.	1·28	..
	3s. 0d.	s.	1·5	..
	3s. 6d.	s.	1·74	..
8	Net cost per ton of pulverized coal at Yallourn, as per items 2, 4, and 7—			
	(*a*) with raw coal at 2s. per ton	s.	19·15	16·69
	(*b*) with raw coal at 2s. 6d. per ton	s.	20·84	18·54
	(*c*) with raw coal at 3s. per ton	s.	22·54	20·40
	(*d*) with raw coal at 3s. 6d. per ton	s.	24·23	22·25

15. Assuming that the Railways Department would not charge a higher rate to compensate for the building of special trucks, the costs at Newport of pulverized coal would be about 6s. 6d. per ton higher than the costs above stated.

16. The cost of pulverizing at Yallourn may be taken at about 2s. 6d. per ton. If this amount be deducted from the costs shown in Item 8 of Table II., the costs at Yallourn of dried, but unpulverized, coal may be obtained.

III. SUMMARY.

17. Owing to difficulties in drying the brown coal, unless it is crushed to a fineness quite unsuitable for use on travelling grates, the estimates made herein are on the basis that pulverized brown coal would be used in the Newport boiler furnaces (para. 6).

18. As direct drying of the coal should not, for reasons of safety in operation, be attempted at present on a large commercial scale, only steam-drying plant should be considered for the preparation of dried brown coal for use in the pulverized form (para. 4(*b*)).

19. The capital cost of a steam-drying and pulverizing plant at Yallourn to produce 200,000 tons per annum of coal, dried from 65 per cent. to 15 per cent. moisture, would be £712,000 (Table I.). Connexion with the mine may provisionally be estimated to cost £45,000 (para. 12). The total capital cost involved in establishing the proposed plant is therefore £757,000.

20. The estimated costs per ton of an output of 200,000 tons per annum of pulverized coal containing 15 per cent. moisture, prepared from raw coal containing 65 per cent. moisture, are as follow, f.o.r. Yallourn (Table II.) :—

	s.	*s.*	*s.*	*s.*
Cost per ton of raw coal	2·0	2·5	3·0	3·5
Cost per ton of dried and pulverized coal	19·15	20·84	22·54	24·23

(Sgd.) H. HERMAN,
Engineer in Charge, Briquetting and Research.

8th June, 1926.

APPENDIX "D."

COAL SUPPLY OPERATIONS—YALLOURN.

EXTRACTS FROM REPORT OF THE STATE ELECTRICITY COMMISSION TO THE GOVERNMENT.

APPENDIX "D."

COAL SUPPLY OPERATIONS—YALLOURN.

(EXTRACTS FROM REPORT OF THE COMMISSION TO THE GOVERNMENT, DATED THE 20TH MAY, 1927.)

Coal Supply.—The development of coal-winning operations at Yallourn must not only keep pace with, but must effectually anticipate the steadily increasing requirements of coal. It must be emphasized that there is no escape from the necessity that, as the demand for coal increases, additional plant must be provided to remove overburden, to dig coal, and to transport both to the respective points of disposal. *This necessity is independent of the type of plant and character of operation adopted,* i.e., whether it be on the lines recommended by Klitzing, or on some other lines. Naturally, the Commission will recommend that type of plant which it considers will result in the most economic methods of operation. On this point the Commission has no hesitation in advising the Government that all future developments of coal-winning operations should follow, as closely as possible, the most modern methods in use on the brown coal-fields of Central Europe.

As to quantities of coal output it was decided, when the works were originally planned in 1920, that the Yallourn coal-field was to be laid out so as to permit of a progressive development to enable an output of 10,000 tons of coal per day to be reached in ten years. The selection of site for opening up, the lay-out, location, and capacities of all railways, ropeways, roads, drainage, dumps, &c., and the unit capacities of the various items of plant were all governed by this underlying policy, the plan being to instal *ab initio* only such actual items of plant as were requisite to provide the initially required output, and to supplement same from time to time as the demand for coal increased. This policy has been in no way altered. The plant originally provided and added to from time to time has hitherto been adequate to meet requirements as they arose, while the general lay-out is such as to permit of an expansion, within the ten-year period, to 10,000 tons per day. This limit may indeed in the more remote future be increased to a higher figure by no very serious increment of cost.

The time is now rapidly approaching, however, when consideration must be given to increased coal-winning plant capacity. The Commission has no hesitation in recommending that all coal-winning plant to be acquired in the future should be of the general type in use on the brown coal-fields of Central Europe, with such improvements thereto as may come into recognized practice as time goes on. The important outstanding question is to decide by what successive dates the various items of such plant will have to be acquired.

It is important that it should be made clear that it is not merely a question of purchasing a piece of machinery and placing it in operation by a specified date. Much preparatory work has yet to be done before such machinery can commence to operate. For example, a coal dredger, before it starts work, must have an adequate body of uncovered coal and a proper coal face to operate upon; it must have its working bench at the right level to suit its vertical range (upwards or downwards), and also to suit the operation of its transportation plant; and the latter must find ready the prepared route to its points of delivery. This is merely an illustration, which applies all along the line. All such preparatory work must be done by the plant presently available before the new plant comes in; and, moreover, that work, and the rate at which it can be executed, are closely related to the rate at which coal is presently being consumed, for it would be out of the question (economically) to prepare benches, levels, faces, grades, inclines, and drainage arrangements other than as part of the *normal process of winning coal for immediate consumption.*

Above considerations illustrate that the processes of to-day must be designed and executed in preparation for the needs of to-morrow, and that the whole procedure must be governed by a carefully considered time programme, which must be rigidly adhered to throughout.

It should now be clear that even a somewhat remote *future* date for the coming into operation of any new coal-consuming activity (such as an enlargement of the Briquetting Factory, or the installation of a large turbo-generator) has a direct bearing upon the activities of to-day, for the dates of such future installations govern the dates by which plant has to be available, and these latter dates govern the dates by which preparatory works have to be initiated. Thus, in the year 1927, plans must be made and works initiated to ensure the efficient availability not only of adequate supplies of uncovered accessible coal, but also of all coal faces of lengths and depths requisite to give the outputs which will be called for in 1930 or 1931. Moreover, it is repeated that the rate at which such preparatory works can be effected is entirely contingent upon the rate at which present-day coal consumption permits of the removal of the quantities of coal necessary to lay bare and otherwise prepare the faces, benches, grades, &c., &c., above referred to.

Coal-winning Costs.—The overall cost per ton of coal produced by coal-winning operations, at any one period, is dependent upon two separate and independent factors, viz.:—

(*a*) The character of the plant and processes employed.
(*b*) The total output of coal.

Each of these factors affects different portions of the aggregate unit cost; that is to say, the plant and processes influence the quantity and therefore the cost of the labour, stores, fuel, power and repairs required, while the total output influences the proportion which each ton of coal has to bear of the overhead charges, comprising interest, depreciation, staff, common services and the like. In addition, the capital invested in the processes of development of the coal deposits has to be amortized over the subsequent output over a series of years, and the greater this output becomes the smaller will be the burden of this charge upon each ton of coal.

A proper criterion of the fluctuating cost of such an operation as coal-winning cannot, therefore, be formed unless an analysis be made to see how much of the total cost is due to *direct operating expenses,* and how much is due to *overhead burdens.* Careful management and the employment of efficient plant and methods can favorably influence the former ingredient, but it is only increase of output that can depress the latter ingredient.

This is pointed out in order to emphasize the important influence which output has upon unit costs. A mere comparison, therefore, of total costs of two different periods is valueless, unless account be also taken of the respective outputs of the two periods.

To illustrate this in actual figures, the "overheads" allocable to coal-winning at Yallourn during the past three months amounted roundly to £60,000 per annum. This comprised interest, depreciation, Yallourn and Melbourne offices, stores, stables, insurance, superintendence, &c., being fixed charges, almost wholly independent of output.

Such a charge upon the present output of about 3,000 tons per day is 16d. per ton of coal; but upon an output of 6,000 tons per day would be only 8d. per ton of coal. Thus, if present output is doubled, the cost of the coal would be reduced by 8d. per ton, quite apart from the many economies in actual operation expenses incidental to the greater production.

The conclusion to be drawn is that one very effective method of substantially reducing cost is to increase output, while any reduction of output will similarly enhance unit costs.

It is, of course, true that increased output involves increased investment in plant and therefore of overhead charges, such as interest and depreciation. But this has only a relatively limited influence upon cost, because a great proportion of these overheads relate to matters which are constant, and which do not fluctuate with output. For example, the whole investment in past developmental work is fixed and unalterable, and holds good for all future increments of output.

The actual experiences of coal-winning operations at Yallourn during the past two years are fully illustrative of above principles, and the gradual decline in the unit cost is traceable, to a substantial extent, to the progressive increase in output. It has, of course, been possible also to effect economies in actual operation, as the working force became trained in its duties, but such economies have practically reached their limit with plant and processes of the type at present in use.

Turning now to the future, and the previously expressed recommendation of the Commission in favour of adopting improved types of plant for any future expansion of coal-winning operations, it is pointed out that the Commission now has at its disposal, not merely the experience gained by its own officers during official visits to Central Europe, but also the considered advice both of Mr. Gaudlitz and Mr. Klitzing, as well as the continuous supervision of the latter in his capacity as Consulting Engineer to the Commission. It also now has, on its Yallourn Coal-Winning Staff, Mr. G. Beck, who is a qualified coal-mining engineer, and has had several years' experience in that capacity on some of the largest German brown coal fields. The modern plant and methods, which all the above advisers concur in recommending, are characterized by a great advance over present plant and methods, in the direction, both of the reduction of labour, and of increased capacity for a given capital investment. These are the lines, therefore, on which the Commission proposes to develop—the works already authorized, viz.—the Bunker and the Overburden Dredger, together with their respective transportation and electrical appurtenances—constituting the first steps in this direction. Substantial economies in operating costs can be safely anticipated from such a policy.

The combined effect of improving the plant and of increasing the output will thus be to effect material reductions in the cost of coal-winning operations. This cost has already been reduced, in the past, to a fairly satisfactory figure, but the possibilities in the same direction which lie open to the Commission in the future are to be measured by annual savings which may, in due course, run to much over £250,000 per annum, *after providing fully for all new investment therein.*

In another part of this report, the Commission makes further reference to the progressive abatement in the cost per ton of coal, which, it feels assured, will eventuate, for the reasons above discussed, if the programme of development herein recommended is adopted in its entirety.

The Proposed Scheme of Development.

N.B.—The proposals explained hereunder, and the time-programme designed to govern same, have been expressed graphically in the diagram appended to this report. (See Plan No. 3.)

Basic Factors.—The coming into operation, in May, 1931, of a major extension of generating plant, based on the use of brown coal, is the governing objective in the design of the subjoined scheme. This date, therefore, is the "control" which determines the prior dates by which the Commission must realize all steps leading to that objective.

The second objective is to develop the coal-winning procedure in the New Cut, so that, by the date named, the equipment provided shall be capable of an output of 10,000 tons per working day, with due provision for stand-by plant to meet breakdowns of major machines. The expectation is that, with such an output, the cost of coal from the new cut will fall, by that date, to a figure less than two shillings per ton.

The earliest date by which any extension of the Briquetting Factory can now be brought into operation is April, 1930. The resulting increase of coal consumption by some 2,500 tons per day is an essential factor, both in the computed abatement of coal costs, and in the choice of the capacities of the coal-winning and transportation plant to be installed.

Coal-winning Plant.—The major plant required to give a continuous and reliable output of 10,000 tons per day is as follows:—

(*a*) One deep coal dredger, having a capacity of 2,500 tons per eight hours.
(*b*) One scraper coal dredger, having a capacity of 2,500 tons per eight hours.
(*c*) The present Ruston electric power shovel.

All this must be fully installed and in operation at latest by March, 1930. In order that above plant may by that date have the necessary faces on which to operate, the coal deposits must have been opened up to their full depth of 180 feet. This work of "opening up" can proceed in no other way than as part of the normal process of coal-winning for daily consumption. That is to say, every ton of coal dug in the process of opening up must pass immediatel and directly to the point of ultimate consumption. The rate of this opening up and the time that it will take are, therefore, governed by the rate at which coal can be usefully consumed.

The plant available to prepare the "faces" for the second or "scraper" coal dredger will be the deep coal dredger and the electric shovel; while the plant available to prepare the "faces" for the deep coal dredger is the present electric shovel.

Computations had therefore to be made, working backwards in point of time from 1931, in order to determine the dates by which the several items of plant must be installed, so as to allow time for this preparatory work.

It has, in this way, been determined that, in order that the scraper dredger may commence to operate by March, 1930, the first, or deep dredger, must be completely installed by October, 1928. And in order that the latter date may be realized, the present electric shovel and the overburden plant must from now on be operated in a manner which will prepare the "faces" in time to be ready for the deep coal dredger by October, 1928.

Concurrently, the several benches, grades, inclines, and roads to accommodate the associated transportation plant, and the whole of the drainage arrangements, must also be executed in pre-determined sequence. Throughout the whole period of development the necessity to maintain uninterrupted coal supplies to the consuming activities is paramount, and controls all detailed procedure.

Overburden Plant.—No additional major overburden plant, beyond that already authorized, will be required in order to realize the above programme. It will be necessary only from time to time to augment the transportation plant (already authorized) by some additional locomotives and wagons, in order to increase the rate of overburden removal, in sympathy with the increased coal production. The addition of a specialized machine, known as an "Overburden Spreader," will also be desirable at a later date, in order to reduce the labour required on the overburden dump; but the acquisition of such a machine, while definitely included in the estimates submitted, may be postponed until the present dumps are brought to a stage at which the new machine can operate to advantage, say by the middle of 1928.

The scheme provides for the operation of the overburden plant (actually now available and in process of acquisition) in such a manner as gradually to restore a full year's supply of uncovered accessible coal, and thereafter to maintain that margin, but no more. Experience at Yallourn has shown that exposure of coal surfaces in this way operates very beneficially in dissipating moisture, and thereby improving the calorific value of the fuel.

Estimate of Cost.—The estimated cost, fully installed and ready for operation, of the whole of the new plant required for above coal-winning developments between now and 1931 is £334,150, spread over succeeding financial years (July to July) as follows:—

Financial year 1927–28..	£157,700
,, ,, 1928–29..	96,200
,, ,, 1929–30..	80,250
Total	£334,150

This sum is less by roundly £160,000 than Mr. Klitzing's total estimate for his main scheme, which was £490,000. The reason for this difference is mainly because Klitzing's transition scheme, and the overburden plant now under acquisition (both of which have already been authorized, and for which funds have already been provided by Parliament) have been so designed that expenditure to that extent on the main scheme has been obviated.

The new expenditure proposed has been postponed to the latest respective dates that are considered prudent, if the programme is to be realized with certainty.

Mr. Klitzing's Scheme.—Above proposals conform, in every respect, as to type of plant and character of processes to Mr. Klitzing's recommendations. His time-programme, however, has of necessity had to be radically altered.

There remains the question of the *alignment* on which these several stages of development are to be materalized This is a question which has been considerably affected by the lapse of time and the altered situation. At the time of Mr. Klitzing's inspection (March, 1926) the Yallourn open cut was only 530 feet wide, measured on the coal surface. After allowing for the necessary batters and berms to ensure stability of the boundary walls of the cut, insufficient width remained to permit of the introduction in the present site of the principle of radiating coal faces. That is the main reason why Mr. Klitzing propounded the adoption of a new alignment involving a south-easterly extension of the open cut.

But by reason of the postponement of this scheme, the position now arises that, by October, 1928, when the first of the two coal dredgers is timed to come into operation, the width of the present open cut will have been increased to more than 1,100 feet. A very large body of coal lying below the 70-feet level (which is the present "floor" of the cut) will have been laid bare, amounting to over a year's supply of coal, and it would be a serious economic waste to leave these coal reserves unused. A proposal is, therefore, being worked out to put the first coal dredger to work, on the Klitzing radiating-face principle, in the *present* cut for a period of 12 months or more, and to postpone the south-easterly extension by a similar period. This alternative will not, however, be adopted without prior consultation with Mr. Klitzing, whose services, in a consultative capacity, remain available to the Commission.

Cost of Coal.—It has been explained above that the over-all cost of winning coal is compounded of actual operating costs and of capital charges. The Commission now has at its disposal lengthy experience of operating costs under present methods. Mr. Klitzing has furnished, in great detail, similar estimates for the new methods recommended by him, and these have been adapted by the Commission's expert officers to the actual local conditions and interpreted in the light of our past experiences. In addition, growth, on the one hand, of capital investment in additional plant, and, on the other hand, of coal output, permit of accurate estimates being made of the future incidence of capital charges.

As a result, the Commission is in a position to forecast, with considerable reliability, the probable over-all cost per ton of coal, and its gradual abatement during the progress of the developmental work foreshadowed in this report. The results of this investigation have been embodied in the diagram submitted, and may be epitomized here, as follows:—

Cost of Coal—	Pence per ton.
At present	42
By 1st October, 1928	30
By 1st April, 1930	24
By 1st May, 1931	21

The above estimates include a liberal margin for contingencies.

The total annual savings which are possible, if above costs can be realized, over and above costs prevailing to-day are as follows:—

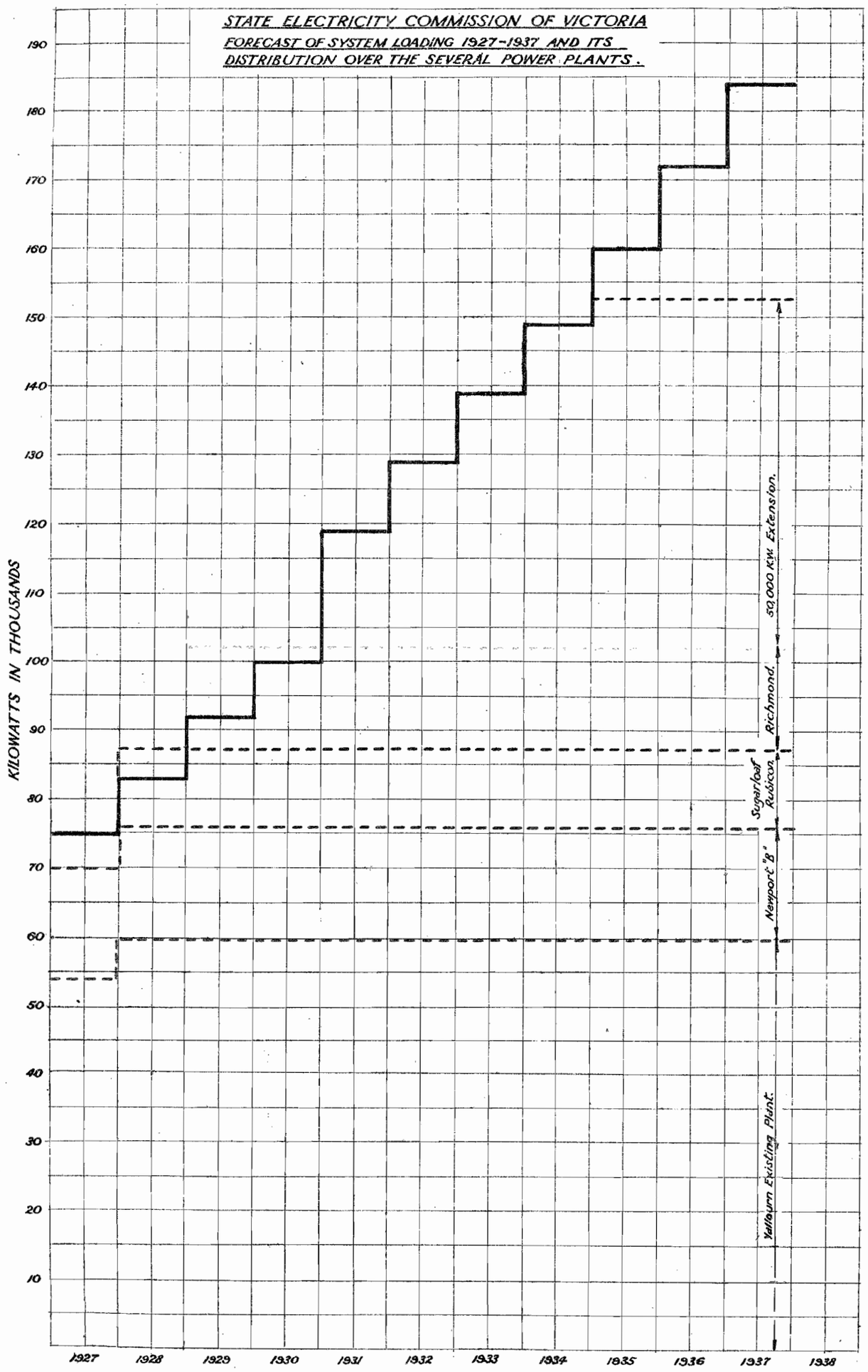
Year.	Output. Tons per day.	Saving Per Ton of Coal. Pence.	Total Annual Saving.
			£
1929	5,900	12	88,500
1930	8,800	18	198,000
1931	10,300	21	270,000

The aggregate savings which it will be possible to realize by the end of 1931 will be £550,000, or much more than the proposed investment in new plant.

Diagram.—The diagram furnished with this report merits close and detailed perusal. (See Plan No. 3).* It embodies, in graphic form, the whole of the programme now submitted. A description of the lines and annotations of this diagram, to facilitate its perusal, is prefaced thereto.

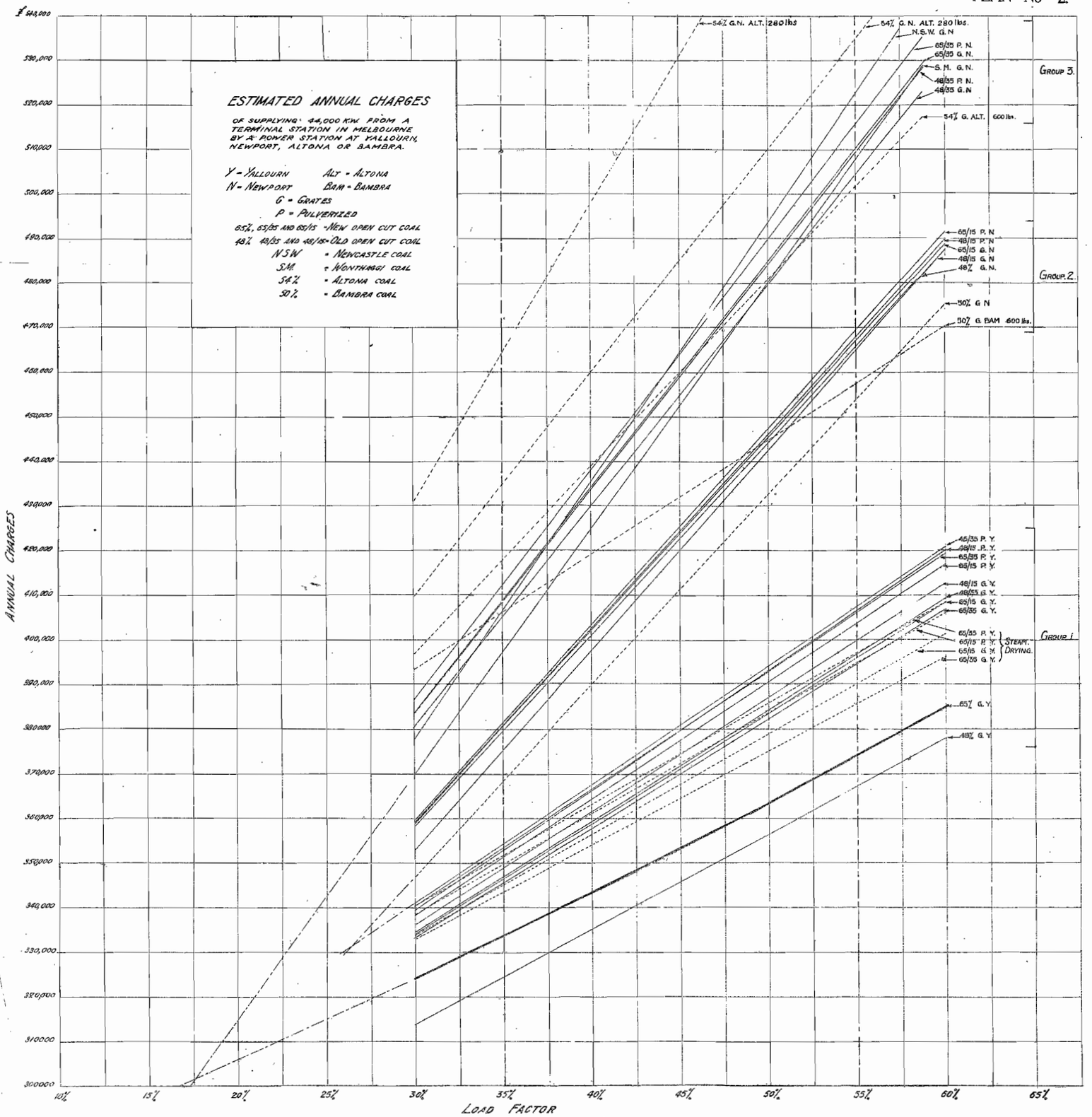
* In order to take a conservative view of future savings, the present day cost has purposely been stated at the lowest figure yet touched.

PLAN No. 1.


STATE ELECTRICITY COMMISSION OF VICTORIA
FORECAST OF SYSTEM LOADING 1927-1937 AND ITS DISTRIBUTION OVER THE SEVERAL POWER PLANTS.
KILOWATTS IN THOUSANDS
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
50,000 KW. Extension.
Richmond.
Sugarloaf
Rushcon.
Newport "B"
Yallourn Existing Plant.

INVESTIGATION OF LOCATION OF REQUIRED GENERATING PLANT.

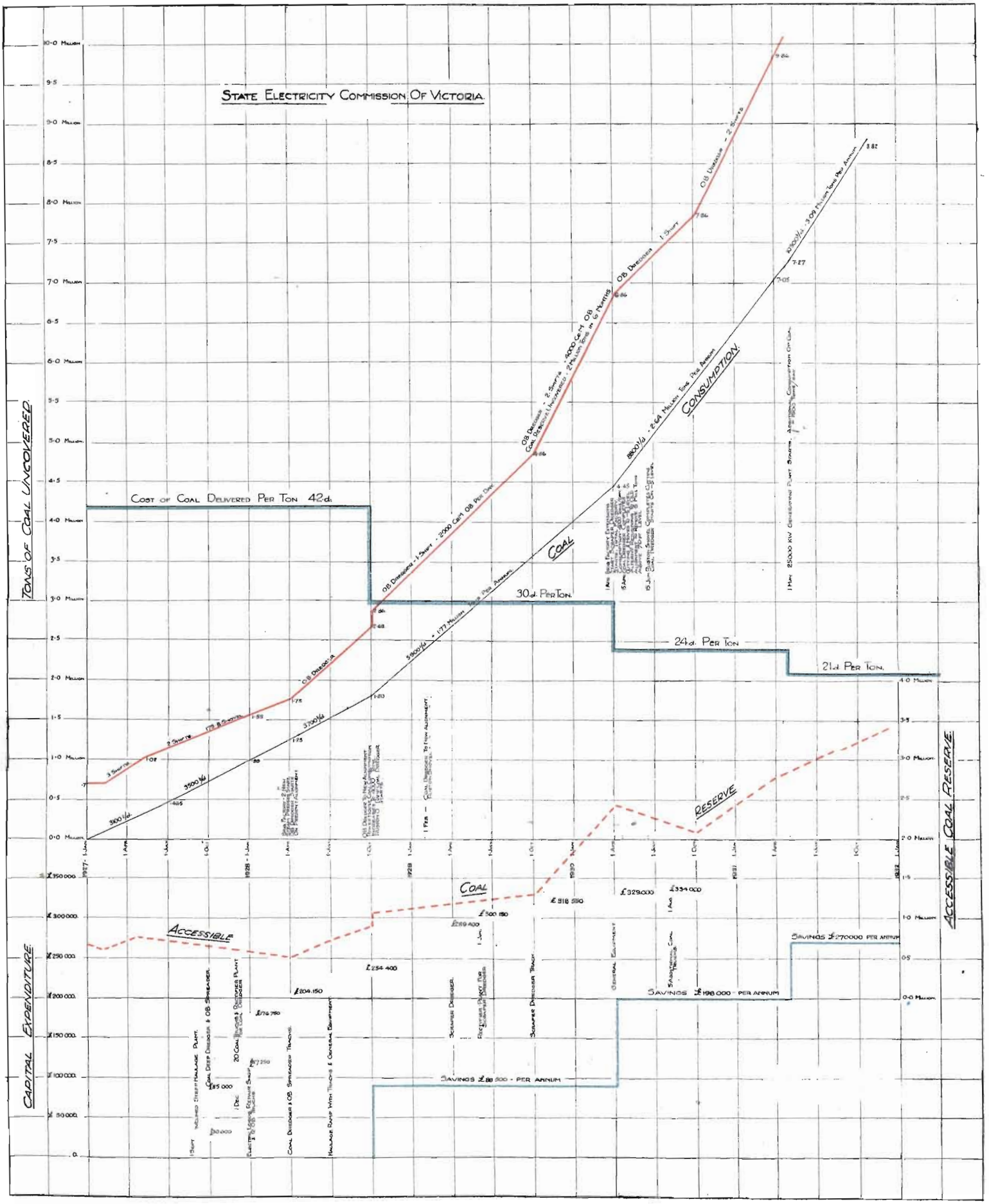
PLAN No 2.



PROGRAMME OF OPERATIONS—YALLOURN OPEN CUT.

(See Explanatory Reference on Page 43.)

PLAN No. 3.



PLAN OF COAL SUPPLY DEVELOPMENT, YALLOURN.

REFERENCE TO ATTACHED PLAN NO. 3, AND TO BE READ IN CONNEXION THEREWITH.

1. All material factors have been graphically expressed.

2. The Abscissae, or horizontal measurements, represent *time*, extending from 1st January, 1927, on the left to the beginning of the year 1932.

3. The Ordinates, or vertical measurements, represent quantities or money values, those applicable at any given date being represented by the height of the relevant curve above the base line, on that date. The scales respectively employed for these quantities, or values, are shown in both margins of the diagram, in colours corresponding to the curves themselves.

4. The lines and notes in *black*, refer to coal consumption, and the curve shown is an integration of the total coal consumed since 1st January, 1927. The rising daily rates of coal consumption are entered upon the curve itself.

5. The lines and notes in *red* refer to Overburden Operations. The curve is an integration of the total coal designed to be uncovered, as from 1st January, 1927; the successive daily quantities, and the method of employing the plant being entered upon the curve itself.

6. The *red dotted* line is a curve showing the *difference* between the above two curves, and represents, at any point of time, the total accessible uncovered coal which has not yet been consumed. The objective is to reach and maintain a full year's supply of such coal.

7. The *blue lines* in the lower diagram show the capital expenditure which will be necessary to develop the coal supply operations herein described, and its distribution, in point of time, over the period dealt with.

8. The *heavy green line* represents the line of cost per ton of the production and delivery of coal; this line gradually falls, in sympathy with the progressive introduction of labour-saving machinery, and the increase in output. This line is not an integrated curve, its purpose being to indicate the probable cost of coal on any given date.

9. The *green dotted line*, similarly, shows the anticipated growth in the total savings in coal supply operations, as against present costs, these savings being expressed in terms of pounds sterling per annum. This curve is compounded of the coal cost at any given date, with the coal output at the same date.

By Authority: H. J. GREEN, Government Printer, Melbourne.