*POWER STATION, SOUTH FREMANTLE

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SOUTH FREMANTLE POWER STATION and its place in the STATE ELECTRICITY COMMISSION'S power generation and distribution scheme.

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## INTRODUCTION

Electric light was first used on a commercial scale in W.A. in 1891 when C.J. Otte & Co. supplied power to light the old Legislative Assembly building.

C.J. Otte later became manager of the West Australian Electric Light and Power Co., which produced electricity for a time and then disappeared from record.

Electricity was also being generated about that time as a sideline by the Perth Gas Company which had been wise enough to recognise the potential of this new competitor.

The Perth City Council considered building a power station in competition with the gas company but eventually purchased the electricity works of the gas company in 1912 after four years of haggling over the price. The following year the W.A. Government took over the tramways which had been a private concern prior to this.

The need for a larger power station was now obvious and the Government became the sole generating authority.

The East Perth power station commenced operation in 1916 and was extended in 1922, 1928, and 1938 in which year its capacity was 57,000 K.W.

Administration of electricity in its present form commenced on the 1st July, 1946 with the creation of the State Electricity Commission of W.A., a body to manufacture and distribute electric current and generally control electricity supply in this state.

The commission when formed took over the assets of the W.A. Government Electricity Supply, which included the East Perth power station, bulk supply transmission lines and plans for the proposed South Fremantle power station.

At the time safe generating capacity was below demand and this demand was increasing at the rate of 10% per annum. This shortage of generating equipment was due to the unavailability of generating equipment, owing to the war in Europe where such equipment in made.

The commission was also charged with the administration of the South West power scheme Act of 1945. This particular act adopted the report of the Electricity Advisory Committee and authorised the carrying out of this committee's recommendations. Briefly these recommendations were concerned with the supply of electricity to 25,000 sq. miles of the South West.

One of the main problems confronting the S.E.C. was the widely dispersed population which made it difficult to supply outlying properties with electricity at a price which would be close to that prevailing in the metropolitan area.

In a scheme of this nature many small towns and individual farms that would like to have A.C. power supplied from the main S.E.C. transmission lines are doomed to disappointment as the profit from the small amount of power they could be expected to consume would hardly justify the expense of connection to the transmission line.

This is not always the case of course and depends on the distance from the power line, the voltage of the power line[1], the probable annual consumption and the importance to the state economy of the prospective consumer.

It will be realised that if it were entirely a matter of economics between the consumer and supplier, many potential consumers would be ruled out as unprofitable, however due to the importance of the South West and the agricultural area generally, the state is prepared to suffer some loss on the country undertakings, at least in its initial stages.

The two block graphs present interesting information regarding S.E.C. country consumers[2].

Looking at the top graph it will be seen that in 1947 virtually all power sold by the S.E.C. outside the metropolitan area was to coal mines. The amount sold to the coal

1. It is not feasible to make direct connections to high voltage transmission lines.

2. S.E.C. Report for 1956.

mines has remained relatively constant whilst the amount sold to other consumers has steadily increased.

The lower graph indicates, the number, at yearly intervals of country consumers being supplied by the S.E.C. Note the steady increase in rural consumers (farms) since 1953.

The South West power scheme, a major section of the country power scheme, showed a loss of £56,562 for the year 1956-57, a big improvement on the loss of £92,301 for 1955-56[1]. The financial position should continue to improve as the load increases. Although the South West Power Scheme is operating at a loss it must not be judged on these figures alone as it has indirectly benefited the state to a very great extent.

The commission, when it took over, planned to enlarge the Collie power station and build a station at Bunbury to supply much of the power needed for this scheme and it also intended that the station already planned for South Fremantle would provide power for this scheme also, as well as to the metropolitan area.

1. S.E.C. Report for 1956.

# FACTORS DETERMINING THE LOCATION OF A POWER STATION.

I t is interesting to consider the factors which influenced the choice of the particular site for the new power station which was needed. The deciding factors were mainly technical and geographical and were factors common to the placement of any large power station. These factors are in turn dictated by economics and any factor which can effect a reduction in the cost of supplying electricity to a consumer must be carefully considered and weighed against any possible disadvantage that may accompany it.

At times a site may be found that satisfies ideally all but one of the conditions needed for efficient power generation, then the favourable factors must be weighed against the unfavourable one and the decision made after very careful calculation of the operating costs.

Generally, capital cost of the station, which varies considerably according to location and nature of the soil, is not allowed to affect the choice of a site if it is going to adversely affect the cost of generating and supplying electricity, because although the capital cost may be lowered by building in another spot the generating cost may be higher for the life of the station.

1. Other factors being equal, the power station should be as close to the centre of the load as is possible. Factors such as cost of land, smoke and dust nuisance, appearance, etc., have some influence in this matter but seldom outweigh this point. A certain amount of latitude is permissable here but a reasonable balance must be struck between these factors and distance from

the load.

2. A thermal power station consumes large quantities of fuel such as coal, lignite, wood and even tar.[1] The cost of fuel at the bunkers represents the major part of the cost of producing electricity.

An example of the division of costs in producing electricity is seen in figures published in the latest State Electricity Commission report. The figures are for the three metropolitan power stations combined[2].

| | |
|---|---|
| Supervision and operating labour | £284,888 |
| Fuel | 1,960,354 |
| Operating supplies and expenses | 17,156 |
| Maintenance of building & improvements | 35,869 |
| Maintenance of steam plant and auxiliaries | 167,129 |
| Maintenance of electric plant and auxiliaries | 83,523 |
| Sundry generating expenses | 90,299 |
| | £2,639,218 |

$$\text{Fuel as a fraction OF TOTAL EXPENSE} \quad \frac{1{,}960{,}354}{2{,}639{,}218} = .743$$

The cost of the coal therefore represents .743 of the total generating costs. It will be apparent then that

1. S.E.C. has available residual tars from its gas works.

2. South Fremantle, East Perth and Bunbury which is regarded as part of the metropolitan system.

even a slight variation in the price of coal will markedly affect the cost of generating electricity.

These figures, it should be noted, are related to the cost of producing electricity at the power station. Transmission costs, interests, capital expenditure, etc., modify this figure greatly but the importance of coal price is still very great.

A further example of the importance of coal costs is shown in this example. An agreement between the government and the Collie Miners' Union regarding coal from open cuts was due to be reviewed in 1955 and the commission hoped that it would be able to call tenders for the supply of coal and that cheaper coal would be offered. Tenders were called and the tenders revealed that on a basis of using a larger proportion of open cut coal substantial savings could be made. However, the acceptance of the lowest tender would have affected the government promise to the Collie Miners' Union and could not be accepted. If the commission could have accepted this tender which was 10/- per ton below the old rate a saving of £200,000 could have been made in the annual fuel bill for the four S.E.C. thermal stations.[1]

The South Fremantle power station which we are considering uses about 4,400 tons of coal per week. It will be seen that the availability of cheap coal is of prime importance when considering the erection of a power station.

1. S.E.C. Report 1956.

LOCATION OF SOUTH FREMANTLE POWER STATION.

A railway line from Armadale, which is on the main line to Collie, passed close to the site and provided an economical and ready means of delivering coal to the station.

The proposed site was also within a fairly short distance of the Port of Fremantle oil bunkers, a most desirable point, as coal supplies in this state have not been reliable and it was considered wise to design the new station so that it could burn fuel oil if coal was in short supply. In any case oil is needed to start a modern pulverised coal fired boiler. It is interesting to note here that the three metropolitan power stations in the year ending 30th June, 1957, burned the equivalent of 17,000 tons of coal in oil and tar (ex gas works).

It might be asked at this stage "Why not build the station at the Collie coalfield and eliminate the cost of transport entirely and then send the electricity to the metropolitan area by cables?" This is a good question and one which will be considered in some detail.

Although electricity in large amounts can be transmitted economically over comparatively long distances a stage is reached when the line losses become so great that it may be more economical to generate the power close to the actual load centre and transport the fuel by road rail or sea. The decision as to whether it is best to build the station at the coalfield and transmit power to the load or alternatively convey coal to a station built near the load is governed by a number of factors. Maximum potential load, existence or otherwise of roads and railways from the coalfields to the vicinity of the load are two important ones. In this particular case there was such a railway in existence and so far as was known at the time there was insufficient water at Collie for a large power station, if the railway had not been in existence to supply this cheap transport of coal to South Fremantle other sites nearer Collie would perforce have been investigated.

The next requirement for a thermal power station of the size proposed was a plentiful supply of cooling water which is used to condense the steam after it has passed through the turbines.

In the site selected the proximity to the sea is obvious from the photographs and the location plan. The need for a copious supply of cooling water is seen when it is realised that South Fremantle power station uses at peak load 5,000,000 gallons of sea water per hour.

Either the Swan or Canning River could have been used to supply cooling water but the temperature of the Indian Ocean around Fremantle is on an average throughout the year at least 10°F. lower than the cooling water available from the Swan at East Perth power station. Therefore less water is required for cooling and the lower temperature permits an increase in efficiency, so adding that extra advantage that is sought in selecting a power station site. A site away from a river or the sea is less desirable as far as economical operation is concerned.

Even a lake, unless it be a very large one is unsuitable as the terrific amount of heat imparted to it through the condensers will soon raise its temperature enough to detract from the efficiency of the power plant.[1]

The alternative to a river, sea or lake is a cooling tower or stray pond which involves a large capital expense, maintenance and reduced efficiency. In England where saturation point has been reached as far as the availability of suitable inland cooling water is concerned, there cooling towers are a common sight.

Another factor to consider is the load bearing capacity of the soil at the proposed site.

Modern power generating equipment is very heavy and modern boilers, for reasons of efficiency are very tall, so placing great weight on a small area. Thus good foundations are an essential of a modern power station and the cost of these foundations can represent a significant part of the capital cost of the station. These costs are largely dependent on the load bearing capabilities of the ground, and other factors being equal, choice of a suitable site may be influenced by this factor.

[2] However, I wish to stress that even an increase in capital cost would not warrant rejection of a site because of poor soil if the alternative site were at fault in regard to the

1. Gaffert.

2. See opposite.

first 3 factors which I have discussed.

In this state we are fortunate that foundations for power stations are generally straightforward and do not involve so many problems as they do, for example, in England.

Foundations, roads and civil works in general represented roughly 10% of the total construction cost of the South Fremantle power station. In comparison a figure of 29%-37% would not be considered unusual in England.[1]

The cost of sites in West Australia has also been negligable and did not have to be given any special consideration in choosing the South Fremantle site.

Careful consideration of all these factors, i.e. availability of cooling water, supply of coal per medium of the existing railways and oil from Port of Fremantle, proximity of load, cheap land, and good solid ground for foundations led those concerned to decide upon South Fremantle as the best all round position for this power station.

1. Gaffert.

CONSTRUCTION OF SOUTH FREMANTLE POWER STATION.

In 1943-44 planning for the new station had reached the stage where site investigation was in progress, in addition to making a study of prevailing wave action and drift a number of bores were sunk to a depth of 40 or 50 feet to determine the nature of the ground. This proved to be of sand and limestone in undulating layers and was considered to be very good foundation material.

On November 23rd, 1944, the Premier, Hon. John Collings Wilcock, speaking in the Legislative Assembly said[1] "In connection with the new power station at South Fremantle, a small amount has been included (in the budget) as preliminary expenses, mainly concerned with drawings prior to the calling of tenders. It is not anticipated that material will arrive this financial year in time to spend any substantial amount for this work."

At this time Mr. Taylor, the engineer responsible for the design of the station, was in England, where in collaboration with the Agent General he was interviewing people who might have been able to supply generating equipment.

It had also been decided about this time to build the station to generate at 50 cycles rather than at 40 in order to bring it into line with other Australian states and world standards.[2]

Mr. V.J. Braine, a most highly qualified electrical

1. Hansard.

2. Parliamentary papers.

expert who had been investigating the position by courtesy of the N.S.W. Premier, submitted a report pointing out the wisdom of this course and the Commonwealth Government realising the national advantages of this move towards standardization had agreed to provide £300,000 on a pound for pound basis towards the task of changing our reticulation system from the then 40 cycle system to 50 cycle.[1]

This was a most difficult time as regards availability of building materials and the foundation design was, to some extent, dictated by available materials. In particular there was a shortage of reinforcing steel and designs had to be evolved whereby economies could be effected in its use. The eventual foundation design used a large number of piles driven to depths of 12 or 15 feet capped by mass concrete to support the weight of the main columns. Alternators, condensers, etc., were built on spread foundations and no difficulties were encountered with the foundation work.

In October 1950 the buildings for the first half of the power station, known as "A" station were complete and foundations were completed for the second half of the power station known as "B" station.

Work on the first two boiler units and the first alternator had reached an advanced stage by this date also. A little later in the month the first boiler unit was placed under

1. Parliamentary papers.

test and the commission was confident that power would be available for the winter of 1951.[1]

In the Legislative Assembly the Premier said "The Commission is planning ahead in order to prevent the metropolitan or South West system from ever again suffering a shortage of electricity as has been experienced over the last three years." This was indeed so and the S.E.C. was already well advanced in the planning of its next power station.

At present it is necessary to commence planning the building of a power station seven or eight years ahead of the time it will be called on to supply power and even though South Fremantle was well under way boring was in progress at Bunbury on the site of the nxt power station.

Construction of South Fremantle power station proceeded under difficult industrial and supply conditions caused by a shortage of labour and delays in receiving equipment from overseas. The first alternator was commissioned on June 27th, 1951, and the second alternator during November 1952.

During the early part of 1953 most equipment associated with "A" station was taken over from the contractors by the commission. In the meantime work continued on "B" station where good progress was being made.

1. Hansard.

The cooling water chlorination plant was also ready for testing in June of this year. This chlorination plant is rather an interesting item of equipment and is worthy of special mention. The sea water when drawn from the ocean contains its normal amount of marine plants and creatures. The largest of these are excluded by two separate systems of self cleaning sieves, but the very smallest organisms pass through these sieves into the piping and condensers where they attach themselves and continue to grow, due to the ideal conditions, i.e. constant stream of water containing their foodstuffs, and the slightly above normal temperature of the water. To kill them and prevent clogging of the condensers chlorine is introduced into the cooling water at intervals.

During the early part of 1954 the first alternator of "B" station was completed and placed on load. The automatic chlorination plant had been placed in service and was reported to be operating satisfactorily.

Trouble had been experienced in the "A" station with the equipment which removes dust and fine ash from the flue gasses and the contractors were making modifications in an attempt to correct it.

On December 20th, 1954, the final alternator was commissioned and by the first June, 1955, all outstanding work had been completed and both "A" and "B" stations were taken over by the commission.

Water turbine and alternator at the Wellington Dam Station.

Unique and unexpected perhaps in Western Australia is the Wellington Dam hydro-electric station which has a present output of 1600K.W., soon to be increased to 2,000 K.W..
The power from this station is fed into the South West power scheme and in the year ending 30th. June 1957 this station produced 3,230,400 units of electricity.

## S.E.C. POWER DISTRIBUTION SCHEME

With the formation of a central authority to control electricity generation and distribution in the state, it became possible to consider for the first time the generation and distribution of electricity on a state wide basis in place of each town generating and consuming its own electricity. An interconnected and integrated electrical supply system offers very great economical advantages and can provide cheap electricity to many consumers, who would otherwise have had to pay very high rates for electricity.

When the commission was formed in 1946 it took over the East Perth power station and bulk supply lines and the Collie power station. Plans were under way to construct a power station at South Fremantle, as we have already seen, to assist in supplying the metropolitan load and the South West Power Scheme. The South Fremantle power station was fully commissioned in June 1955 and the first unit of Bunbury power station in May 1957.

The Commission now had four thermal power stations, East Perth, South Fremantle, Bunbury and Collie, all interconnected by High Tension transmission lines and a small Hydroelectric station at Wellington dam also linked to the system.

A great advantage in having all power stations in an area linked together is that in the event of a failure in one station its load can be carried by one or more power stations

1 See opposite.

through the medium of a transmission line, even though the line losses would normally be too high to be economical. This idea of linking power stations together is an old one but it is only in recent years that it has been possible to consider it in this state. I propose to give a couple of examples to show the value of this system.

Consider four power stations A, B, C and D. A had a maximum load of 100,000 K.W., C - 30,000 K.W., D - 10,000 K.W. To safely handle their respective loads each station would require generating equipment very much in excess of this to cover breakdowns and the normal closing down of boilers and alternators for routine maintenance.

A spare alternator and boilers in each station would represent a big outlay which would earn nothing for the greater part of the year. If, however, these stations were linked by transmission lines it would be possible for only one station to keep a spare alternator and boilers, reducing the cost of equipment between the four of them even after allowing for the cost of the transmission lines. It may even be possible to dispense with the spare alternator and boilers altogether if the combined reserve margins of any three stations is sufficient to cope with the extra load imposed by the shut down of the largest alternator in the fourth station.

This linkage of stations allows all stations to be run nearer their full capacity, the most efficient and economical condition.

The map facing page shows the main transmission lines that are used in connecting the five main power stations of the commission.

It will be noticed by reference to the key that the longer and heavily loaded lines are operated at a higher voltage in order to reduce line losses. The photograph below shows a section of the 132.KV. transmission line which connects Bunbury to the Cannington sub-station.

It is most fortunate that this state has such fine timber available, as the cost of using imported steel towers to support the cables would be very much greater.

A further 132.KV. transmission line is planned to link Bunbury and the metropolitan area and clearing has begun along this route already.

The graph facing page shows the total estimated load and the plant capacity of the stations that are linked together in this system and it will be observed that plant additions or extensions are due in 1961. The S.E.C. has no doubt prepared plans already for a new power station but has not officially announced its intended location. This is quite natural and is only sensible business practice.

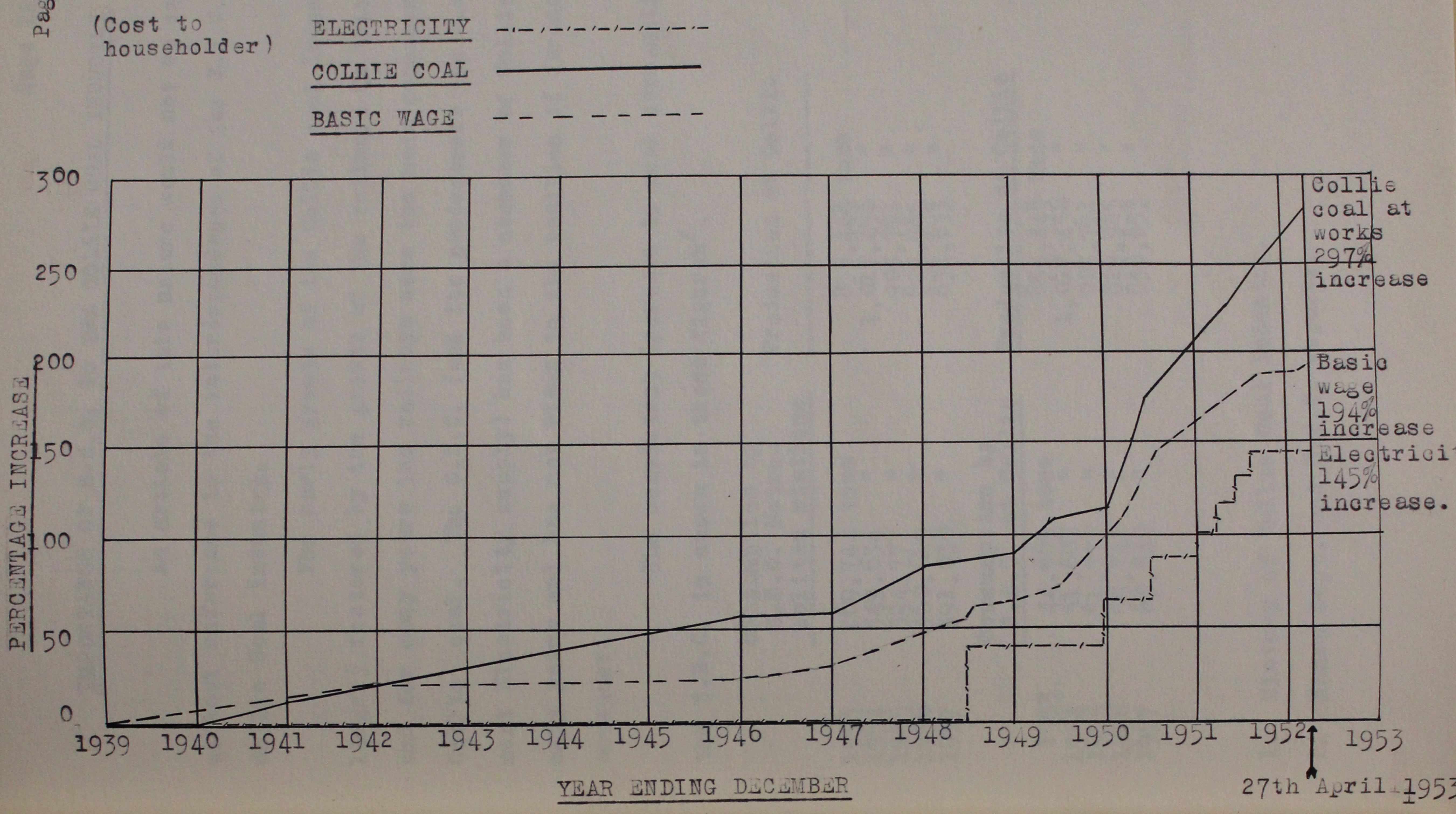
It is interesting to consider just where it will be located in the light of the previous dissertation. South Fremantle was designed and built as a self contained 100 megawatt power station and it is unlikely that it will be enlarged. When the obsolete 40 cycle alternators are removed from East Perth Power Station its capacity could be increased, but there is a limit to the increase that can be made there because of cooling water limitations.

There are a number of sites still available along the coast. Rocky Bay was at one time considered as a possible site for what is now the South Fremantle power station, it was rejected then mainly due to coal difficulties but these could be overcome.

Railway freights have risen considerably since South Fremantle power station was planned in 1944 and so has the price of Collie coal. The steady increase in the delivered cost of coal at East Perth, (approximately the same at South Fremantle) since 1944 when South Fremantle was planned can be seen from the graph facing page        This increase is rather staggering, and has brought the delivered cost of coal to a point where serious thought may be given to construction of a power station on the coalfields at Collie in an attempt to reduce the fuel bill.

This is going to present problems in supply of cooling water as I mentioned before, but new ideas in cooling towers and condensers may make it feasible to operate more efficiently at Collie. Bunbury, it should be noted, has not such a great advantage over South Fremantle as far as coal freights are concerned because cost of cartage is still high even to Bunbury.

## THE TWO MAIN PRODUCTION COSTS OF ELECTRICITY SINCE 1939



## IMPORTANCE OF S.E.C. TO THE COLLIE COAL INDUSTRY

An article of this nature would not be complete without reference to the interdependance of the S.E.C. and the Collie Coal Industry.

The early growth of the Collie coal industry was largely fostered by the growth of the railways in this state[1] and for many years the railways were the main consumers of Collie coal. The S.E.C. (and its predecessor the W.A. Government Electricity supply) has been a consumer of Collie coal for many years and has now risen to the position of foremost consumer.

The consistent increase in coal consumption by the S.E.C. is shown in these figures[2].

| | Consumption by S.E.C. Metropolitan stations | Production at Collie | % of total |
|---|---|---|---|
| 1953 | 269,744 tons | 855,448 tons | |
| 1954 | 349,634 " | 1,017,456 " | 34.37% |
| 1955 | 324,777 " | 903,791 " | |
| 1956 | 360,619 " | 829,985 " | |
| 1957 | 391,030 " | 838,653 " | 46% |

| | Consumption by S.E.C. at Collie | Production at Collie | % of total |
|---|---|---|---|
| 1953 | 44,689 tons | 855,448 Tons | 5.05% |
| 1954 | 51,603 " | 1,017,456 " | 5.07% |
| 1955 | 51,777 " | 903,791 " | 5.73% |
| 1956 | 55,742 " | 829,985 " | 6.72% |
| 1957 | 63,840 " | 838,653 " | 7.61% |

1. History of Collie Coal Industry.

2. Mines Dept. and S.E.C. reports.

It will be seen that the S.E.C. is a steadily growing consumer of Collie coal, in fact the only consumer worthy of note who is increasing consumption.

The railways having embarked on a dieselisation programme are reducing coal consumption and some previous consumers such as the Swan Portland Cement Works, which used 7% of the Collie coal output in 1955, have been lost completely in the last few years.

It is obvious that the continued increase in S.E.C. demand for coal has been a bolster for the Collie coal industry which would otherwise have been more seriously hit by the general trend away from coal consumption in recent years. The industry provides direct employment for over 1,200 workers and the town of Collie has a population of approximately 9,000.

The Collie coal reserves are thought to be in the vicinity of 1,500 million tons and the states only proved source of power.

Without the Collie coalfields electricity would be very much dearer in this state and we would be in a most difficult position if shipping were to be interrupted due to Eastern States strikes or war. It can be seen that the S.E.C. and the coal industry in this state are most dependent on each other and will probably match each other in development in the future.

Much criticism has been levelled at the Collie coal industry at various times on both grounds of cost and quality. This is a field I do not intend to discuss and if the reader is interested in this aspect of coal production he will find a very full treatment of the matter in "A History of the Collie Coal Industry." by L. Johnson.

By way of conclusion I would like to note some of the progress made by the State Electricity Commission since its inception in 1946.

It has eliminated rationing and at the same time reduced the cost of electricity compared with living costs[1]. It has changed the metropolitan reticulation system from 40 cycle to the Australian and World Standard 50 cycle system, so effecting big economies to industry and domestic consumers.

The S.E.C. has also made available 50 cycle electricity to a large number of country towns and farms in the South West and Northam areas[2] and given both technical and material assistance to local authorities outside its area of supply. To do this the S.E.C. has built two new stations, South Fremantle and Bunbury, and enlarged stations at East Perth, Collie and Albany, installing in the process 160,000 K.W.

1. See graph on page 21

2. See map on page 4

of generating plant and building a transmission system in the metropolitan South West and Northam areas to provide an inter-connected grid capable of meeting any likely load. Finally the S.E.C. has looked ahead into the foreseeable future and made plans to increase its generating capacity, when and where required.

## OPERATING OF SOUTH FREMANTLE POWER STATION

The purpose of the station is to convert the energy stored in coal into electricity with as great an efficiency as is possible.

In order to achieve this transformation of energy a considerable amount of equipment is necessary but basically the essential equipment is firstly a boiler in which the coal can be burnt to produce heat which in turn converts water into steam. This steam is very hot and at a very high pressure and now contains the majority of the energy that was contained in the coal. It now passes to the second unit, a turbine.

In the turbine the high pressure steam is directed on to a large number of windmill like blades mounted on a shaft, the force of the steam causes the shaft to rotate with considerable force and we can now say that the steam has imparted its energy, originally obtained from the coal, to the turning of this shaft. The shaft is directly connected to a generator which is the third and final stage in the generation of electricity.

In the generator a powerful magnetic field is forced to rotate and cut through copper conductors in which a current is thereby induced to flow. The current is then distributed to the consumers, but this is a story on its own and I have dealt with it from the geographical viewpoint in my main article.

This brief description of power generation would certainly not of itself explain the complicated appearance of a modern power station as shown in the accompanying photographs. To do so I must go into some detail and become a little technical at times, but with the aid of diagrams and simple terms I hope I can explain the mode of operation in a clear and interesting manner.

Starting at the beginning, coal arrives at South Fremantle from Collie mines by rail and is emptied very quickly and simply by means of a tippler which is a machine that tips the complete truck upside down over a pit. The coal tips very easily as it is in small pieces, this is not a disadvantage as it would be to the railway locomotive engineer, as it is to be crushed to an even finer size by the crushers in the building at the end of the rake of coal trucks. A reserve of coal is kept at the power house in case there is an interruption to normal coal supplies.

From the crushing plant the coal is transferred to the boiler house by means of a conveyer belt[1] which can easily be seen in the photograph. In the boiler house there are eight separate boilers, each with an individual coal bin or bunker to supply its requirements.

Incidentally, the coal used by each boiler is weighed at this stage so that a check can be continually kept on

[1] See adjoining photograph

the amount of coal used by each boiler.

The coal then leaves the bunker in a steady stream and passes to a pulveriser which grinds the coal into a fire dust. The coal dust is then blown by heated air into the boiler where it burns in a steady sheet of flame. The air for this combustion is drawn from the top of the room in which the generators are operating by means of big fans, something like the ones used in fish and chip shops but much larger. This is done for two reasons, (1) It helps to keep the generating room cooler, and (2) The air is cleaner than if drawn from outside.

Returning to the boilers, the hot gases produced by the combustion of the coal play upon and pass over many tubes containing water and known as boiler tubes. The heat causes the water in these tubes to boil and steam is produced. Each boiler can evaporate 150,000 lbs. of water per hour if needed. Any one who has looked into a well used kettle has noticed a brownish lining in it caused by impurities in the water settling out and attaching themselves to the sides and bottom of the kettle. The same deposit would form in boiler tubes if these impurities were not removed by means of special chemical treatment before the water was fed into the boilers. If these impurities were allowed to form in the boilers there would be a marked decrease in efficiency and serious damage could result.

The chemical treatment plant for the boiler feed water was, when installed at South Fremantle, something new to

Australian power stations. It has operated so efficiently and successfully that similar plants have been installed at many other power stations in place of older and less efficient evaporative types of water purifiers.

Mention must now be made of the way in which ash is removed from the boilers. The heavier ash falls to the bottom of the boilers and is at intervals allowed to drop out into a channel running the full length of the boiler house, swiftly flowing sea water running along this channel flushes the ash to an underground tank at the end of the boiler house. From here a pump lifts what is now mud and forces it through a pipe to a group of open settling tanks[1] where the water evaporates and leaves a heavy mud that can be carted away without having dust everywhere.

Finer ash and dust that does not fall to the bottom of the boiler passes with the flue gases into a device known as an electrostatic precipitator which is an extremely efficient filter capable of removing the very finest dust from the flue gases. These dust particles are removed at intervals from the precipitator by a machine that is really a giant vacuum cleaner and are then taken away by truck. The electrostatic precipitators are located atop each boiler and they can be clearly seen in

1 See far right of adjoining photograph to page 26.

the photograph.[2] These precipitators are so efficient that very little smoke can be seen leaving the smoke stacks. This equipment operates automatically as does the equipment feeding coal dust and water to the boilers; automatic equipment can operate the boilers far more efficiently than manual controls and it also reduces labour cost. Very few men are seen in the boiler house and their job is to watch and see that the automatic equipment functions correctly. These boilers are so efficient that little heat is lost to the surrounding air. I was intrigued by an electric radiator that was in use only a few feet away from one of the boilers.

The steam produced by the boilers is piped to the turbines at a temperature of 800° F., about four times as high as the steam leaving a kettle and at a pressure of 600 lb. per sq. inch.

There are four turbines in the power station and each one requires 237,000 lbs. of steam per hour for maximum output. In the turbine the steam blasts against set after set of steel blades causing them to rotate the shaft of the turbine with considerable force but mechanical governors maintain the speed of rotation at 3,000 revolutions per minute.

The photograph shows a steam turbine being installed and assembled.[1] Note the large number of blades as referred to in the article.

1 See photograph adjoining page 29

2 See photograph adjoining page 27

After leaving the turbines the steam must be condensed to water again, this is done by allowing the steam which leaves the turbine to pass over the surface of a large number of copper pipes through which relatively cold water is passing. As the steam touches the cold pipes it is cooled and becomes water which then falls to the bottom of the condenser from which it is continually removed by pumps and sent back to the boilers.

The cooling water at South Fremantle is taken direct from the ocean through a number of screens and filters, designed to keep out weed and rubbish, and then passed through the cooling pipes of which there are 9,350 in each condenser. Approximately 5,000,000 gallons of sea water per hour are required to be circulated through the condensers when the four turbines are running. This is equivalent to 330 tons of sea water for every ton of coal burned. The huge pumps and valves required to handle this vast amount of water are all electrically operated and remotely controlled from a central panel.

The condensers installed at South Fremantle were a new design incorporating a feature that has ensured very reliable operation. This new design has been so successful that a turbine has not to date had to be stopped because of a fault developing in its condenser.

The availability of a huge quantity of cooling water is a prerequisite of power house operation and the proximity of the sea was, as I have pointed out earlier, a deciding factor in locating the South Fremantle power station. Considerable care has been taken to ensure that no rubbish of any sort enters the cooling water pipes and investigation of the photograph on page will show the amount of work that has been done to ensure that even in rough weather only clean sea water enters the condensers.

Note the protruding groyne on the north side of the artificial cove designed to prevent sand drifting south along the foreshore. At the very entrance to the cove is a long screen intended only to keep out big floating debris and weed clumps. Further in is another fine screen which removes all but the finest pieces of weed and marine life. This screen can be made self cleaning if a lot of rubbish is present as is the case during winter storms.

Yet another self cleaning filter is needed to remove the very finest marine creatures and weeds. Only microscopic marine creatures can possibly pass through these filters and to take care of those that do pass through chlorine is fed into the cooling water at intervals to kill them, and at least ensure that they do not attach themselves to the tubes in the condenser and continue to live and grow.

The outlet from the condensers can be seen entering the sea on the south side of the cove. The water is of course perfectly clean and the white appearance is due to air bubbles freed from the water as it is warmed in the condensers.

The shaft of the turbine is directly connected to the rotor of the generator or as it is more correctly termed the alternator.

This rotor is a large rotating electric magnet which is energised by a smaller auxilliary generator. The rotor creates an intense magnetic field and as it rotates this magnetic field cuts through the electric windings of the stator, or fixed part of the alternator causing a current to flow in them.

Both the stator and the rotor tend to become very hot when in operation and would soon be damaged if a large fan was not used to circulate cool air through the alternator. This air is cooled by forcing it to flow over a series of pipes through which sea water is pumped.

The electricity produced by the alternators at South Fremantle is known as alternating current because it is generated in such a way that its direction of flow is being continually reversed.

The reversal of flow occurs one hundred times each second and the electricity generated is known as 50 cycle alternating current.

Alternating current has one great advantage over direct current as is produced by some of the older country power stations. It can have its voltage or pressure readily raised by a device known as a transformer and can then be economically transmitted over long distances so that distant areas can be supplied from one conveniently located power station.