HISTORICAL DOCUMENTS ABOUT THE BROKEN HILL ELECTRICITY SUPPLY

The following three documents are retypes of copies of documents held by the Broken Hill City Library. Although the library documents do not appear to be original, they do, however, contained hand written corrections. Where these corrections occur in the text, this retyped version uses the correction. Also, the original spelling and punctuation has been maintained

The purpose of the retyping is to reproduce the documents in a digitised form to enable the material to be more accessible, and to be readily and easily disseminated by electronic means.

All three documents appear to have been prepared as a guest speaker presentation. The authors appeared to have had access to, and used, the same primary information source relating to the earlier years of Broken Hill's electrical history. For a full appreciation of this history, each documents needs to be read in its chronological order. Each document updates its predecessor. As a result, some of the earlier information is repetitive. However, it will be observed details have been deleted, added or expanded. These variations highlight the individuality of each author's experiences, providing the reader with a unique window into the social mood of each time period.

The documents have been written at intervals of 6 and 17 years. Thus, the reader, with the hindsight of: time, social and political changes, industry restructure, and changes in/to climate (real, imagined &/or political) is able to reflect on the changing philosophy of Broken Hill's developmental direction and compare it with today's situation and attitudes.

Ian R. Holder
REVESBY NSW 2212
Electrical Trades Teacher (Retired)
NSW TAFE

17th December 2015

Footnotes

1. *page 5*

The use of the word **"Dynamo"** would suggest that this was a Direct Current (dc) system.

2. *page 5*

In retrospect, in the year 1880 the inclusion of the word **"Power"** to the company's proposed name infers a visionary anticipated future use for electricity other than "lighting"

3. *page 6*

Single phase **ac** motors first appeared in 1897 in the form of the repulsion motor.
The electric fan was developed and patented in 1902

In retrospect, had this bit of trivia contained slightly more technically detail of the motors and/or fans (say, shaft speed) it may have revealed a deeper insight (glimpse) as to how far power appliances technology had developed.

Also, it's not clear who owned the motors. It was common, at that time, for the supply authorities to own the motors and rent them out to the customers.

4. *page 6*

It is important to stress that when the initial contract was let (between June 1890 and commission date 5th September 1891) the electrical industry was, in any manifestation, in its absolute infancy.

Also, Alternating Current (ac) electricity was single phase and only useful for providing electric lighting. The first practical ac induction motor appeared in 1894, designed, developed and patented by **Nikola Tesla(1856-1943)** and it required a polyphase ac supply.

At this time the practical method of electrically illuminating large public areas was to use electric arc lighting.

Using an ac supply for arc lighting introduced the problem of Lamp flicker (due to the electrodes cooling between each half cycle). One line of thought to best overcome this was to use a minimum frequency of 80 Hz. This could account for the decision to use a 100 Hz supply which, at the time, was common for this type of application. The 100 Hz would have allowed sufficient tolerance to guarantee the generating plant frequency, under load conditions, did not drop below the minimum 80Hz required to maintain the lamp arc. The ability for generating equipment, especially of that era, to hold frequency was notoriously difficult.

Another line of thought believed arc flicker at 50 to 60 Hz was acceptable

In 1890 George Westinghouse, needed to chose a common frequency for both light and power, around which, **he** could design, develop and manufacture both his existing lighting products and then ***NEW " patented" Tesla ac 3 phase ac induction*** motor**.**

Westinghouse chose 60Hz. This then became the Westinghouse **"*company's* standard".** Due to the patent Westinghouse's dominance of the ac induction motor market, was such, that to compete, other companies followed suit. This resulted in the now standard North American **frequency** of **60 Hz**.

5.. *page 6*

This street lighting was a 1100V, ***series*** (or constant ***current***) system which remained in service until the final change over to the 240/415 50Hz ***parallel*** (or constant ***voltage***) system in 1956

6. *page 6*

In 1910 the *Tungsten Filament* Incandescent lamp (Mazda™ Lamp) became commercially available. The change to incandescent lamps, technically, removed the necessity for the 100 Hz supply frequency. Practically however, the 100Hz by then had become the City's infrastructure standard. A situation which was to remain, with all its disadvantage, till 1956 (ref. page 7)

7. *page 7*

The Electricity Commission of NSW (Elcom) established 22 May 1950, becoming Pacific power in 1992
Split up into TransGrid (1995), Delta Electricity (1996), Macquarie Generation (1996), Eraring Energy (2000)
NSW Gov. announced Transgrid sale on a 99 year lease Nov.2015

8. *page 15*

Programmable "***Desktop Calculators"***, although a boon to industry at the time, were however, by to-days standards very primitive, expensive to purchase and cumbersome to use. They preceded the earliest personal computers (PC). There was no monitor only a basic paper printout. Any programming error could not be corrected and required the complete re-entry of the modified or corrected program.

Up until this time calculations were normally performed on a slide rule (logarithm tables being used where greater accuracy was required)

The Apple I &II ***desk top PC with 64kB of memory being introduced in 1977*** and the first spreadsheet program (VisiCalc) in 1979.

9. *page 19*

The Standard Gauge (4'-8½") rail across Australia (via Broken Hill) was completed in 1969
The first India Pacific left Sydney on Monday 23rd February 1970 arriving in Perth on the 27th
Prior to this, the route was via Albury, Melbourne and Adelaide (involving 6 gauge changes)

Also, of note;
The rail link between Sydney and Broken Hill was not completed until 1927. Prior to this Broken Hill's rail link was to Port Pirie, South Australia, via the privately owned narrow gauge (3'- 6") Silverton Tramway. This line opened in 1887. It ran for 58km from Broken Hill, in NSW, across the NSW/SA boarder to Cockburn in South Australia. This tramway then connected to the South Australian Railways narrow gauge railway which ran to Port Pirie. The private tramway connection overcame the NSW Government's objection to the South Australian Government's Railways operating within NSW. The line closed in 1970.

10. *page 30*

Procurement of 3phase induction motors suitable for connection to 550V, 40Hz.

The mines purchase "**standard commercial**" 3 phase, 400/440, **50Hz** squirrel cage induction motors, with both ends of the each phase winding brought out to the terminal block (i.e. standard 6 stud terminal block). The motor being designed to normally run in Delta(Δ), but may be started, if required, in Star(Y) with the aid of a Star/Delta Starter.

The shaft speed (RPM) of ac induction motor is directly proportional to the line frequency. Thus, when the 50Hz motors are connected to the 40Hz supply they will rotate slower resulting in a loss in output power. (Power: $P=2\pi nT/60$)

To compensate for loss in power caused by reduced speed(RPM) due to the reduced mines supply frequency, the next size ***"up"*** in kilowatt(kW) or Horsepower(HP) rating, to that required, is purchased.

To compensate for change of voltage the motor is connected across the 550V mines supply in Star(Y)

Theory

The motor winding **phase** voltage (V_p) should be adjusted in direct proportion to the change of the frequency (or speed). Historically motors manufactured in Australia are designed to operate in Delta(Δ) across a 400/440V, 50Hz, 3 phase supply(V_L). For calculation purposes, using the lower voltage value of 400V, (where, when connected in delta the motor's normal phase voltage $Vp = V_L = 400V$; then:

The required winding phase voltage (V_p) for 40Hz will be:

$$V_p = \mathbf{f}_{new}/\mathbf{f}_{original} \times V_{p\ (original)} = 40/50 \times 400 = 320V,$$

Thus, when the motor phase windings are connected in Star(Y), the required Supply Line voltage (V_L) between phases will be:
$\sqrt{3} \times 320 = 554V$, which is for all practical purposes equal to the Mine's supply of 550V between phases.

The kilowatt output rating also changes in direct proportion to frequency ratio, thus when the calculation is done for any required output, the selection of next kW rating above that required will be found to conveniently reduce back to the actual kW rating required.

Further,

Historically, Australian electric motor manufacturers rated their motors 400/440V to accommodate differences in the various State distribution supply voltages.

Up until 2006, the NSW nominal distribution supply voltage was 240/415V +/- 6%

However, in a further progressive move towards International Standards (SI), the ***"Service and Installation Rules of New South Wales"*** (October 2006) formally altered to 230/400V +10% -6%

Document 1

Originally typed using a typewriter onto 5 foolscap pages

THE HISTORY OF ELECTRICITY IN BROKEN HILL FROM 1887 TO 1968

The first electric light plant to operate in broken Hill was on the Broken Hill Proprietary Mine (B.H.P.) on 2nd April, 1887. This was a very modest beginning, three only Weston arc lamps being used, one each over Rasp's and McCulloch's shafts and a third in front of the smelters. The plant consisted of one **Weston five light dynamo**[1] driven by an 8 h.p. Tangye engine, steam being obtained from the smelter boiler. The population of Broken Hill was amazed at the brightness of the lamps on the "Hill" and all agreed that it was a pretty sight.

The first electric light plant to operate in the Town section was on 20th September, 1889 when the York Hotel, situated on the corner of Blende and Oxide Streets, (site of the present Masonic Club), was lighted for the first time, one 3,000 candlepower arc lamp being erected on one of the Hotel towers. The whole of the Hotel was lighted by electricity the following day.

A prospectus was drawn up on 31st March,1890 for a Company to be known as the Broken Hill and Suburban Electric Light and **Power**[2] Company with a capital of £14,000 in shares of £1 each. Provisional Directors being Lawrence Finn, T.C. Tait, John Ford and Robert Sayers.

On Saturday, 15th April, 1890 the Company carried out a successful trial of shop lighting in Argent Street, the shop being that of Ford and Callaghan.

On 4th June, 1890 the Company was formed with 8,000 shares being applied for and it was decided on this date to call tenders for the supply of a complete plant.

The small power station was erected at the corner of Argent Lane and Bromide Street. The new plant purchased and erected was known as a "complete Westinghouse Electric Light plant of 1,000 lamps". The Contractors for the complete installation was let to Messrs. Wescott, Marshall and Adams and it is interesting to note that Mr. Adams was George Adams of Tattersalls fame. The contract price was £8,000. The installating Company purchased 1,000 shares in the local company. The site for the new power station was in Blende Street next to the Barrier Miner Office. On 5th September, 1891 Argent Street was lighted for the first time by electricity, there being 9 arc lamps in all, the trial was most successful.

On the night of October 3rd, 1891 at the Central Station in Blendde Street the formal opening was celebrated when the lamps were switched on by Miss Sayers, thus inaugurating electricity supply for public and private use in the Town of Broken Hill. On this date twenty premises were using the new source of light.

In the 14 years that followed the ownership of the plant changed hands at least twice. Firstly, it was taken over by Messrs. Strike and Mars and later by Strachan and Mars.

In 1905 the latter Company decided to sell the plant and it was offered to the Broken Hill City Council.

At a meeting of the Broken Hill City Council on Wednesday, 6th December, 1905 it was decided to purchase the Broken Hill light and Power Station complete with reticulation, the arbitrators appointed between the private Company and the Council were Mr. G. Job and Mr. L.H. Beck.

The undertaking comprised of 44 transformers of 132 kW total capacity and 178 street poles. There were 151 customers with a lighting load of 1987 equivalent 16 candlepower lamps and 40 arc lamps taking some 290 amperes, in all, equal to 2487 16 candlepower lamps. The power load consisted of 6 **single phase motors**[3] aggregating 22 horsepower and 60 fans. The frequency of the system was ***100 cycles***[4] and the distribution single phase 3 wire 110/220 volt. The annual output of the plant was in the vicinity of 160,000 units. The unit charge to customers was on a maximum demand system of 1/3 for the first hour and 6d. per unit for the remainder. Taking an average of 7½d. per unit the expected gross revenue was estimated at £5,000. The value of the plant as estimated by Messrs. Job and Beck was £11,200 and it was decided that £12,000 was not an excessive amount to pay, this being agreed upon the plant was purchased and so the Broken Hill City Council became the proud owners of a system of light and power that was to grow out of all expectations. Mr. Mars was retained for 3 months as a consultant and the first Engineer and Manager was George Job and it was through his untiring efforts up to his retirement in 1924 that put the "Electric Light Works" on a sound financial footing.

In 1906 Council decided to extend its street lighting to all reticulated areas. The new street lighting equipment installed was manufactured by the American General Electric Company and was of the very latest type known as the ***high voltage series system***[5], the lamps being arc lamps. Later in 1906 the Steam tram tracks were lighted for their entire length. In about ***1910***[6] the arc lamps were replaced by incandescent lamps, being more efficient the street lighting source could supply three times the number of lamps. In this period the street lighting poles were erected in the center of the intersection, this proved to be a hazard to bolting horse drawn vehicles and was finally changed. The method of transport in the Electricity Department at this time was by push cart, and, then by one horse drawn vehicle. By 1923 Council had 350 connected customers, with the plant becoming overloaded it was decided to install a peak load unit that could be started up at short notice. As oil engines were beginning to find their way into power stations and on the advice of the Engineer a Vickers-Petter four cylinder semi diesel engine, directly coupled to a 125 kilowatt generator, was installed. This unit proved to be a huge success and considerably reduced operating costs. Up to 1923 the plant had been steam generated by hand fed boilers. Steam was also sold at 150 lbs. Pressure to the Barrier Miner Office, the Ice Works, and, the Barrier Truth Office. With the introduction of the new unit street mains were extended to all parts of the City. The load now started to grow with such rapidity that it became necessary to purchase more generating plant. As the first oil engine installed proved to be so successful, four more units were ordered from the same manufacturer, three of 250kW and one of 50kW. By the time this new plant was installed it became necessary to look for further plant. At this time the Pinnacles Mine was closed down by the owners and the Council bought the generating unit which was of the same capacity as those recently installed. With the installation of the sixth oil

engine the coal fired boilers were changed over to oil fired, thus cutting out costly coal altogether.

The present plant was able to cope with the load until 1935 when further units were urgently needed. The power station site in Blende Street could not be enlarged to take further plant so in 1936 Council built and commissioned a new power plant situated at the corner of Talc Street and Galena Street (the present site). Two new full diesel units of 400kW were installed in the new powerhouse the two stations being run in parallel. Then came the task of removing all the oil plant from Blende Street to the new station, this being done smoothly without any inconvenience to the public whatever. By 1937 the steam plant at Blende Street was scrapped and the premises became the store and depot for the installation, reticulation and maintenance, etc.

Administration was moved from Blende Street to the Town Hall in 1936. Up to this period the type of system was as purchased, 100 cycle single phase 110/220 volt. We became the only City in the world operating on 100 cycle single phase so Council wisely decided to change to a standard modern system, that is 415/240 volt, 50 cycle three phase.

The changeover started in 1938 and with the war period out was completed in 1956 including all new 50 cycle generating units in the power station. With change over to 50 cycle a very rapid growth of load occurred and it was found almost impossible for Council to keep up with the expansion necessary in the power station. **The Electricity Commission of New South Wales**[7] had been formed to eventually take over generation in New South Wales so Council approached the Commission to take over generation in the City of Broken Hill. This was agreed upon and after installing new equipment in the power station,. Officially became responsible for generation on 1st January, 1958. The installed capacity of the station at present is 22,000kW. The Broken Hill City Council now buys electricity in bulk from the Commission and is responsible for the distribution within the Town and Rural areas.

With a reliable supply the loading has increased enormously, 141% in the past 7 years

With power to spare Council decided to stretch out into the Rural areas. In 1959 a 72 mile 66,000 volt line was built to supply Kinalung and Menindee. This was operated at 22,000 volts until late 1967 when the line was converted to 66,000 volts. Because of the necessity to provide power for pumping plant in excess of 1,000 hp along the River Darling. From Menindee Township the Rural extends 20 miles down River and 9 miles up stream. In the past five years supply as been made available to the Menindee Lakes Trust at Lake Menindee, to the Speed Boat Club at Copi Hollow and to Sunset Strip weekend cottages on the South West end of Lake Menindee. The largest single installation on the system is a 500 hp motor installed at the Imperial Lake, January 1968. In the South Western direction supply is given by Rural line to the Township of Cockburn, Thackaringa Sheep Station, The Television Repeater Station and the Pinnacles Mine. Power was connected to the village of Silverton in 1967. At this juncture, with the supply area growing it became necessary to install two-way radio in all the vehicles, operating from 3 base stations in Menindee and Broken Hill.

In 1960 it became necessary to modernize the street lighting in the City and a start was made firstly on the two highways passing through Broken Hill. This modernization is still in progress, with a modest beginning of 9 lamps in Argent Street we now have over 1,000 with more being added each week. In the suburbs all old type filament lamps are being replaced by more efficient fluorescent lamps. In 1963 due to growing pains the old original power station building, which was being used as a depot and store, was closed down and a new modern depot built in Crystal Street. It is from here that all work is undertaken, administration being from the New Electrical Centre in Argent Street.

At no time in the past has there been any great effort to promote the sale of electricity but with the opening of the New Electrical Centre in Argent Street it is hoped by sound advice to the public on all electrical matters, to promote a still greater use of electricity. Buyers will be helped in every way possible to select the right appliance or piece of apparatus to suit their particular needs. Demonstrations will be a feature of the new Showroom.

The Engineers that have been in charge of the undertaking responsible to Council are Mr. G.F. Job, Mr. T.A. Reece, Mr. E. Tweddell, Mr. C. Robinson, Mr. L.G. Job, Mr. S.D. Berry and at present as Chief Engineer, Mr. A.L. Bunning. The operating staff at present consists of 68 persons made up of Electrical Fitters, Linesmen, Meter Readers, Storemen, Clerks, Inspectors, Drivers and Assistants.

In summing up may I quote just a few statistics.

When Council took over electricity generation and distribution in 1905 there were 151 customers, at present over 10,000, the peak load was estimated at about 50kW, this year our peak has already passed 14,600kW. First year of operation an estimated generation of 160,000 units, this year we expect to purchase some 50,000,000 units.

The expected revenue in 1906 was £5,000, this year $1,400,000 and like Hordens tree we are still growing.

From a push cart in 1905 for installation and maintenance work, in 1966 we have 17 modern vehicles operating daily in the City and Rural areas.

……..

Document 2
Originally typed using a typewriter onto 12 foolscap pages

THE ELECTRICITY SUPPLY ENGINEERS ASSOCIATION OF N.S.W.
CENTRAL WEST ZONE CONFERENCE
JUNE 13-14, 1974

A BRIEF HISTORY AND DESCRIPTION OF THE ELECTRICITY SUPPLY UNDERTAKING OF THE COUNCIL OF THE CITY OF BROKEN HILL

PRESENTED BY :-
R.J. BAKER M.I.E. (AUST.)
CHIEF ELECTRICAL ENGINEER
BROKEN HILL CITY COUNCIL

A BRIEF HISTORY AND DESCRIPTION OF THE ELECTRICITY SUPPLY UNDERTAKING OF THE COUNCIL OF THE CITY OF BROKEN HILL

The earliest reference which I could find to electric lighting was 1881 when an arc light was installed at Redfern Railway Station by a Mr. H.H. Kingsbury who claimed that this was the first installation in the State.

The first recorded instance of electric lighting in Broken Hill was on April 2, 1887, only six years later, and barely four years after the first settlers on the field. Three Weston Arc Lamps were installed on the Broken Hill Proprietary Mine (B.H.P.) lease, one each over Rasp's and McCulloch's shafts, and one in front of the smelters. The plant consisted of a Weston five light dynamo powered by a Tangye 8 hp engine, steam being obtained from the smelter boiler. According to newspaper reports, the population was amazed at the brightness of the lights on the "Hill".

The first lighting plant to operate in the town section was installed at the York Hotel, site of the present day Masonic Club, on September 20, 1889, when a 3000 candlepower lamp was erected on one of the hotel towers. This was apparently an isolated plant to supply the hotel only.

A prospectus was drawn up on March 31,1890 for a company to be known as the Broken Hill and Suburban Electric Light and Power Company, with a proposed capital of £14,000 in £1 shares, the directors being local businessmen. In April of the same year the company carried out a successful trial of shop lighting in the premises of one of the directors, and the company was formed on June 4, 1890 with 8000 shares being taken up.

A new plant described as a "complete Westinghouse Electric Light Plant of 1000 lamps" was supplied and installed by the Sydney Electric Light Company, comprising Messrs. Wescott, Marshall and Adams and it is interesting to note that Mr. Adams was Geo. Adams of Tattersalls fame. The contract price was £8000, and the installing Company accepted 1000 shares in the local Company as part payment. Installation apparently included some of the overhead reticulation, and on September 5, 1891, nine arc lamps were lit for the first time in Argent Street, although the formal opening did not take place until October 3, 1891.

The archives of the Charles Rasp Library contain some interesting sidelights on these early activities.

There is a copy of a letter published in the Sydney Daily Telegraph of June 7, 1890, written by Mr. H.H. Kingsbury, who had just installed a lighting system in the town of Young, pointing out the "distorted facts and extravagant inference" of the claims made by a writer of a few days earlier, who proved (on paper) that electricity could never be a serious competitor to gas, and had no future at all except as a novelty.

A hand written copy of the draft agreement between the Municipal Council of Broken Hill and the Broken Hill Electric Light and Power Company had some unusual provisions – biased very much towards the Council.

For instance, "all poles were to be erected and wires stretched within six months; if the Company went bankrupt, Council acquired all erected plant; permission to supply electricity in any specific area could be revoked on seven days notice; the Company had to pay the salary of a Council "Officer" (not to exceed £200 per annum) who would supervise and approve all works, and after all this, the right to supply was not exclusive and Council could extend similar rights to any other person if it chose. There is no record to say that the agreement was actually signed.

"Safety" regulations included a limit of "120 volts electromotive force, poles to be at least 30 feet out of the ground and 3'6" in the ground, not less than 50 yards apart, and all wires to be not less than 2'6" apart and insulated to prevent any leakage.

One can imagine this as the forerunner of the Overhead Line Construction and Maintenance Regulations, and it is conceivable that there were as many different sets of regulations as there were Councils, and probably all drawn up by the Solicitors.

A letter written in August 1891 by the contractors presented testimonials from satisfied users of the "Newcastle Cable" – best Overhead Cable, which they intended to use, although some Councilors were of the opinion that "submarine" cable should be used.

The new Company apparently had a very shaky beginning, and in 1894 the whole of the assets and rights were acquired by Geo. Adams, and Council was requested to waive its rights under the earlier agreement.

By1898 Mr. Adams was trying to dispose of the undertaking and placed it under offer to the Council for a three month period, apparently without success, as a Mr. F.J. Mars advised the Council in 1900 that he had taken over all the plant of the Company.

However, by 1903 discussions were taking place on the acquisition of the undertaking as a going concern by Council, and on December 6, 1905, it was decided to purchase the Broken Hill Light and Power Station, complete with reticulation.

The undertaking at this time comprised 44 transformers of 132 kW total capacity and 178 street poles. There were 151 customers with a lighting load of 1987 equivalent 16 candlepower lamps and 40 arc lamps, taking some 290 amperes, in all equal to 2487 sixteen candlepower lamps. The power load consisted of 6 single phase motors aggregating 22 horse power and 60 fans. The frequency of the system was 100 cycles and distribution was 110/220 volt 3 wire single phase. The annual output of the plant was 160,000 units, charged on a maximum demand system of 1/3 per unit for the first hour (apparently calculated on connected load) and 6 pence per unit thereafter. Gross revenue was estimated at £5000 at an average of 7½ pence per unit, and since the independent arbitrators valued the entire assets at £11,200 it was considered that £12,000 was not an excessive amount to pay, and so our present organization began.

Mr. Mars was retained as a consultant for three months, and the first Engineer and Manager was Mr. George Job.

Mr. Job continued in this capacity until his retirement in 1924, by which time the "Electric Light Works" was on a sound financial footing and was quite a successful undertaking.

In 1906 Council decided to extend street lighting beyond the main business areas, and the very latest American General Electric Company high voltage series system (1100 volts) using arc lamps was installed. The arc lamps were changed for incandescents in 1910 – interestingly, our old friend Mr. H.H. Kingsbury had published an article in 1890, still in the archives, expounding the superiority of incandescent lamps over the arc lamp. Street lighting poles at that time were erected in the center of the road, but this proved to be such a traffic hazard to bolting horses that they had to be changed.

Method of transport in the Electricity Department at this time was by hand push cart, but as the system expanded a horse drawn vehicle was bought into service.

By 1923 there were 350 consumers and plant was increased. As the oil engine was beginning to find its way into power stations, a Vickers Petter four cylinder semi diesel engine coupled to a 125 kilowatt alternator was installed. This unit reduced operating costs very substantially, and over the next few years a further five were installed, the boilers for the remaining steam engines being converted from coal to oil firing. This expansion was able to cope with load growth until 1935, when it was decided that it was not feasible to enlarge the existing station in the center of a commercial area, and a new station, commissioned in 1935, was built on the site of the present E.C of N.S.W. Station in Talc Street.

Two new full diesel sets of 400 kW capacity each were installed in the new power house and the two stations were operated in parallel for some time, as the smaller units were removed one by one to the new site, without inconveniencing a single customer.

At the same time the administrative offices were shifted to the Town Hall and in 1937 the original power station was used only as a store, maintenance depot, and workshops. By 1963 the facilities offered by the original old building, parts of which dated back to the 1890's had become totally inadequate and the present modern store and workshops in Crystal Street were erected.

As mentioned before the earliest system was 3 wire 110-220 volt single phase, with a primary distribution network at 2400 volts single phase, and a frequency of 100 cycles per second (before the days of Hertz). This system persisted unchanged until about 1938, when it was decided to introduce the modern 50 cycle 415/240 volt 3 phase system with 6.6 kV distribution voltage, and gradually change the existing network to the new voltage and frequency. At that time we were the only city in the world operating a 100 cycle generating plant, and it was almost impossible to buy equipment to suit the frequency.

The changeover was interrupted by the war years and hampered by lack of funds immediately after the war, and was not finally completed until the late 1950's – about 1956 or 57. Shortly after this the last of the series street lights were phased out, and the original constant current transformer scrapped. I recall as a young apprentice

being intrigued by the scientific methods used to balance the counterweight on this unit – a number of pennies were stacked on the weight to give fine adjustment.

During the period of almost 20 years when both frequencies were available, there were some interesting pole configurations where both systems were run together. It was not unusual to have 6.6 kV delta construction at the top, then a 4 wire crossarm with 2.4 kV 100 cycle on one side of the pole and lead and return conductors of the 1100 volt series street lights on the other, a 4 wire low voltage 50 cycle arm, and a 3 wire low voltage 100 cycle arm or 3 vertical 100 cycle L.V. on swan neck insulators. A corner pole could have eight crossarms, and tracing connections on a dark night could become quite a problem.

The 100 cycle distribution system followed the American pattern of small transformers from 5 kVA to about 30 kVA, at close intervals, operated for most part in parallel, with primary fuse protection only.

Growth in maximum demand has increased very rapidly in recent years – the 10 years from 1960 to 1970 in particular being times of rapid increase in loading, requiring accompanying increases in capacity of both the power station and the distribution network. From early records we find figures for :-

1937	925 kW
1944	1425 kW
1960	6984 kW
1970	15300 kW

During the 69 years from when the Council acquired the electricity undertaking, there have been seven Chief Electrical Engineers, apart from myself, and I have had the privilege of serving under six of those seven. I am not sure of the years of service of each engineer, but from 1905 there were :-

G. Job
T.A. Reece
E. Tweddell
C. Robinson
L.G. Job
S.D. Berry
A.L. Bunning

THE PRESENT SYSTEM

Since 1959 when the Electricity Commission of New South Wales assumed control of the Galena Street powerhouse, energy has been purchased in bulk at standard rates at 6600 volts.

Supply is via 4 underground circuits into Council's distribution station adjacent to the powerhouse. A 14 panel Westinghouse type LC switchboard using the J18 circuit breaker, divided into four sections, provides seven outgoing feeders. All four sectioning switches are normally closed, as the Commission's switchboard is also in several sections in different parts of the engine room, and it would be possible to lose

synchronism between sections if both ends were inadvertently open at the same time. There is provision in the switch room for a fifth incoming circuit and further three outgoing feeders, giving the station a firm maximum projected capacity of 30 MVA.

A Landis & Gyr 500 Hertz audio frequency control system has been operating since 1966 and has proven very successful. Functions controlled at present are off peak hot water (4 channels) block storage heaters (1 channel) a lockout demand tariff system (1 channel) and dusk to dawn street lighting initiated by a photo electric relay. There is provision for automatic load control of a further five channels, but these have to been utilised to date.

Of the seven output circuits, two supply transformers situated in the switch yard; one 22 kV rural line gives supply to the area generally west of the city to Cockburn in South Australia, the other through a 70 mile 6.6 kV line east to Menindee on the Darling.

The five 6.6 kV feeders supply the urban Broken Hill areas. The most remote part of the system is less than three miles from the power station, but even so peak demands of the order of 16 megawatts are pushing these feeders to the limit. Three already have peak currents in excess of 300 amps and voltage drops of 7-8% at the extremities, and in some sections are approaching the limits of thermal capacity. Consequently the 6.6 kV system must be considered as being close to the end of its economic life.

The majority of the city loading is domestic, and so most of the distribution substations are in residential areas The usual capacity is 200-300 kVA, and substation design has pass through two pole and platform, and one and a half pole, to the present single pole design for up to 300kVA on a stobie pole, which we have found to be more durable than wood poles for this application. The total connected 6.6 kV transformer capacity is 21,115 kVA.

The low voltage network has grown from the original 3 wire 100 cycle single phase 110/220 volt system, and due to the very rapid load growth over the last fifteen years, there are places where the L.V. mains are inadequate, despite a continuing policy of augmentation during that period. In desperation, about 4 years ago (winter 1970), it was decided in one area to run a group of transformers with secondaries in parallel, to improve regulation.

It was found that this policy was very successful in areas where mains were poor, in some cases increases of the order of 20 volts were obtained immediately. Furthermore peak loading of transformers was found equalize to a certain extent and after a certain amount of “playing chess” with transformer sites a much more stable system has resulted. The decrease in L.V. losses has also been so significant as to be apparent in our loss statistics.

This system has now been broadly adopted over three feeders. The principle is that four or five transformers in one group between adjacent H.V. switches, will be connected firmly in parallel on the secondary side, with provision for paralleling adjacent groups by means of L.V. links. In some cases all links are normally left open, other groups are run in parallel all the time depending on the conditions in the area.

Most of the groups are no larger than one or two substation areas of about ten years ago.

Our ultimate aim is that when augmentation is complete in a particular area, each group will be able to operate satisfactorily with the links normally open, but even so the extra flexibility afforded by being able to parallel groups by closing links has been of great assistance already in maintenance and construction work.

By this means we have been able to avoid buying extra 6.6 kV transformers for the last three years, while a survey of high voltage requirements was conducted and decisions reached on the best solution to the H.V. problem.

A number of operating precautions have to be observed with this system, for instance care has to be taken to ensure that L.V. links are not used to parallel sections fed from separate high voltage circuits. Switching operations on the whole are more complex than before, but are generally well understood by the staff and no serious problems have occurred. All operating personal are issued with a folder containing diagrams of high and low voltage connections, and the normal status of all links and switches. Except in emergencies, all switching operations must be detailed precisely on a standard form and approved by a senior officer beforehand.

Because of our compact area and the lack of really high, dense trees, there is very little low voltage mains damage during windy or stormy weather, and no L.V. protection problems have been experienced over the four years. The most serious difficulties have been open circuited bridges or burnt off transformer taps, which are only apparent during peak loadings, and there have only been two or three instances of this.

Towards the end of the 1960's it became apparent that at the current growth rates, which had been maintained for over ten years, sections of the 6.6 kV distribution network would soon be inadequate for transferring the increasing quantities of power at peak periods.

A preliminary survey in 1969 established the extent to which the present system was loaded, and fairly accurate estimates of losses and regulation in the various sections of each feeder were made, the calculations being confirmed by actual measurement at a number of points.

There were sufficient grounds then to carry out more detailed investigations into the operation of the system under various rates of load growth, and with the assistance of a ***programmable desk top calculator***[8], a comprehensive study was made comparing the performance of the system in terms of losses and regulation at voltages of 6,600, 11,000 and 22,000 volts over a period of 15 years at growth rates between 1% and 10%.

Surprisingly, even at the lowest growth rates it was economically feasible to change the entire system progressively from 6.6 kV to 22 kV, the saving in cost of losses alone being sufficient to make it worthwhile. At 11 kV the proposition was not so attractive except at higher rates of increase, but further projections indicated that an 11 kV system would itself require re-enforcement in a relatively short time at the

higher rates. Consequently after lengthy discussions with the Electricity Commission regarding the transformation from 6.6 kV to 22 kV a decision was made in late 1973 to convert the existing system progressively to 22 kV, commencing with those feeders which were most heavily loaded. It will be quite feasible economically to spread this work over five or even ten years, and so minimize the amount of loan money required for the project.

Three transformers capable of being rewound to our required voltage were acquired under most favorable terms from the Electricity Commission and the rewinding is presently being carried out by Westinghouse Electric (Aust.) Pty. Ltd. To provide 3-15 MVA units which will be installed adjacent to the E.C. of N.S.W. power station in our present switching yard.

It is considered that this will cater for the needs of the city for possibly thirty years and it is very difficult to predict the requirements of a mining community further than that.

THE RURAL SYSTEM

Until 1959 there was no rural system whatsoever centred on the city. The Local Government area of Broken Hill comprises only 26 square miles and outside of this the unincorporated area of the Western Division – an enormous area very sparsely populated, and with no significant centers of population west of the Darling River.

When the Electrical Commission of N.S.W. took over operation of the Broken Hill City Council power station, it was agreed that power supply would be made available to the township of Minindee about 70 miles away on the Darling. Until this time, supply in the township, as in all the properties in the Western Division, was by individual isolated plants, mostly 32 volt.

A 6.6 kV line was built to Menindee and commissioned in November 1959 at 22 kV, reticulation in the town being at 22 kV and 415 V 3 phase low voltage. Agitation for supply to properties external to the township began immediately, and before the line was commissioned work had begun on an extensive rural 22 kV system which now extends approximately 20 miles down river, 12 miles upstream, and 30 miles back into the Minindee Lakes Storage Scheme Area.

Development of this area has been slow because of recurring floods and the unwillingness of Government Departments to initiate any community irrigation scheme. However there are now some exciting developments taking place in the lakes area which could completely alter the position of Manindee from the electrical loading aspect, as well as from the viewpoint of population and industry.

The Broken Hill Water Board operates a pipeline from Menindee to Broken Hill by diesel pumping stations at Menindee and an intermediate point at Kinalung. Several years ago an additional pump was installed at each station powered by 400 hp electric motors, and during pumping seasons these have proven most satisfactory. The Water Board also operates a 500 hp electric pump on the outskirts of the town and all three

installations are fed from the 66 kV line, which, while of very limited capacity, could cope with about twice present loadings without serious trouble.

Thirty miles west of Broken Hill is the small railway village of Cockburn, situated in South Australia on the N.S.W. border. Agitation to the South Australian Government resulted in an agreement for the Broken Hill City Council to supply reticulated power in bulk to the S.A. Railways at Cockburn, and a large part of the cost of the line was met by the S.A. Government. The S.A. Railways in turn provides power back over the border to a hotel on the N.S.W. side, and this could raise some interesting questions in regard to licensing and regulations. Capacity at Cockburn is very limited – single phase 2 wire 22 kV, and the Railways estimate of maximum ever requirements was 50 kVA. This line also supplies a small mine which was a very good consumer until their operation was curtailed by marketing problems, the mining "ghost town" of Silverton, and several rural properties.

The future of the rural system is uncertain. In these days of high wool prices and good seasons, there is increasing agitation for reticulated supply to be extended to more remote areas, and an increasing willing ness on the part of the landholder to contribute ever larger proportions of the cost of these extensions.

However, with a consumer density of approximately one to ten miles, and a property size of 100,00 – 200,000 acres, the cost per consumer rapidly becomes astronomical, and the return from what is for eleven months of the year just a very good domestic customer, is not sufficient to cover depreciation and maintenance costs. I believe that this problem is not confined to our own area and has been experienced by other authorities bordering the unincorporated area.

Along the Darling River is a different story however, and although at present the Electricity Authority is reluctant to permit extension outside a franchise area, there is increasing demand for large scale pumping and I am convinced that development in these areas is inevitable. This is a problem which must be faced realistically by both the Electricity Authority and the Supply Authorities concerned, and the sooner the better.

FINANCIAL POLICIES

The financial policy of the Council in regard to capital works differs from that of most Authorities in one respect – the maximum possible amount is financed from revenue rather than loans. The philosophy behind this policy is that with the uncertain future of mining towns, it is impossible to predict population growth rates – either positive or negative and in a time of recession a large loan commitment would mean that fewer people would be left to repay any debt, and so the burden per consumer would be increased.

All capital works have in fact been financed from revenue since 1959, although it is anticipated that loan money will be necessary for the projected 6.6/22 kV voltage changeover, which has just been commenced.

Domestic tariffs are comparatively high although they fall in about the middle of the rates for all authorities excluding the large metropolitan areas of Sydney, Wollongong and Newcastle. This is partly brought about by the capital financing policy, and partly by the lack of a solid industrial base load – 10,500 consumers, 9,000 are domestic. Very active campaigns are at present being conducted by several organizations to attract more secondary industry to Broken Hill and so decrease the communities' dependence on the prosperity of the mines. Success in this area could improve the undertakings position and help us to maintain a fairly stable tariff structure – tariffs have only been increased twice since 1959, and in that time the efficiency of the organization in terms of losses, has improved from about 80% to last years 91%.

THE MINING INDUSTRY

No description of electricity supply in Broken Hill would be complete without some reference to the very extensive 40cycle system supplying the major mining industry which is our mainstay. During the early period of Broken Hill's development, each mining enterprise generated its own electricity, and I believe that at one time there were as many as 23 plants operating, probably all at different voltages and frequencies.

As the mines consolidated into several large companies, it was natural that the question of standardization of electricity supply should become important, and in June 1931 the Central Power Station was commissioned by Western N.S.W. Electric Power Pty. Ltd. To supply the combined leases of North Broken Hill, Broken Hill South and the Zinc Corporation, these companies also being the shareholders in the Power Company. The system chosen was 40 cycle with a 3 wire delta connected 550 volt low voltage network. This station, expanded to twice its original capacity, still supplies the majority of the power consumed by the mines, and also generates compressed air which is reticulated to the mines in large pipes. The station has an installed capacity of 28,400 kW of electricity and 46,200 cubic feet per minute of compressed air, the total diesel plant having a site rating of 51,000 hp.

Another reasonably large diesel station is operated by Southern Power Corporation and Broken Hill Consolidated Limited, and this supplies part of the 40 cycle requirements of these companies.

A substantial pumping station of about 2000 hp total capacity operated by Broken Hill Water Board at Stephen Creek, about 10 miles from the city is also supplied from the 40 cycle system.

THE FUTURE

Mining is an extractive industry, and no matter how rich or how widespread the deposits of ore, there comes a time when the end of the field is in sight. This possibility is already being considered in Broken Hill, and very active promotion is taking place in an attempt to attract decentralised secondary industry to the district.

We have much to offer, not least of which is a reasonably stable industrial system, (compared to most large centers of population at present), a favorable climate for most of the year, and a very central position on the **Indian Pacific Railway**[9], mid way between east and west.

Although the Council's Electricity undertaking does not supply the mining industry, we do service the homes of the employees, and the commercial enterprises which depend on the mines for their existence. Consequently a large reduction in population would mean a large reduction in our requirements for power.

However, in spite of the fact that there has been no major change in population for many years, our load has continued to grow in keeping with the higher standards of living of our affluent society. There are signs that the continual promotion of the city may bear some fruit in the foreseeable future and a significant industrial component in our load could alter the present pattern altogether.

In the rural sector, there is a large cotton growing venture being established in the Menindee Lakes area at the moment. If successful and there seems no reason why it should not be, there is ample room for more, and only three or four times the present acreage would be sufficient to support a processing plant in Menindee.

There is also a tremendous potential for irrigation, along the Darling River, especially from Menindee down where the lakes can exert some control over the river flow. I cannot see that this potential can be ignored, even actively resisted, for an indefinite time by any responsible government.

Recent years have seen increasing awareness in the unincorporated areas of the Western Division of advantages and amenities available from reticulated power supply. A number of organizations representing the population of this area are pressing very strongly for extension beyond existing franchise limits and this voice must eventually be heard.

All in all, there could be exciting times ahead for our undertaking. One thing only is certain, and that is that while demand still exists in the area for electricity supply, our Council will continue to provide the service and attention to its consumers that it has so capably done over the last seventy years.

STATISTICS : BROKEN HILL CITY COUNCIL ELECTRICITY DEPARTMENT

MAXIMUM DEMAND TO 1973		16,560 kW
ENERGY PURCHASED	1973	67,996,800
ENERGY SOLD	1973	60,451,889
PERCENTAGE LOSSES		11.09%
REVENUE	1973	$1,912,745
NUMBER OF CUSTOMERS		10,500 (approximately)

LENGTH OF OVERHEAD LINES AT :-

66 kV	72 miles
22 kV	124 miles
6.6 kV	39 miles
415/240 V	114 miles

Document 3

This document has been printed using a **"dot matrix"** printer onto 10 pages of standard (11"x 9½") size tractor paper. Implying the use of a **PC Desktop Computer** and **Word Processor program**,

HISTORY OF THE BROKEN HILL ELECTRICITY UNDERTAKING

The history of Electricity in Broken Hill goes back a long time – to a time before the supply undertaking was operated by the City Council, a time when entrepreneurs from capital cities were moving out into country areas to sell the new "electric lighting" to towns and villages, Councils and private enterprises. Competition was strong from the gas people, even more so than today, since they had all the market and were reluctant to let it go. From early literature and reports, some of which are still preserved by libraries and other interested bodies, it would appear that some of the "experts" selling plant and systems all over the country had even less appreciation of the technical attributes of their wares than the people who were purchasing them.

It must be remembered of course that these were the very early days of the use of electricity as a form of energy. Although electricity as a physical phenomena had been known for a very long time, it was not until Edison perfected the carbon filament lamp that a practical use within the reach of ordinary people became a reality. It is a tribute to the persistence and industry of the early proponents of electricity as an energy source that use became so universal throughout the world with in just a few short years after this event. Many of us would have grandparents or even parents who were born before the introduction of electric light.

The first, and still most widely appreciated use of electricity as a form of energy was for lighting, and in the earliest days it was used almost exclusively for this purpose.

The earliest reference which I can find to electric lighting in N.S.W. is that in 1881 an arc lamp was installed at Redfern Railway Station by a Mr. H.H. Kingsbury, who claimed that this was the first installation in the State. Mr. Kingsbury was a pioneer of the new system and was instrumental in introducing it to a number of cities and towns.

The first recorded instance of electric lighting in Broken Hill was on April 2nd,1887, only six years later, and barely four years after the first settlers on the field. Three Weston arc lamps were installed on the Broken Hill Proprietary mine, one each over Rasp's and McCulloch's shafts, and one in front of the smelters. The plant consisted of a Weston "Five Light Dynamo" powered by a Tangye 8 hp engine, steam being obtained from the smelter boiler. According to newspaper reports, the population was amazed at the brightness of the lights on the "Hill".

The first lighting plant to operate in the town was installed at the York Hotel, later the site of the Masonic Club, on September 20th, 1889 when a 3000 candle power lamp was erected on one of the Hotel towers. Lighting for the remainder of the building was available the following day, apparently from a private isolated generating plant to supply the Hotel only.

A prospectus was drawn up on March 31st, 1890 for a company to be known as the Broken Hill and Suburban Electric Light and Power Company, with a proposed capital of £14,000 in £1 shares. The Directors were eight local business men, described as follows :

Lawrence Finn	Hotelkeeper
John Elliot	Hotelkeeper
Robert Sayers	Hotelkeeper
Philip Parker King	Bank Manager
William Charles Wickes	Painter
Otto Van Reiben	Carrier
John Ford	Storekeeper
Edward Dinsdale	Mechanic

The secretary of the proposed Company was J.J. Callaghan

On Saturday April 15th, 1890 the Company carried out a successful trial of shop lighting in the premises of two of the Directors, Ford and Callaghan. The Company, now known as the Broken Hill Light and Power Company Limited, was formed on June 4th, 1890, with 8000shares being taken up.

The Archives of the Charles Rasp Library contain some interesting sidelights on activities of the times.

A hand written copy of a Draft Agreement between the Council and the Company still exists, granting permissive rights to "erect poles and posts and stretch wires – they do not define the difference between poles or posts, but as the agreement was drawn up by Council's solicitors they were probably able to put whatever meaning they wanted on the words. The conditions were very much biased towards the Council. All works had to be completed within six months of the signing of the agreement : if the Company went bankrupt, Council acquired all erected plant ; the permission to supply power in any specific area could be revoked on seven days notice ; the Company was required to pay the salary of a special Council "Officer" (not to exceed £200 p.a.) who was to approve all work carried out. After all this, the right to supply was not exclusive, and Council could enter into similar agreement with any other Company if it so desired.

There were also a number of technical limitations placed on the construction, possibly the forerunner of the present day Overhead Lines Construction and Maintenance Regulations. It is conceivable that there were as many different sets of Regulations as there were Solicitors and Local Authorities making Agreements throughout the country. It was specified that poles should be not less than 50 yards apart – the only present limitation is on maximum spacings. In addition they were to be at least 30 ft.

out of the ground and 3 ft. 6 inches in the ground – a pole of this height has to be the metric equivalent of 5 ft.6 in. in the ground, although until quite recently it was still possible to find an occasional pole set less than 4 feet. There was to be "a maximum of 120 volts electromotive force" and all wires were to be at least 2 ft.6 in. apart and insulated to prevent leakage. There was apparently some misunderstanding between the Company and Council as to the type of cable to be used. Some Council members insisted that "submarine" cable should be used, but the contractor provided testimonials for their "best quality aerial cable which had been used in Newcastle without failure for over eight months".

Although there is no record that the Agreement was actually signed in that form subsequent events indicate that the final document must have been very similar.

A new plant described as a "complete Westinghouse Electric Light Plant of 1000 lamps" was supplied and installed (eventually) by the Sydney Electric Company, comprising Messrs. Wescott, Marshall, and Adams, and it is interesting to note that Mr. Adams was Geo. Adams of Tattersalls fame (later correspondence to Council on Mr. Adams letterhead describes his occupation as "Gentleman"). The contract price was £8,000 and the installing Company accepted 1000 shares in the local Company as part payment. The method of rating a lighting plant as a "5 light plant" or a "1000 light plant" was based on the standard lamp of 16 candlepower in use at that time. Larger or smaller lamps or power appliances were converted to "equivalent 16 candlepower lamps" to determine rating required. Interestingly gas lamps at the time (and I presume at the present time) were rated in "equivalent feet" and this rating i.e. "five feet" or "six feet" referred to the number of cubic feet of gas the lamp would consume in a given period.

The new Company apparently had trouble right from the start – on October 20th, 1890 Mr. Callaghan requested the Council for an extension of six months due to difficulties in obtaining plant, although "the contracts were now let and progressing satisfactorily". Apparently the request was criticized at the Council meeting and reported in the press, as a further letter on November 3rd, 1890 referred to the press report and that some members of the Council believed the Company had no intention of proceeding with the undertaking. The secretary then explained in detail how an arrangement was entered into "last August with Messrs. Harrison and Whiffen" to supply a complete electrical plant, and just when the matter was almost settled, they withdrew from their agreement altogether. New tenders had to be called and it was not until September that a contract was concluded with the Sydney Electric Light Company for a complete installation, and the plant was cabled for immediately. Furthermore it had been impossible to secure poles earlier "because of a shipping strike, and since the vessels could not be unloaded, they had gone on to Melbourne and had only been brought back last week".

Nothing has changed!

Finally, however, the big day (or night) arrived, and on September 5th, 1891, nine arc lamps were lit for the first time in Argent Street.

On the night of October 3rd, 1891 at the Central Station, as it was known, in Blende Street, the formal opening was celebrated. The lamps were switched by Miss Sayers,

daughter of one of the Directors, thus inaugurating electricity supply for public and private use in the Town of Broken Hill. On this date there were twenty premises using the new source of light. It is interesting to record that early this year (1991), a Mr. John Sayers of Sudbury in the U.K. visited Broken Hill while holidaying in Australia to check out a family story that his great grandfather had some connection with the introduction of electricity supply in Broken Hill.

There is some confusion as to the location of the earliest power stations. There is a record of a small power station at the corner of Argent Lane and Bromide Street, but it is certain that the new plant officially commissioned on October 3rd, 1891 was installed at the Blende Street premises next to the Barrier Miner office that was occupied by the Electricity Department until 1963 – and a large proportion of the building at that time was the original 72 year old construction. The site of both the power station and the Barrier Miner office is presently occupied by the Barrier Social Democratic Club car park on the corner of Blende and Sulphide Streets.

It is indicative of the foresight of our pioneers that we were one of the first towns in N.S.W. to have electricity supply available as a reticulated public utility. The City of Tamworth had electricity (at least street lighting) in 1888 and this is credited with being the first public supply in N.S.W. There is a copy in the Archives of a letter published in the Sydney Daily Telegraph of June 7th, 1890, written by our old friend Mr. H.H. Kingsbury, who had just installed a lighting system in the Town of Young, pointing out the "distorted facts and extravagant inferences" of the claims made by a writer of a few day earlier, who proved (on paper) that electricity could never be a serious competitor to gas, and had no future at all except as a novelty. Obviously the town of Young also had an electricity supply before Broken Hill, and it is known that this undertaking was owned by the Council. In spite of the earlier references to the use of "best quality aerial cable" in Newcastle in 1890 there is nothing to suggest that there was an extensive supply system there at that time and I have always considered that Broken Hill was the third community in New South Wales to have public electricity supply.

As with so many enterprise, there may have been more enthusiasm than expertise among the Directors and we find by 1894 the Company was in difficulties, Mr. J.J. Callighan was appointed as liquidator. You may recall that the original Agreement gave the Council the right to acquire all the plant and equipment of the Company in the event of bankruptcy but notwithstanding this the Company's solicitors requested Council on April 7th, 1894 to consent to the sale of the rights acquired under the Agreement to George Adams, who we recall as on of the partners in the Sydney Electric Light Company which carried out the original installation. Mr. Adams, however, may have been somewhat more astute than his predecessors, and would not complete the transaction unless Council waived the conditions contained in the Agreement of May 3rd, 1890.

Another letter in the Archives shows that on November 26th, 1898 George Adams placed the Electric Light Station at Broken Hill under offer to the Council for a period of three months. It would appear that Council did not avail itself of this opportunity however, because a little later a Mr. F.J. Mars applied to Council in the following terms :

" I beg herewith to make application (as per articles presented) for your approval and consent to transfer to myself, or otherwise grant me the permissive rights as held by George Adams, of Pitt Street, Sydney, Gentleman, for carrying on the business of reticulation of Electrical Energy in your Municipality ----"

The Company is once again referred to as the Broken Hill and Suburban Electric Light and Power Company Limited. Unfortunately the only date on this letter was the year, 1900.

Apparently Council was still not interested at that time. The next move appears to have been a letter from Council to Mr. Mars three years later, and his reply dated November 5th, 1903 "acknowledges receipt of your communication of 30th ulto, asking if the owners of our work are willing to sell out as a going concern to your Council, and at what figure".

Mr. Mars advised that the owner were in fact willing to discuss terms and left the next move to Council. The Company letterhead provides the interesting information, in addition to the name, that the Proprietors were Messrs. Strachan and Mars, P.O. Box 58, Telephone 300. This was the telephone number of the power Station in Blende Street and later in Galena Street until the introduction of the automatic telephone exchange in about 1956.

At a meeting of the Broken Hill Council on Wednesday, December 6th, 1905 a decision was finally taken to purchase the Broken Hill Power and Light Station complete with reticulation, and Messrs. George Job and L.H. Beck were appointed Arbitrators between Council and the Company.

At this time the undertaking comprised 44 transformers of in total 132 kVA capacity, and 178 street poles. There were 151 customers with a lighting load of 1987 equivalent 16 candlepower lamps and 40 arc lamps, taking some 290 amperes. The power load consisted of six single phase motors aggregating 22 horsepower, and 60 fans, the total load being equal to 2487 sixteen candlepower lamps. For the more technically minded the frequency of the system was 100 cycles per second (Hertz) and the distribution system was single phase 3 wire 110/220 volts. High voltage reticulation (which may not have been introduced at this time) was at 2400 volts single phase. The annual output of the station was in the vicinity of 160,000 units.

The tariff at the time appeared to be on some form of maximum demand system, with a charge of one shilling and threepence for the first block of units and sixpence a unit for the remainder. Taking an average of seven and a half pence per unit, the expected gross revenue was estimated at £5,000. The value of plant estimated by Messrs. Job and Beck was £11,200 and it was decided that £12,000 was not an excessive amount to pay. This being agreed upon, the deal was finalised and the Broken Hill Council became the proud owners of an electricity system.

The first engineer and Manager was Mr. George Job and Mr. Mars retained as a Consultant for the first three months of operation. Mr. Job continued as Engineer/Manager until his retirement in 1924, by which time the "Electric Light Works" was on a sound financial footing and was quite a successful undertaking.

In 1906Council decided to extend the street lighting system beyond the main business area, and the very latest American General Electric Company high voltage series system (1100 volts) arc lamps were installed. The arc lamps were changed for incandescent (the present type of ordinary lamp) in 1910 – interestingly our friend Mr. H.H. Kingsbury had published an article in 1890, still in the Archives, expounding the superiority of incandescent lamps over the arc lamp. Street lighting poles at that time were erected in the centre of the road, but this proved such a hazard to bolting horse drawn vehicles that they had to be moved to the side of the road.

Method of transport in the Electricity Department in those days was by hand push cart, but as the system expanded a horse drawn vehicle was brought into service.

By 1923 there were 350 consumers on the system and the plant was becoming so overloaded that more generating capacity was required. Until this time all generating plant was steam driven, but as oil engines were beginning to find their way into power stations, a Vickers Petter four cylinder semi diesel engine coupled to a 125 kW alternator was purchased and installed. The Engineer's recommendation was soon justified by greatly reduced operating costs – the steam boilers used costly coal and were hand fired. As a by-product steam was sold at 150 lbs. Pressure to the Barrier Miner, Barrier Daily Truth and the "Ice Works".

With the extra capacity available, mains were then extended into all parts of the City, and the load grew with such rapidity that four more units were ordered from the same manufacturer – three of 250 kW, and one of 50 kW capacity. During this period the Pinnacles Mine closed down and a similar unit of the same rating as the earlier ones was purchased from there. With six oil units operating, the remaining steam boilers were converted to oil firing and coal was cut out altogether.

By the mid thirties, however, both the generating plant and the site at Blende Street were finding it difficult to meet the demands being placed on them, and in 1935-36 a new power station was built at the corner of Galena and Talc Streets. Two new 400kW full diesel sets were installed and commissioned in 1936. The new station was run in parallel with the old one until all the old engines were transferred, one by one, to Galena Street. It was a matter of some pride to the Department that not one customer was inconvenienced during this changeover. By1937 the steam plant was completely redundant and was sold for scrap. The old Blende Street station became a store, workshop and depot for the line, installation and maintenance staff.

Also in 1936 the administration offices were moved from Blende Street to the Town Hall. By 1963 the facilities offered by the original power station building, parts of which dated back to the 1890's, had become totally inadequate. A modern store and workshop was constructed in Crystal Street adjacent to the railway line and all operations apart from Engineering and Administration were transferred there. With the rapid growth of the department from this time these facilities were also outgrown in a very short time and the move to the present much larger premises at 610 Wolfram Street was made in 1986.

As mentioned previously the earliest distribution was 3 wire 110/220 volts single phase 100 Hertz, with a 2,400 volt 2 wire high voltage network. This system persisted unchanged until 1938 when it was decided to introduce the modern standard 240/415

three phase 50 Hertz system. By that time we were the only city in the world operating a 100 Hertz generating plant and it was almost impossible to buy appliances or industrial equipment to suit this frequency.

It was intended to gradually convert the existing network to the new voltage and frequency. However the change over was interrupted by the war years, and hampered by lack of funds immediately after the war so that it was not completed until the late 1950's – about 1956 or 57. Shortly after this the last of the series street light were phased out, and the original constant current transformer was scrapped after 50 years service.

In the late 1950's Council approached the newly formed Electricity Commission of N.S.W. for assistance with the purchase of new generating plant in an attempt to reduce what was by then a sever financial burden in operating very old machinery which had been neglected because of lack of spare parts and manpower during the war years. An agreement was finally reached whereby the Commission took over the entire power station, in accordance with its charter of acquiring all the generating plant in the state. In return the Council was required to extend its distribution system into the rural area and provide reticulated supply to the village of Menindee on the Darling River. Final acquisition of the power station was achieved in 1959, the same year that Menindee was connected to the City by a 116 km transmission line. From that time Council became a distribution authority only, purchasing power in bulk from the Commission at standard Bulk Supply Rate (which was much less than the cost of generation) and selling it to consumers supplied over the distribution network.

Growth in maximum demand supplied was very rapid in those years – particularly between 1960 and 1970, requiring equally rapid increases in the capacity of both the power station and distribution system. From early records to the present time some significant figures for maximum demand are :

1937	925 kW
1944	1,425 kW
1960	6,984 kW
1970	15,300 kW
1980	22,460 kW
1990	58,427 kW (24,928 kW Town, plus, 33,973 kW Mines)

The augmentation required in the power station would certainly have been beyond the capacity of Council's resources. The existing plant was all replaced by the Commission and the station extended to eventually have a firm capacity in excess of 30,000 kW.

A further major augmentation was required by the late 1970's and after comparing the cost of expanding the existing station or constructing a long transmission line to the nearest grid supply it was decided to accept the transmission option. In 1978 the City was connected by 220 kV transmission line to the grid system of the State Electricity Commission of Victoria at Redcliffs, near Mildura. The Electricity Commission of N.S.W. came to an agreement with SECV regarding the transfer of power at other locations to compensate for power taken at Redcliffs and continued to supply to Broken Hill at the standard Bulk Supply rate. Eventually with the connection of all

Mining loads to Council's system the demand out grew the agreement and the ECNSW (Elcom) constructed a further 220 kV line between Darlington Point and Redcliffs (with a considerable financial contribution from the Mining Companies) to connect to the N.S.W. grid. At approximately 800 km this is one of the longest radial 220 kV feeders in operation with only one consumer at the far end of the line.

The Galena Street power station was retained by Elcom as a standby plant for many years. The costs of maintaining staff and equipment eventually became unrealistic and in 1989 two GE gas turbine units of nominal 25 MVA capacity each were commissioned at the site of the Commission's 220/22 kV substation. On Friday 1st September, 1989 the Galena Street station was disconnected from the Council's distribution system. The gas turbine units are completely automatic and are started on demand by signals which can be communicated by satellite from Yass or Wagga Wagga. There is now no Elcom staff permanently located in Broken Hill.

The present system of electricity supply is simply a continuing development of the practices and developments of the past. As demand increases in specific areas, alterations or additions are made to cater for it.

In the early 1970's it became obvious that the original 6,600 volt high voltage system commenced in 1938 was becoming inadequate for the demands which would arise over the next ten years or so. Following a very exhaustive investigation and engineering assessment over several years, it was decided in 1973 to commence changing this system to 22,000 volts. The project was expected to cost about half a million dollars spread over a number of years as it become economical to convert each section because of savings in the cost of losses. For a number of reasons the changeover was not completed until 1985-86 with significant savings in losses and improvement in voltage regulation.

Until 1959 the operations of the Department were restricted to the actual city area of Broken Hill, Following the acquisition of the power station by the Electricity Commission, Council extended supply to Menindee. Over the ensuing years the rural areas around Menindee were progressively reticulated until most properties and other facilities within about 35 kilometres were connected.
In the early sixties the South Australian Railways requested supply for Cockburn on the South Australian border. There was also a need for power for a microwave repeater station to be established in the Thackaringa hills, and with contributions from both Departments a 22 kV line was constructed initially to Cockburn only, and then extended to the Pinnacles Mine and Silverton as demand arose.

The village of Tibooburra about 320 km north of Broken Hill had no public electricity supply apart from various Government Departments supplied from a small power station at the hospital. An agreement was reached between Elcom, the N.S.W. Public Works Department and Council for the PWD to construct and operate a diesel powered generating station: Broken Hill City Council to build and maintain the necessary distribution facilities, provide the administrative and commercial services; and Elcom to make up the financial deficit. There was an official "switch on" by the Deputy Premier and Minister for Public Works, Mr. Jack Ferguson, in October 1977.

Over very many years there was agitation for the Council to take over the privately owned electricity undertaking at Wilcannia. The diesel power station was in need of reconditioning and augmentation, but the capital required was beyond the resources of the operating Company. Finally the State Government through the Electricity Commission agreed to the construction of a 135 km 33 kV line between Menindee and Wilcannia and a step down substation to connect into the existing 6.6 kV system. This was completed in 1988 and was officially "switched on" by the Member for Broken Hill, Mr. Bill Beckroge, on March 17th of that year. Shortly afterwards work was commenced on the extension of reticulated power to rural properties adjacent to the 33 kV line by single wire earth return (SWER) lines. (The first SWER line on the system was completed in the previous year to connect a number of properties south of Broken Hill along the Mildura Road). Elcom also contributed to the rebuilding of the 66 kV line between Broken Hill and Menindee to cater for the additional load at Wilcannia as well as the growing demand in the Menindee area and substantial pumping load for the Broken Hill Water Board.

The private Company (CWR Electrical) which had operated the supply system at Wilcannia had also managed the distribution of electricity at the village of White Cliffs, about 90 km north of Wilcannia. Restricted power was provided to a small number of consumers at White Cliffs by an experimental solar/diesel station operated by the Australian National University. Following the acquisition of CWR assets by the Council, the Company ceased to operate in the Wilcannia district and Council took over the supply contracts with the Department of Minerals and Energy.

In 1989 a proposal was developed to provide reticulated electricity to the villages of White Cliffs and Tibooburra, and to connect every unserviced property in the Western Division of the State by SWER extensions. The then Minister for Minerals and Energy, the Hon. Neil Pickard, set up a Committee of Enquiry chaired by Mr. Martin Thomas in December 1989 to determine the best means by which these objectives could be achieved. As a result a separate organization known as the Darling Electricity Construction Authority (DECA) was established in early 1990 to carry out the project. As of June 1991 the construction phase of the project had not commenced.

In response to the need for representation of the increasing rural community being serviced by the Department, Council's Electricity Committee was expanded to include a nominee of the Central Darling Shire Council in 1988 and of the Darling Electricity Construction Authority in 1991. Also in 1991 the Department adopted a corporate logo and the trading name of Broken Hill Electricity as part of the more commercial outlook required of electricity supply organizations in the changing environment of the nineties.

As a result of the Thomas Enquiry the administration of Council's Electricity Trading undertaking was restructured in October 1990 to conform to the General Manager format adopted several years earlier by County Council undertakings. The first appointee as General Manager was Mr. E. Norris, who was previously Commercial Manager of the Department.

From 1905 until 1991 the operations of the Department had been overseen by an Electrical Engineer as required by Ordinance 4 of the Local Government Act, 1919. The eight Engineers who held this position were

G. Job (Electrical Engineer/Manager)
T.A. Reece
E. Tweddell
C. Robinson
L.G. Job (son of G. Job)
S.D. Berry
A.L. Bunning (1958-70)
R.J. Baker (1970-91) (Manager, Electricity Services from 1989)

At the end of the trading year 1990/1991 the vital statistics of the Department were:

Number of consumers	1156
Maximum Demand 1990/1991	
Units purchased 1990/1991	
Units sold 1990/1991	
Revenue 1990/1991	
Length of line	1200 km
Number of connected transformers	330

No description of Electricity supply in Broken Hill would be complete without some reference to the very extensive private system supplying the mining industry. During the early period of Broken Hill's development, each mining enterprise generated its own electricity, and it is said that at one time there were as many as 23 separate plants operating , mostly at different voltages and frequencies – there was even some D.C. generation. As the mines consolidated into several companies, it was natural that the question of standardization of electricity supply should become important. In June 1931 the Central Power Station, as it became known, was commissioned by the Western N.S.W. Electric Power Pty. Ltd. To supply the combined leases of North Broken Hill, Broken Hill South, and the Zinc Corporation, these companies also being the only shareholders in the Power Company.

The system chosen had a frequency of 40 Hertz and was distributed to the mine leases at 6900 and 22000 volts. The low voltage system designed specifically for the mining loads was ***550 volts 3 phase delta***[10] connected with no earth reference point, using a 550/110 volt transformer to supply underground lighting. The station was expanded to about twice its original capacity in the early 50's and continued to supply the Mine's requirements until August 1986. At that time the installed site rating was 51,000 hp which was capable of supplying 28,400 kW of electrical demand and 46,200 cubic feet per minute of compressed air.

With the availability of relatively unlimited power from the grid system and ever increasing cost of diesel generation, during the 1970's the Mines began to consider purchasing electricity in bulk from the Council and converting it to 40 Hertz for their own use. A pilot GEC solid state converter of 4 MW capacity was established in 1980 and a bulk supply rate was negotiated with the Council. Discussions were then held with the Council and the Electricity Commission, both separately and together, to settle the terms and conditions under which supply for the whole of the Mine's requirements could be agreed. Among other things, the Mines were concerned with the reliability of supply through the SECV and the limitations of the Victorian grid

capacity to supply the long term needs of the City. Eventually a tripartite agreement was finalised under which the Mines would take supply from the Council at an agreed rate, and the Electricity Commission would augment its supply system by constructing the additional 220 kV line from Darlington Point to Buronga which connects Broken Hill to the N.S.W. grid. The Mining Companies made a very considerable contribution to the cost of this line, in addition to the cost of establishing their own 220 kV substation and converter. Power is purchased at 220 kV and converted through two ASEA 20 MW solid state converters to supply the Mine's requirements, although the existing Southern Power diesel station has been retained. Initial restricted supply of about 30 MVA was taken in 1985 pending the completion of the Darlington Point line, and on April9th, 1988 Elcom advised that "normal supply" in the terms of the Tripartite Agreement (up to 65 MVA) was now available.

In this time of rapid industry restructuring by Government direction, it is difficult what the long term future of Council's Electricity Department will be. However it is certain that there will be some form of Broken Hill Electricity organisation with as much local input as possible and a firm commitment to meeting the electrical energy needs of the community as it has in the past.