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Early Electricity Supply in Melbourne

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SUMMARY: *This paper traces the commencement of public electricity supply in Melbourne in 1882, placing it in the vanguard of similar developments worldwide. The subsequent participation of other private enterprise ventures and the entry of the Melbourne City Council into the field are then outlined along with the range of electricity supply technologies that were successively adopted, from HV series DC, single-phase AC, low-voltage DC to 3-phase AC.*

1. BACKGROUND

The practical application of electricity commenced in 1800 with Alessandro Volta's 'voltaic pile', a form of primary battery that enabled the supply of a sustained electrical current. In 1808, Sir Humphrey Davy demonstrated the electric arc light source between two carbon rods connected to a large battery.

The pivotal experiments by Michael Faraday during the 1830s in discovering electro-magnetic induction paved the way for the development of the electric generator and electric motor wherein mechanical energy could be converted into electrical energy and vice-versa. In 1858, Frederick Holmes' permanent magnet magneto-electric machine was successively utilized to power an arc lamp in a UK lighthouse. This was followed in 1867 by Wilhelm Siemens' patented self-excited, continuous-current generator with electromagnetic poles, which he called a 'dynamo'. In 1870, the Belgian, Theophile Gramme produced his ring wound armature, direct current generator with its multi-segment commutator, a machine which operated equally well as an electric motor. Gramme also developed an early AC generator (alternator). These early electro-mechanical machines were rapidly improved upon by other electrical workers in the UK, in Europe and in the USA (Dunsheath 1962; Hughes 1983).

By the beginning of the last quarter of the nineteenth century the means was thus available to generate electricity from mechanical prime movers, most notably the steam engine, and to provide powerful electric lighting by means of the electric arc lamp. The arc light was however not suited for office or domestic lighting applications. The problem of 'subdividing the light' of the arc lamp was solved at the beginning 1879 by the Englishman Joseph Swan's invention of an incandescent electric lamp. Thomas Edison working independently in the USA arrived at a similar solution and patented his incandescent lamp late in the same year (Dunsheath 1962).

In 1885 Ganz & Co. of Hungary successfully developed and marketed a high-voltage alternating current system that used parallel connected transformers stepping down to low-voltage – typically 100V – for end-use applications such as incandescent lighting in commercial and domestic premises. This pioneered the way for the generation and transmission at high AC voltages that overcame the distance constraint on DC electricity supply schemes. The AC system was taken-up in America by the Westinghouse Electric Co. in opposition to Edison's DC supply systems (Hughes 1983).

Early electricity generation for lighting purposes utilized both continuous-current or DC generators (dynamos) and alternating current (single-phase) generators (alternators). The respective systems were vigorously promoted by their protagonists in what became known in the late 1880s as 'the battle of the systems' (Hughes, 1983). Those advocating DC pointed to the ability to utilize storage batteries in conjunction with DC generators and the ready availability of DC motors, whilst the AC system exponents lauded the benefits of high-voltage transmission with transformers being used to furnish low-voltage close to the end-use locations.

2. EARLY ELECTRIC LIGHTING VENTURES IN MELBOURNE

In 1863, three arc lamps powered by primary batteries were erected outside of Parliament House, the Post Office and the Telegraph Office to celebrate the marriage of the Prince of Wales (later King Edward VII). Much interest was aroused at the time but the installations were expensive to run and were thus short lived (Australasian Ironmonger 1890; Bate 1934).

During the 1870s a number of individual companies, including Sands & McDougal and (ironically) the Apollo Candle Co. set up in-house arc lighting installations using gas engine driven dynamos (50V systems). In 1879, a night football match was staged at the Melbourne Cricket Ground using arc lights on temporary tower structures with dynamos driven by portable engines. Reportedly it was not a great success and after one further try it was discontinued.

In September 1880, Melbourne watchmaker, Mr R E Joseph founded the Victorian Electric Company (VEC). Joseph had developed a keen interest in the practical applications of electricity and the business opportunities

that it offered. The initial capital of the company was modest, however its stated objectives were: 'to produce and sell electric machines for electric lighting, motive power, &c, and to supply for hire, and maintain, electric light for public and private purposes' (Australasian Ironmonger 1890). During the following year Joseph demonstrated an arc light outside his premises in Swanston Street, Figure 1, which heightened local interest in the new electric lighting (Slater 1982).

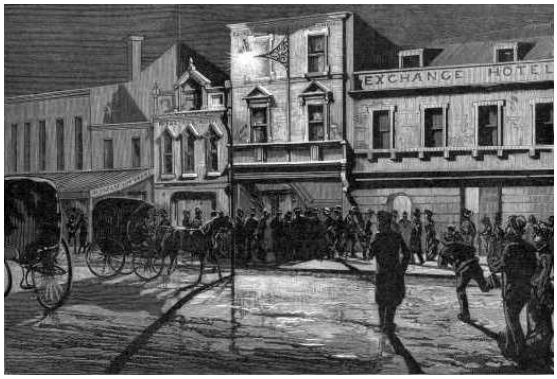

Figure 1 *Arc light demonstration Swanston Street*

In the same year, the VEC obtained a Melbourne City Council (MCC) contract to light the Eastern Market. The installation comprised six arc lights powered by portable engine driven dynamos. This was successful, and the contract was successively renewed through to 1894. The original company was re-floated in late 1881 as the Australian Electric Company Limited (AEC) with increased capital and with W C Kernot (later professor Kernot) as its chairman. The new company purchased land and erected a two-storey brick building in Russell Place, off Bourke Street, for a workshop and the nucleus of a central generating station.

A publication on 'Electric Lighting', authored by Joseph in 1881 as 'Electrical Engineer to the Australian Electric Company', promoted the advantages of electric light and set out information on the generation, transmission and utilization of electricity for lighting and other purposes (Joseph 1881).

3. THE BEGINNING OF PUBLIC ELECTRICITY SUPPLY IN MELBOURNE

In the latter part of 1882 the Australian Electric Company (AEC) commissioned a small central generating plant in the ground floor of its Russell Place building to supply street lighting in adjacent parts of Swanston and Bourke Streets and lighting in some nearby private premises. The initial system comprised two Marshall steam engines of about 100hp (75kW) each driving through counter shafts a series of small 50volt dynamos and a single 100V alternator (Curtis 1930). The company also manufactured dynamos, arc lights and other electrical equipment on the upper floor of its building.

AEC's central generating plant and associated public electricity supply commenced operation in the second half of 1882, and was contemporary with Edison's first public electricity supply scheme in London at Holborn Viaduct, which was commissioned in April 1882, and the famous Pearl Street central public supply power station in New York which started in September 1882. AEC's enterprise was also inaugurated within a year of the public electricity supply for the small town of Godalming in Surrey (UK), which is widely considered to have been the first public electricity supply in the world (Parsons 1939; Haveron 1981).

At the end of 1882, the AEC demonstrated for the first time in Melbourne the then new incandescent electric lamps in the Atheneum Theatre with supply from their Russell Place generating plant. This was followed by an extensive installation of incandescent lights, plus some arc lights, in the also nearby Opera House, later known as the Tivoli Theatre (Australasian Ironmonger 1890; Slater 1982). In 1883, the Victoria Coffee Palace, later known as the Victoria Hotel, installed electric lighting in public rooms, and became another of AEC's early customers.

In 1883 the AEC faced it first competition from the Australian Electric Light & Storage Co. who won a one-year contract from MCC to light Elizabeth St. The contract was however not renewed and the AELSC subsequently disappeared from the Melbourne scene, although they were involved in enterprises elsewhere in Australasia and influenced later electricity industry developments in Melbourne (Salter 1982).

Due to the low initial operating voltage, the AEC was not able to supply customers who were more distant from its Russell Place premises and instead set up company owned generating plant in the customer's premises. These separate installations included the State Library, the Princess Theatre and Parliament House. By 1887 however, the company had installed three 2000V Ganz alternator sets driven by high-speed steam engines at Russell Place with distribution then being at 2kV AC and with 2000/100V Ganz step-down transformers at or close to end-use supply points. This then enabled the former local generating plants to be retired (Curtis 1930).

Around 1886, A U Alcock set up a small generating plant in Alcock's timber yard off Corr's Lane and in 1888 gained permission from the MCC 'to erect 5 masts in the centre of Russell Street, between Bourke Street and Lonsdale Street, and to lay underground wires for street lighting and for lighting premises' (Ruddock c1982). His plant comprised three steam engines driving four arc lighting dynamos and a small alternator (Curtis 1930). About the same time, Alcock also established another small public supply generating station in South Melbourne (Bate 1934).

For the Melbourne Centennial International Exhibition in 1888, a large electric lighting system was designed and implemented by K L Murray who was seconded from the Victorian Railways. This installation comprised 1000 arc lights, 40 'Sunbeam' 400cp lamps and 3000 6cp incandescent lamps. It was supplied from multiple dynamos driven through counter-shafting by Austral Otis slow-speed steam engines housed in a large annex adjoining the Exhibition Building (Murray 1899).

In 1889, the Union Electric Company (UEC) who had established a small generating plant in Heffernan Lane was contracted by the MCC to erect 15 arc lights at city street intersections. This Council contract was reportedly predicated by a general strike effecting gas supply.

Despite its earlier success, by the late 1880s the Australian Electric Company was seriously under capitalized and struggling to survive. It was formally wound up at the end of 1888. The remaining assets passed to a new company called the New Australian Electric Company (NAEC) early in 1889 (Slater 1982). This company, with substantive new financial backing, promptly embarked on the construction of the first part of a new central station at Green Street in suburban Richmond. It commenced operation in the following year.

The initial plant at Green Street in Richmond, comprised three, 2kV Elwell Parker, single-phase alternators (97cps) driven by 200hp (150kW) cross-compound Robey steam engines together with four arc lighting dynamos, Figure 2, (Curtis 1930). AC distribution for public and private electric lighting from this station was by mainly overhead lines, with 2000/100V transformers for individual low-voltage services. The station also contained four constant-current, 3kV, arc lighter dynamos driven via counter shafting from a fourth steam engine. The latter plant was similar to the City Council's c1894 plant at Spencer Street – see below – and probably supplied series connected streetlights in nearby parts of Richmond and South Yarra. The NAEC distribution area included southern parts of Richmond, and across the River to South Yarra and Prahran, as well as back into the central business district (CBD).

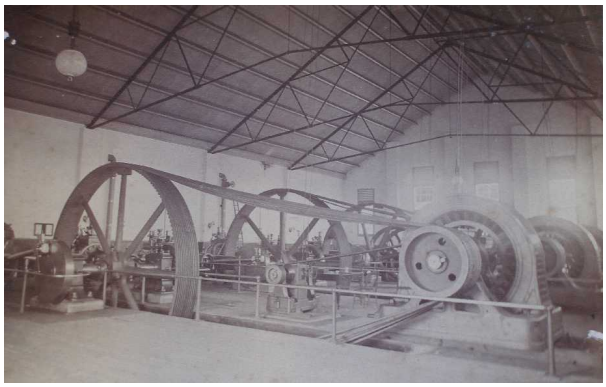

Figure 2 *NAEC Richmond Generating Plant*
Avery Collection Melbourne University Archives

In the next year – 1891 – A U Alcock, as the Electric Light & Motive Power Company (ELMPC), opened the initial part of a planned large central generating station in Burnley Street, Richmond. It comprised four steam engine driven 80kW, 2kV Ganz single-phase alternators, similar to the NAEC plant at Green St. Like the latter, electricity was distributed at 2kV for street lighting and private customers in north Richmond, Abbotsford and Collingwood as well as some parts of the Melbourne CBD, however the AC frequency of 42Hz was different (Building & Engineering Journal 1891). The two companies were in active competition, particularly for CBD customers.

As well as differences in the frequency, the voltage waveform of the early alternators was typically not a simple sine wave. The resulting harmonics would have caused additional losses in the early transformers that were themselves fairly basic devices. Differing voltage waveforms between machines also complicated the successful parallel operation of alternators (Dunsheath 1962).

4. ENTRY OF THE MELBOURNE CITY COUNCIL

The Melbourne CBD streets had been lit by gaslight from 1857. From the outset however, relations between the MCC and the gas company over cost and performance were strained and at times quite antagonistic, aided by a critical press (Slater 1982; Proudley 1987). With the successful deployment of alternative electric arc lighting in parts of some city streets by the private electricity supply companies in the 1880s, the Council, spurred on by its strong minded Town Clerk who had a particular disdain for the gas industry, began to consider entering the electric lighting field in its own right.

In 1891 the Melbourne City Council (MCC) formally resolved to establish its own power station and distribution for electric street lighting in the CBD (Ruddock c1982). Mr A J Arnot from the Union Electric Company was appointed as the first City Electrical Engineer with responsibility for the day-to-day running of the Melbourne City Council Electricity Supply Department (MCCESD).

The MCC's Spencer St. power station (SSPS) was commissioned in March 1894 with the first of four locally built Austral Otis 300hp (225kW) slow-speed steam engines each driving up to five Thomson Houston constant-current 3kV arc lighting dynamos via counter shafting. A rope drive was used between the engine flywheel and its section of the countershaft with the individual dynamos then driven from the latter with flat belting via fast and loose pulleys. Figure 3 shows the original engine room. This was similar to the plant arrangement used for the 1888 Centennial Exhibition lighting (see above), and required a large engine house. Each engine was supplied with steam from a Babcock &

Wilcox water tube boiler in an adjoining boilerhouse. Only three of the four sets of plant were required to carry the full lighting load so as to maintain supply security in the event of a failure of any one item. The dynamos were connected individually - via a plug-and-socket panel - to supply a single series-connected lighting circuit comprising arc lamps for the main streets, plus special incandescent lamps for the minor streets and lanes (Arnot 1894).

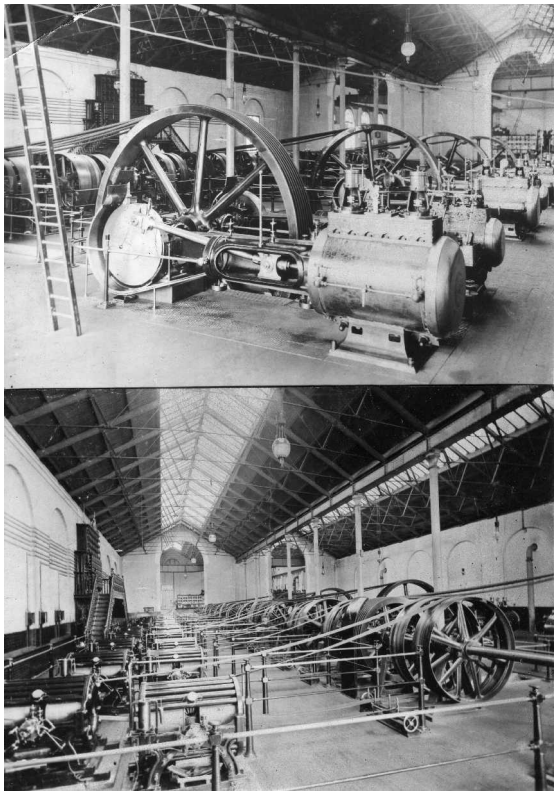

Figure 3 *Spencer St. P S Arc Lighting Plant 1895*

The constant-current series connected system was at that time commonly used for municipal street lighting in the USA and in some places in Great Britain (Arnot 1894) and had the advantage of requiring only a single, small cross-section conductor. However, due to the installed dynamos having only a small number of commutator segments, the current - although unidirectional - had high-frequency variation, resulting in interference to telephone circuits in the vicinity of the single-wire overhead power lines (Ruddock c1982).

The electric street lighting rapidly replaced the old gaslights and was generally considered to provide a much better illumination, although the deep shadows away from the brightly lit areas close to each arc light were sometimes criticised. In all, some 650 arc lamps and 1200 incandescent lamps were installed by the mid 1890s to light the Melbourne CBD streets and laneways (MCCESD 1915).

Four 75kw, 2kV, single-phase alternators were added in 1895 - using the spare positions on the counter shafts – for overhead distribution for street lighting and private premises supply in Council areas outside the CBD. 2000/100V transformers were installed on poles or at customer premises. The frequency of the MCCESD AC system was 72Hz, different again from both the NAEC and ELMPC AC systems, but in the early days of electric lighting AC frequency was considered of little import and it was not referred to in the specification (Ruddock c1982). The generating plant at Spencer Street power station, as described above, was similar to what was installed at Launceston's Duck Reach hydroelectric power station under K L Murray which was commissioned in December 1895, albeit that in the latter case the dynamos and alternators were individually direct-coupled to water turbines, and the AC frequency was 92Hz (Pierce 2007).

The year 1895 saw the passing of the first Victoria Electric Light & Power Act. Inter alia, the Act provided that:

- An Order-in-Council (O-I-C) was required to distribute electricity.
- Existing Council or company electricity supply undertakings were automatically entitled to obtain an O-I-C and Councils similarly entitled in respect to their respective municipal areas.
- Local Councils were able to take out non time limited O-I-Cs for their areas and able to contract out construction and/or operation to other parties.
- Non local government bodies were only able to obtain O-I-Cs for public supply with the consent of the relevant local Council(s) for a period of 25 years and the Council(s) able to compulsorily acquire the assets after expiry of 30 years.
- Electricity distribution was expected to be underground unless specific consent was obtained for overhead distribution.

Order No.1 was granted to Alcock's Electric Light & Motive Power Company, and Order No. 2 to the New Australian Electric Company.

In 1899 the MCC resolved to become the sole electricity supply undertaker in its municipal areas for which it had obtained O-I-C No. 3 in September 1897. Council thoughts of taking over the NAEC and the ELMPC enterprises lapsed without the support of other Councils served by them and arrangements were eventually made to compulsorily purchase only those assets of the two companies within the MCC boundaries. The final transfer was completed in January 1901. The MCC also purchased the Union Electric Co. and its assets in 1899.

Early in the 20th century, other suburban municipal councils took out O-I-Cs for their areas, but although some considered setting up their own generating plant, all ultimately arranged to cede their rights to the MCCESD or the MESC (see later re the latter entity) or

in ten cases, to purchase electricity in bulk from one or other of these undertakings and then arrange their own electricity distribution and retailing.

5. THE INTRODUCTION OF DC SUPPLY

As a result of 'many applications' being received by the MCC for supply of electricity for motive power purposes, the opportunity to do so was actively pursued by the Council (Ruddock c1982). A potential advantage was better generating plant utilization by increasing the daytime load. The idea was however strenuously opposed by the Melbourne Hydraulic Power Company who from 1889 had operated a public hydraulic power utility service in the CBD and some adjacent areas and who considered that they had a monopoly for supplying motive power, especially for lifts (Pierce 2008). After some resultant delay, the Council elected to proceed. Mr Arnot visited England and America to investigate latest practice. A decision was subsequently made to retain the 2000/100V single-phase AC for areas outside of the CBD and to develop an entirely new low-voltage 3-wire DC system for the CBD using underground cables (Ruddock 1982). The merits of the DC system were cited as:

- Direct supply from generators avoids transformers and their losses
- All classes of motors for elevators and other motive power can be economically and successfully operated
- Accumulators can be used for storage and back-up for light day load
- No interference with telephone circuits by induction – no AC
- As the maximum pressure is 450 volts, no danger to life if contact is made at any point.

  The last point is interesting – they must have been tougher in those days!

In 1900 the MCCESD commenced construction of a DC system for the CBD. The new DC plant at Spencer Street PS comprised four 350kW, 460V DC generators driven by Belliss reciprocating steam engines, as depicted in Figure 4, supplied from four Babcock & Wilcox water tube boilers, plus a 300Ah Tudor accumulator. A three-wire, 460/230V supply was provided using conventional motor-generator balancer sets. Underground cable mains were run to cast-iron curbside pillar-boxes from whence fused outgoing circuits supplied consumer premises. The old AC series arc lamps for CBD street lighting were progressively converted to DC flame-arc lamps. A new 120kW steam engine driven single-phase 2000V alternator was also added to augment the four original (1895) alternators that were later to be driven by DC motors from the 460V DC system. The new plant was accommodated in an eastward extension of the original c1893 engine room and a new boiler house and chimney were also added (Ruddock c1982).

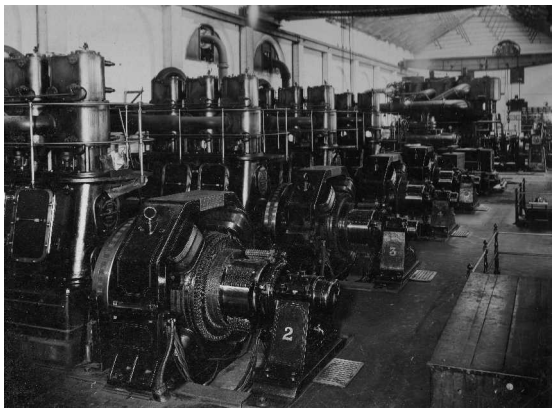

Figure 4 *Spencer St. P S 350kW DC sets c1901*

To encourage the use of electricity for motive power purposes and thus obtain better utilization of generating plant during daylight hours, the Council moved to introduce a separate light and power tariff with the former being charged at 5d/kWh (≈$2 today) and the latter at 3d/kWh (≈$1.25 today). The legality of this intention was vigorously challenged by the Gas Company on the grounds that it discriminated between customers and was contrary to the Act. After multiple court actions and appeals, a special amending Act was passed giving both the Council and the Gas Co. the right to have two-part tariffs. 'An unarmed truce was restored between the parties' (Ruddock c1982).

Whilst the changeover to the new DC system proceeded, the Council continued to operate the generating plant of the former private undertakers at Russell Place and Heffernan Lane as well its own generating plant at the Spencer Street power station. Electricity was also purchased for some time from the NAEC's Richmond power station.

6. SUBURBAN GENERATING COMPANIES

With the sale of the electricity supply assets in the City of Melbourne area to the Council, the Brush Company (UK) was able, in 1901, to complete its planned amalgamation of the former NAEC and ELMPC into a new UK registered company called the Electric Lighting & Traction Company (ELTC). The decision of the two former companies to accept the Brush proposal was reportedly influenced by difficult financial conditions for both companies following the loss of lucrative customers in the City of Melbourne. The protracted negotiations leading to this outcome are detailed in Lincolne, c1956.

The electrical generating plant for the new combined company was subsequently consolidated at the Green Street power station. The ELTC promptly set about a major system reconstruction, with two new 500kW, 4000/4400V, 50cps (50Hz), single-phase alternators and tandem-compound engines plus new Babcock & Wilcox water-tube boilers being ordered and installed. The distribution was then progressively converted to 4.2kV

(nominal) single-phase, mainly via underground cables, with local step-down transformer substations supplying 400/200V, 3-wire LV reticulation (Smith 1951; Lincolne c1956).

Bate, 1943, attributes the adoption by the ELTC of 50cps (50Hz) to the influence of the Brush Electric Co. who themselves had by that time standardized on this power frequency.

A 1000kW, 4.2kV, single-phase, vertical shaft, Curtis-BTH turbo-alternator was installed at Green Street power station in 1905, however BTH discovered a design fault that precluded its commissioning. After fitting of some replacement parts the set was operated at times of high load at up to 50% of rating until the alternator was completely replaced by BTH and then the turbine substantially rebuilt, all of which took until the end of 1908. A 1500kW Brush-Parsons single-phase turbo-alternator was also commissioned in the same year, although it too experienced early operating problems (Lincolne c1956).

In 1907, the Electric Light & Traction Company changed its name to the Melbourne Electric Supply Co. (MESC), and supplied an increasing suburban area outside of that under the control of the Melbourne City Council. The MESC 4.2kV single-phase distribution in 1910 extended from Fitzroy in the north, parts of Kew to the east, Brighton in the south and South Melbourne to the west. Transformer substations for local low-voltage supply were typically in underground pits excepting for main feeder centres (Smith 1951).

A further four single-phase, 4.4kV turbo-alternator sets with capacities from 2MW to 6MW were installed at the MESC Green Street power station between 1911 and 1919 with the earlier sets progressively retired. See Appendix A. Also, in 1921-22, two 5MW, 25/50Hz frequency changers were installed to permit importing then spare capacity from the new Victorian Railways Newport Power station (Curtis 1930; Lincolne c1956). The nominal 4.2kV single-phase underground cable distribution to 'main distributing centres' in surrounding suburbs for which the MESC had O-I-Cs, and for bulk supply to municipal electricity undertakings in other eastern areas, continued to be expanded and augmented (Smith 1951).

Separately, in 1906, the North Melbourne Electric Tramway and Lighting Company commissioned a power station in Mount Alexandra Road with an initial capacity of 250kW at 500V DC for supply of an electric tramway. It also provided public electricity supply at 230/460V DC in the nearby Ascot Vale and Essendon suburban area under its own Order-in-Council authority (Lincolne c1956).

7. MCCESD DEVELOPMENTS

In 1907-08 the MCC outer area supply was converted to 4.4kV, 50Hz, single-phase AC with customer supply transformers stepping down to 200V compared with 100V previously. This meant that supplies for lighting in the CBD were at 230V from the DC system, whilst the outer areas had a 200V AC service, as had been adopted by the ELTC for their suburban supply areas. After some temporary interim provisions, two Westinghouse single-phase 750kW turbo-alternators (T/As) were installed in a space made available in the SSPS engine room by the removal of original 1894 arc lighting dynamo plant. The DC generating capacity was also progressively increased with 3 – 750kW generators driven by Allen triple-expansion engines together with increased boiler capacity. Figure 5 shows the engine room at this time.

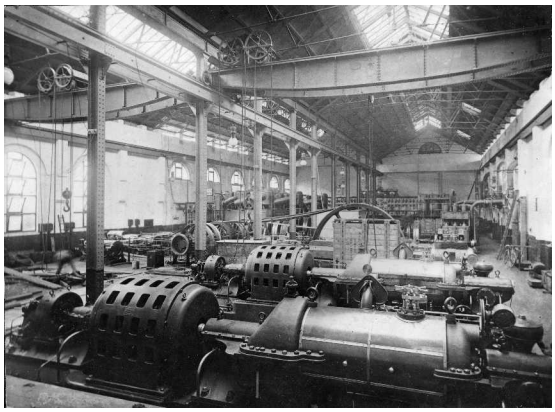

Figure 5 *SSPS Engine Room c1908 showing T/As*

In 1911 a 1500kW DC generator also driven by an Allen triple-expansion steam engine was installed at the MCC's Spencer Street power station and a 4000Ah accumulator installed at the Heffernan Lane site to further augment the CBD DC supply capacity. Voltage-drop on long DC cables was however becoming a major problem. Following a visit to Europe and UK by Mr H R Harper (then the City Electrical Engineer), a major decision was made to changeover to 3-phase, 6.6kV generation at Spencer Street PS and to convert to DC by rotary converter substations closer to the main load centres (Ruddock c1982). The development of the rotary converter in the USA around 1890 made this configuration convenient and it was employed in many other northern hemisphere cities where, like in Melbourne, a DC supply system existed. This expedient was also adopted for DC supply customers in the City of Sydney when the city corporation commenced its public electricity supply scheme in 1904.

Following the installation of a Siemens 4400kW, 6.6kV, 3-phase turbo-alternator at SSPS in 1913, two more 4400kW, 6.6kV, Willans-Robinson turbo-alternators were installed in 1914, in the space vacated by the retirement of the original four 350kW DC engine-generator sets. See Appendix A. A new condenser cooling water system was also constructed in the form of a two-compartment concrete box flume at grade from the

Yarra River to the SSPS under Spencer Street. This replaced the previous pumping station at Spencer Street Bridge and the 600 diameter cast-iron pipeline to SSPS. It is notable that owing to the large floor area requirements of the original c1894 generating plant, the higher capacity new generating plant could be housed in the original engine room and its c1901 extension for the first DC plant.

Four, 1500kW, 460V rotary converters, with associated step-down transformers, were installed at Heffernan Lane substation in 1915 and supplied via 6.6kV, 3-ph underground cable feeders from Spencer Street power station (Ruddock c1982). This was followed by four more rotary converter substations, with the last being commissioned in 1929 at Russell Place on the site of the former AEC's original generating plant. Figure 6 shows a rotary converter at Russell Place substation, c1930.

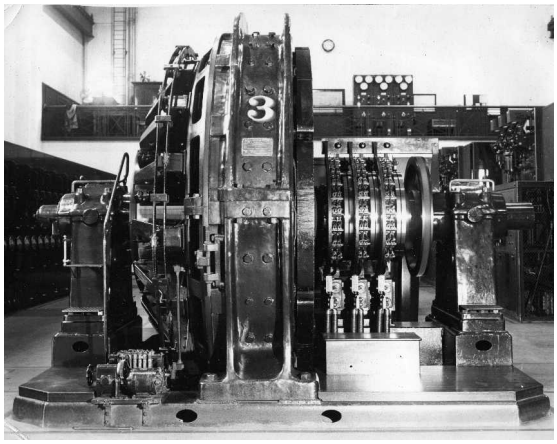

Figure 6 *Rotary Converter Russell Pl. Substation*

Retiring of the former 4400V, single-phase turbo-alternator sets and associated HV distribution in the MCC's outer areas and the conversion to 6.6kV, 3-ph, followed progressively in subsequent years with the low-voltage customer supply then becoming 400/230V, 50Hz – yet another change that was not completed until 1926. This included nearby northern and western municipal areas to which the MCCESD had provided bulk supply from 1912. Remaining parts of the 4400V single-phase system were supplied by auto-transformers from the 6.6kV system in the interim.

In 1921 the MCCESD supply capacity from SSPS was augmented by provision for importing up to 5000kW at 6.6kV from the newly constructed Victorian Railways power station at Newport, similar to the MESC at Richmond. For this supply to the MCCESD, a 25/50 Hz frequency changer was installed at Newport power station (later designated NPS 'A').

1930 was the peak year for the CBD DC supply system with a total of 43.5MW of 460V DC rotary converter capacity installed at five CBD substations and at SSPS. All were supplied in turn from the 6.6kV, 3-phase turbo-alternators at SSPS. A decision was made in 1932 to eventually phase out the DC system in favour of AC. Three-phase 6600/400V AC substations were established in the CBD from 1929 (Ruddock c1982). As the DC demand subsequently declined, the rotary converter plant was progressively reduced and by 1953 the Heffernan Lane substation was the sole DC substation with three 2500kW rotary converters supplying the DC distribution cable network. Two years later, the first of three glass bulb mercury arc rectifier assemblies were installed, initially to permit de-manning at night and weekends and later, as the DC load further reduced, totally replacing the rotary converters by 1957 (Ruddock c1982).

Implementation of the 1932 decision to phase out DC supply in the CBD was however not fully completed until 2003 when the last 460/230V DC customer supply – to the Victoria Hotel for a DC lift – was terminated. From about 1980, the progressively diminishing number of DC customers were supplied from mercury arc rectifier plant that had been relocated in 1962 from Heffernan Lane to the Russell Place substation, on the site of the original c1881 AEC premises. The DC equipment at 'RP' substation was still extant at the time of writing.

8. THE STATE ELECTRICITY COMMISSION

The Victorian Government passed the Electricity Commissioners ACT in 1918 and three part-time commissioners were appointed. Mr Harper, the former MCC City Electrical Engineer resigned from the MCCESD to take up the position of Chief Engineer.

In 1921 the State Electricity Commission of Victoria (SECV) was established under the chairmanship of Sir John Monash. The initial project was to develop Victoria's LaTrobe Valley brown coal deposits for bulk generation of electricity for the state. The first brown coal fired power station to come online was located at Newport adjacent to the Victorian Railways Newport 'A' traction supply power station. Denoted as Newport 'B' (2 x 15MW), it was commissioned in 1923, one year ahead of the first LaTrobe Valley power station, Yallourn 'A' (SECV 1949; Edwards 1969).

By 1923, a 22kV connection was made from the SECV's Newport 'B' power station to a substation on the MCCESD Spencer Street site (later denoted as substation 'J') with 22/6.6kV transformers to interface to the MCCESD's AC system. This enabled up to 10MW importation and superseded the earlier 6.6kV connection from the Victorian Railway's Newport 'A' 25Hz power station. Other provisions for bulk importation from the SECV system were made in later years (Ruddock c1982).

1925 saw the first stage of conversion to 3-phase importation from the SECV for the MESC supply areas with 6.6kV, 3-phase distribution in Fitzroy and Collingwood. In 1927, the single-phase 4.4kV generating plant at Richmond was scrapped and replaced

in 1929 by an SECV, 15MW, 3-phase, 6.6kV turbo-alternator (Curtis 1930; Smith 1951). The still extensive 4.2kV single-phase distribution was supplied by transformers from the SECV network pending its eventual conversion to 3-phase and 400/230V low-voltage services.

In 1930, the Melbourne Electric Supply Company (MESC) was formally acquired by the SECV after having been effectively administered by the Commission since the expiry of MESC's Order-in-Council authority in 1925.

Although the MCCESD took bulk supply from the new SECV power stations, the capacity of its Spencer Street power station continued to be expanded. Four new 5500kW, 6.6kV turbo-alternator sets were installed between 1927 and 1939. After 1941, the generating units at SSPS were dispatched by the SECV but ownership and operation remained with the Council. (Between 1949 and 1959, two 15MW and two 30MW Parsons turbo-alternators were installed in 'B' and 'C' engine rooms on the Spencer Street site and operated until 1981. Most of the site has recently been demolished).

9. MELBOURNE'S PLACE IN PUBLIC ELECTRICITY SUPPLY DEVELOPMENT

As outlined earlier, Melbourne was very much in the vanguard of public electricity supply implementation. However, as with other emerging technologies, this sometimes retarded the adoption of later developments and/or compounded their eventual cost due to the need to transition from the earlier technology.

The City of Sydney Corporation was a comparatively late entrant to public electricity supply and when it inaugurated supply from Pyrmont power station in 1904, electricity generation and distribution to city substations was at 6.6kV, 3-phase, 50Hz, from the outset (Wilkenfeld & Spearritt 2004). The MCCESD did not introduce three-phase generation and distribution until 1913 and converting AC supply areas outside of the CBD from single-phase to three-phase distribution, including an increase in the nominal low-voltage level, took until 1926 to complete (Ruddock c1982). In the case of the MESC, single-phase generation and distribution was retained until 1925 and then the conversion to 3-phase distribution - under the auspices of the SECV - of the many suburbs supplied out of Richmond took until the late 1950s to complete (Smith 1951). By contrast - albeit for a smaller distribution area - the Launceston scheme which commenced in 1895 with HV DC series arc lighting for the CBD and 2000V single-phase AC for other areas, based on generating plant at its Duck Reach hydroelectric power station, converted to 3-phase AC supply and distribution by1905 (Pierce 2007).

Low-voltage DC distribution, as implemented in Melbourne at the beginning of the twentieth century, was similarly adopted by other public electricity supply enterprises elsewhere in the world where the competing claims of the two systems won out in favour of DC rather than AC. For supplies in smaller towns where feeder distances were typically short, DC distribution remained viable until local generation was supplanted by eventual connection to regional electricity transmission networks ('grid supply').

10. CONCLUDING COMMENTS

Melbourne was one of the first major cities in the world, along with London and New York, to have a public electricity supply whereby electricity was distributed from a central generating station to paying private customers and was also used for public street lighting, replacing gaslights. As elsewhere, the pioneering electricity supply enterprises were privately financed and in Melbourne's case were initially quite small. The nascent electricity supply enterprises were adventurous in rapidly taking up and adapting a new public utility technology that had its origins in the UK, USA and Europe but which enabled local ingenuity and entrepreneurial spirit to flourish.

The entry of the Melbourne City Council into the public electricity supply arena from the mid 1890s and the subsequent establishment of other suburban municipal electricity supply undertakings, assisted by provisions of the 1895 Victoria Electric Light & Power Act, was a significant commitment by Local Government to an evolving technology. Until the takeover of the Melbourne Electric Supply Company (MESC) by the State Electricity Commission of Victoria, private enterprise also continued to play an important role in advancing the availability of electricity supply to commercial, industrial and residential consumers in Melbourne.

Following a total restructuring of Victoria's electricity supply industry in the mid 1990s, 'the wheel has turned full circle' with the generation, transmission, distribution and retailing functions again in the hands of private sector entities.

In conclusion, it is contended that as well as being a front-runner, Melbourne's early public electricity supply development encompassed most of the evolutionary technical and structural facets of the industry.

11. ACKNOWLEDGEMENTS

The photographs reproduced in Figures 3 to 6 are from T Ingram's prints collection.

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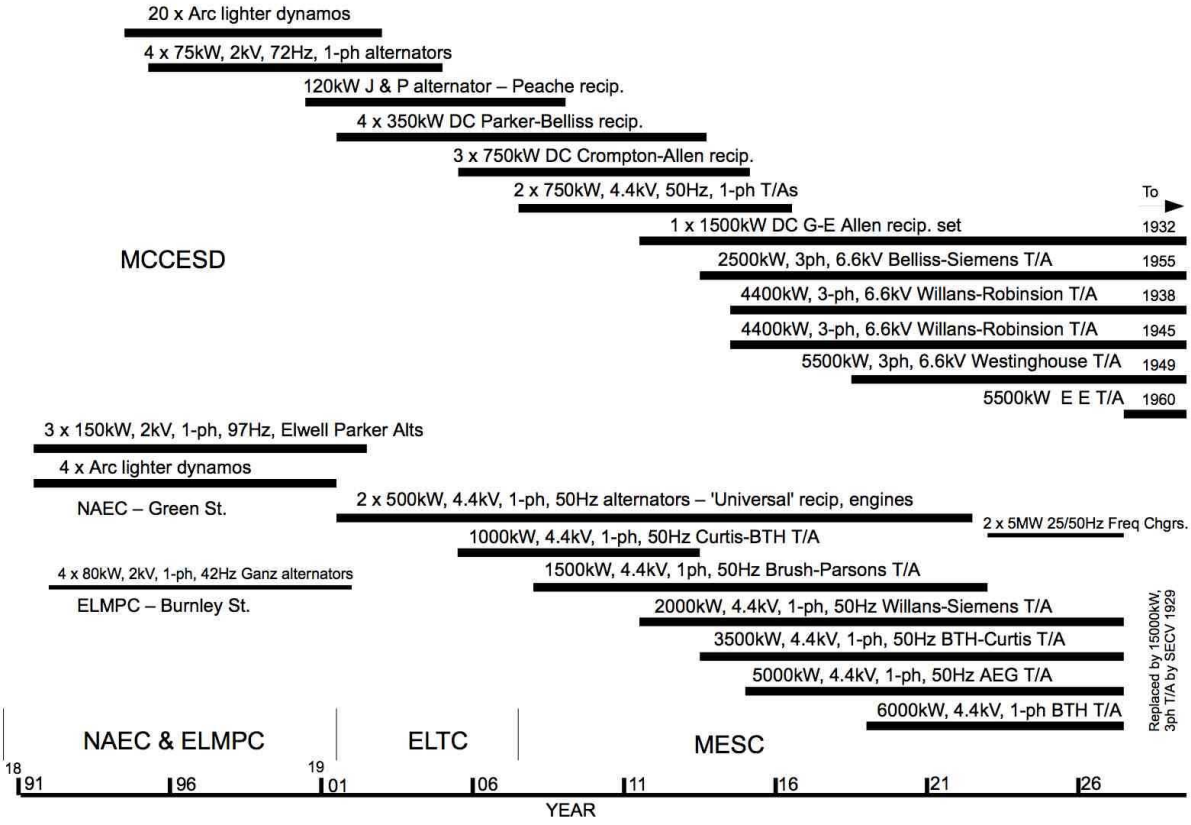
Appendix A. Melbourne Public Electricity Supply – Generating Plant 1890 to 1930*



* Excludes SECV (1923 -)