CITY OF COVENTRY
SINGLE AND TWO PHASE GENERATION AND DISTRIBUTION

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INTRODUCTION

In 1895 a single-phase 2,000-volt generation and distribution system operating at the unique frequency of 87 Hz was established in Coventry. Events, which led to the adoption of this system and its eventual replacement by a two-phase arrangement are examined.

In the 1890s there was a reluctance to consider three-phase systems, principally because the currents must of necessity be interconnected. It was mistakenly believed that it would present some difficulty in regulation. On the other hand with two phases the currents could be independent and were regarded as easily regulated[1]. Dr John Hopkinson approved the adoption of a two-phase transmission system by the Metropolitan Electric Supply Company in 1899 as it appeared to permit simpler cables and balancing of the two phases was easier[2]. A textbook of 1904 refers to three-phase as 'a curious arrangement of currents'[3].

However, by 1907 attitudes were changing and two-phase generation became regarded as obsolete and a survival of the transition period from single phase to multi phase when the industrial supply of power as distinct from lighting began to assume prominence. In 1907 it was judged that two-phase systems are little likely to be utilised in any new works, as they had no advantages over three phases and have several disadvantages[4].

When two-phase generation ceased extensive two-phase distribution systems were maintained for many decades from three phase sources by Scott connected transformers. Two-phase distribution originally associated with two-phase generation was employed in areas of the West Midlands until 1972[5].

DEVELOPMENT OF A 87 HZ SINGLE PHASE SYSTEM IN COVENTRY

The Hammond Electric Light and Power Company approached Coventry Corporation in September 1882 for consent to obtain a Board of Trade Licence to supply electricity in the town. This approval, required under the Electric Lighting Act 1882, was refused. The Edison Company and the Gulcher Company also proposed to apply for a License.

John Fowler and Co. of Leeds well known for building traction engines and agricultural machinery diversified into new products to combat the effects of the agricultural depression of the 1880s. The services of Wm. Lowrie and C.J.Hall were acquired with the rights to manufacture, under license, electrical equipment (Fig.1) under their patents[6]. In addition to steam engines the company was then able to contract for equipping complete generating stations including Lowrie Hall alternators, transformers and switchboards. Robert Hammond (1850-1915) an engineer who established many of the earliest public electricity supply systems in Britain and founded the Hammond Electrical Engineering College (later to become 'Faraday House' training school) also entered into an agreement with John Fowler & Co.

Coventry Corporation with a view to obtaining their own Provisional Order engaged Mr A. Bromley Holmes, the founder of the Liverpool Electric Supply Company, to advise on the streets in which to lay mains. Together with the Electric Lighting Committee he viewed Pool Meadow as a possible site for a generating station[7], a proposal not accepted. After a Provisional Order was obtained in 1891 it was determined that before adopting either a high or low voltage system of distribution enquiries should be made in towns where electric lighting was in operation. Members of the committee visited London on 11 January 1893 to inspect the electric lighting plants at Bankside, Deptford, St Pancras and the John Fowler plant (Fig.2) at West Brompton [8].

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In November 1893 a tender from John Fowler & Co. was accepted for equipping a generating station at Coventry.

Robert Hammond was appointed consulting engineer to execute the work at a commission of 5% of the contract[9]. In October 1894 Gilbert Scott Ram, one of the first students at the Hammond Electrical Engineering College, was appointed Clerk of Works to superintend the engineering portion of the contract.[10].

A site was chosen for the generating station in Sandy Lane adjoining the Coventry Canal and two acres of land purchased. This provided the opportunity of negotiating terms for condensing water with the Canal Company. The supply was commenced in November 1895 with a single-phase 2000 volt (later increased to 2,200 volts) system operating at 87Hz. The frequency of 87 Hz was unique[11]. 50 kW and a 100 kW Fowler alternators were rope driven by 100 and 200 hp Fowler horizontal compound engines. High voltage cables with indiarubber insulation laid in pipes distributed to street transformers provided consumers with a 100-volt supply. Failures of these indiarubber insulated high voltage cables led to a decision, in May 1897, to adopt paper insulated cables in future[12]. In association with Hammond Fowlers constructed similar generating stations at West Brompton, London and Leeds.

In a discussion at the Institution in 1900[13] Hammond suggested that he was responsible for the unusual frequencies of 80, 81, 82, 83, 84.5 and 87 Hz. He explained that while they were all related to one standard with 10,000 complete alternations per minute [83⅓ Hz] station engineers found it convenient to run plant a little faster or slower. At that time there was no concept of interconnected systems or the need to consider induction motor speeds or electric clocks. It was not until 1906 that Board of Trade regulations required the frequency of a supply system to be declared and in addition to be either 50 Hz or 25 Hz.

In 1896 Hammond, who frequently attended the Coventry Electric Light Committee meetings, called attention to the immediate necessity for an extension to meet the demand recommending an additional 200 kW plant. A rope driven alternator was installed with a 400-hp Fowler horizontal engine. The committee authorised the running of the generating station continuously through the winter[14] from November 1897. It had previously run from 8am to 2am on weekdays and from dusk to midnight on Sundays.

Following a request to Hammond, in January 1898, to prepare specifications for an extension employing a vertical high-speed engine a Belliss and Morcom engine directly coupled to a Fynn 300kW alternator was ordered. This alternator was an inductor machine in which both armature and field windings were stationary. In September 1900 G.S.Ram reporting on plant capacity remarked that careful consideration was required to provide supplies for power purposes on a large scale[15]. However, there was no reference at that time to a change of frequency or adoption of a multi phase supply.

The corporation dispensed with the services of Hammond as Consulting Engineer in January 1901 and relied on G.S. Ram as their advisor on all extensions, increasing his salary to £400 per annum. In the following month the committee accepted with very great regret the resignation of Mr Ram when he joined the Nernst Electric Light Company. This was followed by his appointment by the Home Secretary as the first Electrical Inspector of Factories under the 1901 Factories and Workshops Act[16]. Joseph A. Jeckell, Borough electrical engineer at South Shields was appointed engineer and manager at Coventry in April 1901.

A TWO-PHASE 50 HZ SYSTEM ESTABLISHED

In 1901 the Electric Light Sub Committee decided to revise a scheme previously sanctioned by the council and adopt two phase generation at 50 Hz instead of single phase generation at 87 Hz. It was also agreed to increase the new plant from 300 kW to 600 kW[17], the existing 87 Hz generators to remain in service.

A two-phase system was attractive in areas originally supplied with single-phase current when considerable demand had arisen for motors. Two phase induction motors being superior to single phase there was a distinct advantage in substituting a two phase for a single phase supply, extensions being carried out using twin concentric cables. From 1902 the corporation began purchasing electric motors for hire to local manufacturers. They included sizes from ½ hp to 50 hp with annual rental charges from £1-13-6 to £25-0-0[18].

In 1904 a 1000hp Mclarren triple expansion engine and a Siemens Schukert two-phase alternator was purchased to add to two similar sets then in service[19]. Substations incorporating British Westinghouse oil immersed transformers or Berry air-cooled transformers were often controlled by Sparklet CO_2 fuses.

In a curious minute in December 1904 the electricity committee resolved ‘that an allowance of 5s be made at Christmas next to each of the men employed at the electric light works in lieu of the present of beef which has hitherto been made but the men be informed that the practice will be discontinued in future’[20]. Could Dickens Christmas Carol have originally inspired this?

In March 1906 the generating station switchboard was regarded as old and unsafe, there having been three accidents

which could have had serious consequences. Three engines and alternators, part of the original 87 Hz plant, were still in service but unsatisfactory. By November 1906 these remaining single-phase alternators had been removed and generation at 87 Hz together with the use of rope driven plant ceased in Coventry.[21]. The removal of this obsolete plant provided sufficient floor space for two new two-phase 600 kW sets without extending the engine room[22].

This increased the total generating capacity to 2,700 kW and motors now formed a very large proportion of the electrical load in the town[23].

In 1908 the Town Council agreed to the erection of a refuse destructor adjacent to the electricity generating station. An agreement with the electricity department to pay £1,000 annually for steam was based on the estimated saving in coal[24].

Major Cardew when consulted on plant extensions recommended the installation of two 2,500 kW two-phase turbo alternators and the replacement of Lancashire boilers with water tube boilers. Tenders for this plant were accepted from BTH and Babcock and Wilcox in February 1911[25].

Shortly after the outbreak of World War One an abnormal increase in load included an extra 600 kW by the Daimler Company and the immediate prospect of a 500 kW demand from the Coventry Ordnance Works. It was agreed that the Ordnance Works supply could only be given if there was an agreement by them to suspend or reduce the load between 4.30 and 5.30 p.m. on working days[26]. In 1915 after the Corporation entered into a contract with BTH for a 3,000 kW turbo alternator the sub contractors advised that the whole of the blading had been comandeered by the Admiralty. The Coventry Ordnance Works, Daimler Co, Messrs Alfred Herbert and Messrs White and Poppe were notified that unless the decision of the Admiralty was reversed the corporation would be unable to meet the increased demand for electricity, suggesting that they communicate with the Admiralty to support the Electricity Committee[27].

Coventry, as an armaments centre, experienced an exceptional increase in demand for electricity between 1914 and 1918. The impossibility of carrying out any further large extensions at the Sandy Lane station led the Corporation to consider a new site. In 1918 land, then outside the city, was purchased upon which the Longford generating station was to be built. Although it was the intention of the Corporation to proceed at once with the new station it was delayed at the request of the Electricity Commissioners. They refused to sanction this development pending the settlement of the national scheme for electricity generation and distribution then under consideration. It was not until 1925 that consent was given to the construction of the Longford generating station.

INTRODUCTION OF A THREE PHASE SYSTEM

As an interim measure the Leicestershire and Warwickshire Electric Supply Company was authorised to provide the Corporation, from 1 April 1926, with a maximum of 3,000 kW at 33kV, 50Hz[28]. A bulk supply was available from the company's Warwick generating station to Gulson Road substation at Coventry in September 1926. Erection of 2,200-volt two-phase switchboards at the primary substations enabled the extensive two-phase networks to be supplied from the 33kV system via Scott connected transformers

Longford generating station was officially opened on 31st October 1928 with two 18,750 kW, three phase alternators generating at 6,600 volts. In 1938 two 30,750 kW 33 kV alternators were added.

In September 1933 work was proceeding in the city centre to raise the voltage from 200 to 230 volts and it was intended that the single and two phase systems were to exist along with the three-phase system[29]. Generation at 2,200 volts two-phase was discontinued at the Sandy Lane generating station on 31 March 1936[30]. The 2,200-volt two-phase system was finally discontinued on 24th March 1969 when the last remaining consumer was transferred to a standard supply[31].

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